



National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Uncertainty calculation of emissions from Dutch agriculture

Lotte Lagerwerf,
National Institute for Public
Health and the Environment
(RIVM)



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Contents

- Uncertainty calculations of agricultural emissions
- Calculation of NO_x and NH_3 from agriculture
- Uncertainty calculation of NO_x and NH_3
- Uncertainties



Uncertainty calculations

- Approach 1 is used
 - Propagation of error method
 - As described in the guidebook (EEA 2016)

- $\sigma_{combined} = \sqrt{\sigma_1^2 + \sigma_2^2 + (\sigma_1 * \sigma_2)^2}$



Uncertainty calculations

- **Simple** emission calculations
- For example
 - PM from animal houses:
PM emissions = EF * animals in the animal house
 - Uncertainty of PM from animal houses

$$\sigma \text{ PManimal houses} = \sqrt{\sigma_{EF}^2 + \sigma_{animals}^2 + (\sigma_{EF} * \sigma_{animals})^2}$$



Uncertainty calculations

- However, there is more than one type of housing system, each with their own EF
 - PM emissions = EF * animals in the animal house * Fraction of animals in the housing system

The propagation of error formula expands;

$$\sigma PM_{animal\ houses}$$

$$= \sqrt{\sigma_{EF}^2 + \sigma_{animals}^2 + \sigma_{fraction}^2 + (\sigma_{EF} * \sigma_{animals})^2 + (\sigma_{EF} * \sigma_{fraction})^2 + (\sigma_{fraction} * \sigma_{animals})^2}$$



Uncertainty calculations

- Categories are a combination of emission sources
- Summation of the uncertainties is done with:

$$- U_{total} = \sqrt{\frac{\sum_i (emission_i * U_{emission_i})^2}{\sum_i emission_i}}$$



Emissions from agriculture

- NH_3 and NO_x emissions from manure management
 - Manure in animal housing
 - Manure storage
 - Manure treatment
- NH_3 and NO_x emissions from agricultural soils
 - Inorganic N fertilizers (including urea application)
 - Livestock manure applied to soils
 - Sewage sludge applied to soils
 - Other organic fertilizers applied to soils (including compost)
 - Urine and dung deposited by grazing animals
 - Crop residues left behind on soils
 - Cultivated crops



Emissions from agriculture

- NH_3 and NO_x emission from **manure management**
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NH₃ and NO_x from manure

- **Nitrogen** in urine and manure is degraded into NH₃ and NO_x
 - **N₂O** and **N₂** are also emitted
- All these emissions are depended on the **N in manure**
- Calculated with a N-flow model

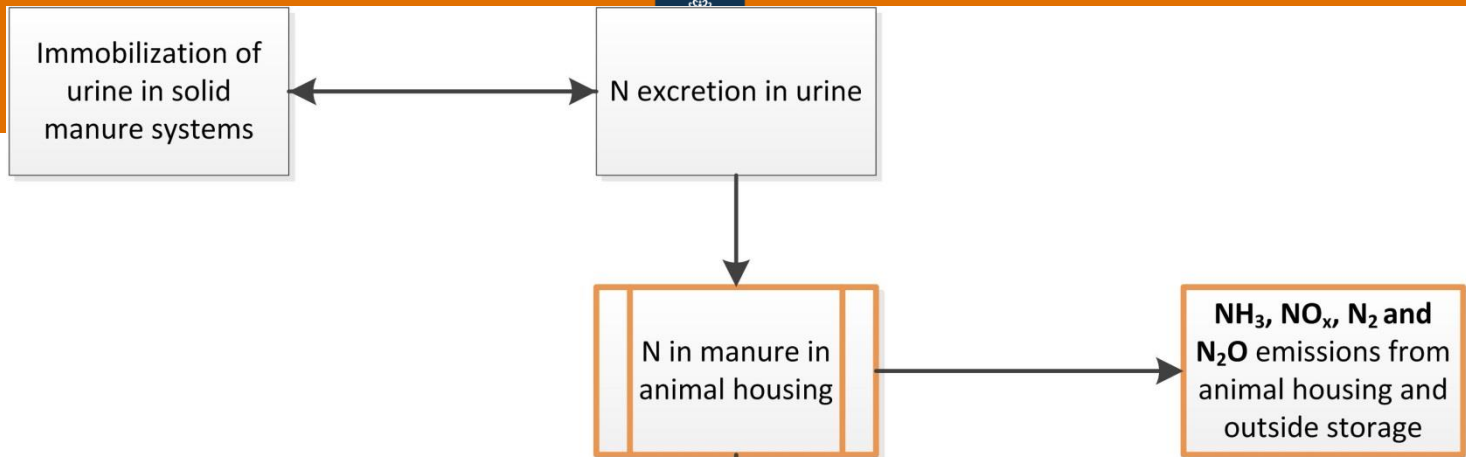
Immobilization of
urine in solid
manure systems

