Consideration of farm-size differences as an aid to cost-effective ammonia emission reduction.

Note submitted by the co-chairs of the Task Force on Reactive Nitrogen[1]

Summary: Ammonia mitigation measures tend to be most cost-effective when applied on medium sized and larger farms. This suggests a case to exclude the smallest farms from ammonia mitigation requirements, especially since there are many small farms that together only contribute a minor share of total ammonia emissions. Here, we compare two metrics for excluding the smallest farms: a) based on the number of Livestock Units (LSU) of each farm and b) based on total nitrogen excretion of the farm.

According to EU-27 data for 2020, 78% (27–99% country ranges) of cattle are on farms with ≥50 LSU. Conversely, only 22% (2–77%) of the farms have ≥50 LSU. Limiting any requirements for ammonia abatement to farms above this threshold thus addresses the majority of emissions at European scale, while focusing action on a small share of farms.

Use of a threshold based on LSU has the advantage of simplicity, given established EU LSU definitions for different animal categories. A disadvantage is that the nitrogen excretion rate per LSU varies widely for different animal categories and between Parties. Drawing on experience from Türkiye, we explore a more equitable approach for excluding the smallest farms, based on the total amount of nitrogen excreted by animals on each farm. A general farm threshold for mitigation requirements of 3500 kg N excretion per year is equivalent to 29 to 51 LU of total cattle across Parties (based on data submitted by Parties to the UNFCCC). A specific threshold for mitigation requirements in Nitrate Sensitive Areas of 1600 kg N excretion per year is equivalent to 13 to 23 LU across Parties. Allowance to use either the LSU or N-excretion metrics would provide flexibility when setting exemptions for ammonia abatement under a revised Gothenburg Protocol, Annex IX.

Background

1. In earlier analyses by the Task Force on Reactive Nitrogen (TFRN), it has been recognized that the cost effectiveness of a revised Annex IX could be improved by specifying farm-size thresholds below which there are no mandatory requirements.[2] In earlier estimates based on data from 2000, it was estimated that a farm size threshold for cattle of 50 Livestock Units (LSU) would mean that ammonia mitigation measures would apply for ~80% of livestock (allowing control on the largest share of ammonia emissions from cattle). Conversely, it was estimated that this threshold would mean that requirements to reduce ammonia emissions only needed to be applied on ~12% of farms.[3] In this way, the largest share of Europe's

[1] Note prepared by experts from the Task Force as a basis for further discussion.
[2] See ECE/EB.AIR/WG.5/2010/4, ECE/EB.AIR/WG.5/2011/3 and ECE/EB.AIR/WG.5/2026/INF.8 https://unece.org/environment/documents/2026/03/informal-documents/opportunities-revising-annex-ix-gothenburg
[3] See appendix to See ECE/EB.AIR/WG.5/2010/4.

ammonia emission sources could be addressed with appropriate measures, while leaving most European farms (88%) free of mandatory requirements.

2. As part of the discussions at the 64th meeting of the Working Group on Strategies and Review (WGSR-64), Türkiye submitted written comments on the paper on Options for Revision of Annex IX prepared by TFRN.[4] Follow up between Türkiye and TFRN has clarified the potential to allow flexibility in setting possible thresholds for the exclusion of the smallest farms from any mandatory requirements. In particular, it was asked: Could a threshold be set that was based on total nitrogen excretion per farm, rather than simply on the number of LSU? This reflects that there may be substantial differences in nitrogen excretion per LSU between farm types and across the UNECE region.
3. In preparing the present note, we have drawn on information sharing between experts from Türkiye and TFRN and on official datasets, including data on nitrogen excretion submitted by Parties to the United Nations Framework Convention on Climate Change (UNFCCC), data on livestock populations and farm sizes compiled by Eurostat, and data on livestock populations and farm sizes from the Turkish Statistical Institute.[5,6]

Animal number distributions in relation to Livestock Unit thresholds.

