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Special

Cows and pigs for sale!?

Assessing the side-effects of low carbon transition pathways in the livestock sector in the Netherlands

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TRANSrisk project

TRANSrisk (www.transrisk-project.eu) aims to explore low emission transition pathways and analyse the possible associated risks. A key feature of TRANSrisk is that it brings together quantitative techniques (such as models) and qualitative approaches (such as participatory consultations with stakeholders). This combined approach enables identification of possible low emission transition pathways which are technically and economically feasible, and acceptable from a social and environmental viewpoint.

Are you a stakeholder involved in agriculture, livestock, manure management or bioenergy? Feel free to join the discussion and share your thoughts and insights with the TRANSrisk project. For more information, please contact Eise Spijker of JIN Climate and Sustainability (eise@jin.ngo) or, for the economic modelling used in this case study, please contact Annela Anger-Kraavi of Cambridge Econometrics (aak@camecon.com).

TRANSrisk
TRANSITION PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE POLICIES

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The impact of livestock farming systems

Livestock farming is linked to a range of positive socio-economic developments. It provides nutrition, and income to a region. But in developed economies with highly-intensified systems, like the Netherlands, livestock farming is also often linked to negative environmental impacts. In the European Union (EU), the Netherlands has one of the highest levels of livestock density (Figure 1).

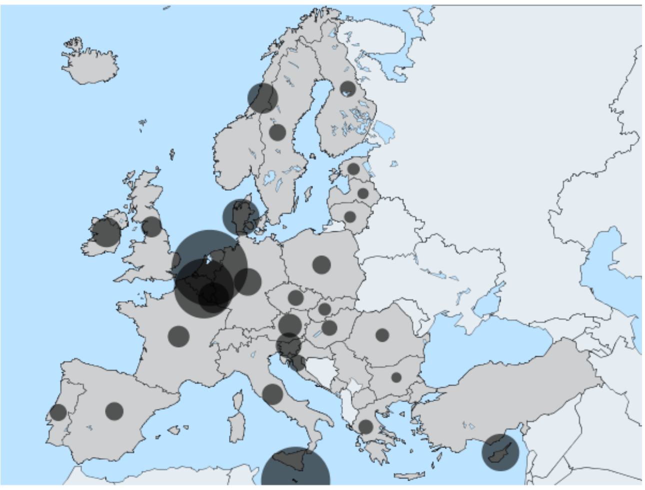

Figure 1. Livestock density in the EU-28 in 2013 in livestock units per hectare of arable land. Source: Eurostat (2015).

The Dutch agricultural sector is responsible for a broad range of environmental impacts related to climate change and air pollution (Table 1).

Table 1. Main GHG and air quality polluting emissions at national level and share of agricultural sector in the Netherlands. Source: Emissieregistratie.nl (2015).

Year 2015	National total	Agricultural sector	*%-share of total gas*
CH_4 (in CO_2-eq.)	19	13	*68*
N_2O (in CO_2-eq.)	8	6	*75*
CO_2 (in CO_2-eq.)	167	7	*4*
PM_{10} (in kton)	26	7	*27*
NH_3 (in kton)	134	117	*87*
NO_X (in kton)	229	14	*6*

Key emissions from agriculture are methane (CH_4,), nitrous oxide (N_2O) and ammonia (NH_3), contributing 68%, 75% and 87% respectively towards total national emissions. Other environmental issues from livestock are a result of nutrient loading, which causes eutrophication (over fertilization with excess animal manure). There are also increasing concerns about human and animal health (use of antibiotics, GMO feed, etc.). Despite these concerns, the economic impact of the Dutch agro-sector is considerable. The entire Dutch agriculture-horticultural sector (including livestock) generates about 9% of total Dutch GDP. It is the 4th largest global meat exporter and the 3rd largest global exporter of dairy.[1]

Low carbon transition pathways in the Dutch livestock sector

The abovementioned situation is not unique in the world. There are several other regions of the world with intensive livestock farming systems that are facing similar sustainability issues. Within the TRANSrisk project we are exploring the positive and negative side-effects of two low-carbon transition pathways in the livestock sector in the Netherlands. One of the first questions to ask is what the options are in terms of selecting low-carbon transition technologies and practices?

