## D.6.4 .1: POLICY EVALUTATION

This deliverable presents the testing of the MIND STEP toolbox to perform an integrated ex-ante policy assessment based on the various spatial scales and economic, environmental and social dimensions of the models in the toolbox. We applied the toolbox to examine two benchmark scenarios for EU agriculture in 2030, regarding climate mitigation and reduction of mineral nitrogen fertiliser use, key issues identified by the MIND STEP stakeholders. These scenarios link different models and activities across the MIND STEP project.

The new modelling possibilities offered by the MIND STEP toolbox are based on the bioeconomic and technology rich farm model FarmDyn and other micro-models that have been added to the set of micro- and macro-models frequently used by the European Commission (IFM-CAP, CAPRI, GLOBIOM, MAGNET). The micro-models include farm management changes and therefore allow more realistic assessment of scenario impacts. The modelling work in MIND STEP has not only improved the representation of farmer behaviour, technological options, and management practices at Individual Decision Making level, but has also established improved linkages with the sectoral models MAGNET, CAPRI, and GLOBIOM, which is a stated objective of the MIND STEP project.

Notwithstanding these improvements, the model results can still exhibit a rather wide range of possible outcomes. This wide range can in particular be attributed to data uncertainty and different levels of mitigation technologies represented in the models.

Our policy recommendations stress gradual implementation, adaptive support mechanisms, and flexible phase-out strategies, all acknowledging the crucial role of evolving technology in achieving sustainable agricultural practices.

The preferential approach seems to lean towards emissions taxation. A gradual implementation allowing farmers and markets the necessary time to adjust and invest in emission-reducing technologies is recommended. Tax revenues could be channelled to support farms adopting these technologies, lessening potential income impacts while acknowledging possible rises in food prices. A careful roll-out of a subsidy on CO2eq emission reduction strategy could also be further investigated. In this case, gradual implementation is also recommended, especially to prevent overcompensation. Periodic assessments of farm-specific emission benchmarks would facilitate a phased policy withdrawal once emission reduction goals are met, considering technological advancements like improved breeding methods.

Regarding  mineral N fertilizer use reduction, emphasizing mitigation technologies remains critical. Redirecting tax revenues to supplement subsidies could help mitigate extreme income and price fluctuations, even though environmental benefits might be somewhat compromised.

Finally, Deliverable 6.4 also sheds light on three main areas for refining the MIND STEP toolbox: (i) improving accuracy in representing farm-level impacts and incorporating structural changes; (ii) improving data quality, especially with regard to the specific costs of each region and sector and the mitigation potentials of new technologies; and (iii) enhancing model alignment and transparency. Addressing these methodological aspects will ultimately strengthen the quality of model-based scientific advice for the CAP, aimed at a nuanced and adaptable implementation of sustainable agricultural practices.

Below the scenario strategies, models used and key results of the Greenhouse Gas mitigation scenario and the mineral Nitrogen (N) fertiliser use reduction scenario are summarised.

**Scenario strategies, models used and key results of the Greenhouse Gas mitigation scenario**

*Scenario strategies and models used:*

| GHG Scenario strategy | Description | Name strategy | Models used |
|---|---|---|---|

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| | | | |
|---|---|---|---|
| TAXATION | 65 and 130 Euro tax on $CO_2$eq emission in the agricultural sector in the EU | 65CO2eq_TAX<br>130CO2eq_TAX | MAGNET,GLOBIOM, FarmDyn |
| TAXATION and REDISTRIBUTION | 65 and 130 Euro tax on $CO_2$eq emission in the agricultural sector in the EU. The national tax revenues are redistributed to the agricultural sector for each MS via a uniform payment per ha of utilised agricultural area (cropland and pasture) | 65CO2eq_TAX_RE<br>130CO2eq_TAX_RE | GLOBIOM |
| SUBSIDY | 65 and 130 Euro subsidy on $CO_2$eq emission reduction in the agricultural sector in the EU without budget neutral finance. | 65CO2eq_SUB<br>130CO2eq_SUB | MAGNET, FarmDyn |
| SUBSIDY and ADJUSTMENT VIA CAP DIRECT PAYMENT | 65 and 130 Euro subsidy on $CO_2$eq emission reduction in the agricultural sector in the EU with budget neutral financing of the subsidy, which is assumed to happen at MS level via adjustment of MS specific direct payments in Pillar 1 of the CAP. The adjustment depends on $CO_2$eq emission reduction and subsidy budget needed per MS. | 65CO2eq_SUB_DP<br>130CO2eq_SUB_DP | MAGNET, FarmDyn |