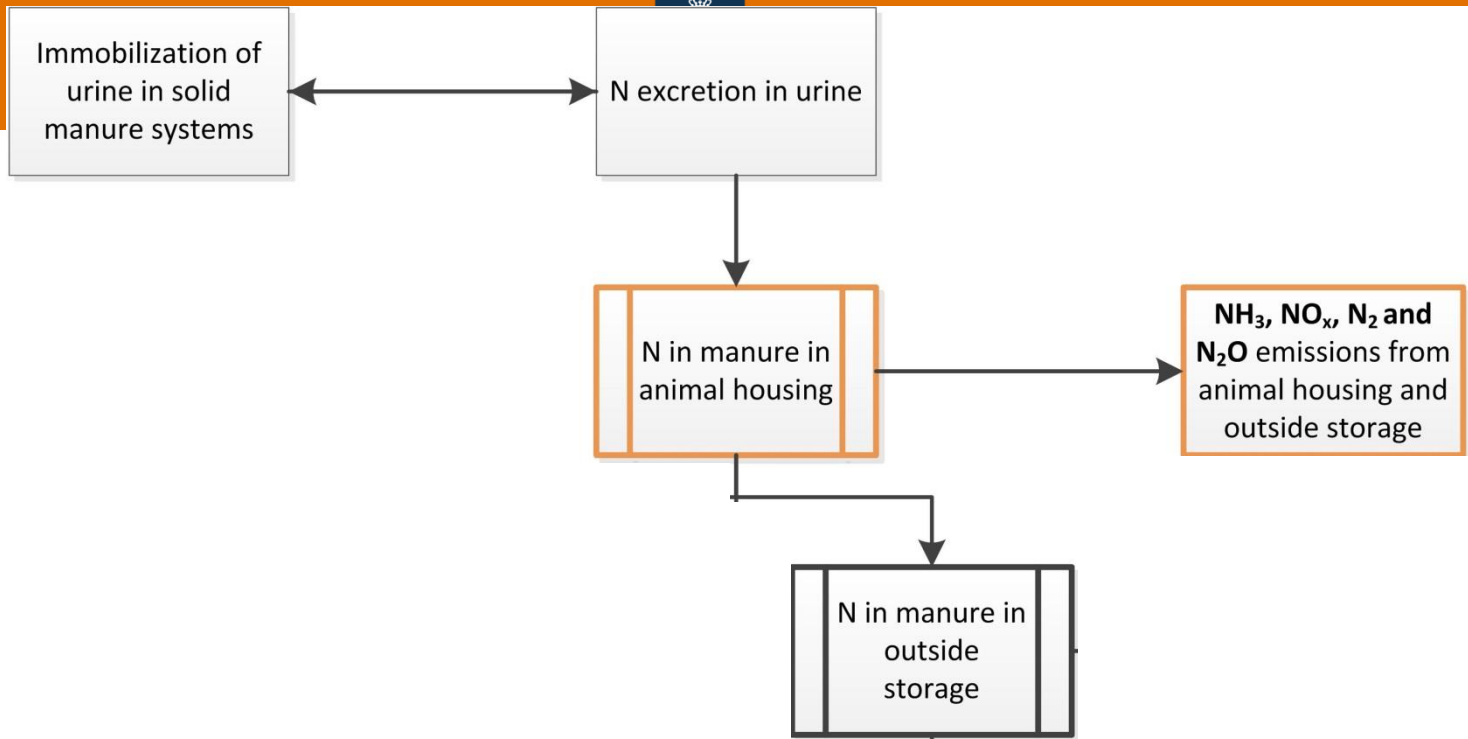


N excretion in urine



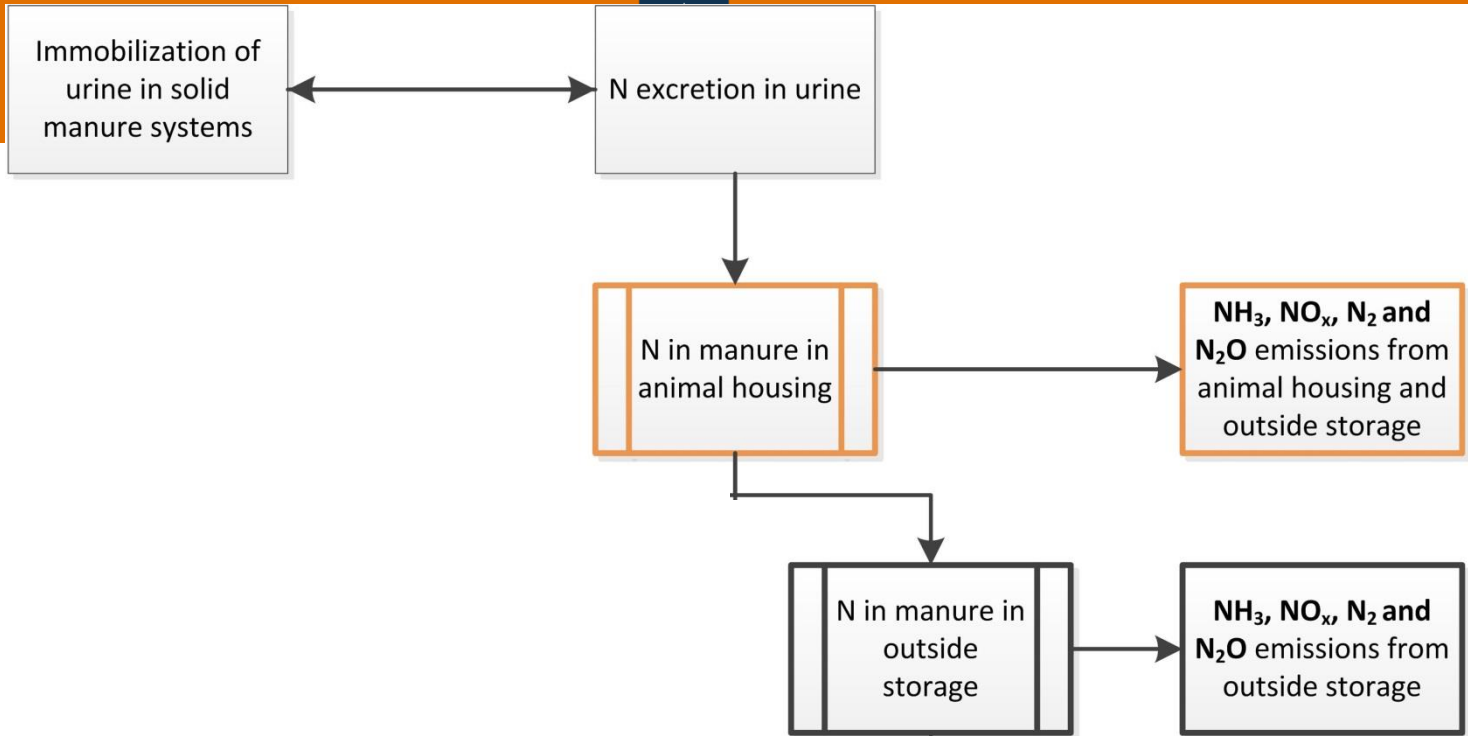
