Landfill gas production modeling on landfills in Serbia

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Landfill gas

Component	%
Methane	45-60
Carbon dioxide	40-60
Nitrogen	2-5
Oxygen	0.1-1
Ammonia	0.1-1
Non-methane volatile organic compounds (NMVOC)	0.01-0.6
Sulphides	0-1
Hydrogen	0-0.2
Carbon-monoxide	0-0.2
Compounds in traces	0.01 – 0.6

The most important factors that affect landfill gas production:

▪**Waste composition**

▪**Temperature**

▪**Moisture**

▪**Waste density**

▪**Oxygen concentration**

▪**pH value**

▪**Nutrients**

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Actual state in Serbia

- Collected waste is disposed at inadequate landfills

- In most cases there is no waste selection before landfilling *(hazardous waste at municipal solid waste landfills)*

- There is no daily cover at landfills and closure after usage is inadequate

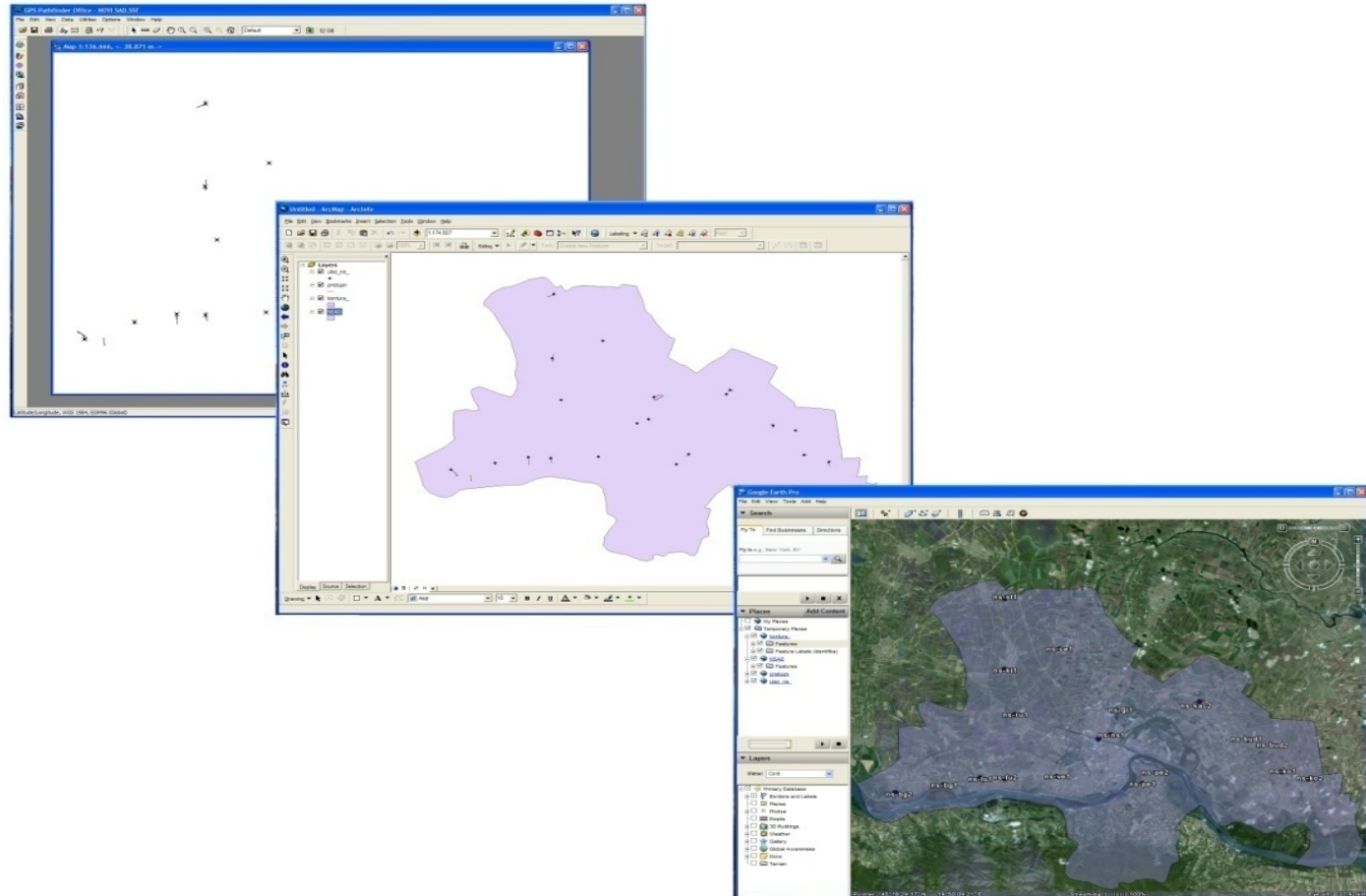DEPARTMAN ZA INŽENJERSTVO ZAŠTITE ŽIVOTNE SREDINE
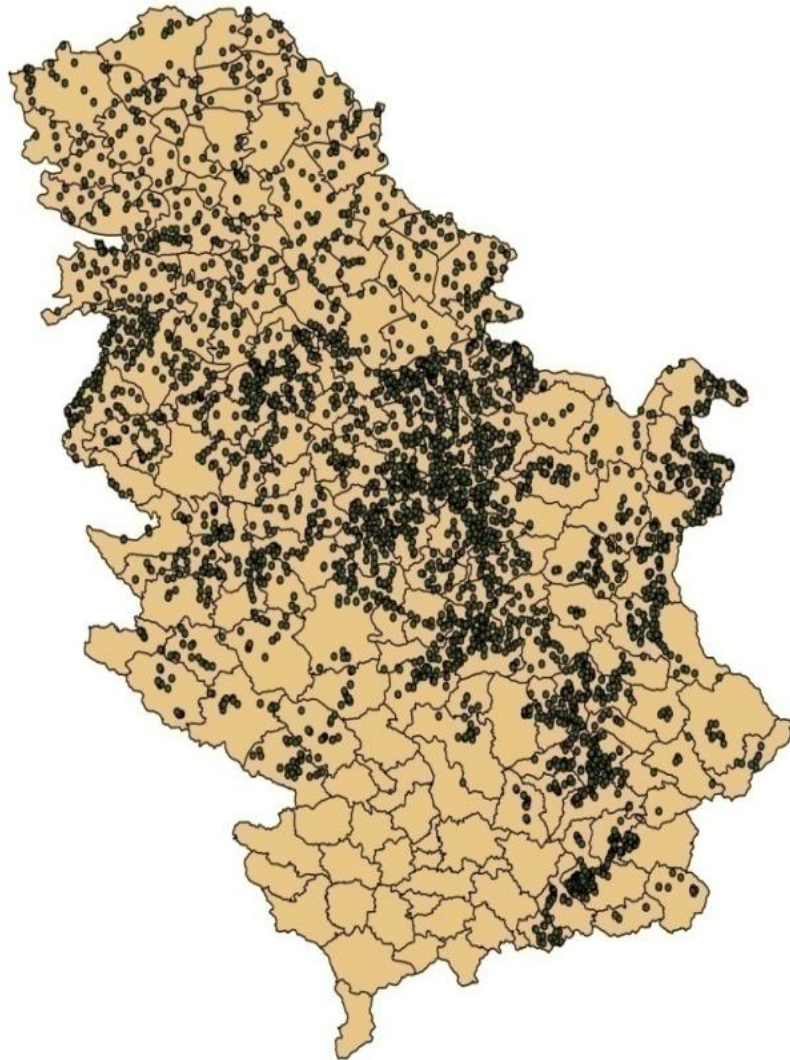
Landfills in Serbia

