

The Future of **Energy**

Transporting energy to and from customers through transmission and distribution networks



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Executive summary

Networks are the delivery vehicles of the UK's energy.

As we move to a low carbon future, with growth in Electric Vehicles (EVs), decarbonised heating and wider changes in technology, the size and use of these networks will change. Innovation can not only make network operations more efficient (and save customers money) but also revolutionise how networks are regulated and how they can better support our transition to a low carbon energy system.

Flexibility relies on energy system actors being able to understand and respond to market signals, and adapt their demand for, or supply of, energy in a way that realises direct or indirect benefits. This results in a system that helps to meet carbon targets, while delivering energy security at the lowest cost via efficient competitive markets. The report 'An analysis of electricity system flexibility for Great Britain' estimates the benefits of a smart energy system to be £17-40 billion to 2050¹, and analysis from Imperial College, London for the Committee for Climate Change estimates £2.9 billion per annum in gross benefits of flexibility by 2030².

It is widely recognised that our network infrastructure needs to evolve from being passive to active. This will facilitate a wide range of technologies, update and streamline our market design and maximise new smart systems. There are significant challenges for the networks depending on the continued route to decarbonising power, heat and transport. This creates a number of issues that this report examines:

- progressive funding frameworks
- least-regrets options in moving to Active Network Management (ANM)
- the different roles of market actors
- customer expectation and interaction with networks.

Setting out our view on what's needed to address these issues will be critical to whether the network infrastructure can adapt to new system challenges.

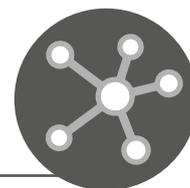
“It is widely recognised that our network infrastructure needs to evolve from being passive to active.”

Cover image: iStock.com/DrAfter123

¹www.gov.uk/government/uploads/system/uploads/attachment_data/file/568982/An_analysis_of_electricity_flexibility_for_Great_Britain.pdf

²www.theccc.org.uk/wp-content/uploads/2015/10/CCC_Externalities_report_Imperial_Final_21Oct20151.pdf

Emerging thinking and potential solutions



No.	Opportunity	Forward direction	Potential solution
1	Make better use of existing network assets where it is more economically efficient than building new infrastructure.	RIIO-2 needs to be more flexible to allow optionality in network development as we transition to a smarter and more flexible energy system.	BEIS and Ofgem to facilitate optionality through the RIIO-2 price control by incentivising innovative solutions to network reinforcement/development, as well as putting an incentive on delivering whole system outcomes where gas and electricity networks interact.
2	Design open competitive markets on the distribution network to drive down the cost of operating the power system.	National and local markets for energy and system services need to be accessible by all market participants to ensure these operate efficiently.	Ofgem to ensure that the accessibility of markets is a fundamental principle when they determine the framework for Distribution System Operators (DSOs) in GB.
3	Implement a regulatory framework which appropriately supports new regulated network infrastructure whilst maintaining robust competitive markets.	Ofgem needs to clarify its position on unbundling of ownership and operation, as well as commercial activities of Distribution Network Operators (DNOs) and future DSOs.	Energy UK to produce a report on the importance of unbundling ownership and operation of network infrastructure as well as commercial activities of DNOs and future DSOs. This will help Ofgem clarify its position as part of RIIO-ED-2 price control.
4	Set a market framework which ensures the value of Distribution Energy Resources (DER) is utilised.	BEIS and Ofgem need to determine the roles and responsibilities of the different system actors.	BEIS and Ofgem to establish an industry task force to develop the future design of the electricity system, once the Open Network Project has reported its initial findings.
5	Providing access to comprehensive levels of information on the state of the network to encourage efficient investment.	Additional monitoring equipment is needed to ensure that granular network data is available for the DNOs and the ESO.	Depending on the findings of the data task force, Ofgem should include an incentive for DNOs to improve infrastructure which improves data monitoring and availability of that data in the RIIO-2 framework, subject to a full cost benefit review.



A smarter network

Pipes and wires will still be needed to deliver electricity and gas, although there will be new challenges as the network adapts to changes in generation technologies, new gases being injected into the network and changing demand patterns.