N in manure in
animal housing

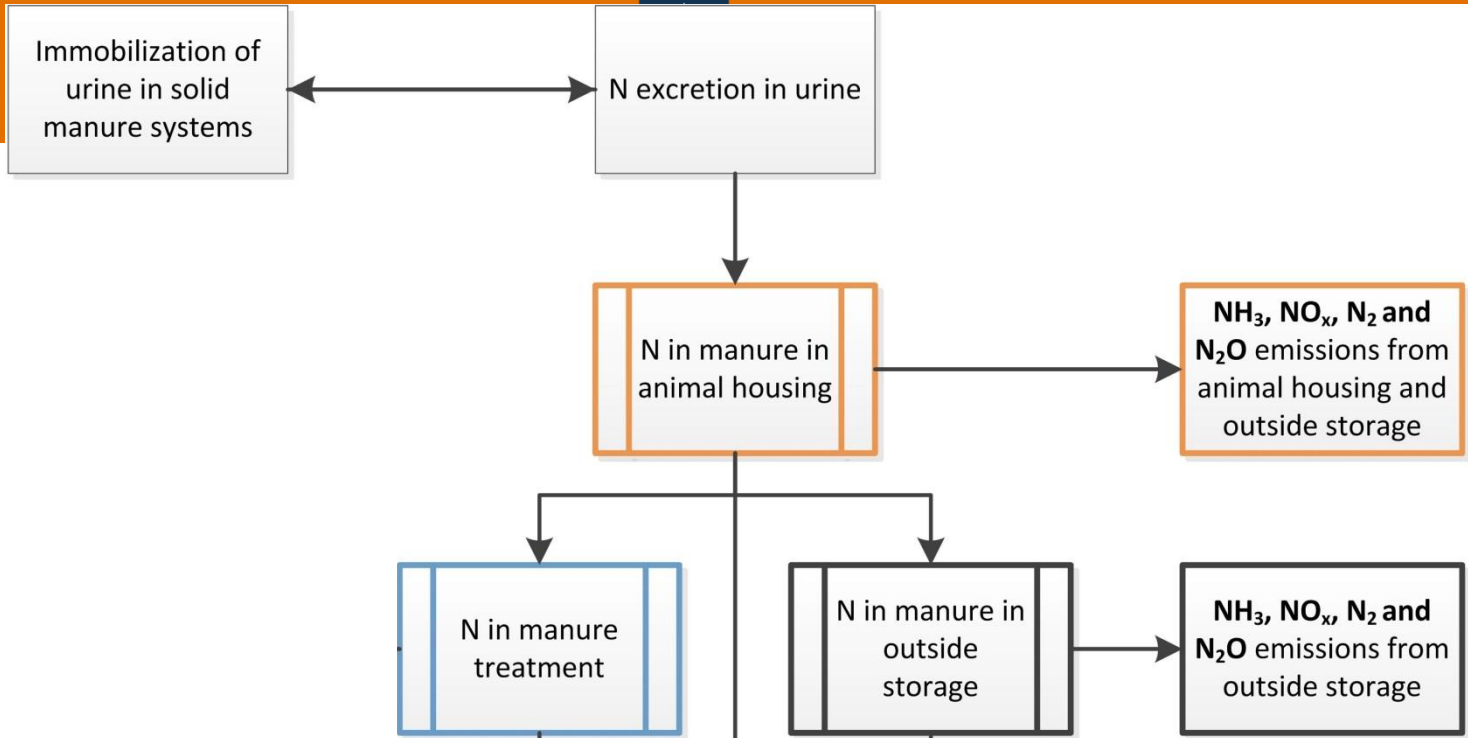


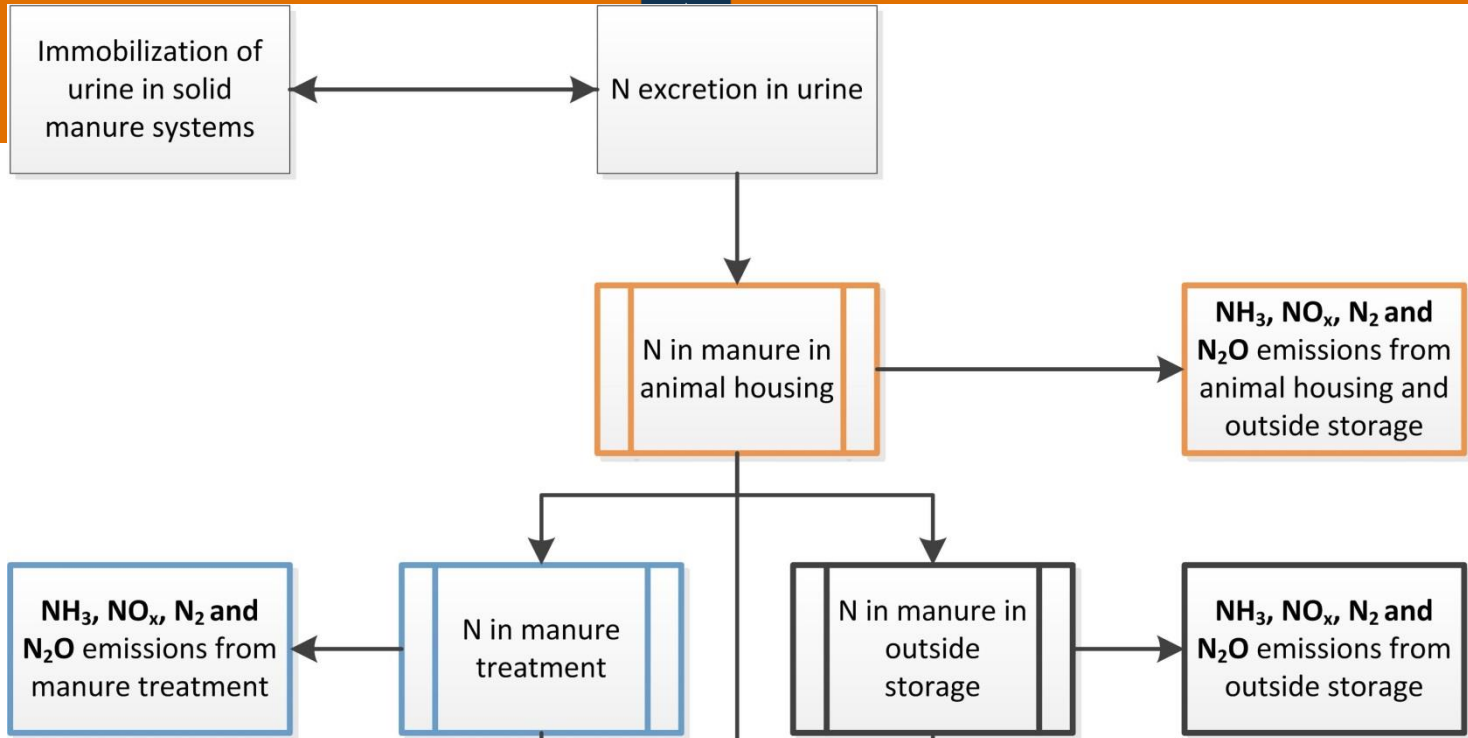


