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Wind & solar energy and nature conservation

Contents

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Table 1: BirdLife Europe (2011)

Figure 1: Katsaprakakis (2012)

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Introduction

Future brief: wind & solar energy and nature conservation

'Efforts to address climate change and protect natural ecosystems can – and need to – benefit each other.'

Climate change and the degradation of ecosystems and biodiversity cannot be solved in isolation. Land and marine ecosystems play a crucial role in the climate system, capturing roughly half of carbon dioxide emissions generated by human activities (UNEP, 2009). Protecting biodiversity preserves ecosystem services that are important for regulating the climate and helping us to adapt to the impacts of climate change. Meanwhile, increasing the share of energy we generate from renewable sources eases pressure on ecosystems by slowing climate change. Thus, efforts to address climate change and protect natural ecosystems can – and need to – benefit each other.

However, conflicts can also arise between renewable energy and nature conservation policy. For example, important habitats may be lost, or fragmented by, wind farm and solar park developments, and bird and bat collisions with wind turbines are widely documented. This Future Brief focuses on how land-based ecosystems are affected by wind and solar photovoltaic (PV) development, and how win-win solutions which maximise both conservation and climate benefits may be developed.

We cannot tackle biodiversity loss without addressing climate change. The shift from fossil fuels to renewable energies, like wind and solar, is necessary to avoid climate change spiralling out of control. However, it is equally impossible to tackle climate change without maintaining and restoring biodiversity and ecosystem services. Careful strategic-level planning combined with project-by-project assessment will help harmonise efforts towards meeting renewable energy and nature conservation and restoration goals, including by minimising energy installations' negative impacts on biodiversity and habitats.

EU policy context

In 2008, EU Member States agreed on a Climate Change and Energy Package with three clear targets for 2020: to cut greenhouse gas emissions by 20%[1]; to cut energy consumption by 20%[2]; and to increase the share of energy consumption derived from renewable sources to 20% (EC, 2011). With respect to the third target, Directive 2009/28/EC later set mandatory targets for individual countries. Targets ranged from 10% of energy from renewables for Malta to 40% for Sweden. In January 2014, a new overall target of at least 27% was proposed for 2030, along with a framework of national plans for meeting the collective target[3] (EC, 2014).

Meanwhile, as a Party to the Convention on Biological Diversity, the EU is committed to achieving the Strategic Plan and Aichi Targets[4], which include reducing the loss of natural habitats, preventing extinctions of threatened species and protecting important ecosystem services[5], such as water cycling, pollination and carbon storage. The Birds and Habitats Directives form the cornerstones of EU nature conservation policy and establish the Natura 2000 network of protected areas. The network, which is comprised of over 27 000 sites, stretches across all 28 countries and covers over 18% of the EU's total land area as well as significant marine areas[6].

The Natura 2000 model of conservation is designed to enable sustainable development – protected areas do not exclude people and infrastructure. However, economic and social activities must be consistent with

1 Compared to 1990 levels (EC, 2011).
2 Compared to projected 2020 levels (EC, 2011).
3 No binding national targets were set.
4 http://www.cbd.int/decisions/cop/?m=cop-10
5 http://www.cbd.int/sp/targets/
6 http://ec.europa.eu/environment/nature/natura2000/barometer/index_en.htm

the conservation objectives of the sites. Following an appropriate assessment, if it is determined that a plan or project will affect the integrity of the site this development may only be permitted for "reasons of overriding public interest", when there is an "absence of alternative solutions" and where measures are taken to compensate for the damaging effects of the project. Several EU Guidance documents deal with development under the Habitats Directives and with wind farms and Natura 2000. See: http://ec.europa.eu/environment/nature/natura2000/management/guidance_en.htm#art6 for an explanation of assessment procedures[7] for projects affecting Natura 2000 sites (EC, 2011). Outside of the Natura 2000 network, the presence of species of "community interest" listed under the Birds and Habitats Directives means that projects which risk damaging their breeding sites or significantly disturbing them also need to comply with EU law.

