Deliverable C2.1, Part 4: Other IPCC sectors, agriculture, sector process emissions, IPCC sector waste

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Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis

Final report

LIFE ClimatePath2050 (LIFE16 GIC/SI/000043)

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
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Poročilo projekta št. C2.1, Metode in modeli za analizo strateških scenarijev blaženja podnebnih sprememb do sredine stoletja, Četrti del: Drugi IPCC sektorji, kmetijstvo, procesne emisije in odpadki, končno poročilo

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Introduction

In the scope of LIFE ClimatePath2050[1] the **Deliverable C2.1: Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis**, **Part 4: Other IPCC sectors, agriculture, sector process emissions, IPCC sector waste** the methodological approach for assessment is reported and presented. The document presents the information on the models developed or updated in the scope of the project along with some basic results.

The composite deliverable C2.1: Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis consists of several parts, namely:

- **Part 1: Summary report on methods and models for scenario analysis**, condense summary report on methods and models for scenario analysis;
- **Part 2: Energy sector models**, includes the detailed information on sectoral models used for climate mitigation scenario analysis, the report enlightens general approach approach and presents final energy demand and supply models including households, services and agriculture energy use, energy use in transport and industry, models for district heating expansion analysis and CHP cross sectorial impact, distributed electricity production assessment and optimisation of power sector operation;
- **Part 3: LULUCF model**, includes the detailed information on Carbon Budget Model (CBM-CFS3) that is used for simulating the dynamics of forest carbon pools, considering various assumptions such as the type of forest management, land use changes, the occurrence of natural disturbances and timber harvesting;
- **Part 4: Other IPCC sectors, agriculture, sector process emissions, IPCC sector waste**, includes information on the models used for assessing agriculture sector, process emissions and waste in accordance with IPCC reporting requirements;
- **Part 5: Macroeconomic model**, includes the detailed information on the newly developed multi-sectoral Computable General Equilibrium model (CGE) of the Slovenian economy (GreenMod Slovenia) that was developed and used specifically for the analysis of energy and environmental issues, considering the quantitative results of the energy sector models.

The deliverable **Part 4: Other IPCC sectors, agriculture, sector process emissions, IPCC sector waste**, includes information on the models used for assessing agriculture sector, process emissions and waste in accordance with IPCC reporting requirements.

1 LIFE ClimatePath2050 (Slovenian Path Towards the Mid-Century Climate Target)

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Agriculture

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1.1 Purpose of the model

The model AGRI AIR aims to estimate greenhouse gas (GHG) and air pollutant emissions from agriculture. The emission estimates are based on assumptions about future trends in agricultural production volumes, assumptions about changes in agricultural practices, and the assumed effects of emission reduction measures.

The model allows simultaneous estimation of methane, nitrous oxide, ammonia and nitric oxide emissions and quantification of gross and net nitrogen balance. The model enables the tracking of nitrogen in agriculture and the evaluation of the impact of different techniques to reduce greenhouse gas and air pollutant emissions. It was improved and upgraded as part of the LIFE Climate Path 2050 project. Among the other things:

- The AGRI LIVESTOCK and AGRI SOILS models were linked. A module for estimating gross and net nitrogen balance was also added. The upgrade allows tracking of all forms of nitrogen in agriculture and modelling of nitrogen demand from mineral fertilisers based on information on emission reductions from animal housing, manure storage, manure application, and expected changes in nitrogen uptake by agricultural crops.
- New emission sources (rabbits, composts, digestate) were added to the model.
- An updated methodology for estimating emissions of nitrous oxide, ammonia and nitric oxide (EMEP / EEA 2019) was implemented.
- Solutions were included in the model to assess the impact of some emission reduction measures (low protein feed rations, direction of fermentation in the rumen, nitrification inhibitors, efficiency of milk and meat production, …).

After merging the two models (AGRI LIVESTOCK and AGRI SOILS), the model for agriculture can be considered as a single model (AGRI AIR).

1.2 Model Inputs

1.2.1 External influencing factors

External influencing factors were considered qualitatively in the modelling, in the formation of key assumptions. It was taken into account that a large part of land in Slovenia is located in the less favoured areas for agriculture, that the structure of agricultural land is dominated by grassland and that Slovenia is characterized by fragmented ownership and fragmentation of agricultural land.

1.2.2 Internal Input Parameters

To calculate emissions, data on the scale of agriculture and agricultural practices are needed. The scale of agriculture is described by the number of animals, land cultivated and crop yields. Livestock practices are described by rearing systems and the intensity of livestock production. Cultivation practices are described by the intensity of fertilization and by manure application techniques. The details are given below.

Number of livestock by species and category

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- Cattle < 1 year, including slaughter calves and other calves
- Cattle 1-2 years, separately for male and female cattle
- Cattle > 2 years, separately for male cattle, heifers, dairy cows and other cows
- Pigs < 50 kg
- Fattening pigs > 50 kg live weight
- Breeding pigs > 50 kg live weight, separately for boars and sows
- Sheep, separately for ewes, other sheep and lambs
- Goats, separately for female breeding goats, other goats and kids
- Broilers
- Layers
- Other chickens
- Turkeys
- Ducks
- Geese
- Horses
- Rabbits

Harvested crops areas and yields

- Cereals by species
- Dried pulses by species
- Root crops by species
- Industrial crops by species
- Vegetables by species
- Fruits by species
- Fodder crops by species
- Permanent grasslands

Livestock rearing systems

- Housing and grazing (proportion of grazed animals, slats or solid floors, farmyard manure or slurry, deep bedding, battery or floor systems in poultry rearing, …)
- Manure storage (opened or covered slurry tanks, anaerobic digestion, slurry separation, …)

Intensity of livestock production

- Intensity in dairy production (milk production per cow, body weight, pregnancy rate, milk fat content, milk urea content)
- Intensity in beef production (growth rate, average body weight)
- Intensity of fertilization
- Nitrogen consumption from animal manures by type (liquid, solid)
- Nitrogen consumption from other organic fertilizers by type (digestates, sewage sludge, urban composts)

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- Nitrogen consumption from mineral fertilizers by type (urea, CAN, complex fertilizers, …)
- Nitrogen fixation by legumes

Manure application techniques (splashing plate, band application, incorporation into soil, …)

Application of mineral fertilizers (urea incorporation).

1.3 Key assumptions, scenarios and border conditions

It was assumed that the mitigation targets would not be met by reducing the volume of agricultural production. It was assumed that mitigation measures would take into account the natural conditions for agriculture (including a large area in less favoured areas for agriculture), food security objectives and other multifunctional objectives of agriculture such as biodiversity conservation. In preparing the projections, we considered the following:

- Slovenia lags behind countries with comparable conditions in terms of crop yields. It was estimated that by 2050 yields per hectare will increase by 50% for potatoes, 30% for other crops and 20% for grassland.
- Given the yield increases, past trends, and needs, we can expect a change in the sowing structure - less grain maize, silage maize, and wheat, and more oilseeds, legumes, and potatoes.
- In view of this, crop nitrogen requirements will increase. The amount of nitrogen in agricultural crop harvests will increase from 11,750 t in 2018 to 12,700 t in 2030 (+ 8%) and 15,200 t in 2050 (+ 29%).
- The increased nitrogen needs will be met mainly by improving the efficiency of livestock and mineral fertilizer use.
- The volume of milk, meat and egg production will be maintained at current levels. The exception is pork, where Slovenia's level of self-sufficiency is very low.
- GHG emissions in livestock production are to be reduced by improving production efficiency. The above targets will be achieved with a smaller number of animals than are kept now.

Three scenarios were elaborated: a) without measures (WOM), b) with existing measures (WEM) and c) with additional measures (WAM).