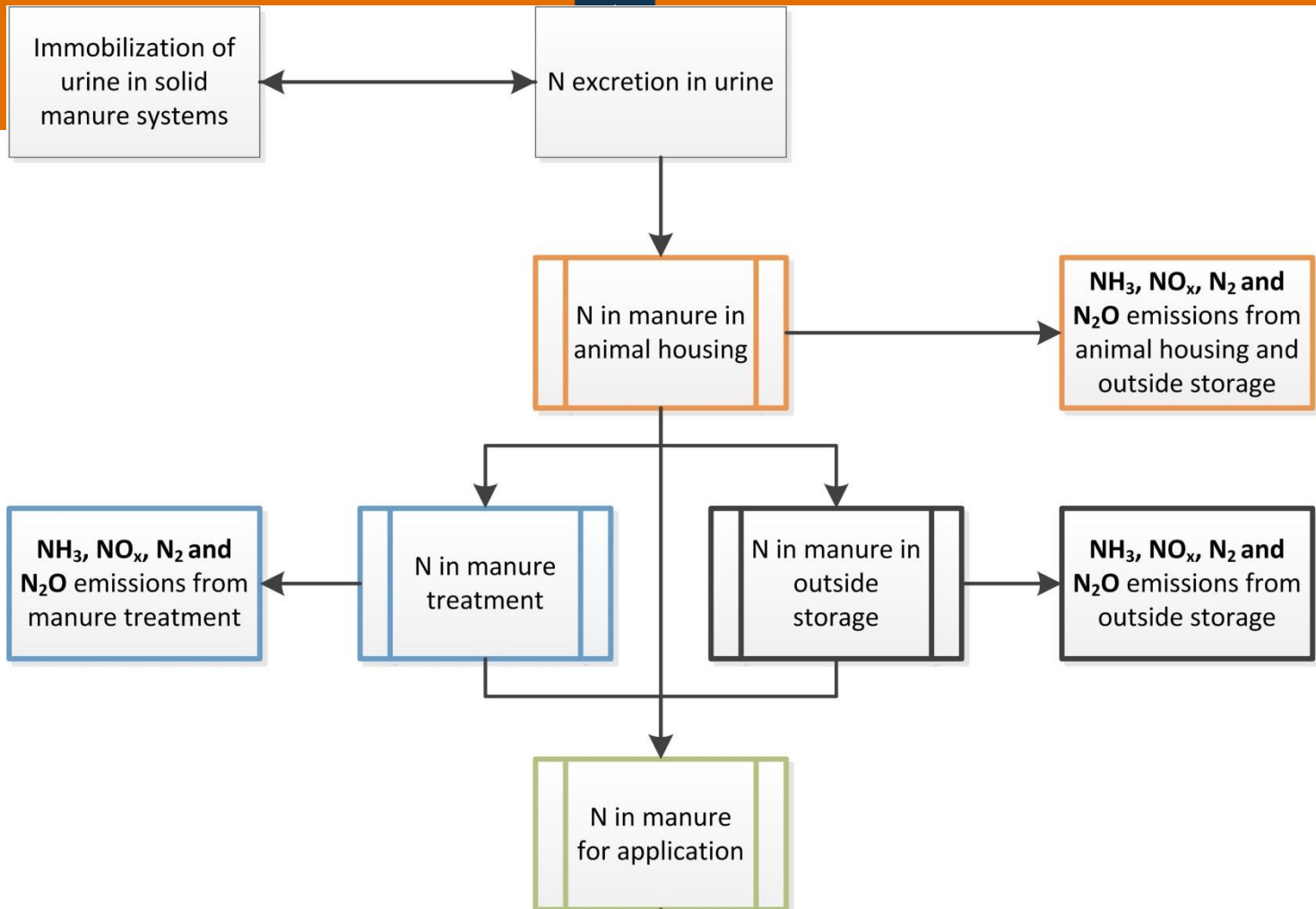


- $N_{\text{manure storage}} = N_{\text{manure animal house}} - \text{NH}_3, \text{NO}_x, \text{N}_2\text{O} \text{ and } \text{N}_2 \text{ emissions}$