1. Challenges and opportunities

Meeting renewable energy targets whilst protecting biodiversity presents both challenges and opportunities at national, regional and local levels. Some countries are already making good progress in meeting these two goals, including Germany, which is a leader in onshore wind and solar energy (BirdLife Europe, 2011). The German Solar Industry Association, in conjunction with the German Society for Nature Conservation, has drawn up criteria to guide nature-friendly solar development (Peschel, 2010). Meanwhile, other countries are making less progress in developing renewable energy infrastructure. For instance, investment in solar development is not currently considered profitable in Poland due to a lack of economic incentives (Sliz-Szkliniarz, 2013).

In the short term, increasing renewable energy production will reduce carbon emissions, but the long-term effects of converting large areas of habitat to achieve this reduction are not well understood (Katzner, 2013). Methods for modelling energy scenarios over the long term do not provide enough spatial detail to analyse local impacts (Krewitt et al., 2005).

One crude measure of the potential habitat impacts of energy generation is given by estimating the land area required to generate a given amount of electricity. Most studies suggest solar and wind energy are more space-intensive than traditional electricity sources. For example, one study finds that solar power requires 37km^2 to generate a terawatt-hour per year, while wind energy needs 72km^2. In comparison, coal power needs 10km^2 to produce this amount of energy and nuclear power needs just 2km^2 (McDonald, 2009). However, these figures are dependent on the specific site used and do not take account of other direct or indirect environmental impacts that could also occur in future, such as extraction of coal and uranium, waste storage, nuclear catastrophe or area of potential hazard. Carefully siting energy infrastructure (for example installing solar panels on already existing buildings and sealed land) can minimise its impacts on valuable habitats and could even provide opportunities for regeneration and combined use, for instance, with agriculture.

A further challenge is the upgrading and expansion of national power grids to cope with renewable energy development. This adds to the land 'footprint' of renewable energy production and its impact on ecosystems – which is also a consideration with conventional energy production. As is the case with energy plants themselves, engaging early on in the planning process with local communities, transparent decision-making and managing expectations will be key to the success of these projects (Schneider & Bätjer, 2013).

7 Any plan that is likely to have a significant impact on a Natura 2000 site must undergo an 'Appropriate Assessment' to assess effects on habitats, species and ecological structure and function, and to design mitigation measures, before approval can be granted.

2. Renewable energy impacts and solutions

'Appropriate siting of energy infrastructure is key to avoiding or reducing many destructive impacts.'

Wind turbines and ground-mounted solar panels pose medium-level risks to nature, according to BirdLife Europe (2011). The bird and bat deaths caused by wind turbines are widely known. Other important impacts of energy infrastructure include habitat loss and habitat fragmentation, which may cause changes in the behaviour of animals. As in other situations where habitats are disturbed by human activities, behavioural changes may include avoidance of an area, as well as changes to movement patterns, foraging and breeding. Some species may be permanently displaced by an energy development, while others may return after the initial construction phase. Every project is different, owing to the particular nature of the habitat. Impacts therefore need to be considered on a case-by-case basis, as well as at the strategic level (Hernandez, et al., 2014a; EC, 2011).

The effects on nature of power transmission lines are the same for renewable energy as they are for those caused by traditional methods of electricity generation and include bird collisions and electrocution. In most cases, it is considered preferable to site energy facilities near to existing transmission lines to minimise disruption to wildlife (Cameron et al., 2012). On the other hand, wide transmission corridors for power lines have been known to increase biodiversity by opening up new habitats (Hernandez et al., 2014a). Good site selection, through mapping and strategic and environmental impact assessment (see Section 3), emerges as the potential industry best practice, whereas inappropriate siting can lead to valuable species and habitats being disturbed or lost altogether.

Table 1: Solar and wind: impacts and solutions.
Source: Adapted from BirdLife Europe (2011).

TECHNOLOGY	MAIN CONSERVATION RISKS CONSIDERED	AVOIDING AND MITIGATING RISKS	ACHIEVING BENEFITS FOR WILDLIFE
Solar PV arrays	▪ Habitat loss ▪ Direct impacts on birds, mammals and insects ▪ Habitat fragmentation and/or modification.	▪ Avoid protected areas ▪ Retain trees and hedges ▪ Time construction and maintenance to avoid disturbance of birds and bats during breeding seasons.	▪ Manage vegetation around/ beneath panels for wildlife ▪ Use some revenues to support on-site conservation.
Onshore wind power	▪ Disturbance/displacement ▪ Barrier effects ▪ Collision mortality ▪ Habitat loss.	▪ Spatial planning (sensitivity mapping and location guidance) and site selection ▪ Modelling collision risks and estimating displacement impacts ▪ Improved tools and methodologies to assist pre- and post-construction monitoring and research ▪ On- or off-site ecological enhancements.	▪ Positive land management changes ▪ Create wildlife areas on- or off-site as part of community-benefit packages.

