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Integrating the Agricultural Sector into the New EU Climate Policy Framework for 2030: A Scenario Analysis to Highlight Potential Impacts and Challenges

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According to the European Council's recent agreement on domestic climate and energy goals, greenhouse gas emissions from sectors outside the EU's Emission Trading Scheme have to be cut by 30% below 2005 levels by 2030. So far no decision has been taken on agriculture's specific involvement in mitigation obligations or on how mitigation targets would be distributed between Member States. Based on hypothetical assumptions, we employ the CAPRI model to illustrate and highlight some potential impacts and challenges related to an integration of the agricultural sector into the new EU climate policy framework.

Results of the hypothetical mitigation policy scenario show important impacts on EU agriculture, in particular the livestock sector, if the distribution key of the current Effort Sharing Decision would be rigidly applied as in our assumptions. The results highlight the importance of a targeted but flexible implementation of mitigation policy instruments in the EU and its Member States, as well as the need for a wider consideration and adoption of technological mitigation options.

1. Introduction

On 23 October 2014, the European Council, comprising EU Heads of State and Government, agreed on the domestic climate and energy goals for 2030. The agreement follows the main building blocks of the 2030 policy framework for climate and energy, as proposed by the European Commission in January 2014. A key element of the new policy framework is the reduction of greenhouse gas (GHG) emissions, and the European Council agreed that domestic GHG emissions have to be cut by at least 40% by 2030 compared to 1990 levels. As in the current EU climate and energy package, emission reduction obligations will be distributed between Member States (under the Effort Sharing Decision, ESD) and industry (under the Emission Trading Scheme, ETS). To achieve the overall 40% target, the sectors covered by the EU ETS are supposed to reduce their emissions by 43% compared to 2005 and emissions from sectors outside the EU ETS (i.e. the ones covered within the ESD) will need to be cut by 30% below the 2005 level. Furthermore, the agreement of the European Council states that the mitigation effort in the non-ETS sector would have to be shared “equitably” between the Member States (Council of the European Union, 2014; European Commission, 2014a). So far no decision has been taken neither on the concrete design of the new EU climate policy framework nor on a specific involvement of the EU's agricultural sector in mitigation obligations or on how mitigation targets would be “equitably” distributed between Member States.

The agriculture sector, as a non-CO_2 emitter, is currently included under the ESD (Council of the European Union, 2009). In the ESD, the EU Member States have binding GHG emission abatement targets that actually also comprise agriculture, but up to now no explicit policy measures are implemented that would specifically force GHG emission abatement in the agricultural sector. However, the agricultural sector is a large contributor of non-CO_2 emissions, namely methane (CH_4) from ruminants and nitrous oxide (N_2O) from fertilizer use and management. According to GHG inventories of the EU Member States, agriculture GHG emissions accounted for 471 million tonnes of CO_2 equivalent in 2012, representing about 10% of total EU GHG emissions in 2012 (EEA, 2015). Therefore the latest European Council agreement will put the agricultural sector back into focus when it comes to the fine-tuning on how to achieve the overall EU emission reduction targets.

This raises the question on how the EU’s agricultural sector would be affected if it would be required to reduce its GHG emissions by 30% relative to 2005 levels by 2030. As mentioned above, there is no decision taken yet on what kind of mitigation policy could be implemented for the agricultural sector or how targets could be distributed “equitably” between Member States.

Therefore we model an illustrative scenario that simulates a rigid implementation of mitigation targets for the EU agriculture sector according to a distribution key that is based on the current Effort Sharing Decision in the EU. Rigid in this context means that mitigation is effectively monitored and that the reduction obligations would be implemented without any flexibility (e.g. obligations are not tradable between regions; nor would MS be allowed any other flexibility when implementing mitigation targets for the agricultural sector). It has to be noted that it is very unlikely that mitigation obligations would be implemented as in our illustrative scenario. Thus, the scenario is purely hypothetical to illustrate and highlight some potential impacts and challenges entailed in both setting mitigation obligations and distributing mitigation efforts in the EU's agricultural sector.[1]