Scenario without measures (WOM)

In the WOM scenario, we assumed that the effects of measures introduced and implemented after 2004 are not realized. This is the year in which the first Rural Development Program was launched. A year later, a Decree on the limits of discharges of hazardous substances and fertilizers into the soil was adopted, which was a precursor document of the Decree on the Protection of Waters against Pollution by Nitrates from Agricultural Sources. It was considered that the intensity of emissions from milk production was kept at the level of 2004 and consequently the number of dairy cows did not decrease. It was assumed that the proportion of

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covered slurry stores remained at the 2004 level. The same assumption was made for the share of low ammonia emission fertilization techniques (for livestock manure and urea). A similar net N surplus as in 2002-2006 was assumed to be maintained in the future (30 kg/ha).

Scenario with existing measures (WEM)

In the scenario with existing measures, it was considered that the emission intensity of milk and beef production remains at the 2017 level. It was considered that the share of livestock manure in biogas plants does not increase and that the share of low-emission fertilization techniques remains at the 2018 level. It was taken into account that the existing measures will increase the share of grazing animals, the share of urea incorporated into the soil and the share of covered manure storage. It was also considered that the existing measures (fertilization restrictions, cover crops, adequate crop rotation, ...) will keep the net N balance surplus at the level of 20 kg/ha.

Scenario with additional measures (WAM)

The scenario with additional measures considers the following:

- Reduction of emission intensities in milk and beef production (reduction of animal numbers at the expense of better production efficiency).
- Use of feed additives to limit methanogenesis in the rumen (unsaturated fatty acids after 2030, other additives after 2040).
- Direct selection to reduce methane production in cattle (genomic selection methods, effects after 2040).
- Significant increase in treatment of livestock manure on biogas plants.
- Increase in the proportion of grazing animals (compared to WEM).
- Use of nitrification inhibitors in fertilization with mineral fertilizers.
- Increasing the proportion of urea incorporated into the soil (more intensive than in WEM).
- Increase in the proportion of covered slurry stores (more intensive than in WEM).
- Significant increase in the use of low ammonia fertilization techniques (band fertilization, injection into the soil).

1.4 Model structure

1.4.1 Methodology

The model AGRI AIR is a complex mechanistic model based on IPCC 2006 (IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4, Agriculture, forestry and other land use. IGES, Japan), EMEP / EEA 2019 (EMEP / EEA air pollutant emission inventory guidebook 2019. Technical guidance to prepare national emission inventories, EEA Report No 13/2019, European Environment Agency) and EUROSTAT / OECD 2019 (EUROPEAN COMMISSION, EUROSTAT. 2013. Methodology and Handbook EUROSTAT / OECD. Nutrient Budgets EU 27, Norway, Switzerland) methods. It works in the Microsoft Excel software environment. The model allows simultaneous estimation of methane, nitrous oxide, ammonia and nitric oxide emissions.

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Among other things, it also allows nitrogen fluxes in agriculture to be tracked. Based on expected (or projected) yields of agricultural crops, based on measures to reduce emissions of nitrogen compounds and based on projected trends in animal production, it can quantify future nitrogen demand from mineral fertilizers.

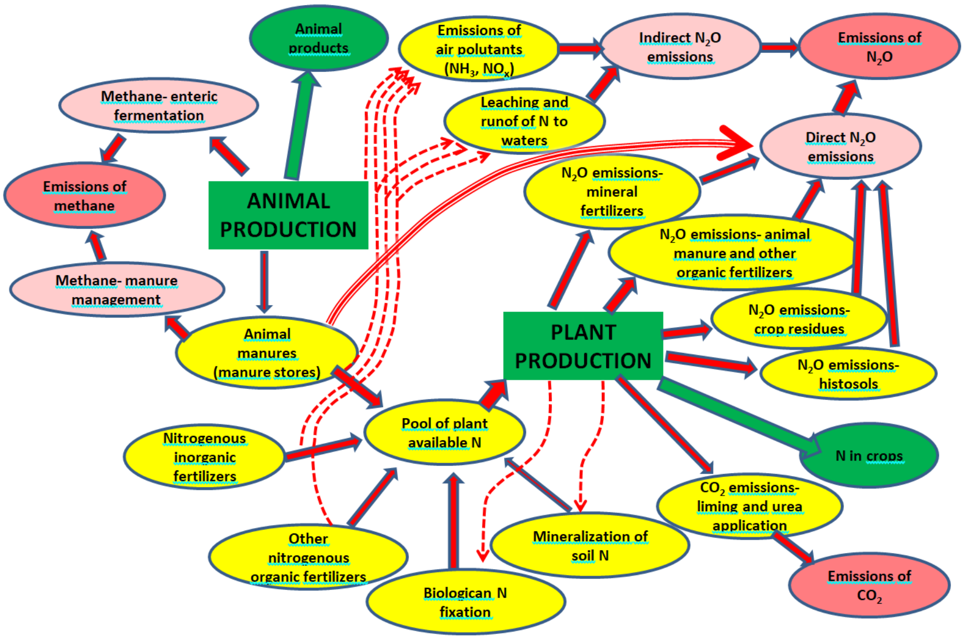

Figure 1. Simplified flowchart of the AGRI AIR model

1.4.2 Technologies, sectors, processes

The basic principles for estimating emissions of individual greenhouse gases (methane and nitrous oxide) by source are presented below. In addition, procedures for estimating carbon dioxide emissions from liming of agricultural land and fertilisation with urea and calcium ammonium nitrate (CAN) are given.

Methane

Methane emissions from enteric fermentation - cattle

Methane from enteric fermentation in cattle is the main source of GHG in agriculture (52.5% of total emissions). Emissions are related to gross energy intake, which is estimated by considering detailed information on animal performance. The above information includes animal body mass, milk production, milk composition, pregnancy rate of dairy cows and suckler cows, growth rate of beef cattle and heifers, and additional energy requirements for grazing. Gross energy intake information is converted to methane emissions using the methane conversion rate (Ym) recommended by IPCC (2006). At this stage, emission mitigation options, such as feed additives, can be considered by adjusting the Ym.

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Methane emissions from enteric fermentation - livestock other than cattle

Methane emissions from enteric fermentation in livestock other than cattle contribute only about 2% of total agricultural GHG emissions. For these livestock species, the IPCC (2006) default factors are used to estimate methane emissions. Only mitigation options that result in a reduction in livestock can be quantified for these species.

Methane emissions from manure management

Methane released from the decomposition of animal excreta in manure storage facilities contributes 13.7% of total GHG emissions from Slovenian agriculture. The amount of methane produced depends largely on the type of manure management system. Liquid manure storage produces significantly larger amounts of methane than solid manure storage or grazing. Emission estimates are based on the amount of volatile solids excreted (VS), the methane-producing capacity of the manure (B0, in m3 per kg VS) and the manure management system (MMS), resulting in a specific methane conversion factor (MCF). In the case of cattle, VS is estimated based on gross energy intake (see Methane emissions from enteric fermentation). For other livestock species, the default values of IPCC (2006) are used. Various options to mitigate methane emissions from manure management can be considered - from reduced VS excretion to grazing and low-emission manure storage techniques, such as anaerobic biogas digestion.

Nitrous oxide

Nitrous oxide emissions from manure storage and due to the application of animal manures

Direct nitrous oxide emissions from manure storage contribute 3% to the total GHG emissions from Slovenian agriculture. Additional 6.6% is contributed by emissions resulting from fertilization with animal manures and 2.3% by nitrogen excreted by grazing animals.

