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The further economic consequences of Brexit: energy

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Abstract

The UK left the European single market in energy on 31 December 2020, having been a leading light in its promotion. It entered into a new energy relationship with the EU-27 as outlined in the EU-UK Trade and Cooperation Agreement (TCA) on 1 January 2021. This paper discusses what has happened to the UK energy sector since the Brexit referendum of June 2016. Since our previous paper on this topic in 2017, there has been a significant clarification in the impact of Brexit on the energy sector in the UK. We outline what the TCA says about energy. We then discuss the current and potential future effects of Brexit on the UK electricity and gas systems in turn. We observe that the likely economic welfare impacts on electricity are larger than the impacts on gas, but the overall microeconomic impact appears likely to be modest (but negative). We offer a number of concluding observations.

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1. *Introduction*

In this paper we examine the further economic consequences of Brexit for the energy sector in the UK in the light of developments since our original paper in early 2017 (Pollitt, 2017). We now know a lot more than we did then about how Brexit will play out in the energy sector in the immediate post-Brexit period, which we take as beginning on 1 January 2021.

In our 2017 paper, we noted that the economic consequences for the energy sector per se were expected to be small because of the UK's dependence on internationally traded oil and gas and lack of dependence on the EU for imports and exports of oil, gas and electricity. Thus, the effect on electricity and gas prices could be expected to be small beyond the macroeconomic impact of Brexit on GDP and exchange rates (which could be large!).

Going forward there was a possible loss of the relative benefits of being part of the single market in energy for electricity and gas if the single market increased its integration without incorporating the UK. We discussed the possibility that the UK would follow the Norway model of being part of the single market in energy or the Swiss model of more limited integration (which the Swiss had been subjected too following their vote to end free movement of labour with the EU). We now know that the UK as a whole is not part of the single market, though Northern Ireland is (of which more below).

In terms of energy policy there were questions in early 2017 about how Brexit would affect CO_2, renewables and energy efficiency targets. We speculated in 2017 that an electricity market characterised by more intermittent renewables might see a return to vertical integration and that the unbundling agenda, pursued first by the UK and then by the EU as a whole, was getting challenging. We also said that there needed to be city level experimentation with decarbonisation of heating and transport which might necessitate new forms of organisation of the sector. The UK could play a role as the California of energy within Europe, leading the way on low carbon initiatives, and that given the UK's past history of leadership on climate and energy issues any weakening of commitments to decarbonisation seemed unlikely.

We now know that there has indeed been no weakening of policy in any of these areas since 2017, indeed in June 2019 the UK enacted the world's first net zero target of 100% decarbonisation of the UK economy by 2050. This provides the context for any discussion of energy policy in the UK.

In terms of other issues, there were open questions about the UK's continuing relationship with ACER, the European Union Agency for the Cooperation of Energy Regulators,

[1] The author wishes to thank Anupama Sen and participants at the Oxford Review of Economic Policy conference on Brexit in May 2021 for their constructive feedback. He would also like to thank Leigh Hancher, David Newbery and colleagues at BEIS, Ofgem and National Grid for their comments. All errors are his own.

and membership of European transmission organisations for electricity and gas (ENTSO-E and ENTSO-G). Trade deals with the US and Canada might have energy implications. There was the issue of whether the UK could introduce border tax adjustment in electricity to end the distortion caused by higher carbon prices in the UK vs the rest of the EU. The single electricity market in Ireland was an open issue and there were significant questions about skilled migration in energy, access to EU energy R+D and the impact on EU investment in the UK energy sector. Many of these issues have been addressed, to some extent, in the EU-UK Trade and Co-operation Agreement of December 2020 (which we refer to as the TCA in this paper), as we discuss below.