2. Methodology

For the analysis we adjusted and applied the CAPRI (Common Agricultural Policy Regional Impact Analysis) modelling system. CAPRI is an economic large-scale comparative-static agricultural sector model, with a focus on the EU (at NUTS2, Member State and aggregated EU-27 level), covering also global trade of agricultural products (Britz and Witzke, 2014). The regional supply models capture links between agricultural production activities in detail, which makes CAPRI suitable for the analysis of GHG emissions by thoroughly calculating activity-based agricultural emission inventories (Pérez Dominguez, 2006; Pérez Dominguez et al., 2012). In previous GHG mitigation policy analyses in CAPRI, technological mitigation options (i.e., technical and management-based GHG mitigation measures) were not endogenously implemented. For this study, the calculation of GHG emission inventories in the CAPRI model has been further improved, and, for the first time, also specific endogenous GHG mitigation technologies have been introduced in the optimisation procedure. The following GHG technological mitigation options have been specifically considered as options that can be voluntarily applied by farmers: (1) farm scale anaerobic digestion; (2) community anaerobic digestion; (3) nitrification inhibitors; (4) timing of fertilization; (5) precision farming, and (6) changes in the composition of animals' diet (feed).[2] The model allows the simultaneous use of different technological mitigation options, e.g. nitrification inhibitors, the timing of fertilisation and precision farming can be combined to reduce the N2O emissions due to fertilizer applications.

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[1] This paper draws on one of the scenarios of the EcAMPA project. For more information on the project and further scenarios see Van Doorslaer et al. (2015).

[2] Regarding the assumptions of these technological mitigation options we heavily relied on the GAINS database (GAINS, 2013; Höglund-Isaksson et al., 2013). The technologies considered in CAPRI are a subset of those available in GAINS, translated into CAPRI terms as in Van Doorslaer, 2015.

Modelling the response of GHG emissions in agriculture to economic incentives and policies is a challenge that is typically addressed only with a number of simplifications. The complexity is due to several factors, for example (1) production occurs in a farm population that is heterogeneous across space, size classes and specialisation; (2) the product mix may be changed flexibly in case of price changes, productivity changes or policy measures (CAP premiums and side conditions for them); (3) emissions of various types are linked to the composition and volume of production, as well as to the choice of mitigation technologies; (4) the cost of mitigation technologies indirectly determines the profitability of a certain specialisation within agriculture.

As a consequence of this complexity, frequently made simplifications include (1) only a subset of mitigation options is considered in the context of an otherwise detailed sector model (e.g. in the CAPRI or in the GLOBIOM model (Havlik et al., 2011)); (2) a rich description of the mitigation technologies is considered but with a given set of emission causing activities (e.g. in the GAINS model, see GAINS, 2013).

In this study, we make a first attempt to endogenise the choice among selected mitigation options within the CAPRI model (Britz and Witzke, 2014). The agents in the regional programming models representing the European farm sector are assumed to maximise their income. However, various factors constrain the level of production activities (e.g., the number of animals or hectares cultivated with some crop) and the use of mitigation technologies. These factors include land availability, fertilization requirements of the cropping systems versus organic nutrient availability, feed requirements in terms of dry matter, net energy, protein, and fibre for each animal (Pérez Dominguez, 2006; Leip et al., 2010). Furthermore, policy restrictions, including emission targets, as used in this impact analysis, may also influence decision making.

Agricultural GHG emissions and ammonia are affected by the amount and intensity of animal or plant production. In CAPRI, emissions are calculated according to the IPCC Tier 2 method for the most important drivers (in particular cattle-related emissions). In previous CAPRI versions, technical methods of GHG emissions reduction have been largely neglected (with some exceptions). In this study, the rich description of technical mitigation options in the GAINS model has been tapped in a selected form. In particular, the mitigation potential (in the form of expected upper bounds for implementation), the costs and the current implementation rates of certain mitigation technologies in the reference scenario have been adopted.

Formal model set-up[3]

The regional income maximisation may be formulated as:

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[3] This section is entirely taken from the EcAMPA report (Van Doorslaer et al., 2015, p. 35-37).

$$
\begin{aligned}
&\max\ R(act) - C^{T}(act,\ fert,\ feed\ ,mshar)\\
&s.t.\\
&G(act,\ feed\ ,\ fert) \le 0 \qquad\qquad (1)\\
&0 \le mshar_{a,m,e} \le 1, \forall\, m\\
&\textstyle\sum_{m} mshar_{a,m,e} = 1
\end{aligned}
$$

where the regional indices are omitted and

R	revenue function, combining sales from marketable outputs from production activities as well as premiums directly paid to activities
C^T	total cost function, combining cost elements directly related to activities, as well as purchases of marketable inputs (feed, fertilizer), and costs of mitigation efforts
G	Vector constraint function representing agricultural technology
act	vector of production activities with a certain intensity. Typical element: act_a.
a	set of production activities (e.g., dairy cows with high yield)
$fert$	vector of mineral fertilizer purchases. Typical element: $fert_n$
n	set of plant nutrients (N, P, K)
$feed$	matrix of feed input coefficients. Typical element: $feed_{a,f}$
f	set of feed items (e.g., feed cereals)
$mshar$	vector of mitigation shares. Typical element $mshar_{a,m,e}$
m	set of mitigation technologies (including “no mitigation”)
e	set of emission types (e.g., CH_4 from manure management)

