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## POWER SYSTEM CHANGE DELIVERING A NET ZERO POWER SECTOR IN THE G7

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### Executive summary

This year's G7 statement highlighted that a net zero power sector by 2035 has become both a climate and an energy security objective for industrialised nations. Delivering this at pace, low cost and high reliability requires strategic plans. So far, no G7 country has produced such a strategic plan, but the UK and the EU both could demonstrate the way forward.

This briefing shows how legislation, policies and processes can fit together to form an effective power sector decarbonisation plan. Plans will need to cater for individual characteristics of power systems in different countries. However, some general principles apply. Plans must be coherent across energy sectors, able to adapt to emerging opportunities, and command the support of society.

These principles must be reflected in the supporting legislative and policy framework. The proposed framework involves:

- > **Core legislation, which sets obligations on delivery bodies (e.g. regulators, financing agencies, infrastructure planners).** Key requirements include: a net zero obligation on energy regulators, a strategic "whole-system" infrastructure plan, the system operator to update approaches in line with latest digital technology, and local-level mandates.
- > **Adaptive policy which maintains momentum as technology evolves and economic circumstances change.** This should include mechanisms to support investment in zero-carbon technologies and a robust consumer protection framework.



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- > **Delivery processes that continually update infrastructure plans and electricity market design.** This will ensure they remain consistent with changing technology and meet evolving consumer needs.

This briefing additionally assesses progress in the EU and UK against this idealised approach. Both have many of the elements of this framework already in place. However, while this makes EU member states and the UK well-placed to move forward and produce plans to decarbonise the power sector, there are areas for improvement. Areas to focus on are the mandates for key delivery bodies and processes for market design and infrastructure planning.

## The challenge

Early decarbonisation of the electricity sector is essential to achieve the overall reductions in greenhouse gases necessary to stabilise global temperatures. G7 countries have a wide range of domestic initiatives underway to realise their ambition to achieve “predominantly decarbonised electricity sectors by 2035”.<sup>1</sup> These include investment support for renewables, expansion of grid infrastructure, consideration of new market designs, and deployment of batteries and other forms of electricity storage.

The building blocks to move forward quickly are already available. However, the task ahead requires a fundamental system change. Operating a power system on variable sources of renewable energy, such as wind and solar, requires new technologies to maintain system stability. To date, we remain dependent on fossil fuels to provide much of the storage, flexibility and other services needed. Electrifying other energy sectors and end uses like transport will change the nature of electricity demand, as will improvements in energy efficiency and the changing climate. New approaches are also needed to infrastructure planning and electricity trading.

Achieving this transformation requires all G7 countries, including those in the EU and the UK, to develop national delivery plans for decarbonising the power sector. These plans must address three critical issues:

1. **Coherence:** All the elements of system change must be synchronised. There is little point in pressing ahead with renewable deployment if there is no network capacity available or limited ability to shift demands to meet available supply. The timescales involved in infrastructure deployment and

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<sup>1</sup> G7, May 2022, [G7 Climate, Energy and Environment Ministers’ Communiqué](#)



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innovation in new products and services mean that we cannot wait and expect the new system to fall into place at the last minute. Also, decarbonisation pathways in heat, transport, and industry sectors must form part of an integrated overall approach to energy system decarbonisation.

2. **Learning and adaptation:** Technology is constantly evolving, offering new solutions to the challenges involved. Digital information and control technologies have the potential to sweep away many of the constraints that currently hamper electricity system operation and market functioning. Consumer behaviour and needs will also evolve, and retail innovators should be constantly striving for new ways to provide comfort and convenience as cheaply as possible. Markets and regulations must be able to continually adapt to make the most of the emerging opportunities.
3. **Consumer focus:** System change must not be viewed as a purely technical exercise. Telling consumers that they must change to help the electricity system decarbonise is doomed to fail. The electricity system transformation must make lives better. This is not only about providing access to new product innovations but also ensuring fairness and maintaining the consent of the wider population for the actions that are needed and to pay the costs involved.