- There are 3582 identified landfills in Serbia, 165 of them are municipality landfills, 5 are sanitary landfills and rest are wild dump sites

- There are 5 more regional sanitary landfills in construction progress, as well as closure and sanation and/or recultivation of some municipality landfills

Forming of landfill database in Serbia

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Landfills in Serbia

Criteria (m³)	Number of landfills	Total area (ha)	Total volume (m³)
to 1.000	2.702	154,50	604.628,93
from 1.001 to 10.000	698	480,04	2.251.995,18
from 10.001 to 100.000	131	313,11	4.087.590,55
from 100.001 to 500.000	37	199,24	8.693.492,43
from 500.001 to 1.000.000	7	62,59	5.296.214,07
Over 1.000.000	7	131,98	23.123.124,56
Total	3.582	1.341,46	44.057.045,71

Criteria height h (m)	Number of landfills	Total area (ha)	Total volume (m³)
to1 m	3322	819,69	3643830,68
From 1,1 to 5m	227	274,36	7340340,56
Over 5m	53	246,92	33601845,34
Total	3602	1340,97	44586016,58

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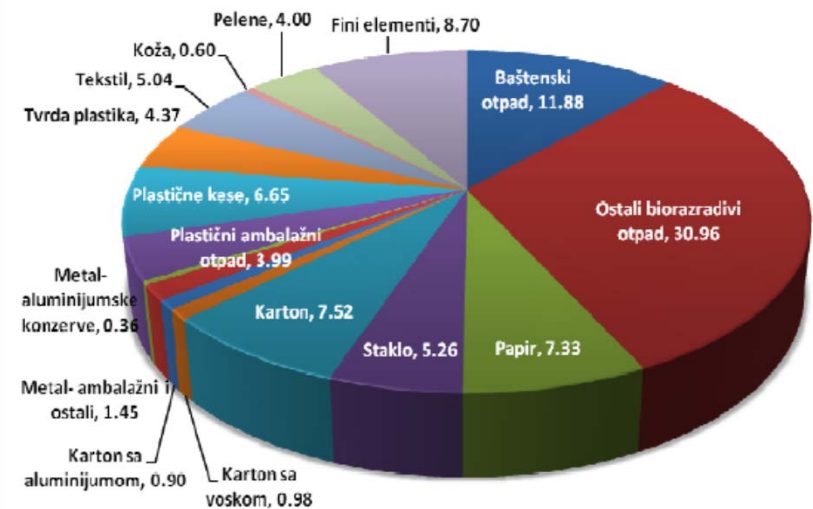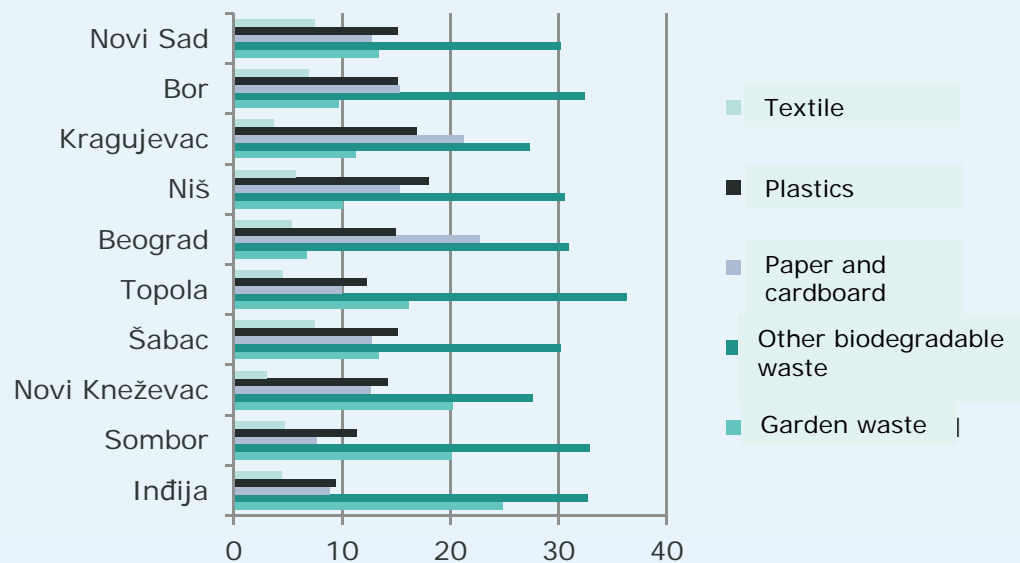
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Determining waste composition and amounts

