SWANA
SOLID WASTE ASSOCIATION of North America

Washington Evergreen Chapter
educate • innovate • communicate
The Leading Professional Association in the Solid Waste Field

Green House Gas Emissions and Solid Waste's Role and Impact

Friday, September 16, 2016, Spokane, Washington

"WTE vs Landfill Greenhouse Gas Calculations"

Philipp Schmidt-Pathmann, MBA, MIS
Neomer

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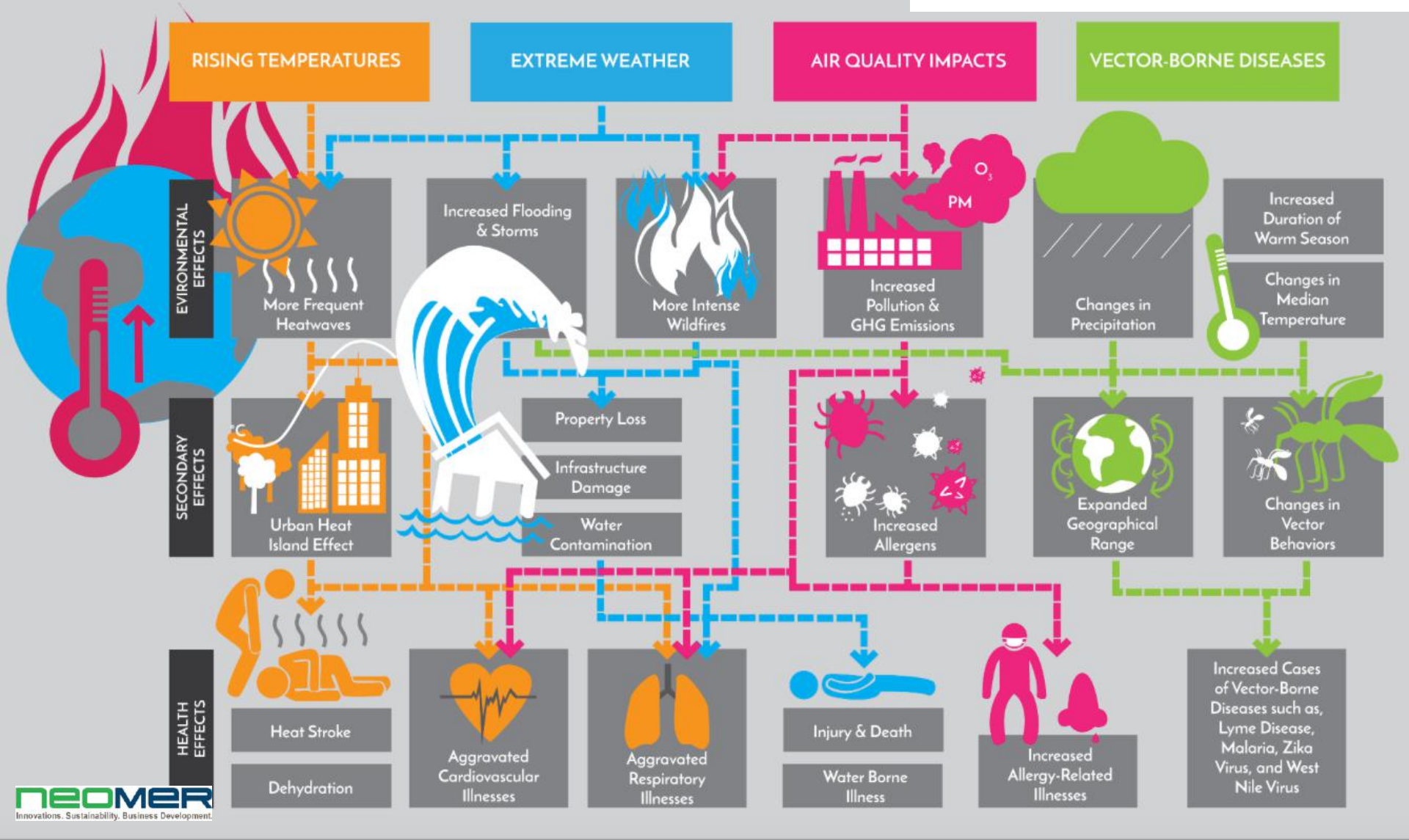
Index *Continued*

Index *Continued*

Four Infographics That Show How Climate Change Is Affecting Your Health

From carbon to coffin.

By Jeremy Deaton and Mina Lee



WTE

Landfill

vs

Landfill

WTE

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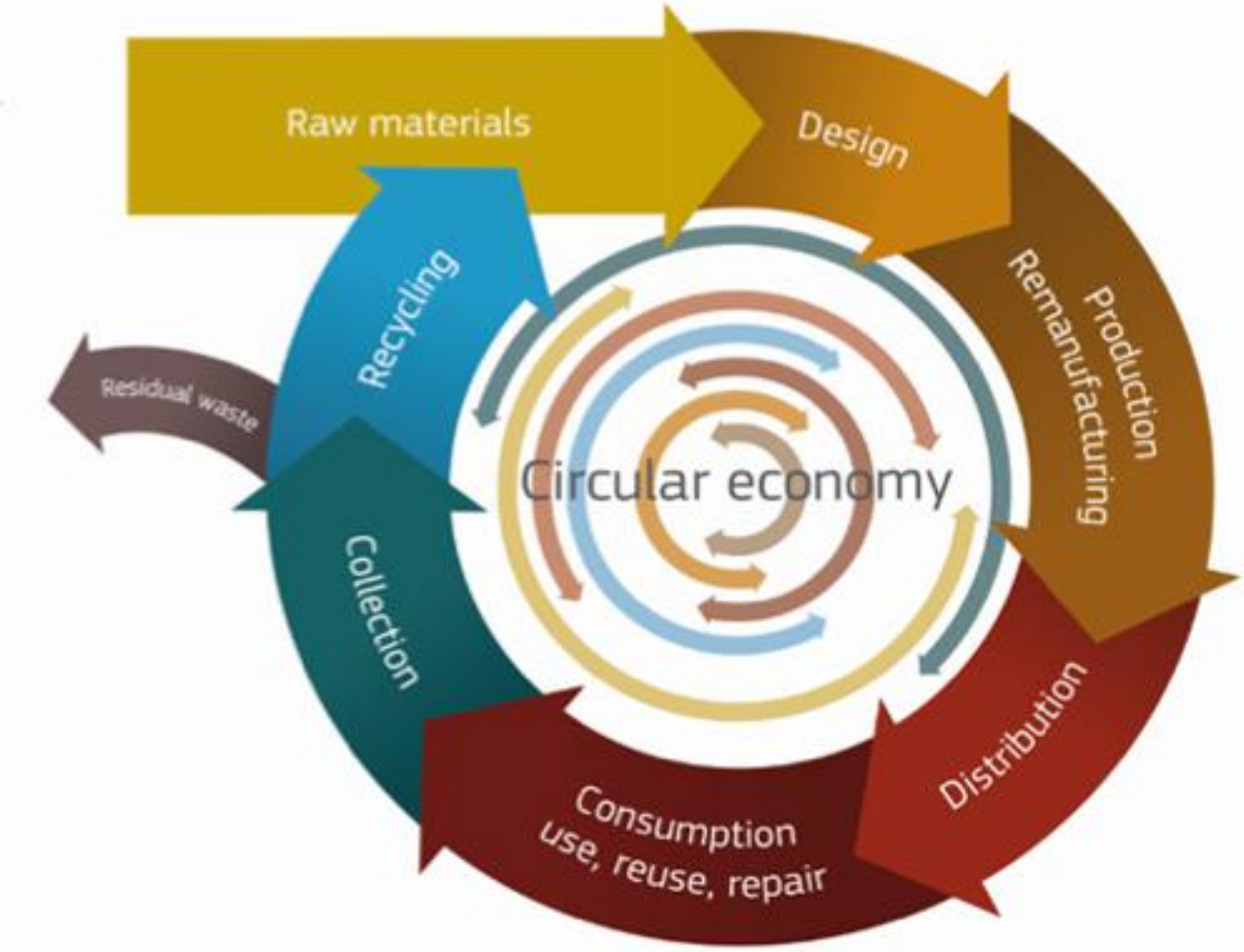
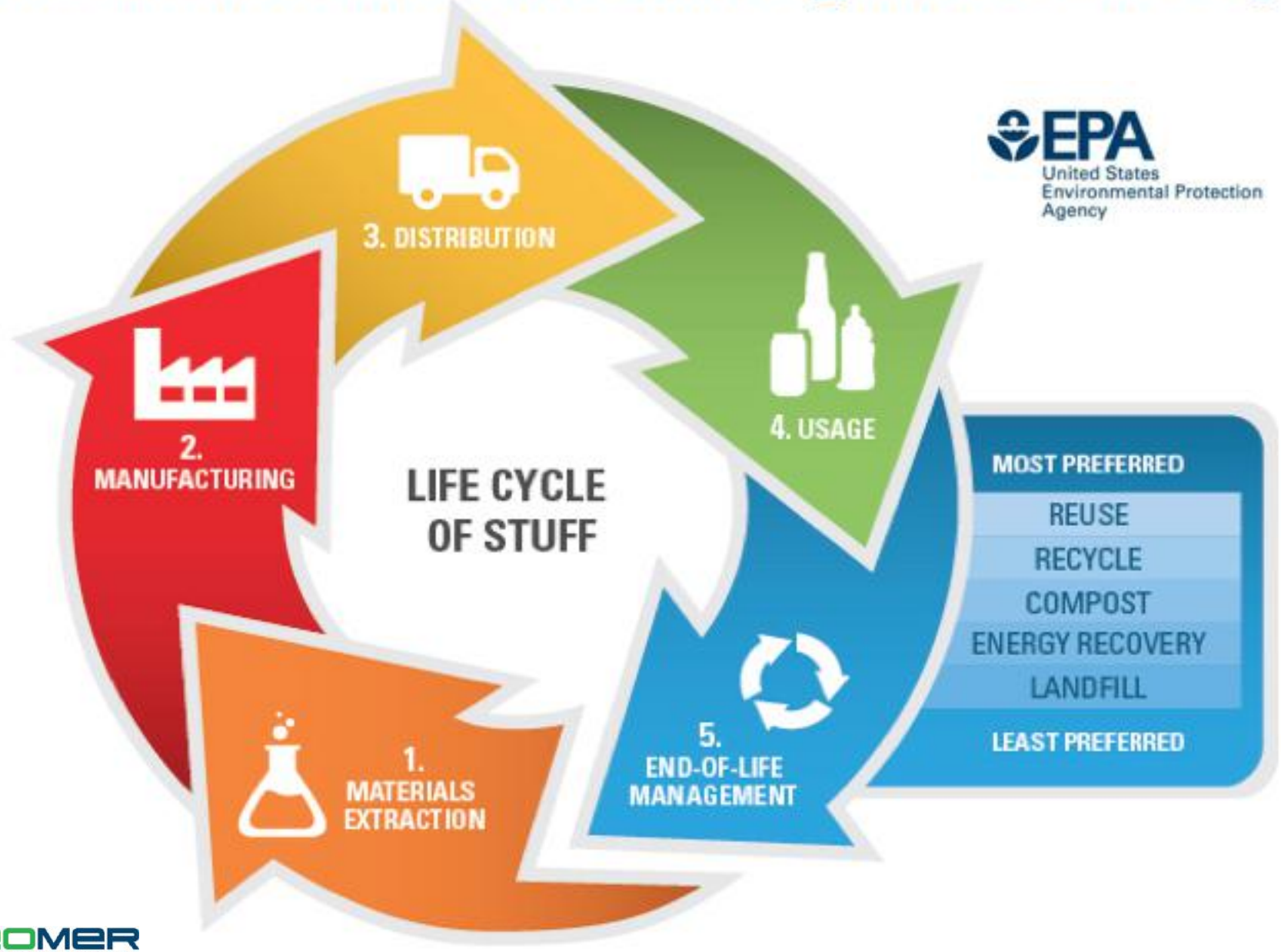
EU waste policy: circular economy



