



ROYAL HASKONING

consultants architecten ingenieurs

Dramatic reduction in
emissions of methane from
landfills in the Netherlands

June 2009

Reduction of methane from Dutch landfills

- Introduction
- Methane emissions from Dutch landfills
- Basic assumptions
- Additional measures
- Feasibility of potential measures
- Conclusions





Assignment:

Senter Novem

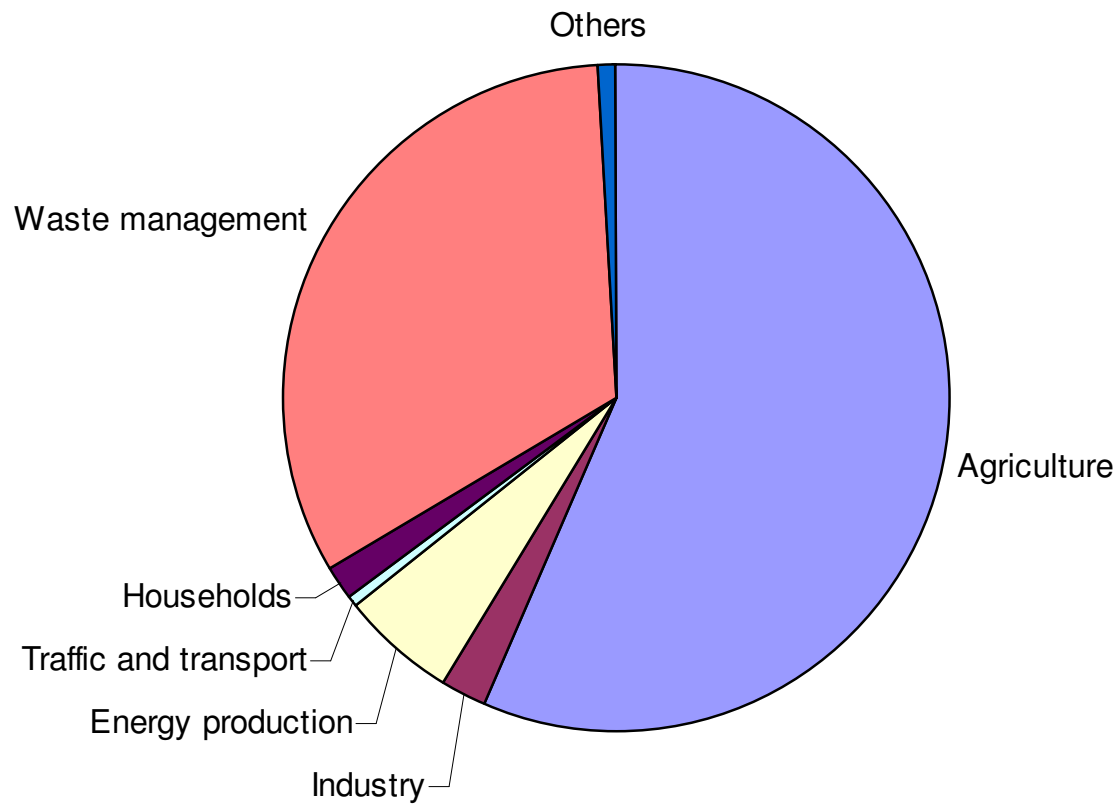
Reduction Programme non-CO₂ greenhouse gases

(Reductieplan niet-CO₂ broeikasgassen or ROB)

- Methane emissions from landfills in the Netherlands
 - 1990: 6% of total greenhouse gas emissions
 - 2007: 3% of total greenhouse gas emissions