The cost function is assumed to be separable into parts related to mitigation efforts and other costs:

$$
\begin{aligned}
C^{T}(act,\ fert,\ feed\ ,mshar) = &\textstyle\sum_{a} act_{a} \sum_{m,e} C^{m}(mshar_{a,m,e}) + fert_{N} \sum_{m} C^{m}(mshar_{N,m,N2O\min})\\
&+ C^{O}(act,\ fert,\ feed) \qquad\qquad (2)
\end{aligned}
$$

where

C^m	mitigation cost per activity level for mitigation option *m*, which depends on mitigation share $mshar_{a,m,e}$ for activity *a*, mitigation option *m*, and targeting emission type *e*.
C^O	other (non-mitigation) cost depending on activity levels, feed coefficients, and fertilizer quantities.

This framework involves an important simplification: the mitigation shares do not enter the constraint function G(.) nor the cost function C^O. In the case of anaerobic digestion (AD), a relevant mitigation technology targeting CH_4, this seems to be approximately correct, if we assume that the residues (containing the nitrogen and other plant nutrients from the manure and other feedstocks for AD) are returned to the soil without significant losses. The only effect of AD is then to reduce CH_4 emissions from manure and to generate income (negative cost C^m).

The assumption of no influence of mitigation on constraints and other costs is more questionable for measures to reduce N_2O emissions from fertilizer application such as precision farming or improved timing of fertilization. These measures should also influence the overall nutrient balance in the crop sector which is neglected for the time being.

Most emission types are calculated as the product of emission factors per activity level (determined as a function of yields and other characteristics) and activity levels. For some of them, mitigation measures may reduce emissions according to a factor $mfac_{a,e}$ below the standard, uncontrolled amount (= 100%). The most important example is the reduction in CH_4 emissions from manure management according to the GAINS mitigation options "farm scale and community scale anaerobic digestion plants". Formally,

$$
\begin{aligned}
&emi_e = \sum\nolimits_a mfac_{a,e} \cdot \varepsilon_{a,e} \cdot act_a \\
&where \qquad\qquad (3) \\
&mfac_{a,e} = \sum\nolimits_m \mu_{a,m,e} \cdot mshar_{a,m,e}
\end{aligned}
$$

and

emi_e emissions of type e.

$\varepsilon_{a,e}$ uncontrolled emission factor for emission type e from activity a.

$\mu_{a,m,e}$ reduction factor for emission type e from activity a, if a certain mitigation technology m were fully implemented (which may be infeasible).

Emissions of N2O from synthetic fertilizers are incorporated similarly with the total use of mineral fertilizer adopting the role of emissions causing activity. Relevant mitigation technologies are nitrogen inhibitors, timing of fertilization and precision farming, as defined in the GAINS model (the mitigation technologies can also be combined):

$$
\begin{aligned}
&emi_{N2O\min} = mfac_{N,N2O\min} \cdot \varepsilon_{N,N2O\min e} \cdot fert_N \\
&where \qquad\qquad (4) \\
&mfac_{N,N2O\min} = \sum\nolimits_m \mu_{N,m,N2O\min} \cdot mshar_{N,m,N2O\min}
\end{aligned}
$$

Emissions from enteric fermentation per animal category are calculated according to IPCC Tier 2 methods from animal numbers, feed intake in gross energy, and a methane conversion factor. As feed intake is generally not available, CAPRI used to follow a methodology described by the IPCC (2006, Chapter 10) to estimate the intake from parameters characterizing animal needs, such as weight, and milk yield. This permits to estimate net energy requirement, convert it into gross energy by using average digestibility, and finally apply the methane conversion factor. This methodology has been used in CAPRI since many years (Perez-Dominguez, 2006; Leip et al., 2010) and it also results in emission factors per animal activity like those in equation (3).