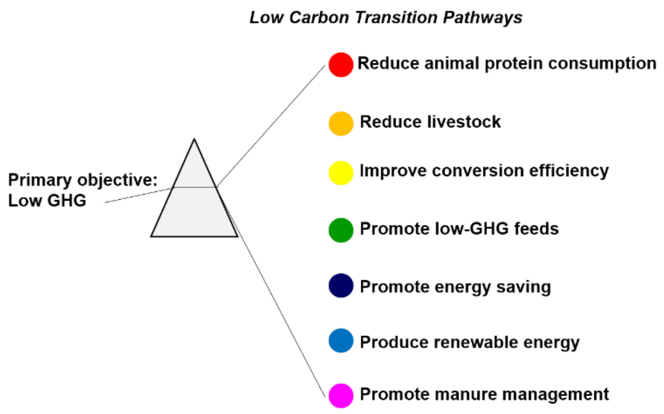

Figure 2. Low carbon transition options for the Dutch livestock sector.

Figure 2 provides a number of low carbon transition options for the livestock sector. The list contains technologies and practices that can be implemented in order to reduce the GHG emissions of the livestock sector. ***1***) Reducing animal protein consumption has the advantage that it would result in a substantial reduction of CH_4 emissions (reduced enteric fermentation and reduced CH_4 emissions from manure management). Similar CH_4-effects can be achieved by actively reducing the size of the livestock sector in terms of number of animals. Since agricultural production in the Netherlands is highly export oriented, a strategy to reduce animal protein consumption has to be achieved globally. Similarly, when ***2***) reducing animal protein production domestically, no 'carbon leakage' should occur, where other countries would increase production levels.

3) Improving the conversion efficiency is considered a promising strategy, as many developed and developing economies aim to produce a higher levels of output with a similar level of resource inputs (e.g. land, feed). However, within the Netherlands the average conversion efficiencies are already quite high. This makes incremental improvements more costly and difficult.

Another option is ***4***) to promote the production and consumption of low-GHG animal feed products. This can relate to feed products that, once digested by the animal, result in lower GHG emissions, but can also relate to animal feed crops that are being cultivated with low-GHG technologies and fewer fossil fertilizers. The key question here would be if the global and local animal feed markets would be able to supply such feed products on a large scale, while minimizing / preventing any (in)direct land-use change.

5) Establishing energy savings in this sector is also a viable strategy, albeit it mainly targets CO_2-emissions and not so much targets N_2O and CH_4 emissions.

6) The option to stimulate the sector to produce more renewable energy has already been activated in the Netherlands, albeit with mixed and marginal success. Livestock farmers have invested in solar PV and onshore wind, but much more is needed to phase-out fossil fuels. Subsidies for bioenergy production, especially biogas, have been less successful thus far. Biogas investment projects are typically confronted with a higher level of (technology, investment) risk. One of the issues with manure-based biogas production in the Netherlands is that it is not a cost-competitive renewable energy option relative to other renewables. Also manure digestion does not help Dutch livestock farmers reduce their manure (nutrient) surpluses, which currently is considered a more urgent environmental and policy issue to tackle.

7) Integrated Manure Management (IMM) tries to combine biogas production based on manure digestion with a better nutrient management. IMM bears the potential of being able to address multiple environmental issues at once.

Each individual transition pathway option has its advantages and disadvantages, and therefore one option might be preferred over another. In order to allow for a robust assessment we have chosen to perform an in-depth comparative analysis of the side-effects of two out of the seven low carbon transition pathways.

The first transition pathway considers Integrated Manure Management (IMM). IMM combines a set of technologies including stable and floor systems, manure handling-storage systems, anaerobic digesters as well as manure/digestate treatment (possible configuration shown in Figure 3). IMM results in the production of biogas and organic fertilisers, while reducing emissions of CH_4 and NH_3.