In our 2017 paper we concluded that the microeconomic impact of Brexit would be small in the energy sector and that energy would be a low priority area for agreement. There were opportunities for rationalising domestic energy policy following Brexit and that what happened to domestic energy policy could have more impact for prices than any trade related impact of Brexit. This conclusion has mostly been borne out by subsequent developments, with some interesting differences. Naturally, COVID-19 hangs over developments since March 2020 and the reaction to the pandemic continues to dominate macro-economic developments, with significant consequences for individual sectors, including energy.

In section 2, we briefly discuss what has happened to the energy sector since the Brexit referendum of June 2016. In section 3 we outline what the EU-UK Trade and Co-operation Agreement says about energy. Sections 4 and 5 discuss the effects of Brexit on the UK electricity and gas systems in turn. Section 6 looks at the wider effects of Brexit on energy and the questions raised. Section 7 offers some concluding comments.

2. What has happened in the energy sector since 2016

The UK has continued its dependence on imported oil and gas since 2016. Oil and gas represented 36% and 39% percent of primary energy consumption in the UK in 2019, and import dependency for fossil fuels was 35%[2]. Electricity demand has fallen and the electricity sector has continued to decarbonise, with renewables now representing more than 40% of electricity production and continuing to rise[3]. Net imports in electricity has risen slightly (to 6% of electricity demand) in 2019.[4]

In terms of policy developments, the UK has continued with its commitment to decarbonisation. This has been manifested in a revision to the Climate Change Act in 2019, changing the 2050 target from 80% reduction (on 1990 levels) to 100% ('net zero'). This was followed by the publication of a 'Ten Point Plan for a Green Industrial Revolution' for decarbonisation in November 2020[5] and a commitment to ending sales of new fossil fuel vehicles by 2030 in the UK. This was in line with an earlier 'Clean Growth Strategy' (HM Government, 2017). Among other things, the Ten Point Plan commits the UK to 40 GW

[2] See BEIS (2021a, p.9).
[3] Renewables were 42.8% of electricity production in 2020 (see BEIS, 2021b, p.12).
[4] See BEIS (2020).
[5] HM Government (2020).

offshore wind by 2030. The energy sector was only 2.5% of GDP in 2019 in the UK, but it was 9.1% of total investment and 29.5% of industrial investment.[6]

The UK Government has established the UK Infrastructure Bank (following HM Treasury, 2020) to fund green infrastructure. A key motivation for this was to replace European Investment Bank (EIB) funding of UK energy projects.[7] The EIB can only lend to EU members, but its investment in UK energy projects was €13.334bn over the period 2010-2020. The new UK bank also has a regional growth agenda which will favour energy projects in Northern port cities.[8]

Some external trade agreements have an energy aspect. For instance, the EU-South Korea trade agreement exempted oil exports to South Korea from a 3% import tariff.[9] This has now been rolled over in its trade deal with the UK.

Political commitment to net zero remains high and covers the main political parties in the UK. The Labour Party published 'Bringing Energy Home' in May 2019[10]. This involved a commitment to renationalise and reorganise the UK's electricity and gas networks, with a view to reducing costs, increasing control and coordinating gas and electricity decarbonisation at the regional and local level. This document remains Labour Party policy as of the time of writing.

On the EU side, the EU published its Winter Energy Package in November 2016. This set of measures is known as 'Clean Energy for all Europeans' (or the Fourth Energy Package) revised the Electricity and Gas market directives and continued to deepen the role of market mechanisms in electricity and gas, in the context of deep decarbonisation. These were translated into new directives and regulations in the course of 2018 and 2019.[11] The UK adopted all of the changes required by this package of EU legislation prior to the end of the transition period on 31 December 2020, so by that date was fully compliant with all EU directives on energy.[12]

The EU Commission also proposed a net zero target in March 2020 and has proposed extending the EU Emissions Trading Scheme to both heating and transport[13]. Net zero has now been enshrined in EU law following the passage of the European Climate Law (Regulation EU 2021/1119) in July 2021.[14] This suggests that both the UK and EU have strengthened and extended their commitments to energy sector decarbonisation since Brexit.