A mass balance approach that tracks nitrogen throughout the system was used to estimate N2O emissions (EMEP/EEA, 2019). The method is based on the principles of total N and total ammonia-nitrogen fluxes (TAN) through the manure management system. The model starts with TAN excretions followed by emissions of NH3, N2O, NO and N2 from animal housing and manure storage. It was considered that only the nitrogen that was not lost from the animal houses and manure stores remains in animal manures. Therefore, the emissions in each phase depend on the extent of emissions in the previous phases. In the case of slurry-based systems, mineralization of non-TAN was considered and in the case of farmyard manure, it was considered that part of TAN is immobilized into organic matter. At the final stage, the method provides information on the total amount of N returned to the soil. It was used to evaluate N2O emissions due to nitrification and denitrification processes resulting from the use of animal manure applied to soils.

The model allows quantification of various mitigation measures that result in reductions in direct or indirect nitrous oxide emissions. These include various practices ranging from low-emission animal housing design, low-emission manure storage, and low-emission manure application methods to the use of urease, nitrification, and denitrification inhibitors.

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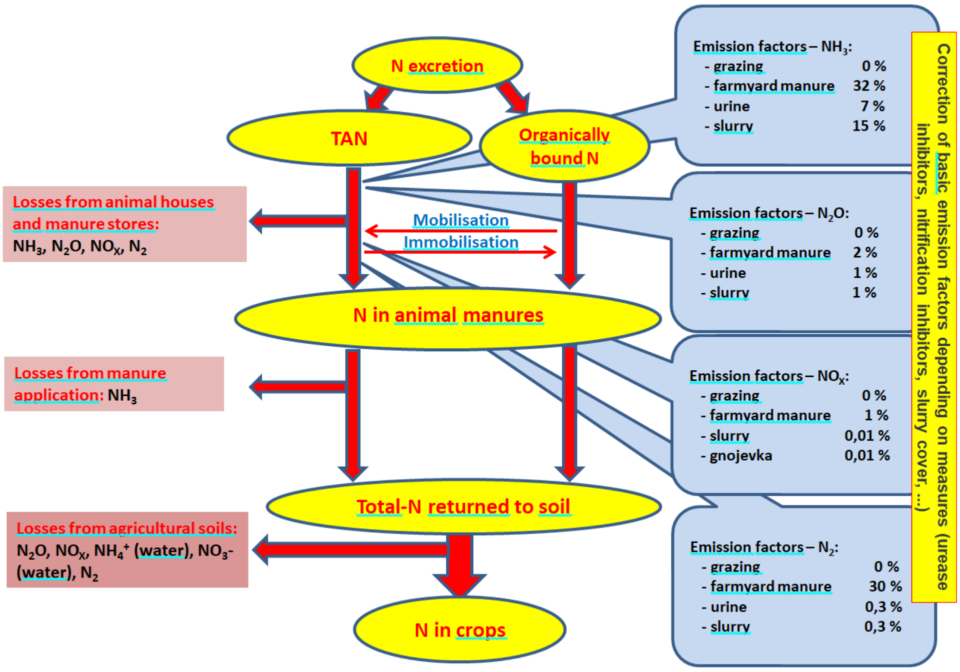

Figure 2. Example of estimation of emissions of different gases during grazing and storage of livestock manure considering emission factors (in % of total ammoniacal N - TAN). The emissions in this phase influence the emissions in the next phase (manure application).

Nitrous oxide emissions from fertilization with mineral fertilizers

Direct nitrous oxide emissions due to fertilization with mineral fertilizers contribute 7.6% to total GHG emissions from Slovenian agriculture. They arise from the processes of nitrification and denitrification in agricultural soils. Quantification of these emissions is based on information on nitrogen consumption from mineral fertilizers and emission factor given by IPCC (2006). The impact of mitigation options, such as the use of inhibitors of urease, nitrification and denitrification, can also be quantified. The last one requires the definition of the type of mineral fertilizer (urea, CAN, compound fertilizer, ...).

Nitrous oxide emissions from fertilization with other organic fertilizers

The model includes procedures to estimate nitrous oxide emissions due to fertilization with other organic fertilizers, such as digestate of non-agricultural origin, sewage sludge and urban compost. Currently they are a minor source of emissions (0.1% of agricultural emissions).

Nitrous oxide emissions from the decomposition of crop residues

A significant source of nitrous oxide emissions is nitrogen from the mineralization of crop residues (above and below ground mass) that remain in or are returned to the soil (2.0% of agricultural emissions). The model includes the equations to estimate the amount of nitrogen in crop residues based on crop yields. The IPCC (2006) emission factor is used to convert the above nitrogen to nitrous oxide emissions.

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Nitrous oxide emissions due to cultivation of organic soils and mineralization/immobilization associated with loss/gain of soil organic matter

Nitrous oxide emissions due to cultivation of organic soils and emissions from nitrogen mineralization due to land use change can be estimated within the model. The procedure is based on the methodology of IPCC (2006). Currently, both sources contribute 0.5% of GHG in agriculture.

Indirect emissions of nitrous oxide

Indirect nitrous oxide emissions are caused by atmospheric deposition of nitrogen, that is lost into the air in the form of ammonia and nitric oxide, and by leaching/runoff of nitrogen compounds into water bodies. The major sources of indirect nitrous oxide emissions are volatilization of nitrogen from animal houses and manure storage (1.7% of agricultural GHG emissions), volatilization of nitrogen from agricultural soils (2.2% of agricultural GHG emissions), and leaching/runoff of nitrogen from agricultural soils (4.0% of agricultural GHG emissions). Under the AGRI AIR model, these nitrogen losses are quantified simultaneously as part of the procedures for direct nitrous oxide emissions. The IPCC (2006) emission factor was used to convert nitrogen losses to nitrous oxide emissions.

Carbon dioxide

In the frame od CRF (UNFCCC Common Reporting Format) sector Agriculture, only carbon dioxide emissions released from the application of limestone, urea, and calcium ammonium nitrate (CAN) are reported. The method used to estimate emissions is based on application rates and IPCC (2006) default emission factors.

1.5 Connections with other models

Model AGRI AIR is not connected with other models. It is a stand-alone model and does not depend on any other model.

1.6 Future development of the model and research challenges

The model requires constant updating and adaptation to changes in the official methodology for reporting greenhouse gas emissions. Implementation of initiatives from audit reports to annual National Inventory Reports is also required. It would be useful to improve the procedures for estimating methane and nitrous oxide emissions in pig and small ruminant production so that the effects of production intensity can be taken into account. The model needs to be upgraded with solutions that allow quantification of the impact of emerging emission reduction techniques. The need to implement the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories will become apparent in the near future. It has already been adopted by the Intergovernmental Panel on Climate Change in 2019 but has not yet come into force. In the long term, the model will likely need to be adapted to the new approach to assessing the greenhouse effect of short-lived climate pollutants.

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1.7 Model results

The AGRI AIR model was used to produce projections of agricultural greenhouse gas emissions. The results were used for the Integrated National Energy and Climate Plan of the Republic of Slovenia and the Resolution on the Slovenian Climate Long-Term Strategy 2050. The model has also been used for projections of air pollutants in agriculture. In addition, it has proven useful for quantifying the impacts of measures of Rural Development Programme.

The results of GHG projections according to different scenarios are presented in Table 1. Scenario with additional measures (WAM) has shown that in the long term the greatest potential for reducing GHG emissions lies in measures to reduce methane emissions from enteric fermentation (inhibitors of methanogenesis, vaccination against methanogens, direct selection (breeding) for low methane emissions) (168 kt CO_2 ekv per year). This is followed by treating livestock manure in anaerobic digesters (biogas production) (149 kt CO_2 ekv per year) and by improving the efficiency of livestock production, i.e. producing the same amount of milk and meat with a smaller animal population (131 kt CO_2 ekv per year). There is also considerable potential in nitrification inhibitors used in combination with mineral fertilizers (32 kt CO_2 ekv per year), low emission manure application techniques (22 kt CO_2 ekv per year) and precision farming on the area of fertilization with N containing mineral and organic fertilizers (16 kt CO_2 ekv per year).