Municipal solid waste composition

- In 2008. for the first time determination of waste composition and amounts was realized on multiple locations in Serbia.

- Regions of different industrial, economic, social and geographic characteristics were covered

Bar chart locations: Novi Sad, Bor, Kragujevac, Niš, Beograd, Topola, Šabac, Novi Kneževac, Sombor, Inđija

Legend:
- Textile
- Plastics
- Paper and cardboard
- Other biodegradable waste
- Garden waste

Pie chart labels:
Pelene, 4.00   Fini elementi, 8.70
Koža, 0.60
Tekstil, 5.04
Tvrda plastika, 4.37
Baštenski otpad, 11.88
Plastične kese, 6.65
Plastični ambalažni otpad, 3.99
Ostali biorazradivi otpad, 30.96
Metal-aluminijumske konzerve, 0.36
Karton, 7.52
Metal- ambalažni i ostali, 1.45
Staklo, 5.26
Papir, 7.33
Karton sa aluminijumom, 0.90
Karton sa voskom, 0.98

Grafik 6.2 Morfološki sastav komunalnog otpada u Republici Srbiji

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Landfill gas production modeling

- For landfill gas production modeling IPCC 2006 and Ukrain models are used

- Calculation of gas production in both listed models is based on first order equation where landfill gas production depends on waste disposal time

$$Q_{CH4} = \sum_x \left[(A \, k \, MSW_T (x) \, MSW_F(x) \, L_0(x)) \, e^{-k(t-x)} \right]$$

Where:

t – inventory year for which emissions are calculated

x – year in which waste was disposed

A – simulation corrective factor

k – methane generation rate constant (1/god.)

$MSW_T(x)$ – total amount of waste generated in year of x

$MSW_F(x)$ – fraction of waste disposed in year of x

$L_0(x)$ – methane generation potential (t_{CH4}/t_{otpada})

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Model base parameters

- ## DOC – degradable organic carbon

Waste type	Value
Food scraps	0,15
Garden waste	0,2
Paper and cardboard	0,4
Wood	0,43
Textile	0,24
Diapers	0,24

Waste composition data are needed. Table shows only biodegradable waste categories and recommended values of DOC, IPCC software for that waste types.