2.1 Wind power

Including offshore production, Europe's installed capacity[8] for producing electricity from wind energy could increase from 117 GW, or 117 000 MW, in 2013 (EWEA, 2014) to over 200 GW in 2020 (EC, 2011). Most impacts of wind infrastructure are not due to direct clearing of land or habitat loss, but to bird and bat collisions, habitat fragmentation and avoidance behaviour (McDonald, 2009). While bird fatalities have received much attention, the wider and long-term habitat-related impacts of wind power are not well studied (Lovich and Ennen, 2013), especially for reptiles, amphibians, forest carnivores and small mammals (Strickland et al., 2011).

Estimates of bird and bat collisions vary from site to site, and depend on the location, the technology used and the abundance of birds locally. In the US, birds have been estimated to be killed at a rate of between 3-5 individuals per MW per year, while bat collisions at some sites are as common as 30 per MW per year (AWWI, 2014). It is important to note that the number of bird deaths arising from turbine collisions overall represents a tiny fraction of the total bird deaths caused by humans: pet cats, windows and transmission lines kill many more (Kiesecker et al., 2011).

However, it is also important to note that certain species may be more affected by turbines than others. Deaths of bats and birds that have slower reproductive rates, like raptors, may be most significant, because their populations will replenish more slowly. High collision rates have been recorded for griffon vultures in Spain and red kites in Germany (Gove et al., 2013). At some older wind farms built before improvements in strategic planning, up to two raptors per MW per year may be killed (Arnett et al., 2007). Newer generation turbines sited with appropriate planning may pose lower risks, but comparisons between sites are difficult to make because different sites have different sizes of bird populations, as well as different species with different behaviours. Radar systems are available that can be used to scan the sky for birds and bats, and automatically shut down turbines while they pass through (DeTect, 2014; Swiss Birdradar Solution AG, 2014). Operational adjustments, such as changing the cut-in speed[9] or the angle of blades relative to the wind, may also reduce collisions. Data from ten US studies suggests that bat collisions are halved when turbine cut-in speed is increased by 1.5 metres per second above the manufacturer's speed (NREL, 2013). This may be because bats are more active at lower wind speeds; the insects that bats feed on do not fly in high winds.

Long-term studies are needed to understand whether species habituate to wind turbines or whether they leave and stay away permanently (EC, 2011). Some birds avoid turbines, while others remain loyal to particular habitats. Bats seem to be drawn to turbines, perhaps because the turbines attract insects through heat or the creation of clearings in forests (Strickland et al., 2011). It is not clear to what extent wind turbines and other infrastructure may act as barriers to the movement of deer (Lovich and Ennen, 2013) and smaller mammals. The additional fragmentation caused by access roads may compound the effects. For example, roads have been shown to act as barriers to gene flow in vole populations, affecting genetic diversity (Kuvlesky, 2007).

Other impacts of wind power include compacting soil, which affects burrowing animals (Lovich and Ennen, 2013), and disturbance of local weather patterns by giant turbines (Leung and Yang, 2012), with potential impacts on local wildlife. It is possible that turbine noise and shadow flicker may also affect wildlife, but there is very little research into these issues.

Again, appropriate siting of energy infrastructure is key to avoiding or reducing many destructive impacts. Buffer zones around nesting, roosting and foraging sites can also help avoid impacts (EC, 2011). Dual use of farmland for agriculture and wind energy production could be beneficial, by using land that is already disturbed by human activity while increasing its profitability for farmers (Kiesecker, 2011). Low-quality habitats, such as the ridges surrounding abandoned mines (see Case Study 1) and roadsides, could also be considered.