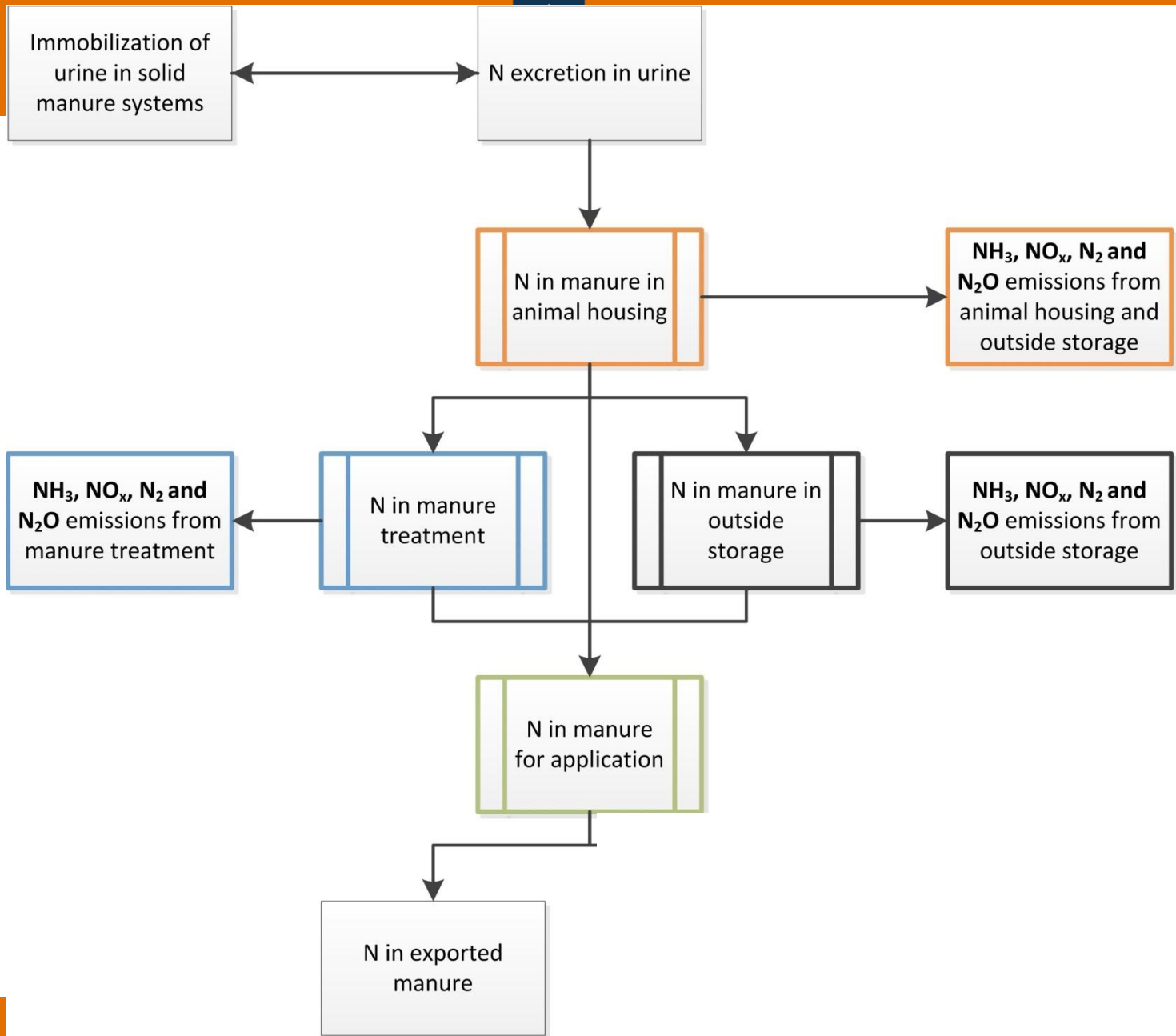


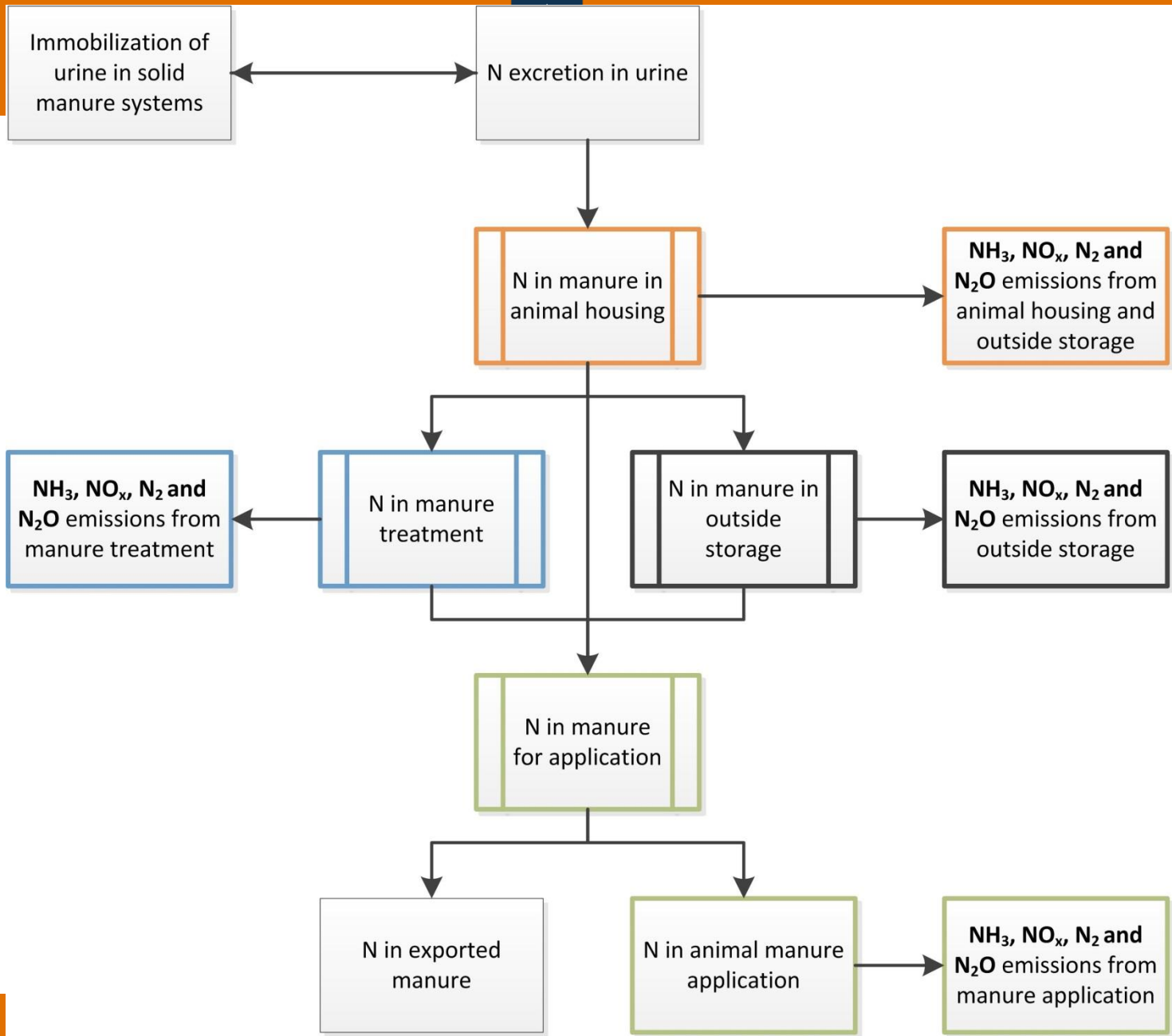






- $N_{\text{manure application}} = N_{\text{manure animal house}} - \text{NH}_3, \text{NO}_x, \text{N}_2\text{O} \text{ and } \text{N}_2$
storage and treatment emissions







Uncertainties N-flow model

- First the **uncertainties for animal houses** was calculated
- **Basis** for the uncertainties for manure **outside storage** and manure **treatment**
- Which was the **starting point** of the calculations of the manure **application**



Uncertainties N-flow model

- **Activity data** animal houses
 - animal number
 - amount of N excreted
 - manure is slurry or solid
 - fraction of N which is TAN
 - mineralization of N
 - emission factor per housing system

$$\sigma \text{ combined} = \sqrt{\sigma_1^2 + \sigma_2^2 + (\sigma_1 * \sigma_2)^2}$$



Uncertainties N-flow model

- **Activity data** outside storage
 - amount of N in the manure
 - N losses in the animal house