4. Based on data from Eurostat (for 2020) and Türkiye (for 2016) we show in Table 1 the percentage numbers of livestock (as heads of animals) that would be above three possible farm-size thresholds of 20, 50 and 100 LSU.
5. Variation in the livestock herd distributions is reflected in different percentage values between countries and between cattle and pigs. For cattle, the overall value for the EU-27 is 78% of the animals (and hence roughly the emissions) are on farms of ≥50 LSU.[7] If this threshold were applied for mandatory measures in Annex IX, it would exempt 22% of EU cattle from requirements.
6. A tighter threshold of ≥20 LSU would include 91% of cattle. If this threshold were used for mandatory measures in Annex IX, then only 9% of EU cattle would be

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[4] https://unece.org/environment/documents/2026/05/informal-documents/turkiyes-comments-tfrns-paper-opportunities

[5] UNFCCC data on livestock N excretion from Table 3B(b) of national inventory reports for year 2020, accessed through the UNFCCC GHG Data Interface (https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc). Eurostat data on livestock populations from the 2020 Farm Structure Survey (https://doi.org/10.2908/EF_FSI_LSK). Turkish Statistical Institute data on bovine livestock population by farm size, from the 2016 Agricultural Holdings Structure Survey (https://veriportali.tuik.gov.tr/en/statistical-themes). All datasets accessed on 8 July, 2026,

[6] For the purpose of this note, we adopt the standard multipliers for Livestock Units (LSU) as follows: Bovine animals <1 year old (0.4 LSU), Bovine animals ≥1 to <2 years old (0.7 LSU), Male bovine animals ≥2 years old (1.0 LSU), Heifers ≥ 2 years old (0.8 LSU), Dairy cows (1.0 LSU), Non-dairy cows (0.8), Piglets liveweight <20 kg (0.027 LSU), Breeding sows ≥50 kg (0.5 LSU) and Other swine (0.3 LSU). https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Livestock_unit_(LSU)

[7] A slightly higher value is reported in ECE/EB.AIR/WG.5/2026/INF.8 based on projections for 2030.

exempted from requirements. Conversely a looser threshold of ≥100 LSU would include only 60% of EU cattle (exempting 40% from requirements).

7. Using the middle threshold of ≥50 LSU for cattle shows variation for 2020 from 27% of livestock included for Slovenia (which has the largest fraction of small farms) to 99% for Cyprus (which has the smallest fraction of small farms).
8. On average, pigs are reared in farms with higher numbers of LSU than for cattle. This is reflected in much larger percentages of the national herds occurring above the farm size thresholds. For the EU-27 as a whole, 95% of pigs are on farms with ≥50 LSU, with this figure varying from 54% (Croatia) to 100% (Belgium, Denmark, Ireland, Netherlands). As will be seen below, the higher percentage values for pigs also should be seen in relation to the LSU values for pigs representing a smaller nitrogen excretion per LSU than for cattle.

Farm number distributions in relation to Livestock Unit thresholds.

9. Using the same data sources for 2020 and 2016, we show in Table 2 the percentage numbers of farms that would be above the three farm-size thresholds of 20, 50 and 100 LSU.
10. For cattle farms, the overall value for the EU-27 is that 22% of farms with cattle have ≥50 LSU.[8] If the threshold 50 LSU were applied for mandatory measures in Annex IX, it would exempt 78% of EU cattle farms from requirements.
11. The threshold of ≥20 LSU would include 39% of cattle farms. If this threshold were used for mandatory measures in Annex IX, it would exempt 61% of EU farms with cattle from requirements. Conversely, the looser threshold of ≥100 LSU would mean that requirements only apply to 11% of EU cattle farms (i.e., 91% of farms with cattle being exempted).
12. Using the middle threshold ≥50 LSU shows variation for 2020 from 2% of cattle farms included for Romania (which has many small farms under the threshold) to 77% for Cyprus (where cattle are mainly on large farms).
13. The percentage numbers of farms above the LSU thresholds are smaller for pigs than cattle, reflecting the typically larger size of pig farms. For the EU-27 as a whole, only 8% of farms with pigs have ≥50 LSU, with this figure varying widely from 0% (Romania) to 93% (Belgium).