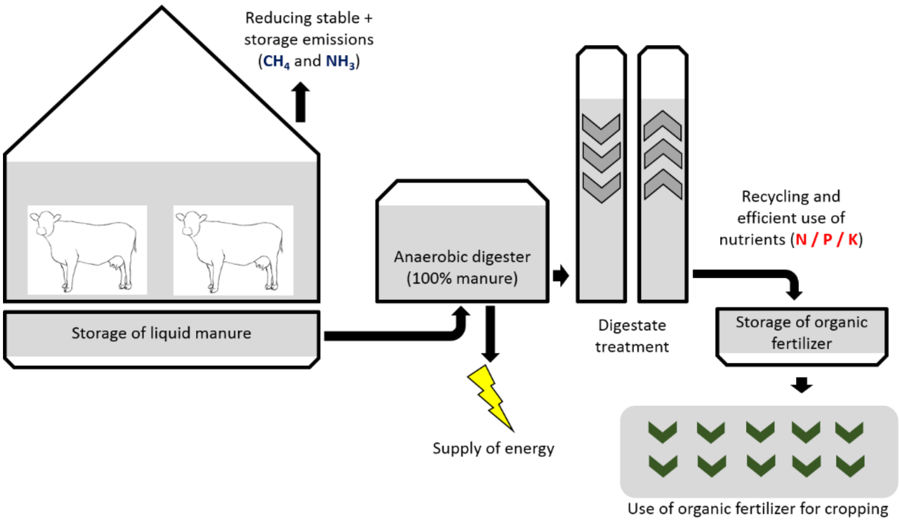

Figure 3. Integrated Manure Management as a low carbon transition option for the Dutch livestock sector.

An alternative to IMM is a reduction of the livestock (RL) sector in terms of animal numbers. This second pathway can achieve a similar environmental performance as with IMM. These two pathways have been selected because of their distinct nature. The RL pathway tackles the environmental issues at the origin, while IMM is more a 'retro-fit' solution. On top of that, implementing the RL or IMM pathway could be done unilaterally and does not require full international collaboration. Moreover, both transition pathways have recently received more pronounced attention within the market and amongst policy makers.

While deliberately decreasing or limiting the size of the important livestock sector in the Netherlands may seem odd, there are clear signals that a decline of livestock farming is upcoming.[2,3] In recent years, societal concerns and environmental impacts have increased in parallel with the growth and industrialisation of the sector. Limiting further growth of the sector to mitigate the existing health, safety and/or environmental risks, hardly seems sufficient knowing that a substantial reduction of various impacts is needed. In this case study a reduction of livestock (RL) is considered to be a realistic alternative low carbon transition pathway.[4,5] Within this context IMM is considered essential to the long-term viability of the livestock sector in the Netherlands, especially in relation to the problem of nutrient loading, but also in relation to reducing NH_3 and CH_4 emissions.

Multi-purpose transition pathways & green growth

The former section illustrates that a low-carbon transition within the Dutch livestock sector cannot be developed without considering other relevant socio-economic and environmental issues. In order to succeed, there is a need for multi-purpose transition pathways. Such pathways address environmental issues in one go, while remaining economically viable and socially acceptable. This formulation resembles the definition of 'Green Growth' formulated during the United Nations (RIO +20) Conference on Sustainable Development (UNCSD) in 2012.

"Green growth, should contribute to eradicating poverty as well as [achieving] sustained economic growth, enhancing social inclusion, improving human welfare and creating opportunities for employment and decent work for all, while maintaining the healthy functioning of the earth's ecosystems."

A meaningful low carbon transition in the Dutch livestock sector would ideally serve several purposes. The key question is what the actual performance of these transition pathways will be, measured against a subset of relevant effects (or indicators)? Does one pathway generate more domestic employment over the other? Is animal welfare improving? Or can we expect some pollution swapping (e.g. lower GHG emissions, but worse soil/water quality)? Via the in-depth assessment of both transition pathways we expect to find a series of 'co-benefits' and 'trade-offs'. Co-benefits are a positive side-effect of the low carbon transition action, for example where GDP increases while GHG emissions fall. Trade-offs, on the other hand, are situations where a positive effect (e.g. lower

GHG emissions) will be associated with a negative side-effect (e.g. deterioration of animal health).

The impact of a nation-wide transition

Both the IMM and RL transition pathways can be explained relatively easily at the project or farm level. RL implies a reduction in the number of animals on a farm, or in a region. IMM implies that liquid manure is stored only for a short amount of time under stable floors, and is quickly fed into an anaerobic digester to capture CH_4. Afterwards the digestate is processed in such a manner that (marketable) organic fertilizers are produced. But what do these two transition pathways mean at the national level? What is the order of magnitude of such a transition? How many animals should be taken out of production? How quick should it be implemented? How many manure digesters are we talking about? And what is the sum of required investments (or divestments) are needed?

In order to get a feeling of how a low-carbon transition in the livestock sector could look like in more tangible figures we have made a 'back-of-the-envelope' calculation.