However, one of the contributions of our study is a straightforward but important modification of the "standard" Tier 2 approach. In the CAPRI model, unlike the situation in inventory calculations envisaged by IPCC (2006), feed intake and its composition are known model variables. Therefore it is possible to directly compute gross energy intake from the endogenous feed input coefficients and thereby capture the effects of endogenous changes in the feed mix on digestibility and emissions. Mitigation factors are applied as above, reflecting the saving of methane emissions if anaerobic digestion plants are used, whereas two other technologies included in the

GAINS data base (anti-methanogen vaccination and propionate precursors) are not considered in this study.

$$
\begin{aligned}
& emi_{CH4en} = \sum\nolimits_{a} mfac_{a,CH4en} \cdot act_{a} \cdot \sum\nolimits_{f} \varepsilon_{a,f,CH4en} \cdot feed_{a,f} \\
& where \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (5) \\
& mfac_{a,CH4en} = \sum\nolimits_{m} \mu_{a,m,CH4en} \cdot mshar_{a,m,CH4en}
\end{aligned}
$$

In summary, the objective of a CAPRI supply model is to maximize the net revenues as in equation (1), considering given parameters like product prices and CAP premiums as well as the costs for mitigation measures and other costs. The model finds an optimum of activities, mitigation technologies and feed use for a given emission target.

3. Specification and major results of the simulation scenarios

To assess the impact of a rigid implementation of mitigation targets for the EU agricultural sector, a reference scenario (REF) and a mitigation policy scenario (HET28) have been constructed. Simulation year for both scenarios is 2030 and in both scenarios farmers have the possibility to voluntarily apply the above mentioned specific technological mitigation options. The REF scenario assumes status quo policy as scheduled in the current legislation based on the information available at the end of May 2014. Thus, while the abolishment of the milk and sugar quotas are covered in REF, some other measures of the CAP Reform 2014-2020 are not specifically considered as their exact implementation at Member State level was still unclear when modelling the scenario. Furthermore, no specific GHG emission reduction requirements for the agricultural sector are implemented in REF.

The mitigation policy scenario (HET28) aims at an EU-27[4] wide GHG emission reduction of 28% in the year 2030 compared to EU-27 emissions in the year 2005. Why do we opt to model a 28% emission reduction instead of the 30% the European Council agreed on for the EU ESD? We do so because the 28% reduction obligation is in line with the European Commission’s roadmap for moving to a low-carbon economy in 2050. According to the Roadmap 2050 and an accompanying impact assessment, it can be expected that reduction of emissions from agriculture for the EU as a whole should be about 28% by 2030 compared to 2005 to meet a total reduction in EU GHG emissions of 40% in 2030 compared to 1990 (cf. European Commission, 2014b, p.57).

The emission reduction obligations in our scenario are set per Member State (MS) and NUTS2 region by implementing emission standards (caps). As there is yet no decision taken on

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[4] By the time the analysis was done, the CAPRI model was not yet updated to include Croatia as 28th Member State of the EU.

how a new and "equitable" distribution of mitigation obligations between MS could look like, we use a distribution key that is based on the current EU Effort Sharing Decision (ESD). According to the current ESD, the overall GHG emission reduction objective in the EU is distributed across MS, corresponding to a non-uniform GHG emission standard (Council of the European Union, 2009). The ESD aims at a total GHG reduction in the non-ETS sectors of 20% by 2020 compared to 2005 emission levels. However, simply applying the specific MS targets only to emissions in the agriculture sector would translate to a total emission reduction in EU-27 agriculture emissions by 9%. Therefore we adjust the MS mitigation commitments according to a linear modification (ESD +19%), such that a 28% emission reduction is achieved for the EU-27 (Table 1). Again it has to be emphasized that the rationale behind the HET28 scenario is to model an uneven distribution and rigid implementation of MS targets. The targets we implement do neither reflect current nor future policy, i.e. for the sake of this modelling exercise the distribution key of the ESD is taken as the only existing approximation of an uneven distribution of MS targets.

Table 1. MS GHG emission reduction commitments in 2030 compared to 2005 emission levels as given in the current ESD and as assumed in the HET28 scenario

Member State	GHG emission limits ESD	GHG emission limits HET28 (ESD+19%)	Member State	GHG emission limits ESD	GHG emission limits HET28 (ESD+19%)
Austria	-16	-35			
Belgium-Lux.	-15	-34			
Denmark	-20	-39	Bulgaria	20	1
Finland	-16	-35	Cyprus	-5	-24
France	-14	-33	Czech Republic	9	-10
Germany	-14	-33	Estonia	11	-8
Greece	-4	-23	Hungary	10	-9
Ireland	-20	-39	Latvia	17	-2
Italy	-13	-32	Lithuania	15	-4
Netherlands	-16	-35	Malta	5	-14
Portugal	1	-18	Poland	14	-5
Spain	-10	-29	Romania	19	0
Sweden	-17	-36	Slovak Republic	13	-6
United Kingdom	-16	-35	Slovenia	4	-15

Regarding the practical implementation and monitoring of specific mitigation obligations in the agricultural sector, it has to be noted that farmers in the EU are already subject to large reporting obligations in terms of nutrient loads and activity numbers when it comes to compliance with agricultural and environmental regulations. The compliance with the regulations is controlled at a (sometimes random but) frequent basis by local authorities. Therefore we assume that the additional transaction costs related to both reporting and monitoring of agricultural GHG emissions would be low enough to be ignored in the simulation efforts.