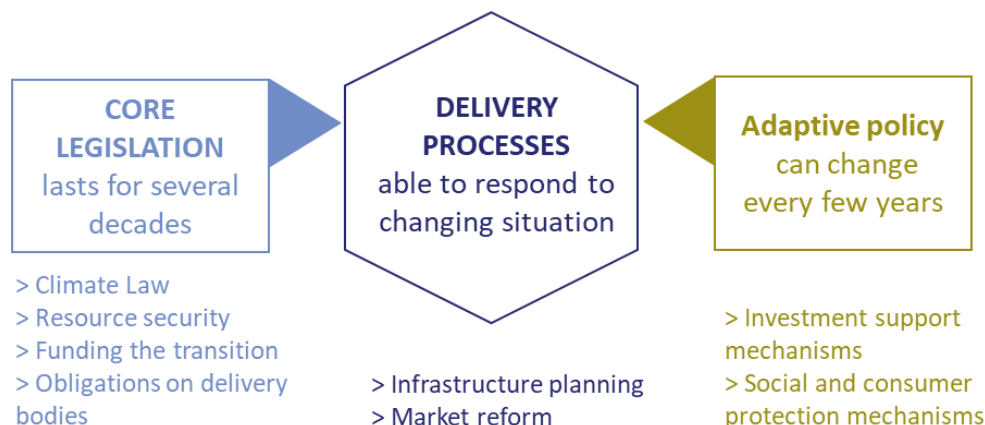
## Framework for power sector decarbonisation

Actions to decarbonise the power sector will be founded on the legal and regulatory framework. A solid legislative basis that remains constant over time will provide continuity in the direction of travel and assurance for investors. Other policies will need to adapt as circumstances evolve. Delivery processes must be designed to ensure momentum is maintained in response to these legislative drivers (see Figure 1, next page).

### Core legislation

The EU and UK have adopted Climate Laws as the overarching legislative vehicle to drive emissions reductions. Within the EU, some countries have transposed the law into domestic legislation, giving it more power to influence investment decisions. While these laws set out overall ambition and the governance for reducing emissions, separate legislation covers the operation of the energy system and markets and the statutory obligations for key institutions.

Figure 1: A high-level framework for delivering power sector decarbonisation



Governments are likely to retain responsibility for delivering on certain aspects of this strategy, such as resource security and deciding how the transition should be funded. This will require a set of enabling powers that allow them to put in place the necessary actions.

Other aspects of the strategy must be delegated to delivery bodies, and these delegations must be embodied in the core legislation. These should include:

1. **Power network design:** Network infrastructure plans (power, gas, carbon, hydrogen) must be mutually coherent and align with the decarbonisation objectives. It is especially important that this involves a “whole system” approach which considers investment options across the supply chain and ensures all options to improve energy efficiency and demand side action are taken. This will avoid wasting consumer and/or taxpayer money on assets that are not needed.
2. **Power network operation:** Approaches to balancing supply and demand will need to transform from dispatching a few tens of large power stations to millions of connected devices. Moreover, dynamic management of supply and demand must be introduced to local low-voltage power systems. All system operators must be mandated to deliver efficient use of resources given best available technology and be required to innovate and partner with innovators to enact change. This will accelerate the uptake of existing digital technologies and ensure future innovations are adopted to make the most from system assets.
3. **Local delivery:** Much of the energy system transition will need to happen at local level as individual consumers change how they meet their energy requirements. Delivery solutions will vary from location to location and



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cannot be driven at national level. It is necessary to allocate responsibility for planning and delivering change at local level and to ensure it is aligned with the capabilities of the national energy system.