Making networks smarter is one of several major challenges for network owners who have witnessed the dramatic change in the level of distributed generation, aggregated Demand Side Response (DSR), large increases in renewable generation and the injection of low carbon gas.

Investments in networks need to be economic and efficient. It is vital that network design reflects the Government's wider economic policies covering emissions, heat, transport and industrial growth. The future network investment framework will deliver the critical infrastructure the UK needs. Although there is a desire to use new methods and technologies to defer traditional investment, we cannot avoid building this infrastructure when it will help to ensure the UK economy can continue to grow.

Digitalisation of energy should make it cheaper and easier for users to have the option to engage in, and potentially compete in, various energy markets. Developments include the smart meter rollout, Half Hourly (HH) settlement, smart apps for managing operations and an enhanced role for aggregators. To maximise this potential, market frameworks should make the most effective use possible of data and pricing information, which growing digitalisation can enable.

As far as possible, every customer should have the tools they need to shift their demand and make economically efficient decisions. From the perspective of electricity network charging, the different charges should be able to provide signals that allow generation and demand to compete to reduce network constraint costs. We have seen the start of this through the introduction of platforms such as Piclo¹⁴¹ but further options will open up as we become better able to access granular data in real-time.

Case study

With funding from BEIS, Piclo has developed and trialled the first GB-wide flexibility marketplace. This allows DSOs in the UK to source flexibility from the rapidly growing number of flexibility providers (including demand-response aggregators, electricity suppliers, generation operators, battery operators, I&C customers, local authorities, community groups and electric vehicle charging operators).

All six UK DNO's were involved in the trial along with 175 smart and flexible energy providers; over 4GW worth of flexibility (or 2.8 million household's worth) was uploaded to the Piclo Flex platform.

Piclo's platform allows DSO's to make decisions that could significantly reduce the need for new investment, minimising the cost to the consumer whilst maximising the role of flexible, low-carbon plant in the overall mix. Piclo have now successfully signed two commercial contracts for use of the platform.



¹⁴¹ Piclo Flex is an independent marketplace for buying and selling smart grid flexibility services

In gas, we must adopt a whole-system approach for the future planning of the network, which faces significant change as we decarbonise heating with the potential use of hydrogen. The Government should also make bold decisions over the coming years in relation to decarbonisation of heat and transport. Regionally developed solutions will mean, at the very least, that there is a much greater need to coordinate the different groups and actors, and take decisions holistically.

How should network companies deliver?

The right principles will enable networks to meet the needs of the future system, but to do this at least-cost will depend on a number of factors. These include:

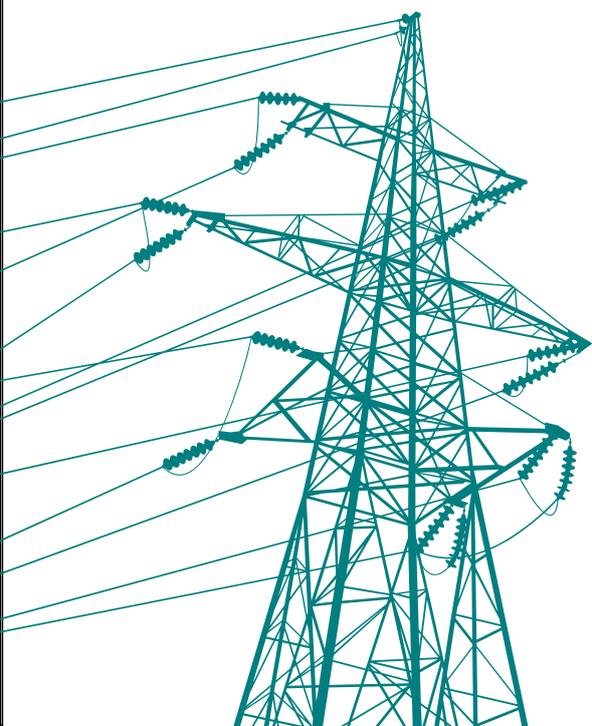
- regulatory change following clear principles so participants can predict the direction of travel for future reforms
- facilitation of effective competition. This includes reducing opportunities for regulatory arbitrage whereby some users may be able to obtain a competitive advantage by choosing to operate within different regulatory rules from their competitors
- change balancing the implications of conflicting principles. For example, a potential solution to make prices as cost reflective as possible may make it difficult for users to respond to those price signals, and so undermining the worth of the solution
- aligning commercial interests of network companies with the public interests of society and the objectives set out by the Government
- explicit lineage of each element of a charge so that it is designed to achieve its purpose in the most effective way
- all energy system participants should face cost-reflective price signals for economically efficient investment and operational dispatch/consumption decisions as far as reasonably possible
- practicality and proportionality to be considered when changing arrangements
- minimise distortions arising from revenue recovery in a way that is fair, subject to conditions of proportionality and practicality