- ## DOC_f – fraction of DOC that will degrade

Model base parameters

- MCF – methane correction factor

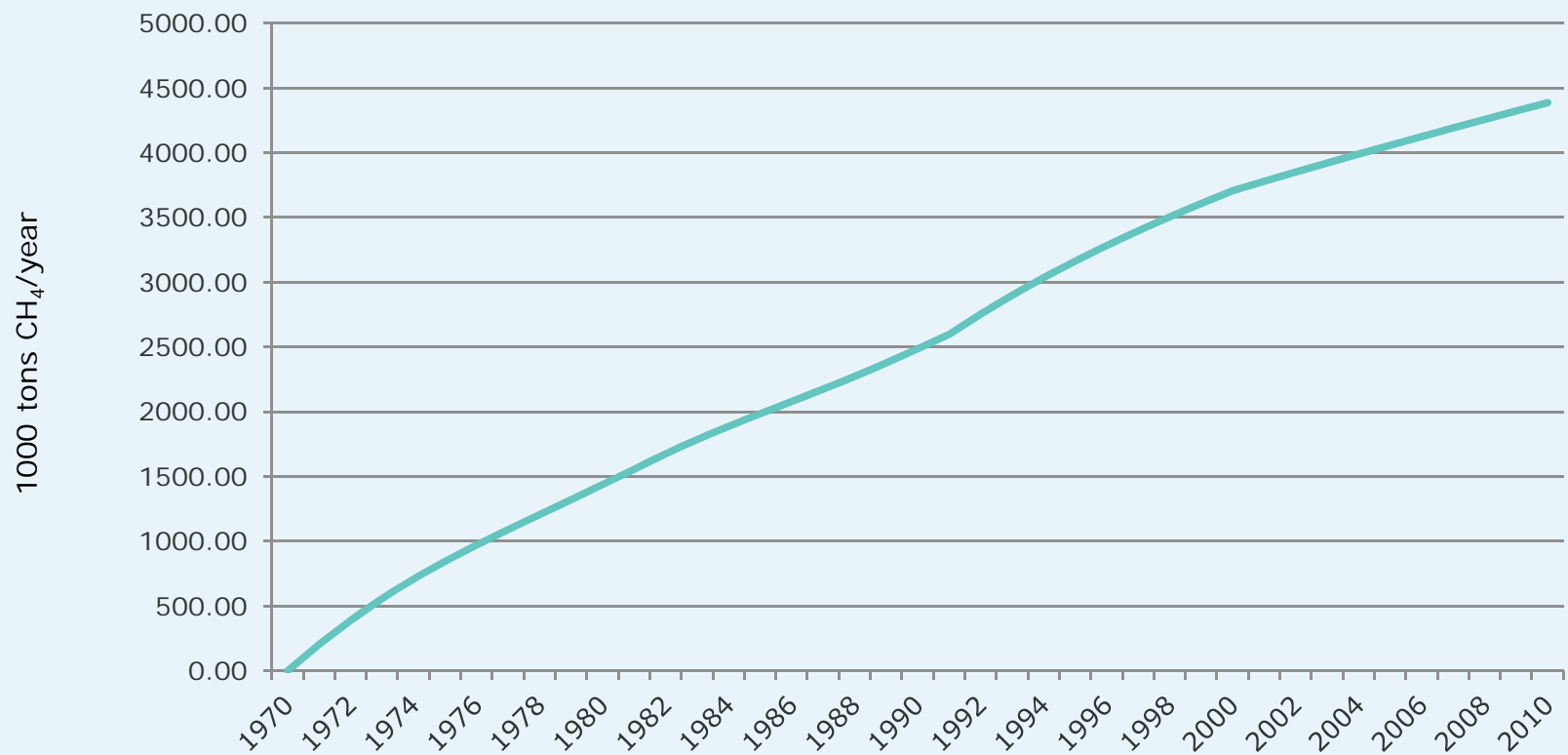| Landfill type	Average MCF values
Controlled anaerobic landfills	1.0
Controlled semi-aerobic landfills	0.5
Uncontrolled landfills – deep (with >5m of depth and high groundwater level)	0.8
Uncontrolled landfills – shallow (with <5m of depth)	0.4
Uncategorized landfills	0.6

- F – fraction of CH_4 in LFG composition

- OX – oxidation factor, represents methane fraction which will be unavailable due to the oxidation process in surface layer of landfill