Use of thresholds for ammonia mitigation based on Livestock Units

14. Overall, use of a threshold based on LSU provides a simple approach using a widely farm size indicator, which is able to distinguish between the large number of small farms (overall contributing only a small amount to ammonia emissions) and the smaller share of medium and large farms (with many animals, contributing to most of the ammonia emissions).

[8] A somewhat smaller value is estimated for ECE/EB.AIR/WG.5/2026/INF.8 based on projection for 2030.

15. Here we have focused on three potential thresholds below which a future Annex IX could allow exemption from mandatory measures. From a technical perspective, a threshold of 50 LSU has the advantage that mandatory actions would apply to most of the animals (~78% of cattle and 95% of pigs), while only requiring mandatory actions on a small share of the farms (22% of cattle farms and 8% of pig farms). Such a threshold also matches a broad distinction between small farms run on a part-time basis (with less possibility for investment) and farms run by full-time professional farmers.
16. Selecting a threshold based on 20 LSU would imply a higher level of ambition for ammonia mitigation, as only 9% of cattle and 3% of pigs would be exempted from requirements, while this requires actions on 39% of cattle farms and 13% of pig farms (almost double that for the 50 LSU threshold). Such a threshold (or even smaller) would suit the context where ammonia mitigation is a high political priority given its adverse effects.
17. Selecting a threshold based on 100 LSU would imply a lower level of ambition for ammonia mitigation. This would require mandatory action on only 11% of cattle farms across the EU but would, conversely, only require measures for 60% of the EU cattle herd. Such a threshold would be reflective of a low level of political priority to control ammonia emissions.
18. Subject to feedback from the Parties on their level of ambition for ammonia mitigation, we here take the 50 LSU threshold further as a pragmatic balance that looks to maximize the application of measures to reduce ammonia emissions while minimizing requirements to the smallest farms.

Variation in nitrogen excretion per Livestock Unit and opportunities for flexibility

19. Based on the discussions at WGSR-64, we understand that flexibility would be welcome regarding the choice of units to allow exclusion of the smallest farms from any mandatory requirements. In this regard, Türkiye has reported its use of such thresholds in relation to nitrate pollution, where the thresholds are defined in terms of total nitrogen excretion (kg N excretion per farm per year). The use of total nitrogen excretion makes sense also for ammonia emissions, since the primary driver of emissions is the quantity of excreted nitrogen.
20. We here examine this approach with a view to identifying an alternative way to define exclusion of the smallest farms. For this purpose, we used data reported by Parties to the UNFCCC on total nitrogen excretion in combination with Eurostat data on livestock numbers and livestock units (LSU).
21. Based on the combined UNFCCC/Eurostat dataset, we summarize in Figure 1 the variation in annual nitrogen excretion per LSU for total cattle, dairy cows, other cattle and for pigs. Firstly, the reported nitrogen excretion is much smaller per LSU for pigs than for cattle.[9] Secondly, dairy cattle tend to have higher nitrogen excretion

[9] As already noted in paragraph 8.

per LSU than other cattle (total cattle reflect the average). This difference reflects the more intensive production systems of dairy farming that is not fully reflected in the standard LSU equivalents. Substantial differences are also seen between countries submitting data. For dairy cows, the highest N excretion rates are reported for Denmark and the Netherlands (157, 150 kg N /LSU/year), with the lowest value for Romania (81 kg N /LSU/year). Parties might therefore wish to set thresholds for exempting small farms using a more equitable approach based on total nitrogen excretion.