Case study

Now legally separate from the rest of the National Grid Group, the Electricity System Operator (ESO) has **announced** its intention that it will be able to operate Great Britain's electricity system with zero carbon by 2025.

By taking this step the ESO will help to foster greater market access for low carbon generation sources, whilst ensuring that energy continues to be transported across the country in a safe and secure manner. This will be achieved through the completion of a number of new and existing projects conducted in partnership with industry, government and the regulator, to find resolution to the technical challenges such as frequency management, inertia challenges and voltage management.

nationalgridESO



Ensuring network companies deliver for consumers in a changing system – RIIO and the wider competitive regime

Key points:



- **The RIIO-2 price control needs to incentivise the innovation needed to support the changing system and the benefits that can be delivered through active network management.**
- **Optionality will need to be worked into the next price control to ensure that the best pathway to decarbonise the energy system can be followed as the system evolves.**

The design of price controls and incentive schemes is critical to ensuring monopoly network companies maintain, innovate and develop networks in line with the changing needs of the industry. With the scale of these price controls, there is certainly a need to reduce risk and ensure frameworks provide sufficient incentives and penalties to achieve optimum results.

Energy UK believes that price controls should:

- represent good value for money for customers
- incentivise fairness and efficiency for network owners, operators and users
- enable stakeholders to engage effectively with the process
- be implemented in a way that minimises uncertainty and translates into stable, transparent and predictable charges
- successfully accommodate the energy transition with a focus on whole system outcomes.

Networks can facilitate faster transformation, including accommodating the uptake of low carbon generation; flexible technologies that are important to the security of supply; and a range of smarter technologies for enhancing system capabilities and providing information. All of this is required while taking into account the costs to an increasingly varied range of network users (customers). Efficient risk and reward mechanisms can drive change and innovation from regulated monopolies.

The “whole system” can be defined in many ways but the Future of Energy project looks across the transmission and distribution of both gas and electricity, as well as heat and transport.

With continuous technological shift changing the nature of the system in terms of market participants and value chain, roles are evolving and we need to look beyond historic sector boundaries to ensure an economic system design. Price controls are about forecasting and trying to put in place the optimum structure to facilitate efficient whole-system outcomes for the benefit of customers.



The RIIO-2 framework must therefore be flexible enough to be adapted as choices around future decarbonisation pathways become clearer. The following points should form the basis of the forthcoming RIIO-2 framework to ensure it is fit for purpose.

Electricity:

- allowing alternative solutions to compete on a level playing field with traditional network reinforcement when addressing network constraint issues
- promoting competition in network construction
- incentivising network architecture that delivers smart, active network management.

Gas:

- Ofgem, network owners/operators and the wider industry to create a future gas strategy to look at what technologies and systems will be in place for gas-fired generation, domestic heating and industrial needs
- acknowledge that gas networks may need to be upgraded in line with future gas characteristics (hydrogen and low carbon methane would require upgrades to certain network assets)
- recognise the network resilience and flexibility required to meet the changing supply/demand profiles, including renewable intermittency and seasonal demand to promote competition in network connections by allowing independent companies to build the network.

Whole system:

- coordination between gas and electricity network operators needs to be improved with whole-system solutions being addressed
- assessment of best solutions should be carried out before significant upgrades/installation of gas or electricity networks
- regional solutions to be used in conjunction with government-level schemes to ensure that the benefits of local solutions work with national strategic direction.

Case study

Hitachi Europe, Moixa and PassivSystems have created a new energy platform for the Isles of Scilly, part-funded by the European Development Fund. The Universal Smart Energy Framework (USEF) architecture and machine learning determine the best mix of demand-side response and enables dynamic changes to balance local energy generation and consumption.