3. EU-UK Trade and Co-operation Agreement and Energy (TCA)

[6] See BEIS (2021a, p.5).
[7] Norton Rose Fulbright (2021).
[8] See: https://www.ukib.org.uk
[9] Norton Rose Fulbright (2021).
[10] Labour Party (2019).
[11] See https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en
[12] See https://www.ofgem.gov.uk/system/files/docs/2020/12/electricity_directive_open_letter_0.pdf
[13] See Pollitt and Dolphin (2020). This has been formally proposed by the EU Commission in July 2021.
[14] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2021.243.01.0001.01.ENG&toc=OJ%3AL%3A2021%3A243%3ATOC

The EU-UK Trade and cooperation agreement was agreed on 24 December 2020.[15] The TCA applies until 30 June 2026, but can be extended to 2028 by the Partnership Council. The TCA establishes a Specialised Committee on Energy (SCE) as part of implementation and functioning process.[16] Other aspects of trade in energy may be overseen by other specialist committees, which sit under the Partnership Council. The TCA does not fully replicate the benefits of full membership of the Single Market in Energy.[17]

Title VIII (Part 2) to the TCA (The Energy Title) is one of the more detailed parts of the whole Agreement.[18] At a high level it states that no tariffs can be imposed on exportation of electricity and gas by either party. The TCA is generally supportive of continuation of competitive markets and of not supporting renewable electricity (RES-E) in a way that would undermine competition. The TCA reiterates joint commitments to competitive wholesale, balancing and capacity markets. Regulated third party access and transmission system operator (TSO) unbundling should continue. Standardised capacity products should be offered. Capacity markets should not include capacity from the other's jurisdiction, which implies that interconnectors cannot provide capacity in the GB capacity market. There is also a commitment to work together on balancing and intra-day markets. Network charges should not be charged on interconnectors and no reserve prices placed on their use. There must be monitoring of competition and an independent energy regulator. Thus, the role of Ofgem is secured by the TCA.

The TCA specifically preserves the Single Electricity Market in Ireland (I-SEM) and states that the UK and EU could link their carbon markets in the future. Both parties have committed to net zero by 2050 and committed not to weaken their 2030 targets in place at 31/12/20.

The TCA commits the parties to efficient use of interconnectors and to reducing barriers to trade, but the final rules on cross border trading are not agreed. For electricity trading, day ahead trading is to be based on net position between UK and interconnected zones, so is not part of the common trading platform used in the single electricity market (EUPHEMIA). There will be a 'distinct and separate' algorithm resulting in 'multi-region loose volume coupling' (MRLVC), which is yet to be developed. A cost benefit analysis and outline proposals were to be published within 3 months; proposals for technical procedures within 10 months; with entry into force within 15 months of the TCA entering into force. The cost benefit analysis was completed in April 2021, concluding that MRLVC could be an improvement on the current arrangements.[19]

The TCA commits the parties to cooperation on networks with published network plans and security of supply and network condition information sharing, together with the use of market mechanisms. The SCE will look at markets, efficient use of interconnectors, network access and infrastructure pricing. UK electricity transmission system operators (TSOs) are

[15] See Willis (2021) for an excellent summary of the energy provisions of the TCA.
[16] This had its first meeting on 14 July 2021. See: https://www.gov.uk/government/groups/specialised-committee-on-energy
[17] McCann Fitzgerald (2021).
[18] See LK Shields (2021).
[19] See CEPA (2021).

explicitly not members of ENTSO-E[20]. The UK is no longer part of North Seas Energy Cooperation[21] which includes a number of EU countries with interests in developing offshore wind and grid developments in Northern Europe. However TSOs need opinions of ACER and UK regulators on matters of joint interest. The UK is no longer a member of ACER, but remains (as of August 2021) a member of the Council of European Energy Regulators (CEER), which represents regulators to the EU Commission and works closely with ACER. ENTSO-E and UK TSOs should cooperate on markets, efficient use of interconnectors, network access, infrastructure planning, security of supply, offshore energy. A Joint European Stakeholder Group established between ENTSO-E and UK TSOs is already overseeing this (see NGESO, 2021).