- R – recovered fraction of methane

Results of methane production modeling for Novi Sad landfill

IPCC

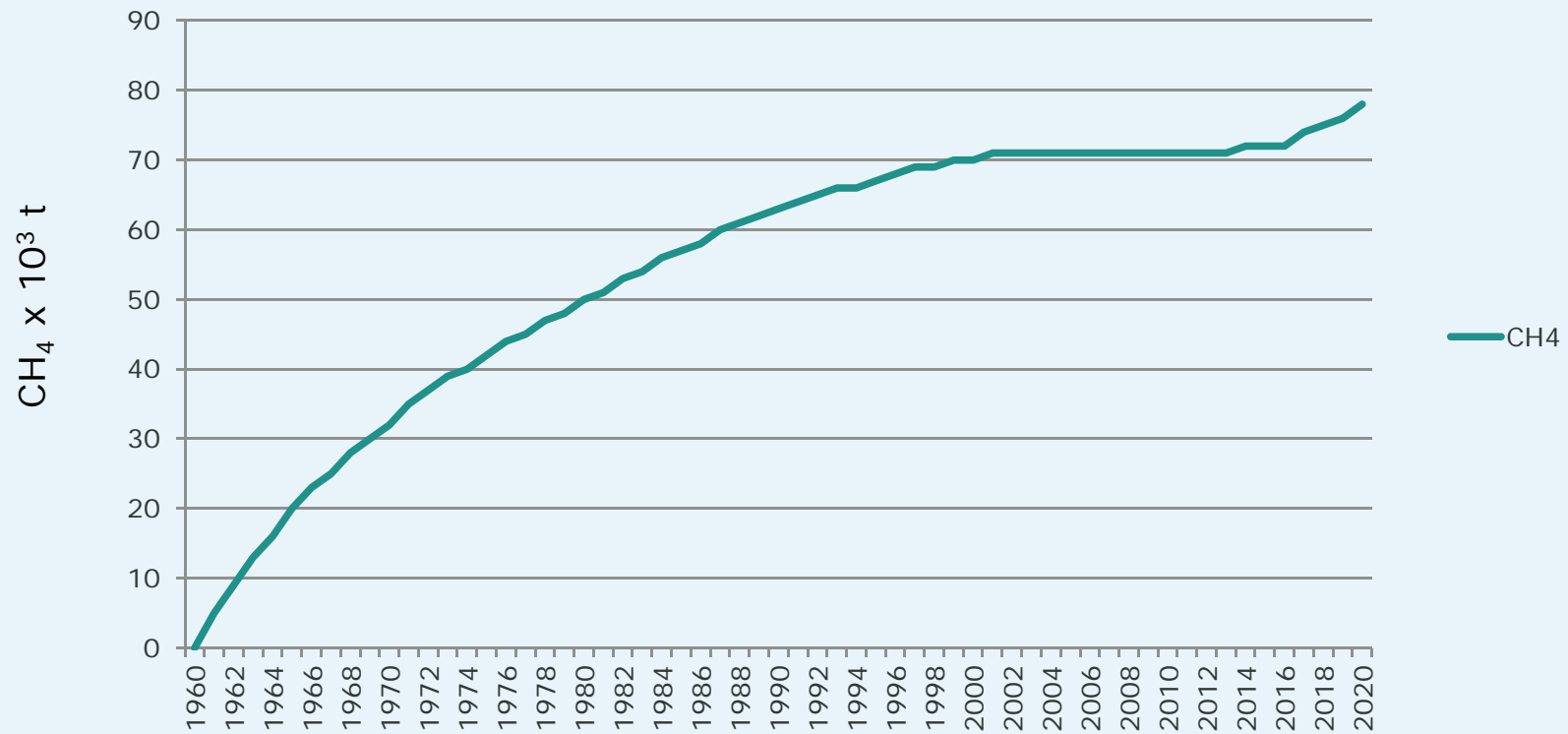X-axis: years 1970 to 2010 (every 2 years)
Y-axis: 1000 tons CH$_4$/year (0.00 to 5000.00)

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Results of methane production modeling for Novi Sad landfill

Production of CH$_4$ for the period 1960 - 2020.