Key result per scenario strategy:

TAXATION strategy (65CO2eq_TAX, 130CO2eq_TAX): summary of results from MAGNET, GLOBIOM and FarmDyn

- GHG emission from agriculture decreases around - 27% at a CO2eq price level of 130 euro/tonne (130CO2eq_TAX) in the EU27 but leads to a substantial reduction of primary agricultural production, caloric consumption and economic growth. Employment of skilled labour in primary agriculture decreases with more than 1% (MAGNET). The change in GDP is projected to be around -0.8% (MAGNET).
- Tax income equals about 22 bn euro in the 65CO2eq_TAX variant and about 39.6 bn euro in the 130CO2eq_TAX variant (GLOBIOM)
- The balance of trade worsens, with particular strength on the livestock sector (MAGNET)
- Adoption of technologies is the most important source of GHG emission reduction in the EU (GLOBIOM).
- Nevertheless, especially GHG intensive products like milk and cattle production decreases and fallow land is increasing as some cropland (-11%) and pastures (-14%) are being moved out of production as livestock production declines (GLOBIOM).
- There are noticeable cross-country differences. The effect on primary agricultural production is particularly strong in Ireland and East Europe (Estonia, Latvia, Lithuania). In Ireland primary

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agricultural production decreases with around 26%. In East Europe this is between 10 and 15% (MAGNET).
- Most pronounced increases in prices are observed for ruminant products (beef, milk). In the 130CO2eq_TAX variant price of beef decreases with around 16% (GLOBIOM). For milk Kproducts this is about 14% (GLOBIOM).
- Although agricultural prices increase, food consumption in the EU is rather constant (GLOBIOM)
- Milk production per NUTS2 average continuing dairy farm in the EU is constant (FarmDyn). This is especially explained by the market-feedback as taken from MAGNET.
- Average in EU27 income decreases with around 4000 euro per Agricultural Working Unit (AWU) per average dairy farm in the 65CO2eq_TAX variant and with around 5000 euro per AWU per average dairy farm in the 130CO2eq_TAX variant (FAMDYN). This about 12 and 15% of average dairy farm income in 2018 respectively.
- In the 130CO2eq_TAX variant, land prices in the EU27 decrease with about 12% (MAGNET)

*Table 1 MAGNET Summary Results of EU27 (% change with respect to 2030 baseline)*

| | 65CO2eq_ TAX | 65CO2eq_ SUB | 65CO2eq_ SUB_DP | 130CO2eq_ TAX | 130CO2eq_ SUB | 130CO2eq_ SUB_DP |
|---|---|---|---|---|---|---|
| **Price Agri. Prim.** | 5.33 | 0.53 | 0.76 | 10.30 | 1.21 | 1.77 |
| **Production Agri. Prim.** | -2.53 | -0.16 | -0.35 | -4.55 | -0.36 | -0.80 |
| **Skilled labour (Agri. prim.)** | -1.23 | 0.50 | 0.33 | -1.94 | 1.14 | 0.74 |
| **Unskilled labour (Agri. prim.)** | -0.75 | 0.45 | 0.29 | -1.13 | 1.04 | 0.65 |
| **GDP** | -0,43 | -0,01 | -0,01 | -0,82 | -0,04 | -0,03 |
| **Total Emission (CO2eq)** | -15,77 | -1,33 | -1,34 | -23,87 | -1,79 | -1,82 |
| **Agri Emission (CO2eq)** | -19,05 | -12,47 | -12,63 | -27,00 | -16,77 | -17,12 |
| **Total Calories** | 0.14 | -0.06 | -0.07 | 0.33 | -0.12 | -0.15 |
| **Animal Calories** | -1.07 | -0.18 | -0.24 | -1.93 | -0.40 | -0.54 |