The EU 2030 objective for greenhouse gas emissions is a 40% reduction for non-ETS sectors relative to 2005 emissions levels. The proposed effort sharing up to 2030 results in a reduction effort of -36% for the Netherlands.[6] With regards to CH_4 emissions the initial proposal for a new EU Directive on Air Quality[7] also included a national target. The specific proposed target for the Netherlands entailed a reduction of CH_4 emissions of -33% relative to 2005 levels in 2030.

If we take these targets and relate it to the current (2014) level of CH_4 emissions (enteric fermentation and manure management) coming from the livestock sector, we can establish an indicative CH_4 emission reduction effort for both pathways (Table 2). The sectoral reduction effort is based on the assumption of an even effort sharing with the non-agricultural sectors (2014 CH_4 emissions divide roughly one-thirds for non-agriculture and two-thirds for agriculture).

Table 2 provides a further breakdown of current (2014) and base year (2005) CH_4 emissions between emission categories, as well as animal categories. It shows that cattle is – by far – the largest source of CH_4 emissions from enteric fermentation, while within manure management both swine and cattle have about an equal share of CH_4 emissions.

Table 2. Indicative CH_4 emission mitigation effort sharing between agriculture and non-agriculture sectors in the Netherlands. Source (emissions data): National Inventory Report (NIR, 2016)).

Data in Mt CO_2-eq.	2005	2014	2030	Indicative reduction effort
Target			-33%	
National CH_4 emissions	20	18,6	13,4	-5,2
Share of non-agriculture	8	6	4,31	-1,68
Share of agriculture	12	12,6	9,09	-3,52
Of which				
Ent. Fermentation Cattle[8] Swine Other		8,2 7,2 0,5 0,5		
Man. Management Cattle Swine Other		4,4 2,2 2,1 0,1		

Reduction of livestock (RL)

If the full CH_4 emission reduction of -3,52 Mt CO_2-eq. had to be achieved by reducing livestock, it is likely that NOT the swine herd, but the (dairy) cattle herd would be reduced. After accounting the 'double-bonus'[9] effect of reducing the amount of cattle in the Netherlands, the CH_4 emission reduction target can be achieved by reducing the Dutch cattle herd by about 37,5%. This corresponds to about 1,5 mln. cows and is comparable to, for example, the entire Swedish or Danish cattle sector.

Integrated Manure Management (IMM)

If we aim to achieve the -3,52 Mt CO_2-eq. reduction target by means of IMM, we first need to determine how effective methane capture from manure management would be. What would be the 'capture efficiency'? Based upon current technologies and practices, and existing infrastructures for manure management a capture efficiency of around 80% should be feasible. Hence, 20% of the CH_4 emissions from manure management is considered to persist.

If we multiply the current level of CH_4 emissions from manure management by (4,4*)0,8 we can conclude that this matches the required reduction effort of -3,52 Mt CO_2-eq. This implies that all animal manure in the Netherlands would have to be fed into an IMM process (e.g. anaerobic digester). However, GHG accounting protocols indicate that CH_4 emissions from solid manure, as well as CH_4 emissions from manure excretion during outdoor grazing are relatively low. Hence, the bulk of CH_4 emissions are stemming from liquid manure that is captured in stable systems. [10]

About 96% of the animal manure in the Netherlands comes in the form of liquid manure.[11] The predominantly anaerobic conditions in manure storage generates CH_4. A share of 12,3% of total manure is not captured in stables but is excreted on land during grazing (mainly cattle manure). Hence, 83,7% of total animal manure is captured in stable systems, and is the main source of the CH_4 emissions from manure management that are currently accounted for.[12] From this 68,3% is liquid cattle manure and 15,3% liquid pig manure. In mass (wet) terms this translates into 51,8 mln. ton of liquid cattle manure and 11,6 mln. ton of liquid pig manure per annum.

Current developments in the Netherlands biogas / manure sector show a different technological approach for cattle manure and pig manure. Cattle manure based systems are more likely to have a farm-scale (assumed capacity of about 5.000t manure), whereas most pig manure driven biogas plants would likely be developed at industrial scale (assumed capacity of about 200.000t manure). Using these numbers allows us to calculate how many IMM installations would need to be installed before 2030 in order to meet the CH_4 target for agriculture via IMM.

- Cattle: ≈ 10.000 farm-scale IMM plants
- Swine ≈ 60 industrial scale IMM plants

Knowing that the current number of biogas plants in the Netherlands is about 120, and the amount of (large-scale) manure treatment plants is around 60, the (indicative) investment challenge of around EUR 5.8 bln. in this low carbon transition process towards 2030 is formidable[13]. Although such a transition pathway might not be entirely realistic, it clearly shows the challenge this sector is facing under a stringent climate regime.

