Title: Proposed regulation to reduce ammonia emissions from solid urea fertilisers in England **IA No:** **RPC Reference No:** **Lead department or agency:** Department for Environment, Food and Rural Affairs **Other departments or agencies:**	**Impact Assessment (IA)** **Date:** 05/06/2020 **Stage:** Pre-Consultation draft **Source of intervention:** Domestic **Type of measure:** Secondary legislation **Contact for enquiries:**

Summary: Intervention and Options

RPC Opinion: RPC Opinion Status

Cost of Preferred (or more likely) Option *(Option 1)* (in 2019 prices)			
Total Net Present Social Value	**Business Net Present Value**	**Net cost to business per year**	**Business Impact Target Status**
£968.1	-£124.7	£15.8	Qualifying provision

What is the problem under consideration? Why is government intervention necessary?

The UK is obligated under the National Emission Ceilings Regulations 2018 to reduce ammonia (NH_3) emissions from 2005 levels by 8% in 2020 and 16% in 2030. In addition, there is also the need to protect sensitive ecosystems (such as SSSIs) from eutrophication and acidification, to which ammonia is a major contributor and to limit the concentration of particulate matter (PM), of which ammonia is a precursor. PM has a negative impact on human health leading to increased mortality. We envisage that this policy will also contribute to meet the annual mean level of PM2.5 in ambient air to be set by regulations, as stated by the Environment Bill.

87% of NH_3 emissions come from agriculture (UK, 2017), of which 18% are attributable to inorganic fertiliser use, such as urea. The market does not take into account this negative externality so the government is taking action to protect the public and the environment from the damage caused by exposure to these pollutants.

What are the policy objectives of the action or intervention and the intended effects?

- A cleaner, healthier urban and rural environment, benefiting people and the economy.
- A reduction in the negative impact on health (i.e. including increased mortality from cardiovascular and respiratory diseases and from lung cancer) and the environment from NH_3 and PM pollution.
- A contribution towards achieving our legally binding domestic and International obligations, in particular the National Emission Ceilings Regulations, 2018 ceilings for 2020 and 2030 and International Gothenburg Protocol.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

Option 0: Counterfactual/ Do nothing approach – No additional legislative restrictions applied on users of inorganic fertilisers. This is the baseline against which the other options are assessed.
Option 1 (preferred option): Ban of solid urea. This option entails a complete ban on the use or sale of solid urea fertiliser. It delivers the largest air quality and health benefits.
Option 2: Urease Inhibitor. This option entails a ban on using solid urea fertiliser unless used with the addition of an urease inhibitor. It delivers the best balance between realising the air quality and health benefits and managing the impact on farmers.
Option 3: Restricted application period. This option entails a requirement for urea to be spread only from 15 January to 31 March. It delivers the lowest air quality and health benefits compared to options 1 and 2 but provides flexibility to farmers and limits impact on the fertiliser market.

Other options considered: i) Requiring the addition of a urease inhibitor to both solid urea and other urea-based fertilisers (urea ammonium nitrate, UAN); ii) Requiring the addition of a dual inhibitor (urease and nitrification inhibitor) to solid urea and UAN: iii) Complete ban on the use of urea and other urea-based fertilisers; iv) Enforcing the use of low emissions application techniques and v) A tax on solid urea.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date:** 06 2027

Does implementation go beyond minimum EU requirements?		Yes		
Is this measure likely to impact on international trade and investment?		Yes		
Are any of these organisations in scope?	**Micro** Yes	**Small** Yes	**Medium** Yes	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)		**Traded:**	**Non-traded:** 0.72	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible SELECT SIGNATORY: ________________ Date: ________________

Summary: Analysis & Evidence Policy Option 1 (Preferred option)

Description: Ban of use or sale of solid urea

FULL ECONOMIC ASSESSMENT

Price Base Year 2019	PV Base Year 2020	Time Period Years 9	Net Benefit (Present Value (PV)) (£m)		
			Low: 45.3	**High: 3,350.0**	**Best Estimate: 968.1**

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	0.0		13.7	**100.4**
High	0.0		20.5	**150.7**
Best Estimate	0.0		17.1	**125.5**

Description and scale of key monetised costs by 'main affected groups'

Following the ban, farmers using solid urea are expected to shift to ammonium nitrate (AN) to meet their fertiliser needs. Substitution is anticipated to be associated with additional cost to farmers as AN is a more expensive fertiliser when considering nutrient (nitrogen) content. Cost to farmers is estimated at £132 million over the 2022-2030 period in the central scenario. Farmers will also face familiarisation and administration costs of £3 million over the period. Fertiliser manufacturers are likely to benefit from the substitution, with profits anticipated to increase by £11 million. For government and local authorities, the enforcement cost is expected to reach £0.8m over the period.
Overall, costs are anticipated to increase by £126 million over the 2022-2030 period in the central scenario.

Other key non-monetised costs by 'main affected groups'

Farmers and the fertiliser industry may face additional costs in terms of storage and transport when substituting solid urea with ammonium nitrate. Indeed, additional secure and covered storage for AN may not be readily available. Furthermore, access to AN could be more limited in certain areas of the country. Initial evidence gathered through expert discussion has not been conclusive and government aims to collect further evidence of these possible costs through its consultation and incorporate them if deemed relevant.
If there is differentiation in solid urea fertiliser policy across the UK, farmers in England could be at a disadvantage compared to those in the rest of the UK who will not face the same restriction; this may affect their profits. As ammonia emission is also a concern in devolved administrations (DAs), air quality and fertilisers teams in devolved administrations have been engaged in relation to this policy.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0.0		26.8	**196.0**
High	0.0		471.4	**3450.5**
Best Estimate	0.0		149.4	**1093.6**

Description and scale of key monetised benefits by 'main affected groups'

The proposed regulation will reduce emissions of ammonia (NH_3) resulting in an improvement in air quality for everyone and in particular for people living in rural areas. We use the latest Defra air quality damage cost values based on advice from the Committee on the Medical Effects of Air Pollution (COMEAP). These are likely to underestimate the benefits of the proposed regulation as they do not fully capture impacts on the environment from air pollution. We estimate this air quality benefit at £1,139 million over the 2022-2030 period in the central scenario.

The change of greenhouse gas (GhG) emission is valued using the Green Book guidance and is monetised using BEIS non-traded carbon values. The net additional direct and indirect emissions of nitrous oxide (N_2O) are valued at £45 million, reducing the total benefits.

In the central scenario, we estimate the central present value benefits from the associated change in ammonia and GhG to be £1094 million over the appraisal period and to be significantly higher than the costs of the regulation. The benefit-to-cost ratio is anticipated to be 8.7

Other key non-monetised benefits by 'main affected groups'

We have not monetised some of the indirect benefits that could be achieved through a reduction in ammonia emissions. They are difficult to reflect in monetised terms because of different valuation methodologies employed in research and related difficulties of evaluating complex biological systems. There are four primary mechanisms by which ammonia impacts biodiversity and ecosystems: eutrophication of soil, acidification of soil, direct toxicity to sensitive plant species and other indirect effects, for example on water quality. Deleterious effects on soil, water and air quality occur when ammonia concentrations are moderate or high. Reducing ammonia emissions will help to reverse or halt these effects and may provide some of the indirect benefits as well. However, these cannot be quantified at present in this assessment.

Key assumptions/sensitivities/risks	Discount rate	3.5

There is uncertainty around the scale of health benefits from improved air quality (damage costs) as well as some uncertainty around the business costs.

The high NPV combines low business costs with high damage cost valuation (high benefits), and the low NPV combines high business cost with low damage cost valuation. Full compliance is expected under this Option. However, a sensitivity analysis has been undertaken to consider the range of compliance.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m:
Costs: 15.8	**Benefits: 0.0**	**Net: 15.8**	**79.2**

Summary: Analysis & Evidence

Policy Option 2

Description: A requirement to stabilise solid urea fertilisers with the addition of a urease inhibitor (UI)

FULL ECONOMIC ASSESSMENT

Price Base Year 2019	PV Base Year 2020	Time Period Years 9	Net Benefit (Present Value (PV)) (£m)		
			Low: 112.1	**High:** 2,838.4	**Best Estimate: 884.5**

COSTS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant	**Total Cost** (Present Value)
Low	0.0		7.1	**52.6**
High	0.0		10.7	**78.9**
Best Estimate	0.0		8.9	**65.8**

Description and scale of key monetised costs by 'main affected groups'

In line with the proposed regulation, farmers using solid urea are expected to continue using urea but with the product manufactured in compound with a urease inhibitor or coated with a urease inhibitor. This mitigation technique will result in additional cost estimated at £62 million over the 2022-2030 period in the central scenario. Farmers will also face familiarisation and administrative costs of £8 million over the period. Fertiliser manufacturers are likely to benefit from this new market, with profits estimated to increase by £5 million. For Government and Local Authorities, the enforcement cost is expected to reach £0.8m over the period. Overall, costs are anticipated to increase by £66 million over the 2022-2030 period in the central scenario.

Other key non-monetised costs by 'main affected groups'

Farmers and the fertiliser industry may face additional costs in terms of storage and transport, as the volume of fertiliser increases with the addition of urease inhibitor.

BENEFITS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant	**Total Benefit** (Present Value)
Low	0.0		26.1	**191.0**
High	0.0		395.0	**2891.0**
Best Estimate	0.0		129.8	**950.2**

Description and scale of key monetised benefits by 'main affected groups'

The proposed regulation will significantly reduce emissions of ammonia (NH_3) along with a small decrease in nitrous oxide (N_2O), resulting in an improvement in air quality for everyone and in particular for people living in rural areas. We use the latest Defra air quality damage cost values based on advice from COMEAP. These are likely to underestimate the benefits of the proposed regulation as they do not fully capture impacts on the environment from air pollution. We estimate this air quality benefit at £922 million over the 2022-2030 period in the central scenario.

The reduction of greenhouse gas (GhG) emissions are valued using the Green Book guidance and is monetised using BEIS non-traded carbon values. The contraction of indirect emissions of N_2O lead to an equivalent carbon saving valued at £28 million.

We estimate the central present value benefits from the associated change in ammonia and GhG to be £950 million over the appraisal period and to be significantly higher than the costs of the regulation. The benefit-to-cost ratio is anticipated to be 14.5

Other key non-monetised benefits by 'main affected groups'

We have not monetised some of the indirect benefits that could be achieved through a reduction in ammonia emissions. They are difficult to reflect in monetised terms because of different valuation methodologies employed in research and related difficulties of evaluating complex biological systems. There are four primary mechanisms by which ammonia impacts biodiversity and ecosystems: eutrophication of soil, acidification of soil, direct toxicity to sensitive plant species and other indirect effects, for example on water quality. Deleterious effects on soil, water and air quality occur when ammonia concentrations are moderate or high. Reducing ammonia emissions will help to reverse or halt these effects and may provide some of the indirect benefits as well. However, these cannot be quantified at present in this assessment.

Key assumptions/sensitivities/risks **Discount rate** 3.5

There is uncertainty around the scale of health benefits from improved air quality (damage costs) as well as some uncertainty around the business costs. The high NPV combines low business costs with high damage cost valuation (high benefits) and the low NPV combines high business cost with low damage cost valuation. Full compliance is expected under this Option. However, a sensitivity analysis has been undertaken to consider the range of compliance.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m:
Costs: 8.2	**Benefits: 0.0**	**Net: 8.2**	**40.9**

Summary: Analysis & Evidence

Policy Option 3

Description: Restricted application period

FULL ECONOMIC ASSESSMENT

Price Base Year 2019	PV Base Year 2020	Time Period Years 9	Net Benefit (Present Value (PV)) (£m)		
			Low: 0.0	High: 2,517.5	**Best Estimate: 737.1**

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	0.0		9.5	**69.7**
High	0.0		14.2	**104.6**
Best Estimate	0.0		11.8	**87.1**

Description and scale of key monetised costs by 'main affected groups'

This proposed policy option will allow farmers to continue using solid urea fertiliser but introduce a restriction on the application window, so that it may only be applied from 15 January to 31 March. During the longer non-application or "closed" period of April to 14 January, farmers are expected to shift to ammonium nitrate (AN) to meet their needs for fertiliser. Substitution is anticipated to be associated with additional cost to farmers as AN is a more expensive fertiliser when considering nutrient content. Cost to farmers is estimated at £84 million over the 2022-2030 period in the central scenario. Farmers will also face familiarisation and administration costs of £8 million over the period. Fertiliser manufacturers are likely to benefit from the substitution, with profits estimated to increase by £7 million.

For Government and Local Authorities, the enforcement cost is expected to be higher than in Options 1 & 2 due to increased farm inspections, reaching £2.3m over the period. Overall, costs are anticipated to increase by £87 million over the 2022-2030 period in the central scenario.

Other key non-monetised costs by 'main affected groups'

Farmers and the fertiliser industry may face additional costs in terms of storage and transport when substituting solid urea with ammonium nitrate, as additional secure, covered storage may not be readily available with access being more limited in certain areas. Farmers may also incur greater administrative costs as they may need to keep additional records to substantiate urea use to inspectors, beyond what is asked in current UK regulations. Initial evidence gathered through expert discussion has not been conclusive and Government aims to collect further evidence of these possible costs through its consultation and incorporate them if deemed relevant.
Although less acute than the ban proposed in Option 1, farmers in England could be at a disadvantage compared to those in the rest of the UK (depending on how the rest of the UK proposes to proceed with urea fertilisers) who may not face the same restriction (e.g. this may affect output and in turn their profits).

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0.0		14.3	**104.5**
High	0.0		353.5	**2587.2**
Best Estimate	0.0		112.6	**824.3**

Description and scale of key monetised benefits by 'main affected groups'

The proposed regulation will reduce emissions of ammonia (NH_3) resulting in an improvement in air quality for everyone and in particular for people living in rural areas. We use the latest Defra air quality damage cost values based on advice from COMEAP. These are likely to underestimate the benefits of the proposed regulation as they do not fully capture impacts on the environment from air pollution. We estimate this air quality benefit at £849 million over the 2022-2030 period in the central scenario. The net additional direct and indirect emissions of nitrous oxide (N_2O) are valued at £25 million.

We estimate the central present value benefits from the associated change in ammonia and GhG emissions to be £824 million over the appraisal period and to be significantly higher than the costs of the regulation. The benefit-to-cost ratio is anticipated to be 9.5.

Other key non-monetised benefits by 'main affected groups'

We have not monetised some of the indirect benefits that could be achieved through a reduction in ammonia emissions. They are difficult to reflect in monetised terms because of different valuation methodologies employed in research and related difficulties of evaluating complex biological systems. There are four primary mechanisms by which ammonia impacts biodiversity and ecosystems: eutrophication of soil, acidification of soil, direct toxicity to sensitive plant species and other indirect effects, for example on water quality. Deleterious effects on soil, water and air quality occur when ammonia concentrations are moderate or high. Reducing ammonia emissions will help to reverse or halt these effects and may provide some of the indirect benefits as well. However, these cannot be quantified at present in this assessment.

Key assumptions/sensitivities/risks	3.5

There is a risk under this Option that farmers would not comply with the legislation and it would be difficult to enforce the approach because farmers would have access to unstablised urea and store it on their farms. There is also a risk that farmers might apply more urea during the application period than they do currently which would increase the risk of nitrate leaching. Therefore, there is uncertainty around the scale of health benefits from improved air quality (damage costs) as well as some uncertainty around the business costs.

The high NPV combines low business costs with high damage cost valuation (high benefits), and the low NPV combines high business cost with low damage cost valuation.

BUSINESS ASSESSMENT (Option 3)

Direct impact on business (Equivalent Annual) £m:			**Score for Business Impact Target (qualifying provisions only) £m:**
Costs: 10.8	**Benefits: 0**	**Net: 10.8**	**53.9**

Table of Contents

List of tables

1. Executive Summary

1.1 Policy background

1. In January 2019, the Government published its Clean Air Strategy[1]. This highlighted that air pollution is a major risk to human health, ranking alongside cancer, heart disease and obesity and is the top environmental risk to human health in the UK.

2. Long term exposure to poor air quality reduces life-expectancy through increased risk of mortality from cardiovascular and respiratory illnesses and from lung cancer. Short-term exposure to poor air quality carries a morbidity burden over a wide range of cardiorespiratory health conditions.[2] It can cause harm to the natural environment resulting in damage to sensitive habitats from nitrogen re-depositon and in reductions in yields of key food crops caused by ozone damage and changes to delicate nutrient balances whereby some aspects of the ecosystem thrives at the detriment of others.[3]

3. In the Clean Air Strategy, the government set out its ambition to progressively cut public exposure to particulate matter (PM) pollution. Ammonia is a gas that is emitted into the atmosphere and then either re-deposited back onto land or converted to secondary PM through reactions in the atmosphere. Agriculture is the dominant source of ammonia emissions (87% in 2017[4]). It is emitted during storage and spreading of manures, slurries and fertilisers.

4. One of the key concerns relating to ammonia emissions is its contribution to particulate matter (PM) and the human health effects previously described. Ammonia reacts with nitrogen oxides and sulphur dioxide, producing ammonium compounds that turn into fine PM. PM is transported large distances and adds to the suspended background levels of particulates in the atmosphere. Public Health England attributed the 2014 smog in London, in part, to agricultural ammonia emissions.[5] Ammonia emissions also lead to negative impacts on the environment. When ammonia is present in the air it can be directly toxic to some sensitive plant species. When re-deposited on land it can acidify soil and increase nutrient nitrogen levels on land and in water in a way that favours strong growth by nitrogen-loving plant species. These effects reduce species diversity in sensitive habitats. Once a habitat has received too much nitrogen, recovery can take decades. As such, ammonia can cause significant long-term harm to sensitive habitats. This has led to significant changes to plant communities and the animal species that depend on them. Ammonia stays in the atmosphere for just a few hours as a gas, but this extends to several days when it reacts to form PM. In this form, it can travel very long distances before being removed from the atmosphere by rain and snow and re-deposited to land.

5. Emissions of ammonia fell by 21% between 1990 and 2013. However, there has been a subsequent increase of 10% during the period up to 2017[6]. This recent development is mainly the result of emissions from agriculture which increased by 11%. Application of inorganic nitrogen fertilisers, which contributed to 16% of total ammonia emissions in the UK and 18%[7] of agriculture ammonia emissions in 2017, increased by 25% during this period.

---

[1] UK Government (2019) Clean Air Strategy 2019
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf

[2] COMEAP (2010) The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom. Committee on the Medical Effects of Air Pollutants. Available from: https://www.gov.uk/government/publications/comeap-mortality-effects-of-long-term-exposure-tohttps://www.gov.uk/government/publications/comeap-mortality-effects-of-long-term-exposure-to-particulate-air-pollution-in-the-ukparticulate-air-pollution-in-the-uk

[3] RoTAP (2012) Review of Transboundary Air Pollution: Acidification, Eutrophication, Ground Level Ozone and Heavy Metals in the UK. Contract Report to the Department for Environment, Food and Rural Affairs. Centre for Ecology & Hydrology.

[4] https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1904121008_GB_IIR_2019_v2.0.pdf

[5] Vieon, L et al (2016) The UK particulate matter air pollution episode of March–April 2014: more than Saharan dust. *Environmental Research Letters.* Vol 11 (4)
https://iopscience.iop.org/article/10.1088/1748-9326/11/4/044004/meta;jsessionid=27D9C697A7D7DC2F5F041CCD03FF9174.c1

[6] The year 2017 is the latest for which data are available in the NAEI, at the time of writing. (https://naei.beis.gov.uk/data/)

[7] Misselbrook, T.H. and Gilhespy, S.L. (2019). Inventory of Ammonia Emissions from UK Agriculture 2017. DEFRA Contract SCF0107. Report by Rothamsted Research, February 2019

6. The Government must take action to reduce ammonia emissions. The emissions reduction target was to reduce emissions of ammonia against the 2005 baseline by 8% in 2020. However, it is likely that this emissions target will not be met, and this will be known in February 2022 when the emissions data will be published for the year 2020. Therefore, this policy focuses on reducing ammonia emissions as early as possible after 2020 and on achieving the 16% reduction by 2030, in line with commitments made under National Emissions Ceilings Regulations, 2018[8] as well as the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the Gothenburg Protocol.

7. The proposed policy aims to reduce ammonia emissions from England only. Emissions of ammonia in England were estimated to be 193kt in 2017 and accounted for 68% of the UK total in 2017[9]. We aim to shift farmers' fertiliser use in England towards less polluting products or apply mitigation techniques to reduce emissions.

8. Air quality is a devolved issue within the UK, but all parts of the UK are expected to make a fair contribution to reducing ammonia emissions. Devolved administrations (DAs) will be consulting separately on their plans to reduce ammonia emissions. Urea fertiliser[10] use in England is considerably higher as a proportion of inorganic nitrogen fertiliser use than it is in other parts of the UK. Implementation of restrictions on its use or sale will have a greater impact in England. Considering this, and the urgent need for action to achieve ammonia emissions reductions in line with 2020 and 2030 commitments, the Government is consulting on an England-only basis at this stage.

9. A range of options aiming to shift users of fertiliser towards fertiliser products and application methods with lower ammonia emissions were considered for this analysis as set out in Section 6. Three options were selected for more detailed analysis after the level of emissions reduction, cost-effectiveness and practicality of the initial options was considered. This document assesses the impacts associated with: a full ban on the use of solid urea fertiliser; the ban of solid urea unless urease inhibitors are added to mitigate emissions of ammonia; and a restriction of the solid urea application period.

Option 1 (preferred option): A complete ban of use of solid urea in England.

Option 2: A requirement to use a urease inhibitor with solid urea in England.

Option 3: A restricted application period of solid urea in England**.**

10. We propose that a post-implementation review should take place 5 years after the legislation comes into force.

1.2 Key Findings: Monetised Impacts

11. The analysis finds the largest reduction in emissions are achieved under Option 1. A complete ban on solid urea fertiliser would result in farmers switching to ammonium nitrate as the alternative fertiliser in England. This will achieve an estimated abatement of 15.9kt of NH_3 emissions in 2022, when the regulation is expected to start impacting emissions, and 15.7kt in 2030.

