Supergen

Offshore Renewable Energy

Delivering Net Zero: the role of Offshore Renewable Energy

A COP26 Briefing note prepared by the Supergen Offshore Renewable Energy Hub

UKRI Engineering and Physical Sciences Research Council

Supergen Offshore Renewable Energy (ORE) Hub

Contents

Acknowledgements

This COP26 Briefing Note has been written by the Supergen Offshore Renewable Energy (ORE) Hub and the wider offshore renewable energy community. The Supergen ORE Hub is a £9 Million Engineering and Physical Sciences Research Council (EPSRC) funded programme which brings together academia, industry, policy makers and the general public to support and accelerate the development of offshore wind, wave and tidal technology for the benefit of society.

The Hub is led by the University of Plymouth, and includes Co-Directors from the Universities of Aberdeen, Edinburgh, Exeter, Hull, Manchester, Oxford, Southampton, Strathclyde, and Warwick.

The Supergen ORE Hub is one of three Supergen Hubs and two Supergen Network+ created by the EPSRC to deliver strategic and coordinated research on Sustainable Power Generation and supply.

COP26 Offshore Renewable Energy & the Road to Net Zero

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1.0 Context – COP26 and Offshore Renewable Energy

1.1 Introduction

In the year of the UK's presidency of the UN Climate Change Conference, COP26, huge momentum is growing towards focusing ambitions for the UK and globally to deliver net zero greenhouse gas emissions. The UK Climate Change Committee's Sixth Carbon Budget [1] identifies a pathway for completely decarbonising electricity by 2035, despite electrification of the energy system as a whole requiring greater volumes of electricity supply. Decarbonisation of the electricity supply is to be achieved by phasing out unabated fossil fuel generation and significantly increasing renewable generation. In 1990, renewables generated just 1% of the UK's electricity supply. Twenty years later in 2010, this had risen to over 6% [2] and in 2019 accounted for 37.1% of the electricity generated in the UK [3]. This transition has mostly been driven by an increase in offshore wind generation and a significant decrease in coal use [4]. As the UK's favoured renewable electricity generation technology, offshore wind is supported by policies for the coming decade as part of the Offshore Wind Sector Deal [4]. This set a target of 30GW of offshore wind capacity by 2030. This target has now been superseded by the UK Government's Energy White Paper [5], which increases the target to 40GW, representing a fourfold increase compared to the current installed capacity of 10 GW. The scenarios envisaged for Net Zero in 2050 are even more ambitious, with projections ranging from 75GW to 140GW of offshore wind (or offshore renewables) [1]. To meet this tenfold increase in offshore wind capacity in less than 40 years will require significant innovation to be achieved to reduce costs, speed up project development and better understand environmental constraints. The UK's waters host both a growing ORE industry, but also other industry sectors and a range of ecosystems. Economic and environmental success are intertwined, as shown in the 2021 Dasgupta review of the economics of biodiversity [6].

1.2 The Sixth Carbon Budget

The Sixth Carbon Budget and Balanced Pathway recommended by the Committee for Climate Change (CCC) [1] sets the UK emissions limit between 2033-37 at 965 $MtCO_2e$, reducing the UK's annual per capita emissions to under 3 tCO_2e per person (Figure 1). These limits are in line with global pathways consistent with meeting the Paris Agreement 1.5°C goal, and will require full decarbonisation of the power sector, full switchover to electric vehicle sales and installation of low-carbon heating. Meeting the budget requires average annual reductions in UK emissions of 21 $MtCO_2e$, similar to those achieved each year since 2012 (19 $MtCO_2e$) (Figure 1). To achieve this will require electricity to provide more than 50% of final energy demand in 2050, in comparison with 17% in 2019 [5]. A four-fold increase in clean electricity generation is needed, making renewable energy pivotal to Net Zero.