Scoring of pathways

In the previous section we have shown in more tangible numbers what the key impact of either the RL or the IMM pathway is at the national level. After this it is possible to start 'scoring' both pathways in terms of their contribution to meeting the various environmental targets (e.g. GHG, air, soil, water), as well as their socio-economic performance. To illustrate, the IMM pathway positively contributes to reducing CH_4, CO_2 and NH_3 emissions, and increases the production of renewable energy. IMM, however, has a neutral effect on the excretion of nutrients, while the RL pathway directly results in a reduction of nutrient excretion. The RL pathway results in reduced emissions of CH_4 and NH_3.

On top of these environmental effects both pathways also have a number of other socio-economic and environmental side-effects (Table 3). The RL pathway would result in a direct loss of GDP as meat and dairy output decreases substantially, while the IMM pathway could be considered more suitable for animal health as the in-stable climate improves due to shorter manure storage times.

The RL pathway could also lead to a lower level of international cost-competitiveness of the Dutch agricultural sector (i.e. cropping), as at some point a shortage of cheap soil nutrients might arise. This could result in higher use of fossil fertilisers and cover crops. Also in terms of domestic employment both pathways are considered to have a different impact.

Next steps

Table 3 provides a qualitative comparative assessment of the side-effects of two low carbon transition pathways. The next step within the TRANSrisk project will be to start to (as much as feasible) quantify these and other effects with the help of the macro-econometric Energy-Environment-Energy model (E3ME) in order to be able to further explore the relative importance of these side-effects when it comes to implementing low-carbon transition pathways in the livestock sector.

With a better (quantitative and qualitative) understanding of the key side-effects of alternative low carbon transition pathways it will be easier to develop a more robust and integrated policy framework for the livestock sector in livestock dense areas.

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Table 3. Overview and qualitative comparative assessment of relevant (side-)effects of IMM and RL transition pathways

Contribution to target	IMM	RL	Remark
Renewable energy			
PJ	+	0	**IMM** - Manure digestion = biogas
GHG emission reduction			
CH_4 – enteric fermentation	0	+*	**IMM** - Does not reduce enteric fermentation
CH_4 – manure management	+	+*	**IMM** – Reduces CH_4 emissions from manure storage **RL** - Less livestock = lower manure excretion = less manure stored
CO_2 – avoidance of fossil fuel	+	0	**IMM** - Due to biogas production **RL** – Smaller sector might result in lower use of fossil energy
Ammonia emissions			
Stables & storage	+	+	**IMM** - Improves in-stable air quality (shorter manure storage times)
Application to soil	0	+	**IMM** – Use of organic fertiliser/digestate does not seem to significantly change NH_3 emissions on land relative to RL where untreated manure is used **RL** – national NH_3 emissions on land reduce due to lower manure use
Nutrient excretion			
N	0	+	**IMM** - only changes manner in which N and P become available
P	0	+	**RL** - will immediately result in lower excretion of N and P
Possible side-effects[14]	**IMM**	**RL**	**Remark**
Domestic availability of 'cheap' soil nutrients	-	-	**IMM** – does not change absolute production levels of soil nutrients, but is likely to increase costs for fertilisation relative to use of untreated animal manure **RL** – When scarcity on manure market arises alternative, more expensive means of fertilisation needed (e.g. increase fossil fertilisers and more intermediate/cover crops for organic matter) In both cases, this might could affect competitiveness of NL agricultural sector
Animal health – air quality	+	0	**IMM** - stimulates short manure storage times (increases biogas yield), which helps to improve in-stable climate
Animal health – use of antibiotics	+	+*	**IMM** - Quality standards for using organic fertilisers likely to include max. pharmaceuticals concentrations **RL** – in absolute terms use of antibiotics in NL would reduce
Animal welfare – grazing time (cattle only)	0 / -	+ / -	**IMM** - is likely to increase cost of production, hence, when a farmer has committed to IMM there is an incentive to capture most manure to be fed into the process (could reduce grazing time to legal minimum) **RL** – Implies more hectares grazing land per animal, and could increase grazing time per animal. However, it has to remain economic to retain same amount land for grazing/roughage production
Animal welfare – stable space	+	0	**IMM** – Requires investments in innovative stable systems, which is mostly done in relation to mayor refurbishments that are likely to ensure more spacious stables **RL** – Implies consolidation/reduction of livestock sector investments, hence is less likely to foster investments in more innovative stable systems
Human health	+	+*	**RL** - Does not guarantee that human health effects are properly tackled (it does reduce intensity and probably reduce significance of overall risk) **IMM** - controlled IMM processes provide an ideal background for better sanitisation and overall hygiene
International competitiveness livestock sector	-	-	**IMM** – cost of production likely to increase, which might be offset by sustainability price premium on products (or a government subsidy), but this premium is not certain in international competitive markets (and with state aid regulations)
Impact on GDP	+ / -	-	**IMM** – has potential to increase domestic investments in IMM activities, could result in lower imports of food products and (renewable) energy, and export of organic fertilisers, but could be mitigated by loss of market share in export markets for animal protein **RL** – smaller sector results in less feed imports, but also could reduce size of animal feed industry and reduces exports of food products and increases imports of food products, can have negative effect on NL food processing industry.
Employment	+	-	**IMM** – employment levels likely to remain stable (or slightly increase) due to operation and management needs of IMM facilities, only when (inter)national demand pays a good price for more sustainable animal proteins **RL** – employment levels likely to decrease in, directly in livestock farming, but also in associated (sub-)sectors such as food processing