4. **Energy regulation:** Economic regulators will have a critical role in authorising expenditure on networks and ensuring markets work in the interests of consumers, current and future. This will inevitably involve balancing several competing options. However, facilitating delivery of decarbonisation targets should not be optional and should be enshrined as a core statutory objective. Also, many national regulatory bodies will need to invest in new capabilities to effectively deliver their role, especially in consumer protection, digitalisation, and energy system modelling.

### **Adaptive policy**

#### **Investment support**

A system in transition will inevitably generate risks for investors as they attempt to predict uncertain future revenues. Technology or policy change can strand investments that had previously seemed economic. Governments must strike the balance between maintaining fast-paced deployment of existing low-carbon technologies while benefitting from new technologies as they emerge.

The net zero delivery strategy should identify minimum deployment levels for the key infrastructure required to remain on-track in achieving decarbonisation targets. Where necessary, delivery of these infrastructures must be underpinned by investment support mechanisms that minimise overall costs to consumers. This will generally involve insulating investors from future revenue fluctuations that they cannot control through good asset management, thereby reducing financing costs. It is also important to promote competition between providers and, where possible, a range of potential technologies. These mechanisms must be robust to future changes in the market and regulatory framework.

Technology costs, benefits and deployment potentials will continually evolve. This means that the net zero delivery strategy and plan for infrastructure deployment must adapt accordingly. The relevant support mechanisms must, therefore, be subject to constant review. It is important that changes are founded on clear scientific evidence and this process must be transparent and, ideally, based on expert independent advice to maintain investor confidence.



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### **Social and consumer protection policies**

Social cohesion depends on affordable energy. It is essential to maintain support from across society for paying the costs involved in the transition to net zero. Involving citizens and their representatives in the policy process is important, but government has the ultimate responsibility to determine how costs are shared between different groups, now and into the future. These are highly political choices which create relative winners and losers.

The scope for current consumers or taxpayers to bear these costs depends on underlying commodity costs and the prevailing economic conditions. For example, the current energy and cost of living crises have created a very challenging situation.

It is, therefore, inevitable that approaches to paying for the energy transition will change. The regulatory and market environment must be robust to these changes, and they should not impact the operation of the investment support mechanisms described above or the efficient use of resources.

### **Delivery processes**

Network planning and market design processes are critical in enabling effective and timely decarbonisation of the power sector.

#### **Network planning**

Energy infrastructure plans must be coherent across the energy system, including the demand side, and be able to adapt to changing circumstances.

It is essential that the net zero delivery strategy is achievable. It must be possible to cost-effectively connect the minimum infrastructure capacities specified by government to the energy network within the required timescales. It must also ensure money is not wasted on infrastructure “white elephants” that will not be needed. A nominated system architect must produce this plan considering several key inputs:

- > Constraints imposed by the operational requirement to balance supply and demand, including how these will diminish with new digital technologies.
- > The plans produced by those bodies nominated to deliver local aspects of energy infrastructure.
- > The evolving costs of network congestion, including curtailment of renewable energy resources.



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- > The operation of neighbouring interconnected (or potentially interconnected) markets and how this might evolve.

The system architect must be able to provide feedback to the government where it believes that these inputs cannot be reconciled, either practically or cost-effectively, with delivery of the net zero strategy. The government, probably delegated to an economic regulator, should be the ultimate arbiter when conflicts arise. The significance of these decisions is such that expert independent scientific advice should be sought.

### Market design

Power market design cannot be static given the rapidly evolving context. New digital technologies have the potential to remove constraints on data processing and predictive capability that define current system and market operation. They will also give rise to new products and services that meet evolving consumer needs.

Market design processes define the changing nature of the boundary between the power grid and system users – the so-called “grid edge”. They must enable system operators to meet their legislative requirement to deliver efficient use of resources given best available technology, as well as support consumer-facing innovators in offering new products and services. A market operator is required to work with these two key stakeholder groups to constantly adapt the market design within a broad framework that preserves the integrity of legacy investment support mechanisms and allows government to implement new charging methodologies.