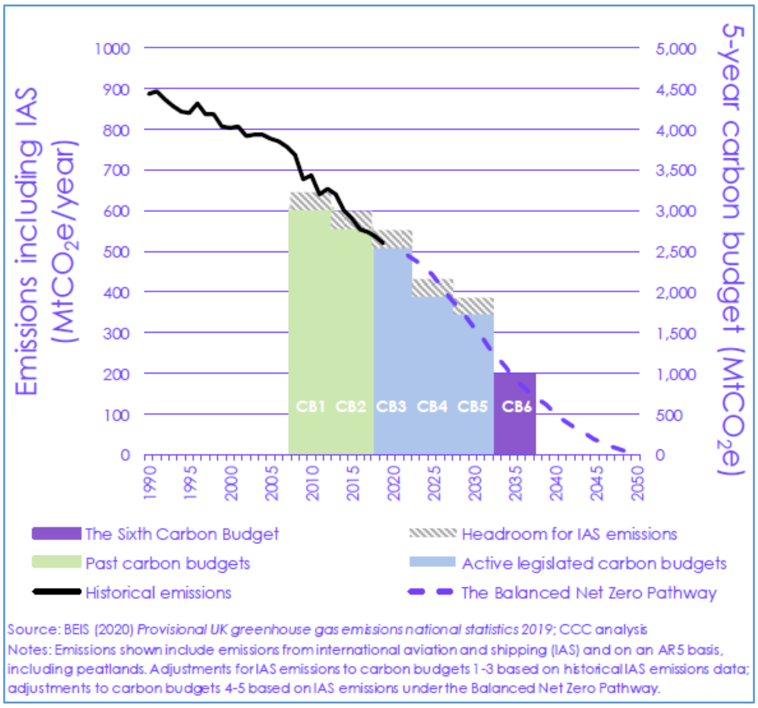


Figure 1: The Sixth Carbon Budget and the UK's pathway to Net Zero

1.3 UK leadership in Climate Change action

As president of the UN COP26 climate talks and of the G7 conference in 2021, the UK is a beacon among the world community for emissions reduction and climate action. Key examples of our track record and future action points showing the UK's leading role are highlighted below.

- *Mitigation* – UK emissions from electricity generation have fallen by 68% since 1990, reflecting a reduction in coal use and increase in variable renewables, which accounted for 37.1% of electricity generation in 2019, up from 6% in 2010. This renewables deployment has been supported by the UK Government's Contracts for Difference (CfDs) commitments, which have auctioned 16 GW of capacity since 2015. Offshore wind costs have fallen from £150/MWh to £45/MWh over the last decade and are now cheaper than gas generation. As a result, 45% of Europe's offshore wind turbines are in UK waters, and the UK has a mature market, supply chain, workforce, infrastructure and academic support for offshore renewables [11]. Whilst the carbon intensity of UK electricity was 529CO_2e/kWh in 2013, it has reduced every year since, to 215CO_2e/kWh in 2019. And in August 2017 emissions dropped to a record low of 57gCO_2e/kWh, making it the greenest day for the electricity system since the Industrial Revolution [7].
- *Adaptation* – The UK's 2008 Climate Change Act legislated on the mitigation of, and adaptation to, climate change, recognising that even if the Paris goal of limiting global temperature rise to 1.5°C is met, there will be further impacts from climate change beyond those already occurring today. The UK Government's third Climate Change Risk Assessment (CCRA3) will be released in 2022, informed by an evidence report published by the Climate Change Committee in 2021.
- *Finance* – Climate financing in the UK requires a major investment programme, worth around £50 billion each year from 2030 to 2050, led by Government, but largely funded and delivered by private companies and individuals [1]. Future emissions reductions will require the population and the private sector to be actively involved, with a just transition where fairness must be embedded throughout policies to secure public support as well as private investment.
- *Collaboration* – The UK has been a strong contributor to international climate finance, recently doubling its commitment to £11.6 billion in aggregate over 2021/22-2025/26 [1], along with other UK contributions to technology development, policy and capacity building. Engaging academia, young people, investors, civil society, and business will be vital to delivering Net Zero.