12. Reducing air pollution yields benefits through improvements to public health and biodiversity. Benefits of cleaner air resulting from the reduction of NH_3 emissions are estimated using the damage cost approach

[8] National Emissions Ceilings Directive: https://www.eea.europa.eu/themes/air/national-emission-ceilings/national-emission-ceilings-directive

[9] Air Pollutant Inventories for England, Scotland, Wales, and Northern Ireland: 1990-2017 - Prepared by Ricardo Energy & Environment for the Department for Environment, Food & Rural Affairs, The Scottish Government, The Welsh Government and The Northern Ireland Department for Agriculture, Environment and Rural Affairs – October 2019 https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1910031755_DA_Air_Pollutant_Inventories_1990-2017_Issue_1.1.pdf

[10] Data and tables throughout this analysis refer to solid urea when "urea" is stated.

as recommended under the Green Book.[11] This approach consists of multiplying the total reduction in the emissions of a pollutant by the associated damage cost. The data used to estimate the benefits reflect the latest iteration of updates published May 2020.[12]

13. The shift from solid urea to ammonium nitrate fertiliser will increase greenhouse gas (GhG) emissions through additional direct emissions of nitrous oxide (N_2O). The change of GhG emission is valued using the Green Book guidance and is monetised using BEIS non-traded carbon values.

14. Present value of net benefits accruing from a reduction in NH_3 emissions and the change in greenhouse gas emissions under the preferred Option 1 range between £45 million (low) to £3,350 million (high), with a central estimate of £968 million over the period 2022 to 2030.

15. Under Option 2, where urea is still used but with the addition of urease inhibitors, present value of net benefits are still relatively high, ranging between £112 million (low) to £2838 million (high), with a central estimate of £884 million over the period 2022 to 2030.

16. Under Option 3, where solid urea is still used but only within a restricted application period, the lowest present value for net benefit is recorded, ranging between zero (low) to £2,518million (high), with a central estimate of £737 million over the period 2022 to 2030.

17. The preferred option provides higher estimated costs of £125 million over the appraisal period than Option 2, with an estimated cost of £66 million. Option 1 gives a lower overall benefit-to-cost ratio (BCR) of 8.7, compared with 14.5 from Option 2, signalling greater public value. Option 3 has a higher cost to farmers and lower benefits than Option 2, with a benefit-to-cost ratio of 9.5. Option 2 creates monetised air quality and human health benefits that are slightly lower than the preferred option: £1,094 million for Option 1 and £950 million for Option 2. However, Option 2, although it gives lower estimated costs and greater BCR, is not the preferred option because it provides a lower amount of emissions abatement necessary to meet the Government's domestic and international obligations to reduce ammonia emissions by 2030. Option 1 provides a total of 142kt of ammonia abatement over the appraisal period, whilst Option 2 provides 115kt of abatement. Therefore, the criteria for preference is based on both value for money and abatement, with greater weight given to the latter over the former due to these immediate legislative obligations s.

18.

Table 1: Emission abatements, costs and benefits

Options, England only		Abatements (kt) 2022 / 2030	Present value benefits (£m) 2022-2030	Present value costs (£m) 2022-2030	Present value net benefits (£m) 2022-2030	Benefit cost ratio
Option 1 (preferred): Ban of solid urea	Low	**15.9 / 15.7**	196.0	150.6	45.3	1.3
	Central		**1093.6**	**125.5**	**968.1**	**8.7**
	High		3450.0	100.4	3350.0	34.4
Option 2: Urea + urease inhibitor	Low	**12.8 / 12.7**	191.0	78.9	112.1	2.4
	Central		**950.2**	**65.8**	**884.5**	**14.5**
	High		2891.0	52.6	2838.4	54.9
Option 3: Restricted application period	Low	**11.8 / 11.7**	104.6	104.6	0.0	1.0
	Central		**824.3**	**87.1**	**737.1**	**9.5**
	High		2587.2	69.7	2517.5	37.1

Source: Defra estimates

19. Three sets of damage costs values are used to develop high, central and low scenarios. The variation in the damage costs reflects uncertainty in the evidence about the lag between exposure and the associated health impacts. We use higher damage costs where the lag between exposure and the health impacts is assumed to be shortest. The damage costs do not fully account for the health impacts and the

[11] The damage costs mainly reflect the mortality effects of air pollution and some of its impacts on morbidity, ecosystems and productivity.

[12] Air quality damage cost update 2019 – Ricardo Energy & Environment https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1902271109_Damage_cost_update_2018_FINAL_Issue_2_publication.pdf

environmental damage that arises from pollution and are likely to underestimate the benefits to society from reducing pollution.

20. Three sets of damage costs values are used to develop high, central and low scenarios. The variation estimation is due to the different health pathways that are included in the analysis and, regarding pollutants, different concentration-response functions and varying valuations for the health impacts. Furthermore, Defra guidance states that the valuation of PM chronic mortality impacts may be overestimated as they have not been adjusted to account for possible confounding effects of other pollutants.[13] Defra damage costs for NH_3 are likely to underestimate the true monetised value of benefits as the environmental impacts have not been fully factored into the calculation (such as on habitats other than acid grassland, heathland, bogs and sand dunes). The Royal Society conducted an analysis of the impacts of ammonia emissions on biodiversity, including a review of studies attempting to quantify the cost of biodiversity loss, despite the challenges faced with various methodologies.[14]

21. The proposed regulation will result in additional cost burdens. Following the ban (Option 1), farmers using solid urea are expected to shift to ammonium nitrate (AN) to meet their needs for fertiliser. Substitution may be associated with additional cost to farmers, as AN is a more expensive fertiliser when considering nutrient content. In Option 2, farmers using solid urea are expected to continue using urea but with the addition of urease inhibitor in the form of coating, adding 10% to the cost of urea. In Option 3, farmers are restricted in when they are able to apply solid urea fertilisers; these fertilisers may be applied only during 15 January to 31 March, outside this period farmers are assumed to shift from urea to AN to meet their inorganic nitrogen fertiliser needs, thereby incurring additional fertiliser costs since AN is more expensive on a nitrogen nutrient basis. Fertiliser manufacturers are likely to benefit in Options 1, 2 and 3, with profits anticipated to increase. Enforcement activities to ensure compliance will result in additional costs for government and/or local authorities depending on the regulatory route used.

22. The proposed regulation is expected to deliver between 23% (Option 3), 25% (Option 2) and 31% (Option 1, preferred) of the anticipated gap in required reduction of ammonia emission in 2030 based on the target set under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP Gothenburg Protocol) and the EU National Emission Ceilings Directive (NECD).

Table 2: Projected emissions reductions from the baseline in 2030, England only

Options, England only	Abatement (kt) 2030	Projected gap between baseline and NECD NH_3 emission reduction commitments for 2030 (kt)[15]	Percentage of gap filled by the proposed regulation
Option 1 (preferred): Ban of solid urea	15.7	51.3	30.6%
Option 2: Urea + urease inhibitor	12.7	51.3	24.8%
Option 3: Extended closed period	11.7	51.3	22.8%

Source: Defra estimates

[13] Air quality damage appraisal: damage cost guidance – Defra, 2020. https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance#damage-costs

[14] The impact of ammonia emissions from agriculture on biodiversity – The Royal Society, 2018. https://royalsociety.org/~/media/policy/projects/evidence-synthesis/Ammonia/Ammonia-report.pdf

[15] The projected 51.3kt gap has been calculated based on UK NAEI Projected Emissions and Projected activity data for NOx, SOx, NH_3, VOCs and PM2.5 as published in October 2019. This gap includes emissions from Anaerobic Digestion estimated at 19.4 kt. With reference to the NEC Directive procedure agreed by Parties under the Gothenburg Protocol of the LRTAP Convention, the UK may qualify for a downward adjustment.

23. Based on a review of existing options in terms of farm management[16] to meet our ammonia target, reducing emissions from the use of urea fertilisers has been identified as the one which can deliver the most ammonia reduction in a relatively cost-efficient way within the timeframe identified (2022 to 2030).

24. However, it is clear that additional action would be needed to fill the gap left in order to achieve the ammonia emission reduction target. This could be from the rest of the UK taking action on solid urea fertilisers or from implementing additional agricultural measures in England only (e.g. regulating slurry stores and covers or low emissions spreaders).

2. Problem under consideration

25. This Impact Assessment sets out evidence that demonstrates that the proposed policy to regulate the use of solid urea fertiliser delivers value for money over a nine-year period, from 2022 to 2030. This nine-year policy period reflects the Government's commitment under the Convention on Long-Range Transboundary Air Pollution (CLRTAP), Gothenburg Protocol Ceilings and the National Emissions Ceilings Regulations (NECR) 2018, to reduce ammonia emissions by 16% in 2030, against the 2005 baseline.

26. The use of urea fertiliser has been an increasing source of ammonia emissions over the past years. While total UK emissions of ammonia fell by 21% between 1990 and 2013, it was followed by a rise of 10% during the period up to 2017[17]. This recent increase originates in the agricultural sector where emissions rose by 11%. Application of inorganic nitrogen (N) fertilisers increased by 25% during the 2013-2017 period, contributing to 16% of total ammonia emissions in the UK and 18%[18] of agriculture ammonia emissions in 2017. This change in ammonia emissions was largely associated with increased use of urea fertilisers, emissions of which surged by 85% from application on arable land and by 48% from application on grassland.

27. In 2017, emissions from solid urea fertilisers contributed to 8% of total ammonia emissions in the UK and accounted for 48% of emissions from inorganic N fertilisers in the same year, compared to 34% in 2013.

Table 3: N fertilisers emissions in the UK – 2005-2017

		2005 (in kt)	2013 (in kt)	2017 (in kt)	Change 2005-2017	Change 2013-2017
Total UK ammonia emissions		**283**	**258**	**283**	**0%**	**10%**
Urea Application	Arable	11.56	9.34	17.28	50%	85%
	Grass	3.09	2.99	4.43	44%	48%
Total		**14.65**	**12.33**	**21.71**		
Urea Ammonium Nitrate (UAN) Application	Arable	4.82	5.41	7.19	49%	33%
	Grass	0.13	0.70	0.40	207%	-43%
Total		**4.95**	**6.11**	**7.59**		

[16] Rapid incorporation of solid manure, separated fibre, cake or compost into the soil by plough, disc or tine; low emission spreading techniques; cover slurry and digestate stores or allow your slurry to develop a natural crust; wash and scrape cattle yards; use of acid scrubbers or bio trickling filters to remove ammonia from the air; use grooved floors in cattle housing to channel urine; consider using a professionally formulated diet to match the nutrient content of the feed to the requirements of the animal at different production stages; etc.

[17] The year 2017 is the latest for which data are available in the NAEI at the time of writing (https://naei.beis.gov.uk/data/)

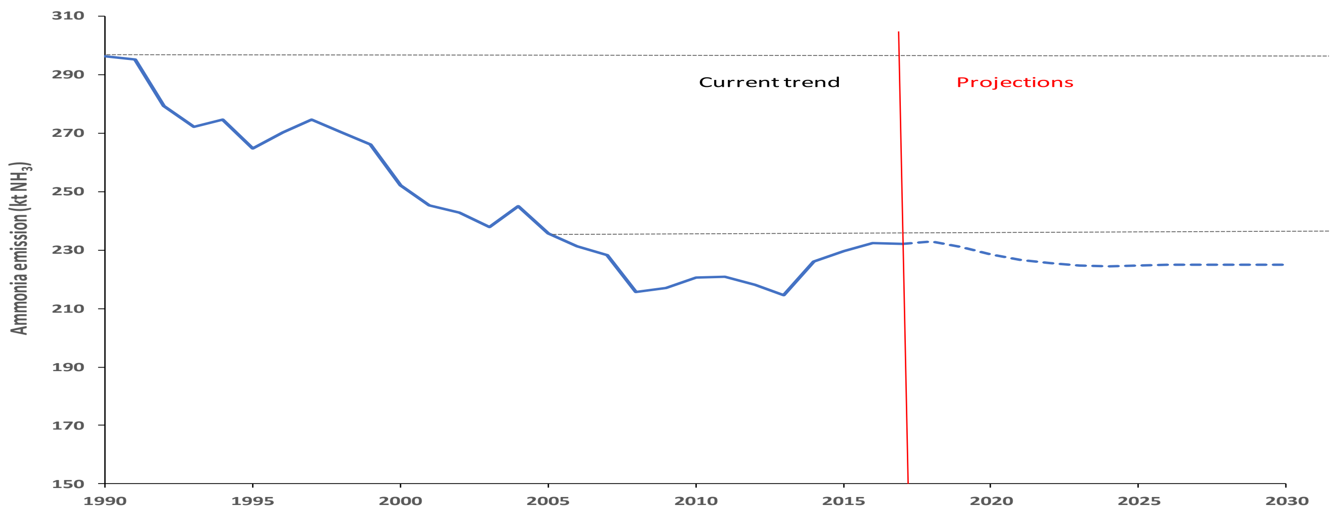
[18] Misselbrook, T.H. and Gilhespy, S.L. (2019). Inventory of Ammonia Emissions from UK Agriculture 2017. DEFRA Contract SCF0107. Report by Rothamsted Research, February 2019

Ammonium Nitrate (AN) Application	Arable	5.69	6.83	5.99	5%	-12%
	Grass	2.66	2.71	2.64	-1%	-3%
Total		**8.35**	**9.54**	**8.63**		
Ammonium Sulphate and Diammonium Phosphate Application	Arable	1.03	0.31	0.40	-61%	29%
	Grass	0.61	0.91	0.85	39%	-6%
Total		**1.64**	**1.22**	**1.25**		
Calcium Ammonium Nitrate (CAN) Application	Arable	0.89	0.19	0.19	-78%	-1%
	Grass	0.49	0.76	0.71	46%	-7%
Total		**1.38**	**0.95**	**0.9**		
Other Nitrogen Including Compounds Application	Arable	2.27	1.50	1.34	-41%	-11%
	Grass	6.03	4.18	3.45	-43%	-18%
Total		**8.30**	**5.68**	**4.79**		

Sources: National Atmospheric Emissions Inventory (NAEI) online database (accessed on 05/11/2019), Defra calculations

28. Air quality pollutant emission projections were made for the UK Agriculture sector for the years 2017-2030 using the 1990-2017 inventory submission model. Agriculture is expected to remain the dominant source of ammonia emissions in the UK. The trend in ammonia emissions from agriculture from 1990 and projected to 2030 is given in Graph 1. If no additional measures are taken, ammonia emissions from agriculture are anticipated to effectively level-off in the period to 2030, accounting for gradual improvements in farming techniques.

Graph 1: Actual past ammonia emissions and projections from UK agriculture, 1990 - 2030



Source: UK Informative Inventory Report, 2019

3. Rationale for intervention

29. This section sets out the rationale for government intervention that underpins the regulation of the use of urea fertiliser, looking at legal obligations, market failures, and wider government objectives.

Legal Obligations

30. The UK has committed to reducing ammonia (NH_3) emissions under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP Gothenburg Protocol) and the UK National Emissions Ceilings Regulations 2018, including legally binding targets to reduce emissions from 2005 levels by 8% by 2020 and by 16% by 2030. 87% of NH_3 emissions come from agriculture (UK, 2017), of which 18% are attributable to inorganic fertiliser use.

Market failures

31. A market failure occurs when the market does not allocate resources to generate the greatest social welfare. Poor air quality is the classic example of a negative externality as the market does not account for the costs associated with human health and biodiversity impacts of ammonia emissions from inorganic N fertilisers application. The market is formed from the relationship between farmers and fertiliser producers. Each group is responsible for the existence of fertiliser: farmers represent demand, producers represent supply. As given in Table 3, emissions from solid urea fertilisers contributed to 8% of total ammonia emissions in the UK and accounted for 48% of emissions from inorganic N fertilisers in 2017, a 34% increase compared to 2013. The government is taking action to protect the public and the environment from the damage caused by exposure to emitted pollutants.

32. Without further action (Business As Usual), ammonia emissions are projected to be above the 2020 and 2030 reduction targets in the National emission ceilings regulations 2018, and human health and biodiversity will be significantly impacted as a result.

Wider Government objectives

33. Agriculture plays a crucial role for rural communities in the UK, not only in producing high quality food and creating and maintaining landscapes but also in protecting our environment. Several existing frameworks are in place that help to limit ammonia emissions from agriculture. Intensive pig and poultry farms are point sources of ammonia emissions and those over a certain size are regulated under the Environmental Permitting Regulations in England. Operators of intensive farms over specified thresholds must hold an environmental permit which requires adoption of Best Available Techniques for their production processes to reduce emissions to air, water and land. The planning regime plays an important role in protecting habitats that are sensitive to nitrogen deposition from sources of ammonia emissions, such as animal houses and slurry stores. Policies such as Farming Rules for Water, the Nitrates Regulations and measures within existing agri-environment and farm advice schemes also help to reduce ammonia emissions.

34. To achieve the required reduction in ammonia emissions from farming, government has committed in the Clean Air Strategy (published in January 2019) to:

- Introduce rules on specific emissions-reducing practices (including “a requirement to take action to reduce emissions from urea-based fertilisers”)
- Regulate to minimise pollution from organic and inorganic fertiliser use, putting “in place a robust framework to limit inputs of nitrogen-rich fertilisers such as manures, slurries and chemicals to economically efficient levels backed up by clear rules, advice and, where appropriate, financial support”
- Extend environmental permitting to dairy and intensive beef farms by 2025

35. As set out in the 25 Year Environment Plan, Government will support farmers and land managers to provide public goods and enable them to meet rules to control pollution. The forthcoming Agriculture Bill will allow transitional schemes enabling financial investment in new equipment, technology and infrastructure to support farmers to pay for public goods, including better air quality. This will replace the current European Union subsidy system of Direct Payments.

4. Rationale and evidence to justify the level of analysis

36. The evidence used across the impact assessment has been gathered from a variety of sources, from Defra farm surveys and analyses, industry associations and sectoral experts. We have consulted with industry, from fertiliser to farmer industry and union bodies, to obtain key insight and evidence to better inform the analysis and its effects on business. The evidence used reflects the best possible evidence we could obtain without significantly burdening businesses at a pre-consultation stage to collect more information.

37. Our assumptions are applied across all businesses, including small and micro business. We have produced three options which impact on business differs in size, but which seek to reduce ammonia emissions and protect vulnerable habitats and ensuring biodiversity; with a view to ensuring long-term recovery of terrestrial and aquatic sensitive habitats. We have carried out a separate assessment on small and micro-businesses to analyse the effect of each policy option on their business profits. This level of analysis is justified due to the need to meet government objectives of improving air quality, human and environmental health, as well as commitments to reduce ammonia emissions. It is also necessary to consider impacts on industry and farm business across all relevant scales so as to pursue an effective, balanced approached to achieving these objectives.

38. The core assumption but primary evidence gap of the analysis is that farmers will comply with the regulation: stop applying any solid urea following the ban in Option 1, apply urea with the urease inhibitors in Option 2 or apply solid urea only outside the restricted period in Option 3 without increasing application of urea outside the restricted period. We assume that farmers will not bypass the regulation by using fertiliser compounds. We have produced sensitivity analyses on these areas of compliance can be found in detail in Annexes 3 & 4.

39. We aim to collect further evidence and views during the consultation process, in particular on logistic constraints and costs as a result of higher use of ammonium nitrate, farmers' constraints and likely response to the proposed measured.

5. Policy objectives

40. The Government is committed under the Convention on Long-Range Transboundary Air Pollution (CLRTAP), Gothenburg Protocol Ceilings to reduce ammonia emissions from 2005 levels by 8% by 2020 and under the National Emissions Ceilings Regulations, 2018 to reduce ammonia emissions by 8% in 2020 and 16% by 2030 with respect to the 2005 baseline. Our proposed policy on solid urea is an essential step to meeting the official ceilings which we are obligated to meet.

Solid urea fertilisers

41. The overarching policy objective of the proposed regulation is to deliver benefits to human health and the natural environment by reducing emissions of pollutants emitted from solid urea fertilisers. Considering only English farms, the government proposes to either: ban the use of solid urea fertilisers; or to require the imposition of urease inhibitors, which have been approved for use in the UK, to be incorporated with solid urea before application; or restrict the application period of solid urea to 15 January to 31 March.

Geographical scope - England only

42. Air quality is a devolved issue within the UK, but all parts of the UK are expected to make a fair contribution to reducing ammonia emissions. Devolved administrations (DAs) will be consulting separately on their plans to reduce ammonia emissions. Air quality and fertilisers teams in devolved administrations have been engaged by Defra in relation to this policy.

43. Urea use in England is considerably higher as a proportion of nitrogen fertiliser use than it is in other parts of the UK[19] and implementation of restrictions on its use or sale will have a greater impact in

[19] England uses 149kt of N from Urea, Wales 6kt N, Scotland 21kt N and Northern Ireland 6 kt N.

England. In view of this point and the urgent need for action to achieve ammonia emissions reductions in line with our commitments, Government is consulting on an England-only basis at this stage. We will engage with DAs to determine whether the policy could also apply in other parts of the UK.

Timescale

44. Government will also consider an implementation period to allow current untreated solid urea stocks to be depleted and provide domestic manufacturers with the time to adjust production processes to meet changes in demand of fertiliser products. Government has proposed a maximum period of no more than six months from the point of laying the legislation.

6. Policy options considered

45. This section reviews all the policy options we have considered and explain the rationale for selecting the most viable options for a full cost-benefit analysis. The policy development process has drawn on evidence from the scientific community, industry and targeted stakeholder consultation. The proposed measure will be on an England only basis, as air quality policy is devolved. There is a risk that at English border farms between Scotland and Wales, regulation may be weaker due to an asymmetry in devolved policies.

46. While the policy intends to target all solid urea-based fertilisers, the analysis does not consider other nitrogen compounds with less than 46% carbamide nitrogen (urea) or mixes of fertiliser due to the lack of reliable information. Government is currently gathering further information to complete the policy analysis. Implications of this limitation are presented in Section 11.

6.1. Option 0: Baseline / Do nothing approach

47. The costs and benefits of all policy options (Options 1 - 3) need to be assessed against the Business as Usual scenario (Baseline) in order to estimate a net change in terms of ammonia emissions, costs and/or cost savings.

48. Option 0 is the baseline against which the other options are assessed. There are no additional legislative restrictions applied on users of inorganic N fertilisers. Fertiliser use projections have been taken from the inventory projections.

49. This section sets out details on:

- historic trends in ammonia emissions and fertiliser use;
- baseline information for the year 2017; and
- future projections in N fertiliser application and ammonia emissions.

Historic trends in ammonia emissions and fertiliser use (England only)

Ammonia emissions

50. Data on ammonia emissions associated with inorganic nitrogen fertiliser use including urea and urea-based fertilisers[20] are available from the UK National Atmospheric Emissions Inventory (NAEI)[21].

51. The 14th Informative Inventory report (IIR, 2019)[22] from the UK NAEI highlights that emissions from soils are an important source of ammonia emissions especially urea-based fertilisers. Total ammonia

[20] Use of urea and urea-based fertilisers correspond to the 3Da1 NFR code - "Inorganic N-fertilisers (includes also urea application)".