Tab. 1: Projections of greenhouse gas emissions according to different scenarios (kt CO2 ekv per year)

	2020	**2030**	**2050**
Without measures (WOM)	1820	1871	1932
With existing measures (WEM)	1751	1801	1860
With additional measures (WAM)	1734	1700	1343

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IPCC sector process emissions

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2.1 Purpose of the model

Industrial processes emission model is a model that covers very diverse set of processes in which GHG and air pollutant emissions occur. Detailed representation of the processes covered in the model is shown in the Figure 3. The model covers Mineral industry, Chemical industry, Metal industry, Non-energy products from fuels and solvent use, Product uses as substitutes for ODS (Ozone Depleting Substances), Other products and Other. The model is used for emission calculations by multiplying activity (external parameter) and emission factors (internal parameters).

Figure 3: Processes covered in the Industrial processes emission model with GHG and air pollutant emissions that are being calculated in each sector

2.2 Model Inputs

2.2.1 External influencing factors

External input parameters for the model are very diverse since the model covers many different processes. All the input parameters needed by the model presented in the Tab. 2. Majority of the parameters are related to industrial production (clinker, lime, glass, steel, aluminium, etc.) but there are also processes that are related to consumption of products in households and construction related to solvent use and use of products with HFC (Hydrofluorocarbons).

In the figure below, it is presented which processes are covered and which emissions occur in different subsectors.

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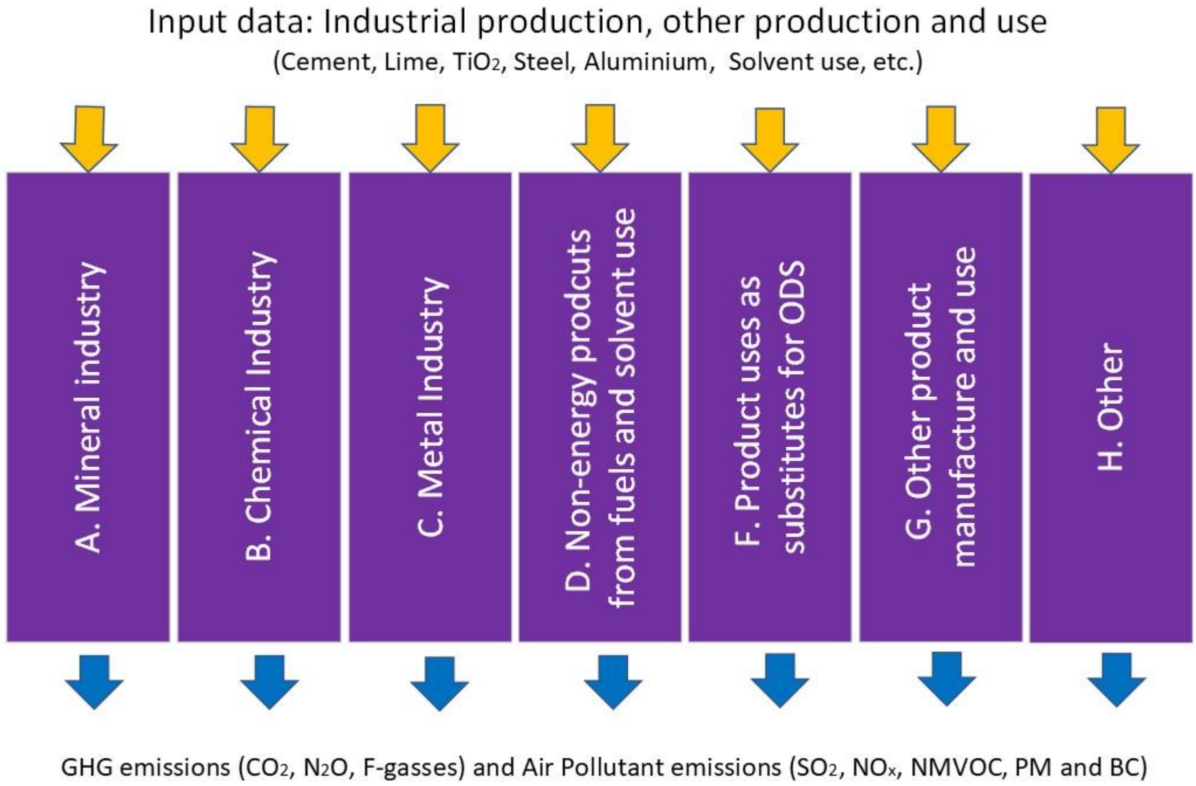

Figure 4: The main schematic of the Industrial Processes emission model

Table with input parameters contains information on the source for each parameter and the main assumptions used for their definition.

Tab. 2: Overview of input parameters to the Industrial Processes emission model with assumptions behind them

Process	Input parameters	Assumption regarding input parameter
A.1 Cement	Clinker production	REES industry model – information from the industry
A.2 Lime	Lime production	Growth of index of production for C23 branch without cement - REES industry model
A.3 Glass	Glass production	Expert estimate - decreasing growth from 1.2 % to 0.7 % in 10-year periods
A.4.a Ceramics	Ceramics production	Growth of index of production for C23 branch without cement - REES industry model
A.4.b,d Other uses of soda ash, carbonate use	Soda ash use, Mineral wool production	Expert estimate based on industry information
A.5.a Quarrying and mining	Excavated material	The same growth as for clinker production

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Process	Input parameters	Assumption regarding input parameter
A.5.b Construction and demolition	Demolition of single-family houses, multifamily houses, non-residential buildings; Surface of new roads	The same growth as construction sector
B.6 Titanium dioxide	Titanium oxide production (CaCO3 use for GHG emissions)	Average past growth (2007-2017)
B.10.a Formaldehyde	-	No production from 2014 onward
B.10.b Sulphuric acid	Sulphuric acid production	Data from only producer in Slovenia
B.10.c Phosphate and NPK fertilizers	Phosphate and NPK fertilizers production	Expert estimate based on past trends
B.10.d Hydrogen production	Hydrogen production	Expert estimate based on past trends on estimate on future development - decrease of grey hydrogen production
C.1 Iron and Steel	Steel production	REES industry model – information from the industry
C.3 Aluminium	Primary aluminium production	REES industry model - information from the industry
C.5 Lead	Lead production	Expert estimate based on past trends
C.6 Zinc	Zinc production	Growth of production index for C24 branch without steel and aluminium productions
C.7a Copper	Copper production	Expert estimate based on past trends
D.1 Lubricant use	Lubricant use in industry	Growth of production index for other industry (C_Other)
D.2 Paraffin wax use	Paraffin wax use	Expert estimate: Constant number - average of 2008-2017 period
D.3.a Domestic solvent use	Population	The same as in REES households' model
D.3.b Road paving with asphalt	Production of asphalt	Expert estimate: Constant number - average of 2008-2018 period
D.3.c Asphalt roofing	NMVOC emissions from bitumen products	Expert estimate: Extrapolation of past trend
D.3.d Coating applications	NMVOC emissions from manufacture of cars, car repairing, construction and building and domestic use, coil coating, wood preservation and boat building and other industrial coat application	Expert estimate: constant number - average of 2010-2018
D.3.e Degreasing	NMVOC emissions from degreasing	Expert estimate: Extrapolation of past trend