Sustainable Materials Management Life-Cycle



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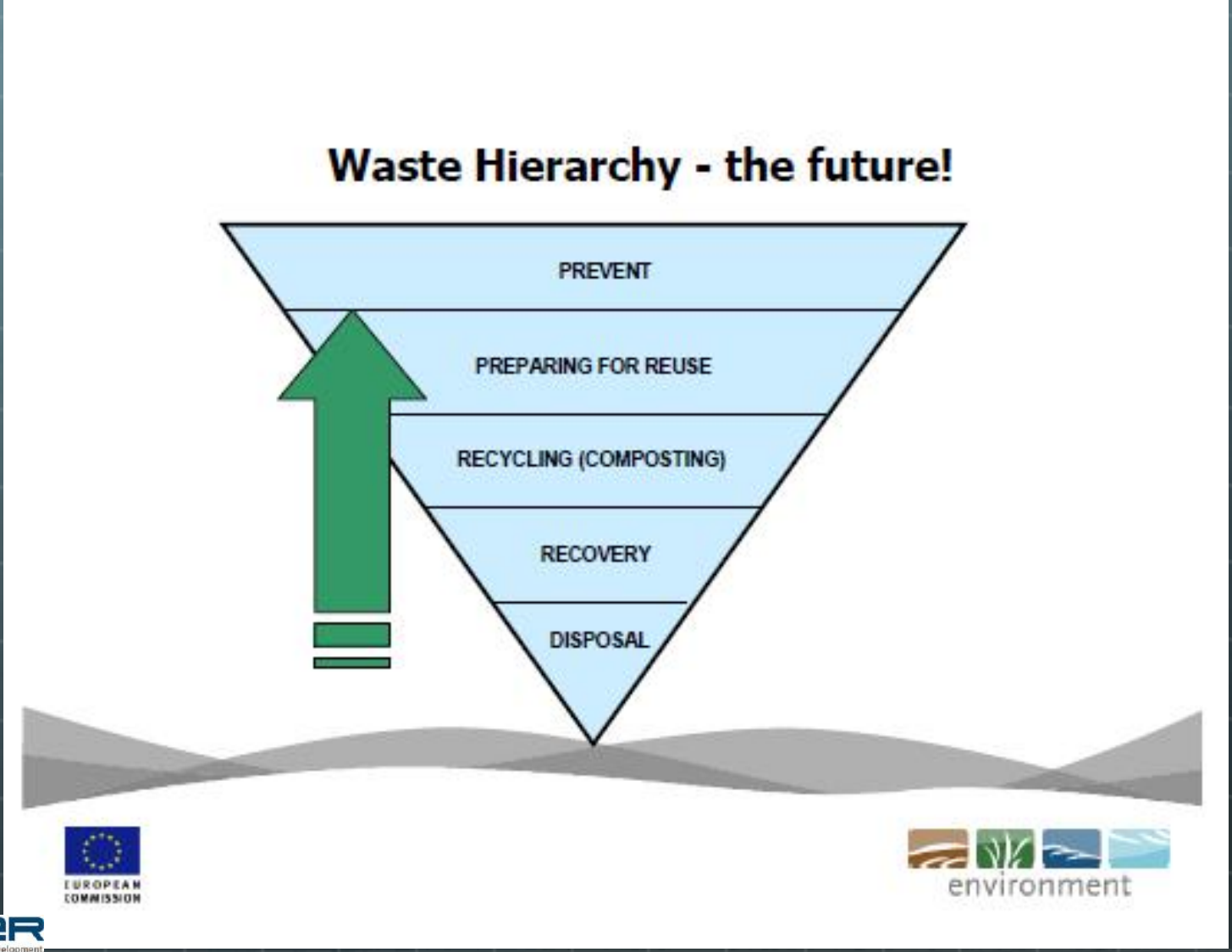
Waste Hierarchy - WFD

Focus on the Prevention Side:



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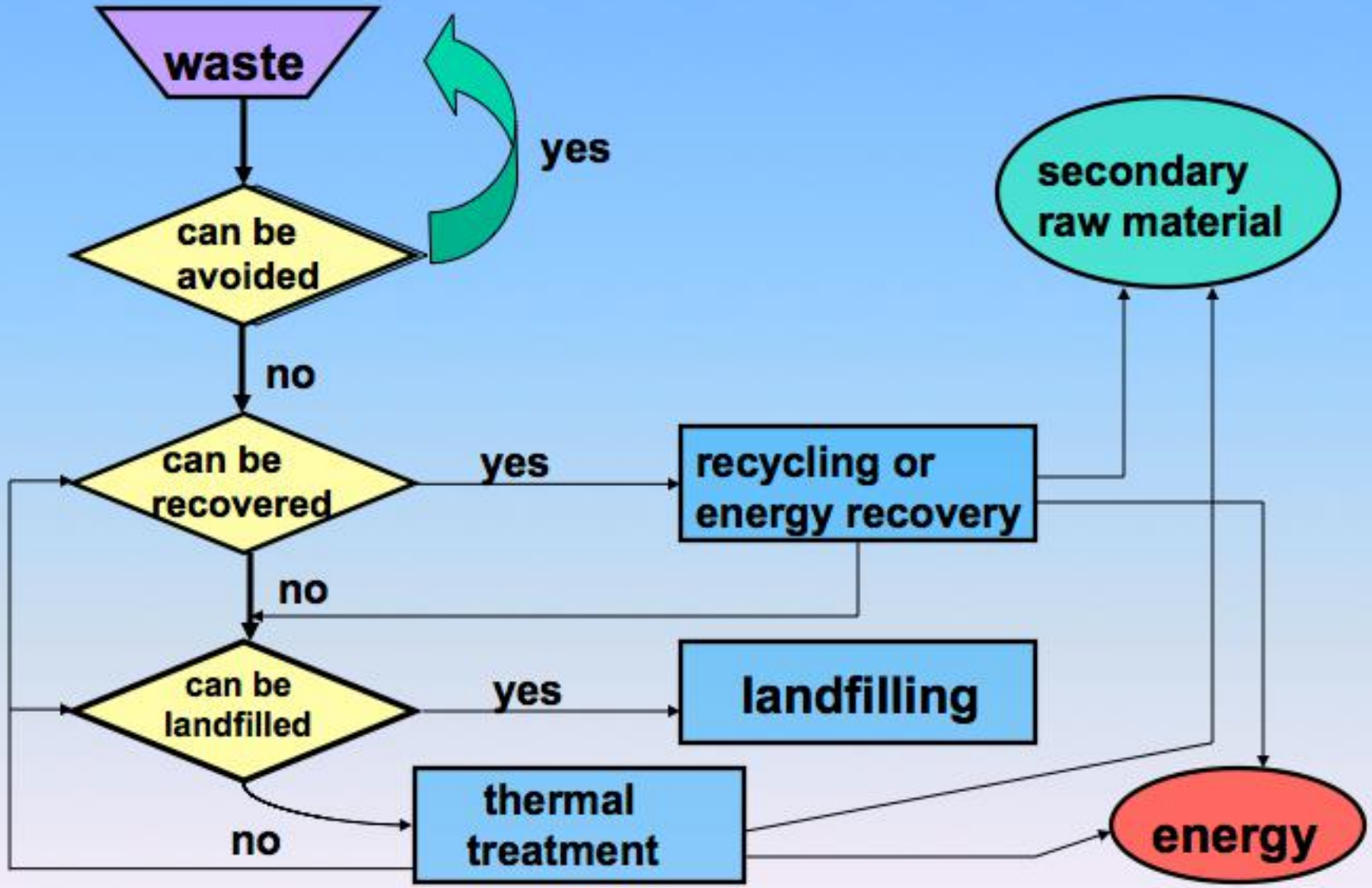
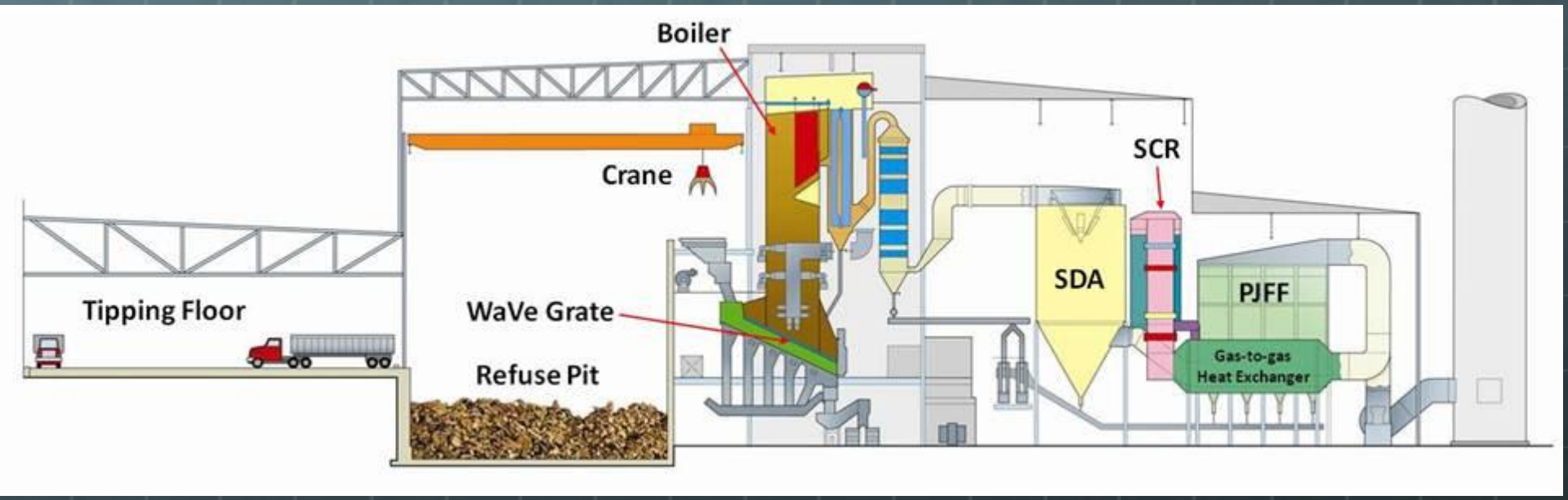
Integrated Waste Management System

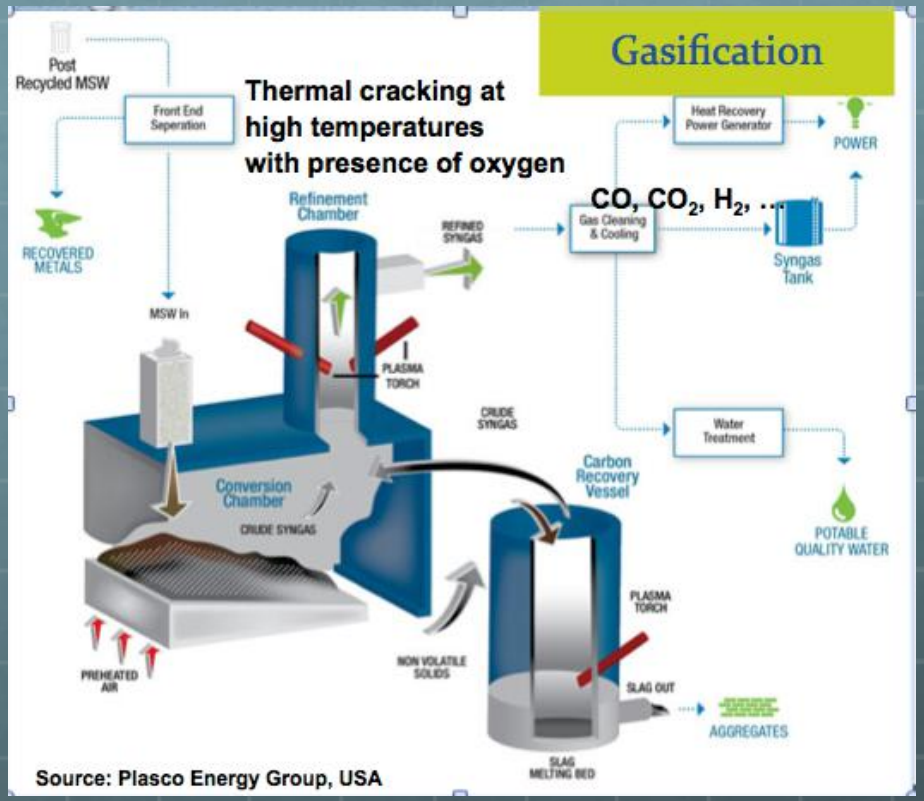


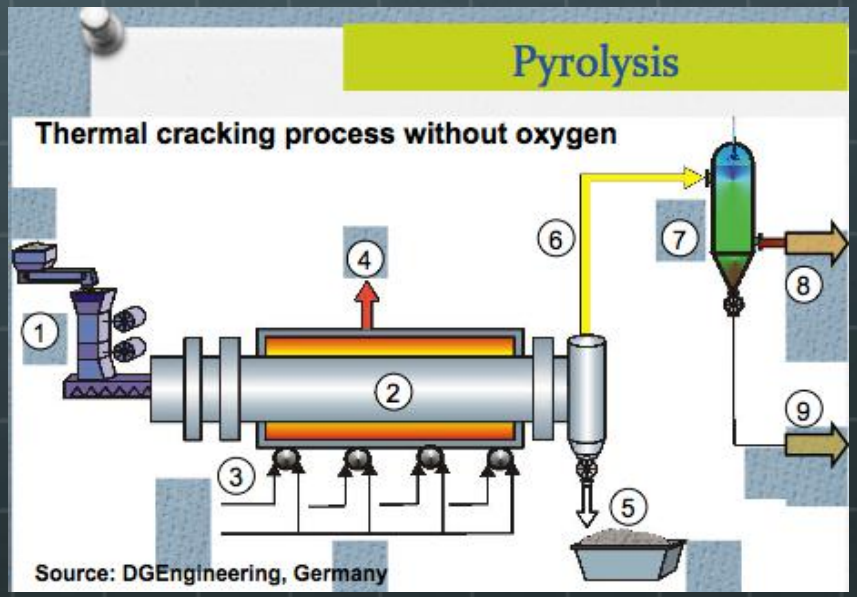
WTE Example Mass Burn



Pictures show the newest WTE facility in the US: Palm Beach completed in 2015 courtesy of The Babcock & Wilcox Company.