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TAXATION and REDISTRIBUTION strategy (65CO2eq_TAX_RE, 130CO2eq_TAX_RE). summary of results from GLOBIOM

- Compared to variants without redistribution (variants 65CO2eq_TAX and 130CO2eq_TAX), the redistribution of the GHG tax (variants 65CO2eq_TAX_RE and 130CO2eq_TAX_RE) decreases agricultural non-CO2 mitigation potentials and increases GHG emissions.
- Hence, compared to the variants without redistribution, tax income increases to about 22.5 bn euro in the 65CO2eq_TAX_RE variant and about 42.8 bn euro in the 130CO2eq_TAX_RE variant (GLOBIOM)
- The redistribution of the GHG tax, buffers negative effects on production and areas
- Redistribution of GHG tax smoothens negative impacts on prices also on the demand side.

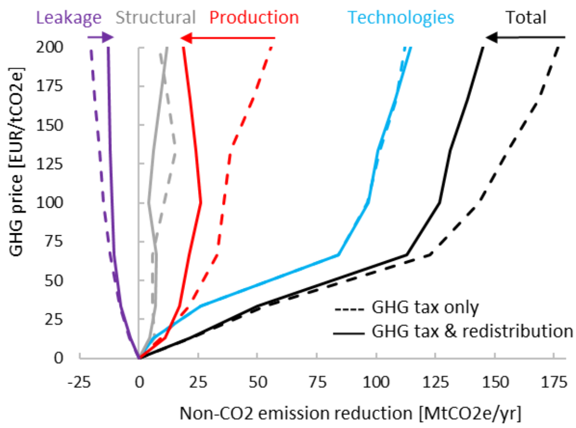


Figure 1. GLOBIOM. Agricultural non-$CO_2$ mitigation potential decomposed by mitigation mechanism across GHG price variants (from 0 euro/ton CO2eq to 200 euro per ton CO2eq) with and without redistribution of carbon tax.

SUBSIDY and ADJUSTMENT VIA CAP DIRECT PAYMENT strategy (65CO2eq_SUB_DP 130CO2eq_SUB_DP). Summary of results from MAGNET and FarmDyn

- Compared to the TAXATION strategy, the 130CO2eq_SUB_DP strategy largely mitigates the economic damages, though it leads to less significant effects in terms of GHG emission reduction. In fact, impact on total, economy-wide GHG emission reduction reduces to less than 2%, while GHG emission from primary agriculture decreases with around 17% (MAGNET). Employment of skilled labour in primary agriculture increases with around 0.7%, while GDP is about constant as compared to the base (no change) (MAGNET)
- Milk and cattle production decreases with less than 0.5% and less than 1% in the 65CO2eq_SUB_DP and 130CO2eq_SUB_DP variants respectively (MAGNET).
- Prices of ruminant products (beef, milk) increases with around 1% and 3% in the 65CO2eq_SUB_DP and 130CO2eq_SUB_DP variants respectively (MAGNET).
- The redistribution of the direct payments of the CAP equals about 3.5 bn euro and 9.6 bn euro in the 65CO2eq_SUB_DP and 130CO2eq_SUB_DP variants respectively (MAGNET, own calculations)
- Milk production per NUTS2 average continuing dairy farm in the EU27 is constant (FarmDyn)
- dairy farm income increases around 3000 euro and 6000 euro per AWU per farm in the 65CO2eq_SUB_DP strategy and 130CO2eq_SUB_DP strategy respectively (FarmDyn). This

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increase in farm income on the NUTS2 average dairy farm in the EU, includes the market-feedback as taken from the market model MAGNET. In more detail the increase in farm income on the average dairy farm in the EU is explained as follows:

- Number of dairy cows per average dairy farm is constant (see above)
- Subsidy exceeding the average costs of CO2eq emission reduction per average dairy farm
- Higher market output prices especially milk, via slight reduction in milk output at aggregate level (MAGNET)
- Total revenue from milk and meat per average dairy farm increases.
- The sum of subsidy over average extra costs plus higher output prices exceed the decrease in direct payments per average dairy farm