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Process	Input parameters	Assumption regarding input parameter
D.3.f Dry cleaning	NMVOC emissions from dry cleaning	Expert estimate: Extrapolation of past trend
D.3.g Chemical products	Production of plastic masses, paints and glues	Expert estimate: Extrapolation of past trend
D.3.h Printing	NMVOC emissions from printing	Expert estimate: constant number - average of 2014-2018
D.3.i Fat, edible and not edible oil extraction	NMVOC emissions from other solvent uses	GDP growth – REES model
D.3.j Urea based catalyst	Urea consumed (in catalysts)	Fossil fuel consumption in transport
F.1 Refrigeration and air conditioning	Amount of coolant in cars, buses and trucks - detailed stock model	REES transport model, model assumptions on coolant in cars
F.1 Refrigeration and air conditioning	Amount of coolant in air conditioning devices and heat pumps in buildings - stock model	Expert estimate on amount and structure of new coolant in A/C and heat pumps
F.1 Refrigeration and air conditioning	Amount of coolant in industrial refrigerant applications	Expert estimate on amount and structure of new coolant in industrial refrigeration applications
F.1 Refrigeration and air conditioning	Amount of coolant in service sector cooling applications	Expert estimate on amount and structure of new coolant in service sector cooling applications
F.1 Refrigeration and air conditioning	Amount of coolant in households cooling appliances	Expert estimate on amount and structure of new coolant in household cooling appliances
F.2 Foam blowing agents	Consumption of halocarbons in production of foams	Expert estimate on past trends
F.3 Fire protection	Amount of fluid filed in fire extinguishers	Expert estimate on past trends
F.4 Aerosols	Use of HFC 143a	Expert estimate considering EU cap on HFC
F.8 Electrical equipment	Use of SF6 in electrical equipment	Expert estimate based on past values
G.2.a Use of fireworks	Net import of pyrotechnic products	Expert estimate: Average past value (2008-2017)
G.2.b Use of tobacco	Amount of smoked tobacco	Expert estimate: Population trend
G.2.c Use of shoes	Population and assumption on shoes per capita	The same as in REES households model
G.2.d Use of pesticides	Use of pesticides	Expert estimate: Extrapolation of past trend
G.2.e Airplane de-icing	Use of de-icing agents	Expert estimate: Extrapolation of past trend
G.3.a Medical applications (N2O used)	Use of N2O in medicine	Expert estimate: Extrapolation of past trend

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Process	Input parameters	Assumption regarding input parameter
H.1 Pulp and paper	Paper production	Growth of production index for C17 branch
H.2 Food and drink	Production of food and beverages	Trend in population
H.3 Wood processing	PM TSP emissions	Growth of production index for other industry (C_Other)

2.2.2 Internal Input Parameters

Main internal input parameters are emissions factors that are used for emission calculation. They are defined for each process and for each emission that occurs. Along that Industrial Processes emission model contains F-gases emission sub model that is used for the calculation of HFC emissions from use of HFC gases in the refrigeration, cooling and air/conditioning and use of SF6 gas. This sub model is using the same structure as is used in the inventory model for estimation of these emissions. F-gases emissions from these processes are defined by the amount of gases that are leaked during production of products containing HFC and SF6, their use and manipulation after end of lifetime. Based on information on the amount of gases used in the products and their structure and different assumptions on leakage rates for different steps emissions are calculated. Along that additional assumptions are used in the model for the CCS/CCU. Use of CCS/CCU is foreseen for the production of cement that is a very big source of CO2 emissions in the industrial processes sector. It is assumed that efficiency of the unit is 80 % based on (Fleiter et al., 2019).

2.3 Key assumptions, scenarios and border conditions

Emissions from the industrial processes have been calculated for two scenarios: with existing measures WEM(OU) and with additional measures – moderate implementation of measures WAM(DU). Difference between scenarios is in the cement production where WAM(DU) scenario assumes use of CCS/CCU from 2040 onward and in aluminium production where in the WAM(DU) scenario it is assumed that production of primary aluminium will gradually phase out until 2050 while in WEM(OU) scenario the same production is projected for the period 2020-2050. For other processes WAM(DU) scenario is the same as WEM(OU) scenario.

In the table below (

Tab. 3) assumptions regarding input parameters for key sources of GHG and air pollutant emissions are presented.

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Tab. 3: Assumptions for selected most important input parameters

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Parameter	Unit	2017	2020	2030	2040	2050
Clinker production	[kt]	796.93	806.14	836.84	867.53	880.00
Lime production	[kt]	77.59	77.82	87.44	95.49	102.29
Glass production	[kt]	78.87	79.11	89.13	97.49	104.53
Mineral wool production	[kt]	109.68	120.03	138.91	153.14	168.84
Demolition of single-family houses, multifamily houses, non-residential buildings; Surface of new roads	[2017 = 1.0]	1.00	1.08	1.22	1.38	1.54
Titanium oxide production (CaCO3 use for GHG emissions)	[kt]	67.57	71.58	86.72	105.07	127.30
Sulphuric acid production	[kt]	186.18	170.49	269.50	368.50	467.70
Steel production	[kt]	676.67	707.12	768.02	788.32	808.62
Primary aluminium production[2]	[kt]	84.42	85.00	85.00	85.00	85.00
Lead production	[kt]	32.57	34.39	41.21	49.39	49.39
Lubricant use in industry	[kt]	35.98	37.06	42.02	48.33	48.33
Population index	[2017 = 1.0]	1.00	1.01	1.01	1.00	0.99
NMVOC emissions from manufacture of cars, car repairing, construction and building and domestic use, coil coating, wood preservation and boat building and other industrial coat application	[kt]	2.60	3.04	3.04	3.04	3.04
Production of plastic masses	[kt]	155.11	176.94	250.46	323.98	397.51
Amount of coolant in cars, buses and trucks - detailed stock model	[kt]	0.73	0.83	0.87	0.85	0.79
Amount of coolant in air conditioning devices and heat pumps in buildings - stock model	[kt]	0.59	0.74	0.94	1.03	1.07
Amount of coolant in industrial refrigerant applications	[kt]	0.15	0.20	0.28	0.31	0.34
Amount of coolant in service sector cooling applications	[kt]	0.37	0.37	0.38	0.38	0.38
Use of SF6 in electrical equipment	[t]	27.20	32.97	34.90	36.82	38.75
Net import of pyrotechnic products	[kt]	0.29	0.45	0.45	0.45	0.45
Amount of smoked tobacco	[kt]	4.37	4.38	4.34	4.23	4.17
Paper production	[kt]	23.11	23.58	25.50	29.19	35.32

Regarding HFC and SF6 emissions the projections take into account full implementation of the European Regulation on certain fluorinated greenhouse gases (Regulation EC 517/2014, F gas regulation) and Directive relating to emissions from air-conditioning systems in motor vehicles (EU 2006/40/EC) (MAC directive) which strongly influence use of HFC until 2030 by substituting them with alternatives with lower GWP. The additional phase out after 2030 is projected in accordance with Kigali Amendment. Numbers in the Table 14 represent total coolant used but

[2] Assumptions for aluminium production presented are from OU projection. In DU projection there is a difference for year 2050 (and 2045) where linear reduction is foreseen from 85 kt in 2040 to 0 kt in 2050.

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due to assumption presented above structure of coolant changes rapidly. While in 2017 HFC's share in coolant is 100 % towards 2050 it is completely substituted with low GWP variants.

For the ETS[3] / nonETS division of emission in Industrial processes the methodology is based on definition which processes are included in the ETS. After 2012 these processes are: cement production (2.A.1), lime production (2.A.2), glass production (2.A.3), carbonate use (Production of mineral wool) (2.A.4.d), steel production (2.C.1) and Aluminium production (2.C.3 and 2.C.7 – Aluminium anode burnoff). CO2 and PFC emissions are included in the ETS. All other GHG emissions are included in the nonETS or ESR (Effort Sharing Regulation).