Connected heat and energy stores can be triggered to turn up energy demand to make the most of the energy produced locally on the islands. This optimisation happens within preferences set by householders.



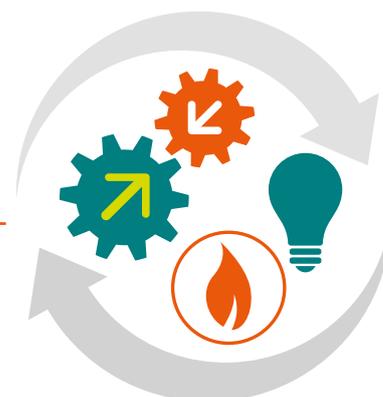
Together, these challenges indicate that optionality is needed, and that assessment frameworks for whole-system outcomes need further development to ensure they deliver optimal solutions.

Ofgem could implement obligations or metrics that incentivise network companies to consider alternative options to traditional ones. This should focus on arriving at the right whole system outcome from the consumer perspective, which may of course differ from a networks-proposed solution. Ofgem should also guard against incentivising the delivery of sub-optimal whole-system solutions, where these solutions are unduly rewarded.

More widely, network companies should be encouraged to make better use of the existing network where it is more economically efficient than building new infrastructure. Where reinforcement is needed on the transmission network, we support the Competitively Appointed Transmission Owner (CATO) regime to ensure that there is a competitive process for building new assets. For DNOs, we support the Energy Networks Association's (ENA's) flexibility commitment¹⁴² where Britain's DNOs have agreed to:

- open up requirements for building significant new electricity network infrastructure to include smart flexibility service markets as part of day-to-day operations. This covers all new relevant projects of significant value, where local electricity operators face congestion in grid infrastructure that results from increased electricity demand and/or distributed energy projects being connected to the grid
- openly test the market to compare relevant reinforcement and market flexibility solutions for all new projects of any significant value
- work with Ofgem and other stakeholders to develop the forthcoming RIIO-2 price control framework. This is to ensure that the financial incentives received by network companies are fully aligned with the greater use of flexibility services, and do not favour building new infrastructure where those services are more efficient.

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¹⁴²See: www.energynetworks.org/assets/files/ENA%20Flex%20Commitment.pdf

Facilitating change in the energy system

Key points:



- **Getting the design of the system right is essential as we move towards the implementation of DSOs.**
- **Fair and open access to markets for all participants is an important principle that needs to be maintained as new markets are developed.**
- **The energy sector is ready to support BEIS and Ofgem as they make decisions on the design of the future system.**

The future interfaces seen across UK networks will reflect the direction of travel provided by the EU in its Clean Energy Package, and by Ofgem in its own regulatory principles. The ESO, for example, currently holds overall responsibility for system balancing and is expected to retain this responsibility to ensure whole-system outcomes.

Where complexity will increase is in the development of local system operators and distributed markets for flexibility. In this section we examine some of the defining changes that will shape the future of UK energy networks.

Market operation within a multi-SO system

To ensure safe and secure operation of the energy system in an efficient manner, robust competitive markets must be enabled by greater levels of transparency and cooperation across the growing range of network and system operation actors. This principle is central to recent changes made to the role of National Grid as the ESO, and should further drive the development of the GB energy system.

The most economically efficient approach to incentivising operational dispatch decisions tends to be found in the development of market arrangements which enable price discovery based on marginal cost. It is generally less economically efficient for participants to compete in multiple small markets for the same services; instead, it is more efficient for smaller markets to be linked, or combined into larger markets.

It is vital that markets are coordinated and integrated across the UK to avoid fragmentation or divergence that could lead to increased complexity and lower levels of market participation. Market participants should have the option to directly access national markets regardless of their participation in local markets. Common standards and guidance for all markets, from the local peer-to-peer markets to the national balancing mechanism, should be set out in advance to ensure consistency in services across markets. This will need to include processes for governance and review.