Other Waste to Energy Technologies





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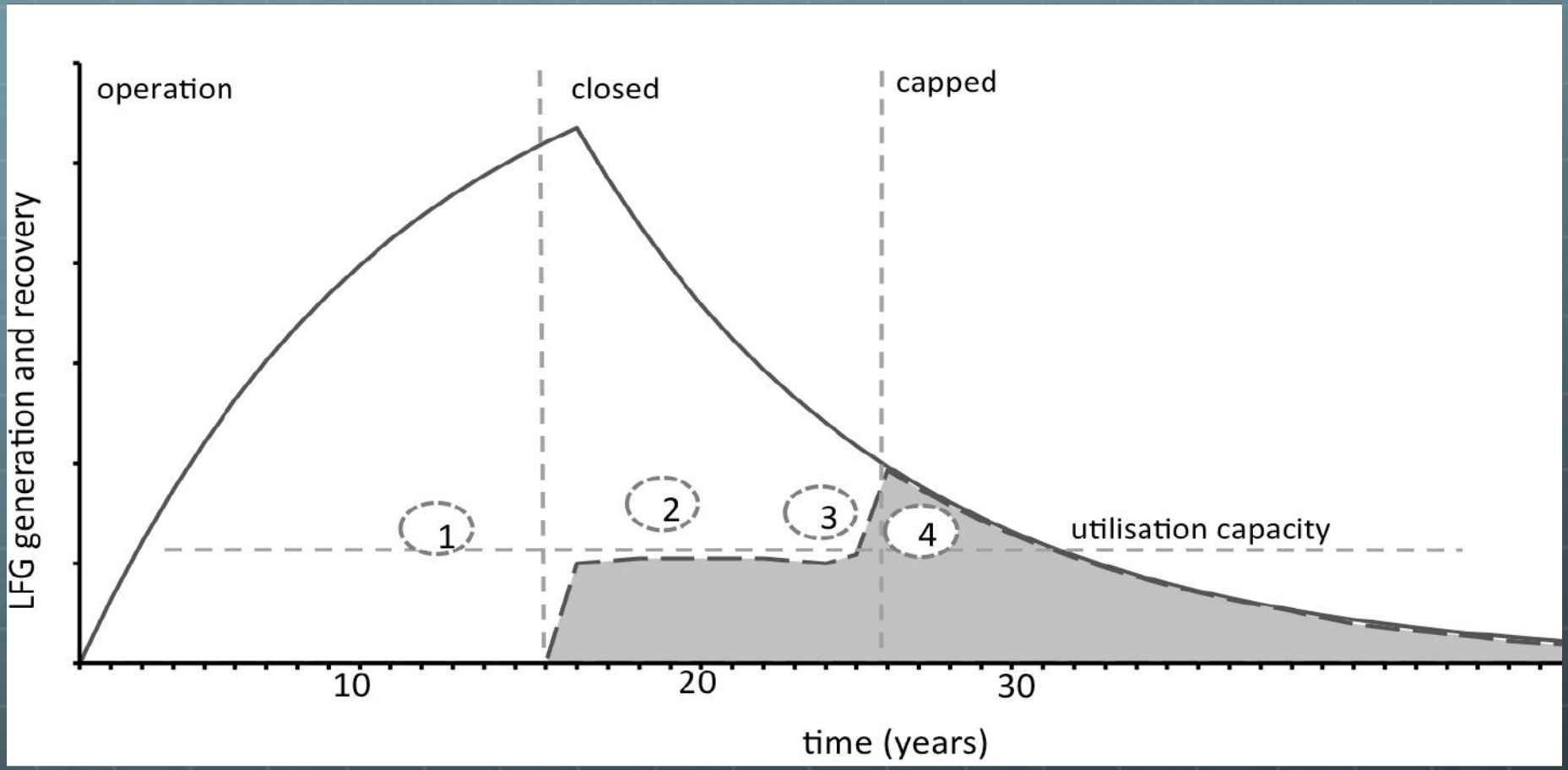
Landfilling

Landfill Gas Calculation Modeling

Recovery Efficiency

- The recovery efficiency is defined as the ratio of the amount of landfill gas recovered to the amount generated.
- There are two different ways to look at recovery efficiency:

  - The efficiency at a single moment in time (hour, day, year); and
  - The total efficiency integrated over the landfills life-time.



Reasons for landfill gas collection inefficiency:

(1) No landfill gas collection during operation
(2) Collection effeciency limited by utilization capacity
(3) Technical limitations to landfil gas collection and
(4) Late capping of the landfill

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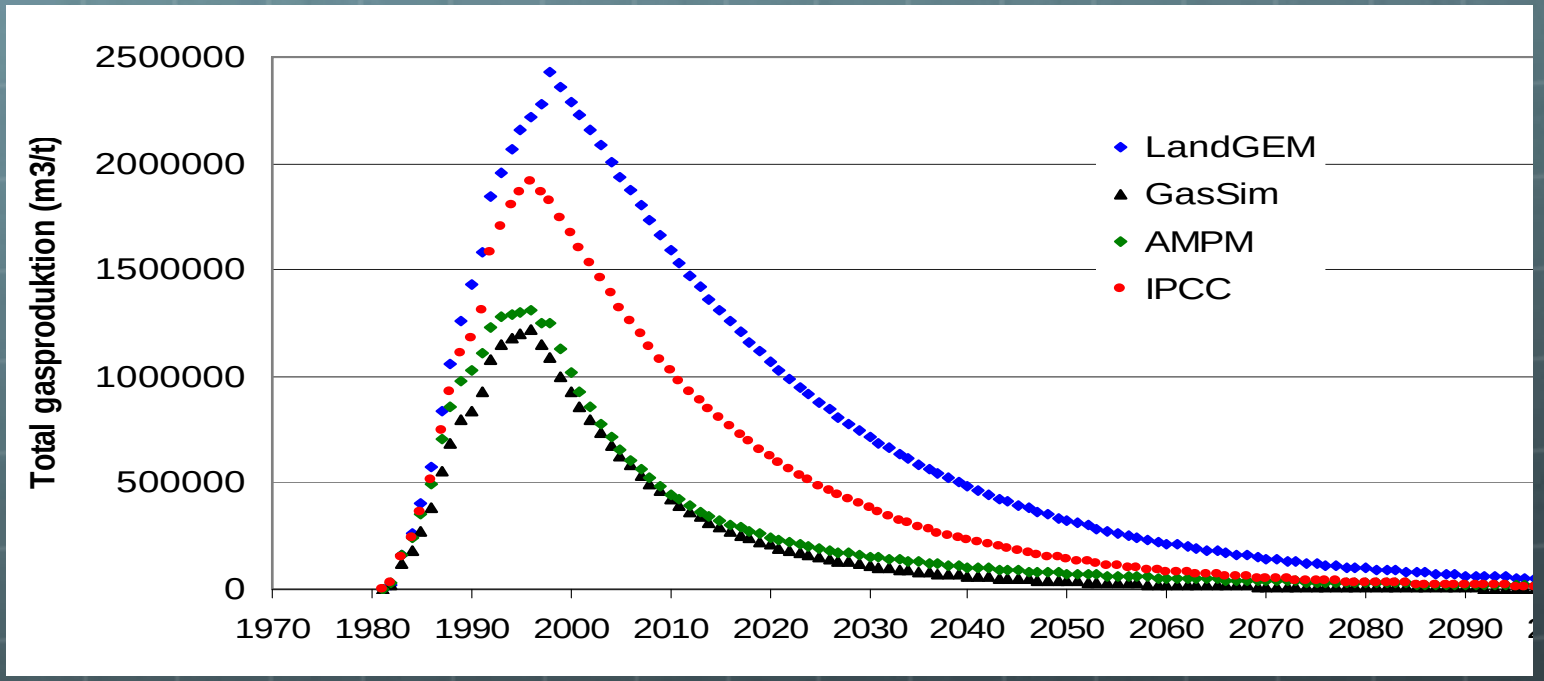
Recovery Efficiency

- In many cases landfill gas extraction only starts after operation of the site (or landfill cell) has ended and the site, c.q. cell has reached its final height.
- In the years after, the collection efficiency often increases, as gas generation reduces, the cover layer and its vegetative cover develops and emissions from 'short-cuts' and hot-spots become less important.
- In this period operators gradually have to put more and more effort in op- timisation of landfill gas recovery, to make sure that the utilisation capacity can be filled. Ultimately, sometimes only 10-20 years after end of operation, the landfill is capped with surface sealing.
- A surface sealing enables an extraction efficiency of almost 100%. If the top cover is a clay or soil cap a lower instantaneous efficiency applies

Problems with Modeling of Gasproduction



Methan calculation from a danish landfill with 4 different gasproduction models

Model	**Gas production, 2005 (m^3 gas pr. hour)**	**Gas production, 2005 (kg CH_4 pr. hour)**
LandGEM (US EPA)	221	79
GasSim	71	25
Afvalzorg multi-phase	75	27
IPCC	151	54

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LFG models - uncertainty

- In general all LFG models - determined from mathematical models (have had little validation, whether they are accurate in practical situations)
- Models are generally built-up from estimates how much biogenic material is deposited, what part of the biogenic material is converted to landfill gas and how fast the process proceeds.
- Extent is a function of methane loading rate, cover materials, cover thickness, quality/ condition of the cover, and ambient temperature
- Function of pressure and concentration difference across cover as well as cover condition (e.g. presence of cracks, permeability)
- Primary sources of uncertainty are variations in barometric pressure, precipitation, temperature, wind conditions, and gas generation rates.

LandGem uncertainty

- Uncertainty is largely associated with model parameters (i.e. athmosphereic pressure, temperature, etc.)
- LandGem does not offer the possibility to adapt methane potential to waste composition
- LandGEM, significantly overestimate CH4 generation, because it applies too high default values for key parameters to handle low-organic waste scenarios
- The LandGEM model, developed by the EPA, is a single-phase tool that only requires users to input the total weight of annual disposed waste
- Previous modelled collection efficiencies were consistently higher than those calculated from field measurements (by 20% on average)

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Runnning the Numbers

King County Cedar Hills Landfill Gas Calcualtions using US and EU models:

- LandgGEM : >90% Methane capture
- Avfalzorg: < 20% Methane capture
  - => Discrepancy of more than 70%!!!!!!!!
  - => Internationally Greenhouse Gas Captures from US landfills using the LandGEM model will not be recognized.
  - Current anticipated GHG reduction goals from the waste management secort relying predominantly on landfilling will be dismissed as inadequate

Information is out there and can no longer be ignored!

www.gov.uk/defra

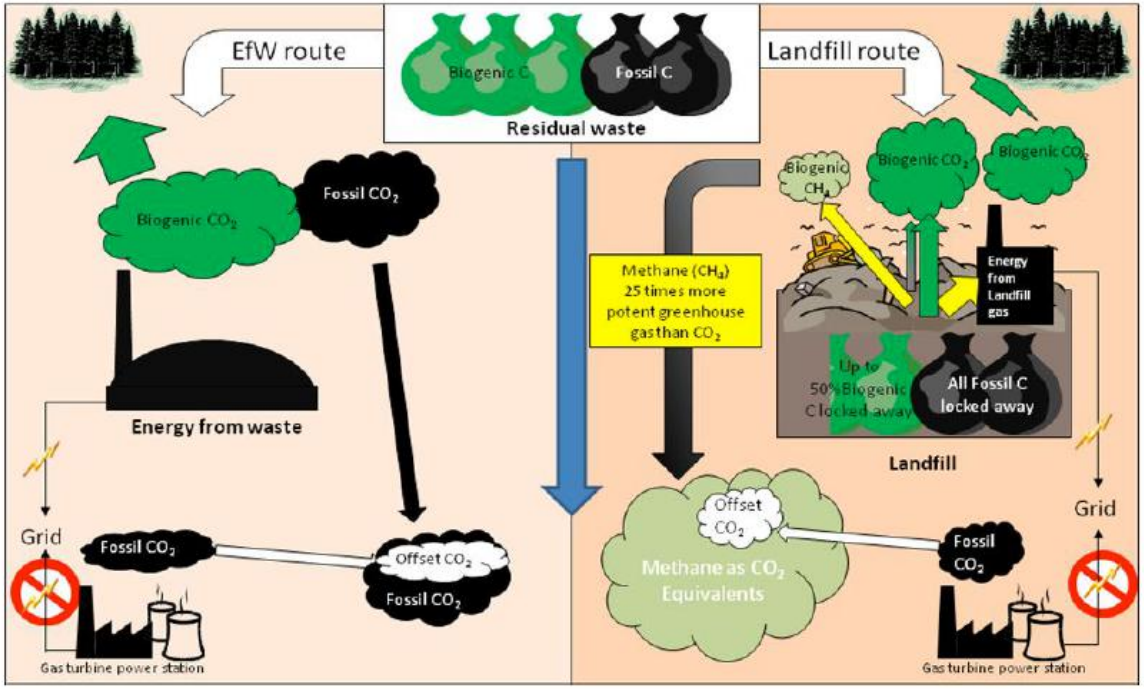
Department
for Environment
Food & Rural Affairs