2.4 Model structure

2.4.1 Methodology

Methodology used in the Industrial Processes Emission Model is the same as is used in the Slovenian Inventory for the GHG and air pollutant emissions. This methodology is in detail described in National Inventory report (NIR; 2019) for GHG emissions and in Informative Inventory Report (IIR, 2020) for air pollutant emissions. Different years of submissions have been used so that the latest available information was used in the preparations of the projections.

2.4.2 Connections with other models

Model is implemented in excel environment. Some of the results from the model are also used in the MESAP model. Industrial Processes Emission Model is connected to other models through input parameters. Connections are clearly indicated in the Tab. 2.

2.4.3 Future development of the model and research challenges

Future development of the model is strongly tied to methodology changes in the inventory preparation as the inventory is constantly improved and consistency between projections and inventory has to be assured.

Additional development will be needed to reflect technology changes that will happen in the future to address various challenges in emissions reduction of GHGs and also air pollutants in this sector. Along CCS/CCU also other options have been identified to decrease CO2 emissions, like low carbon cement, use of hydrogen etc.. Further development of the model will be needed to address impact of circular economy on the needs for different materials. This will have large impact on emissions from industrial processes.

[3] EU Emissions Trading System

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2.5 Model results

GHG emissions from industrial processes are declining in both scenarios although decline under WEM(OU) scenario is rather modest, while in WAM(DU), WAMa(DUA) scenario is especially after 2030 intensive. In 2030 GHG emissions under WEM(OU) scenario are 11 % lower compared to 2017, while in 2050 they are 17 % lower. Under WAM(DU), WAMa(DUA) scenario emissions in 2030 are 12 % lower while in 2050 they are 61 % lower compared to 2017. The biggest reduction in WAM(DU) scenario is in cement production (A. Mineral industry) due to CCS/CCU unit installation, in aluminium production (C. Metal industry) due to phase out of primary aluminium production and in emissions of F-gases (F. Product uses as ODS substitutes). Tab. 4 presents the GHG emissions projections for OU and DU (DUA) scenarios for industrial processes per subsector.

Tab. 4: GHG emissions projections for OU and DU (DUA) scenarios for industrial processes per subsector

[kt CO2 ekv]		WEM(OU)			WAM (DU&DUA)		
	2017	**2020**	**2030**	**2050**	**2020**	**2030**	**2050**
2. Industrial processes and product use	**1.208**	**1.207**	**1.073**	**1.008**	**1.207**	**1.066**	**471**
A. Mineral industry	497	518	545	585	518	539	204
B. Chemical industry	65	54	60	72	54	60	72
C. Metal industry	223	225	232	239	225	232	83
D. Non-energy products from fuels and solvent use	30	31	34	41	31	34	41
E. Electronic Industry	0	0	0	0	0	0	0
F. Product uses as ODS substitutes	357	330	149	13	330	149	13
G. Other product manufacture and use	36	50	52	58	50	52	58
H. Other	0	0	0	0	0	0	0

By far the most important gas in industrial processes is CO_2 contributing more 2/3 of emissions in 2017. Share of CO2 in both scenarios increases, in WEM(OU) to 91 % and in WAM(DU), WAMa(DUA) to 85 % as shown in Tab. 5. HFC emission show strong decrease due to implementation of F-gas regulation and MAC directive.

Tab. 5: GHG emissions projections for WEM(OU) and WAM(DU), WAMa(DUA) scenarios for industrial processes per gas

[kt CO2 ekv]		WEM(OU)			WAM (DU&DUA)		
	2017	**2020**	**2030**	**2050**	**2020**	**2030**	**2050**
CO2	797	812	856	922	812	849	401
N2O	20	35	37	40	35	37	40
HFC	357	330	149	13	330	149	13
PFC	17	16	16	16	16	16	0
SF6	16	15	16	18	15	16	18

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Air pollutant emissions from industrial processes represent for SO2 and NMVOC important part of total national emissions especially towards later years of the observed period. In 2017 industrial processes contribute 31 % to SO2 emissions and 34 % to NMVOC emissions. These shares increase to 76 % and 86 % for SO2 under WEM(OU) and WAM(DU), WAMa(DUA) scenario and to 50 % and 55 % for NMVOC, respectively. For NOx and PM emissions industrial processes are minor source but non the less for PM 2.5 towards 2050 their share increases to 10 %, while in NOX it stays low (1 %).

The table below shows emissions for selected pollutants (SO2, NOx, NMVOC and PM 2.5), while emissions have been calculated also for PM TSP, PM 10 and BC. Table shows total emissions in industrial processes sector and emissions for three (for NMVOC four) largest contributors.

Tab. 6: Air pollutant emission projections for selected gases and years for WEM(OU) and WAM(DU), WAMa(DUA) scenarios

				WEM(OU)			WAM(DU&DUA)		
			2017	2020	2030	2050	2020	2030	2050
SO2	**2. Industrial processes**	**[kt]**	**1,50**	**1,32**	**1,66**	**2,36**	**1,32**	**1,66**	**1,78**
SO2	2 B 10 a Other chemical industry	[kt]	0,65	0,51	0,81	1,40	0,51	0,81	1,40
SO2	2 B 6 Titanium dioxide production	[kt]	0,12	0,11	0,14	0,20	0,11	0,14	0,20
SO2	2 C 5 Other metal industry	[kt]	0,07	0,07	0,09	0,13	0,07	0,09	0,13
NOx	**2. Industrial processes**	**[kt]**	**0,12**	**0,12**	**0,13**	**0,14**	**0,12**	**0,13**	**0,13**
NOx	2 C 1 Iron and steel production	[kt]	0,09	0,09	0,10	0,11	0,09	0,10	0,11
NOx	2 B 6 Titanium dioxide production	[kt]	0,01	0,01	0,01	0,01	0,01	0,01	0,01
NOx	2 G Other products use	[kt]	0,01	0,01	0,01	0,01	0,01	0,01	0,01
NMVOC	**2. Industrial processes**	**[kt]**	**11,04**	**11,50**	**11,65**	**11,86**	**11,41**	**11,08**	**11,12**
NMVOC	2 D 3 a Domestic solvent use	[kt]	4,48	4,49	4,50	4,43	4,40	3,93	3,68
NMVOC	2 D 3 d Coating applications	[kt]	2,60	3,04	3,04	3,04	3,04	3,04	3,04
NMVOC	2 D 3 g Chemical products	[kt]	2,27	2,27	2,37	2,60	2,27	2,37	2,60
NMVOC	2 H 2 Food and beverages industry	[kt]	0,88	0,86	0,86	0,85	0,86	0,86	0,85
PM 2.5	**2. Industrial processes**	**[kt]**	**0,35**	**0,37**	**0,39**	**0,44**	**0,37**	**0,39**	**0,41**
PM 2.5	2 A 5 Minig, Construction, Storage	[kt]	0,13	0,13	0,15	0,20	0,13	0,15	0,20
PM 2.5	2 G Other products use	[kt]	0,13	0,14	0,14	0,14	0,14	0,14	0,14
PM 2.5	2 A 1 Cement production	[kt]	0,02	0,02	0,02	0,03	0,02	0,02	0,03

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Waste

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3.1 Purpose of the model

The purpose of the waste emission model is to calculate GHG and air pollutant emissions that originate from solid waste disposal (5.A[4]), Biological treatment of solid waste (5.B) – composting, Incineration of waste (5.C), Wastewater handling and discharge (5.D) and other waste emissions (vehicle fires, building fires and industrial site fires) (5.E). Emissions for each category is calculated in separate sub model as can be seem on the schematic representation (Figure 5).