[21] Source: http://naei.beis.gov.uk/data/data-selector?view=air-pollutants

[22] Ricardo Energy & Environment (2019). UK Informative Inventory Report (1990 to 2017). [online] Available at: http://naei.beis.gov.uk/reports/reports?report_id=978 [Accessed March 2019]

emissions in England in 2017 were 193 thousand tonnes of which agriculture accounted for 162 thousand tonnes (84%). In 2017, application of inorganic N fertilisers (including urea) was responsible for 36 thousand tonnes or 22% of total ammonia emissions from the agriculture sector. Historic ammonia emission values from agriculture and application of inorganic fertilisers are presented in Table 4.

Table 4: Ammonia emissions from agriculture and from application of inorganic fertilisers in England (2005-2017)

	1990	2005	2010	2015	2016	2017
Agriculture total, thousand tonnes	209	156	147	160	161	162
Fertiliser application (3Da1), thousand tonnes	47	31	33	38	38	36
Share in total agriculture (%)	22	20	22	24	24	22

Source: NAEI, Air Quality Pollutant Inventories for England: 1990-2017 [accessed online 27/11/2019]

52. While total ammonia emissions from agriculture are 22% lower in 2017 compared to 1990, the trend has reversed in recent years. During the 2008 – 2017 period, ammonia emissions from the agriculture sector in England have increased by 13%[23]. The rise in the emissions from the application of inorganic N fertilisers contributed to half of this increase. The IIR (2019)[24] reported that this increase in ammonia emissions was largely associated with increased use of urea and urea-based fertilisers.

Fertiliser use

53. The UK NAEI calculates England ammonia emissions using activity data and associated emission factors. In particular, the NAEI uses the data from the annual British Survey of Fertiliser Practice (BSFP). Fertiliser quantity data are then converted into the estimates for total N use based on industry data and expert opinion on the N content for each type of fertiliser. In order to ensure consistency with the NAEI, this Impact Assessment uses the same baseline activity data that underpinned the inventory.

54. The latest published dataset from BSFP (2019) provides a wide range of information on fertiliser use by fertiliser type and crop for the UK in 2017. Data on fertiliser use for England only were extracted from the BSFP database (see Table 5).

Table 5: Total fertiliser use by fertiliser type in England

	Total England fertiliser use ('000t)														
Fertiliser name	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	***Total (14 years)***
Urea	216	184	306	156	308	279	344	311	187	316	359	379	343	321	***3,793***
Urea ammonium nitrate (UAN)	201	303	305	265	169	267	288	283	331	327	379	330	399	439	***4,085***
Ammonium nitrate (AN)	1327	1180	1244	1331	1300	1351	1321	1282	1306	1378	1318	1205	1153	1241	***16,610***
Calcium ammonium nitrate (CAN)	29	37	59	23	46	63	68	34	40	50	43	42	32	59	***596***
Other N fertilisers[25]	970	893	767	680	562	633	672	667	715	634	624	628	568	597	***8,640***

Source: BSFP (2005-2018) for England

[23] National Atmospheric Emissions Inventory (NAEI) online database: https://naei.beis.gov.uk/reports/reports?report_id=996 [Accessed in November 2019]

[24] Ricardo Energy & Environment (2019). UK Informative Inventory Report (1990 to 2017). [online] Available at: http://naei.beis.gov.uk/reports/reports?report_id=978 [Accessed March 2019]

[25] Other N fertilisers considered include Other Straight N, NK, Low N (<19% N) and High N (>=19% N)

55. Ammonium nitrate has been consistently the most popular fertiliser product in England with the quantity used almost stable during the 2005-2018 period. Application of solid urea increased by 75% over the 2005-2016 period, followed by a 15% contraction in the subsequent 2 years. However, it should be noted that AN has lower N content than urea; 100 kg of ammonium nitrate contains typically 34.5 kg of N while 100 kg of urea contains 46kg of N.

Baseline fertiliser N use and ammonia emissions (2017)

56. The IIR (2019) presents the total fertiliser N use ('000 tonnes) by land use and fertiliser type (see Tables 6 & 7). The data shows that England is disproportionately using more urea-based fertilisers (both solid urea and liquid UAN) than devolved administrations. It also highlights that in England during 2017, 51% of ammonia emissions from inorganic fertilisers application originates from urea fertiliser application (18.4kt), while urea represents only 18% of inorganic fertiliser N use.

Table 6: Fertiliser N use and ammonia emissions by fertiliser type (2017)[26]

	Urea	UAN	AN	CAN	AS and DAP[27]	Other[28]	Total
Fertiliser N applied, 2017 (thousand tonnes N)							
England	134.4	105.9	385.5	10.7	23.0	101.2	**760.8**
UK	159.9	111.7	460.1	46.6	42.0	248.1	**1068.4**
Ammonia emission from fertiliser N applied, 2017 (thousand tonnes NH_3)							
England	18.4	7.2	7.2	0.2	0.9	1.9	**35.8**
UK	21.7	7.6	8.6	0.9	1.3	4.8	**44.9**

Source: Rothamsted Research (2019) – background data for Ricardo Energy & Environment (2019). UK Informative Inventory Report (1990 to 2017)

The impact assessment is using 2017 data on fertiliser use on tillage, grassland and associated emissions as a baseline year[29]. The data have been provided by Rothamsted Research as part of the 2019 UK NAEI submission[30]. The summary of input data on fertiliser use and ammonia emissions used is presented in Table 7.

Table 7: Fertiliser N use and ammonia emissions by land use in England (2017)

	Urea	UAN	AN	CAN	AS and DAP[31]	Other[32]	Total
Fertiliser N applied (thousand tonnes N)							
Tillage	117.7	102.1	293.6	7.5	10.1	43.8	**575.0**
Grassland	16.7	3.8	91.8	3.2	13.0	57.4	**185.9**

[26] This evidence from Rothamstead Research was the most recent available at time of writing.

[27] Ammonium Sulphate and Diammonium Phosphate

[28] Other Nitrogen including Compound Blends

[29] See Appendix C for further information on tillage and grassland crop areas.

[30] Source: 2017 tillage fertiliser data.xls; 2017 grassland fertiliser data.xls

[31] Ammonium Sulphate and Diammonium Phosphate

[32] Other Nitrogen including Compound Blends

Ammonia emission from fertiliser N applied (thousand tonnes NH_3)							
Tillage	15.7	6.9	5.4	0.1	0.4	0.8	**29.3**
Grassland	2.7	0.3	1.8	0.1	0.5	1.1	**6.5**

Source: Rothamsted Research (2019) – background data for Ricardo Energy & Environment (2019). UK Informative Inventory Report (1990 to 2017)

Projections of fertiliser N use and ammonia emissions

57. Baseline ammonia emission projections for fertiliser use have been developed by Rothamsted Research for the IIR (2019) report[33].

58. In the IIR (2019), projections of future ammonia emissions were derived by using the latest available agricultural activity data (2017) in combination with FAPRI[34] projections of crop area and production for the period 2018-2026 expanded to 2030 using the same trend.[35] These were applied to 2017 inventory data to generate projections of total N use and ammonia emissions for 2018-2030 for major crop types[36]. As seen in Table 8, solid urea fertiliser application and ammonia emissions stay flat over the forecast period.

Table 8: Fertiliser N use and ammonia emission projections in England

	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Fertiliser N application (thousand tonnes)											
Urea	136	135	134	134	134	134	134	134	134	134	134
UAN	107	106	105	105	105	105	105	105	105	105	105
Ammonium nitrate	389	386	383	382	382	381	381	381	381	381	381
AS+DAP	23	23	23	23	23	23	23	23	23	23	23
Calcium ammonium nitrate	11	11	11	11	11	11	11	11	11	11	11
Other	101	101	101	101	101	100	100	100	100	100	100
Total	**768**	**762**	**757**	**755**	**754**	**754**	**754**	**754**	**754**	**754**	**754**
Ammonia emissions (thousand tonnes)											
Urea	18.6	18.4	18.3	18.3	18.2	18.2	18.2	18.2	18.2	18.2	18.2
UAN	7.3	7.2	7.2	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Ammonium nitrate	7.3	7.2	7.2	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
AS+DAP	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

[33] Ricardo Energy & Environment (2019). UK Informative Inventory Report (1990 to 2017); File: Revised fertiliser projections 2017 base.xls

[34] Food and Agricultural Policy Research Institute

[35] Latest available agricultural activity evidence at time of writing

[36] Further assumptions were made in the IIR (2019): i) For the period 2027-2030, fertiliser N use values were kept constant at the 2026 value; ii) The relative proportions of different fertiliser types applied to tillage and grassland were assumed to remain the same as for 2017; iii) emission factors for 2017 were assumed to be appropriate for future years as well.

Calcium ammonium nitrate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Other	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Total	**36.2**	**35.9**	**35.7**	**35.5**	**35.5**	**35.5**	**35.5**	**35.5**	**35.5**	**35.5**	**35.5**

Source: Rothamsted Research (2019)

6.2. Option 1 (preferred option): Complete ban on the use or sale of solid urea

59. Option 1 entails a complete ban on the use or sale of solid urea fertiliser, leading to a complete end to the use of solid urea fertilisers. Substitution of solid urea with alternative fertiliser products would result in: lower ammonia emissions; higher costs of fertiliser use to farmers; and higher monitoring costs to government. Anticipated costs to farmers will result from a change in fertiliser price and in application quantity of substitute fertiliser products. There are some potential additional costs of labour, transport and safe storage which have not been accounted for due to limited evidence available at this stage[37]. The emissions reductions will not be expected to be realised until 2022 due to the time it will take to bring the legislation in to force (scheduled for end of 2021).

60. We propose that a post-implementation review should take place 5 years after the legislation comes into force.

Option 1: Complete ban - hypothesis
The following assumptions have been developed at the impact assessment design stage: • Solid urea use is fully substituted with ammonium nitrate (2022-2030) resulting in lower ammonia emissions and higher costs (price differential at N content equivalent). • Substitution takes into account nutrient content of different fertilisers in order to achieve the baseline levels of fertiliser nitrogen applied to tillage/ grassland. This is anticipated to result in the application of a larger quantity of a more expensive fertiliser product.[38] However, as the nitrogen is expected to remain in the soil longer (i.e. has better nitrogen use efficiency) for plant uptake (from AN), it is possible that less N may be required.[39]

61. Key assumptions used in this policy option appraisal are presented in the table below.

Table 9: Option 1 – key assumptions

Element	Assumptions and approach	Source
Substitution *The choice of substitute fertiliser(s) by crop type*	Solid urea use is fully substituted with ammonium nitrate (AN) in 2022-2030 based on economic factors (see below) and preliminary consultations. The substitution will result in lower ammonia emissions achieved through the use of the substitute fertiliser associated with lower emission factors. The amount of additional AN needed for this substitution over the period 2022-2030 is estimated at 3,487kt or 387kt per year on average.	Current and future use: BSFP/ NAEI (2019) data on fertiliser application rates (by crop type) supplemented by preliminary industry consultation. Emission factors: UK NAEI (2019).

[37] The Defra Consultation may provide additional information on these potential additional costs, to be incorporated at the next stage.

[38] However, as the nitrogen is expected to remain in the soil longer for plant uptake (from AN), it is possible that less N may be required.

[39] Information on the comparative nitrogen use efficiency between mineral fertiliser products can be found in a major study conducted in the UK (as part of the NT26 programme: http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=11983) and in Ireland (as part of Teagasc's project: https://www.agriculture.gov.ie/media/migration/research/rsfallfundedprojects/11S138FinalReport%20210817.pdf).

Price *Unit price of urea and substitute fertilisers*	Urea substitution with AN would result in additional cost due to price differential (driven by unit price and application quantity differences). Unit prices/application quantity: data available for urea, UAN, AN and CAN (including future projections using annual growth rate) were converted into price per fertiliser nitrogen applied taking into account fertiliser nutrient content and required application quantity adjustments to achieve net neutral fertiliser nitrogen use. The prices anticipated in 2022 are: • Urea: £0.60 /kg N • UAN: £0.71 / kg N • AN: £0.73 /kg N • CAN: £0.77. /kg N Overall fertiliser prices are anticipated to grow at a compound annual rate of 1.3% based on forecasts by IBISWorld, 2018 for the period 2018-2030.	Prices: AHDB, industry, IBISWorld
Additional costs to farmers, fertiliser manufacturers and Government/Local Authorities *Any additional costs/ cost savings in terms of equipment, labour, familiarisation, transport, storage as well as field research and monitoring costs*	Substitution of urea with alternative fertiliser products may be associated with additional costs in terms of labour, transport and secure storage requirements. The impact assessment assumes no additional costs to farmers and the industry.[40] Enforcements costs at point of use (farm level) based on: • Number of inspections: 175 p.a. • Cost per inspection: £622	Consultation with the industry on anticipated additional costs (if any) and with the Environment Agency.
Crop productivity *Anticipated impacts on crop productivity*	A switch from urea to a nitrate-based fertiliser (i.e. ammonium nitrate) may increase yields by 3-5% for most tillage crops. In view of the uncertainty, we assume no change in crop productivity.	Consultation with the industry on anticipated behavioural response and cost/ yield implications and literature review.

6.3. Option 2: Requiring the addition of a urease inhibitor to solid urea.

62. Option 2 entails a ban on use of urea fertiliser unless urea is stabilised with a urease inhibitor in production in the form of a coating or additional compound as a mitigation technique to reduce ammonia emissions.

63. The requirement to use urease inhibited solid urea fertilisers would result in a reduction by 70% of ammonia emissions[41]. Anticipated costs for farmers will be reflected through the additional costs of urease inhibitors (+10% of the price of urea fertiliser). [42]

64. It should be noted that the option does not preclude the use of substitute fertiliser products by farmers if, for any reason, they would not be willing to use urease inhibitor. This possibility is reviewed in Section 11 and a sensitivity analysis is conducted in Annex 3 – part 2.

65. We propose that a post-implementation review should take place 5 years after the legislation comes into force.

[40] The Defra Consultation may provide additional information on these potential additional costs, to be incorporated at the next stage.

[41] Bittman, S., Dedina, M., Howard C.M., Oenema, O., Sutton, M.A., (eds), 2014, Options for Ammonia Mitigation: Guidance from the UNECE Task Force on Reactive Nitrogen, Centre for Ecology and Hydrology, Edinburgh, UK: NH_3 abatement efficiency at 70% when applied with solid urea

[42] Evidence derived through Defra consultation with industry sources.

Option 2: Addition of a urease inhibitor to solid urea – hypothesis
The following assumptions have been developed at the impact assessment design stage: • Urea use (baseline) will continue at current levels (2022-2030) but the inclusion of inhibitor in the fertiliser will result in lower ammonia emissions and higher costs (additional cost of inhibitors). • The reduction in ammonia emissions will be determined by abatement efficiency of inhibitor products. • If a price of using inhibited solid urea fertiliser is higher than the cost of using alternative N fertiliser products the farmers will be assumed to switch to substitute fertiliser products.

66. The impacts of this Option will be driven by substitution effects: whether the farmers would continue using inhibited solid urea/ solid urea compounds or would switch to substitute fertiliser products. Overall, if the combined cost of inhibited solid urea and solid urea compound fertilisers is higher than the price of using alternative fertiliser products then farmers are assumed to switch to substitute fertiliser products. Substitution of urea with alternative fertiliser products (2022-2030) would result in lower ammonia emissions, higher costs of fertiliser use and potential additional costs of equipment, labour and storage. Key assumptions used in this policy option appraisal are presented in the table below.

Table 10: Option 2 – key assumptions

Element	Type of analysis	Assumptions and approach	Source
Uptake and abatement *Anticipated uptake of urease inhibitor in conjunction with urea use and ammonia emission abatement*	Quantitative	Urea use will continue at current levels (2022-2030) but the inclusion of inhibitor in solid urea fertilisers will result in lower ammonia emissions and higher costs (additional costs of inhibitors). Lower emissions will be achieved through the use of inhibitors resulting in lower ammonia emissions or the use of substitute fertilisers associated with lower emission factors. If the price of using inhibited solid urea fertilisers is higher than the price of using alternative fertiliser product the farmers will be assumed to switch to substitute fertiliser products. Evidence suggests that urease inhibitor can achieve a 70% reduction of ammonia emissions for urea.	Current and future use: BSFP/ UK NAEI (2019) data on fertiliser application rates (by crop type) supplemented by industry consultation. Emission factors: UK NAEI (2019). Abatement efficiency: literature review[43] and industry consultation.
Price *Unit price/ costs of inhibitors.* *Unit price of urea, UAN and substitute fertiliser products*.	Quantitative Qualitative (caveats on future price volatility)	Unit prices/application quantity: data available for urea, UAN, AN and CAN (including future projections using annual growth rate) were converted into price per fertiliser nitrogen applied taking into account fertiliser nutrient content and required application quantity adjustments to achieve net neutral fertiliser nitrogen use. The prices used in 2022 are: • Urea+urease inhibitor: £0.66 / kg N • UAN: £0.71 / kg N • AN: £0.73 /kg N • CAN: £0.77 /kg N	Prices: AHDB, industry consultation, IBISWorld

[43]Bittman, S., Dedina, M., Howard C.M., Oenema, O., Sutton, M.A., (eds), 2014, Options for Ammonia Mitigation: Guidance from the UNECE Task Force on Reactive Nitrogen, Centre for Ecology and Hydrology, Edinburgh, UK: NH_3 abatement efficiency at 70% when applied with solid urea.
The literature provides a wide range of reduction: 43–77% (e.g. Lam et al., 2018; Singh et al., 2013; Suter et al., 2013; Watson et al., 1990)

		The cost of urease inhibitor is estimated at 10% of the price of urea. Overall fertiliser prices are anticipated to grow at a compound annual rate of 1.3% based on forecasts by IBISWorld, 2018 for the period 2018-2030.	
Additional costs to farmers, fertiliser manufacturers and Government/Local Authorities *Any additional costs/ cost savings in terms of equipment, labour, familiarisation, transport, storage as well as field research and monitoring costs*	Quantitative Qualitative	The addition of urease inhibitors may be associated with additional costs in terms of equipment, labour, secure storage requirements. The impact assessment assumes no additional costs to farmers and the industry.[44] Enforcements costs at point of use (farm level) based on: • Number of inspections: 175 p.a. • Cost per inspection: £622	Consultation with the industry on anticipated additional costs (if any) and with the Environment Agency
Crop productivity Anticipated impacts on crop productivity	Quantitative Qualitative (commentary on productivity implications)	Evidence on the impact of urease inhibitors on crop yields shows a neutral to probable improvement with an estimated range of 1%-5% yield improvement in comparison with untreated product. In view of the uncertainty, we assume no change in crop productivity.	Consultation with the industry on any crop related limitations or advantages to uptake and yields.

6.4. Option 3: Restricted Application Period

67. Option 3 entails the introduction of a restricted application period of solid urea fertiliser beginning 15 January and ending 31 March, after which it is assumed that solid urea fertiliser will be substituted with ammonium nitrate. Baseline levels of fertiliser nitrogen applied as urea fertiliser are maintained in this period.

68. This measure may be more favourable to farmers (as urea is still retained in the market), although will lead to lower ammonia emissions abatement than both Options 1 and 2. The impacts of this Option during the closed period will be identical to Option 1 and the assumptions with regard to substitution, price, crop productivity would also apply during the months of the closed period. However, this policy may increase administrative and familiarisation costs for farmers due to enhanced record keeping on fertiliser use, alongside additional transport, storage and labour costs arising from substitution. Enforcement costs will be higher for government as more farms will have to be inspected to ensure compliance with the restricted period.

69. We propose that a post-implementation review should take place 2 years after the legislation comes into force, in view of the increased risk of non-compliance under this Option.

[44] The Defra Consultation may provide additional information on these potential additional costs, to be incorporated at the next stage.

Option 3: Restricted application period- hypothesis
The following assumptions have been developed at the impact assessment design stage: • Urea use (baseline) will continue only within a restricted application period beginning 15 January and ending 31 March. Solid urea use is then fully substituted with ammonium nitrate (2022-2030), resulting in lower ammonia emissions and higher costs (price differential at N content equivalent). • Substitution takes into account nutrient content of different fertilisers in order to achieve the baseline levels of fertiliser nitrogen applied to tillage/ grassland. This is anticipated to result in the application of a larger quantity of fertiliser product (equivalent levels of nitrogen). • All farmers will comply with the stipulated closed period and cease using solid urea outside the restricted period.

70. BSFP data (5-year average, 2013-2017) suggests that about 54% of urea (and 65% of UAN) application is taking place during the period from April to December[45] and there are several crops that require nitrogen application during this time. Such crops include milling wheat and some vegetable crops (e.g. potatoes/ brassicas).

71. Key assumptions used in this policy option appraisal are presented in the table below.

Table 11: Option 3 – key assumptions

Element	Assumptions and approach	Source
Substitution *The choice of substitute fertiliser(s) by crop type*	Solid urea use will continue but only within a restricted application period from 15 January to 31 March. Solid urea use is fully substituted for the period 1 April to 15 January with ammonium nitrate (AN) in 2022-2030 based on economic factors (see below) and preliminary consultations. The amount of additional AN needed for this substitution over the period 2022-2030 is estimated at 2,222kt tonnes or 246kt tonnes per year on average. The substitution will result in lower ammonia emissions achieved through the use of the substitute fertiliser associated with lower emission factors. No impact on emission factors is anticipated.	Current and future use: BSFP/ NAEI (2019) data on fertiliser application rates (by crop type) supplemented by preliminary industry consultation. Emission factors: UK NAEI (2019).
Price *Unit price of urea and substitute fertilisers*	Urea substitution with AN would result in additional costs due to price differential (driven by unit price and application quantity differences). Unit prices/application quantity: data available for urea, UAN, AN and CAN (including future projections using annual growth rate) were converted into price per fertiliser nitrogen applied taking into account fertiliser nutrient content and required application quantity adjustments to achieve net neutral fertiliser nitrogen use. The prices used in 2022 are: • Urea: £0.60 /kg N • UAN: £0.71 / kg N • AN: £0.73 /kg N • CAN: £0.77 /kg N	Prices: AHDB, industry, IBISWorld

[45] Defra Analysis of monthly fertiliser practice from the British Survey of Fertiliser Practice 2013 – 2017

	Overall fertiliser prices are anticipated to grow at a compound annual rate of 1.3% based on forecasts by IBISWorld, 2018 for the period 2018-2030.	
Additional costs to farmers, fertiliser manufacturers and Government/Local Authorities *Any additional costs/ cost savings in terms of equipment, labour, familiarisation, transport, storage as well as field research and monitoring costs*	Substitution of urea with alternative fertiliser products may be associated with additional costs in terms of administration/recording keeping, labour, secure storage requirements. The impact assessment assumes no additional costs to farmers and the industry.[46] There will be more farm inspections to ensure farmer compliance with the restriction period and fertiliser substitution. Enforcements costs at point of use (farm level) based on: • Number of inspections: 500 p.a. • Cost per inspection: £622	Consultation with the industry on anticipated additional costs (if any) and with the Environment Agency.
Crop productivity *Anticipated impacts on crop productivity*	A later switch from urea to a nitrate-based fertiliser (i.e. Ammonium Nitrate) may increase yields by 3-5% for most tillage crops. In view of the uncertainty, we assume no change in crop productivity.	Consultation with the industry on anticipated behavioural response and cost/ yield implications and literature review.