Energy recovery for residual waste

A carbon based modelling approach

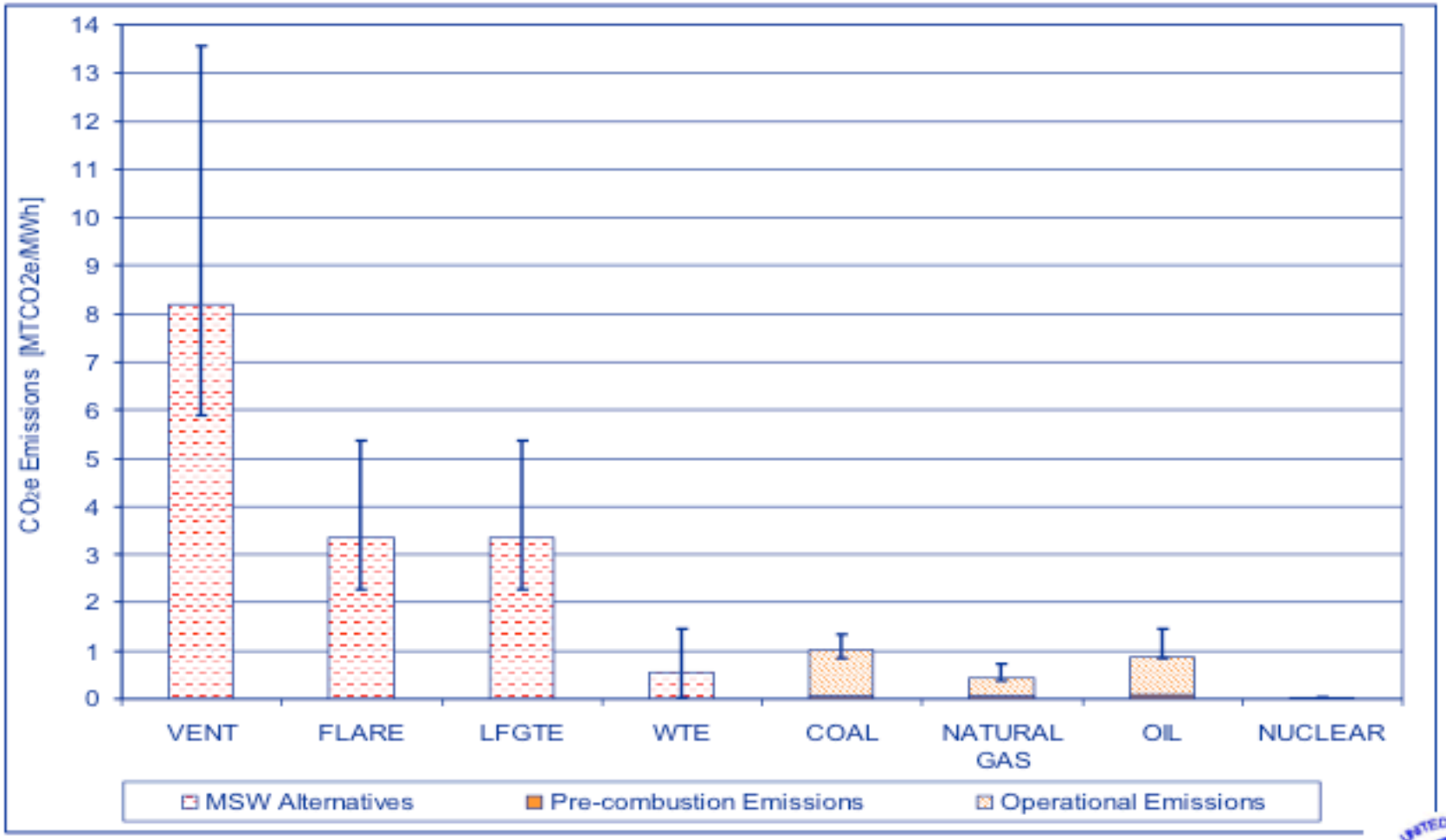
February 2014

Diagram 1. Emissions routes from landfill and EfW



- The calculations based on natural gas substitution (even considering electricity-only WtE plants and landfills with a very optimistic gas capture of 75%) conclude that whenever electricity-only WtE plants have a higher energy efficiency than 11%, they always provide a better carbon performance than very efficient landfills.

Comparison of MSW Discards Management to Conventional Electricity Generating Technologies



Source: EPA/ORD : Kaplan, P. O.; DeCarolis, J.; Thorneloe, S. (2009) Is It Better to Burn or Bury Waste For Clean Electricity Generation? *Environmental Science and Technology*, 43, (6), 1711-1717

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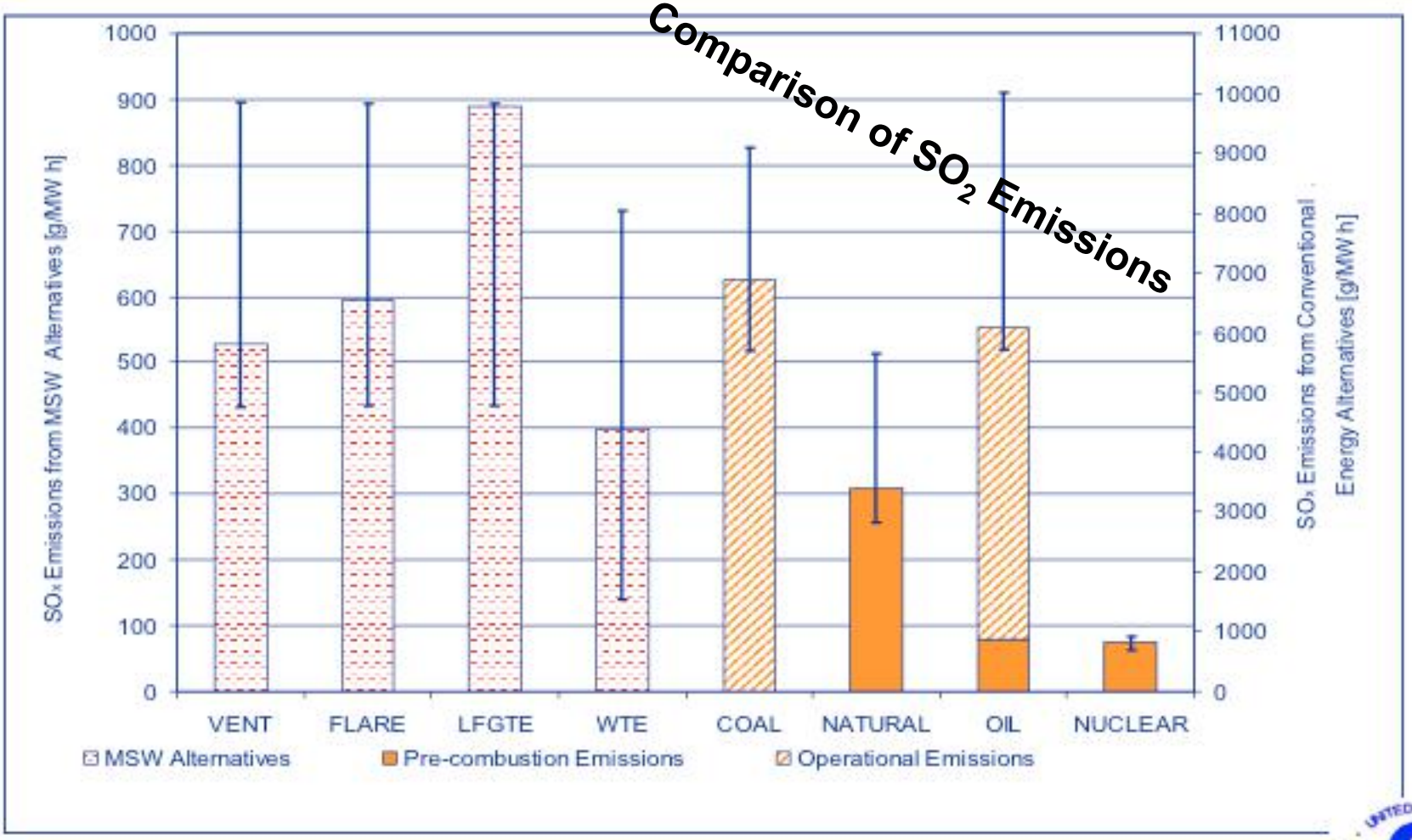
Comparison of MSW Discards Management to Conventional Electricity Generating Technologies



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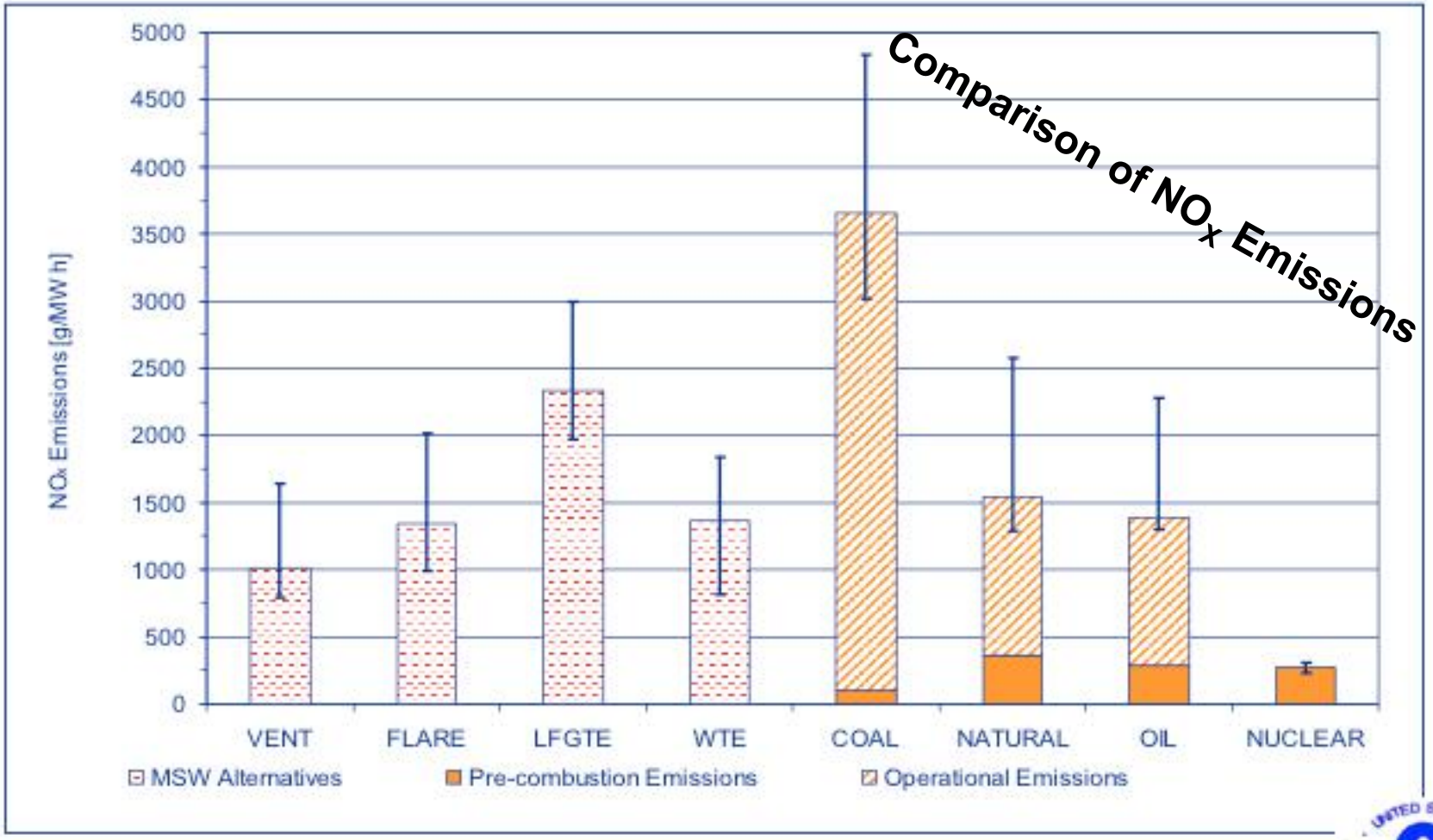

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Global Climate Impacts – Carbon Footprint

Category	Emissions (tons CO_2 eq/ MWe-hr)
Landfill (with energy recovery)	3.7
Coal-Fired Power Plant	1.1
WTE Facility	0.7

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And yet…..

In Washington State Energy obtained from Landfill Gas Systems is considered Renewable and credited, WTE is not!!!