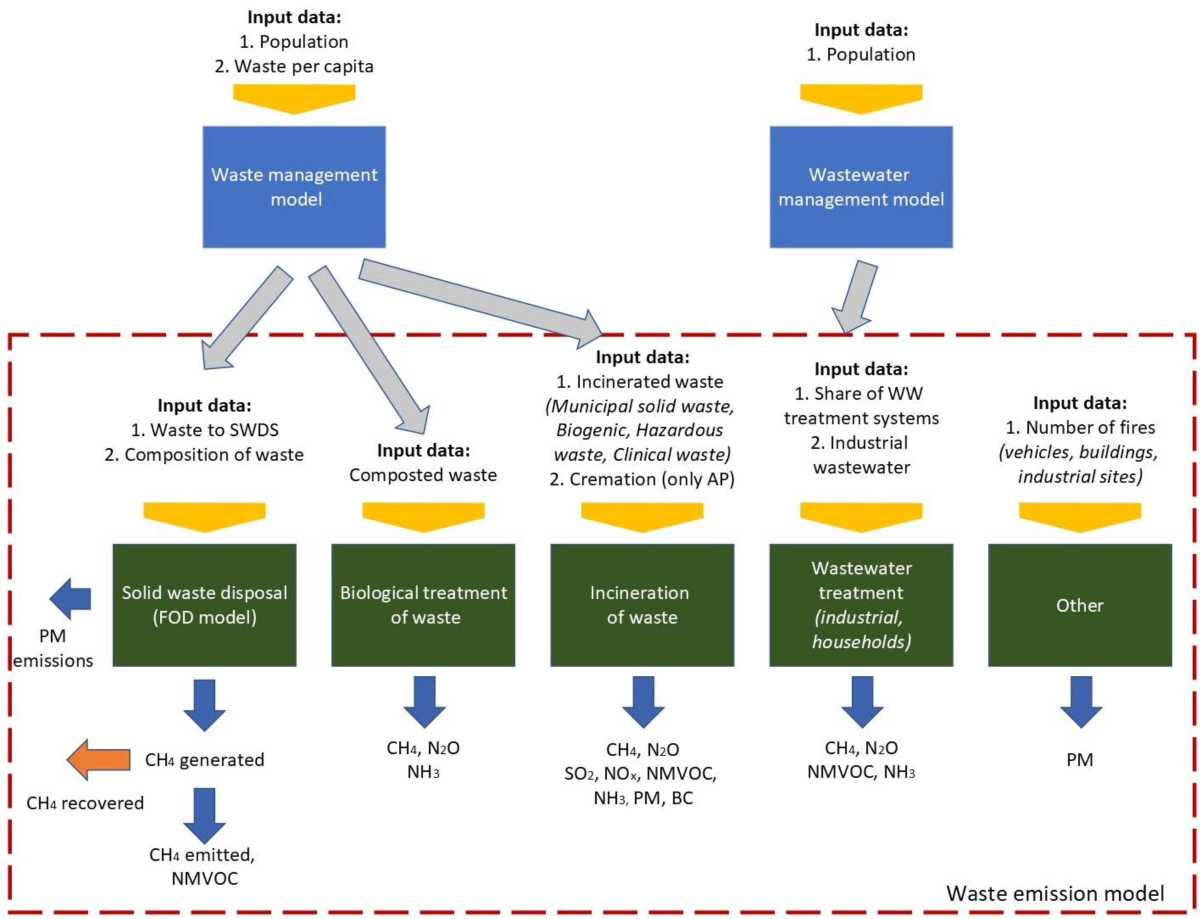

Figure 5: Schematic representation of the waste emission model and connection to waste and wastewater management model5

3.2 Model Inputs

3.2.1 External influencing factors

Waste emission model requires a handful of inputs. A lot of the inputs are provided by the Waste management model which from number of population and generation factor of waste per capita based on different assumption on the management of waste, like separate collection rate

[4] CRF and NFR code for sectors
[5] AP – air pollutants

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and recycling, implementation of different techniques of waste management, etc, estimates amount and composition of waste going to landfills, amount of waste being composted, and amount of waste being incinerated. This model is run by the Ministry of Environment and Spatial Planning and for the LIFE Climate Path 2050 results from 2019 run have been used.

For determining shares of different wastewater techniques another model has been prepared. Input to this model is population and based on Operational programme for wastewater treatment connection to different wastewater systems is estimated. Results from this model are than used to calculate emissions in the Wastewater treatment sub model.

External influence factors are presented in the list below with a description of connections with inputs to other models used in the project LIFE ClimatePath 2050. For each input also a waste sub model, where input is used, is indicated.

Output from Waste management model:

- Amount of waste landfilled with composition of waste (Sold waste disposal sub model)
- Amount of waste composted (Biological treatment of waste sub model)
- Amount of waste being incinerated + assumptions on incineration of other types of waste not included in the waste management model i.e. Hazardous waste, Clinical waste, Biogenic waste (Incineration of waste sub model)
- Number of cremated bodies (Incineration of waste sub model)
- Output from Wastewater treatment model – people connected to different types of wastewater treatment
- Amount of industrial waste water
- Number of fires for vehicles, buildings and industrial sites – Other sub model.

3.2.2 Internal Input Parameters

Internal input parameters are limited to two models:

1. Solid waste disposal model uses the following parameters:
    a. Parameters for FOD (first order decay) model:
        i. DOCf – fraction of DOC (Degradable Organic Carbon) dissimilated (0.5)
        ii. Methane generation rate constant (k) (Food waste (0.185), Garden (0.1), Paper (0.06), Wood and straw (0.03), Textiles (0.06), Disposable nappies (0.1), Sewage sludge (0.185), Industrial waste (0.09)
        iii. Delay time (6 months)
        iv. Fraction of methane (0.5)
        v. Conversion factor (C to CH4 – 1,33)
        vi. Oxidation factor (OX – 0)
    b. Fraction of recovered methane (10 %)
2. Wastewater (WW) treatment model:
    a. Share of people using different wastewater treatment plants (%)
    b. Parameters for wastewater generation (BOD (Biological Oxygen Demand) = 60 g/cap/day, I = 1.25 – only for collected WW (Wastewater))

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c. Parameters for CH4 generation for each treatment plant / technology (B0 = 0.6, MCFj (*methane* conversion factor): well managed wastewater treatment plants (WWTP) = 0; not well managed WWTP = 0.3; septic tank = 0.5, latrines = 0.1)

Other internal parameters are emission factors that are used for emission calculation. All emissions are calculated as a product of activity and emission factor with the exception of FOD (First Order Decay) model. Emissions factors are the same as are used in the inventory preparation and are in detail presented in the National inventory report for GHG and Informative Inventory report for air pollutants. For GHG version from 2019 was used, while for air pollutants version from 2020.

3.3 Key assumptions, scenarios and border conditions

For emissions from waste and wastewater treatment only one scenario was modelled, i.e. scenario with existing measures since no additional measures are foreseen. In this scenario no biodegradable waste is landfilled since 2016, meaning that no additional biodegradable waste is entering the landfills contributing to decrease of emissions. Amount of composted waste slowly increases towards 2025, after which it stays on the same level. For the incineration of waste constant levels have been used for the whole projection period (2020-2050). Levels have been the same as maximum levels in the 1991-2017 period for each type of incinerated waste. Number of cremations is expected to rise until 2025. Share of different wastewater systems will gradually shift towards well managed systems based on measures foreseen in the Operational programme for waste water. Key assumptions for the waste emission model are presented in the table bellow.