- Within the dairy sector positive income effects of the SUBSIDY and ADJUSTMENT VIA CAP DIRECT PAYMENT strategy are lowest/highest on farms with relative low/high CO2eq emissions per ha (FarmDyn)
- Land prices in the EU27 increase with about 5% (MAGNET)

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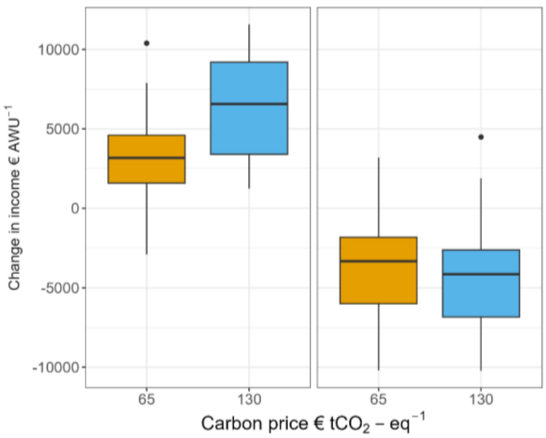


Figure 2 FarmDyn. changes in farm income per AWU. Left panel 65CO2eq_SUB_DP and 130CO2eq_SUB_DP variants. Right panel 65CO2eq_TAX and 130CO2eq_TAX variants

**Scenario strategies, models used and key results of the mineral Nitrogen (N) fertiliser use reduction scenario**

*Scenario strategies and models used*

| Reduction scenario strategy | Description | Name strategy | Models used |
|---|---|---|---|
| TAXATION | Between 3 and 132 % tax on N mineral fertilizer prices, based on emissions originating from fertilizer application and production (**Error! Reference source not found.**) | 3 % – 132 % | GLOBIOM, CAPRI, FarmDyn, IFM CAP, INRAE-MC |

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| | | | |
|---|---|---|---|
| TAXATION and AREA BASED REDISTRIBUTION | Between 3 and 132 % tax on N mineral fertilizer prices. The national tax revenues are redistributed to the agricultural sector for each MS via a uniform payment per ha of utilised agricultural area (cropland and pasture). | 3 % – 132 %, area redistribution | GLOBIOM, CAPRI, IFM-CAP |
| TAXATION and COMPLIANCE BASED REDISTRIBUTION | Between 3 and 132 % tax on N mineral fertilizer prices. The national tax revenues are redistributed to mitigation technologies as an additional incentive per ha mitigation technology (cropland and pasture). | 3 % – 132 %, area redistribution | GLOBIOM |

Key results for the mineral N fertilizer taxation scenario. For reasons of readability and clarity, the focus is on the highest taxation variant, namely a tax of 132% on the price of mineral N fertilizer. Results refer to TAXATION strategy, unless mentioned otherwise.
*Reduction in mineral N fertilizer use at sector level:*

- Between -30% (CAPRI, GLOBIOM) and -11% reduction (IFM-CAP) of mineral fertilizer input at sector level at high levels of taxation
- Including redistribution policies (TAXATION AND AREA BASED REDISTRIBUTION and TAXATION AND COMPLIANCE BASED REDISTRIBUTION) largely dampens the reduction of mineral fertilizer input across the EU as compared to the TAXATION strategy (GLOBIOM).
- Threshold to reduce mineral fertilizer use by 20% is between 23 and 66% tax on the price of mineral N fertilizer (CAPRI and GLOBIOM)
- Noteworthy variations across EU regions indicate spatial heterogeneity (CAPRI results indicate strongest reduction in Netherlands, while IFM-CAP suggests hotspots of input reductions across the EU).
- Precision farming emerges as a significant mitigation source (CAPRI).