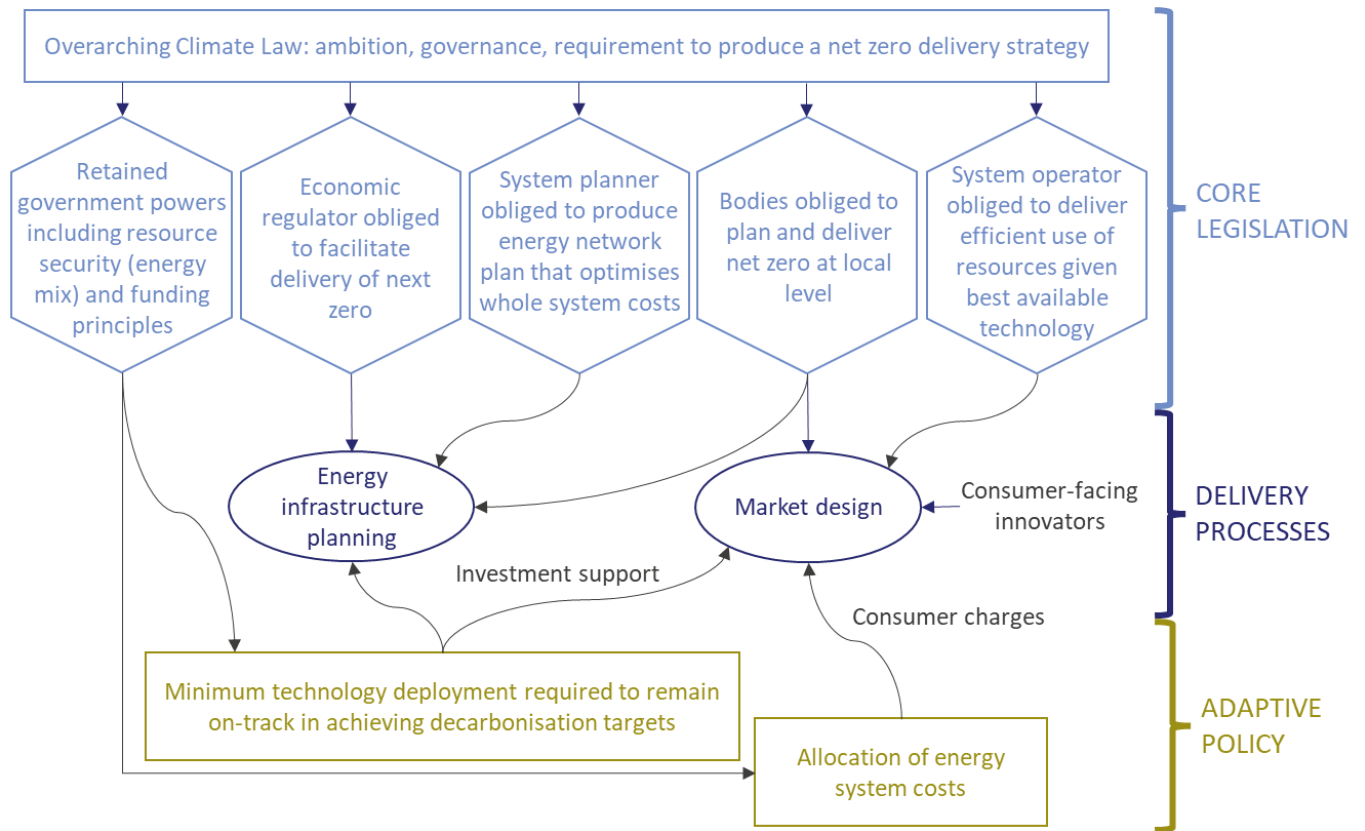
It is likely that the combined requirement for efficient use of resources and the need for new products that meet individual consumer needs will lead to markets that are much more granular (in space and time) than the largely national markets that exist today.