Tab. 7: Key assumptions for the waste emission model

		2017	2020	2025	2030	2035
Biodegradable solid waste disposed on landfills	[kt]	0.16	0.14	0.15	0.15	0.15
Composted waste (wet weight)	[t]	97,860	107,646	111,234	111,234	111,234
Biogenic waste incinerated	[t]	133	677	677	677	677
Municipal waste incinerated	[t]	2	33	33	33	33
Clinical waste incinerated	[t]	247	671	671	671	671
Hazardous waste incinerated	[t]	10,906	11,110	11,110	11,110	11,110
Number of cremations	[000]	17	18	20	20	20
Wastewater systems (% of people using):						
well managed WW treatment plants	[%]	61%	69%	100%	100%	100%
not well managed WW treatment plants	[%]	5%	3%	0%	0%	0%
septic tanks	[%]	34%	24%	0%	0%	0%
latrines	[%]	0%	3%	0%	0%	0%
Fires on vehicles	[ ]	441	442	491	544	604
Fires on buildings	[ ]	2,234	2,006	2,065	2,125	2,187
Fires on industrial sites	[ ]	184	170	170	170	170

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3.4 Model structure

3.4.1 Methodology

Waste emission model is a simple linear model. It has been developed in excel environment and is based on the same models as are used in the inventory preparation which enables the easiest way to ensure consistency between projections and inventory.

3.5 Connections with other models

Waste emission model uses outputs from the Waste and wastewater management models. The first one is run by the Ministry of Environment and Spatial planning. Data used in the waste emission model are shown in previous chapters. Wastewater management model was prepared on the basis of the Operational programme for waste water at the "Jožef Stefan" Institute with historical data being provided by the Environmental Agency of Slovenia.

3.6 Future development of the model and research challenges

Further development of the model is determined by the improvement of the methodology of inventory calculations either for GHG or air pollutants, since projections have to be consistent with the inventory.

In 2020 FOD (First Order Decay) model used in the inventory was changed so this means that current model for projections will have to be upgraded.

3.7 Model results

Based on projections, emissions in 2017 are at 558 kt CO2 eq. Until 2030 they will be halved and reduced to almost a quarter of 2017 emissions by 2050.

The main source remains solid waste disposal, followed by wastewater treatment, incineration and composting, although emissions from the main sources have decreased significantly and emissions from composting and incineration have increased. GHG emissions in the waste sector according to projections with existing measures are presented in the table below.

Tab. 8: GHG emissions in the waste sector according to projections with existing measures

		2017	2020	2030	2050
GHG emissions from waste	**kt CO2 eq**	**557.9**	**464.7**	**261.9**	**148.1**
5.A Solid waste disposal	kt CO2 eq	341.2	280.5	172.0	64.4
5.B Composting	kt CO2 eq	16.8	18.5	19.1	19.1
5.C Incineration of waste	kt CO2 eq	28.3	29.0	29.0	29.0
5.D Wastewater treatment	kt CO2 eq	171.6	136.8	41.8	35.7

Air pollutant emissions have been calculated for NO_x, NMVOC, SO_x as SO_2, NH_3, different fractions of PM and BC. Trend per different pollutants are diverse. Emissions of NOx, SOx and

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BC increase by 17 %, 24 % and 169 % respectively while emissions of NMVOC, NH3 decrease. Emissions increase where the main source is incineration of waste or fires (Other) while emissions decrease where solid waste disposal is the main source or wastewater management. Emission of different fractions of PM stay on similar level throughout the observed period. Air pollutant emissions in the waste sector according to projections with existing measures are presented in the table below.

Tab. 9:Air pollutant emissions in the waste sector according to projections with existing measures

			2017	2020	2030	2040	2050
NOx	**5 C Waste incineration**	**[t]**	**24.225**	**25.483**	**27.272**	**28.445**	**28.445**
NMVOC	**5 Waste**	**[t]**	**297.852**	**261.737**	**194.674**	**151.170**	**126.982**
NMVOC	5 A Landfilling of waste	[t]	214.190	176.073	108.009	64.587	40.398
NMVOC	5 B Biological waste treatment	[t]	0.000	0.000	0.000	0.000	0.000
NMVOC	5 C Waste incineration	[t]	81.097	82.707	82.735	82.951	82.951
NMVOC	5 D Waste water	[t]	2.564	2.957	3.930	3.632	3.633
NMVOC	5 E Other waste	[t]	0.000	0.000	0.000	0.000	0.000
SOx	**5 C Waste incineration**	**[t]**	**2.579**	**2.758**	**3.003**	**3.206**	**3.206**
NH3	**5 Waste**	**[t]**	**30.101**	**29.319**	**26.697**	**26.698**	**26.698**
NH3	5 B Biological waste treatment	[t]	23.486	25.835	26.696	26.696	26.696
NH3	5 C Waste incineration	[t]	0.000	0.001	0.001	0.002	0.002
NH3	5 D Waste water	[t]	6.614	3.483	0.000	0.000	0.000
TSP	**5 Waste**	**[t]**	**148.709**	**136.361**	**140.151**	**149.172**	**153.123**
TSP	5 A Landfilling of waste	[t]	0.066	0.062	0.056	0.056	0.056
TSP	5 C Waste incineration	[t]	4.959	7.013	7.096	12.289	12.289
TSP	5 E Other waste	[t]	143.684	129.286	132.998	136.827	140.778
PM_10	**5 Waste**	**[t]**	**144.382**	**130.014**	**133.799**	**137.629**	**141.580**
PM_10	5 B Biological waste treatment	[t]	0.031	0.030	0.027	0.027	0.026
PM_10	5 C Waste incineration	[t]	0.667	0.699	0.774	0.775	0.775
PM_10	5 E Other waste	[t]	143.684	129.286	132.998	136.827	140.778
PM_2.5	**5 Waste**	**[t]**	**144.322**	**129.956**	**133.743**	**137.573**	**141.524**
PM_2.5	5 B Biological waste treatment	[t]	0.005	0.004	0.004	0.004	0.004
PM_2.5	5 C Waste incineration	[t]	0.634	0.666	0.741	0.742	0.742
PM_2.5	5 E Other waste	[t]	143.684	129.286	132.998	136.827	140.778
BC	**5 C Waste incineration**	**[t]**	**0.098**	**0.144**	**0.144**	**0.264**	**0.264**

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Abbreviations, figures and tables

List of abbreviations

AP	Air pollutants
BC	Black Carbon
BOD	Biological Oxygen Demand
CAN	Calcium ammonium nitrate
CCS	Carbon capture and storage
CCU	Carbon capture and utilization
CRF	UNFCCC Common Reporting Format
DOC	Degradable Organic Carbon
DOCf	Degradable Organic Carbon fraction
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Programme
ESR	Effort Sharing Regulation
ETS	EU Emissions Trading System
FOD	First Order Decay
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HFC	Hydrofluorocarbons
IIR	Informative Inventory Report
IPCC	Intergovernmental Panel on Climate Change
LIFE	EU's funding instrument for the environment and climate action
LTS	Long Term Strategy
MAC	Mobile air-conditioning systems
MCF	Methane Conversion Factor
MESAP	Modular Energy System Analysis and Planning Environment
MMS	Manure Management System
NEC	National Emission reduction Commitments
NECP	National Energy and Climate Plan
NIR	National Inventory report
NMVOC	Non-methane volatile organic compounds
nonETS	not included in the EU Emissions Trading System
NPK	Nitrogen, phosphorus and potassium
ODS	Ozone Depleting Substances
OECD	Organisation for Economic Co-operation and Development
PFC	Perfluorinated compound
PM	Particulate Matter

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REES	Reference Energy and Emission System
REES-SLO	Reference Energy and Emission System model for SLOvenia
SWDS	Solid waste disposal
TAN	Total Ammonia-Nitrogen
TSP	Total Suspended Particles
VS	Volatile Solids
WAM	With Additional Measures
WAMa	With Additional Measures - ambitious
WEM	With Existing Measures
WOM	Without Measures
WW	Wastewater

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