To ensure any level of confidence across market participants and investors, developing homogenous products provides an inclusive method to enable both local and national needs to be met. This also reduces complexity while ensuring the overall utility of services being procured, particularly those purchased for locational/temporal requirements. Further integrating a single platform for the purchase of services, either at distribution or transmission level, may potentially benefit ESO, DSO and market participants. This could also minimise conflicts or double-procurement of services.

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2	Design open competitive markets on the distribution network to drive down the cost of operating the power system.	National and local markets for energy and system services need to be accessible by all market participants to ensure these operate efficiently.	Ofgem to ensure that the accessibility of markets is a fundamental principle when they determine the framework for Distribution System Operators (DSOs) in GB.



Distribution System Operators

A view from techUK

According to the International Energy Agency, one billion households and 11 billion smart appliances could participate in interconnected electricity systems by 2040 thanks to smart meters and connected devices.

With the massive amounts of data collected, DNOs and suppliers should be infinitely better armed with knowledge and real-life accurate tracking of electricity demand to be able to ensure energy is provided based on real consumption, and that the consumer will be able to participate in DSR schemes through the provision of time-of-use tariffs.

Whilst dynamic tariffs are starting to become available, we need more modelling and user research across private and public sectors if we are to fully realise the potential benefits of this revolution in data and technology. A lot more needs to be done to provide the customer with enough visible benefits in order to share their data.

tech^{UK}

The roles of ESOs, DNOs and Transmission Owners (TOs) have remained largely unchanged since privatisation, as has the structure of the electricity system. Large transmission-connected plant still provides the majority of power, and energy bills from suppliers are still the mechanism for customers to interact with the sector.

In preparing for significant changes due to occur across the sector, a series of workstreams are reviewing whether this framework works for the new world. As part of the actions set out in the Smart Systems and Flexibility Plan¹⁴³, the ENA is leading the Open Networks Project¹⁴⁴ which has, since its inception in 2017, worked to advance industry thinking in defining the day-to-day operation and activities of DSOs.

This work is being integrated into additional open networks workstreams, exploring the development of new market frameworks to enable a DSO to tender for and dispatch flexibility locally. This has the potential to provide benefits to customers and enable further integration of Low Carbon Technologies (LCTs), much in the same way the ESO does today.

The ENA will use the discussions, consultations and modelling from the Open Networks project to make a series of recommendations to Government and Ofgem. Ofgem will then consult on the regulatory framework for DSOs and is expected to introduce a new DSO licence that reflects the acceptable operations for DSOs.

It is vital that these decisions be made in full consultation with a broad range of stakeholders. The existing process has led to concerns that a network-focused view will be the only one sufficiently developed for Ofgem to analyse. Energy UK will be working closely with other industry actors to develop detailed positioning on future roles over the coming year, as well as drawing on international examples of best practice.

¹⁴³www.gov.uk/government/publications/upgrading-our-energy-system-smart-systems-and-flexibility-plan

¹⁴⁴www.energynetworks.org/electricity/futures/open-networks-project/

The future role of the DSO should be to:

- aid the ESO in maintaining security of supply
- realise the value of flexibility
- enhance information provision at distribution level
- act as a neutral facilitator of competitive markets
- remove barriers to market entry.

In the absence of clear regulatory direction while this work progresses, DNOs have continued to develop DSO business models, through a combination of innovation projects, ownership of storage solutions and direct contracting of services to National Grid. These should not be a barrier to a future optimised system.

The GB energy system is at a crossroads, where decisions need to be made now to define the level of separation of commercial activities from regulated monopolies. The independence of DSO bodies, as well as of commercial activities and all regulated monopolies, is expected to impact directly on levels of participation and investment in flexibility markets. The efficiencies and cost reductions promised by a smart and flexible energy system cannot be realised without effective and competitive markets.

It may be most efficient to ensure overall system security by extending the remit of the ESO to distribution level, removing the need to coordinate activities across a range of DSOs. Alternatively, it may be more efficient for the ESO to contract out responsibility for specific areas of third-party system operation. If DSOs are separate entities, wholly independent from the ESO, there will be a need for a comprehensive set of requirements governing the relationship between all system operators.