6.5. Other options considered but not developed

Table 12: Other Options considered but not developed

Option	**Product**	**Ammonia abatement (kt)**	**Benefit:Cost ratio**	**Annual cost to farmers in 2022 (£m)**
(5) Complete Ban on use	Urea & UAN	21.2	2.2	£77.8
(6) Requiring use of urease inhibitors	Urea & UAN	15.8	8.2	£16.8
(7) Dual (nitrification and urease) inhibitors	Urea & UAN	7.9	1.9	£42.0
(8) Enforcement of low emissions spreaders	Urea & UAN	12.5	1.5	£75.1
(9) Tax on solid urea	Urea	≤15.9	≤4.6	≥£20.0

Sources: Defra Estimates

Option 4: Voluntary approach

72. The need for any regulatory approach can be minimised when a voluntary approach produces the required reduction in ammonia emissions. The recently published Code of Good Agricultural Practice (COGAP)[47], which was produced by Defra in collaboration with the farming industry, sets out

[46] The Defra Consultation may provide additional information on these potential additional costs, to be incorporated at the next stage.
[47] www.gov.uk/government/publications/code-of-good-agricultural-practice-for-reducing-ammonia-emissions/code-of-good-agricultural-practice-cogap-for-reducing-ammonia-emissions

recommended measures for ammonia abatement. The practices set out in Annex 2 could be considered as the package of voluntary measures. The Fertiliser Industry Assurance Scheme (FIAS)[48] standards could present a template from which to develop a checklist for farms, with compliant farms verified by environmental public bodies or independent agencies such as Red Tractor.

73. However, given that the UK is obligated to reducing ammonia emissions through achieving 2020 and 2030 targets set under UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP Gothenburg Protocol) and the National Emission Ceilings Regulations 2018, voluntary and assurance measures not complemented by a regulatory approach would have to provide sufficient evidence and necessary guarantees that they would be effective methods to meet targets.

74. A recent review on the efficacy of the voluntary Greenhouse Gas Action Plan (GHGAP) for Agriculture[49] provides further evidence that voluntary schemes could require significant lead-in times to achieve objectives. The GHGAP was initiated in 2010 with an annual target for greenhouse gas emission reductions of 3MtCO_2e per year by 2022 by encouraging farmers to take up a range of CO_2e emission reduction measures. The review found that the agriculture sector achieved 1Mt of CO_2e emissions reduction in 2016, four years after its initiation. Farm Practice survey data found that under half of farms (48%) in 2016 found it fairly or very important to consider greenhouse gases when taking decisions about their land, crops and livestock. 57% of farmers reported they were taking action to reduce greenhouse gas emissions from their farm. The review concluded that the pace in which farmers take-up of CO_2e mitigation measures would need to be increased in order to achieve the 2022 target. Annex 3 – Part 1 sets out compliance modelling. Based on the GHGAP evidence, it assumes a 50% compliance rate from farmers which acts as the proxy rate for a non-regulatory voluntary approach. A voluntary approach is very likely to significantly limit air quality improvement with the benefit value decreasing from: £1,139 million to £547 million in Option 1; £922 million to £461 million in Option 2; and £849 million to £425 million in Option 3.

75. Due to the pressing commitments the government has made in terms of habitat restoration and ammonia emissions reduction targets, there is little scope to achieve these commitments without regulatory action.

Option 5: Complete ban on the use of solid urea and urea ammonium nitrate (UAN)

76. This option entails a complete ban on the use of solid urea (Option 1) as well as urea ammonium nitrate (UAN), a liquid urea-based fertiliser. Substitution of urea/ UAN with alternative fertiliser products (2022-2030) would result in lower ammonia emissions, higher costs of fertiliser use and additional costs of equipment, labour and for safe storage. Anticipated impacts will be reflected through increased price and (potentially) application quantity of substitute fertiliser products.

77. UAN is more difficult to substitute than solid urea as it is applied in liquid form with specialised equipment. Substitution with a solid alternative is more difficult but is assumed to follow the same pattern as solid urea, with the preferred substitute being ammonium nitrate.

78. Such substitution will be associated with additional costs as farmers have often invested in specific storage and liquid application equipment. Additional spreading equipment costs are estimated at £20,000-£30,000 (capital) or £0.48 per kg of nitrogen applied.[50] Additional storage costs may be incurred when substituting UAN with a solid fertiliser to provide a secure and covered storage when not readily available.

79. The use of a solid fertiliser instead of UAN will be considerably less accurate than liquid application through a sprayer, and this would lead to reduced crop productivity and increase the risk of environmental impact. A reduction in application accuracy especially on headlands/ field margins could result in a yield penalty of 1-3%. Furthermore, UAN and other liquid fertiliser products are used by farmers in late season

---

[48] www.aictradeassurance.org.uk/latest-documents/fias-scheme-rules-effective-from-february-2016/

[49] The Greenhouse Gas Action Plan for Agriculture Review 2016, (2017) https://www.gov.uk/government/publications/greenhouse-gas-action-plan-ghgap-2016-review

[50] Evidence derived consultation with industry

application on milling wheat to increase grain protein content and on oilseed rape to enhance yield. There appears to be no viable substitute for these applications.

80. On the other hand, the reduction of ammonia emissions is expected to be 28% larger than in Option 1 (ban of solid urea only), reaching about 20kt per year. However, when compared to Options 1 - 3 , this measure creates the highest annual cost to farmers in the first year of implementation at £78 million and provides a very low benefit to cost ratio of 2.2 (see Table 12). Compared to the cost to farmers of £18 million in 2022 for Option 1, this extremely high relative annual cost would have a disproportionate effect on farm business costs for the emission abatement gain.

Option 6: Requiring the addition of a urease inhibitor to solid urea and urea ammonium nitrate (UAN)

81. This option entails the use of urease inhibited solid urea products (Option 2) as well as requiring the addition of inhibitors to urea ammonium nitrate (UAN), a liquid urea-based fertiliser, shortly before application to a crop. The requirement to use urease inhibitors when applying urea/ UAN (2022-2030) would result in lower ammonia emissions and additional costs of fertiliser products (+10% vs untreated urea/UAN).

82. This option presents practical difficulties, as the inhibitor doesn't retain its efficacy when stored in solution. As such, an inhibitor would need to be added separately to UAN shortly before application to a crop. This would present enforcement challenges for regulators.

83. Ammonia emissions are reduced by 70% when using urease inhibitor with solid urea (down by about 13 kt p.a.) while they are reduced by 40%[51] when using with UAN (down by about 3 kt p.a.). However, compared with Option 2, which does not include UAN, this option incurs double the annual costs for farmers at £16.8 million for a relatively small gain in emissions abatement (15.8 kiloton compared with 12.7 kiloton in Option 2) and records a lower benefit cost ratio: 8.2 compared with 14.5 for Option 2 (see Table 12) . As a result, this measure would create a disproportionate burden on farm business costs for the emission abatement it would obtain.

Option 7: Requiring the addition of a dual inhibitor (urease and nitrification inhibitor) to solid urea and UAN

84. This option entails the addition of a nitrification inhibitor to solid urea and UAN as well as the addition of a urease inhibitor (Option 65). The application of nitrification inhibitor is an effective method for reducing agricultural nitrous oxide (N_2O) emission.

85. The agricultural sector is the source of about 8% of greenhouse gas emissions (GhG) in England, including through emissions of nitrous oxide from the application of nitrogen fertiliser. The emissions of nitrous oxide occur through both a direct pathway (i.e. directly from the soils to which the N is added/released), and through two indirect pathways: (i) following volatilisation of NH_3 and NO_x from managed soils; and (ii) after leaching and runoff of N, mainly as NO_3, from managed soils[52].

86. Although this option would result in lower ammonia emissions and GhG emissions, it would accrue higher costs of fertiliser use and higher cost of fertiliser products (+ 20-30% vs. untreated urea and UAN) for farm businesses: initial annual cost of £42 million compared with around £10 million for Option 2. Furthermore, whilst dual inhibitors are highly effective at reducing nitrous oxide, the urease inhibitor is only half as effective at reducing ammonia emissions as a urease inhibitor used alone; there have been negative environmental impacts when nitrification inhibitors have been applied incorrectly.

87. Ammonia emissions are reduced by 35% when using dual inhibitor with solid urea (down by about 6.5kt p.a.) and by 20% when using with UAN (down by about 1.5 kt p.a.)[53]. There will also be a slight decrease

---

[51] Bittman, S., Dedina, M., Howard C.M., Oenema, O., Sutton, M.A., (eds), 2014, Options for Ammonia Mitigation: Guidance from the UNECE Task Force on Reactive Nitrogen, Centre for Ecology and Hydrology, Edinburgh, UK: NH_3 abatement efficiency at 40% when applied with urea ammonium nitrate (UAN)

[52] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 11

[53] Misselbrook, T. H., Cardenas, L. M., Camp, V., Thorman, R. E., Williams, J. R., Rollet, A. J. and Chambers, B. J. 2014. An assessment of nitrification inhibitors to reduce nitrous oxide emissions from UK agriculture. Environmental Research Letters.

by about 0.2 million tonnes of CO_2eq emissions per year. However, this option provides a low-cost benefit ratio of 1.9 (see Table 12).

Option 8: Enforcing the use of low emissions application techniques (solid urea incorporated and UAN is injected)

88. Ammonia volatilisation[54] from solid urea and UAN can be reduced by injecting liquid fertiliser into the soil or incorporating solid fertiliser by tillage shortly after spreading. NH_3 emission reductions depend on the time period between urea application and soil incorporation, and on the cultivation technique employed. Emissions can also be reduced by using irrigation systems to apply these fertilisers to high value crops.

89. Implementation of these techniques will be associated with additional costs in terms of equipment, labour and materials.

90. Total ammonia emissions are anticipated to be reduced by about 12kt per year with this option. However, compared with Options 1 – 3, this option registers a low benefit cost ratio of 1.5 and the second highest annual cost to farmers in the first year of implementation at £75 million (see Table 12).

Option 9: A tax on solid urea only.

91. We have investigated the option of imposing a tax on urea as an alternative to a regulatory intervention. For it to be effective and contribute to our commitments under the Clean Air Strategy and NECD 2018, we would need to set the tax at a rate that would encourage an emissions reduction equivalent to the adoption of our preferred Option 1 - a complete ban of the use of urea. This measure registers a tentative benefit cost ratio of around 4.6 and costs of around £20 million (see Table 12).

92. The price differential between urea and ammonium nitrate is the key determinant for farmers when it comes to choosing their fertilisers. The level of tax required to lower the use of urea to the appropriate level would bring the urea unit cost to a level well above the unit price of ammonium nitrate and, as such farmers would likely substitute away from urea. We would expect that this intervention would follow the same outcome as a complete ban where practically all farmers would substitute urea towards ammonium nitrate. However, this measure would incur a greater cost to farmers than Option 1, which has an initial annual cost of £18 million .

7. Monetised and non - monetised costs of options 1 to 3

Monetised costs - business and government

93. The following section sets out the methodology used to assess the costs of implementing legislation to restrict the use of solid urea through a complete ban (Option 1 – preferred option), a requirement to use urease inhibited solid urea (Option 2) and a restricted application period of solid urea (Option 3). We assess the impact of the proposed legislation over 9 years commencing from 2022, a few months after the regulation is intended to come into effect and when the first costs related to it are incurred. The benefits are estimated over the same period. The impacts are assessed based on information collected through discussions with the industry and from desk research. The following impacts are considered.

Farmers

94. Most of the costs are anticipated to fall onto farmers, shifting away from solid urea to a more expensive fertiliser, ammonium nitrate (Options 1 & 3) or facing the increased cost of using urease inhibited solid urea products (Option 2).

95. The farming sector faces significant challenges, in particular due to uncertainty linked to changes in trade relationships with partner countries following EU exit, the loss of direct payments from the EU and the year-on-year volatility of their income. The price farmers receive for their products are usually out of their

---

[54] This is a chemical process that occurs at the soil surface when ammonium from urea (and/or ammonium-containing fertilisers) is converted to ammonia gas at high pH.

control as well as the price of inputs. The impact of increased costs of fertilisers on farmers' income is reviewed in Section 13.

96. The determinants of the costs incurred by farmers will depend on:

Price of fertilisers:

97. A key determinant to use a specific fertiliser is the price differentials between fertilisers that can be substituted. The impact assessment assumes that farmers will use the cheapest option when technically feasible, taking into consideration the fertiliser nutrient content and the impact on yields. Price data available for urea, UAN, AN and CAN (including future projections using annual growth rate) were converted into price per fertiliser nitrogen applied taking into account fertiliser nutrient content and required application quantity adjustments to achieve net neutral fertiliser nitrogen use. Based on information provided by the industry, the cost of urease inhibitor compound or coating to be added to urea fertiliser corresponds to 10% of the price of urea. The baseline prices used correspond to the 6-year average for the 2015-20202 period (when available) obtained from industry sources and are as follows:

Table 13: Price of fertilisers - assumptions

	Average price (2015-2020), £ per tonne (current prices)	% Nitrogen content of fertilisers	Average price (2015-2020), £ per tonne of N (current year)
Urea	262	46%	569
Urea + urease inhibitor	288	46%	626
UAN	196	30%	655
AN	238	34.5%	690
CAN	220	27.5%	801

Sources: Agriculture and Horticulture Development Board (AHDB), fertiliser industry, IBISWorld (2018)

Storage and transport:

98. Additional storage precautions are required as AN is classed as an explosive chemical. AN will not explode due to friction and general handling of the chemical but if put under stress (heat, confinement etc.) it could explode, especially if it is contaminated.[55] Precautions must be taken for the additional AN that farmers are expected to switch towards in the case of Options 1 and 3. Based on preliminary consultation with the industry, we have not assumed any cost related to storage and transport but this will be further investigated during the formal consultation process.

Familiarisation and Administration:

99. There will be costs faced by farmers in adjusting to possible new measures regarding urea and ammonium nitrate applications, dependent on the chosen policy option. These costs will be in familiarising and adjusting to new measures as well as complying with new administrative duties. These costs are difficult to quantify and will vary across farm size, farm staff expertise and the extent to which these measures are already being implemented. We have valued these time requirements using the Annual Survey of Hours and Earnings for farm manager time and for the costs to farmers. The central assumptions are that a farm manager's time is valued at £26 per hour (including non-wage costs of employment) and staff time valued at £10.5 per hour. [56] [57] We assume farmers will, although only in the first year of implementation, spend 2 hours reading any necessary guidance, 6 hours planning the implementation of the new policy and, where applicable, 3 hours training any staff on the requirements of

[55] http://www.hse.gov.uk/pUbns/indg230.pdf - AN Storage

[56] These figures also include on-costs at a rate of 25%, such as pension and national insurance contributions.

[57] ONS (2019) Annual Survey for Hours and Earnings (ASHE)https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/agegroupbyindustry2digitsicashetable21

that policy. It is assumed staff will spend 3 hours on any training being given. Where record keeping is necessary we assume that farmers will spend 3 hours, with this activity being an annual cost. These assumptions on time taken will be further investigated and tested in the formal consultation process.

100. In Option 1, at a cost of £3.5 million, we assume that farmers will spend time reading regulatory requirements and guidance, as well as planning implementation methods for substitution from urea fertiliser to ammonium nitrate. Additional time will be spent planning how increased volumes of AN will be properly held in on farm storage and securely stacked to ensure safety.

101. In Option 2, at a cost of £7.6 million, we assume farmers will spend time: reading regulatory requirements; reviewing technical documentation on application of urea with inhibitors; adaptation of agricultural practices; completing records on the purchasing of urea fertiliser with inhibitor; and, where relevant, discussing new information with staff and training them to fulfil new record keeping duties.

102. In Option 3, at a cost of £7.6 million, farmers will combine elements of both Option 1 and 2, spending time on: reading new requirements and planning substitution implementation; planning secure storage and stackage for increased volumes of ammonium nitrate; completing records on the purchasing of urea fertiliser and the timing of spread as well as training staff in new practices, where relevant.

103. All Options entail farmers spend one hour hosting inspections from the Environment Agency. This activity will register as an annual cost to farmers . These estimates have been discounted at the social time preference rate of 3.5% and summed over the 9-year appraisal period to show the present value of familiarisation and administrative costs in Table 14.

Table 14: Present value for familiarisation and administration costs 2022-2030 - Options 1,2 & 3 (central scenario); 2020 £ millions

	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Total**
Ban of urea (Option 1)	2.29	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.13	**3.47**
Addition on urease inhibitors (Option 2)	2.80	0.67	0.65	0.62	0.60	0.58	0.56	0.54	0.53	**7.56**
Restricted application period (Option 3)	2.80	0.67	0.65	0.62	0.60	0.58	0.56	0.54	0.53	**7.56**

Impact on yields:

104. A switch from urea to a nitrate-based fertiliser (i.e. ammonium nitrate) may increase yields by 3-5% for most tillage crops. In view of the uncertainty, we assume no change in crop productivity but this will be further investigated during the formal consultation process.

105. Evidence on the impact of urease inhibitors on crop yields shows a neutral to probable improvement with an estimated range of 1-5% yield improvement in comparison with untreated product. In view of the uncertainty, we assume no change in crop productivity, but this will be further investigated during the formal consultation process.

Fertiliser availability:

106. Based on a qualitative assessment, there is a short-term risk of a lack of supply of alternative fertiliser as identified in a report produced by IBIS World titled 'Fertiliser & Nitrogen Compound Manufacturing in the UK'[58]. There is limited flexibility in the production of fertilisers due to the capital-intensive nature of the

[58] [IBISWorld] (2018). IBISWorld Industry Report C20.150 Fertiliser & Nitrogen Compound Manufacturing in the UK.

production process. It is expensive to build and operate production plants and most run at full capacity all year round, with little room to suddenly increase production.

107. Not all urea used in the UK is applied in agriculture. We assume that the fertiliser market will have the capacity to adapt to the change in the UK market: world supply of ammonium nitrate is expected to be sufficient to meet the relatively modest level of increase from English farmers that this policy may lead to. About 40% of AN applied in the UK is locally produced by one fertiliser manufacturer, CF Fertilisers UK Ltd and the other 60% is imported primarily from EU countries[59]. In 2018, UK exports of AN amounted to 161 kilotons in 2018 or 145 kilotons on average over the 2015-2018 period.[60]Consultation with industry sources finds that higher demand for AN could see exports retained and re-directed into the more profitable English market, given the expected increase in demand.[61] We will seek further information on this point of fertiliser supply and availability through the consultation process.

108. Urea fertiliser is not produced in the UK, with imports being supplied by EU and non-EU countries in 2018, primarily Germany and Egypt.[62] As the UK is a small importer in an international market, a ban on urea would not lead to insolvency for manufacturers.

109. Regarding the availability of urease inhibitors, previous responses to the urease inhibitor requirement proposal put forward in the draft Clean Air Strategy indicated that the fertiliser industry would be able to upscale production to meet increased demand within a relatively short timescale.

Table 15: Present value fertiliser application costs to farmers - Options 1, 2 & 3 (central scenario); 2020 £ millions

	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Total**
Ban of urea (Option 1)	16.05	15.67	15.32	14.99	14.68	14.37	14.06	13.77	13.47	**132.39**
Addition on urease inhibitors (Option 2)	7.52	7.34	7.18	7.03	6.88	6.73	6.59	6.45	6.31	**62.05**
Restricted application period (Option 3)	10.23	9.99	9.76	9.56	9.36	9.16	8.96	8.77	8.59	**84.38**

110. Based on this approach, the additional costs to farmers to apply fertilisers are estimated for the 2022-2030 period in the central scenario at £132 million for the complete ban of the use of urea (Option 1), £62 million for the requirement to use urease inhibitor with urea (Option 2) and £84 million for the restricted application period (Option 3). The discounted values given in Table 15 were derived from the rate of fertiliser application with its unit costs, giving a total application cost for each Option. Total application costs for each option were then subtracted from Business As Usual conditions.

[59] Defra calculations on HMRC fertiliser trade data, 2020.

[60] Defra calculations on HMRC fertiliser trade data, 2020.

[61] The validity of this assumption may depend on the behaviour of the real exchange rate at that time. Although there may be higher demand in the domestic market, exchange rate movements could make it more profitable for manufacturers to turn production to export markets rather than the domestic market.

[62] Defra calculations on HMRC fertiliser trade data, 2020.

Fertiliser manufacturers and distributors

111. The cost on business in the fertiliser industry is calculated using estimates of loss in profits using data on profit margins in the relevant industry, change in volume of fertiliser sold following the implementation of the legislation and retail fertiliser prices.

Table 16: Present value for loss in profits for the fertiliser industry - Options 1,2 & 3 (central scenario); 2020 £ millions

	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Ban of urea (Option 1)	-1.35	-1.32	-1.29	-1.26	-1.23	-1.21	-1.18	-1.16	-1.13	**-11.12**
Addition on urease inhibitors (Option 2)	-0.63	-0.62	-0.60	-0.59	-0.58	-0.57	-0.55	-0.54	-0.53	**-5.21**
Restricted application period (Option 3)	-0.86	-0.84	-0.82	-0.80	-0.79	-0.77	-0.75	-0.74	-0.72	**-7.09**

Note: negative figures correspond to a profit increase

112. As set out in Table 16, the fertiliser industry will not face a loss but benefit from an increase in profits (negative losses). This is estimated for the 2022-2030 period in the central scenario at £11 million for the complete ban of the use or sale of urea (Option 1). This increase in profit is derived from higher level of consumption of ammonium nitrate which is more expensive than urea fertiliser. In Option 2, industry will see an increase of £5 million for the requirement to use urease inhibitor with urea, given the use of urease-inhibited urea will cost 10% more than unhibited urea. For Option 3, the increase in profits will be £7 million as the result of the substitution of urea by higher priced ammonium nitrate during the closed period.

113. The average profit margin is estimated to be 8.4%[63] in the fertiliser sector and the change in volume of fertiliser used is based on the nitrogen content of each fertiliser. Table 13 provides the fertiliser price and nitrogen content of each of the fertiliser considered.