- Nothing to do with science! -> If it be science based, LFG would not have received preferential treatment over WTE. Minimal: Both processes should or should not be considered renewable energy sources and get or get no credits!!!
- All about the efforts of one lobby group over the other.
- Political decision was not made with a comprehensive understanding of the topic and needs to be revised

Huge Concern!

What's Happening:

California's Recycling Industry is in Rapid Decline

by Leon Kaye on Wednesday, Aug 31st, 2016 CLIMATE & ENVIRONMENT

More recyclables in California are finding their way into landfills. California has long basked in its reputation as a sustainability leader. From its booming solar sector to its cap-and-trade program, the Golden State sets environmental standards that others strive to follow. But a series of trends threaten to have California fall far short of its 2020 goal to recycle 75 percent of its municipal waste. And as is the case with the rest of the country, the state is struggling to recycle the easiest items, such as single-use disposable containers. After several years of a steady decrease, the amount of garbage sent to California's landfills spiked to over 33.2 million tons last year, an increase of approximately 2 million tons. The Los Angeles, San Diego and Inland Empire areas saw the largest spikes in waste disposal tonnage, though most of

California saw recycling decline while landfill disposal increased. The bottom line is that after several years witnessing the state recycle over half of its trash, that rate fell to 47 percent, the lowest in several years.

The state's population has gradually increased, after taking a dip during the aftermath of the 2008-2009 fiscal crises. Meanwhile the economy improved, motivating more Californians to buy more goods. The results: 44 million more tons of trash ended up in landfills, while 24 million fewer tons were recycled in 2015 than in the previous year. And in environmental terms, that means 200,000 more metric tons of carbon emissions were emitted into the atmosphere.

At the recent (2016) Resource Recycling Conference in New Orleans, Waste Management CEO David Steiner

- Steiner said that his main reason for being so publicly open about the challenges of recycling is to start a conversation around sustaining its long-term future. "For good portions of the last years, we've been losing money in recycling," he said, as reported by Resource Recycling. "Guess what follows losses? Disinvestment. … We needed the wider community to understand what was going on."
- In his remarks, Steiner referenced recent research that the company has been talking which measured the potential costs and greenhouse gas reductions of diverting certain materials. Based on this logic it becomes harder to justify the collection of materials such as organic waste and glass when weighing environmental benefits against cost.

By Cole Rosengren - Waste Dive - September 6, 2016

Reality Check: *Loosing Money in recycling because:*

- *Poor quality of recyclables (one bin recycle & MRF (Material Recovery Facilities) inadequate)*
- *Low cost of landfilling* (true cost - lost resources & environmental impact – not reflected)
- Emphasis still on landfilling (missing policies – EPA waste hierarchy not enforced)
- Export of 'recyclables' to other countries like China to offset trade deficit – getting more challenging to justify, awareness of quality issues, pollution issues, CO_2 Impact
- Artificially low cost of fossil fuels/non-renewables, raw materials

Lower cost ‘solutions’ move us even further away from carbon reductions and getting toward a circular economy.

The damage from low cost ‘solutions’ has now become our financial and environmental burden.

We are of track when it comes to calculating Greenhouse Gases (GHG) emitting from landfills. A recent (2015) analysis according to the life cycle assessments (LCA) method based on the ISO (International Organization for Standardization) 14040 and 14044 for waste management, found that methane emissions from landfilling are the main contributor to the GHG burdens in for example the USA. Even with best technology employed at landfills, methane capture rates are no more than 50%. Key differences are described in this report as well as in previous slides comparing the US Landfill model LandGem with new, scientifically more accurate models:

TEXTE
56/2015

The Climate Change Mitigation Potential of the Waste Sector

Illustration of the potential for mitigation of greenhouse gas emissions from the waste sector in OECD countries and selected emerging economies; Utilisation of the findings in waste technology transfer

For our Environment

Umwelt Bundesamt

Secondly, another special feature of landfilling in the USA is the gas collection efficiencies quoted, which are relatively high. The majority of landfills in the USA are operated by two large companies, one of which is Waste Management Inc. An expert (Thorneloe 2012) states that the efficiency of the gas collection systems used in landfills varies. Operators postulate the "CO_2-neutral landfill" with 95% gas collection efficiency. According to measurements performed by USEPA (ORD), these gas collection efficiencies are unrealistic. Measurement programmes at three landfills yielded the gas collection efficiencies shown in Figure 21.[32] However, these apply only to the landfilling period that was considered or investigated. There are no data on effective gas collection efficiencies over the entire storage period, which should be considered to last 100 years.

The effective gas collection efficiency over the 100-year time span is not given; it depends on the annual methane formation rate that is applied. However, it can be assumed that the effective gas collection efficiency, if calculated, would be over 80% and hence significantly higher than is generally postulated under the current state of scientific knowledge. It is for this reason that (EEA 2011), for example, does not adopt the high gas collection efficiencies reported by some EU countries; instead, a maximum technically feasible effective national gas collection efficiency of 45% is assumed, even if all landfills have gas collection systems.

The SOG survey results in considerably larger waste amounts than the USEPA data; in particular, it shows larger amounts landfilled. According to the survey, the MSW generated in 2011 was about 389 million short tons, of which 64% was landfilled. On the basis of the volumes in the SOG survey the net debit in the GHG balance for the USA is 3.6 times higher at 64.5 million Mg CO_2-eq. The GHG emissions from landfilling are nearly twice as high.

For the USA a medium and an ideal future scenario were analysed with the following conditions:

2030 medium:	45% recycling, 25% incineration, 30% landfill
2030 ideal:	60% recycling, 40% incineration, 0% landfill

Table 4: Absolute net results – global warming potential, status quo and future scenarios to 2030 in the USA

in 1,000 Mg CO_2-eq	status quo	2030 medium	2030 ideal
Collection	2,151	2,151	2,151
Landfill	64,689	39,591	0
Incineration (with energy)	-3,454	-28,840	-50,840
Recycling	-44,688	-65,906	-89,850
Composting/anaerobic digestion	-595	-712	-2,863
Total	**18,104**	**-53,717**	**-141,402**

Example of a country that detached from landfill lobby, got educated and took an in-depth look at the holistic infrastructure and then came up with a system that now serves as a model for the EU:

Germany

Myth:

- Germany and many other European Countries are moving away from landfilling because they have less available land so they in needed to come up with alternatives, which cost more.

Fact:

- In 1990, Germany had >10,000 landfills.
- Due to the proximity to the population, environmental awareness and education the impacts from landfills were felt more immediate vs far away out of sight out of mind landfills -> not due to less available space.
- The EU, Switzerland and Norway determined that landfilling is least desirable and an infrastructure that does not depend on landfilling is needed.
- Moving away from landfilling was recognized as not only providing urgent environmental but key economic benefits as well.

Recognizing the negative environmental and economic impact from landfilling waste, a law went into affect in Germany on June 1st 2005 that bans untreated waste in landfills, which was recognized in a statement by the German Environmental Minister:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

As of: 03. June 2005

Waste Management

As of: 03. June 2005

A milestone for environmental protection: landfilling of untreated wastes consigned to the past

Waste Storage Ordinance enters into force on 1 June 2005

A new era of domestic waste management has begun: from 1 June 2005 wastes can no longer be landfilled in Germany without pretreatment. This protects our health and the climate - and creates jobs. Federal Environment Minister Jürgen Trittin: "Today marks an end to the practice which created innumerable contaminated sites for future generations - that of burying waste in landfills and forgetting it. This fundamental change is a milestone for environmental protection, comparable with the introduction of the legally regulated catalytic converter for cars."

Just 15 years ago a great deal of domestic and commercial wastes ended up untreated on the rubbish tip. First residents complained about the stench, then pollutants such as dioxins were found in the groundwater and drinking water. The digester gas methane emitted from landfills causes 21 times more damage to the climate than carbon dioxide (CO_2). Domestic waste landfills became contaminated sites which result in costs for rehabilitation and after-care amounting to billions.

Since 1 June 2005 this has changed. Prior to storage, waste must be treated in such a way that it cannot degrade further or release pollutants. In future, recoverable substances will be separated in state-of-the-art installations and the energy from the wastes utilised. Only a small non-recoverable part of maximum 30% will still have to be stored in well-equipped landfills. Landfills with poor liners and a lack of technical monitoring will be gradually be closed down by 2009.

For 12 years the industry, local authorities and environmental activists have been working towards 1 June 2005. Local authorities alone have invested €7.5 billion, especially over the past four years. 15,000 jobs have been created. Federal Environment Minister Trittin: "This is a major achievement on the part of local authority and private waste management companies. The investments are worthwhile because of the jobs. And also because we are avoiding new contaminated sites and preventing damage to the environment which future generations would have had to rehabilitate at great cost."

The Waste Storage Ordinance also implements the 1999 European Union Landfill Directive. Along with Austria, Denmark and the Netherlands, German waste management is thus assuming a pioneering role in the implementation of this EC directive. "Other countries, both within and outside the European Union, face massive unsolved waste problems," said Trittin. "This is a great opportunity to export advanced German environmental technology. Thus the implementation of the Waste Storage Ordinance also contributes to strengthening Germany as a business location."

Further information::

Speech of the Federal Environment Minister Jürgen Trittin
[/english/waste_management/reports/doc/35870.php]
: "An important stage has been reached: Today marks an end to the above-ground storage of biodegradable waste"

Source: http://www.bmu.de/english/waste_management/current/doc/35589.php
28.08.2005, 10:01:36

landfilled in Germany without pretreatment. This protects our health and the climate - and creates jobs. Federal Environment Minister Jürgen Trittin: "Today marks an end to the practice which created innumerable contaminated sites for future generations - that of burying waste in landfills and forgetting it. This fundamental change is a milestone for environmental protection, comparable with the introduction of the legally regulated catalytic converter for cars."

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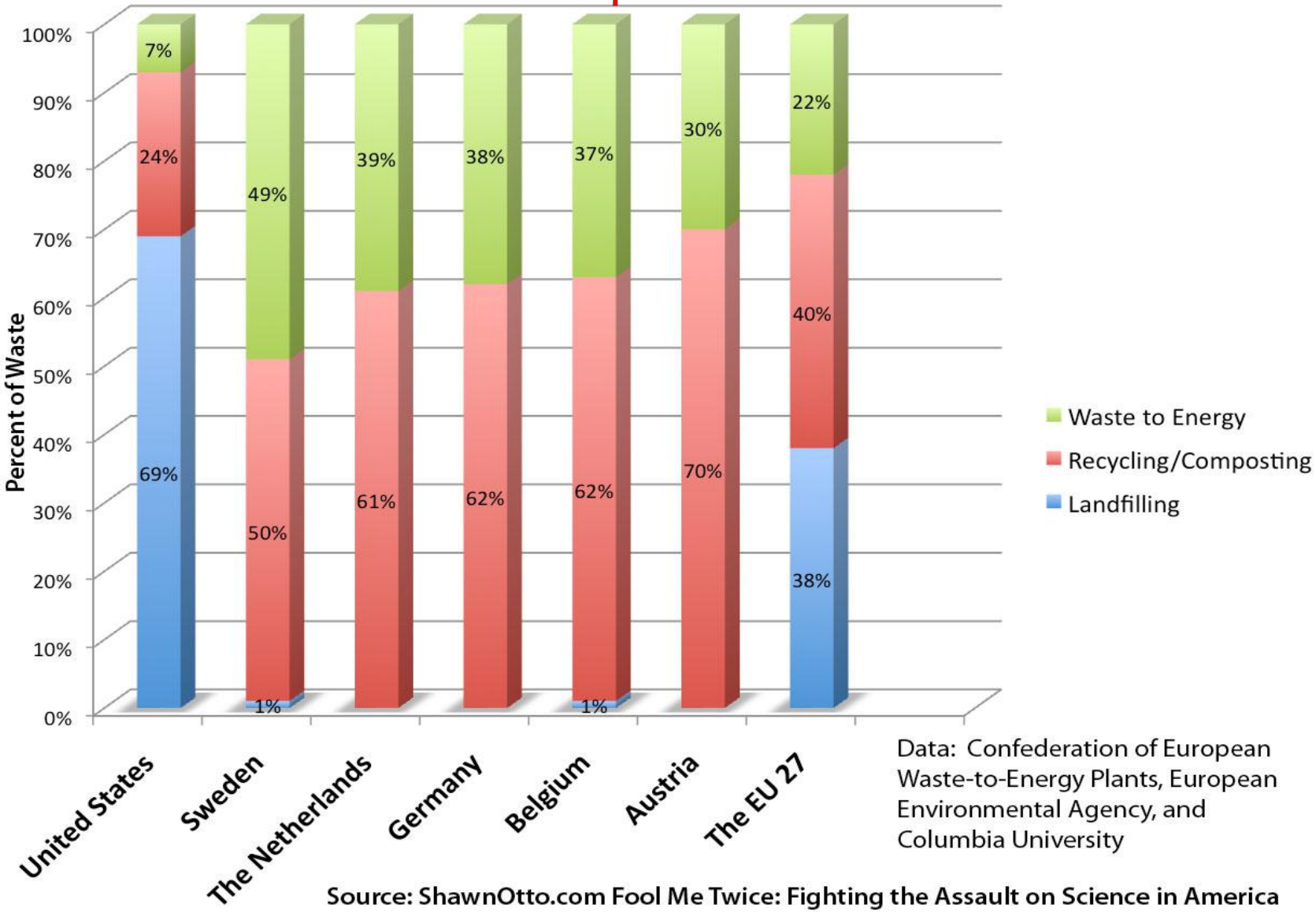
United States is Far Behind Europe on Recycling and Waste to Energy