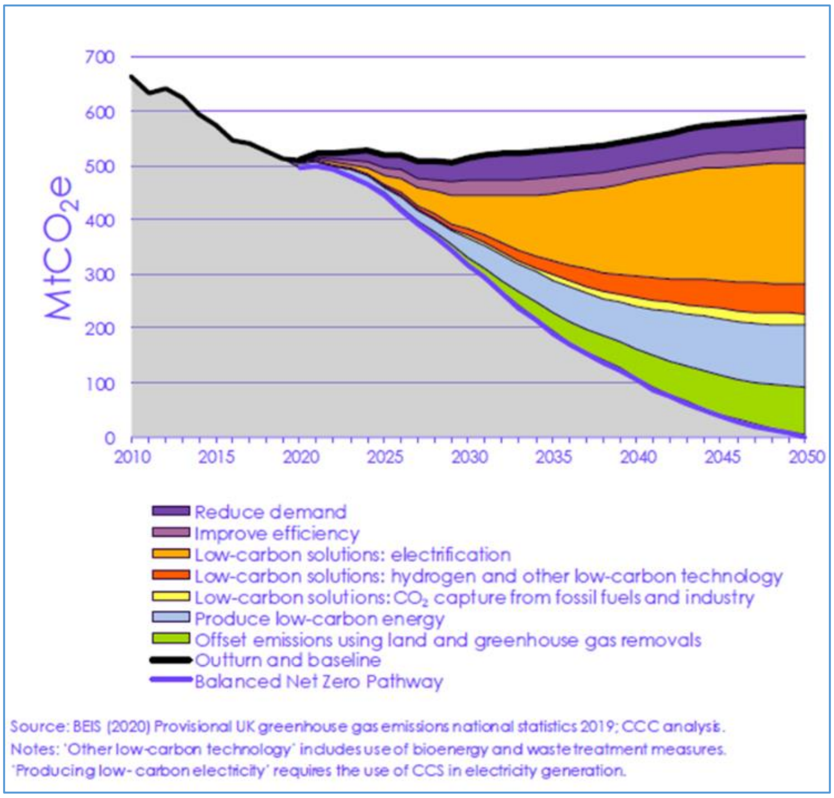


Figure 2: Types of Abatement in the Balanced Net Zero Pathway

2.0 What is Offshore Renewable Energy's role in Net Zero?

2.1 Introduction

Electricity demand is expected to double from current levels by 2050, reflecting electrification of sectors across the economy [10]. The CCC Balanced Net Zero Pathway [1] represents a decisive transition to Net Zero, with over 60% of the necessary reduction to Net Zero achieved in the coming 15 years and the fastest rate of decarbonisation occurring in the early 2030s. The key challenge in the next decade is to scale up investment, markets and supply chains to enable all new energy investments to be zero-carbon by the early 2030s.

2.2 Increasing variable renewables to 80% of generation by 2050

Under the Balanced Pathway, variable renewables reach 60% of generation by 2030, 70% by 2035, and 80% by 2050. This generation allows new electricity demands to be met with minimal emissions and at low cost. Offshore wind is the backbone of the system, providing 265 TWh of generation in 2035 and 430 TWh in 2050. That requires deploying 3 GW of new offshore wind capacity each year, plus repowering of older sites as they reach the end of their (25-30 year) operating lives. Based on current turbine sizes, 3 GW/year corresponds to a new wind turbine installed every weekday, nearly double the new capacity of 1.8 GW installed in 2019; thus, rapid acceleration of the industry is needed [12]. This expansion will cover new geographical regions, which reduces the dependence on local wind conditions, helping to provide a more stable supply. However, this requires the use of sites further from shore in deeper waters and off new coastal regions where ports and grid connections require development.

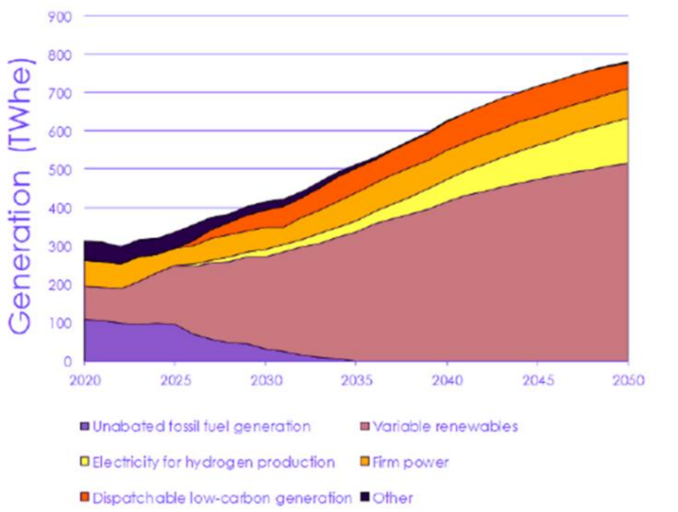
2.3 Dispatchable low-carbon generation is needed to balance variable renewables