Scenario results

Changes in agricultural GHG emissions per EU Member State

Table 2 presents a decomposition of the overall agricultural GHG emissions developments under the REF and HET28 scenarios. The technological GHG mitigation options considered in the analysis are available in both scenarios and can be voluntarily applied by farmers. The REF scenario indicates the development of GHG emissions with no specific emission reduction requirements for agriculture in place, and shows the relative difference in emission levels between the projection year 2030 and the base year 2005. The HET28 scenario shows the policy effect of implementing the GHG reduction obligation by depicting the relative change compared to the REF scenario in the year 2030.

Table 2. Changes in agricultural GHG emissions per EU Member State in 2030

	2005	**REF**	**HET28**
	[1000t]	% difference to 2005	% difference to REF
EU-27	400,965	-0.2	-28.6
Austria	7,461	8.7	-40.6
Belgium-Lux	9,354	2.1	-35.3
Denmark	9,747	-0.9	-37.9
Finland	7,284	5.9	-39.0
France	74,366	-4.2	-30.4
Germany	61,139	-2.2	-32.0
Greece	5,945	-11.6	-13.3
Ireland	21,298	4.5	-41.9
Italy	28,216	-4.8	-29.0
Netherlands	17,216	5.8	-38.1
Portugal	5,048	15.8	-29.5
Spain	31,009	7.1	-34.0
Sweden	6,909	4.1	-38.7
UK	45,654	-3.7	-32.9
EU-15	330,647	-0.6	-33.2
Bulgaria	3,969	20.4	-15.8
Cyprus	397	7.2	-29.0
Czech Republic	6,096	3.8	-14.6
Estonia	1,232	5.0	-12.7
Hungary	7,249	-4.9	-4.8
Latvia	1,799	20.3	-20.1
Lithuania	3,681	12.7	-16.3
Malta	67	12.4	-23.5
Poland	27,185	3.7	-8.7
Romania	14,995	-11.2	4.4
Slovak Republic	2,335	-4.5	-2.3
Slovenia	1,311	-2.8	-13.2
EU-N12	70,318	1.2	-7.7

Projection results of the REF scenario show that by 2030, agricultural GHG emissions in the EU-27 are just 0.2% below year 2005 levels. However, projection results are quite diverse between the MS, and while some MS show a decrease in emissions, others are projected to have an increase. In the EU-15, results show a decrease of 0.6%, with highest reductions projected for Greece (-almost -12%) and Italy (-5%), whereas eight countries show an increase in emissions, with the highest increases indicated for Portugal (+16%) and Austria (+9%). For the EU-N12 an increase of 1.2% is projected, with eight countries increasing their emissions. Projected emission increases are most pronounced for Bulgaria and Latvia (both about +20%) and highest decreases for Romania (-11%) and Hungary (-5%).

The emission reductions at MS level in the HET28 scenario have to be seen in the context of the individual MS emissions in the REF scenario and the emission reduction obligation the MS is faced with according to the modelled policy (as indicated in Table 1 above). The complex part was to achieve the overall reduction at EU-27 level by also taking into account the fact that for some of the EU-N12 Member States the respective reduction commitments imply that they can actually increase their emissions compared to REF. The modelling effect in CAPRI is that, depending on the number of iterations, the bounds around the reduction objectives can vary the result for the overall emission reduction in the EU-27. This variation occurs because other constraints, related to agricultural production and not to emission reduction targets, prevent some of the MS from fully using the emission possibilities they are allowed to. In order to get hold of the variation, we had to concentrate on the modelling of the achievement of the overall emission reduction target at EU-27 level. As a result of this variation in the EU-N12, the emission reduction objective in the scenario is actually slightly surpassed.

Impact on agricultural activity levels

Table 3 presents how agricultural activities in the EU-27 are affected in Scenario HET28 compared to REF. Most of the adjustments to the GHG mitigation obligation are made through lower activity levels. Largest decreases in agricultural activity are projected to take place in the livestock sector, particularly beef meat. Compared to the impact on the beef meat sector, effects on the arable sector are rather small. Cereals production in the EU-27 is projected to decrease by 6%, with production decreasing by 10% in the EU-15 while increasing by more than 3% in the EU-N12.