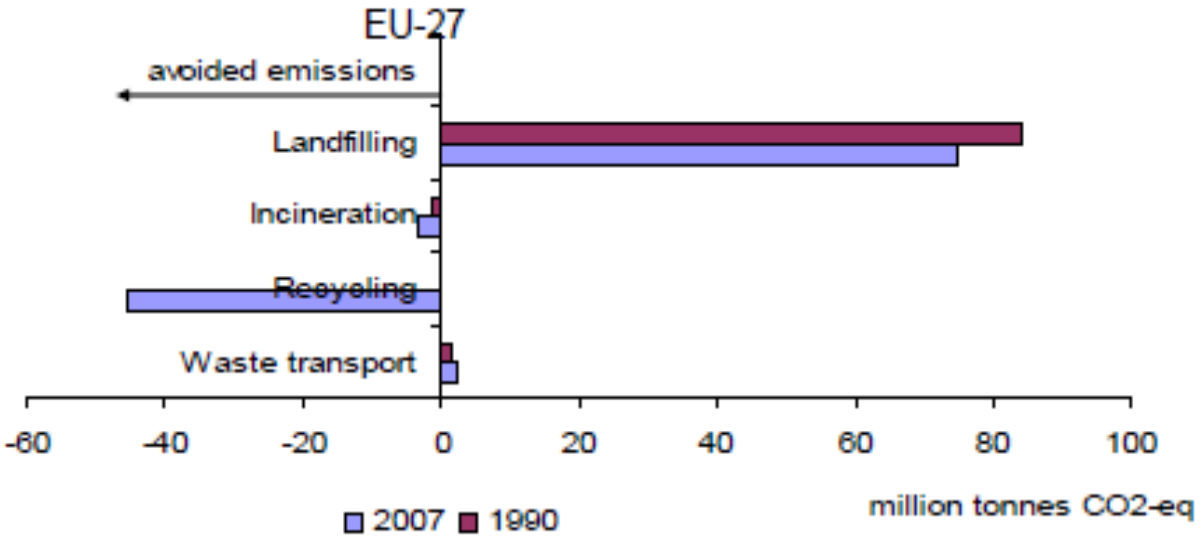
=> Far behind on environmental performance i.e. reductions in CO_2!!!



Data: Confederation of European Waste-to-Energy Plants, European Environmental Agency, and Columbia University

Source: ShawnOtto.com Fool Me Twice: Fighting the Assault on Science in America

CO2 emission reduction by better management of municipal solid waste



Source: EEA, upcoming *State and Outlook of the Environment Report 2010, draft version June 2010*

EUROPEAN COMMISSION

environment

Taking a closer look at German Waste Management Policies and what they accomplished:

(Germany was chosen as an example due to the countries firm environmental stand and industry unbiased & scientific approach that is exceptionally well documented)

19 years experience with “closed loops policies”

Important and decisive regulations in Germany

- Technical guidance for municipal solid waste 1991
- Packaging Regulation 1992
- 17. Regulation to the Clean Air Act for waste incineration plants 1992
- Law about „Kreislaufwirtschaft“ and Waste Management 1996
- Regulation on Biowaste 1998
- Regulation on Disposal of Waste 2001
- Waste Wood Regulation 2002, End-of-live-vehicle Regulation 2002 und others
- Law concerning the Management waste of electronic and electrical devices 2005

Landfill ban of untreated waste by technical guideline 1991

untreated waste

treated waste

landfill gas

Odour

leachate

landfill gas

odour

leachate

before

2005

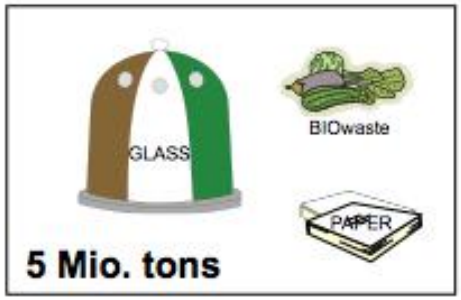
after

Increase of separate collection by Packaging Regulation 1992

1990

87 %

13 %

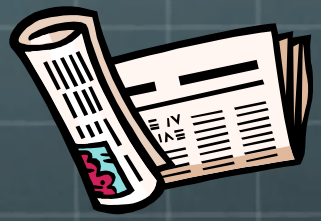


2004

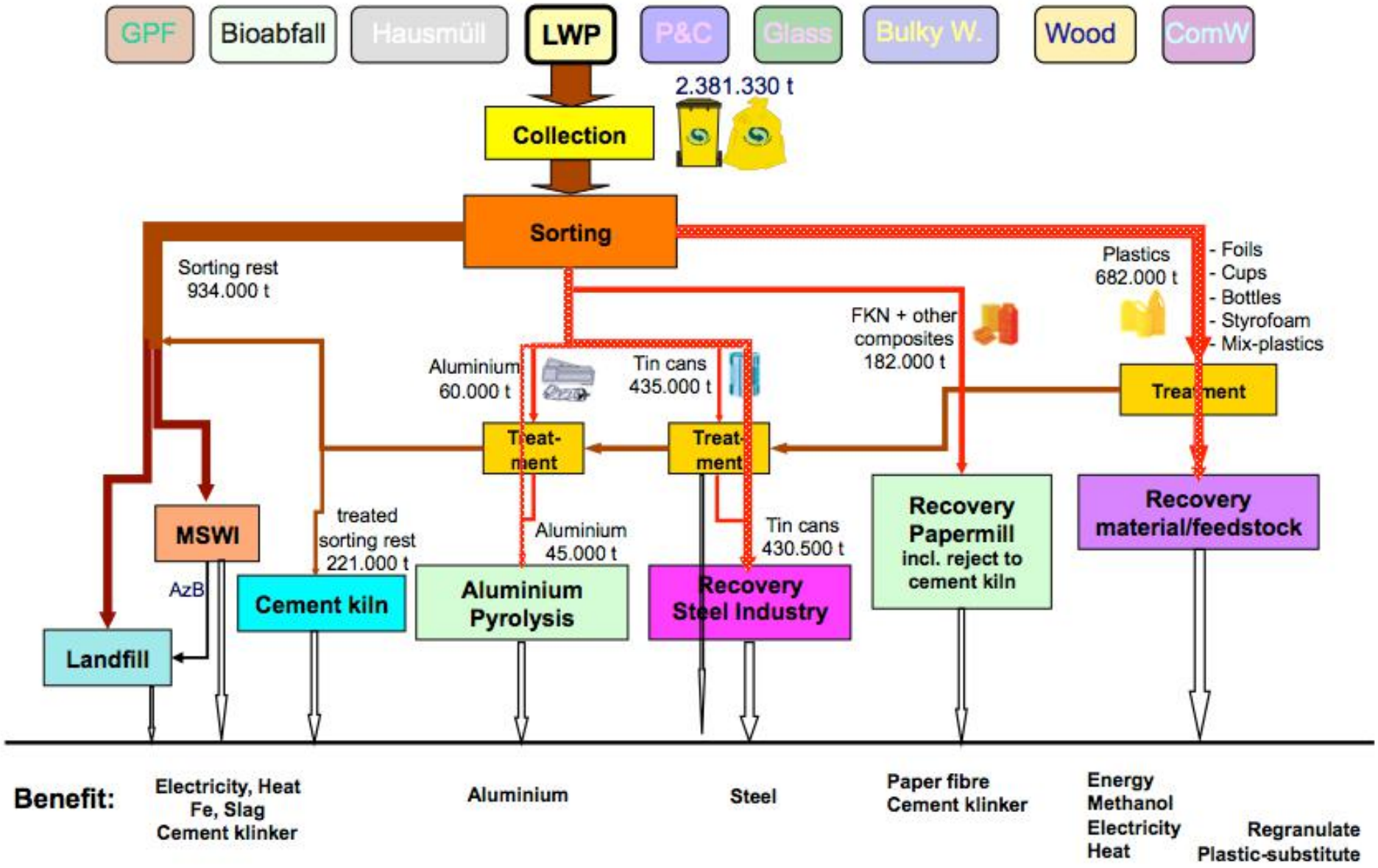
43 %

57 %

Separately collected valuable materials

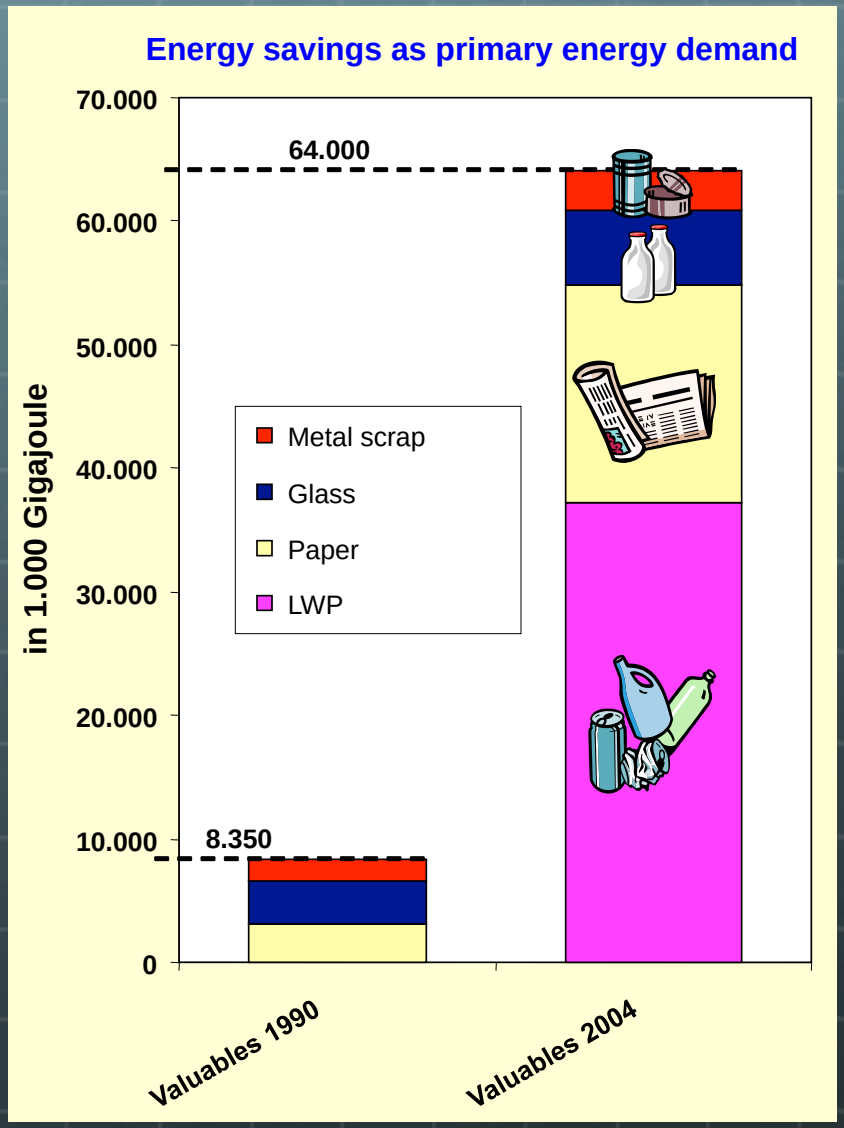
	1990		2004	
2 Mio. Tons		→		8 Mio. Tons
1,6 Mio. Tons		→		7,7 Mio. Tons
1,3 Mio. Tons		→		3,1 Mio. Tons
0 Tons		→		4,7 Mio. Tons

Complex material flows for recycling of light weight packaging



Energy savings through recycling and energy recovery

Recycling stands for the saving of energy between 1990 and 2004 equivalent to the annual energy demand of 450,000 people