22. According to such an approach, exemptions for the smallest farms would be based a threshold for total nitrogen excretion per farm per year. Application of this approach by Türkiye is informative and provides a benchmark that links to the LSU-based approach. According to the approach of Türkiye for management of nitrate pollution of water courses, the following are used:
    a. **General threshold for mitigation requirements by farms: 3500 kg N excretion per farm per year.** Informally, this limit is roughly equivalent to 50 LSU for cattle excreting 70 kg N per year.
    b. **Specific threshold for mitigation requirements by farms in nitrate-sensitive areas: 1600 kg N excretion per farm per year.** Informally, this limit is roughly equivalent to 23 LSU for cattle excreting 70 kg N per year.
23. Recognizing the differences in nitrogen excretion per animal between Parties, we illustrate the application of these thresholds in Table 3 (general threshold) and Table 4 (specific threshold for requirements by farms in nitrate-sensitive areas).
24. According to the **general threshold**, application of the values outlined in paragraph 22 leads to a somewhat more ambitious approach to setting the thresholds, as these equate to smaller amounts of LSU. In Croatia, Greece, Iceland and Türkiye, the threshold of 46 to 51 LSU is close to the benchmark of 50 LSU for total cattle. However, the threshold of 29 LSU for total cattle in Denmark and the Netherlands is somewhat smaller. The thresholds of 22 to 23 LSU for dairy cows in these countries is smaller still, but is larger (more relaxed) than the thresholds for mandatory mitigation requirements for ammonia already in force in these two countries.[10] For pigs, the general threshold is in all cases larger than the 50 LSU benchmark.
25. According to the **specific threshold for requirements by farms in Nitrate-Sensitive Areas**, the LSU thresholds for several are substantially smaller than the 20 LSU benchmark. The smallest LSU thresholds are those for dairy cows in Denmark and the Netherlands (since these excrete the most per animal), at 10 to 11 LSU. Again, these thresholds remain more relaxed than already in place in these two countries.

[10] In Denmark an exemption from mandatory requirements applies for farms of less than 5 LSU.