*Reduction in mineral N fertilizer use at farm level:*

- Arable farms exhibit limited responses to taxation, with a <15% reduction in mineral N use even at the highest taxation rate (FarmDyn).
- Contrastingly, dairy farms show on average a 41% reduction due to the ability to substitute mineral N fertilizers owing to organic N surplus (FarmDyn).
- The impact on mineral N fertiliser use on Italian FADN arable crop farms equal around – 22%. This is mainly achieved by  a decrease of mineral N fertilizer of 22% on cereals (soft and durum wheat, barley and corn)

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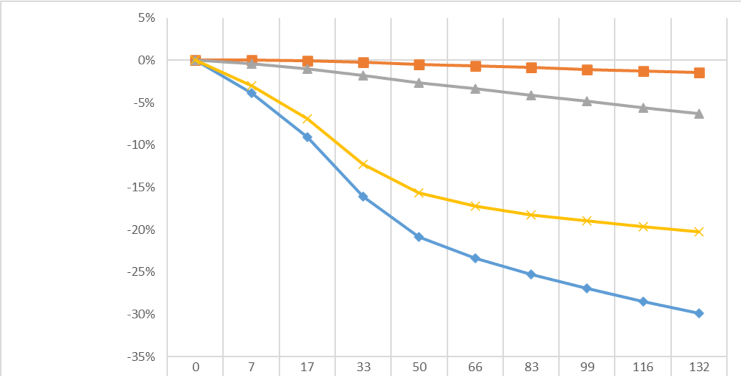


| | 0 | 7 | 17 | 33 | 50 | 66 | 83 | 99 | 116 | 132 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mineral fertilizers | 0 | -3.92% | -9.07% | -16.07% | -20.83% | -23.39% | -25.30% | -26.88% | -28.44% | -29.86% |
| Manure | 0 | 0.01% | -0.08% | -0.25% | -0.46% | -0.65% | -0.87% | -1.07% | -1.29% | -1.48% |
| Crop residues | 0 | -0.40% | -0.98% | -1.81% | -2.65% | -3.38% | -4.15% | -4.87% | -5.61% | -6.29% |
| Surplus total | 0 | -2.99% | -6.93% | -12.27% | -15.67% | -17.24% | -18.22% | -18.95% | -19.64% | -20.25% |

Figure *3.* CAPRI. Reduced N fertilizer application in response to increased taxation of mineral N fertilizer in the EU, with mitigation technologies.

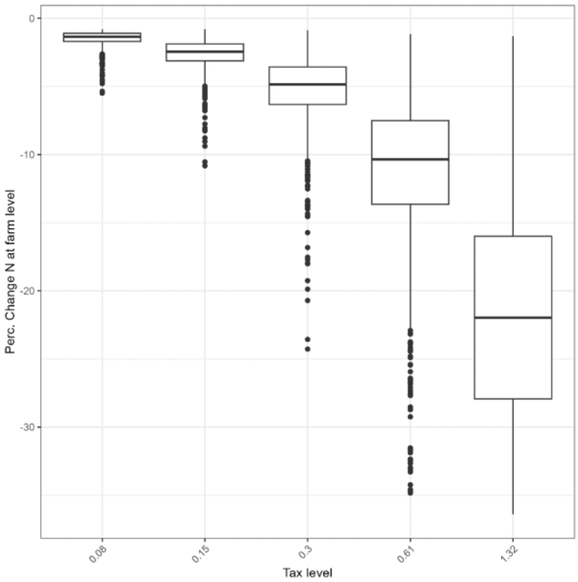


Figure 4 Change in Nitrogen application at farm level under different mineral fertiliser tax rates (INRAE Model - Italian arable crop farms)

*Income and yield implications:*

- Limited effects of fertilizer prices increase on arable crop yield levels, consistent with flat N-response curves for arable crops (FarmDyn).
- The impact on yields on Italian FADN arable crop farms can reach -6% on average for winter cereals (soft wheat, durum wheat and barley) and -4/5% for corn and soybean.
- The highest tax strategy variant project income decrease in EU agriculture as a whole between 4% (IFM-CAP) and 14% (CAPRI). Depending on income definition.