CASE STUDY 1:

Black Law wind farm, South Lanarkshire, UK

A 97 MW wind farm incorporating 47 turbines and 14km^2 of nearby managed land has been sited on degraded moorland previously used in opencast mining, in Scotland, UK. The project is a partnership between a national electricity supplier, wildlife organisations and a university. Non-native Sitka spruce trees were cleared to make way for regeneration of blanket bog – a globally rare habitat that is important for carbon storage. A monitoring programme has shown that plants including heather and bog cotton have started to recolonise the site, which is also intended to provide habitat for locally important populations of breeding waders and farmland birds. Further research is underway to identify measures needed to restore the site to 'active bog', a key habitat type listed under the Habitats Directive.

Sources: EC (2011), Scottish Renewables/Scottish National Heritage/SEPA/Forestry Commission Scotland (2010) and RSPB (2014).

8 The maximum number of watts of electricity that can be produced in one hour. For wind turbines, this assumes optimal wind conditions.

9 The wind speed set by the operator that allows the turbine blades to start turning.

2.2 Solar power

Photovoltaic (PV) cells mounted on or integrated into buildings avoid impacts to natural habitats completely. However, because ground-mounted PV is more attractive to investors in some European countries as a profit-making endeavour (Sliz-Szkliniarz, 2013), development of solar parks will likely continue.

The number of direct animal deaths at solar parks is thought to be negligible (Katzner, 2013). The worst impacts of ground-mounted solar installations occur when all natural habitat in the vicinity is cleared, stripping vegetation and compacting soil. This can reduce the carbon content of the soil compared to undisturbed areas and, in arid regions, allows the transport of dust, which can reduce the efficiency of solar panels (Hernandez et al., 2014a). As with wind installations, many impacts can be reduced or avoided by appropriate siting. The German Renewable Energy Sources Act only allows installations on land that has previously been disturbed, for instance, by farming or for military use, in order to avoid new negative impacts (Krewitt et al., 2005). Siting on forested lands increases carbon emissions by a factor of up to four compared to grasslands or deserts, due to the trees that are cut down (Turney and Fthenakis, 2011). Ideal sites include brownfield and degraded land – creating so-called 'brightfields' (Hernandez et al., 2014b). At any site, avoiding soil sealing is highly desirable and the use of support spikes instead of heavy foundations minimises the land area affected (Peschel, 2010).

Fragmentation of habitats remains a problem with solar parks. However, due to the lack of moving parts and minimal ground disturbance, with careful management solar parks can be havens for wildlife (BRE Trust, n.d.). Sowing wildflower meadows and installing animal boxes, alongside careful management of hedgerows, field margins and livestock grazing, allows grasslands to flourish without excessive maintenance costs. In one case, a brownfield site in Germany previously used for military training was cleaned of munitions and is now a solar park and bird conservation area. Preliminary research shows that the habitat has been improved in the long term for a number of different bird species (Peschel, 2010). (See Case Study 2 for a further example of co-benefits for wildlife.)

Other risks to wildlife from solar park operation include chemicals, such as dust suppressants and rust inhibitors (Hernandez, et al., 2014a). Water is also used to clean the panels, which may pressurise scarce resources in dry regions (Cameron, et al., 2012). However, these impacts may be reduced by using more appropriate chemicals and safety and waste disposal practices, and by minimising water use (Tsoutsos, 2005).

It is also important to take into account the life-cycle assessment: processes involved in obtaining rare materials used for making solar panels may lead to biodiversity impacts elsewhere, e.g. at the source of extraction, often in countries outside the EU. Improved technology for solar panels may reduce these impacts in future.

CASE STUDY 2:

Salmdorf Solar Plant near Munich, Germany

A small 1 MW solar PV park in Salmdorf near Munich was completed in 2007 and is built on a site that was previously used as a gravel pit in an area of intensive farming. The site included special provisions for nature conservation, such as managed grassland; a hedgerow border; trees and bushes; a chain-link fence to allow small animals, such as hares, pheasants and partridges, to pass; and ponds to create spawning grounds for endangered toads under a 'green toad scheme', developed in partnership with the local authority. Rare plants including spreading bellflower, meadow cranesbill, oxeye daisy, meadow salsify and meadow sage are now established on the site.

Source: Peschel (2010).

3. Planning with conservation in mind

Renewable energy projects should give environmental impacts special consideration during planning. They should not be overlooked, but should be viewed alongside the social, political, economic, technical and cultural factors which influence planning decisions.