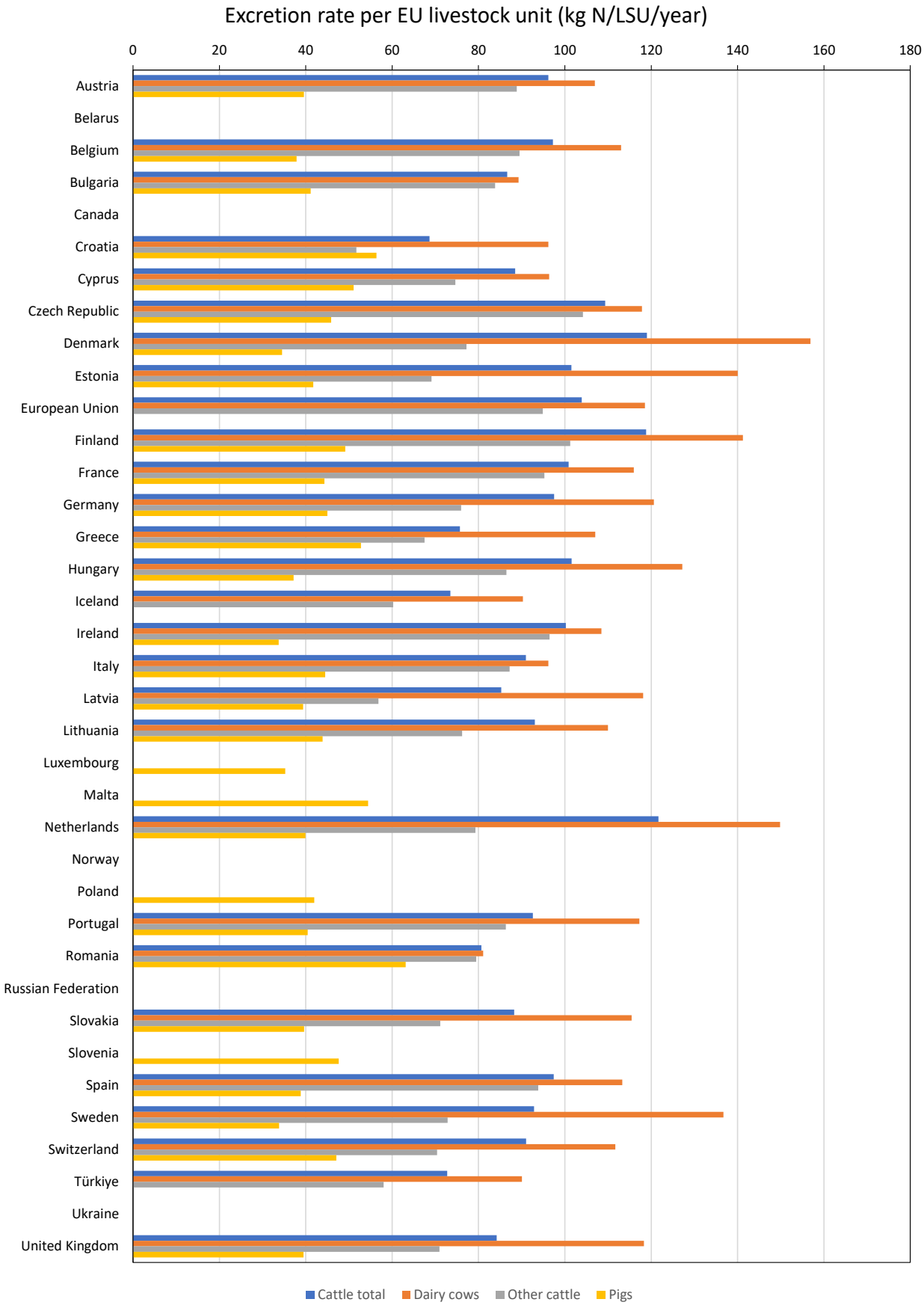

Figure 1: Variation in the annual amount of nitrogen excreted per Livestock Unit (LSU) between animal types and between Parties to the Convention on Long-range Transboundary Air Pollution (based on official data reported to the UNFCCC and Eurostat).

26. For the purpose of drafting possible revisions to Annex IX, the present examination highlights the potential for flexibility in setting exemptions from requirements for the smallest farms (e.g. a simple exemption based on LSU, or a more equitable exemption based on total annual nitrogen excreted per farm).
27. The data requirements are relatively simple in each case, since standard ratios apply between livestock numbers and LSU, with values of annual nitrogen excretion per animal already reported to the UNFCCC.

Possible framing of an exemption for small farms in Annex IX

28. It is relevant to consider how such thresholds could appear in a revised Annex IX. Here we simply illustrate the case of a generic ammonia abatement requirement, which is first specified, and then an exemption for 'Small farms' is provided.[11] Such a requirement / exemption could read:

"For livestock farms defined as 'small farms', this requirement applies only as far as the party considers it feasible. This relaxation does not apply to manure transported for application to arable farms.

'Small farms' are defined as either: a) those livestock farms holding less than 50 livestock units (Note 1), or b) those livestock farms where total nitrogen excretion is less than 3500 kg nitrogen per year. Parties shall report which threshold they adopt in implementing these provisions.[12]

Note 1: The following equivalents for Livestock Units (LSU) shall apply: Bovine animals <1 year old (0.4 LSU), Bovine animals ≥1 to <2 years old (0.7 LSU), Male bovine animals ≥2 years old (1.0 LSU), Heifers ≥ 2 years old (0.8 LSU), Dairy cows (1.0 LSU), Non-dairy cows (0.8 LSU), Piglets liveweight <20 kg (0.027 LSU), Breeding sows ≥50 kg (0.5 LSU) and Other swine (0.3 LSU).

Questions to Parties

29. The Task Force invites feedback from the Parties:
    a. Would the use of exemptions from requirements for the smallest farms provide a helpful flexibility to support ultimate agreement on cost-effective ammonia mitigation?
    b. Does the level of ambition of the options presented here provide a useful starting point for further discussions by the Parties?

[11] For example, see Table 2 of ECE/EB.AIR/WG.5/2026/INF.8 "Opportunities for revising Annex IX of the Gothenburg Protocol" (WGSR-64, May 2026).
[12] Parties would be at liberty to adopt and report lower thresholds for environmentally sensitive areas, such as based on 1600 kg N per farm per year (see Table 4).

Table 1: Percentage of cattle and pig (based on total *number of heads*) that are on farms of more than or equal to 20, 50 and 100 Livestock Units (LSU), based on Eurostat data for 2020, and Türkiye data for 2016. Conversions to LSU for Türkiye are approximate. Note: * 150 LSU in the case of Türkiye.