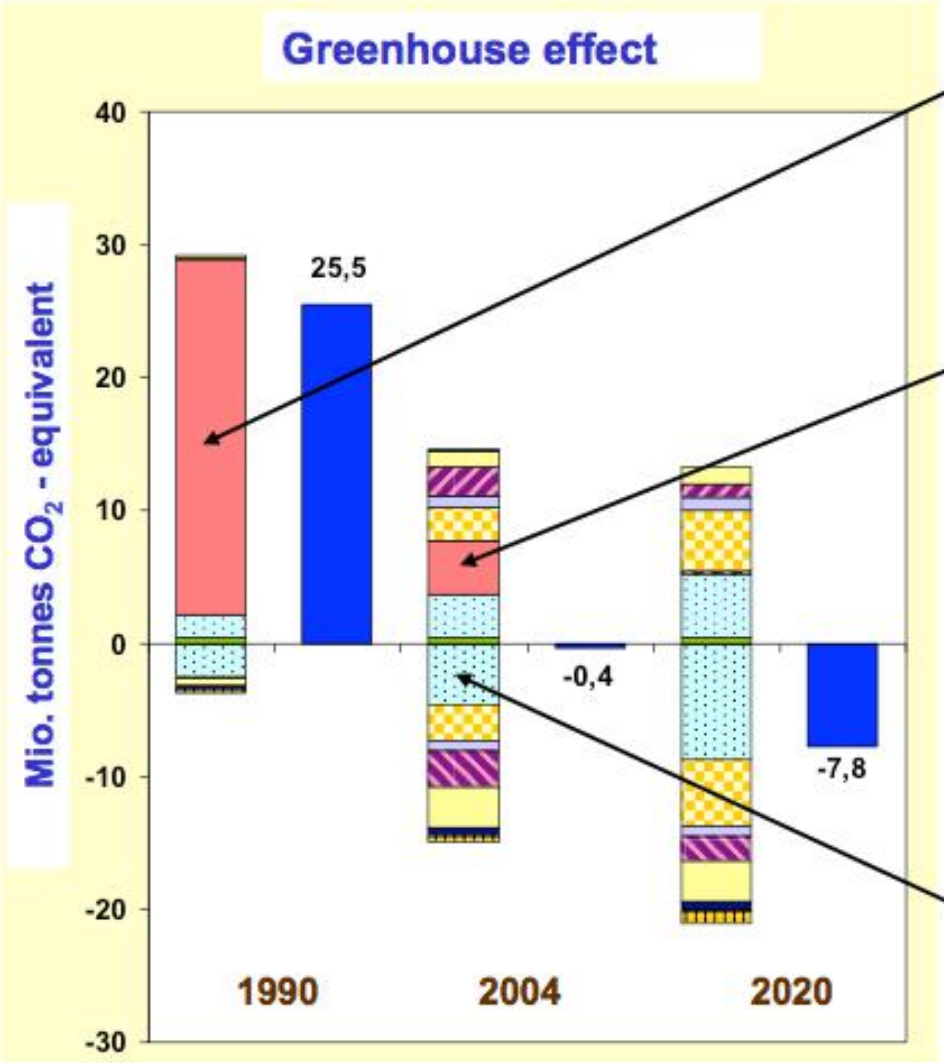


Ferrous metals
Glass

Paper and cardboard

Light weight packaging

Climate protection by integrated waste management



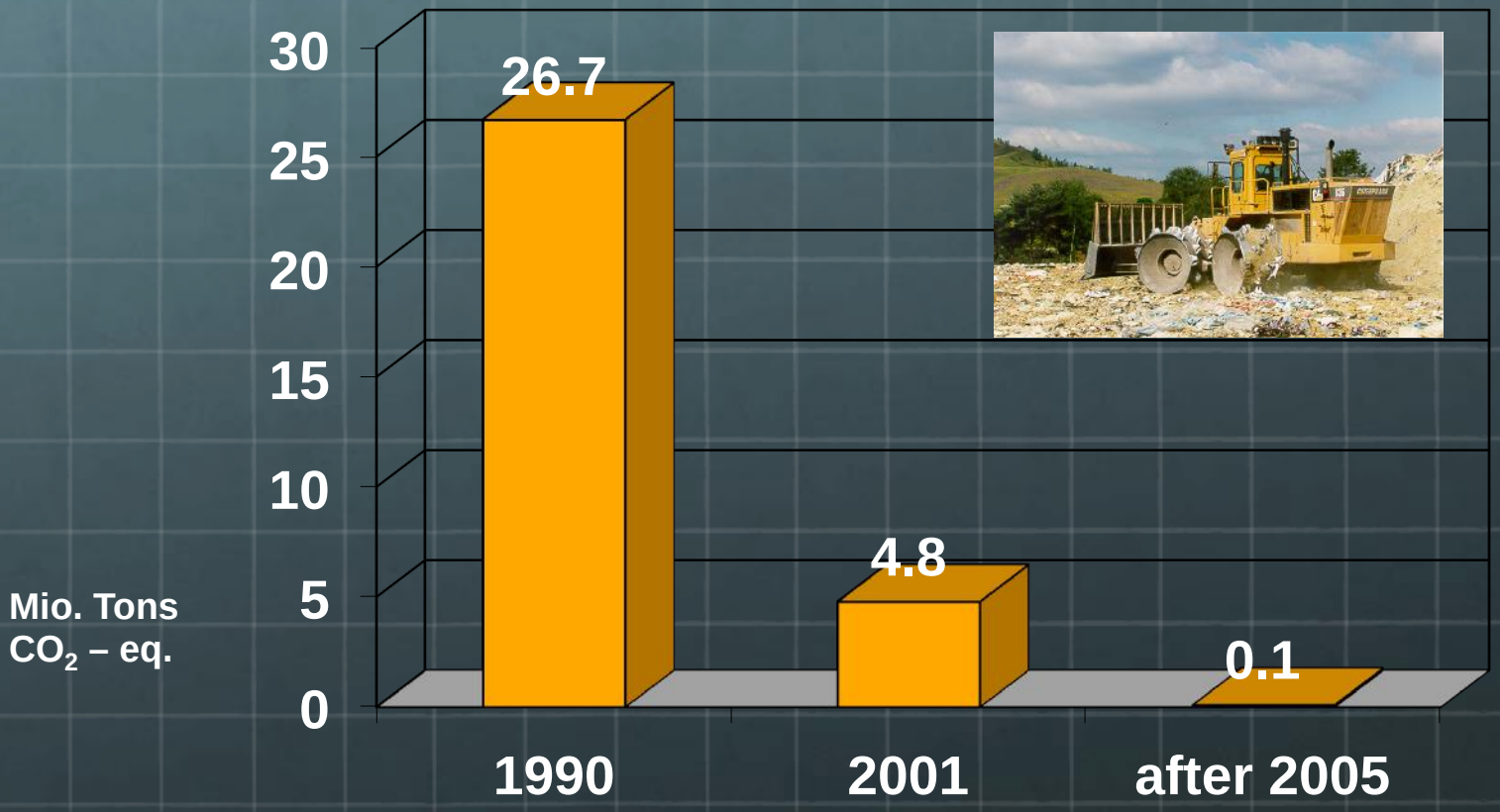
Impacts by methane 1990 dominated by landfill

Reduction of green house gas emissions 2004 mainly by diverting waste from landfill to recycling and incineration

Green house gas credits for incineration by substituting fossil fuels in energy generation

Climate change relevance of landfills

Reduction of GHG emission from landfills
calculated for waste in landfill which are disposed of in one specific year but integrated over the whole emission period



- Separate collection of recyclables is still a prerequisite for high recycling rates

- The landfill ban of untreated waste has caused the largest contribution of waste management to climate gas mitigation. On top of the ban the higher cost for disposal (pre-treatment and disposal) has supported the economics of recycling.

- The strict emission standards for waste incineration have contributed to an extraordinary reduction of environmental impacts through waste management. Note: It has to be ensured that co-incineration of waste in industrial furnaces does not undermine the achieved high standards.

The Problems with landfilling in the US:

- Landfilling is too cheap!
- Externalities such as lost resources and environmental impact are not included
  - Result: Alternatives to landfilling can not develop to offer viable solutions
  - Large amounts of recyclables are exported to countries like China -> According to Wall Street Journal and New York Times "Waste is the largest Export commodity of the US to China"
  - What happens once the 'recyclables' reach China is not clear! There is mounting evidence that a large percentage does not get recycled but is either burned or dumped.
  - That is not Recycling… and can and should not be counted… but it is… because it makes a fake system look good.

Political, Environmental & Economic Recognition

Since the mid 1980s, Germany has had a Political Party in the Bundestag representing the environment and social justice and they have come to the conclusion on the debate WTE vs Landfilling:

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Sustainable Waste Policy

Dr. Michael Weltzin
Scientific Assistant
in the Parliamentary
Group

Landfilling as a shift of problems

- **Landfill sites are black boxes, with unknown biological and chemical processes.**
- **They need intensive care for generations, leaching water has to be treated for years.**
- **Permanent danger of leaks and rents, with heavy consequences for groundwater and soil. Such problems are usually more or less not reparable.**
- **Methane emission from landfiling is responsible for a significant part of the global warming problem (up to 2.6 % in 1990 in Germany).**

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Future concept for 2020: zero waste

- **Greens are campaigning to end the disposal of waste from human settlements on landfill sites by 2020 completely. That means:**

1.) much more waste avoidance (e.g. by taxes on raw materials)

2.) more production of reusable and recyclable products (e.g. by producer responsibility, integrated product design, ...)

3.) automatically sorting of the residual waste

4.) recover all valuable substances

5.) residues that are left over should be used to generate energy

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Landfilling with Methane recovery

- **Methane capture /recovery is only a practical way of dealing with existing old landfills. Reasons:**
  - **Capture of methane only up to a maximum of 50% possible**
  - **ever lasting costs for landfill security**
  - **problem of leaches and danger of groundwater contamination is not solved**
  - **no sustainable solution black box**
  - **probably later need for remediation**

This technology is not for the future!

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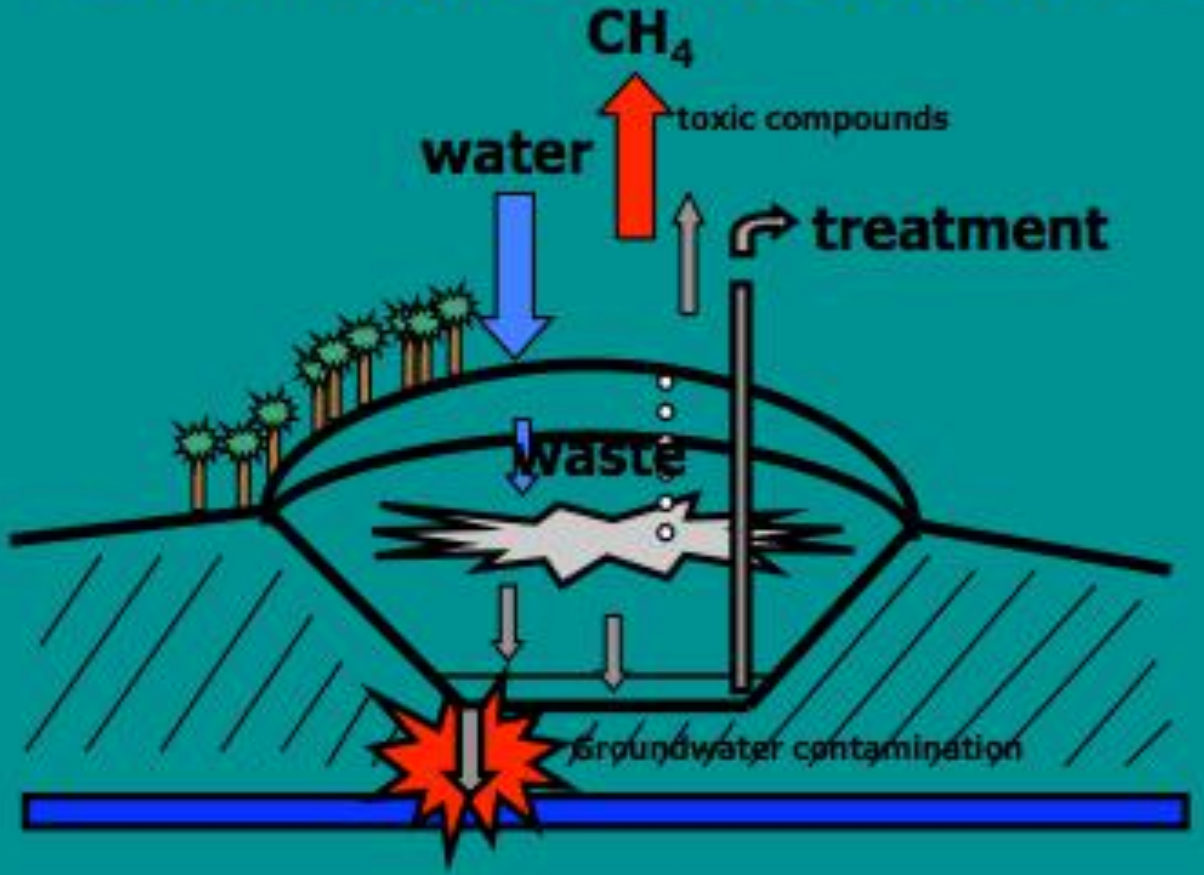

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"Landfill-methane" as a climate problem

- **Landfills are the single largest anthropogenic source of methane (US EPA)**
- **they account for 34% of all methane emissions in the U.S.**
- **Methane has a 23 times greater warming potential than CO2 (!)**
- **Methane accounts for 16% of global greenhouse gas emissions from human activities**
- **Landfills are a significant emitter of greenhouse gas emissions and a serious climate change problem (!)**