ACER and UK regulators will cooperate on arrangements covering: efficient use of interconnectors, market abuse, infrastructure planning, network access, security of supply, markets, cooperation between TSOs and offshore energy. There will also be cooperation between the parties on offshore RES-E, on hybrid joint projects, grid planning, maritime spatial planning, new technologies, support and finance and best practice on regulation.

The UK has left Euratom, the EU body which governs nuclear trade and cooperation. Its role has been replaced and Office of the Nuclear Regulation (ONR) has assumed responsibility for nuclear safety regulations.[22] The UK has a Voluntary Offer Agreement and addition protocol with the International Atomic Energy Agency (IAEA) and nuclear cooperation agreements with Canada, Australia and the US to replace their agreements with Euratom. Japan and several other non-EU countries have existing bilateral agreements with UK, but nuclear cooperation arrangements with several other countries covered by Euratom have been lost (e.g. with Argentina and South Africa). UK and Euratom have agreed a separate Nuclear Cooperation Agreement. There will be free transfer of nuclear material and research cooperation. UK will be part of Euratom's Research and Training Programme for 2021-25 and this can be extended to 2026-27.

4. The effect of Brexit on the UK electricity system

The most sophisticated part of the EU single market in energy has been the single market in electricity. This is because electricity is traded in real time both within and between European countries. Supply and demand must instantaneously balance at all times and at all nodes, meaning that any barrier to trade will impose (some) cost.

Three direct things have happened as a result of Brexit. First, the UK market has been separated into the Northern Irish and Great Britain (GB) markets. Northern Ireland has remained in the single electricity market. GB has not. Second, trading arrangements between GB and the single electricity market have been subjected to changes which have reduced trading efficiency. Third, the UK left the EU ETS emissions scheme and transitioned to its own carbon trading arrangement. The first of these has secured the benefits of the single electricity market in Ireland (the I-SEM) which already had a common electricity

[20] This has also been clarified in ministerial guidance. See BEIS (2021c). However UK TSOs are still listed as full members on the ENTSO-E website as of August 2021.
[21] See https://ec.europa.eu/energy/topics/infrastructure/high-level-groups/north-seas-energy-cooperation_en
[22] See Norton Rose Fulbright (2021).

market platform and shared governance arrangements. The second has been the subject of a lot of analysis, which we discuss below. The third caused significant initial uncertainty which appears to have been largely resolved.

The issue is how electricity is traded across the electricity interconnectors between GB and the European single electricity market (SEM). From 2014 to end of 2020 GB was subject to day ahead market coupling (DAMC) within the SEM.[23] Under the DAMC implicit auction, capacity is made available to the auction and then the power traded on power exchanges with implicit capacity attached. This makes use of the EUPHEMIA algorithm to calculate market clearing power prices in each zone of the single market, while observing the capacity constraints imposed by the interconnectors. Prior to this there was explicit capacity allocation where capacity had to be bought in a separate auction by traders and then power traded based on pre-bought capacity, but the auction times did not match creating trading errors and increasing trading risk.

From January 1st 2021 each interconnector with the EU is subject to a two stage process, like the ones which existed under the prior regime. For instance on the IFA interconnector between England and France the day ahead auction window for capacity is 0940-1000 CET on the prior day, and then the day ahead energy transfer nomination window is 1205-1400 CET on the prior day. The result is likely to be a mismatch between realised energy prices and available transmission capacity, with the likelihood of under-utilisation of capacity and slightly higher prices in GB. There is some evidence that, initially at least, interconnector utilisation between GB and Ireland fell.[24]

The initial losses from this arrangement are likely to be small, and relatively short-lived as the new market coupling algorithm is due for introduction by April 2022 (i.e. after 15 months). This final algorithm will be costly to design and (very) slightly less efficient than the original EUPHEMIA algorithm. Guo and Newbery (2021) estimate the effects of the net social cost of uncoupling of GB interconnectors under the TCA as only being 26 million Euros per year. This is much lower than previous estimates, largely because the forecast errors are now going to be quite small and the volume of interconnection is not going be effected (not in the period to 2022). The total revenue of the electricity sector in 2019 in the UK was £39337m[25].