Some flexible low-carbon generation (e.g. gas or bioenergy with carbon capture and storage (CCS), or hydrogen) will be required, in particular during periods of low production from variable weather-dependent renewables. Hydrogen can provide a flexible form of dispatchable generation similar to unabated gas, and hydrogen production from renewable electricity will be central to a stable supply grid.

2.4 A flexible future electricity system

A more flexible electricity system will help balance out the variability in renewable generation, both from demand (e.g. demand-side responsiveness, and use of surplus renewable generation to produce hydrogen) and supply (e.g. use of electricity storage). In addition, tidal and wave technologies provide predictable power into a variable renewables-driven system, and have scope for upscaling.

- **Storage.** With an increasing share of variable renewables, storage can capture surplus energy when demand is low and provide backup generation when demand is particularly high.
- **Use of surplus electricity.** The Balanced Pathway has an important role for electrolysers to produce hydrogen at low cost from surplus generation. In the Balanced Pathway 25% of hydrogen supply comes from electrolysis in 2035, increasing to 45% by 2050.
- **Interconnectors.** Interconnectors between the UK and neighbouring countries allow the sale of surplus energy to neighbouring markets and provide access to resources in other countries. However, until the power systems in the rest of Europe become fully decarbonised, there is uncertainty around the carbon intensity of imported electricity.



Source: CCC analysis.
Notes: Chart reflects UK electricity generation. Additional capacity is available through interconnection. Unabated fossil fuel generation includes coal and gas. Variable renewables include wind and solar. Firm power includes nuclear. Dispatchable low-carbon generation includes gas CCS, BECCS and hydrogen.

Figure 3: Illustrative generation mix for the Balanced Net Zero Pathway (2020-50)

- **Industrial opportunities and Just Transition.** The investment required to expand renewable generation, and to develop new markets in CCS and hydrogen, will help create new opportunities for firms, exports, and jobs. New Offshore Renewable Energy (ORE), hydrogen and CCS industries could also help support the Government's 'levelling up' agenda through investment in regional economies, and by providing new jobs.
- **Exports.** There is a significant opportunity for the UK to export engineering expertise, components, and services to the rapidly growing EU and global market for offshore wind and other offshore renewables.

2.5 Education and skills

In order to meet the rapid growth required in Offshore Renewable Energy, the sector's ability to attract skilled workers and researchers to resource existing projects and develop future technologies will be a key factor. The National Grid *Net Zero Energy Workforce Report,* [8] estimates that in 2018 there were 114,500 jobs in renewable energy (~1/3rd in the wind industry), out of 144,000 people directly employed in the energy sector. Job generation is set to accelerate, with an estimated 260,000 new roles by 2050, which can provide significant regional effects, as seen in Hull, halving unemployment through the development of a wind energy cluster [9]. The Hull cluster is forecast to grow to up to 55,000 direct jobs and 50,000 indirect jobs by 2023.

A core component of the Supergen ORE Hub is supporting a network of Early Career Researchers (ECRs) across the ORE Academic sector. This network aims to connect ECRs with more senior researchers, in the UK and internationally, to create a diverse and supportive community that nurtures the next generation of ORE research leaders. The Supergen ORE Hub also seeks to embody best practice in terms of supporting Equality Diversity and Inclusion (EDI) and to capture and disseminate the benefits that this can bring. This is aligned with UK Government policy such as the Wind Sector Deal EDI target of one third of the workforce being female by 2030. Through partnership with other organisations, we seek to influence the wider ORE industry and promote offshore renewables as a supportive and rewarding career. Our activities span all career stages – from promotion of ORE as a green STEM career to school children, through to collaborations with SMEs and larger companies seeking to enter the ORE supply chain.