 - › Dependent on the animal house emissions
 - fraction of manure that is stored
 - emission factor
- And so on



Results

			2015	
	NFR code	Description	Uncertainty	Emission (kg ton emission/year)
NOx	3B	Manure management	97%	2.3
	3D	Agricultural soils	87%	19.2
		Total	79%	21.5
NH3	3B	Manure management	20%	57.3
	3D	Agricultural soils	29%	53.8
		Total	25%	111.1



Results

			2015	
	NFR code	Description	Uncertainty	Emission (kg ton emission/year)
PM10	3B	Manure management	21%	5.7
	3D	Agricultural soils	136%	0.7
		Total	24%	6.4
PM2.5	3B	Manure management	31%	0.5
	3D	Agricultural soils	111%	0.1
		Total	33%	0.6



Results

			2015	
	NFR code	Description	Uncertainty	Emission (kg ton emission/year)
NMVOG	3B	Manure management	143%	66.7
	3D	Agricultural soils	99%	26.1
		Total	107%	92.8



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Questions?



Results NH3

		2015			
Manure management		Aggregated uncertainties			Emission
NFR code	Description	Activity data	Emission factor	Emission	kg NH ₃ /year
3B1a	Dairy cattle	2%	45%	45%	19.4
3B1b	Non-dairy cattle	1%	29%	29%	10.8
3B2	Sheep	5%	106%	106%	0.1
3B3	Swine	8%	37%	38%	15.4
3B4d	Goats	5%	90%	90%	0.6
3B4e	Horses	4%	78%	78%	0.5
3B4f	Mules and asses	5%	88%	88%	0.0
3B4gi	Laying hens	4%	44%	44%	7.7
3B4gii	Broilers	10%	49%	50%	1.6
3B4giii	Turkeys	10%	44%	45%	0.8
3B4giv	Other poultry	10%	46%	47%	0.2
3B4h	Other animals	5%	47%	47%	0.3
Total, manure management				20%	57.3



Results NH3

		2015			
Agricultural soils		Aggregated uncertainties			Emission
NFR code	Description	Activity data	Emission factor	Emission	kg NH ₃ /year
3Da1	Inorganic N-fertilizers	26%	26%	37%	11.7
3Da2a	Animal manure applied to soils	4%	38%	38%	36.4
3Da2b	Sewage sludge applied to soils	25%	84%	88%	0.06
3Da2c	Other organic fertilizers applied to soils	23%	106%	111%	0.4
3Da3	Urine and dung deposited by grazing animals	1%	56%	56%	1.6
3Da4	Crop residues applied to soils	7%	59%	59%	1.9
3De	Cultivated crops			300%	1.9
Total, agricultural soils				29%	53.8