The changes in beef herd size and production at MS level are presented in Table 4. The impacts on the beef meat herd are most pronounced in those EU-15 MS that are confronted with the highest mitigation obligations, such as the Denmark (82% reduction in beef herd size) and the Netherlands (-76%). Effects on beef meat production are significantly smaller than those on the herd size, indicating a change in herd structure, with an overall increase in productivity per cattle. For the EU-15, a reduction in the beef herd size of 57% is projected whereas the beef production decreases by 34%. Due to lower GHG mitigation commitments, the EU-N12 can partially compensate the decrease in the EU-15 beef meat activities, but beef herd size and production also decrease, by 10% and 2.5%, respectively. The overall effect at EU-27 level is a reduction in beef herd size of 54% and a decrease in beef meat production of 31%.

Table 3. Change in area, herd size and supply for the EU-27 for activity aggregates

	REF		HET28	
	Hectares or herd size	Supply	Hectares or herd size	Supply
	[1000 ha or hds]	[1000 t, 1000 ha]	%-difference to REF	
Utilized agricultural area	181,693	na	-12.4	na
Cereals	52,856	320,148	-6.7	-6.2
Oilseeds	11,856	34,291	-4.9	-5.6
Other arable crops	5,783	164,260	-2.9	na
Vegetables and Permanent crops	25,060	130,747	0.1	na
Fodder activities	77,391	33,378	-25.5	-31.2
Set aside and fallow land	8,746	na	17.6	na
Dairy cows	21,722	160,509	-8.8	-8.7
Beef meat activities	18,213	7,992*	-53.8	-31.0
Pig fattening	252,970	23,494	-8.5	-8.9
Pig breeding	15,037	259,528	-7.9	-8.5
Milk Ewes and Goat	74,090	5,141	-21.8	-11.9
Sheep and Goat fattening	48,548	742	-23.2	-21.9
Laying hens	459	7,776	-2.9	-2.5
Poultry fattening	6,703	13,518	-4.5	-4.3

Note: na = not applicable; total supply of beef includes beef from dairy cows and calves

Table 4. Change in beef herd size and production per EU Member State

	REF		HET28	
	Herd size	Prod.	Herd	Prod.
	1000 hds	1000 t	%-difference to REF	
EU-27	18,213	7,992	-53.8	-31.0
Austria	410	205	-67.0	-43.1
Belgium-Lux	521	285	-60.2	-37.5
Denmark	132	125	-82.3	-49.6
Finland	149	81	-53.5	-29.9
France	4,923	1,688	-57.1	-32.6
Germany	1,288	1,048	-60.3	-40.6
Greece	194	58	-50.3	-7.9
Ireland	2,047	619	-57.0	-38.6
Italy	1,150	755	-41.3	-28.0
Netherlands	143	380	-76.3	-42.6
Portugal	458	122	-49.3	-18.9
Spain	2,191	641	-64.1	-24.9
Sweden	334	152	-68.2	-49.5
UK	3,203	1,007	-50.4	-32.2
EU-15	17,144	7,166	-56.5	-34.3
Bulgaria	46	30	-22.1	-8.7
Cyprus	2	4	-24.6	-17.7
Czech Republic	157	72	-27.8	-4.9
Estonia	19	19	-6.1	-4.0
Hungary	45	33	-1.3	4.2
Latvia	12	21	-22.8	-16.4
Lithuania	33	40	-19.8	-13.3
Malta	3	2	-27.7	-22.8
Poland	473	396	-0.7	-3.3
Romania	92	134	7.0	5.3
Slovak Republic	38	26	11.1	10.3
Slovenia	149	48	-33.4	-4.8
EU-N12	1,069	826	-10.2	-2.5

Impact on EU imports, exports and net trade position

The changes in EU imports, exports and net trade position for aggregate activities are presented in Table 5. Regarding the trade balance it has to be noted that the scenario is run under the assumption that current trade agreements and EU border protection mechanisms would remain unchanged in place by 2030. Taking into account the large production drop in the EU, the trade balance is changing in the negative direction for almost all agricultural products. The exceptions are oil cakes, which is due to lower feed demand from the EU livestock sector. In line with the production developments, changes in EU imports and exports are more pronounced in the livestock than in the crop sector. Beef imports increase considerably in HET28 and beef exports are decreasing, but regarding the latter quantities involved are relatively small. Exports of pork and poultry meat also decrease significantly. For the dairy sector, the trade balance also weakens considerably, with especially the EU export potential being significantly lowered (-31%).