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Influence of different waste fractions on methane production in Serbia

Legend:
- Diapers
- Textile
- Wood
- Paper
- Garden waste
- Food scraps

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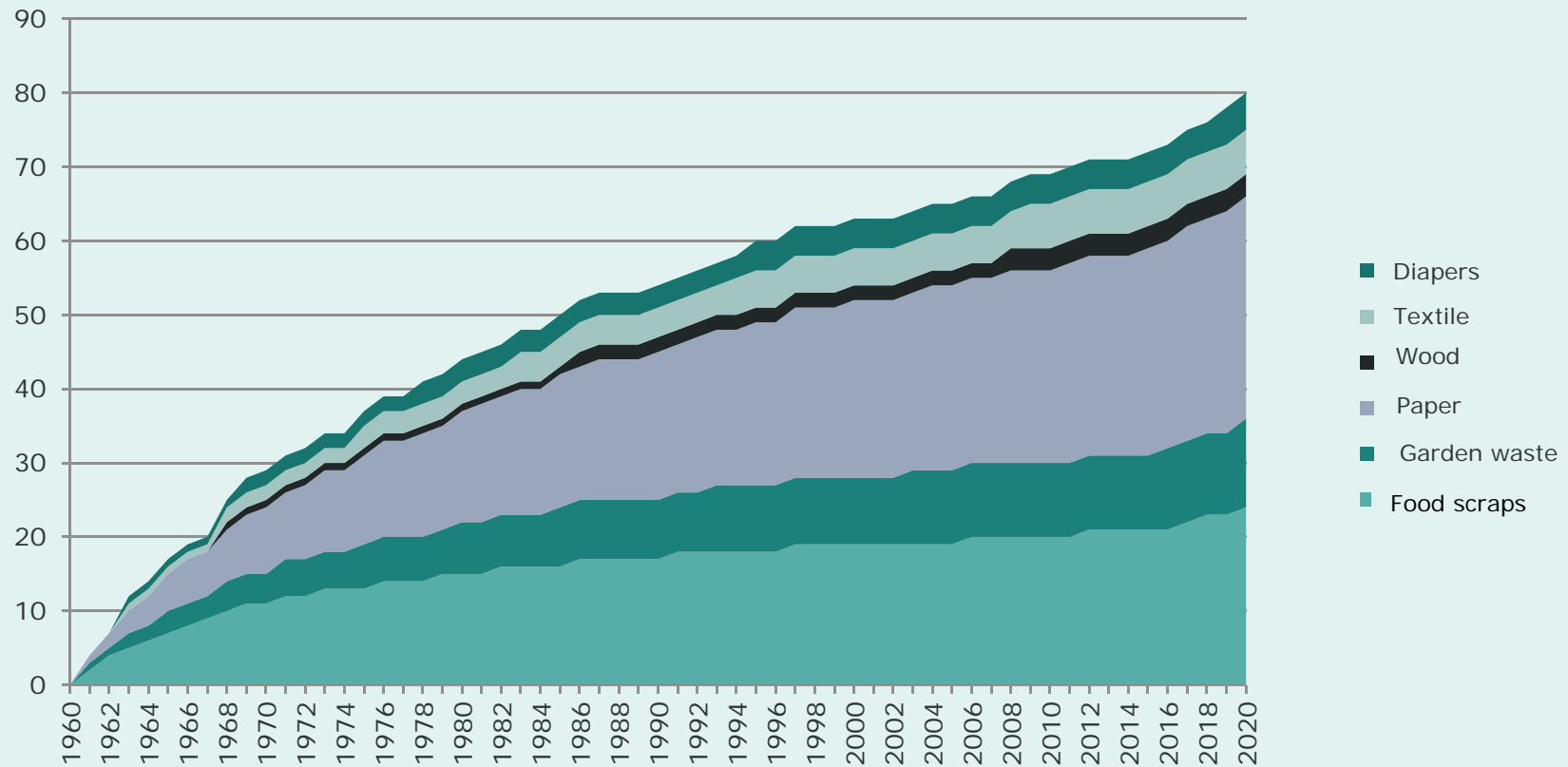
Comparison of production results depending on starting year of calculation

Production results of CH_4 depending on time period

Time period

- 1950 - 2020
- 1960 - 2020
- 1970 - 2020

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