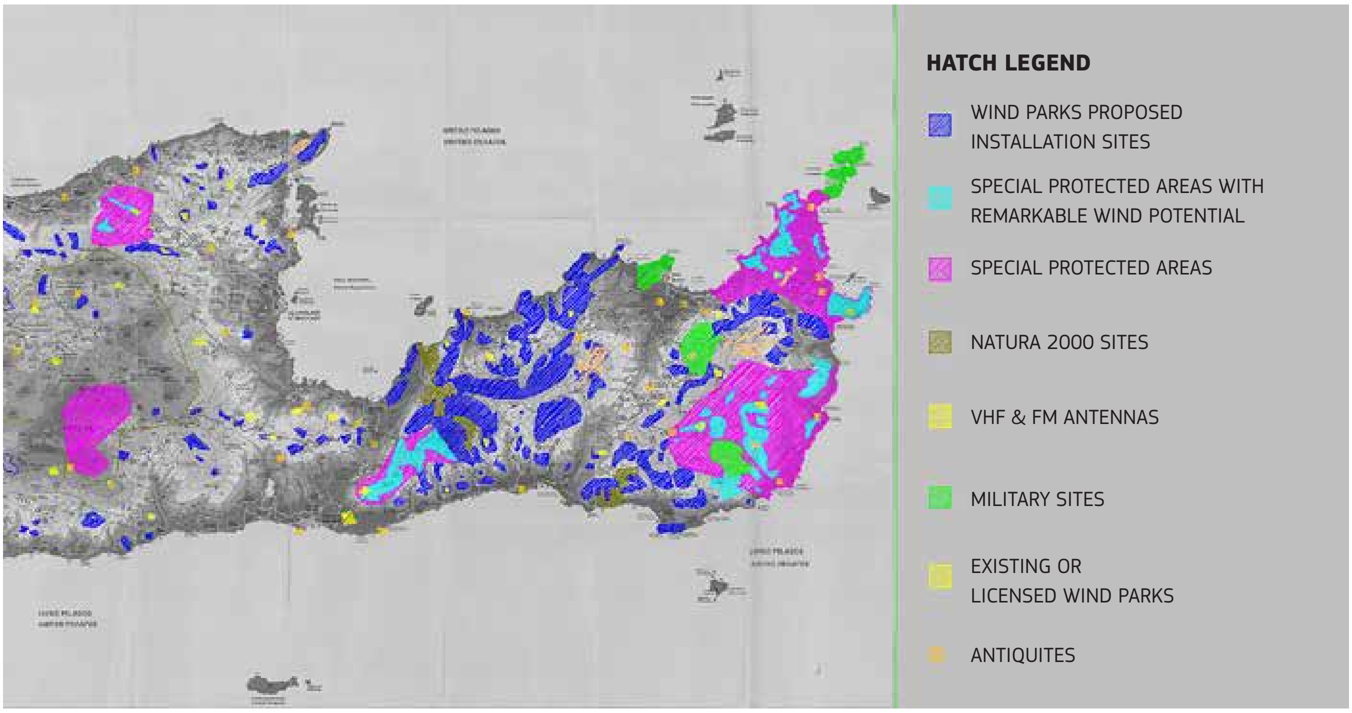
Spatial planning approaches are needed to identify suitable sites for wind and solar parks. Some planning approaches use 'hard constraints' to eliminate high-risk or legally prohibited areas, whereas others balance energy production potential against environmental factors to produce suitability scores (Stoms, 2013). Eliminating unsuitable sites may require development of criteria for high-risk conservation areas that should be avoided (Arnett et al., 2007). Various sources suggest identifying areas of land that may be said to have 'existing footprints', so that impacts on habitat quality are kept to a minimum. This means choosing sites that have already been disturbed, for instance, by agriculture or industry and where there are existing transmission lines and roads (Kiesecker, 2011; Cameron, et al., 2012; Hernandez, et al., 2014b).

3.1 Geographical information systems

Planning may involve creating maps that indicate where development might overlap with sensitive habitats and species (BirdLife Europe, 2011). Geographical information systems (GIS) can be used to integrate different types of data to create these maps. Krewitt, et al. (2005) combine spatial data on, for example, bird breeding habitats and wind energy potential. Katsaprakakis (2012) created a map to identify optimal sites for wind farms in the Prefecture of Lasithi in Crete, taking into account Natura 2000 sites, while Mari et al. (2011) used GIS to create an interactive web-based "decision support system" for identifying potential wind farm sites in Tuscany, Italy. (See Fig. 1.)