Government

Table 17: Present value enforcement costs - Options 1, 2 & 3 (central scenario); 2020 £ millions

	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Ban of urea (Option 1)	0.10	0.10	0.09	0.09	0.09	0.09	0.08	0.08	0.08	**0.80**
Addition on urease inhibitors (Option 2)	0.10	0.10	0.09	0.09	0.09	0.09	0.08	0.08	0.08	**0.80**
Restricted application period (Option 3)	0.29	0.28	0.27	0.26	0.25	0.24	0.24	0.23	0.22	**2.28**

63 For profit margin in the fertiliser sector: [IBISWorld] (2018). IBISWorld Industry Report C20.150 Fertiliser & Nitrogen Compound Manufacturing in the UK.

114. Based on this approach, enforcement cost to Government is estimated for the 2022-2030 period in the central scenario at £800,000 for both Options 1 and 2, with Option 3 estimated at £2.3 million. Based on consultation with Environment Agency colleagues, there will be no familiarisation costs associated with government officials and the enforcement of any policy.

Other non-monetised costs

115. **Health and ecosystem**: We have not monetised indirect health and biodiversity costs that could be achieved through a reduction in ammonia emissions, as they depend on the method used to measure them and hence values can vary widely due to lack of uniformity of approach. Options 1 – 3 may carry a slightly increased risk of nitrogen loss and have a negative impact on water quality by increasing nitrogen leaching to water bodies. This is because reduced loss of ammonia to the air will result in more nitrogen retention in soils. However, for Options 2 and 3 these effects are expected to increase leaching by less than 5% and even less of an impact for Option 1. Nutrient management advice could mitigate against the risk of increased loss to leaching and run-off due to higher nitrogen in soils, i.e. nitrogen application rates are adjusted to factor higher retention. Therefore, there will be minimal, if any, costs to water companies to reduce the nitrate concentrations in drinking water.

116. **Greenhouse gas emissions from manufacture of fertilisers**: Ammonium nitrate manufacture requires more energy than urea manufacture. This means that, on average, ammonium nitrate has greater embedded carbon emissions than urea. The size of the increase in GhG from manufacture of ammonium nitrate compare to urea would depend on the technologies used by the plant. Based on a literature review[64] and Defra calculations, it is estimated that additional emissions of GhG can vary between 200 and 800 kt of CO_2e per year, with the lowest emissions when ammonium nitrate is produced in Europe. However, when best available techniques for ammonium nitrate production are used, embedded carbon in ammonium nitrate production can be reduced substantially and in plants that apply these practices, embedded GhG emissions can be lower than the most-emitting urea plants.

117. **Devolved Administrations:** we have not monetised the effects of any disadvantage farmers may face due to these proposed options being England-only policy. Although the National Emissions Ceilings Regulations 2018 requires UK-wide emissions reductions, environmental and agricultural policies are devolved. Therefore, Defra is consulting on these proposals on an England-only basis but will consider joint legislation if other administrations choose to adopt the same implementation approach. The Northern Irish government is considering measures on how to reduce ammonia emissions from urea fertilisers and the Welsh government will be consulting on urea fertilisers policy shortly. Consultation with industry sources highlighted that farmers in England may be at a competitive disadvantage, if farmers in the rest of the UK can use a cheaper urea fertiliser product. However, solid urea fertilisers are used much more in England than anywhere else (149kt of solid urea nitrogen in England compared with the next biggest use, in Scotland, of 21kt, in 2017).

8. Monetised and non-monetised benefits of options 1 to 3

Monetised benefits - Health and ecosystem

118. Defra's updated air quality damage costs provide a simple way to value changes in air pollution. This is an assessment of the cost to society due to a change in emissions. For NH_3 emissions, the damage costs predominantly reflect the societal cost based on mortality and morbidity as a result of fine particulate matter effects on human health. NH_3 reacts with other particles in the atmosphere, contributing to the formation of secondary particulates. Damage costs also account for impacts on ecosystems, including both negative impacts caused by damage to habitats and the positive impact of nitrogen deposition on

[64] Brentrup & Palliere, 2008; GrowHow, 2013; Fertizers Europe, 2014; and Brentrup, 2016

carbon sequestration. The damage costs values used are standardized to 2019 prices (using GDP deflators) and uplifted by 2% per annum, in line with Green Book guidance[65]. The uplift captures the higher willingness to pay of the population and value of health benefits as income (economic growth) rises.

119. Three sets of damage costs have been developed for the high, central and low scenarios. The variation reflects different mortality and morbidity impacts being included in the different scenarios. The damage costs are higher in the 'High Range' where the associated health impacts most prominent and consequently benefits assumed to be largest.

Table 18: Damage cost per tonne of ammonia (NH_3) emitted, 2019 prices

	Low damage cost, £ per tonne	Central damage cost, £ per tonne	High damage cost, £ per tonne
NH3	1,521	**7,923**	24,476

Source: Defra

120. The benefits of each option will be determined by the volume of urea applied following the implementation of the legislation. In the case of a complete ban of the use of solid urea (Option 1) or restricted application period (Option 3), farmers are assumed to switch to ammonium nitrate, increasing the use of this fertiliser. If the policy requires farmers to use urease inhibited urea (Option 2), farmers are assumed to continue using the same volume of urea.

Table 19: Projected volume of urea and ammonium applied in England, 2022 – 2030

	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Baseline, in thousand tonnes of N										
Urea	134.1	133.7	133.6	133.6	133.6	133.6	133.6	133.6	133.6	**1,203.0**
AN	383.4	382.1	381.6	381.3	381.2	381.2	381.2	381.2	381.2	**3,434.4**
Option 1 - Ban of urea, in thousand tonnes of N										
Urea	-	-	-	-	-	-	-	-	-	
AN	517.5	515.9	515.1	514.9	514.8	514.8	514.8	514.8	514.8	**4,637.4**
Option 2 – Use of urease inhibitors with urea, in thousand tonnes of N										
Urea[66]	134.1	133.7	133.6	133.6	133.6	133.6	133.6	133.6	133.6	**1,203.0**
AN	383.4	382.1	381.6	381.3	381.2	381.2	381.2	381.2	381.2	**3,434.4**

[65] The Green Book – Central Government guidance on appraisal and evaluation, HMT, 2018 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

[66] The tonnage does not include the added weight corresponding to the addition of urease inhibitor

Option 3 – Restricted application period, in thousand tonnes of N										
Urea	48.6	48.5	48.4	48.4	48.5	48.5	48.5	48.5	48.5	**436.3**
AN	468.8	467.3	466.7	466.4	466.4	466.4	466.4	466.4	466.4	**4201.2**

Source: Defra calculations

121. The anticipated abatement of ammonia emissions is estimated at about 16kt per year on average or 142kt over the 2022-2030 period when a complete ban of the use of urea is applied (Option 1), 13kt per year or 115 kt over the 2022-2030 period when farmers are required to apply urease inhibited urea (Option 2) and about 12kt per year or 106kt per year over the 2022-2030 period when the application period is restricted (Option 3).

Table 20: Projected ammonia abatement from urea and ammonium nitrate in England, 2022 – 2030, in thousand tonnes (kt)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Ban of urea (Option 1)	15.85	15.82	15.79	15.76	15.75	15.73	15.72	15.71	15.69	**141.82**
Addition on urease inhibitors (Option 2)	12.84	12.81	12.79	12.76	12.75	12.74	12.73	12.72	12.71	**114.85**
Restricted application period (Option 3)	11.81	11.79	11.77	11.75	11.74	11.73	11.73	11.72	11.71	**105.76**

Source: Defra calculations

122. The monetised present value of the anticipated abatement of ammonia emissions is estimated at £1,139 million over the 2022-2030 period in the central scenario when a complete ban of the use of solid urea is required (Option 1) and at £219 million and £3,518 million, in the low and high scenarios respectively.

123. The monetised present value of the anticipated abatement of ammonia emissions is estimated at £922 million over the 2022-2030 period in the central scenario when the use of urease inhibited urea is required (Option 2) and at £177 million and £2,849 million, in the low and high scenarios respectively.

124. The monetised present value of the anticipated abatement of ammonia emissions is estimated at £849 million over the 2022-2030 period in the central scenario when there is a restriction on application period of urea (Option 3) and at £117 million and £2623 million, in the low and high scenarios respectively.

Table 21: Present value benefits on health and ecosystems from the regulation on urea fertiliser – Options 1, 2 & 3 (central scenario) (2020 £m)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Ban of urea (Option 1)	134.85	132.64	130.46	128.31	126.35	124.41	122.5	120.63	118.73	**1138.93**
Addition of urease inhibitors (Option 2)	109.21	107.41	105.64	103.90	102.31	100.74	99.20	97.67	96.16	**922.25**
Restricted application period (Option 3)	100.48	98.86	97.26	95.69	94.23	92.79	91.37	89.97	88.59	**849.24**

Source: Defra calculations

Monetised benefits – Greenhouse gas

Table 22: Monetised carbon costs and savings from regulations

		Present value GhG benefits (£m) 2022-2030
Option 1 (preferred): Ban of solid urea	Low	-22.65
	Central	**-45.31**
	High	-67.96
Option 2: Urea + urease inhibitor	Low	13.99
	Central	**27.99**
	High	41.98
Option 3: Restricted application period	Low	-12.04
	Central	**-24.99**
	High	-36.13

Sources: Defra Estimates

125. Emissions of nitrous oxide (N_2O) occur through both a direct pathway (i.e. directly from the soils to which the N is added/released), and two indirect pathways: (i) following volatilisation of NH_3 and NOx from managed soils; and (ii) after leaching and runoff of N, mainly as NO_3, from managed soils[67].

126. Indirect emissions of N_2O for ammonium nitrate (AN) are higher than for urea. The ban of the use of urea (Options 1 and 3) are anticipated to result in increased emissions of GhG through higher application of AN. Conversely, the use of urease inhibitor with urea is estimated to result in lower N_2O indirect emissions and therefore constitutes a benefit.

127. The costs and savings are valued using the Green Book guidance and are monetised using BEIS non-traded carbon values. and considered with sensitivity prices. Here, negative benefits means an increase in emission. As a result of the proposed regulations, we estimate the central carbon costs to be £45 million for Option 1 and £25 million for Option 3 and a carbon saving of £28 million for Option 2, in

[67] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 11

present value terms over the 2022-2030 period. A sensitivity analysis providing low and high ranges for these values is given in Table 21.

Other non-monetised benefits

128. We have not monetised some of the indirect benefits that could be achieved through a reduction in ammonia emissions, as cost estimates for biodiversity loss can depend on the method used to measure them and hence values can vary widely due to lack of uniformity of approach. Furthermore, the complexities around appropriately extricating interrelated ecological elements and properties for valuation is challenging. There are four primary mechanisms by which ammonia impacts biodiversity and ecosystems: eutrophication, acidification, direct toxicity and indirect effects[68]. Occurring when ammonia pollution is moderate or high, these can have deleterious effects on soil, water and air properties. The preferred policy would have non-monetised benefits which may act to reverse or prevent the effects of these mechanisms.

129. **Water quality**: The preferred policy would lead to lower eutrophication and acidification of fresh water due to lower deposition of nitrogen compounds and reduced nitrogen surface water run-off from farmlands. This should improve fresh water quality due to higher oxygen prevalence within the system and reduce biodiversity loss in species' diversity and composition as aquatic animals experience less direct toxicity from pollution. Improved water quality through less ammonia pollution may also lead to better tree growth beside waterways. There is evidence to suggest that the cost of freshwater eutrophication from ammonia pollution is £0.60 per kg of N.[69]

130. **Impacts on soils**: The effective functioning of the ecosystem is contingent on soil health. Less ammonia pollution, via the atmospheric deposition of nitrogen compounds, would reduce soil acidification.[70] A reduction in soil acidification could positively impact crop and pasture production, because the pH of the soil improves the availability of soil nutrients. This should reduce soil control and management costs faced by the farmer.

131. **Lower direct toxicity**: There will be lower instances of direct toxicity on calcareous grassland, which will ensure the quality of plant leaves and surfaces, improving the ability of plants to resist pests and diseases and reduce changes in species composition and richness. Consequently, the quality and quantity of vegetation and flowering plants will be improved: reducing possibility that herbivorous animal will experience the negative effects of ammonia pollution; and, indirectly, improving the composition and diversity of bee, moth and butterfly species i.e. those species that depend on flowering plants for energy and nutrients.

9. Summary of costs and benefits

Approach for the monetary assessment

132. This section details the estimated costs and benefits that are likely to result from banning the use of solid urea (Option 1), the requirement to add urease inhibitors (Option 2) and from the introduction of a restricted period (Option 3). The results present analysis for a 9-year assessment period commencing in 2022, when the first costs will be incurred. From 2030 onwards, the impacts are assumed to be similar in the absence of any changes to legislation. A discount rate of 3.5% is used to derive the present value cost and benefit as per Green Book guidance with all costs and benefits reported in 2019 prices. In the remainder of this section, the monetised impacts are outlined in more detail.

Monetised costs to business and government

133. As shown in Table 23, the proposed regulations are expected to result in costs of £126 million for Option 1, £66 million for Option 2 and £87 million for Option 3 in the central scenario over the 2022-2030

[68] See "The impact of ammonia emissions from agriculture on biodiversity", The Royal Society, 2018

[69] See, ""The impact of ammonia emissions from agriculture on biodiversity", The Royal Society, 2018

[70] See, ""The impact of ammonia emissions from agriculture on biodiversity", The Royal Society, 2018

period. Costs to fertiliser distributors are negative losses, meaning that costs of production do not exceed sales. Costs to farmers also include familiarisation costs, as set out in Table 14.

Table 23: Present value for total costs of the regulation on urea fertiliser – Options 1, 2 & 3 (central scenario) (2020 £m)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Option 1 – Ban of urea, £m										
Costs to Farmers	18.34	15.83	15.48	15.15	14.83	14.52	14.21	13.90	13.60	**135.86**
Costs to fertiliser distributors	-1.35	-1.32	-1.29	-1.26	-1.23	-1.21	-1.18	-1.16	-1.13	**-11.12**
Costs to Government	0.10	0.10	0.09	0.09	0.09	0.09	0.08	0.08	0.08	**0.80**
Total										**125.54**
Option 2 – Use of urease inhibitors with urea, £m										
Costs to farmers	10.33	8.01	7.83	7.65	7.48	7.32	7.15	7.00	6.84	**69.61**
Costs to fertiliser distributors	-0.63	-0.62	-0.60	-0.59	-0.58	-0.57	-0.55	-0.54	-0.53	**-5.21**
Costs to Government	0.29	0.29	0.27	0.09	0.09	0.09	0.08	0.08	0.08	**1.36**
Total										**65.76**
Option 3 – Restricted Application Period, £m										
Costs to farmers	13.04	10.65	10.41	10.18	9.96	9.74	9.53	9.32	9.11	**91.94**
Costs to fertiliser distributors	-0.86	-0.84	-0.82	-0.80	-0.79	-0.77	-0.75	-0.74	-0.72	**-7.09**
Costs to Government	0.29	0.28	0.27	0.26	0.25	0.24	0.24	0.23	0.22	**2.28**
Total										**87.14**

Source: Defra estimates

Monetised benefits to the environment and human health

134. Table 24 sets out the annual benefits related to regulation on the use of urea fertiliser. The benefits are estimated by applying the damage cost functions and the BEIS non-traded carbon values to the reduction in emissions.

Table 24: Health and environment emission reduction benefits (£m, 2019 prices, discounted), central scenario, 2022 – 2030

	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Option 1 - Ban of urea, £m										
Damage costs (Health and ecosystem)	134.85	132.64	130.46	128.31	126.35	124.41	122.50	120.63	118.78	**1138.93**
GhG	-5.44	-5.34	-5.23	-5.13	-5.03	-4.93	-4.83	-4.74	-4.64	**-45.31**
Total benefits	129.41	127.31	125.23	123.18	121.32	119.48	117.67	115.89	114.14	**1093.62**
Option 2 – Use of urease inhibitors with urea, £m										
Damage costs (Health and ecosystem)	109.21	107.41	105.64	103.90	102.31	100.74	99.20	97.67	96.18	**922.25**
GhG	3.36	3.30	3.23	3.17	3.11	3.04	2.98	2.92	2.86	**27.99**
Total benefits	112.58	110.71	108.88	107.07	105.41	103.78	102.18	100.59	99.04	**950.24**
Option 3 – Restricted application period, £m										
Damage costs (Health and ecosystem)	100.48	98.86	97.26	95.69	94.23	92.79	91.37	89.97	88.59	**849.24**
GhG	-2.96	-2.92	-2.88	-2.84	-2.78	-2.73	-2.68	-2.62	-2.57	**-24.99**
Total Benefits	97.52	95.94	94.38	92.85	91.44	90.06	88.69	87.35	86.02	**824.25**

Source: Defra calculations

135. The proposed regulations are expected to result in benefits of £1,094 million for Option 1, £950 million for Option 2 and £824 million for Option 3 in the central scenario over the 2022-2030 period.

Progress towards UK's legally binding air pollution reduction commitments

136. The UK is required to reduce overall emissions of certain pollutants under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP Gothenburg Protocol) and the UK National Emission Ceilings Regulations 2018. For ammonia, the UK is required to reduce its emissions by 8% and 16% in 2020 and 2030 respectively compared to levels in 2005. Our baseline emission projections show that without further intervention, we are expected to miss our emission reduction commitment by 31.5 kt in 2020 and by 51.3 kt by 2030.

137. Option 1 (complete ban of the use of urea) delivers a reduction of 15.9 kt of ammonia emissions in the year 2022 and 15.7 kt in 2030. Option 2 delivers a 12.8kt reduction in 2022 and 12.7 kt by 2030. Option 3 delivers a reduction of 11.9 kt of ammonia emissions in the year 2022 and 11.7 kt by 2030. Other measures beyond this proposed policy will therefore be required to achieve the 2030 emissions reduction commitments.

Table 25: Projected emissions reductions from the baseline in 2030

Options, England only	Abatement (kt) **2030**	Projected gap between baseline and NECD NH_3 emission reduction commitments for 2030 (kt)[71]	Percentage of gap filled by the proposed regulation
Option 1 (preferred): Ban of solid urea	15.7	51.3	30.6%
Option 2: Urea + urease inhibitor	12.7	51.3	24.8%
Option 3: Restricted application period	11.7	51.3	22.8%

Source: Defra estimate

Summary of the results

138. In the three scenarios, the benefits are assessed to outweigh the costs for the measure related to restrictions on the use of solid urea fertiliser.

Table 26: Emission abatements, costs and benefits

Options, England only		Abatements (kt) 2022 / 2030	Present value benefits (£m) 2022-2030	Present value costs (£m) 2022-2030	Present value net benefits (£m) 2022-2030	Benefit cost ratio
Option 1 (preferred): Ban of solid urea	Low	**15.9 / 15.7**	196.0	150.6	45.3	1.3
	Central		**1093.6**	**125.5**	**968.1**	**8.7**
	High		3450.0	100.4	3350.0	34.4
Option 2: Urea + urease inhibitor	Low	**12.8 / 12.7**	191.0	78.9	112.1	2.4
	Central		**950.2**	**65.8**	**884.5**	**14.5**
	High		2891.0	52.6	2838.4	54.9
Option 3: Restricted application period	Low	**11.8 / 11.7**	104.6	104.6	0.0	1.0
	Central		**824.3**	**87.1**	**737.1**	**9.5**
	High		2587.2	69.7	2517.5	37.1

Source: Defra estimates

10. Direct costs and benefits to business calculations

139. The Equivalent Annual Net Direct Cost to Businesses (EANDCB) for the preferred option (Option 1) in 2019 prices and discounted to a 2020 present value base year is £15.8 million. The business net present value is estimated at -£124.7 million.

140. The Regulatory Policy Committee (RPC) scrutiny is required for policy measures that are above the threshold of ±£5m EANDCB. The regulatory measure is a qualifying regulatory provision (QRP) which will be listed in the annual Business Impact Target (BIT) report.

[71] The projected 51.3kt gap has been calculated based on UK NAEI Projected Emissions and Projected activity data for NOx, SOx, NH_3, VOCs and PM2.5 as published in October 2019. This gap includes emissions from Anaerobic Digestion estimated at 19.4 kt. With reference to the NEC Directive procedure agreed by Parties under the Gothenburg Protocol of the LRTAP Convention, the UK may qualify for a downward adjustment.

141. For Option 2, the EANDCB is £8.2 million, with a business net present value at -£64.4 million. For Option 3, the EANDCB is £10.8 million, with a business net present value at -£84.9 million.

11. Risks and assumptions

Legal aspects

142. We are considering two possible regulatory approaches to regulate specific urea-based fertilisers in England.

143. Section 74A of the Agriculture Act 1970 ("the 1970 Act") provides for primary powers to prohibit the sale or possession of fertilisers. In Great Britain, the domestic regime for the regulation of fertilisers is set out in the Fertilisers Regulations 1991. These regulations are enforced by trading standards officers in Local Authorities on the basis of reported non-compliance. The policy options to reduce ammonia emissions that we propose to consult on could be implemented using powers under section 74A of the 1970 Act. There may be some challenges in enforcing controls on the sale or use of urea if Devolved Administrations do not choose to adopt the same approach to reducing ammonia emissions from urea as is ultimately decided upon in England. At present Devolved Administrations will be consulting on the best approach to adopt.

144. The second option is to restrict only the use of fertilisers using secondary legislation under Section 87 of the Environment Act 1995 (without amendment by the Bill). If this approach is taken, the Environment Agency could be appointed to check compliance with the prohibition as part of its farm inspection regime.

Geographical coverage of the policy

145. Devolved administrations (DAs) will be consulting separately on their plans to reduce ammonia emissions. Air quality and fertilisers teams in devolved administrations have been engaged in relation to this policy but the government is consulting on an England-only basis at this stage.

146. Urea use in England is considerably higher as a proportion of nitrogen fertiliser use than it is in other parts of the UK[72] and implementation of restrictions on its use or sale will have a greater impact in England.

147. There is a risk that farmers bypass the legislation by sourcing urea from distributors located in Wales or Scotland. Government takes this risk into consideration by focusing enforcement in areas near the English borders. In addition, a sensitivity analysis (Annex 3 – part 1) is conducted based on different levels of compliance to the regulation.

Compliance and enforcement

148. The impact assessment assumes full compliance with the policy based on historical behaviours of fertiliser manufacturers and distributors related to compliance with regulations.

149. If this policy is implemented as a ban on marketing under the UK Fertiliser Regulations 1991, it would be enforced through the existing regime at point of sale by trading standards officers in Local Authorities on the basis of reported non-compliance.

150. If this policy is implemented as a ban or restriction on the use of specific urea-based fertilisers in England only, it is proposed that it would be enforced by the Environment Agency. The checks are likely to be carried out as a combination of desk-based intelligence led approaches to detect risks within the supply chain as well as end user checks supported as necessary by on-farm inspections of fertiliser stores. We anticipate that fertiliser distributers would not sell products that are banned for use in England so any non-compliance is likely to be in border areas where farmers may be able to purchase fertilisers from distributers in Wales or Scotland.