Other studies have estimated the effects of Brexit on electricity emphasising the possibility that future investments in electricity interconnectors might be reduced by trade barriers. For instance, Geske et al. (2020) model the constriction of interconnection from 10 GW to 5 GW by 2030 with uncoupling of markets (and increase in trading errors) and final that wholesale electricity prices rise by 2%, but could be 4 times higher if French nuclear power production is high. These figures seem very high and already look extremely pessimistic.

[23] See Arthur Cox (2021)

[24] See https://www.powerengineeringint.com/renewables/strategic-development/brexit-cuts-interconnector-use-and-sends-power-prices-rocketing/

[25] See Digest of UK Energy Statistics Table 1.7, https://www.gov.uk/government/statistics/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes

They are calibrated using 2009 data on uncoupled markets (which could be greater than the errors we might observe now).

Pollitt and Chyong (2017) focus simply on the effect of reduced electricity interconnector capacity to 2025. The failure to build 1 GW of extra capacity (beyond the 8.4 GW planned at the time) due to Brexit produces modest impacts of 3.8p / MWh by 2025 (with current wholesale prices being around £50/MWh), based on 2015 data. So far all of the capacity in train at the time of the referendum has proceeded as planned, and VikingLink (between GB and Norway) has reached final investment decision.

Castageneto Gissey et al. (2019) look at the value of international electricity trading for the UK, they estimate a rising price differential of 2-3% with France and the Netherlands as a result of uncoupling. They also find a loss of €100m loss of revenue from the carbon price floor and an overall welfare loss of €30m. These distortions could be reduced by the EU raising its carbon price.

If Brexit actually were to lead to better matching of carbon prices between GB and the EU this would reduce a deadweight loss which is bigger than the reduction in sector coupling efficiency. Though, if carbon prices are increasingly not coordinated between the GB and the EU this could lead to higher deadweight losses. In the short run the UK leaving the EU ETS might seem likely to potentially reduce the absolute distortion (as the UK ETS price might be lower than in the EU given recent rises in the EU price) but increase the variance between carbon prices in the UK and EU, due to the de-coupling of carbon market fluctuations.

The UK left the EU ETS at end of 2020, with the stated intention of creating its own emissions trading arrangements. The first permits however were not auctioned until 19 May 2021, with secondary trading able to begin then. Until this date there was uncertainty as to what the price of allowances faced by the electricity sector would be in 2021, even though the sector knew it would require allowances. Interestingly, the price of UK allowances has been closely in line with EU allowances since 19 May.[26] This has meant that in reality nothing much has changed in terms of the relative impact of carbon prices on UK electricity prices relative to the EU, since the end of 2020. The additional carbon tax on electricity production in the UK still distorts cross border trade in electricity.

Mayer et al. (2019) model the potential impact of Brexit on electricity as a combination of a devaluation, a reduction of interconnector capacity and higher carbon prices. With high renewables, high carbon prices and no reduction in interconnector capacity Brexit could be positive for consumer welfare, however with reduced interconnector capacity and less domestic renewables production it could be quite negative for consumer welfare (up to an 8bn Euros loss) by 2030. This study shows the impact of macroeconomics and carbon price differentials as being much more important for the consumer welfare in the electricity sector than small impediments to efficient trading.