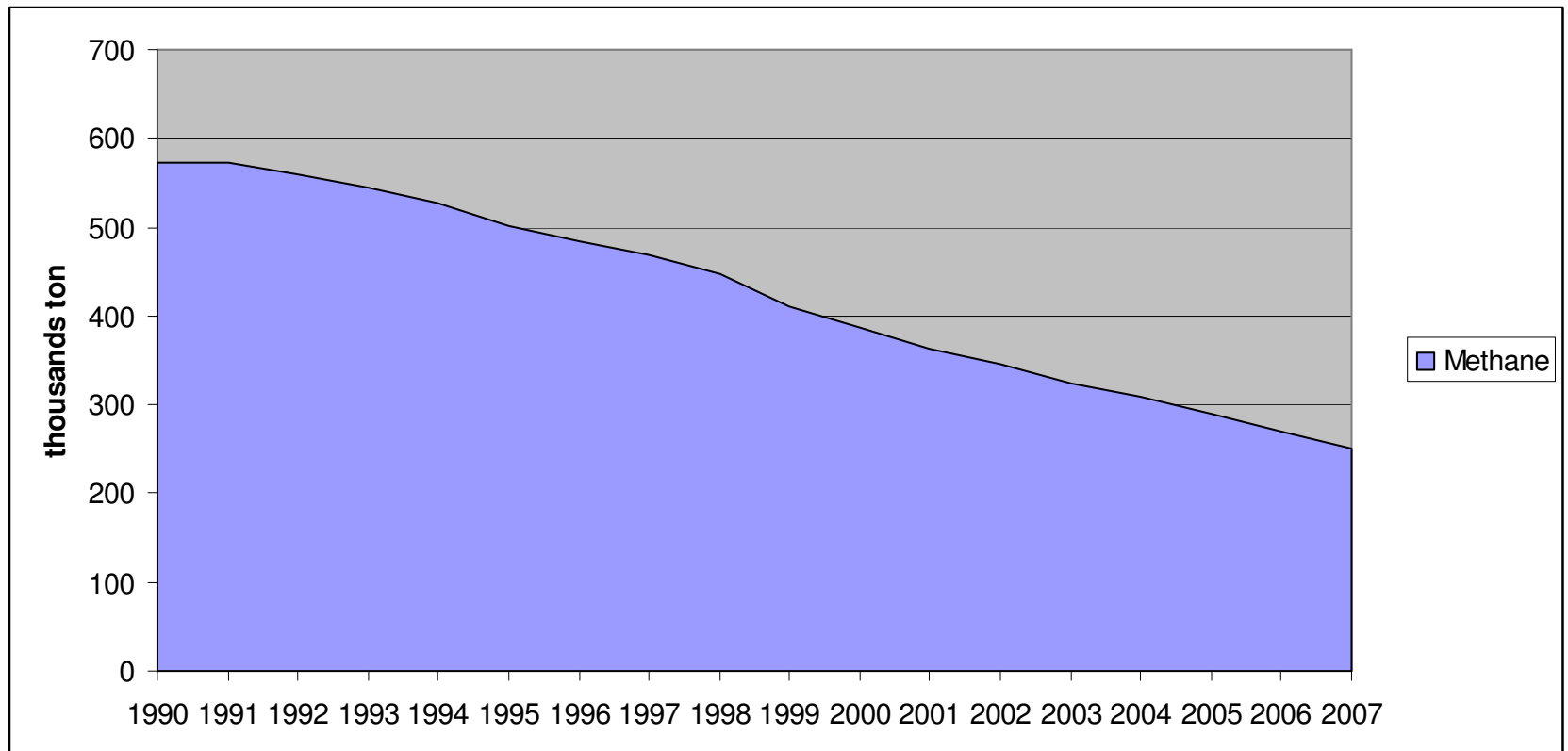


- Methane sources in the Netherlands (2007)