[72] England uses 149kt of N from Urea, Wales 6kt N, Scotland 21kt N and Northern Ireland 6 kt N.

151. Based on discussion with Environment Agency sources, it will be challenging to enforce total compliance with a restricted application period (Option 3). Farmers will be required to keep additional records beyond current Nitrogen Vulnerable Zone (NVZ) and Farming Rules for Water regulations (FrFW). To abide with the proposed requirement farmers will need to keep additional records of fertilisers purchased and, in the case of Option 3, the timings of application. Environment Agency sources state that current recording requirements around fertiliser usage can be difficult to validate. Therefore, increased administration placed on farmers from this Option may exacerbate poor record keeping practice and degrade both enforcement and compliance with the requirement.

152. A sensitivity analysis on compliance level is presented in Annex 3 – part 1.

Bypassing the regulation by using nitrogen compounds

153. The proposed legislation proposes to ban solid urea or to require that all fertilisers that contain solid urea, including "other" nitrogen compound fertilisers that may contain urea, to be coated or produced in compound with a urease inhibitor licensed for use in the UK. As specified in Section 6 this is to limit risk of bypassing the regulation by shifting use of solid urea to other compounds with urea, thereby reducing the impact of the policy.

154. Based on preliminary estimates from industry sources, urea is the source of 10% of the N content in compound fertilisers, while ammonium nitrate making up 90%. We are currently investigating if this estimate is sufficiently reliable, as well as the average N content of these compounds and whether it is adequately reflected in the emission factors used in the NAEI.

155. The emission factors used in the NAEI show that ammonium nitrate and the category "Other Nitrogen Including Compounds" emit the same quantity of ammonia per unit. Therefore, a shift from urea to "Other Nitrogen Including Compounds" instead of AN would have the same impact on emissions, based on current NAEI emissions factors.

Table 27: Emissions factors of N-fertilisers

Source	Fuel Name	Year	Emission Factor	Units	Activity Units
Arable	Ammonium Nitrate	2017	**0.018**	Kiloton	kt N
Arable	Other Nitrogen Including Compounds	2017	**0.018**	Kiloton	kt N
Arable	Urea	2017	**0.131**	Kiloton	kt N
Arable	Ammonium Sulphate and Diammonium Phosphate	2017	0.036	Kiloton	kt N
Arable	Calcium Ammonium Nitrate	2017	0.018	Kiloton	kt N
Arable	Urea Ammonium Nitrate	2017	0.067	Kiloton	kt N
Grass	Ammonium Nitrate	2017	**0.020**	Kiloton	kt N
Grass	Other Nitrogen Including Compounds	2017	**0.020**	Kiloton	kt N
Grass	Urea	2017	**0.157**	Kiloton	kt N
Grass	Ammonium Sulphate and Diammonium Phosphate	2017	0.028	Kiloton	kt N
Grass	Calcium Ammonium Nitrate	2017	0.020	Kiloton	kt N
Grass	Urea Ammonium Nitrate	2017	0.080	Kiloton	kt N

Source: NAEI [online database accessed on 12/12/19]

156. While the policy intends to target all solid fertilisers containing urea, the analysis does not consider other nitrogen compounds and mixes of fertilisers in the calculations due to the lack of reliable information to assess the benefit. We are currently gathering further information and will do so through the consultation process to complete the analysis and risks associated.

Fertiliser market price transparency

157. Lack of market transparency and information asymmetries can lead to inefficient markets and give those with access to the most accurate data disproportionate power. The international commodity price of untreated urea is readily accessible and used as a benchmark price for other fertiliser products in the market, including ammonium nitrate. Research has found a strong correlation between urea and nitrate prices: urea prices determine the price range for nitrates.[73] Based on consultation with industry sources, if untreated urea was removed from the market, then the loss of this benchmark could impact price transparency and distort prices for other fertiliser products for farmers, specifically ammonium nitrate which is expected to be used as a substitute. There may be a risk that ammonium nitrate price will rise as a consequence of Option 1 (ban of solid urea), increasing farmers' fertiliser application costs across the period. However, the risk of price distortion may be minimal due to the international characteristic of the market.

158. Similarly, based on consultation with industry sources, a requirement to use a urease inhibitor with urea fertiliser may incentivise manufacturers to increase fertiliser price given that an inhibitor will be a necessary component of continued urea use, with no transparency on its price. This will increase the fertiliser application costs for farmers.

Farmers behaviours: use of urease inhibitors (Option 2)

159. Preliminary consultation with the industry indicates that some stakeholders may be concerned by a potential, long term negative impact that urease inhibitors could have on soil health. As a result, some farmers may decide to apply ammonium nitrate instead of urea with urease inhibitors despite the higher cost involved. Initial responses from soil science experts suggest there is a lack of definitive evidence on whether urease inhibitors present any adverse effects on soil microbial activity. We have consulted with soils scientists from Natural England and the British Society of Soil Science. In summary, there appears to be no current evidence which would suggest adverse impacts from urease inhibitors on soil microbial activity.

160. A sensitivity analysis on impact on the policy of a proportion of farmers shifting to ammonium nitrate instead of using urease inhibitors as assumed is presented in Annex 3 – part 2. The results show that costs to farmers increase when some farmers, who were using urea before the implementation of the regulation, decide to apply ammonium nitrate instead of continuing to apply urea with the addition of urease inhibitors. However, this farmer behaviour has a positive impact on air quality improvement outcome.

Storage and security for ammonium nitrate

161. Ammonium nitrate is widely used in Great Britain and there are regulations in place to make sure it is imported, transported and stored safely. In 2006, a Fertiliser Industry Assurance Scheme (FIAS) was set up between government and the Agricultural Industries Confederation. FIAS have successfully created and monitored voluntary standards across the industry supply chain – including manufacturers, merchants, hauliers and farmers – to assure fertiliser, and in particular ammonium nitrate, product safety, security and traceability.

162. FIAS requires an independent assessment that every scheme participant fully complies with the current version of the standard as applicable to their operations; the four standards cover fertilisers' manufacturing, transport, storage, and 'merchanting'. For farmers/users wishing to switch from using solid urea to ammonium nitrate for the first time, they would need to follow stricter guidance around storing the

---

[73] YARA (2018) YARA Fertiliser Industry Handbook https://www.yara.com/siteassets/investors/057-reports-and-presentations/other/2018/fertilizer-industry-handbook-2018-with-notes.pdf/

fertiliser,[74] which could mean storing the ammonium nitrate in smaller stacks with greater space between combustible materials than is required with solid urea. Anybody purchasing ammonium nitrate is strongly guided towards FIAS accredited supply chains. In addition, NaCTSO[75] and the HSE[76] offer advice on the safe handling and storage of ammonium nitrate.

12. Impact on Small and Micro Business

163. Small and micro businesses (SMBs) can be disproportionately affected by the burden of regulation. New regulatory proposals are designed and implemented in a manner aiming to mitigate disproportionate burdens where appropriate. As defined by the Better Regulation Framework Manual, micro businesses are those employing up to 10 full-time employees (FTEs) as staff members, while small businesses employ between 11 and 49 FTEs. Given this, there will be approximately 5060 farm businesses[77] of this type affected by Options 1 – 3.

164. Farm business size in England is measured in Standard Labour Requirements (SLR), expressed in terms of FTEs. Part-time farms are defined as having less than 1 SLR, small farms 1-2 SLRs, up to very large farms with 5 or more SLRs. As such, it can be deduced that all farms in England are classified as SMBs, except for the largest. Given this, designing and implementing controls in a manner that mitigates disproportionate burdens against SMBs, such as exemption, is not possible without compromising the efficiency and effectiveness of the policy.

165. While the average farm business income for all farm types was £50,400, it increases with size, with large farms' average farm business income the highest at £115,900 on average and part time and small farms' average farm business income at £18,800 and £28,300 respectively. The cost increases may have a different impact on farms depending on their size, cost structure and especially share of urea in their fertiliser use.

166. Using data from the British Survey of Fertiliser Practice 2018, it appears that 3.6% of fertiliser used on farms less than or equal to 50 hectares in size are urea-based in the UK. This is a smaller proportion of overall fertiliser use than for all larger farm classifications (ranging from 5.5% of fertiliser used by large farms, to 13.5% for very large farms). This means that on a collective basis small farms may be less than proportionately affected by the proposed regulation. However, typically, cost increasing regulations are more burdensome on smaller, lower income farms. 34% of all farms have a farm business income of less than £10,000 per year or make a loss[78]. This could mean that with significant increased costs, many of these farms could exit the market.

167. On this basis, exemption for small and micro businesses would make the policy ineffective since most farms would be classified as an SMB. Even within this, small and part-time farms comprise 71% of all farms, so SMB mitigation measures or adjustments are considered impractical. However, we will be undertaking a consultation with industry to better understand the implications of the proposed policy options and to deliver better regulation and reduce burdens on business and industry.

13. Wider Impacts

Impact on farmers

168. It is estimated that the main costs from the proposed regulations originate from fertiliser application incurred by farmers, with some additional costs relating to familiarisation and administration. Fertiliser manufacturers are expected to see a small increase in net profits with some smaller costs to Government through enforcement at the point of use.

[74] https://www.gov.uk/government/publications/secure-your-fertiliser/secure-your-fertiliser

[75] The National Counter Tourism Office: https://www.gov.uk/guidance/secure-hazardous-materials-to-help-prevent-terrorism

[76] Health and Safety Executive: https://www.hse.gov.uk/explosives/ammonium/index.htm

[77] Defra analysis of Farm Business Survey, Defra, 2019.

[78] Defra analysis of Farm Accounts in England 2018/19

169. A complete ban on urea-based fertilisers (Option 1) is expected to lead to a total cost to farmers per year of £15m on average per year or £136m over the entire period 2022-2030[79]. Assuming 7,128 holdings in England using urea fertilisers[80], there is an additional cost only to farms currently applying solid urea of £2,118 per farm on average per year for Option 1, £19,060 over the period 2022-30, assuming this cost is split equally among all farms.

170. Farm business income is a measure of net profit, calculated by farm business outputs (revenue) minus farm business inputs (costs). Average farm business income per farm for all farm types was £50,400 for the year 2018/19[81], meaning the cost increase from Option 1 represents 4.2% of their income on average.

171. The use of urease inhibitors (Option 2) is expected to give a total cost to farmers of £8m on average per year or £70m for the whole period 2022-2030. This would give a cost per farm of £1,085 assuming that costs are split equally, representing 2.2% of average farm business income.

172. The restricted urea application period (Option 3) is expected to give a total cost to farmers of £10m on average per year or £92m for the whole period 2022-2030. This would give a cost per farm of £1,433 assuming the costs are split equally, representing 2.8% of average farm business income.

Regional impacts

173. The proposed regulation would affect England only and not the UK Devolved Administrations (DAs). In 2018, agriculture contributed £9.6bn (0.5%) of the total net UK economy. England generated 71% of this value[82].

174. For the period 2020-2030 inclusive, the total projected urea fertiliser usage for England is estimated to be 1.5m tonnes (84%) out of a total of 1.7m tonnes for the entire UK (England, Wales, Scotland and Northern Ireland)[83]. DAs typically use a lower share of urea-based fertilisers too: 5-10% of total fertiliser use over the period 2020-2030, compared with 18% of total fertiliser use for England[84]. As such, it can be deduced that the regulation will increase costs for farms in England, relative to farms in DAs that are not impacted.

175. Regionally, the highest farm business income is in the East of England (£78,200) where cost increase represents 2.7% of income on average for a complete ban (Option 1), 1.4% in the case of inhibitors (Option 2) and 1.8% in the restricted application period (Option 3). In the North West, farm business income was the lowest on average at £33,300, meaning a £2,118 cost increase here would represent 6.4% of income (Option 1), 3.3% in the case of a £1,085 cost increase (Option 2) and 4.3% in the case of a £1,433 cost increase (Option 3) [85].

176. However, these estimates do not factor in the regional composition of farms nor the regional differences in urea fertiliser usage due to sample size limitations in the data. There is insufficient evidence available to provide a full assessment of regional distributional impacts from the proposed regulation.

Impact on the fertiliser industry

177. A complete ban of urea fertilisers (Option 1) is estimated to increase the profits of all fertiliser manufacturers by £1.4m in 2022 and £11m in total for the period 2022-30. Option 2 is estimated to increase the profits of fertiliser manufacturers by £0.6m in total in 2022 and £5.2m in total for the period

[79] Defra analysis of Agriculture and Horticulture Development Board – Fertiliser Industry – Average Fertiliser Price Data 2012-17

[80] Estimated based on the total number of holdings in the UK from the British Survey of Fertiliser Practice 2018

[81] Farm Accounts in England 2018/19

[82] Agriculture in the United Kingdom 2018, Defra, 2019

[83] National Atmospheric Emissions Inventory

[84] Defra analysis of British Survey of Fertiliser Practice -(2017 tillage fertiliser data.xls, 2017 grassland fertiliser data.xls)

[85] Farm Accounts in England 2018/19

2020-2030. Option 3 is estimated to increase the profits of fertiliser manufacturers by £0.9m in total in 2022 and £7.1m in total for the period 2020 – 2030.[86]

14. A summary of the potential trade implications of measure

178. We envisage that this policy will impact the volume and origin of UK trade for fertilisers, but it will not introduce different requirements for domestic and foreign businesses, or different requirements for businesses from different foreign countries.

179. In 2018, the import value for solid urea fertiliser into the UK represented £207 million[87], with 52% originating from EU countries (mainly Germany), 26% from Egypt, and 15% from the Russian Federation. Urea is mostly used in agriculture, but also in the chemical industry (e.g. urea-formaldehyde resins), industrial processes (e.g. glues for formica), medical sector (e.g. dermatologic cream), transport (in SNCR and SCR reactions to reduce the NO_X pollutants in exhaust gases from diesel engines combustion), etc.

180. It is anticipated that solid urea use in agriculture will be fully or partially substituted by another fertiliser, ammonium nitrate (AN) in options 1 and 3. About 40% of AN applied in the UK is locally produced by one fertiliser manufacturer, CF Fertilisers UK Ltd and the other 60% is imported, mostly from EU countries. We envisage that the increase in demand for AN will be met by reduced UK exports of AN (valued at £27 million in 2018) and by rising AN imports as capacity to boost national production is quite limited in the short to medium terms.

181. Following the UK's exit from the European Union (EU), the UK will represent itself at the World Trade Organisation (WTO). The UK now acts autonomously in the WTO and takes on the responsibilities which come with independent participation in the WTO's day-to-day business. UK compliance with WTO notification obligations, effective and informed engagement in WTO committee meetings will support the UK vision to be an influential and credible leader at the WTO. Complying with the WTO SPS obligations is in accordance with the UK's intention to be amongst the world's top trading nations, contributing to the reduction of trade barriers globally and enabling foreign organisations to understand how to trade with us.

182. Failing to meet these obligations could lead to WTO members retaliating and causing reputational damage to the UK. The reputational damages may have an impact outside of the WTO and affect our relationships with trading partners which could undermine our ability to negotiate market access through FTAs. This is particularly critical at a time when the UK is re-establishing itself as an independent member.

Option 1: Complete ban on the use or sale of solid urea

183. This measure would fall under the Market Access Committee.

184. Within the WTO, market access for goods is defined as the conditions, tariff and non-tariff measures, agreed by members for the entry of specific goods into their domestic markets. Quantitative Restrictions (QRs) refers to a limit given on the quantity of a good that are allowed to enter a country's customs territory. There can be a quantitative restriction of zero which effectively makes it a ban. The complete ban of the use or sale of solid urea would count as a quantitative restriction of zero.

185. There is an obligation for all Members to make complete notifications of all quantitative restrictions in force by 30 September at two yearly intervals. The new two intervals for notifications are September 2020 and September 2022. Any new or modified quantitative restrictions should be notified as soon as possible, but not later than six months from their entry into force. According to the current timescales, this measure would need to be notified in 2022.

Options 2 and 3

[86] Defra analysis of Agriculture and Horticulture Development Board – Fertiliser Industry – Average Fertiliser Price Data 2012-17

[87] Source: HMRC UK trade statistics - www.uktradeinfo.com/Statistics/Pages/Statistics.aspx

186. These measures are likely to fall under the Technical Barriers to Trade (TBT) Committee.

187. The Agreement covers trade in all goods and is limited to three categories of measures: technical regulations, standards and conformity assessment procedures. Those measure may count as a conformity assessment procedure which are technical procedures by which products are assessed to show compliance against technical regulation and standards.

188. The explanatory note in the Agreement sets out that: "Conformity assessment procedures include, inter alia, procedures for sampling, testing and inspection; evaluation, verification and assurance of conformity; registration, accreditation and approval as well as their combinations."

189. All draft measures, which may have a significant effect on other WTO Members' trade and are not based on relevant international standards must be notified to the TBT Committee. Measures must be notified in a draft form where changes can still be made. It is recommended that Members allow a 60-day comment period for other WTO members to have their say and at least a 6-month gap between the adoption of the measure and the entry into force to allow Members to adjust.

190. According to the current timescales, this measure would need to be notified in either late 2020 or early 2021.

15. Monitoring and Evaluation

Monitoring new policy arrangements

191. The effects of a chosen policy (Options 1-3) will be measured against "business as usual" fertiliser application and emissions projection data during the appraisal period.

192. The British Survey of Fertiliser Practice (BSFP), released annually in June, provides updated data on fertiliser use and application across GB. The BSFP will reflect how solid urea fertiliser use has been affected by the policy, which we will be able to see in June 2023. If more specific data on usage or farmer practice change is required, then this can be gathered through survey exercises which can be considered after the first two years of policy implementation. Furthermore, HMRC annual statistical reporting on fertiliser imports can also be analysed to assess the policy's efficacy.

193. Regarding emissions data, The BSFP figures are used to compile the National Atmospheric Emissions Inventory (NAEI) to estimate ammonia emissions from inorganic fertilisers. The NAEI will be assessed against the objectives of the policy annually when the data is released in February respectively. The data for the first year of implementation (2022) will be released in February 2024. From 2020, Defra's Scenario Modelling Tool will also be used to assess the impact of the policy by estimating ammonia emissions using activity data from the agricultural sector, against "business as usual" projections. This can be conducted annually, from the first year of implementation.

194. In the event of a ban on use, the Environment Agency will be charged with monitoring the efficacy of the policy via its farm inspection regime, which will give us an indication of farmer compliance. Impacts on GHG emissions and water quality will also be monitored. Water quality will be monitored through the existing sampling of levels of nitrate in groundwater and surface water conducted by the Environment Agency and through assessing trends in fertiliser use to ensure good nutrient management. Air Quality will be monitored through the National Atmospheric Emissions Inventory (NAEI) that is available annually in February each year.

Assessing whether policy objectives have been met

195. The main external factor that will have an impact on the success of the intervention will be fertiliser price (total and of different nitrogen fertiliser products) in England and the relative price of the English fertiliser price compared to the UK is likely to have the biggest impact on the success of the policy options consulted on and their implementation.

196. Assessment of the policy will be derived from the whether the predicted reductions in emissions of 15.9kt (Option 1), 12.8kt (Option 2) or 11.8kt (Option 3) are met by 2023 (one year after implementation). This will be known in February 2025 when the modelling results (NAEI) are released.

197. The cost-effectiveness of the policy will be assessed by monitoring the predicted monetised costs to business and government, monetised benefits to human health and environment and analysing any changes to these from those modelled by the chosen policy, in order to avoid undesirable (or unforeseen) effects on these areas. Changes in costs for business will be assessed by monitoring differences in fertiliser price and availability for farmers and loss in profits for fertiliser manufacturers from projected values. This will be done by assessing trade statistics and consulting with trade bodies such as the Agricultural Industries Confederation (AIC) and National Farming Union (NFU); assessing trends in fertiliser use (through the British Survey of Fertiliser Practice amongst other methods).

198. Changes in costs to government will be assessed by monitoring enforcement costs in consultation with the Environment Agency. Changes in human and environmental benefits will be assessed by monitoring differences in projected urea and ammonium nitrate fertiliser application and abatement values with values modelled for the policy appraisal period. This will be done by assessing NAEI; assessing trends in water quality monitoring for nitrate levels in both surface and groundwater samples; and assessing impacts on other pollutants such as nitrous oxide (as well as on ammonia) and nitrates.

199. After five years of the policy being in force (in 2027), there will be a full review of the policy's: efficacy in reducing ammonia emissions against the modelled reduction; its impact on GhG emissions and water quality; the impact of the policy on English, UK and world fertiliser prices; the impact of the policy on crop production; the fitness for purpose of the record keeping, inspection and enforcement regimes. This will provide an indication of whether the policy should be amended.

Current monitoring and evaluation provisions

200. The BSFP, NAEI, Environment Agency sampling of nitrate levels in water bodies, and trade statistics from HMRC are currently used to assess fertiliser use or the effects of fertiliser use on greenhouse gases, ammonia emissions and nitrates in waters. We intend to use these for the assessment of this policy.

201. To collect data that is not already being collected, to assess whether the policy has been successful, farm inspection reports on farmer compliance from the Environment Agency, in addition to the sources of information already identified, will be used. The National Compliance Assessment Database (NCAD) will be updated to accommodate the new inspection requirements for this policy.

202. Unforeseen issues concerning the availability of sufficient nitrogen fertiliser, prices for fertiliser that were significantly limiting crop production and reports of health or environmental impacts would require the policy to be reviewed sooner or require a change to the preferred option.

Annexes

Annex 1: Review of the regulations to restrict urea use in Germany

[This analysis was commissioned by Defra and conducted by Wood Plc]

This section summarises how urea use is restricted in Germany to reduce ammonia emissions. The relevant underlying analysis that was used to support the development of this regulation is identified and summarised with regards to expected impacts. At the end of the section, conclusions are provided regarding lessons that can be learned for possible similar regulation in the UK.

Summary of the regulation

Regulatory background/context

The German Fertiliser Act (Düngegesetz) has the following objectives[88]:

- ensure the nutrition of crops;
- preserve or sustainably improve the fertility of the soil;
- prevent or mitigate hazards to human and animal health and ecosystems from fertilisation;
- ensure a sustainable and resource-efficient use of nutrients in agricultural production; in particular to avoid as far as possible nutrient losses to the environment; and
- transpose or implement relevant acts of the European Union.