## Evaluation of current approaches

The framework described above shows how the various elements of legislation and policy should link together. It provides the core elements for a power sector decarbonisation plan that is derived from an overall net zero delivery strategy. This is illustrated in more detail in Figure 2 (see next page) and provides the basis for evaluating current approaches in the EU and UK.



Figure 2: Framework for a power sector decarbonisation plan showing key interdependencies



## EU

European energy markets are governed by a substantial body of European Union legislation that is adopted within the national legislation of member states. This is summarised in the box below.

### EU energy legislation

#### Core legislation

- > The **Climate Law**. Recently enacted, it requires member states to produce a National Energy and Climate Plan which sets out how they intend to reduce greenhouse gas emissions.
- > The **Clean Energy Package for all Europeans** specifies how the energy system and associated markets should work. EU treaties ensure that member states retain control over certain key energy and fiscal policies, such as energy mix and tax.





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- > Member states are required to have an independent **National Regulatory Authority (NRA)**. The specified duties do not extend to any obligations to facilitate delivery of net zero.
- > **Electricity regulations and operational codes** set out system operator obligations. These require supply and demand of electricity to be balanced within and between transmission systems through market processes. Distribution and transmission operators are required to promote digitalisation of the transmission and distribution grids. However, the legislation is unclear on how that should be achieved.

#### Adaptive policy

- > **State Aids** legislation governs member states' ability to support investments in infrastructure. It does not materially restrict their ability to support technologies needed to deliver net zero. States are more constrained in their ability to deviate from market-based consumer prices; this is limited to support for vulnerable consumers.

#### Delivery processes

- > The **Trans-European Network for Energy Regulation (TEN-E)** requires network operators to plan consistent and cost-optimal networks and for their assumptions to be independently scrutinised. However, the network planning process within member states is largely determined by their NRAs.
- > Electricity trading arrangements are specified in detail in **electricity regulations**. Wholesale prices must be formed through balancing demand and supply with caps or floors generally forbidden. It is not envisaged that these rules will adapt or evolve other than periodically revising the geographical zones within which prices are set.

EU-level legislation involves many of the components of the idealised framework shown in Figure 2. Much of this legislation has only recently been introduced and it is too soon to judge its effectiveness. Also, many of the key policy decisions rest with member states who will inevitably adopt different approaches. Importantly, the delivery of a net zero power system will require significant evolution of delivery bodies and public institutions and there is currently no oversight to ensure these changes occur. Nonetheless, the core legislation sets



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out the ambition to decarbonise and animates member states and other key delivery bodies to take the necessary actions. Member states are, therefore, well-placed to develop power sector decarbonisation plans.

There are, however, three key omissions in the core legislation:

- > NRAs are not obliged to facilitate delivery of net zero and are at liberty to conclude that consumer interests will not be served by taking the action that is required.
- > System operators are not mandated to use best available technology to achieve efficient dispatch and may choose to stick to current approaches. This may limit progress towards a digitalised grid that can provide new opportunities for consumers to interface with the market.
- > Member states have generally not imposed statutory mandates to drive local delivery of net zero. Much of the progress at local level is driven by forward thinking city authorities acting on their own initiative.

Member states have the flexibility to support investments in the technologies needed to achieve net zero. State Aids legislation provides guidance on the most effective mechanisms to employ. The current energy price crisis is testing the scope for member states to insulate consumers from high energy costs and the European Council is discussing a package of measures.

Network planning processes have improved significantly with the latest update to the TEN-E regulation. However, the ability to produce a robust strategic plan is hampered by the involvement of multiple actors operating in different sectors and countries. There will be different assumptions and methodologies adopted by network planners within member states, along with inherent biases towards supply-side rather than demand-side infrastructure. This creates a significant risk that some infrastructure projects may become stranded or that the lack of network capacity will slow the deployment of renewables and technologies to electrify demand.