Table 5. Change in EU imports, exports and net trade position for aggregate activities according to the HET28 scenario

	REF			**HET28**		
	Imports	**Exports**	**Net trade position**	**Imports**	**Exports**	**Net trade position**
	1000 t			**%-diff to REF**		**1000 t**
Cereals	10,391	47,140	36,749	61.5	-23.9	19,108
Oilseeds	24,652	10,376	-14,276	10.3	-10.7	-17,928
Other arable field crops	2,048	3,749	1,701	-4.0	-6.7	1,533
Vegetables and Permanent crops	25,982	7,394	-18,587	2.7	-1.9	-19,443
Oils	10,894	3,766	-7,128	1.2	-7.1	-7,531
Oil cakes	23,306	3,375	-19,931	-18.9	11.4	-15,147
Beef	552	137	-414	318.6	-96.6	-2,304
Pork meat	6	2,278	2,272	*444.0	-70.1	650
Sheep and goat meat	277	20	-257	70.5	-74.9	-467
Poultry meat	252	1,260	1,008	172.1	-40.4	66
Dairy products	385	2,746	2,361	88.7	-31.1	1,166

Note: The high percentage difference for pork meat imports represents only very small absolute quantities

Impact on EU producer and consumer prices

As outlined above, the large production decreases in the EU-27 are not compensated by equivalent imports. As a consequence all producer and consumer prices in the EU are projected to increase (Table 6). The increases in producer prices are in line with the observed production decreases in HET28, showing highest price increases for beef and milk. Consumer price changes are in the same magnitude when looking at absolute changes, but due to high consumer margins (assumed constant), the relative changes are much lower for them. The relative increases in consumer prices for meat and dairy products vary between 10% and 30%. On the other hand, the impact of the mitigation obligation on consumer prices for crops is below 1%.

Table 6. Change in producer and consumer price for selected products

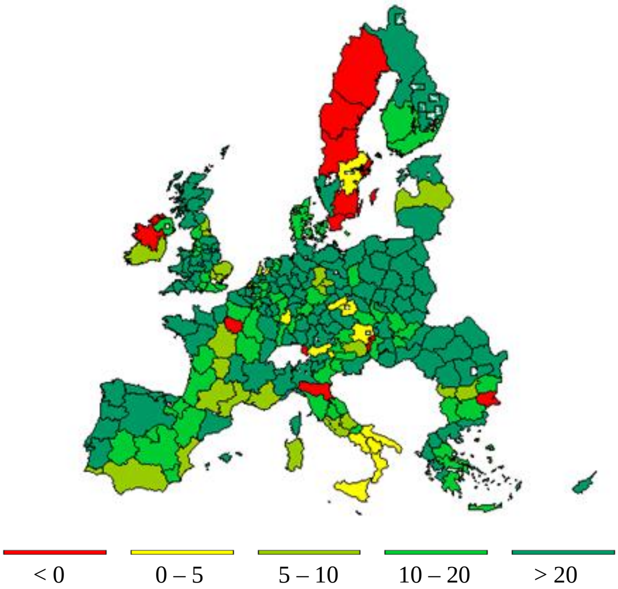
	Producer price		Consumer price	
	REF	HET28	REF	HET28
	EUR/t	%-difference to REF	EUR/t	%-difference to REF
Cereals	251	11.3	3513	0.8
Oilseeds	301	10.9	3962	0.9
Other arable field crops	124	8.1	1296	0.7
Vegetable and Permanent crops	869	2.7	2368	0.4
Beef	5984	64.4	11881	30.7
Pork meat	2394	40.8	7483	13.5
Sheep and goat meat	8564	26.5	13944	11.1
Poultry meat	2131	17.0	4817	10.6
Cow and buffalo milk	403	66.0	na	na
Sheep and goat milk	837	37.5	na	na

Note: na = not applicable

Impact on total agricultural income

Total agricultural income takes into account the changes in the product margins (gross value added – cost) and in the production quantity of all agricultural activities in the particular region. The scenario results indicate that the decrease in supply and the resulting increase in producer prices more than offset the income losses provoked by decreases in production and increases in production costs in about 95% of the regions. As a result, total agricultural income in the EU-27 is projected to increase by 27%. However, the aggregated result hides large differences between the regions in the Member States (Figure 1). Moreover, it has to be kept in mind that it is likely that some farmers would have to leave the sector if they are not able to cope with the rigid GHG mitigation obligation implemented in the scenario. Of course, only farmers remaining in the sector would benefit from potential income increases.