The Fertiliser Act sets the legal framework for the Federal Ministry of Food and Agriculture to issue more detailed regulations, by means of ordinances, regarding placing fertilisers on the market and their application. The Fertiliser Act was amended with effect from 15th May 2017 to enable the passing of a new Fertiliser Ordinance[89] to implement relevant EU laws, specifically the Nitrates Directive and the National Emission Ceilings (NEC) Directive.[90] A revised Fertiliser Ordinance (Düngeverordnung) took effect on 2 June 2017.[91] According to a recent publication from the Federal Office for Agriculture and Food[92], the changes implemented in the new version primarily aim to increase fertilisation efficiency, mitigate eutrophication and to reduce ammonia emissions.

The following review describes the specifications contained in the revised Fertiliser Ordinance that are relevant to the reduction of ammonia emissions, particularly from urea.

Measures to reduce ammonia emissions

The revised Fertiliser Ordinance and an accompanying publication from the Federal Office for Agriculture and Food describing and explaining the revised Ordinance have been reviewed to identify any measures to address ammonia emissions, particularly from urea.

The only specification directly relevant to ammonia emissions from urea is contained in article 6(2):

---

88 Website of the Federal Ministry of Food and Agriculture

89 "Düngeverordnung vom 26. Mai 2017 (BGBl. I S. 1305)". See German original and working translation to English

90 Bundesanstalt für Landwirtschaft und Ernährung (2018): Die neue Düngeverordnung. Available at: https://ble-medienservice.de/1756/die-neue-duengeverordnung.

91 Website of the Federal Ministry of Food and Agriculture

92 Bundesanstalt für Landwirtschaft und Ernährung (2018): Die neue Düngeverordnung. Available at: https://ble-medienservice.de/1756/die-neue-duengeverordnung.

"Urea as a fertiliser may, from 1 February 2020, only be spread insofar as a urease inhibitor is added to it or is worked in without delay or at the latest within four hours of spreading."[93]

In Germany, a fertilising product can be placed on the market as "urea" if it contains 44% of total nitrogen as carbamide nitrogen [CO(NH2)2].[94] As a result, any product with under 44% carbamide nitrogen (for example, Urea Ammonium Nitrate, UAN) is currently not considered urea and therefore not subject to article 6(2). According to anecdotal evidence this definition is currently under review, because it could allow market participants to bypass article 6(2) by reducing the carbamide nitrogen content of their products to just below 44%.[95]

Underlying analysis to support the regulation

The first step in the revision of the Fertiliser Ordinance was an evaluation of the Ordinance by a federal-state working group, published in 2012[96]. This resulted in a proposed amendment to the Fertiliser Ordinance. A summarising environmental impact statement on this proposal was published in 2017[97]. As specified in Article 3 of the Fertiliser Law, a public consultation on the draft Fertiliser Ordinance was conducted. This took place in November 2016 and a short summary of the consultation results was published[98].

In personal communication with the officer responsible for the Fertiliser Ordinance (on 31 October 2018), the German Federal Ministry of Food and Agriculture confirmed that all available information on economic impacts is included in the Government's explanatory statement on the draft revised ordinance to the Bundesrat (the upper house of German legislature)[99].

Insights relevant to the impacts of Article 6(2) and related requirements (such as monitoring and enforcement) from these four identified documents[100] are summarised below.

Evaluation Report

The analysis and evaluation of proposed changes to the Fertiliser Ordinance is contained in Section 3 of the evaluation report (with additional details in Appendix 3). Sub-section 3.4.3 covers the proposition to further specify the requirement of immediate working in[101] (within 4 hours of application – no time limit was previously specified) and the extension of this requirement to further types of fertilisers. According to the evaluation report, the requirement of immediate working in was originally based on a measure in the guidance document on ammonia abatement under the Gothenburg protocol.[102] This was later implemented in Article 6 paragraphs 1 and 2 of the Ordinance. It should be noted that this concerns the requirement of immediate

---

93 Working translation to English of the "Düngeverordnung vom 26. Mai 2017 (BGBl. I S. 1305)"

94 Düngemittelverordnung vom 5. Dezember 2012 (BGBl. I S. 2482)

95 According to personal communication with a German supplier of urease inhibitors.

96 Bund-Länder-Arbeitsgruppe zur Evaluierung der Düngeverordnung (2012): Evaluierung der Düngeverordnung – Ergebnisse und Optionen zur Weiterentwicklung Abschlussbericht. Report on behalf of the Federal Ministry of Food and Agriculture. Available at: https://literatur.thuenen.de/digbib_extern/dn051542.pdf.

97 Federal Ministry of Food and Agriculture (2017): Zusammenfassende Umwelterklärung im Rahmen der Strategischen Umweltprüfung zum nationalen Aktionsprogramm zum Schutz der Gewässer vor Verunreinigung durch Nitrat aus landwirtschaftlichen Quellen - Teilprogramm: Verordnung zur Neuordnung der guten fachlichen Praxis beim Düngen. Available at: https://www.bmel.de/SharedDocs/Downloads/Landwirtschaft/Pflanze/Umwelterklaerung-Umweltpruefung-Nitrat.pdf?__blob=publicationFile.

98 Federal Ministry of Food and Agriculture (undated): Unterrichtung über das Beteiligungsverfahren nach dem Düngegesetz anlässlich der Novellierung der Düngeverordnung. Available at: https://www.bmel.de/SharedDocs/Downloads/Landwirtschaft/Pflanze/Beteiligungsverfahren-Duengeverordnung.pdf?__blob=publicationFile.

99 Bundesrat (2017): Verordnung zur Neuordnung der guten fachlichen Praxis beim Düngen. Drucksache 148/17. Available at: https://www.bmel.de/SharedDocs/Downloads/Service/Rechtsgrundlagen/Entwuerfe/EntwurfDuengeverordnung.pdf?__blob=publicationFile.

100 Evaluation report, Summarising environmental impact statement, Short summary of the consultation results; Government's explanatory statement. Note that these are available in German only.

101 Immediate "working into" the soil is the term used by the Working translation to English of the Düngeverordnung. In England, this is also referred to as "incorporating" into the soil.

102 Gothenburg Protocol Guidance Document On Control Techniques For Preventing And Abating Emissions Of Ammonia: „Incorporation of surface-applied (broadcast) solid manure and slurry into soil within a few hours."

working in, not only for urea but for other types of fertilisers as well (in fact much of the discussion focuses on manure).

The following impacts of the proposition were assessed:

- Impact on plant nutrition: Current rules have a positive impact on plant nutrition (a larger share of ammonia-nitrogen enters the soil, increasing fertilisation efficiency) but the proposed legislation has a further positive impact (as it now covers further types of fertilisers).
- Impact on business: Existing rules contribute to lower fertiliser use due to increased fertilisation efficiency and incur costs of organising/executing immediate working in. In sum, this can lead to overall savings in many cases, but this was only quantified for manure. It was found that the proposed legislation would have the same effect but affect a larger number of businesses and impact individual businesses more strongly. However, it is estimated that the additional burden is low.
- Regional impacts: Costs of organising immediate working in could be higher in regions with smaller farm sizes. Beyond that, regional impacts are only discussed for poultry manure and digestate.
- Environmental impacts: Positive; same as under existing rules (ammonia emission reduction, only quantified for manure) but expanded (as it now covers further types of fertilisers).
- Implications for implementation: This was found to be the same as under existing rules (compliance with immediate working in within a few hours is difficult to check, while working in right away after application would be easier to verify as the required equipment would have to stand by next to the field; restricting the requirement to untilled fields only may lead farmers to apply fertilisers onto planted fields instead, in order to avoid the requirement).

The conclusions stated in the report are:

- The proposition contributes to the ammonia mitigation strategy and should guarantee a consistent minimum implementation nation-wide.
- Without a clear regulation to be presented to the European Commission, the ammonia emissions for Germany would have to be calculated under the assumption of partially later working in of applied fertilisers, which would lead to higher calculated emissions in conflict with the National Emissions Ceiling (NEC Directive).

Appendix 4 of the Evaluation Report contains the results of the quantitative analysis, but this included no data on urea, only on other types of affected fertilisers.

Note that no impacts appear to have been assessed specifically on the specifications regarding urea (Article 6(2)). It is noted[103] that ammonia emissions from mineral fertilisers strongly fluctuated in previous years due to the fluctuations in relative prices between calcium ammonium nitrate (CAN) and urea. The relative prices affect the volumes of urea and CAN used, which in turn affects emissions because urea causes higher ammonia emissions per mass of nitrogen applied than CAN. The reduction potential of specifications on nitrification inhibitors and immediate working in of urea was therefore uncertain and such specifications were listed for further investigation.

Summarising Environmental Impact Statement

The document notes that an environmental impact assessment of the draft revised Fertiliser Act and Fertiliser Ordinance was conducted. The results of the impact assessment were incorporated into the drafts of the revised Act and Ordinance, respectively. However, no further details of the environmental impacts are given.

[103] Appendix 2, Section A2.2.3.

A public consultation on the environmental impact assessment was conducted from September-October 2016 and the responses were assessed by the Federal Ministry of Food and Agriculture. With regards to the requirements on immediate working in, several farmers, associations and a petitioner criticised the 4-hour time limit as "practically impossible to comply with" and/or suggested a more flexible approach in which farmers can decide themselves based on season, temperature and weather. The justification provided in response by the Ministry was that this is necessary to achieve the required reductions of ammonia emissions. Note that urea was not mentioned specifically.

The full environmental impact assessment was mentioned in the summarising environmental impact statement. We have also reviewed the full environmental impact assessment[104] with regards to any information on urea. The environmental impact of working in within 4 hours of application is judged to be neutral because similar practices had already been specified in State-level provisions.

While the environmental impact assessment did not provide any quantitative information on the expected ammonia emission reduction, the Thünen Institute[105] clarified in personal communication that Options for Ammonia Mitigation - Guidance from the UNECE Task Force on Reactive Nitrogen had been used in Germany to estimate ammonia emission reductions. Table 15 of this UNECE guidance suggests that urease inhibitors achieve a 70% reduction of ammonia emissions for solid urea and 40% for liquid urea ammonium nitrate, while incorporation of urea achieves a 50-80% reduction (depending on the delay of the incorporation after fertiliser application, the depth of mixing and the soil texture).

Summary of the Consultation Results

A public consultation on the draft revised Fertiliser Act and Fertiliser Ordinance was conducted from October-November 2016. 478 responses, primarily from farmers, were received and were assessed by the Federal Ministry of Food and Agriculture and other affected ministries.

The summary of the consultation results does not mention any discussion on the specifications regarding urea (Article 6(2) of the Fertiliser Ordinance). The only matter related to ammonia emissions is the requirement to spread in strips on the soil or to directly work into the soil any liquid organic and liquid organic-mineral fertilisers with significant available nitrogen or ammoniacal nitrogen content. This was criticised by consultees on grounds of there being high associated capital expenditures and risk of soil compaction. The criticism was refuted by the Ministry with the argument that this specification is required to reduce ammonia emissions and implement the NEC Directive. Furthermore, State authorities may allow other methods to achieve the same emission reduction according to Article 6(3) of the Fertiliser Ordinance.

Government's explanatory statement to the Bundesrat

In the Government's explanatory statement on the draft revised ordinance to the Bundesrat, a brief summary of expected additional burden is provided. The additional burden of revising the whole Ordinance (compared to the previous legal situation) on business is expected to be in the order of €111.7m (approximately £97.9m) per year.[106] The additional burden for competent authorities is expected to be in the order of €2.2m (about £1.9m) per year plus a €1.4m (approximately £1.2m) one-off cost. No impact on consumers, individual prices or the general price level is expected, although no supporting details are provided.

Table 1 and page 73 of the statement present and explain the additional burden of the changes to each paragraph of the Ordinance and by stakeholder affected. This is reproduced (translated) below for the specifications regarding urea (Article 6(2)):

- Additional burden to business:
    - Quantity affected: 370,000 t pure N (urea)

---

[104] Available at: https://www.agrarheute.com/sites/default/files/atoms/files/umweltbericht2016-novelleduengung.pdf (Accessed 08th October 2018)

[105] A German Federal Research Institute under the auspices of the German Ministry of Food and Agriculture. The environmental impact assessment mentioned that the Thünen Institute had estimated ammonia emission reductions.

[106] Exchange rate used: 1.1413. Bank of England Annual average Spot exchange rate, Euro into Sterling, for the year 2017.

    - Cost per unit: €0.08 per kg urea-N (approximately £0.07)
    - Additional burden: €29,600,000 per year (approximately £25.9 million)
    - Explanation provided: According to consultation with businesses and experts in states where this is already common practice, the addition of urease inhibitors to solid urea fertiliser costs businesses an additional €0.08 per kg of pure N. The assumed amount of urea applied (370,000 t pure N) is the average of the years 2009-2016, to balance annual fluctuations. Note that the resulting burden of €29.6 million per year is at least partly offset by savings from the reduced losses of nitrogen through volatilisation.
- Additional burden to competent authorities:
    - Quantity affected: 5,630 controlled businesses
    - Cost per unit: €8,775 per inspection (about £7,689)
    - Additional burden: €49,403 per year (about £43,287)
    - Explanation provided: The additional burden to competent authorities is a result of the necessity to monitor the use of urease inhibitors via inspection of stocks or receipts. Costs per inspection are based on 15 minutes (additional time) at labour costs of €35.10 per hour (about £30.75).

It should be noted that, urea is defined in German legislation as containing 44% of total nitrogen as carbamide nitrogen. Hence, some or all of the "numbers of cases" quoted above could potentially be higher if products with less than 44% carbamide nitrogen are also considered.

In personal communication with the German Federal Ministry of Food and Agriculture, it was noted that the primary motivation for the specification on urea was the environmental impact, but urease inhibitors are already available on the market and additional costs are largely offset by the reduced loss of nitrogen. According to their experience, the direct working in of urea is not practised, but rather urease inhibitors are being used.

Conclusions

As the main measure to reduce ammonia emissions from urea in Germany, legislation was passed to require either the addition of urease inhibitors to urea or working in (i.e. incorporation) of urea within four hours of spreading, from 1 February 2020.

Based on the available information on the analysis undertaken by the German Government to support the development of this legislation, the following conclusions can be drawn regarding possible impacts of similar regulation in the UK:

- The definition of urea under German law is currently under review, because it could allow market participants to bypass the measure by reducing the carbamide nitrogen content of their products just below 44%. The definition of urea in potential UK legislation should be carefully chosen to avoid such unintended consequences.
- The use of urease inhibitors is already common practice at least in parts of Germany. If it is not as common in the UK, implementing similar regulation could have larger impacts in the UK than were expected for Germany.
- Experts from the German competent authority suggest that the direct working in of urea is not practised, but rather urease inhibitors are being used. It therefore stands to reason that a similar outcome is likely in the UK, but further investigation of circumstances in the UK would be needed for a more robust conclusion
- Urease inhibitors are already available on the market and additional costs in Germany were estimated as £0.07 per kg urea-N. This can be used to inform UK impact assessment assumptions, but UK-specific market data would be preferable.
- Additional burden to competent authorities in Germany was estimated to be £7,689 per installation, based on 15-minute additional time spent on one inspection per year and labour

costs of £30.75 per hour. Depending on the monitoring regime considered in the UK, this could potentially be used to inform UK impact assessment assumptions. UK-specific labour costs should be used instead of the German labour cost estimate.

- The resulting burden was estimated to be largely offset by the reduced loss of nitrogen through volatilisation in Germany, which leads to lower fertiliser use due to increased fertilisation efficiency. To what extent the burden is offset was not specified but this impact should be considered and if possible quantified in a UK impact assessment.
- UNECE guidance[107] on ammonia mitigation was used in Germany to estimate ammonia emission reductions. This suggests that urease inhibitors achieve a 70% reduction of ammonia emissions for solid urea and 40% for liquid urea ammonium nitrate, while incorporation of urea achieves a 50-80% reduction (depending on the delay of the incorporation after fertiliser application, the depth of mixing and the soil texture). The tables within the guidance document can be used to inform assumptions on ammonia emission reductions in the UK impact assessment.

[107] Options for Ammonia Mitigation - Guidance from the UNECE Task Force on Reactive Nitrogen

Annex 2: Voluntary Measures to Reduce Ammonia from COGAP and related documents

Source of Ammonia	Voluntary Measures to Reduce
Assessment	Make use of manure analysis (on-farm and laboratory testing) or use of standard values
	Calculate available nutrients based on manure type, method and time of application. Take account of the nutrient percentage and the availability of nutrients for crop uptake
	Consider placement of fertilisers for responsive crop and periods of demand for it
	Consider the cost effectiveness of alternative fertiliser materials
	Keep accurate field records to help with decisions on fertiliser use
Storage	Ensure farm has enough well-maintained storage to be able to spread slurry only when your crops will use the nutrients
	Fix rigid lids or flexible covers to slurry/digestate stores to retain N, exclude rainwater & develop a natural crust
	Install floating covers on lagoons and slurry tanks
	Cover solid heaps with plastic sheeting
	Consider processing slurry or digestate, such as by acidification (with professional equipment and advice) or separation
	Use a nutrient management plan and regularly test manure and soil to calculate suitable application rates and plan timing
Spreading manufactured fertilisers	Adopt a Nutrient Management Plan to balance grass and crop nutrient requirements with manure and fertiliser applications.
	Make sure that the physical quality of the fertiliser will allow accurate spreading
	Apply manures/slurry/digestate in spring if possible & spread using low emission spreading equipment (trailing hose, trailing shoe or injection) rather than surface broadcast (splash plate). Regularly check and maintain manure spreaders.
	Incorporate solid manure, separated fibre, cake or compost into the soil by plough, disc or tine as soon as possible and at least within 12 hours
	Incorporation of urea into the soil immediately upon spreading, either by closed-slot injection or by cultivation. Depth of injection and soil texture influence reduction efficiency. Use shallow injection (for slurry and urea fertilisers)
	Improve Nitrogen Use Efficiency of urea fertiliser using low-emission application techniques: • rapidly incorporating (>50% ammonia emission reduction) or injecting (>80% ammonia emission reduction) urea fertilisers into the soil when possible • use of urea with urease inhibitors (70% mean ammonia emission reduction for solid urea, 40% mean ammonia emission reduction for liquid UAN). • switching from urea to ammonium nitrate. While AN can be more expensive, the net cost difference may be negligible due to lower nitrogen losses • in irrigated systems, irrigate to at least 5mm immediately after urea application to encourage adsorption into the soil
	Refer to RB209 or seek advice from a FACTS Qualified Adviser for guidance on urea fertilisers, and ammonium sulphate and ammonium phosphate use on calcareous soils.
	Apply ammonium nitrate in cool (< 15 °C), and moist conditions but avoid applying when rainfall is expected
	Avoiding surface applications of all organic manures (solid or liquid) when soils are snow-covered, frozen hard, waterlogged, deeply cracked, or on steeply sloping ground adjacent to watercourses.
	If using urea, consider a fertiliser product with a double inhibitor (urease and nitrification) which can further improve nitrogen use efficiency and reduce ammonia and greenhouse gas emissions. A range of 'stabilised nitrogen' fertiliser products exist; those containing urease inhibitors will have the greatest impact on reducing ammonia emissions and therefore nitrogen losses.

	Apply manufactured fertilisers to the soil during favourable conditions, maximising the adsorption of ammonium ions onto the clay component of the soil and organic matter, and at a time when crops can make maximum use of the nitrogen.
	Do not apply Urea/UAN on Alkaline soils (high pH) as it results in higher volatilisation losses. Consider the use of split applications as it reduces ammonia concentrations and volatilisations risks.
Documentation	http://www.cfeonline.org.uk/cfe-reducing-ammonia-emissions-guide/ Defra (2018) http://publications.naturalengland.org.uk/file/6050484412743680 AHDB, RB209 Section 1 & Section 3 https://www.yara.co.uk/crop-nutrition/agronomy-advice/reducing-ammonia-emissions-from-agriculture/ https://www.gov.uk/government/publications/code-of-good-agricultural-practice-for-reducing-ammonia-emissions/code-of-good-agricultural-practice-cogap-for-reducing-ammonia-emissions

Annex 3: Sensitivity analyses

Part 1 - Compliance – Options 1 to 4

Compliance level to the proposed legislation has a significant impact on its outcome, both in terms of costs to business and of air quality improvement. The Better Regulation Framework Manual (2015)[1] states "*When planning to introduce a regulatory measure, costs and benefits should assume 100% compliance, unless there is evidence of the contrary. However, differing levels of compliance should also be investigated through sensitivity analysis.*"

Full compliance with the proposed regulations is assumed as the fertiliser industry has strong records in the UK in complying to legislation and is expected not to make urea fertiliser available (Option 1) or available without the addition of urease inhibitors (Option 2).

However, there is some uncertainty on the level of compliance by farmers, in particular with regard to Option 3 (restricted period). With DAs still consulting on the approach to take on reducing agricultural ammonia emissions, opportunity may arise for farmers to source solid urea from Scotland or Wales.

We performed a sensitivity analysis of the results based on a level of compliance by farmers ranging from 80% to 100%. The results for the central scenario are presented in Table 28 for Option 1 (complete ban of the use of urea), Table 29 for Option 2 (requirement to add urease inhibitors with urea) and Table 30 for Option 3 (requirement for restricted application period).

Table 28: Option 1 - Sensitivity of the results to the level of compliance of farmers with the regulation, in £m, central scenario, 2022 – 2030

Compliance level	50% (Option 4)	80%	90%	100%
Fertiliser application (£m)	66.2	105.9	119.2	132.4
Fertiliser manufacturers - net profit loss (£m)	-5.6	-8.9	-10.0	-11.1
Government costs (£m)	0.8	0.8	0.8	0.8
Familiarisation costs (£m)	1.7	2.8	3.1	3.5
Total costs (£m)	**63.2**	**100.6**	**113.1**	**125.5**
Air quality improvement	569.5	911.1	1025.0	1,138.9
GhG improvement	-22.7	-36.2	-40.8	-45.3
Total benefits (£m)	**546.8**	**874.9**	**984.3**	**1093.6**
TOTAL NPV Option 1 (£m)	**483.6**	**774.3**	**871.2**	**968.1**
Benefit-Cost ratio	**8.7**	**8.7**	**8.7**	**8.7**

For Option 1, the results show that costs to farmers from fertiliser application decrease from £132 million to £106 million when 20% of farmers do not comply.

[1] The latest version of the Better Regulation Framework Guidance (August 2018) does not advise on this matter.