Energy UK understands Ofgem's hesitation to review unbundling rules until DNO evolution and DSO development is further advanced, but it is vital for flexibility to ensure that UK markets continue to be competitive and attractive now. As stated by Ofgem and evidenced by the Directorate-General Competition's (2005) Energy Sector Inquiry¹⁴⁵, delaying further action by the Government and Ofgem will hinder market confidence and much-needed industry investment in distributed flexibility. This has already been seen with the actions of Electricity North West (ENW) bidding its assets into the FFR market, thereby reducing competition in the market for non-monopoly backed services.

The current regulatory uncertainty undermines the agreed objective of DSOs as neutral market facilitators, as set out under the Open Networks Project, and discourages market investment in LCT. The Government and the Regulator need to take stock of decisions that have already been taken, ensuring that they are consistent with unbundling rules, regulatory principles, and principles set out by the Council of European Energy Regulators (CEER) regarding DSO participation in flexibility markets.

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¹⁴⁵ http://ec.europa.eu/competition/sectors/energy/2005_inquiry/index_en.html

In the near-term, an urgent action for Ofgem is to set out a DSO framework for a comprehensive consultation process. As well as defining functional and operational responsibilities of the DSO, Ofgem will need to address:

- unbundling of DNO ownership and operation of storage assets, soon to be classified as ‘generation’ within licensing and legislation, and other LCT assets such as EV chargepoints
- unbundling commercial activities from DNO and DSO operations, removing any conflict of interest created by DNOs participating in markets for flexibility as set out by CEER.

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How wider networks communicate with each other

Interactions between transmission and distribution, and electricity and gas, require optimisation of the operation between all these actors and further focus in the coming years. Market participation will be bolstered if participants are assured over the whole-system coordination of markets, products and processes available across the energy system.

Information provision between operators and market participants, and between networks and system operators, should be as transparent as possible. There has been considerable attention focused on information flows between networks to date, with less attention being paid to the provision of near-to-real-time information to and from the market.

As raised by the Government's Panel of Technical Experts (PTE), data available to the ESO and wider industry from the distribution level is of relatively poor quality, requiring urgent remedy¹⁴⁶. It is therefore important that monitoring capabilities and smart network assets be encouraged as part of the developing RII0-2 price control in order to ensure capabilities are improved in a timely manner. If this control fails to prioritise the deployment of monitoring technologies, the UK's development of competitive and efficient local markets for flexibility will be stalled.

The ESO must retain the ability to call on DNO and TO assets to address a national balancing issue, and the surrounding communications capability will need to be further developed to ensure that any DSO actions are not in conflict with national balancing activity.

When considering generation flexibility, we also need to understand how the gas network will manage the short-term demand increases from peaking power stations that are mostly distribution-connected, as these are likely to coincide with peak demand from domestic customers.

Renewable generation technologies account for an increasing part of the generation mix. Where these technologies are intermittent, consideration will be needed as to how this growing need for back-up for intermittency is managed by dispatchable technologies such as storage or thermal generation. Where gas is one of the dispatchable technologies, the gas networks, both transmission and distribution, will need to be able to meet the profile requirements of gas generators. It also needs to be established whether incentives and services are equitable for transmission- and distribution-connected gas generating plant; if not, there could be skewed incentives for connection to a particular network.

As we noted above, an increasing level of market participation already comes from sources that are either outside the balancing and settlement arrangements (i.e. non-BM) or behind the meter. To allow this increased competition to continue to flourish, transparency and availability of data must be improved. Its availability will grow more important as Half Hourly (HH) settlement and changing system requirements drive the need for system transparency at a much more granular level. Open access to this data, while ensuring customer and commercially sensitive data is protected, should be a key principle in realising the benefits of a smart system for all parties.

Distribution network charging will also benefit from more granular data, with the potential for network charging to change in real-time to give accurate signals representative of actual load on networks. These signals should complement any other signals/price coming from transmission and wholesale markets.

¹⁴⁶ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/625885/PTE_Report_2017.pdf

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5	Providing access to comprehensive levels of information on the state of the network to encourage efficient investment.	Additional monitoring equipment is needed to ensure that granular network data is available for the DNOs and the ESO.	Depending on the findings of the data task force, Ofgem should include an incentive for DNOs to improve infrastructure which improves data monitoring and availability of that data in the RIIO-2 framework, subject to a full cost benefit review.



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