[26] Averaging the allowance prices from May 19 to August 27 2021 and adjusting for exchange rate, EU Allowances were 99.4% of the value of UK Allowances. For the data see: https://ember-climate.org/data/carbon-price-viewer/

5. *The effect of Brexit on the UK gas system*

As we noted natural gas is the UK's largest source of primary energy, providing 41% of electricity production[27] and a large share of heating in 2019. Although the UK is heavily interconnected with the EU and Ireland is dependent on UK gas, the gas sector has been largely unaffected by the UK leaving the single market. Gas trading arrangements are less sophisticated than electricity arrangements, in part, because gas supply and demand do not need to be balanced in real time and prices do not vary intra-day. However UK gas transmission system operators (TSOs) are explicitly not members of ENTSO-G, under the TCA. However as of August 2021, UK TSOs were still listed as full members of ENTSO-G on the ENTSO-G website.

Gas interconnector capacity is less regulated under EU legislation and offers a mix of implicit and explicit capacity allocation on individual gas interconnectors. BBL (NL-UK) allocates 40% of its capacity via an implicit auction, while IUK (UK-Belgium) has a mix of capacity products, including long run implicit contracts (of up to 15 years ahead). LNG import terminals are exempt from regulated third party access (TPA) and hence fees are negotiated commercially. Gas interconnectors have continued to use the existing European gas trading platform. This might be revisited in the future, but has not been affected by Brexit so far.

Gas demand in the UK is not growing, but there is an issue with investments to maintain existing gas infrastructure capacity. It is possible that gas infrastructure could contract under certain Brexit scenarios and this could impact prices. This was a concern prior to the TCA (see Pollitt and Chyong, 2017).

Pollitt and Chyong (2017) modelled the impact of restrictions on gas flows to the EU. They found small overall impacts from large trade disruptions to gas trade. UK wholesale gas prices could end up 3.9% higher or 5.6% lower in 2025, depending on whether UK demand grows or contracts. These were average price impacts, the price impacts could be higher at peak times, especially in the winter when gas flows into the UK from the EU.

Bradshaw (2018) examines the future of the UK's gas security after Brexit. The UK remains significantly integrated into the European single gas market (which includes Norway, from which much of the UK's imported gas comes) and will lose the benefit of the EU's diplomacy on gas and EU energy solidarity measures and become significantly dependent on imported LNG. This could mean riskier and more volatile gas prices. Bradshaw argues that the role of gas in the UK's energy system is underestimated given its starting position. He points out that gas with carbon capture and storage (CCS) could be essential to power generation and to future of hydrogen from methane. He admits that uncertainty over future of gas existed prior to Brexit and has not been addressed by it, but points out that the need to invest in maintaining gas infrastructure is more necessary than many appreciate, given its likely continuing importance even in a net zero energy system.

Makholm (2017) makes a more radical argument for using Brexit to get rid of unbundled gas market competition and returning to a more integrated gas system, where local distribution

[27] See BEIS (2020, p.77).

companies with consumers on default tariffs represent them in negotiating point to point contracts with suppliers. This introduction of this US type of competition model into the UK would mark a departure from the unbundled, competitive entry and exit model of gas in the EU-UK. Makholm argues that this now standard EU model of competition has failed in the UK and this would reflect the global experience of the successful representation of gas consumers by their regulated gas distribution companies.

This is an interesting argument, though it rather ignores the fact that gas prices have been low in the UK and that there have been spectacular failures of gas distribution companies to represent their consumers, most notably in Japan where for year's Japanese gas companies signed long term LNG contracts committing them to much higher prices than equivalent prices in Europe, without attempting to arbitrage between price basins. The TCA would seem to commit the UK (and the EU) to continue with the current model.

6. The wider effects of Brexit and questions raised

The direct micro-economic effects of Brexit on electricity and gas trading appear to be very small. However a number of wider effects on the UK and the EU have been identified and are worth considering. For the UK, these can roughly be characterised as covering governance issues, energy policy and macro-economic impacts. For the EU, the loss of the UK might have voting implications for the direction of its energy policy, but also for strategic policy competition with the UK.