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- Without tax redistribution, average income losses on specialist COP and other fieldcrops farms equal around 10% and 7.5% respectively (IFM-CAP).
- The impact on crop returns (gross margin i.e. the difference between revenues and costs for the crops considered in the model) on Italian FADN arable crop farms equals -36%, as results of the decrease in yields and of the increase in fertiliser costs.
- Income (Farm Net Value Added) per AWU for average arable farms decrease by about 25% if output price changes are not taken into account and by about 12% if product price changes are taken into account (FarmDyn).
- At the highest mineral N fertiliser tax scenario, gross margin at farm level decreases with about 35% on Italian arable crop farms (INRAE model)
- In the case of dairy farms, farm incomes at highest tax rate decrease with around 6%. Farm income may increase by 2% if output (milk) price increases from the CAPRI model are taken into account (FarmDyn).
- Tax revenue collection, including the effect of the tax on the use of mineral N fertilizer, ranges from about 8 bn euro (GLOBIOM) to 11.4 bn euro (IFM-CAP). The difference can be mainly attributed to GLOBIOM not representing fruit and vegetable farms, as opposed to IFM-CAP.

Table 2. IFM-CAP: Effects on gross margin under 132 % taxation of mineral N fertilizer variant. Percentage change compared to the base

| | |
|---|---|
| **Specialist COP (15)** | **-10.30%** |
| **Specialist other fieldcrops (16)** | **-7.50%** |
| **Specialist horticulture (20)** | -3.20% |
| **Specialist wine (35)** | -2.50% |
| **Specialist orchards - fruits (36)** | -5.40% |
| **Specialist olives (37)** | -3.70% |
| **Permanent crops combined (38)** | -2.80% |
| **Specialist milk (45)** | -1.50% |
| **Specialist sheep and goats (48)** | -1.10% |
| **Specialist cattle (49)** | -1.70% |
| **Specialist granivores (50)** | -1.20% |
| **Mixed crops (60)** | -4.50% |
| **Mixed livestock (70)** | -2.10% |
| **Mixed crops and livestock (80)** | -5.00% |
| **All farms** | -3.80% |

*N-surplus and GHG emission implications:*

- Change in N surplus in EU27 equals around 20% at sector level (CAPRI). So, while the target of mineral N fertiliser recuction is reached (namely in CAPRI a reduction of about 30%), the targeted reduction of N losses of 50% is not reached (assuming that ammonia emission from

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application of mineral N fertilizer is limited). Among other this is explained by the use of organic fertilisers (animal manure).
- At the highest mineral N fertilizer taxation rate the decrease in nitrogen surplus equals around 25% on the average EU dairy farm (FarmDyn).
- The decrease in the N surplus on the average arable farm in the EU is highly sensitive to the use of animal manure on the farm and the assumptions regarding initial nutrient use efficiency. Sensitivity analysis show that decrease in the N surplus on the average arable farm in the EU could range between -30% and - 60%, with variation between these percentages (FarmDyn).
- Increased nitrogen taxation leads to between 28 MtCO2eq. (CAPRI) and 51 MtCO2eq. (GLOBIOM) reduction of emissions from the agricultural sector in the EU.
- The reduction is accompanied by a 78 MtCO2eq. increase in emissions in the rest of the world, leading to a total of 27 MtCO2eq. global net increase of emissions from the taxation policy (GLOBIOM).
- Including redistribution policies (TAXATION AND AREA BASED REDISTRIBUTION (tax revenue repayment as basic income support for crops and livestock) the taxation of N fertilisers would have a global net zero effect in terms of MtCO2eq (GLOBIOM).
- Under the TAXATION AND COMPLIANCE BASED REDISTRIBUTION strategy (redistribution of the taxation as a subsidy to mitigation technologies), the emissions in the EU would not change substantially, however, global emissions would be reduced by 27 MtCO2eq (GLOBIOM).

*Land use effects and implications:*
- Changes in land use observed across the EU due to taxation without redistribution can be large, e.g. a 35% reduction of cropland in the highest taxation strategy variant (GLOBIOM)

Including redistribution policies (TAXATION AND AREA BASED REDISTRIBUTION and TAXATION AND COMPLIANCE BASED REDISTRIBUTION) largely dampens the changes in land use observed across the EU due to taxation (GLOBIOM).*Impacts on structural change:*
- Impacts on land concentration and number of farms (structural change) are limited (IFM-CAP).

Appendix
MIND STEP project references (ctrl click)

- MIND STEP Website
- Statement Paper
- MIND STEP Toolbox
- Video of Final Event
- Last Newsletter

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