This approach to mapping can be used to help minimise impacts on wildlife, ensure compliance with the Birds and Habitats Directives and protect developers from costly investments in inappropriate sites (EC, 2011), thus protecting the reputation of the industry as a whole.

Figure 1: Mapping of proposed wind farm sites for Lasithi, Crete, taking into account protected areas and other restrictions.
Source: Adapted from Katsaprakakis (2012).



3.2 Strategic environmental assessment, environmental impact assessment and appropriate assessment

Environmental assessment for renewable energy projects may take place at two levels: strategic environmental assessment (SEA)[10] and environmental impact assessment (EIA). Ideally, SEA engages stakeholders in higher-level discussions that form part of the process of developing renewable energy plans and programmes – at national, regional or local levels. In Europe, often, the lack of strategic-level planning can delay wind energy development and threatening valuable habitats and bird species (Gove et al., 2013). On the other hand, SEA provides no guarantee that the particular projects that are authorised are those that will have the least impact on the environment. This is why a more project-oriented assessment – an EIA – is needed. The EIA considers impacts on a specific site (Athanas & McCormick, 2013). Used conscientiously, it can be seen as a way for developers to ensure that their projects are sustainable and should include transmission lines as well as energy infrastructure

Negative environmental impacts will inevitably occur in some cases but these can be mitigated by: carrying out thorough SEAs, developing mitigation and monitoring strategies early on in the planning process, adjusting plans for specific sites based on environmental assessments, incorporating the views of all key stakeholders, and, where possible, 'environmental enhancements', such as those described in Section 2.2 for solar parks (BirdLife Europe, 2011; Peschel, 2010; Arnett et al., 2007; Gove et al., 2013). At the project level, engaging with local communities from the start brings benefits by drawing on local knowledge and experiences, and increases public acceptability of the final plans (Sliz-Szkliniarz, 2013; Tsoutsos, 2005).

An appropriate assessment, in accordance with the procedure set out in the Habitats Directive, is required where there is a likelihood of a significant effect on Natura 2000 sites (EC, 2011). Particular attention is needed to base decisions on sound scientific information and expertise. Delays in the approval process can result from a poor quality assessment that prevents the competent authorities from making clear judgement on the impact of a plan or project. Whereas an appropriate assessment is a distinct legal requirement from an SEA or EIA, it makes sense to streamline these procedures to ensure that assessments are carried out in an integrated, timely and cost effective manner.

10 Relevant policy: SEA Directive (2001/42/EC).

4. Summary

It is clear that the shift from fossil fuels to renewable energies such as wind and solar is necessary to avoid uncontrolled climate change. The EU aims to be producing 20% of its energy from renewable sources by 2020. Meeting this target will affect the environment at a local level, through new infrastructure, including renewable energy facilities and transmission lines.

"Given the planned expansion of renewable energy production in the EU, a considered approach is necessary to prevent decline and loss of habitats and species."

At present, the long-term effects of wind and solar parks on ecosystems are not well understood – more research and standardised approaches to research are needed in this area. However, impacts can be minimised by appropriate site selection, strategic and project-level environmental assessment, and engaging key stakeholders and local communities from the outset. Appropriate sites for these developments may include brownfield sites and dual-use farmland.

The available research suggests that, given the planned expansion of renewable energy production in the EU, a considered approach is necessary to prevent decline and loss of habitats and species. Environmental impacts should be given special consideration when planning – along with other types of assessment. It is imperative to consider ecosystem data at a specific, local level as well as at a national and regional level.

While wind turbines pose a threat to some bird and bat species, collisions that cannot be avoided by careful siting may be reduced by operational adjustments. Site regeneration and environmental enhancement can even provide new habitats, for example, by planting meadows at solar parks and managing hedgerows on these sites. Careful, integrated spatial planning approaches, such as geographical information systems mapping together with environmental impact assessment are shown to be important prerequisites to wind and solar developments – not to stymie their development, but to ensure the greatest benefits result.

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