Cairney et al. (2018) discuss how Brexit will affect the whole UK energy system and the division of responsibilities within it. EU legislation has provided a framework and direction for significant parts of both national and devolved energy policy and the loss of this influence will have consequences for who does what, and what bits will be picked up by the market, government or civil society. Cairney et al. (2019) develop this further. They point out that repatriation of certain energy policy functions from the EU back to the UK, means that there is a question of who they will be allocated to within the UK, especially with respect to the environment. For instance, will the Scottish government may give more or less support for RES-E in Scotland, than it had from the EU. For instance, they point to the potential for an increased focus on energy justice through the work of the Just Transition Commission in Scotland.

Lockwood and Froggatt (2019) discuss potential post-Brexit effects on energy policy. These might include 'taking back control' as public ownership, especially in the light of extensive current EU ownership of assets; increased localism exacerbating the separateness of NI and Scotland; increased decentralisation of electricity system because of Brexit. This may present opportunities such as in battery production for EVs and consumer engagement with energy either in a decentralised way or via large consumer centric companies like Amazon or Google. They also mention that there could be beneficial competition between EU and UK on climate policy.

Brexit has indeed had a reallocation effect within the UK of responsibilities for energy governance. We now know that Brexit has substantially left responsibility for energy policy with respect to electricity in Northern Ireland with the EU, in contrast to what has happened

for Great Britain. Brexit, inter alia, has indeed re-activated an interest in regional industrial policy which has been strongly manifested in the energy sector, as exemplified by the Ten Point Plan mentioned earlier. This has a focus on boosting manufacturing and jobs in the Midlands and North of England, where extra battery and renewables related manufacturing plants would be located.

Ifelebuegu et al. (2017) suggest that the winding up of the Department of Energy and Climate Change (DECC) and its merger with the Department of Business, Innovation and Skills (BIS) to become the Department of Business, Energy and Industrial Strategy (BEIS) in July 2016 was a consequence of Brexit. This happened immediately following Teresa May becoming Prime Minister and is in line with the reactivation of industrial strategy.

Turning to the macroeconomic impacts, Rocco et al. (2020) present an input output analysis of Brexit for the whole UK economy in the context of trading with the EU and the Rest of the World. This allows them to examine the impact of Brexit in energy and non-energy sectors. The most plausible scenario shows contraction in GDP and energy demand. This sort of analysis serves to highlight that if Brexit contracts energy intensive sectors this might amplify the negative GDP impact on the energy sector. However under a somewhat implausible scenario where Brexit promotes GDP and exports, the energy sector increases output significantly (leading to possible growth constraints in energy), in part driven by rising output in the chemicals and other manufacturing sectors.

Turning to the impact of Brexit on the EU, Hix et al. (2016) discuss the voting record of the UK in the European Council. The UK was the most defeated member, with it being on the losing side 12.3% of the time from 2009-15 (more than twice the next highest member, Austria). Though they point out that UK was less of an outlier in votes on the single market and the environment. They also highlight how support for unconventional technologies and for nuclear would be go down in the European Parliament with the loss of UK MEPs. Ifelebuegu et al. (2017) also note that the UK opposed the Nord Stream II investment (which would have boosted the EU's dependence on Russian gas) and supported the development of European shale gas (including in the UK).

More generally, it would seem to be the case that the loss of the UK from the European Council and from the European Parliament will weaken internal EU support for further energy market integration, the EU Emissions Trading Scheme, nuclear power and carbon capture and storage. In turn, there might be less EU support for network extension investments involving the UK (Projects of Common Interest) and less desire to strengthen integration of the UK into the single electricity and gas (and, in the future, hydrogen and CCS) markets. The TCA offers some reassurance that this is not actually the envisaged future for EU-UK energy market integration, however the changed internal dynamics within the EU may yet have negative consequences for the UK energy sector.