	All cattle			All pigs		
Country or region	**≥20 LSU**	**≥50 LSU**	**≥100 LSU***	**≥20 LSU**	**≥50 LSU**	**≥100 LSU***
Austria	78%	39%	10%	98%	92%	73%
Belgium	98%	92%	76%	100%	100%	99%
Bulgaria	82%	60%	37%	99%	98%	97%
Croatia	76%	54%	40%	61%	54%	50%
Cyprus	100%	99%	94%	#N/A	#N/A	#N/A
Czechia	95%	88%	81%	99%	98%	97%
Denmark	95%	89%	84%	100%	100%	100%
Estonia	94%	84%	73%	#N/A	#N/A	#N/A
EU-27	91%	78%	60%	97%	95%	92%
Finland	97%	78%	48%	100%	98%	92%
France	98%	91%	72%	100%	99%	98%
Germany	96%	86%	69%	99%	97%	93%
Greece	93%	75%	44%	97%	94%	91%
Hungary	90%	80%	70%	92%	90%	88%
Iceland	99%	94%	62%	#N/A	#N/A	#N/A
Ireland	92%	74%	51%	100%	100%	99%
Italy	92%	80%	64%	98%	96%	93%
Latvia	80%	60%	42%	96%	95%	94%
Lithuania	74%	55%	38%	95%	94%	94%
Luxembourg	99%	95%	82%	#N/A	#N/A	#N/A
Malta	93%	85%	65%	#N/A	#N/A	#N/A
Netherlands	99%	95%	82%	100%	100%	99%
Norway	95%	70%	36%	99%	96%	82%
Poland	72%	37%	17%	89%	79%	68%
Portugal	89%	75%	58%	96%	95%	93%
Romania	49%	30%	19%	58%	56%	55%
Slovakia	93%	88%	82%	97%	95%	94%
Slovenia	55%	27%	11%	72%	58%	45%
Spain	94%	80%	61%	100%	99%	97%
Sweden	95%	83%	65%	100%	99%	98%
Switzerland	88%	43%	18%	99%	90%	68%
Türkiye	65%	40%	20%*	#N/A	#N/A	#N/A

Table 2: Percentage of *farms* that have more than or equal to 20, 50 and 100 LSU of cattle or pigs, based on Eurostat data for 2020, and Türkiye data for 2016. Conversions to LSU for Türkiye are approximate. Note: * 150 LSU in the case of Türkiye.

	All cattle			All pigs		
Country or region	**≥20 LSU**	**≥50 LSU**	**≥100 LSU***	**≥20 LSU**	**≥50 LSU**	**≥100 LSU***
Austria	45%	13%	2%	53%	26%	12%
Belgium	79%	61%	41%	96%	93%	86%
Bulgaria	21%	9%	3%	9%	5%	4%
Croatia	20%	5%	2%	5%	1%	1%
Cyprus	87%	77%	65%	#N/A	#N/A	#N/A
Czechia	44%	24%	15%	31%	17%	12%
Denmark	42%	28%	23%	89%	86%	83%
Estonia	48%	25%	15%	#N/A	#N/A	#N/A
EU-27	39%	22%	11%	13%	8%	6%
Finland	82%	44%	17%	95%	82%	64%
France	79%	62%	37%	79%	69%	58%
Germany	67%	44%	26%	77%	64%	52%
Greece	60%	32%	12%	31%	14%	6%
Hungary	29%	14%	8%	5%	2%	1%
Iceland	95%	77%	35%	#N/A	#N/A	#N/A
Ireland	62%	33%	15%	63%	43%	30%
Italy	45%	24%	12%	31%	16%	10%
Latvia	20%	8%	3%	15%	5%	2%
Lithuania	13%	5%	2%	6%	2%	1%
Luxembourg	84%	72%	51%	#N/A	#N/A	#N/A
Malta	46%	33%	17%	#N/A	#N/A	#N/A
Netherlands	84%	71%	48%	93%	88%	81%
Norway	78%	40%	15%	85%	73%	52%
Poland	29%	8%	2%	31%	13%	7%
Portugal	31%	17%	9%	10%	5%	3%
Romania	6%	2%	0%	2%	0%	0%
Slovakia	26%	16%	12%	12%	7%	5%
Slovenia	16%	4%	1%	16%	5%	2%
Spain	53%	32%	17%	64%	53%	42%
Sweden	60%	36%	20%	73%	63%	55%
Switzerland	67%	20%	6%	90%	55%	25%
Türkiye	16%	5%	1%*	#N/A	#N/A	#N/A