The static nature of the market design process is a key concern. The adoption of digital technologies will revolutionise the nature of system balancing and create new opportunities for consumer engagement with the market. Markets must be able to adapt to take advantage of digitalisation. The European Commission will be reviewing market design over the coming months, largely in response to the



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energy price crisis. It is also due to publish a communication on the digitalisation of energy. These initiatives provide the opportunity to address this deficiency.

Member states are progressing at different rates towards decarbonisation and digitalisation and the institutional reforms needed to sustain progress towards zero emissions power system. Whilst there is a common EU framework, countries are at very different starting positions in terms of power mixes, and approaches to retail and network regulation and incentive regimes. Decarbonisation of the EU power system requires that all countries progress and this is likely to require extensive and accelerated knowledge sharing.

## UK

The UK transposed the Clean Energy Package into national legislation before leaving the EU. It therefore has the same legislative baseline as the EU. However, the UK Climate Change Act involves an explicit requirement to produce a net zero strategy and all other legislation must support the delivery of this strategy. Importantly, an independent Climate Change Committee has been established to provide rigorous independent assessment of policies and progress towards achieving net zero. This Committee recently highlighted the absence of a power sector decarbonisation plan as a key risk to delivering net zero targets.<sup>2</sup>

The UK government has identified two significant institutional and market reforms required to decarbonise the power sector:

1. **An independent system operator and planner responsible for electricity and gas transmission network planning and the operation of the electricity network.** The regulator, Ofgem, is also considering if this remit should be extended to cover local distribution networks. This will overcome some of the challenges experienced in the EU due to the involvement of different actors in producing a single strategic network plan. However, this organisation will be extremely influential, and it remains to be seen if appropriate independent oversight is adopted to monitor the assumptions and strategic decision methodology. Also, the basic obligations on the system operator function remain unchanged without any requirements to adopt latest technological opportunities.
2. **A fundamental review of the electricity trading arrangements to make them fit for a high-renewables and electrified power system.** The UK government has concluded that the current system is inadequate and that

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<sup>2</sup> Climate Change Committee, June 2022, [2022 Progress Report to Parliament](#)



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significant changes are required. However, it aims to identify the optimal future arrangements through a policy process without the benefit of learning from any transitional reforms. This is not consistent with the ideas set out above for a dynamic and responsive market design process.

The independent system operator and planner is due to be established via the Energy Security Bill that is currently being considered by parliament. The outcome of the market reform process is not expected to be implemented for several years and may require further legislation in the next parliamentary term. The new Prime Minister has initiated a review of net zero delivery within a framework of driving economic growth. This could lead to substantial changes to UK net zero delivery strategy.

## Conclusions

Both the EU and UK have the basic legislative framework in place that will enable countries to produce a robust plan to decarbonise the power sector by 2035. However, these plans are not being produced and the UK Climate Change Committee has highlighted this omission as a key delivery risk.

Three additions to the legislative framework would improve the deliverability of power sector decarbonisation plans:

- > Requirement for NRAs to facilitate delivery of net zero.
- > Obligation on system operators to efficiently dispatch resources using best available technology.
- > Mandate on bodies (e.g. local government authorities) to deliver net zero energy systems at the local level.

The current energy price crisis has shown that a power sector decarbonisation plan must be robust to short-term shocks. The key test is whether momentum can be maintained while policy adapts to cope with the evolving situation. Governments must be able to change investment support mechanisms in line with evolving technology. They should also be able to insulate consumers from high costs. The European Council is currently considering their approach here.