The sensitivity analysis with a 50% compliance rate[2] is shown here to illustrate the effects of a non-regulatory voluntary approach where farmers will be incentivised to shift from solid urea to ammonium nitrate. Additional costs to farmers from fertiliser application are reduced to £66 million and the social net benefit is halved, decreasing from £968 million to £484 million.[3]

Table 29: Option 2 - Sensitivity of the results to the level of compliance of farmers with the regulation, in £m, central scenario, 2022 – 2030

Compliance level	**50% (Option 4)**	**80%**	**90%**	**100%**
Fertiliser application (£m)	31.0	49.6	55.8	62.0
Fertiliser manufacturers - net profit loss (£m)	-2.6	-4.2	-4.7	-5.2
Government costs (£m)	1.4	1.4	1.4	1.4
Familiarisation costs (£m)	3.8	6.0	6.8	7.6
Total costs (£m)	**33.6**	**52.9**	**59.3**	**65.8**
Air quality improvement	461.1	737.8	830.0	922.3
GhG improvement	14.0	22.4	25.2	28.0
Total benefits (£m)	**475.1**	**760.2**	**855.2**	**950.2**
TOTAL NPV Option 2 (£m)	**441.6**	**707.3**	**795.9**	**884.5**
Benefit-Cost ratio	**14.2**	**14.4**	**14.4**	**14.4**

For Option 2, the results show that costs to farmers decrease from £62 million to £50 million when 20% of farmers do not comply.

The sensitivity analysis with a 50% compliance rate[4] is shown here to illustrate the effects of a non-regulatory voluntary approach (Option 4) will be incentivised to add urease inhibitors to solid urea. Additional costs to farmers from fertiliser application are reduced to £31 million and the social net benefit is halved, decreasing from £885 million to £442 million.

[2] Voluntary compliance rate formulated from evidence given in the Greenhouse Gas Action Plan for Agriculture Review 2016, (2017) https://www.gov.uk/government/publications/greenhouse-gas-action-plan-ghgap-2016-review.f

[4] Voluntary compliance rate formulated from evidence given in the Greenhouse Gas Action Plan for Agriculture Review 2016, (2017) https://www.gov.uk/government/publications/greenhouse-gas-action-plan-ghgap-2016-review.f

Table 30: Option 3 – Sensitivity of the results to the level of compliance with the regulation, in £m, central scenario, 2022 – 2030

Compliance level	50% (Option 4)	80%	90%	100%
Fertiliser application (£m)	42.2	67.5	75.9	84.4
Fertiliser manufacturers - net profit loss (£m)	-3.5	-5.7	-6.4	-7.1
Government costs (£m)	2.3	2.3	2.3	2.3
Familiarisation costs (£m)	3.8	6.0	6.8	7.6
Total costs (£m)	**44.7**	**70.2**	**78.7**	**87.1**
Air quality improvement	424.6	679.4	764.3	849.2
GhG improvement	-12.5	-20.0	- 22.5	- 25.0
Total benefits (£m)	**412.1**	**659.4**	**741.8**	**824.3**
TOTAL NPV Option 3 (£m)	**367.4**	**589.2**	**663.2**	**737.1**
Benefit-Cost ratio	**9.2**	**9.4**	**9.4**	**9.5**

For Option 3, the results show that costs to farmers decrease from £84 million to £68 million, when 20% of farmers do not comply.

The sensitivity analysis with a 50% compliance rate[5] is shown here to illustrate the effects of a non-regulatory voluntary approach (Option 4) will be incentivised to apply urea only between 15 January and 31 March. Additional costs to farmers from fertiliser application are reduced to £42 million and the social net benefit is halved, decreasing from £737 million to £367 million.

[5] Voluntary compliance rate formulated from evidence given in the Greenhouse Gas Action Plan for Agriculture Review 2016, (2017) https://www.gov.uk/government/publications/greenhouse-gas-action-plan-ghgap-2016-review.f

Annex 3 - Part 2: Shift to ammonium nitrate (Option 2)

Preliminary consultation with the industry indicates that some stakeholders may be concerned by a potential negative impact of urease inhibitors on soil health in the long term. As a result, some farmers may decide to apply ammonium nitrate instead of urea with urease inhibitors despite the higher cost involved.

A sensitivity analysis on impact on the policy of a proportion of farmers shifting to ammonium nitrate instead of using urease inhibitors.

Table 31: Option 2 - Sensitivity of the results to proportion of farmers shifting to AN instead of using urease inhibitors, in £m, central scenario, 2022 – 2030

Proportion shifting to AN	30%	20%	10%	0%
Fertiliser application (£m)	83.2	76.1	69.1	62.0
Fertiliser manufacturers - net profit loss (£m)	-7.0	-6.4	-5.8	-5.2
Government costs (£m)	1.4	1.4	1.4	1.4
Familiarisation costs (£m)	7.6	7.6	7.6	7.6
Total costs (£m)	**85.1**	**78.6**	**72.2**	**65.8**
Air quality improvement	987.3	965.6	943.9	922.3
GhG improvement	6.0	13.3	20.7	28.0
Total benefits (£m)	**993.3**	**978.9**	**946.6**	**950.2**
TOTAL NPV Option 2 (£m)	**908.2**	**900.3**	**892.4**	**884.5**
Benefit-Cost ratio	**11.7**	**12.4**	**13.4**	**14.4**

The results show that costs to farmers increase from £62 million to £83 million when 30% of farmers, who were using urea before the implementation of the proposed regulation, decide to apply ammonium nitrate instead of continuing to apply urea with the addition of urease inhibitors. This type of farmer behaviour has a positive impact on air quality with the benefit value increasing from £922 million to £987 million.

Annex 3 – Part 3: Shift to ammonium nitrate (Option 3)

As most solid urea is applied in March and April and therefore during the proposed restricted period, farmers may perform different application strategies to conform to the restricted period and to maximise the economic and yield benefit from their solid urea stock. As a result, some farmers may bring forward the entire application made in April to March or bring forward half of any urea application made in April to March (substituting the remainder for ammonium nitrate). Below is presented a sensitivity analysis on the impact of the policy on farmers bringing forward their fertiliser application of urea entirely (100%) or half (50%) from April to March.

Table 32: Option 3 - Sensitivity of the results to proportion of farmers bringing forward their urea application from April to March, in £m, central scenario, 2022 – 2030

Proportion shifting to AN in April and March	100%	50%	0%
Fertiliser application (£m)	29.4	56.9	84.48
Fertiliser manufacturers - net profit loss (£m)	-2.5	-4.8	-7.1
Government costs (£m)	2.3	2.3	2.3
Familiarisation costs (£m)	7.6	7.6	7.6
Total costs (£m)	**36.7**	**61.96**	**87.1**
Air quality improvement	539.1	694.2	849.2
GhG improvement	-4.2	-14.6	-25.0
Total benefits (£m)	**534.9**	**679.5**	**824.3**
TOTAL NPV Option 2 (£m)	**498.2**	**617.6**	**737.1**
Benefit-Cost ratio	**14.6**	**11.0**	**9.5**

The results show that costs to farmers decrease from £84 million to £57 million when 50% of urea applied in April is moved to March with the remainder substituted with ammonium nitrate (AN) before the end of the restricted period. This type of farmer behaviour has a negative impact on air quality (and water quality), which decreases from £849 million to £694 million. When farmers shift all of their urea application from April to March (or 100%), costs decrease from £84 million to £29 million but air quality improvement decreases further from £849 million to £539 million.

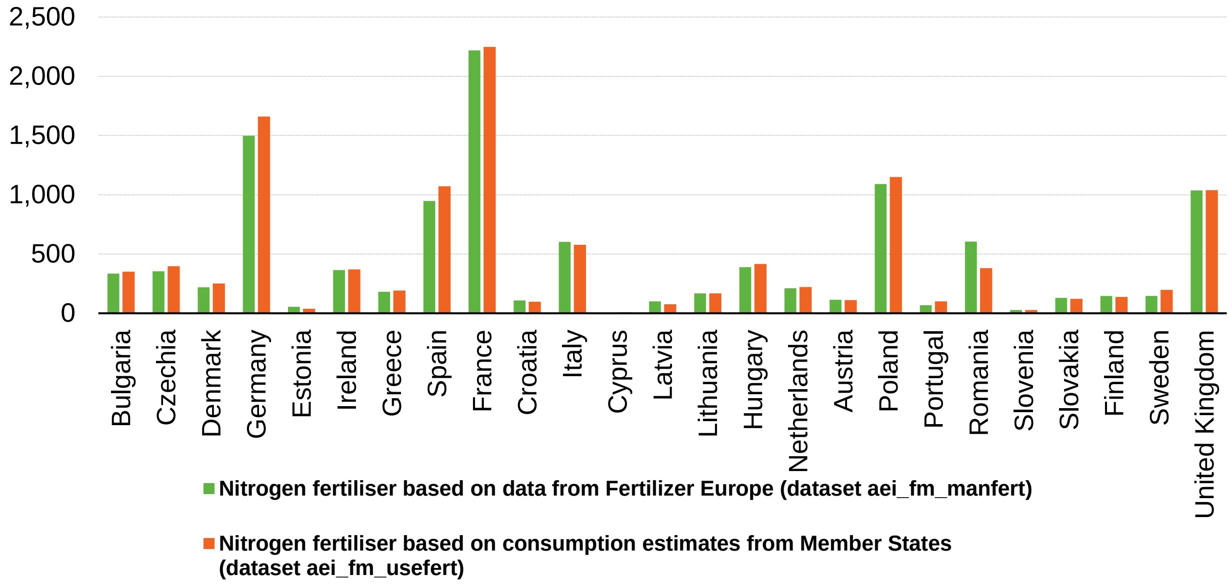
Annex 4 – Review of the UK Fertiliser Market

Review of the UK fertiliser market

The European nitrogen fertiliser market

The UK is a significant player in the European fertiliser market. It is the fourth largest consuming country for nitrogen fertiliser in Europe.

Graph 2: Statistics on nitrogen fertiliser, EU-28, 2017 (thousand tonnes)



Source: Eurostat [accessed on 22 November 2019]

Fertiliser use in the UK

The UK National Atmospheric Emissions Inventory (NAEI)[6] calculates ammonia emissions using activity data and associated emission factors. For fertiliser use, the NAEI sources the data from the annual British Survey of Fertiliser Practice (BSFP) that covers England, Wales and Scotland and from DAERA statistics[7] and the Northern Ireland Farm Business Survey for Northern Ireland. Fertiliser quantity data is then converted into estimates for total N use, based on industry data and expert opinion on the N content for each type of fertiliser. In order to ensure consistency with the NAEI, this Impact Assessment uses the same baseline activity data that underpinned the inventory.

The latest published dataset from the annual British Survey of Fertiliser Practice (BSFP) in 2019[8] provides information on fertiliser use by fertiliser type for Great Britain (see Table 30).

Table 33: Total UK fertiliser use ('000 tonnes) by fertiliser type

Fertiliser	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Urea	227	207	319	162	317	308	358	327	199	350	422	443	392	373	**4,404**

6 https://naei.beis.gov.uk/index

7 Department of Agriculture, Environment and Rural Affairs – Fertiliser Statistics (Accessed 07th October 2018)

8 The British Survey of Fertilizer Practice, 2019
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/806643/fertiliseruse-report2018-06jun19.pdf

Urea ammonium nitrate (UAN)	218	278	315	284	172	291	324	311	362	350	400	353	418	467	**4,453**
Ammonium nitrate (AN)	1,555	1,429	1,285	1,381	1,350	1,526	1,489	1,460	1,507	1,577	1,532	1,406	1,367	1,449	**20,313**
Calcium ammonium nitrate (CAN)	32	18	65	26	49	94	105	53	67	59	54	52	53	83	**810**

Source: The British Survey of Fertiliser Practice (BSFP)

Ammonium nitrate has been consistently the most popular fertiliser product in the UK. It should, however, be noted that AN has lower N content than urea; 100 kg of ammonium nitrate contains typically 34.5 kg of N while 100 kg of urea contains 46kg of N.

The Informative Inventory Report (IIR) (2019)[9] presents total fertiliser N use ('000 tonnes) by land use and fertiliser type (see Table 5). The report shows that nitrogen fertiliser use has decreased significantly since 1990, particularly to grassland. At the same time, the proportion of nitrogen fertiliser applied as urea (associated with a much larger NH_3 emission than other fertiliser types) has increased as a proportion of total fertiliser N use. Data available suggests that in 2017, 25% of total fertiliser N use was applied as urea-based fertilisers. The IIR (2019) highlights that dominant crop types are cereals (i.e. wheat, barley) and oilseed rape, representing approximately 90% of total crop area.

Table 34: Total fertiliser N use in the UK by land use and fertiliser type ('000 tonnes)

	1990	1995	2000	2005	2010	2015	2017
Total fertiliser N use, of which	**1,567**	**1,490**	**1,347**	**1,156**	**1,103**	**1,083**	**1,068**
As urea-based fertiliser (% of N use)	206 (13%)	93 (6%)	84 (6%)	127 (11%)	170 (15%)	222 (21%)	185 (25%)
Total to **tillage**, of which	727	671	691	647	666	686	659
As urea-based fertiliser (% of N use)	144 (20%)	64 (10%)	63 (9%)	107 (17%)	141 (21%)	191 (28%)	241 (36%)
Total to **grassland**, of which	840	819	655	509	437	397	410
As urea-based fertiliser (% of N use)	62 (7%)	29 (4%)	21 (3%)	20 (4%)	29 (7%)	31 (8%)	31 (9%)

Source: Ricardo Energy & Environment (2019). UK Informative Inventory Report (1990 to 2017)

Fertiliser price

Fertiliser prices are extremely volatile and are susceptible to a range of domestic and global factors affecting their supply and demand chain. Following a literature review, the drivers behind fertiliser price volatility were grouped into two broad categories: supply-side factors and demand-side factors. The analysis was further supplemented by information received from stakeholders via targeted consultation on the manufacture and use of urea-based fertilisers.

These drivers are presented in the sections that follow. Natural gas price is identified as the most important driver for all nitrogen fertilisers. Other important drivers include: limited fertiliser production; capacity; prices of

[9] UK Informative Inventory Report (1990 to 2017). Ricardo Energy & Environment (2019 - http://naei.beis.gov.uk/reports/reports?report_id=978 [Accessed March 2019]

(mostly imported) raw materials used to produce fertilisers; and seasonal variation in the demand for fertiliser (due to growing seasons).

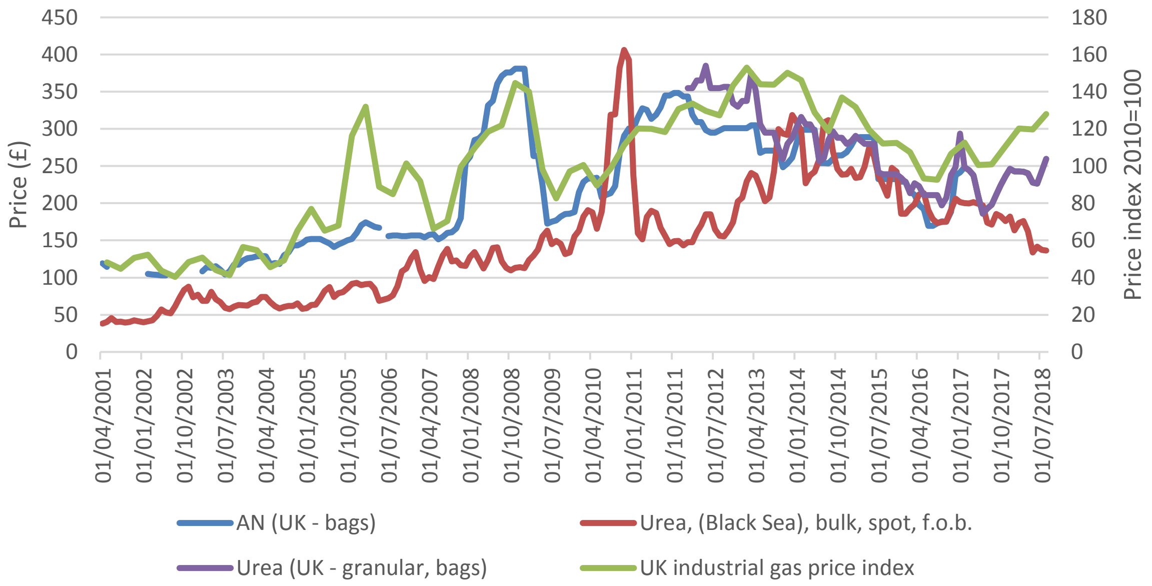
Fertiliser price - Supply-side factors

Fertiliser production has limited flexibility as production plants are expensive to build and operate and consequently run at full capacity all year round with little opportunity to suddenly increase production[10]. As a result, fertiliser production cannot easily respond to increases in demand, which results in price increases in the fertiliser market.

The cost of energy and raw materials also play a significant role in fertiliser price volatility. A research study by IBISWorld[11] highlights that fertiliser prices broadly follow fluctuations in the price of natural gas and reports that the costs of purchasing natural gas is thought to account for as much as 70% of the cost of producing nitrogen (which then forms the basis for all nitrogen fertilisers). In terms of price, natural gas is amongst the most volatile of commodities, second only to electricity[12].

Graph 3 shows a comparison of prices of AN and urea (monthly, in £) with UK industrial gas prices (quarterly, index 2010=100). Urea prices are available from 2012 onwards only, a strong correlation of UK urea and AN prices with industrial gas prices can be observed. This is particularly visible in the following common developments: a strong peak in 2008 (only AN and gas), a common increase from 2009 to 2011, then decrease from 2013-2016 and another smaller peak in 2017 (urea, AN and gas).

Graph 3: Comparison of the UK industrial gas price index with AN and urea prices over the period 2001-2018



Sources:
UK industrial gas price index: Department for Business, Energy & Industrial Strategy. Fuel Price Indices for the Industrial Sector. Last updated 20/12/2018. Available at: https://www.gov.uk/government/statistical-data-sets/industrial-energy-price-indices.
UK urea and AN prices: AHDB (2018)
Urea bulk spot prices f.o.b. ("freight on board", refers to the point in the supply chain at which the costs are measured): Index Mundi. Urea Monthly Price - US Dollars per Metric Ton. Available at: https://www.indexmundi.com/commodities/?commodity=urea&months=240. Converted to GBP using monthly average exchange rates from https://www.ofx.com/en-gb/forex-news/historical-exchange-rates/monthly-average-rates/.

10 Agricultural Industries Confederation. (n.d.). Competition and Prices. [online] Available at: https://www.agindustries.org.uk/sectors/fertiliser/competition-prices/ [Accessed 5 Nov. 2018].

11 [IBISWorld] (2018). *IBISWorld Industry Report C20.150 Fertiliser & Nitrogen Compound Manufacturing in the UK*.

12 Kenkel, P. (2015). Extension. [online] Causes of Fertilizer Price Volatility. Available at: https://articles.extension.org/pages/72692/causes-of-fertilizer-price-volatility [Accessed 5 Nov. 2018].

The prices of other raw materials used to produce fertilisers, such as nitrogen, phosphate rock, sulphur, etc. are also unpredictable. For UK fertiliser production, most of the nitrogen and sulphur has to be imported, while all the phosphate needs have to be imported.[13] Consequently, UK fertiliser prices are not driven by UK producers but by global markets.

Furthermore, imported products are subject to exchange rate variations. IBIS World (2018) reports that the fall in the value of the pound in the recent years has affected industry's margins due to increased prices of imported inputs. About £922 million worth of fertilisers were imported into the UK in 2018/19 to satisfy about 40% of domestic demand. Approximately 70% of imports are from EU countries; mainly Netherlands, Germany and Belgium. Other suppliers include low-cost regions in central and Eastern Europe, Russia, the Middle East and North Africa. For urea specifically, Egypt and more recently Algeria are the UK's biggest suppliers[14].

Another key supply-side trend identified was the strong correlation between the price of urea and the price of UAN and AN. Based on weekly data from industry sources, a correlation of 0.95 between both the price of urea and AN and the price of urea and UAN in 2013-2017 is identified.

Fertiliser price - Demand-side factors (impact on price volatility)

The demand for fertiliser is strongly linked to the price of farm produce, which also affects the demand for produce and planted areas. An increasing world population together with rising average incomes have led to an increase in food demand and a consequent increase in the demand for fertilisers. Fertiliser demand is projected to increase in the long run as population and income growth continue to rise. However, IBIS World (2018) states that overall UK use of straight and compound nitrogen products is estimated to have been relatively flat over the period 2014-19. Crop type trends in fertiliser demand are as follows:

Cereals account for approximately two-thirds of tillage. Over the long term, total fertiliser use has not changed dramatically and is unlikely to alter in the future. The weather has an overwhelming impact on demand from this market, as heavy rainfall in the autumn can result in a greater proportion of spring crop being planted, and these use less fertiliser than winter crops.

Oilseed rape is the third-largest market for fertiliser production and the use of fertiliser on oilseed rape has followed a similar trend to other tillage crops, as they are also largely affected by weather conditions.

Other tillage (sugar beet, potatoes, maize, vegetables, peas, beans and linseed) has remained a small but stable market for fertiliser. Demand levels in this segment are largely in line with tillage.

Grassland has seen a dramatic fall in total fertiliser use in the decade from 1998 to 2008 but since that period fertiliser use on grassland has remained relatively static, with volatility only occurring due to weather patterns and price fluctuations (IBIS World, 2018)

Although fertiliser production operates all year round, fertiliser application occurs mainly within a span of four months in a year. Demand for fertiliser rises greatly close to time of application, which also affects the price of fertiliser. The British survey of fertiliser practice 2017[15] indicates that 80% of all fertilisers, 89% of urea, 94% of UAN, 86% of AN and 68% of CAN are used in March-May in the UK. From consultation with the industry, it can be noted that buyers are offered lower prices for buying fertiliser during the summer/autumn period when its use on farm is typically low. The seasonal price and consumption trends are thus not necessarily aligned, i.e. purchases often are made months in advance (e.g. in winter).

IBIS World, 2018 provides a medium term forecast on fertiliser prices, showing an annual increase in fertiliser prices of 1.3% in 2018-2023. However, there are no details available on individual fertiliser products (e.g. urea, AN, UAN).

---

[13] Agricultural Industries Confederation (2018). [online] Available at https://www.agindustries.org.uk/sectors/fertiliser/competition-prices/ [Accessed 25 Feb. 2019].

[14] Profercy. (2014). 2013: A record year for UK urea imports. [online] Available at: https://www.profercy.com/2014/02/2013-a-record-year-for-uk-urea-imports/ [Accessed 5 Nov. 2018].

[15] Defra (2018). British survey of fertiliser practice 2017. https://www.gov.uk/government/statistics/british-survey-of-fertiliser-practice-2017 [Accessed 25/02/2019].

Industry production costs and profit margins

There is limited publicly available information on profit margins of the UK fertiliser industry and production costs. IBIS World (2018) indicated that the annual revenue of the UK fertiliser and nitrogen compound manufacturing industry is £1.6 billion, and the annual profit is £136.4 million in 2018. Profit was estimated to account for 8.4% in 2018/19.

The report highlighted that industry profitability is influenced by several factors, including raw material and energy costs, both of which can be highly volatile, and the final selling price of the fertilisers.