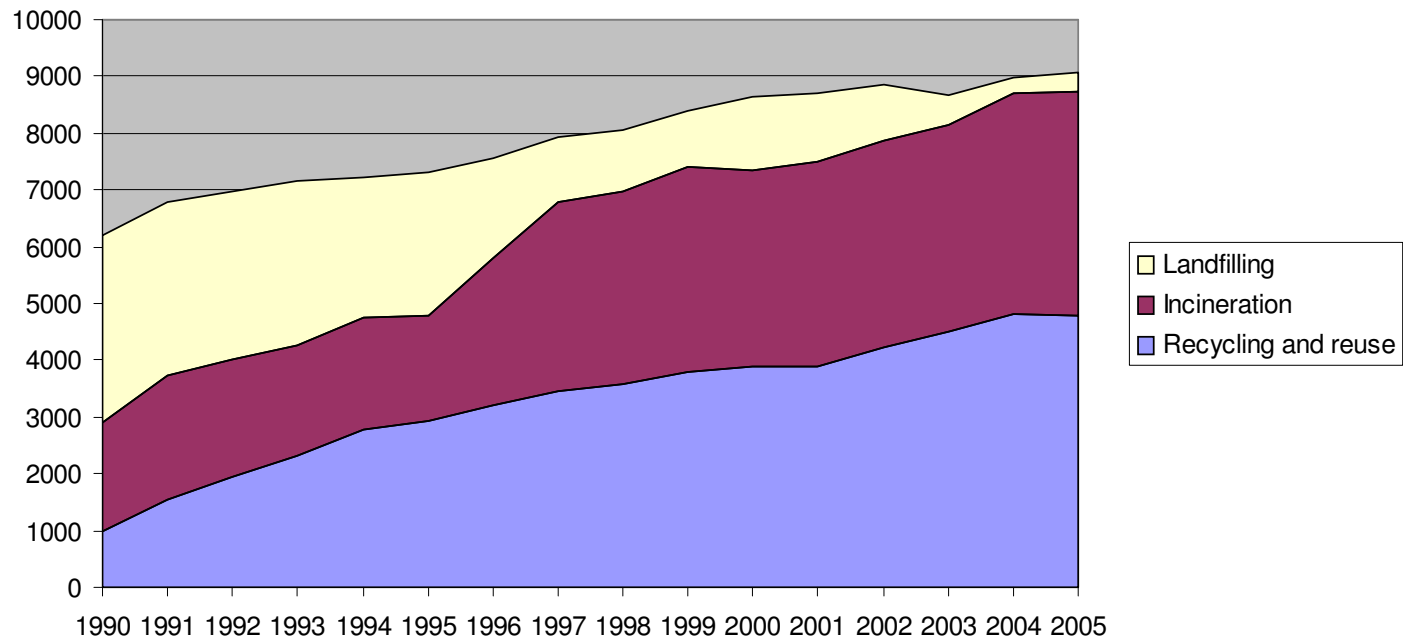
Reduction of methane from landfills

- 572 kton methane in 1990
- 243 kton methane in 2007



Reduction of methane from landfills

- Less waste disposal
- Separate collection of biodegradable waste



- The use of landfill gas for generating power
- Flaring of landfill gas

- Landfills in the Netherlands
 - Former landfills
 - approximately 4000
 - Medium size landfills
 - closed before 1-9-1996
 - organic household waste
 - approximately 30
 - Landfills in use
 - approximately 20
 - guidelines (BAT)
 - landfill gas collection
 - landfill gas utilization



Additional measures (types)

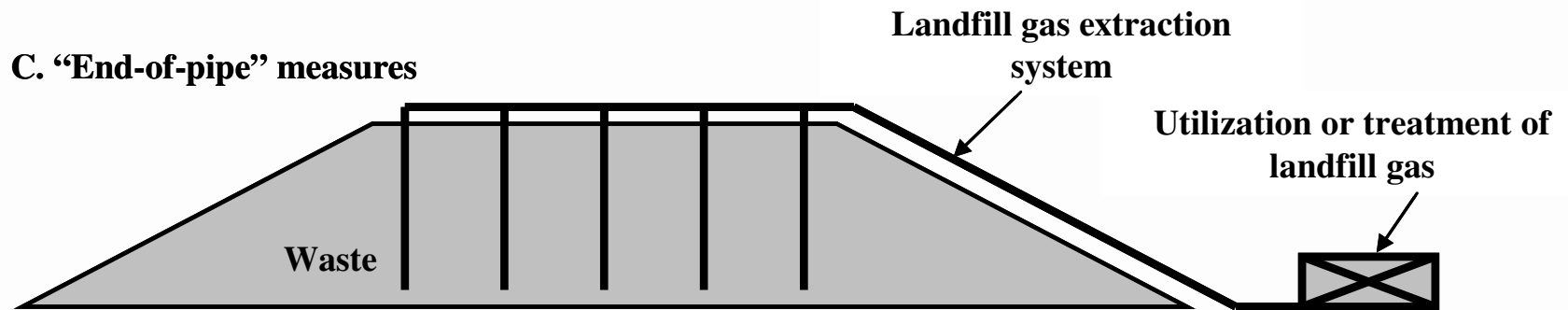
A. Measures related to landfill body, waste conditions and waste body



B. Measures directly related to capture of landfill gas in top layer



C. "End-of-pipe" measures



A Landfill body and waste

- A1 shift waste to a sanitary landfill
- A2 Waste mining
- A3 Anaerobic bioreactor landfill.
- A4 Aerobic bioreactor
- A5 Adjusting waste body shape
- A6 Waste pretreatment
- A7 Waste management



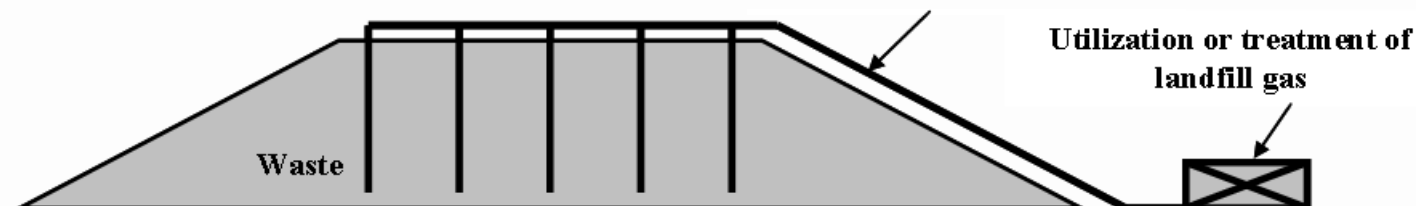
B Landfill gas capture

- B1 Methane oxidation in top layer
- B2 Early sealing of landfill
- B3 Aeration of top layer