Figure 1. Impact on total agricultural income (HET28 scenario, %-change relative to REF)



4. Concluding remarks

We employ a revised version of the CAPRI model to run a reference scenario and to illustrate and assess the impact of a rigid GHG emission mitigation policy of a heterogeneous emission standard with an uneven distribution of GHG emission mitigation obligations at EU Member State level. For the illustrative mitigation scenario we follow a distribution key of emission mitigation obligations that is based on the current EU Effort Sharing Decision, and the mitigation target is an EU-27 wide GHG emission reduction of 28% in the year 2030 compared to the year 2005.

The modelled mitigation policy shows important impacts on agricultural production in the EU-27, especially for cattle and fodder production. Compared to the reference scenario, results of the policy scenario show decreases in the cattle herd size of 54%, and in crop and grassland of up to 12% of total UAA in the EU. Crop production is directly affected by the GHG emissions reduction obligations and indirectly by the reduced demand for feed from the livestock sector. The decrease in production levels leads to increases in producer prices that are projected to compensate losses provoked by decreases in production and increases in production costs, leading to an increase in total agricultural income at EU level, although large regional differences exist, and even some negative income impacts are projected at regional level. Consumers, on the contrary, would have to pay a higher price for food, especially for meat and dairy products. In the context of producer and consumer prices it is important to note that the higher prices in the policy scenario are reached under a specific set of assumptions, especially with respect to the assumed EU border protection mechanisms in place in 2030. It also has to be kept in mind that it is likely that in the scenario some farmers would have to leave the sector in case they are not able to cope with the GHG mitigation obligations. Of course only farmers remaining in the sector could benefit from potential increases in total agricultural income.

In previous GHG mitigation policy analyses with the CAPRI model technological mitigation options (i.e. technical and management-based GHG mitigation measures) were not endogenously implemented in the CAPRI model. For this study, a limited set of specific endogenous GHG mitigation technologies have been introduced to the CAPRI model. In our analysis almost 100% of EU crop production would potentially use the provided mitigation options in 2030. On the other hand, based on the included set of technological mitigation options, the impact of a change in livestock production management and technology on overall agricultural GHG emissions in the EU tends to be rather limited. However, it has to be noted that (i) the modelled set of technologies is very restricted and there are other technical mitigation options so far not considered in the CAPRI model (see e.g. Smith et al. 2014; Hristov et al., 2013); (ii) the share of livestock production assumed to be able to apply the considered technology options is sometimes very limited and country specific, basically reflecting the share of farms large enough to implement such technologies. Taking more technological mitigation options into consideration and assuming a wider applicability, say due to additional farm structure change or accelerated technological maturation, mitigation options in the animal sector might become more important. In a recent analysis with the CAPRI model, Witzke et al. (2014) demonstrate the general importance of considering technological mitigation options when analysing the impact of mitigation policies in the agricultural sector. Correspondingly it can be assumed that a wider range of mitigation technologies could also considerably downscale any negative impacts on the EU's agricultural production and trade in the scenario. To improve this point for future scenario analysis, further mitigation technologies are currently integrated into the CAPRI model.

With respect to global GHG emissions reduction, it has to be kept in mind that even though the EU meets its emission reduction target of 28% in our policy scenario, the projected increase in EU imports go along with emission leakage (i.e. an increase of emissions outside the EU) and the net gain for global GHG emission reduction depends significantly on the relative GHG efficiency of agriculture in the exporting countries compared to the EU (Pérez Dominguez and Fellmann, 2015; Van Doorslaer et al., 2015).

Concerning the European Council’s agreement on a new policy framework on climate and energy for 2030, our scenario results illustrate that if the agricultural sector in the EU would be obliged to reduce its GHG emissions by 30% below the 2005 level, and mitigation obligations would be rigidly implemented according to the distribution key outlined in the current EU ESD, the policy could have a considerable impact on the EU's agricultural sector. However, our analysis does not take into account potential support measures that might be introduced in order to help farmers adjusting to the new policy framework. Moreover, our assumption on the mitigation policy is only illustrative and it is not likely that any mitigation obligation for the agricultural sector would be implemented like in our scenario. A different implementation of the mitigation policy would certainly alter the scenario results. In this context our modelling results might give a good indication on the upper end of the impacts of the modelled mitigation target in the agricultural sector if the policy would be implemented in a very rigid way. This should help to highlight that the use of flexible policy instruments for climate change mitigation will be crucial to keep mitigation costs for farmers at a minimum. Moreover, the scenario results underline the importance of technological mitigation options to efficiently reduce agricultural GHG emissions. It seems important for policy makers to assess the possibilities to strengthen innovation in the area of technological mitigation options as well as to facilitate the uptake of technical and management options to efficiently mitigate GHG emissions in the agricultural sector.

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