As the ORE sector rapidly matures, there is an opportunity to shape its development and embed better EDI practice for the long term. Both initiatives within the Supergen ORE Hub aim to safeguard and enhance the sustainability of the ORE workforce in order to meet future needs.

3.0 Current status of Offshore Renewables

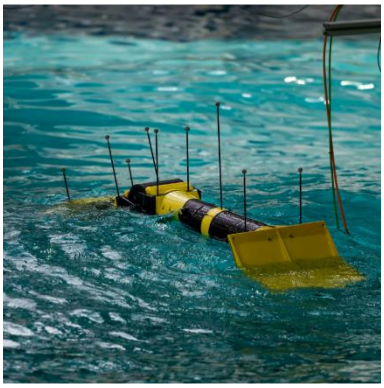
3.1 Current Status: Offshore wind

The UK is the world leader in offshore wind:
- We have more installed capacity than any other country. Already, offshore wind powers the equivalent of 4.5 million homes annually, generating over 10% of UK electricity in 2020, with 10GW capacity.
- The Crown Estate for England and Wales has already leased seabed rights for 45 GW of offshore wind, and Crown Estate Scotland will lease an additional 10 GW.
- Existing leasing is sufficient to meet the Government target of reaching 40 GW of offshore wind by 2030, which will be met by around 3,000 new turbines of 10 MW, added to the current fleet of 2,400 turbines, which are smaller.
- Floating offshore wind turbines could be deployed in deeper waters where there are likely to be fewer constraints from other marine users but introduce new technologies and supply chain requirements.
- The cost of new offshore wind has fallen by over 50% since 2015 and it is now one of the lowest cost options for new power in the UK – cheaper than new gas and nuclear power.

3.2 Current Status: Wave and Tidal

UK has the global lead in wave and tidal energy development:
- Approximately 50 wave and tidal stream developers are based in the UK.
- UK has over 1GW of leased tidal stream sites
- Over 40GWh of marine energy generation have been recorded
- Over 800MW of sites are in development in English, Welsh, and Scottish waters

- The UK holds 35% of Europe's wave resource and 50% of its tidal resource.
- Up to 20% of UK energy demand could be met by marine energy.
- Marine energy has a high level of UK content – 80-95%
- The UK leads Wind + Wave energy innovation, generating economic benefits



4.0 Challenges to ORE deployment

The challenges faced by the ORE sector are as follows:

- Deploying 40 GW of installed offshore wind capacity by 2030 and up to 140 GW by 2050
- Offshore wind deployment must consider a range of constraints, including seabed availability, wildlife and radar interference.
- Increased deployment requires the use of less ideal sites with deeper water further form shore.
- Supply chain considerations and the need to increase pace of deployment.
- Leasing - securing of new seabed leases requires several years as projects need to do pre-development planning, consenting applications, and construction. Accordingly, the UK will need to hold new leasing rounds to provide clarity to developers.
- Energy networks - governance of energy networks for offshore wind will need to be increasingly coordinated as deployment levels increase.
- Cumulative environmental impacts - deploying offshore wind at very high levels could result in changes at the level of ecosystems. Increased use of autonomous technologies could help close critical knowledge gaps about these impacts.
- Tidal and wave technologies that have not been commercialised at large scale could provide predictable power to a variable renewables-driven system, but costs need to substantially decrease to be competitive against other technologies.

5.0 The role of ORE Research and the Supergen ORE Hub

ORE Research	Supergen ORE Hub
• Offshore Wind deployment needs to accelerate in the 2020's backed by new research to overcome challenges. • Accelerating Innovation – Research working with industry and government to reduce costs and speed up project development. • Consider and investigate a range of constraints, including seabed availability, wildlife and cumulative impacts. • Develop new technologies – floating offshore wind, wave and tidal.	• Increase collaboration through Internationalisation. • Taking a whole system approach to ORE research and identify synergies between offshore wind, wave and tidal • Develop links with other research Hubs: energy storage, energy networks, robotics, health & safety. • Develop People Skills and infrastructure, supporting researchers of the future. • Champion a Just transition through an Equality, Diversity and Inclusion culture

6.0 The Supergen ORE Hub Research Landscape

The Supergen ORE Hub Research Landscape summarises the research needs in ORE identified by the community through a series of consultation workshops involving stakeholders from academia, industry, policy and NGOs. It is accessible through the interactive web-based landscape tool (available to access here), which brings together and helps communicate UK based offshore wind, wave, and tidal energy research. The Research Landscape enables industry, government, and researchers to share opportunities and challenges across eight research themes. The Supergen ORE Hub, through its core research programme and flexible funding calls, is taking a strategic approach to tackling these challenges.