C End of pipe techniques

- C1 Installment of additional extraction wells
- C2.1 Flaring of low-calorific landfill gas (30% to 45% CH₄)
- C2.2 Flaring of low-calorific landfill gas (15% to 30% CH₄)
- C2.3 Flaring of low-calorific landfill gas (8% to 15% CH₄)
- C.2.4. Collection and flaring of landfill gas without the use of compressor
- C3 Gas utilization by ORC (Organic Ranking Cycle)
- C4 RTO (regenerative thermal oxidation)
- C5 Separate extraction and treatment of high-calorific and low-calorific landfill gas
- C6 Discontinuous landfill gas extraction
- C7 Optimization of existing landfill gas extraction systems



Additional measures

Most promising (after multi criteria analysis)

C2.1 Flaring of low-calorific landfill gas (30% to 45% CH₄)



C1 Installment of additional extraction wells



B2 Early sealing of landfill



C7 Optimization of
existing extraction systems



Feasibility of potential measures

- Former landfill types (assumptions)

Scenario	Operation Period	Area (hectare)	Waste amount (m3 per year)
1 Very old landfill	1950 – 1960	2	4000
2 Small old landfill	1975 – 1980	2	8000
3 Large old landfill	1970 – 1985	10	54000
4 Small landfill	1990 – 1995	2	12000
5 Large landfill	1985 – 1995	15	150000

- Landfills in use

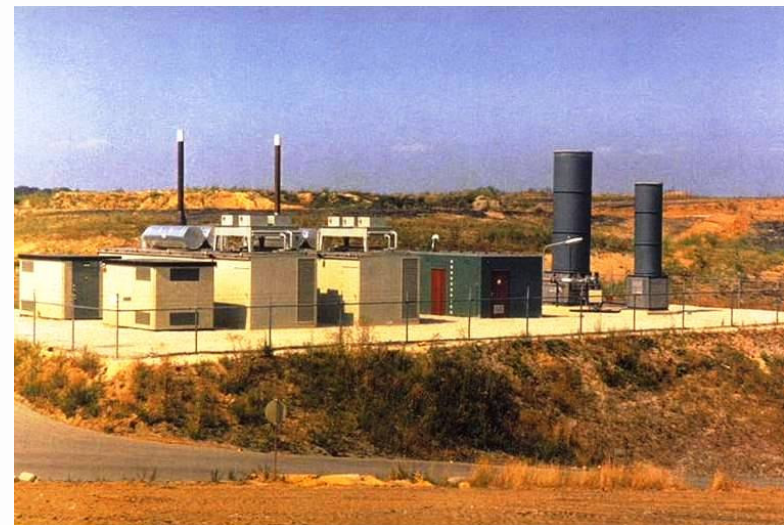
Feasibility of potential measures

Revenues and feasibility at former landfills

Scenario	Operation period	Revenues period 2009 – 2020 (Euro)	Conclusions (summary)
1 Very old landfill	1950 1960	2,500	<ul style="list-style-type: none"> Revenues do not cover costs of measures
2 Small old landfill	1975 1980	23,000	<ul style="list-style-type: none"> Revenues do not cover costs of measures
3 Large old landfill	1970 1985	500,000	<ul style="list-style-type: none"> Revenues are calculated for 100% utilization of methane. In practice a maximum of 70% is realistic. Then revenues will not cover costs of measures (over a period of 12 years).
4 Small landfill	1990 1995	156,000	<ul style="list-style-type: none"> Revenues do not cover costs of measures
5 Large landfill	1985 1995	3,132,000	<ul style="list-style-type: none"> Flaring of low-calorific landfill gas and increasing the amount of gas wells might be cost effective. Early sealing of landfill specific for landfill gas capture is not viable. A site specific business case shall give further insight in potential measures.

Feasibility of potential measures

- Landfills in use
 - Have to fulfil guidelines
 - Best Available Technology
 - Additional measures have minor impact on methane emissions in the Netherlands
 - Quick win: Optimization of existing landfill gas extraction systems



- Significant reduction of methane emission from landfills since 1990
- Additional measures in general not cost effective
- Low-calorific gas flares most promising
- Several potential measures are expected to be feasible at large former landfills
- Quick wins at landfills in use, by optimization of the extraction system





Maria Vatamanu

- M.Vatamanu@senternovem.nl

**SenterNovem**

René Boerboom

- R.Boerboom@royalhaskoning.com

Thank you for your attention!