Finally, it is worth emphasising that while not much seems to have changed in the current and near term energy relationship between the UK and EU there has been some increase in uncertainty about the future direction of UK energy and climate policy relative to that in the EU. Stua (2018) surveys 100 informed UK and non-UK stakeholders on the effect of Brexit on the UK's energy and climate strategies. She finds that there is some uncertainty introduced

by Brexit that the UK's climate and energy ambitions will be reduced. However, there is a lot of confidence that the UK's climate ambitions won't be reduced and that its commitments to RES-E and nuclear will be largely unaffected.

7. Concluding Comments

Since our previous paper in 2017, there has been a significant clarification in the impact of Brexit on the energy sector in the UK. This allows us to offer a number of concluding observations.

First, the micro-economic impact of Brexit on energy remains modest at the price and policy target level. There has been a minimal increase in trade barriers in the electricity sector and no change to trading arrangements for the gas sector. There is a commitment to reduce, but not eliminate, the trade barriers that have been introduced. At the policy target level, both the UK and EU have committed to even tougher targets on climate change and renewables roll-out. In terms of energy R+D, the UK continues to participate in the wider Horizon Europe R+D programme and Euratom's Research and Training Programme.

Second, the macro-economic consequences of Brexit are playing out in the energy sector, as they are across the whole UK economy. Thus the output effect on individual energy intensive sectors, aggregate GDP, the political integrity of the UK and on a more muscular industrial policy do have bigger implications for the energy sector. Energy and climate change are a key part of a Green Industrial Strategy, which in turn is a key policy response to Brexit (and, now, COVID-19).

Third, Brexit has increased fundamental uncertainty with respect to energy policy because of the exposure of all policies returning from the EU to more scrutiny and because of the impact of Brexit on EU energy and climate policy. The loss of UK influence on EU energy and climate policy increases the likelihood of future policy divergence, in spite of the fact that energy policies were initially fully aligned as of 31 December 2020 and remain closely aligned until 2028 via the TCA.

Fourth, so far the impact of Brexit has been largely benign in the energy sector. Somewhat surprisingly energy was prioritised within the EU-UK Trade and Co-operation Agreement and the 'loss' for the UK was minimal. Since the 2016 referendum the UK and EU have committed to Net Zero, which would seem to strengthen the incentives for continuing and growing integration of both electricity and gas systems. The UK's role as an exemplar to the EU may, if anything, have been strengthened, because there may be a genuine positive political competition emerging in a sector on which the hopes for decarbonisation and industrial strategy depend.

Fifth, the emergence of sensible long term arrangements between the UK and EU could benefit from increased transparency on what is actually happening with energy market arrangements. In a sector that has benefitted from increased transparency, market integration and shared climate goals it seems a great shame when shared efficiencies are being actively prevented. There should be full transparency around the Specialised Committee on Energy, membership of ENTSO-E and ENTSO-G, the sharing of capacity in

capacity markets and the market coupling arrangements in electricity. Electricity could learn from gas in finding a private solution to the achievement of market coupling, which achieves genuine free trade in electricity.

Sixth, it is worth saying that the TCA focuses on electricity and natural gas, but it is (largely) silent about new sources of energy such as hydrogen. These might give rise to entirely new energy networks with market and regulatory arrangements which are outside the scope of today's arrangements in both the EU and the UK. The UK might find that any ambition to become a hub for hydrogen trade and production could be thwarted by its position as a non-EU member.

This last point begs a general question about Brexit and energy that remains to be answered, which is over what time period might we expect to see an effect? While the initial impact was designed to be modest in energy significant divergences might yet emerge. For instance, there is an increased risk of a substantial weakening of climate policy at some point, with consequences for the energy sector. However, there is also the possibility of a significant strengthening of climate policy powered by a more interventionist industrial strategy towards energy under governments of both the left and right as a result of Brexit. As time progresses it will likely be more difficult to say if Brexit was a significant driver of a given future energy policy shift.

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