Theme A: Resource and environment characterisation	Better measurement techniques for forecasting and resource characterisation
	Improved modelling tools for resource and loading assessment
	Resource and environmental characterisation in physical modelling facilities
	Long-term sediment transport measurement and modelling
Theme B: Fluid-Structure-Seabed Interaction	Realistic fluid-structure-seabed design tools that work together, not in isolation.
	Novel device concepts – rethinking the mechanism of energy extraction
	Moorings, anchors and foundations
	Multi-purpose hybrid systems for ORE and ocean resources
	Design of reliable cabling systems
Theme C: Materials and Manufacturing	Structural Integrity in the Marine Environment (corrosion, fatigue, coatings)
	Serial (volume) manufacturing of complex structural systems
	Design for safe and cost-effective installation methods.
	New materials and coatings
	Recycling/reuse of composites
Theme D: Sensing, Control and Electromechanics	Control of ORE farms
	Smart sensor system use
	Drive train design
	Power Electronic Conversion
Theme E: Survivability, Reliability and Design	Higher and more consistent reliability through risk-based design
	Extending limits to operation or performance by mitigating extreme actions
	Innovative sub-systems to provide higher and more consistent reliability and better performance.
	Sustainable whole-life design methods.
	Design tools for arrays
	Whole systems approaches to operate large scale ORE
Theme F: Operations, Management, Maintenance and Safety	Analysis of remote sensing and condition monitoring data.
	Use of autonomous systems for inspection.
	Data and digital cyber security.
	Increased use of automation to reduce risk in installation and operation (O&M).
Theme G: Environmental and Ecosystem Aspects	Fit-for-purpose approaches to environmental monitoring
	Development of population level environmental impact models
	Ecosystem Modelling
Theme H: Marine Planning Governance	Communication: Ocean literacy and public perception of ORE
	Interaction with other marine users
	Development of market mechanisms for ORE
	Reducing uncertainty of both technology and social costs of ORE

References

[1] CCC (2020) Climate Change Committee, 'The Sixth Carbon Budget', https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf]

[2] Johnstone, P. Rogge, K. Kivimaa, P. Fratini, C. Primmer, E. Stirling, A. (2020) Waves of disruption in clean energy transitions: Sociotechnical dimensions of system disruption in Germany and the United Kingdom, Energy Research & Social Science, 59

[3] BEIS. (2020) 'UK Energy in Brief 2020', [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904503/UK_Energy_in_Brief_2020.pdf]

[4] Allan, G. Comerford, D. Connolly, K. McGregor, P. Ross, A. (2020) The economic and environmental impacts of UK offshore wind development: The importance of local content, Energy, 199.

[5] HM Government (2020), 'Energy White Paper – Powering Our Net Zero Future, [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper Accessible.pdf]

[6] HM Treasury (2021) The Economics of Biodiversity: The Dasgupta Review [https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review]

[7] National Grid [https://www.nationalgrideso.com/news/eso-data-shows-record-breaking-year-britains-electricity]

[8] National Grid (2020), *Building the Net Zero Energy Workforce Report*, National Grid, Warwick, January, [https://www.nationalgrid.com/document/126256/download]

[9] Reed, S. (2020), "U.K, finds that green business is good business", *New York Times*, 4 June, [https://www.nytimes.com/2020/06/04/climate/uk-windrenewable-energy.html]

[10] HM Government (2020), 'Energy White Paper – Powering Our Net Zero Future, [https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future]

[11] Wind Europe (2019) Offshore Wind in Europe Key trends and statistics 2019 [https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Offshore-Statistics-2019.pdf]

[12] The Crown Estate (2019) Offshore wind operational report [https://www.thecrownestate.co.uk/media/3515/offshore-wind-operational-report-2019.pdf]

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