Symbols indicate (+) positive, (-) negative, (+/-) uncertain/unknown or (0) neutral/insignificant effect of the low carbon transition scenario.
*Provided that this does not lead to replacement of same livestock practices to other regions in the world (i.e. 'leakage').

Source: TRANSrisk project / JIN Climate and Sustainability, 2016

Notes

[1] The Netherlands is the 2nd largest agricultural exporter in the world (after the United States), and is the 4th largest milk producer in the EU, while it has the 7th largest cattle herd. It also is the EU's largest producer of veal, and has the 5th largest swine herd in the EU.

[2] In a letter (7 July 2016) publishing a report regarding the human health risks related to livestock farms the Dutch Cabinet announces to submit the legislative proposal 'animal numbers and public health' (*Wetsvoorstel dieraantallen en volksgezondheid*) to the 2nd Chamber. This legislative proposal – which already dates back from 2014 - would enable the Dutch provinces to assign areas where the total animal numbers can be maximised/limited.

[3] In the run up to the implementation of the (new) quota system for so-called phosphate production rights already in 2017, during the first half of 2016, already 63.000 more (mainly dairy) cows have been brought to slaughterhouses in the first half of 2016 relative to the same period in 2015.

[4] Preliminary (own) calculations suggest that swine and dairy cattle stocks might need to be reduced by a maximum of 40% in order to meet the national 2030 target for NH_3 emissions and that might lead to about 1% decrease in Dutch GDP that is equal to the current economic growth in Netherlands.

[5] Other low carbon transition pathways are also possible. In this case study only the IMM and RL pathways are considered.

[6] http://europa.eu/rapid/press-release_MEMO-16-2499_en.htm

[7] http://ec.europa.eu/environment/air/clean_air_policy.htm

[8] Cattle:

- Mature dairy cattle: 5,0
- Other mature cattle: 0,2
- Growing cattle: 2,0

[9] Less cattle, implies lower level of enteric fermentation, but also less manure produced. This, in turn, results in lower levels of CH_4 emissions from manure management.

[10] CH_4 emissions from liquid manure during grazing of cattle are quite minimal. To illustrate, the Methane Conversion Factor (MCF) for liquid manure excreted on land is 0,01, while the MCF for liquid cattle manure in stables is 0,17 and 0,39 for liquid swine manure. Hence, it would be fair to assume that almost all (>95%) of the CH_4 emissions in manure management occur in stable systems.

[11] About 4% of total animal manure is solid manure.

[12] As reported in the Netherlands National Inventory Report (NIR).

[13] This is a best-guess estimate, based upon informal contacts with stakeholder from the biogas industry. This estimate is subject to revision. Farm-scale IMM systems are assumed to require an investment (CAPEX) of around 100 EUR per ton of manure. Industrial scale IMM systems are considered to require a CAPEX of around 52 EUR per ton of manure. An IMM system is considered to include an anaerobic digester, an energy production unit, and a manure/digestate treatment unit.

[14] List of side-effects is non-exhaustive. Other side-effects to consider are 1) N_2O emissions, 2) rural development, 3) technological innovation, etc.