Table 3: Livestock Unit (LSU) thresholds for farms that are equivalent to 3500 kg N per year. Based on 2020 nitrogen excretion and livestock population data submitted to the UNFCCC and Eurostat.

Country or region	Cattle total	Dairy cows	Other cattle	Pigs
Austria	36	33	39	88
Belarus	#N/A	#N/A	#N/A	#N/A
Belgium	36	31	39	92
Bulgaria	40	39	42	85
Canada	#N/A	#N/A	#N/A	#N/A
Croatia	51	36	68	62
Cyprus	40	36	47	68
Czech Republic	32	30	34	76
Denmark	29	22	45	101
Estonia	34	25	51	84
European Union	34	30	37	#N/A
Finland	29	25	35	71
France	35	30	37	79
Germany	36	29	46	78
Greece	46	33	52	66
Hungary	34	28	40	94
Iceland	48	39	58	#N/A
Ireland	35	32	36	104
Italy	38	36	40	79
Latvia	41	30	62	89
Lithuania	38	32	46	80
Luxembourg	#N/A	#N/A	#N/A	99
Malta	#N/A	#N/A	#N/A	64
Netherlands	29	23	44	88
Norway	#N/A	#N/A	#N/A	#N/A
Poland	#N/A	#N/A	#N/A	83
Portugal	38	30	41	87
Romania	43	43	44	55
Russian Federation	#N/A	#N/A	#N/A	#N/A
Slovakia	40	30	49	88
Slovenia	#N/A	#N/A	#N/A	73
Spain	36	31	37	90
Sweden	38	26	48	103
Switzerland	38	31	50	74
Türkiye	48	39	60	#N/A
Ukraine	#N/A	#N/A	#N/A	#N/A
United Kingdom	42	30	49	89

Table 4: Livestock Unit (LSU) thresholds for farms that are equivalent to 1600 kg N per year. Based on 2020 nitrogen excretion and livestock population data submitted to the UNFCCC and Eurostat. Such a lower threshold compared with Table 3 could be applied in environmentally sensitive areas (e.g. nitrate sensitive areas, as used in Türkiye).

Country or region	Cattle total	Dairy cows	Other cattle	Pigs
Austria	17	15	18	40
Belarus	#N/A	#N/A	#N/A	#N/A
Belgium	16	14	18	42
Bulgaria	18	18	19	39
Canada	#N/A	#N/A	#N/A	#N/A
Croatia	23	17	31	28
Cyprus	18	17	21	31
Czech Republic	15	14	15	35
Denmark	13	10	21	46
Estonia	16	11	23	38
European Union	15	13	17	#N/A
Finland	13	11	16	33
France	16	14	17	36
Germany	16	13	21	36
Greece	21	15	24	30
Hungary	16	13	19	43
Iceland	22	18	27	#N/A
Ireland	16	15	17	47
Italy	18	17	18	36
Latvia	19	14	28	41
Lithuania	17	15	21	36
Luxembourg	#N/A	#N/A	#N/A	45
Malta	#N/A	#N/A	#N/A	29
Netherlands	13	11	20	40
Norway	#N/A	#N/A	#N/A	#N/A
Poland	#N/A	#N/A	#N/A	38
Portugal	17	14	19	40
Romania	20	20	20	25
Russian Federation	#N/A	#N/A	#N/A	#N/A
Slovakia	18	14	22	40
Slovenia	#N/A	#N/A	#N/A	34
Spain	16	14	17	41
Sweden	17	12	22	47
Switzerland	18	14	23	34
Türkiye	22	18	28	#N/A
Ukraine	#N/A	#N/A	#N/A	#N/A
United Kingdom	19	14	23	41