Processes for creating a strategic and coherent infrastructure plan are improving. Establishing an independent system operator and planner in the UK is an especially encouraging step. However, the extent to which decisions are based



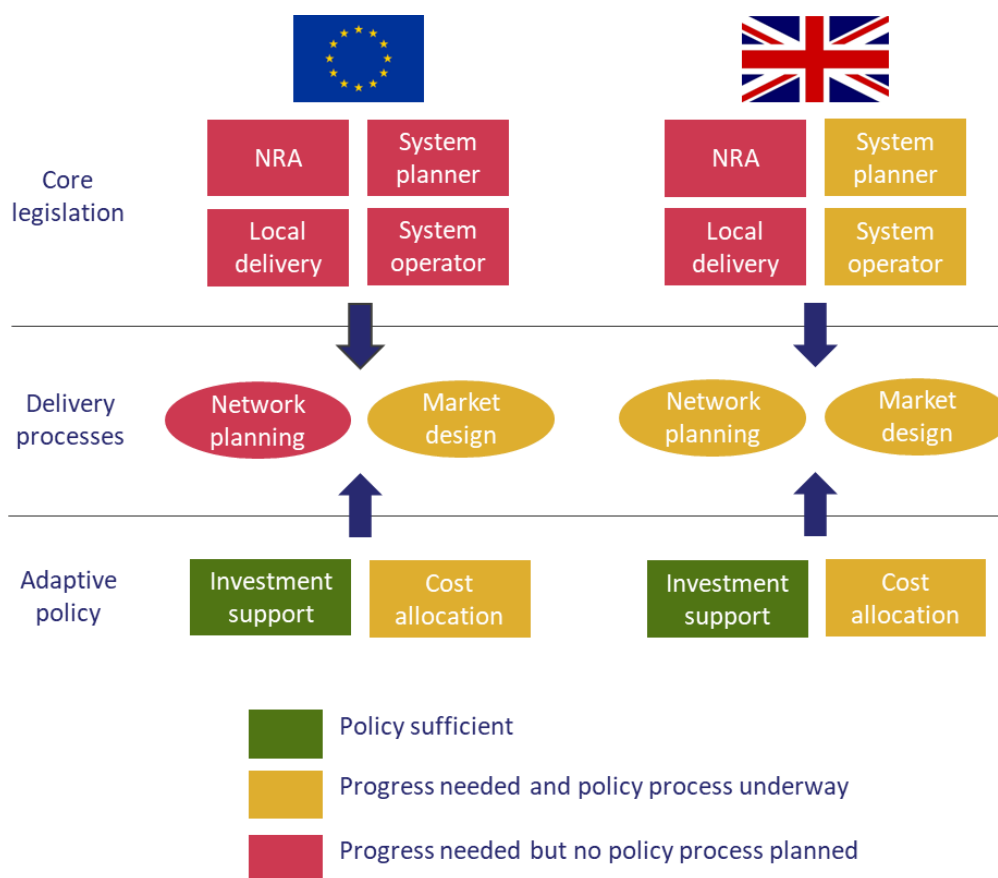
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on a single up-to-date set of technology assumptions and pay equal attention to demand and supply side investments, remains to be tested.

Market design processes are inflexible, progressing in decadal leaps that are soon overtaken by events. While there is now broad recognition that the current design is inadequate for a high-renewables and decentralised energy system, reform processes are incapable of capturing the benefits of digitalisation and achieving the smart, flexible system that is required. Markets define the “grid edge” boundary between system operation and consumer-facing retailing. Digitalisation will change the nature of both activities and markets must constantly adapt as current constraints on system operation fall away and consumers demand new products and services.

Figure 3 provides a schematic representation of progress in the EU and UK.

Figure 3: Assessment of progress in EU and UK towards creating the power sector decarbonisation plan that is required.





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## About E3G

E3G is an independent climate change think tank with a global outlook. We work on the frontier of the climate landscape, tackling the barriers and advancing the solutions to a safe climate. Our goal is to translate climate politics, economics and policies into action.

E3G builds broad-based coalitions to deliver a safe climate, working closely with like-minded partners in government, politics, civil society, science, the media, public interest foundations and elsewhere to leverage change.

More information is available at [www.e3g.org](http://www.e3g.org)

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