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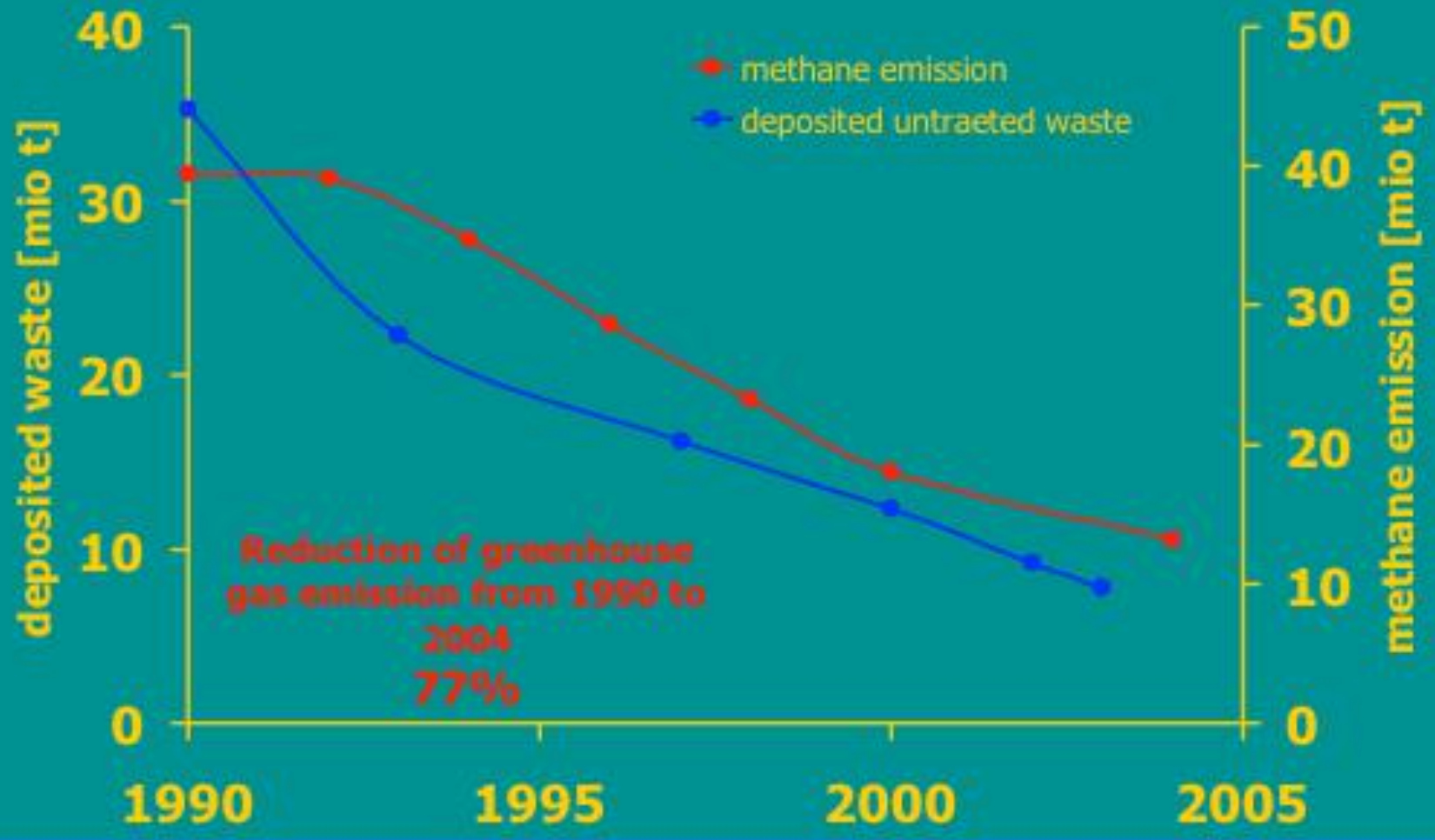
Benefit for the climate



Data from German Environmental Agency, Dessau 2006

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Summary

There are still challenges to meet!

A sustainable handling of waste is a central element of environmental and climate protection.

- **Closing the loop for raw materials and increasing of Recycling**
- **Ending of landfilling as soon as possible.**
- **Therefore using the best available and reliable technology.**

Quick Facts:

- King County, Washington, landfills more than 800,000 tons of waste (untreated) from approx. 2 million people.
- Germany (country of over 80 million people) landfills less than 200,000 tons (treated) -> less than ¼!

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Benefit for the economy and the environment

Waste treatment

- **is climate protection, in Germany 4.5 % reduction of greenhouse gas emissions since 1990,**
- **is active protection of groundwater and soil,**
- **is a job generator, in Germany 250.000 employees in waste economy in 2006,**
- **business with a turnover of 50 Bill. €uro a year in Germany,**
- **is a lead market for environmental technologies and technology transfer.**

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Lessons learned

- **Waste avoidance and recycling quotas are not the solution, they are just a part of it,**
- **Recycling has limits, e.g. plastics!**
- **Even recycling products become waste after use,**
- **Using best available technology for the incineration of residual waste means less impact to environment and to climate than landfilling.**
  - *although many members of the green party started their "career" in action groups against incineration plants, incineration with low emission levels, energy and material recovery is accepted today.*

Statement sent to King County (Washington State) Councilmember 2007 to answer inquiry why Germany moved away from landfilling:

Position of Alliance 90/The Greens belonging to disposal of waste

Dear Ms. Lambert,

Thank you for your request and your interest in our position belonging to the disposal of waste in landfill sites. As parliamentary group of Alliance90/The Greens in the German Bundestag our policy is evidently focussed on sustainability. And due to the disposal of waste in landfill sites we have an absolute clear position:

Disposing of waste in landfills is not a solution. It is the most unsustainable way of waste treatment and it is also not the cheapest way to get rid of waste. Landfill site deposition is just shifting problems and costs to next generations. Landfill sites are more or less black boxes with unpredictable processes and a burden for the future. Keywords are greenhouse gases, many other toxic emissions, danger of leaks, heavy metals etc… Therefore the minimum requirement is to treat waste before disposing of it. This is not only an effective protection of groundwater and soil, it is last but not least also an inexpensive reduction of greenhouse gas emissions e.g. methane. And of course: Treatment of waste before disposition is much cheaper than a remediation of a contaminated landfill site.

Therefore in Germany and Europe a lot of efforts are made to decrease the amount of waste being disposed in landfill sites. We from Alliance 90/The Greens are going even further. We want to close the loop for raw materials. Therefore we are campaigning to end the disposal of waste from human settlements on landfill sites until 2020 completely. This ambitious target presupposes the complete sorting and recovery of waste. This 2020 target is not an utopian goal, it is a realistic objective:

- waste can already be sorted fully automatically and the valuable substances can almost completely be recovered
- Sorting residues that are left over can be used to generate energy in waste incineration plants operated by very high standards. The different by-products of waste incineration can also be reused (for example the waste incineration facility in Hamburg at Rugenberger Damm)

For us it is not comprehensible, that waste disposal in landfill sites should bring a reduction of greenhouse gas emissions by low costs. It is the opposite of the wide accepted knowledge in Europe and Germany, that recovery and treatment are essential elements of a sustainable waste and environmental policy.

Best regards

Alliance90/The Greens

cc: Philipp Schmidt-Pathmann, WRSI

Disposing of waste in landfills is not a solution. It is the most unsustainable way of waste treatment and it is also not the cheapest way to get rid of waste. Landfill site deposition is just shifting problems and costs to next generations. Landfill sites are more or less black boxes with unpredictable processes and a burden for the future. Keywords are greenhouse gases, many other toxic emissions, danger of leaks, heavy metals etc... Therefore the minimum requirement is to treat waste before disposing of it. This is not only an effective protection of groundwater and soil, it is last but not least also an inexpensive reduction of greenhouse gas emissions e.g. methane. And of course: Treatment of waste before disposition is much cheaper than a remediation of a contaminated landfill site.

Comparing (Summer 2016) two fundamentally different systems: One depening on landfilling (USA) and another (Germany), which chose to move away from landfilling and implement a system focused on alternatives to landfilling:

Price comparison: USA and Germany

	Germany	USA Ex: King County
Inhabitants	~80 Mio.	~320 Mio.
Landfilling	~1%	>60%
Recycling	~68%	~33%
Energy from Waste	~30%	~7%
Disposal costs to consumer	~294 USD/ year	~300 USD/ Year

1990

GERMANY

- 70% landfilled
- 15% recycled
- 15% Waste-to-Energy

US

- 70% landfilled
- 15% recycled
- 15% Waste-to-Energy

2015

GERMANY

- Less than 1% landfilled
- >67% recycled & composted
- 32 % Waste-to-Energy

USA

- > 62 landfilled
- < 30% recycled
- < 7% Waste-to-Energy

What is the Problem?

- The U.S. still landfills well over half of our MSW which:
  - decomposes in increasingly large centralized units, producing methane emissions and leachates that can pollute ground and surface waters
  - requires long haul transport by train/truck, using significant amounts of energy
  - wastes a significant amount of potential energy
  - LOCKS THE U.S. INTO AN UNSUSTAINABLE MATERIALS MANAGEMENT CYCLE
  - Fails to realize green job growth potential through higher management options
  - Why do we do it? Because it is cheap and we have a lot of land

Mitigation of Climate Change

- WTE is base-load generation, available 24/7 and unaffected by days that are cloudy or calm
- WTE is also a prime example of "distributed generation" that serves nearby load without the need for new long-distance transmission lines
- EPA's hierarchy for "integrated waste management" recommends waste combustion with energy recovery over landfilling (as does the European Union)

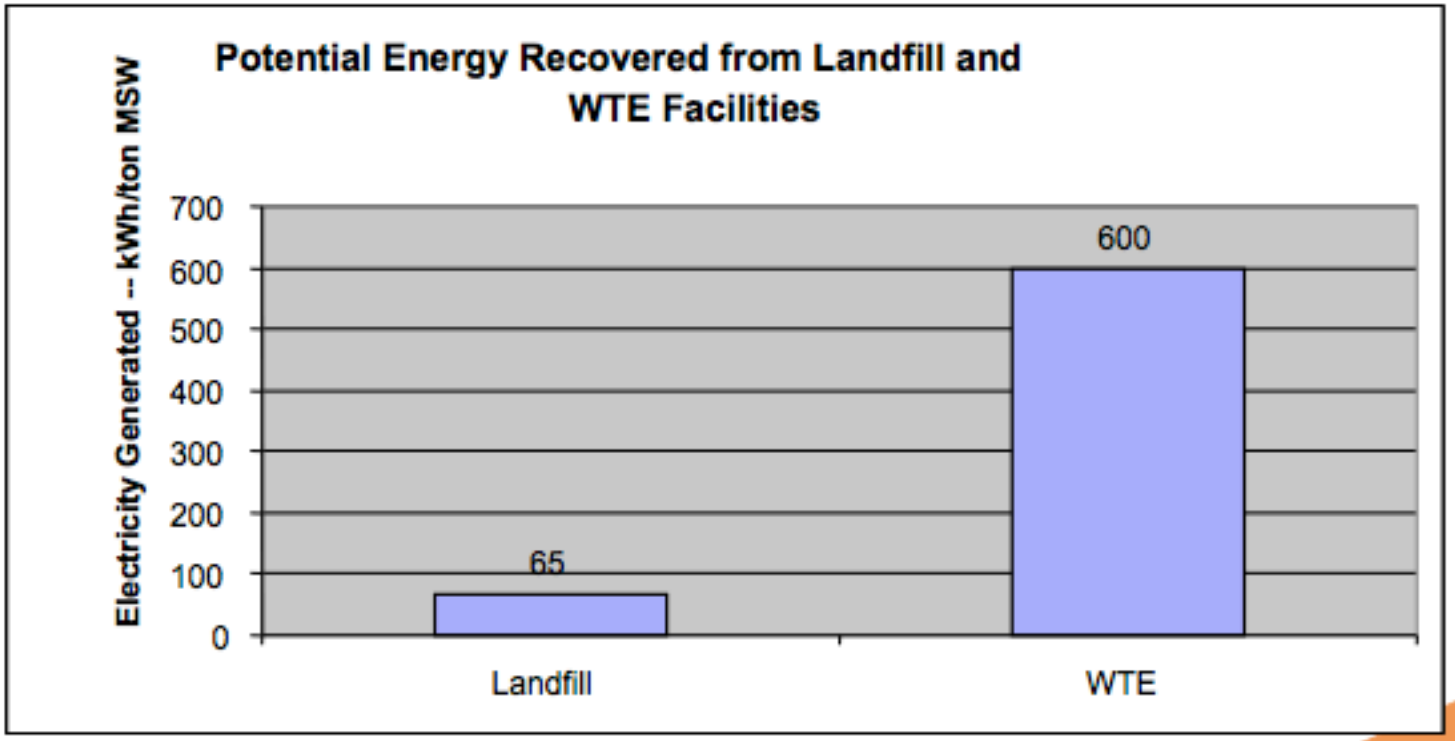
Mitigation of Climate Change

- WTE's role in reducing GHG emissions is widely recognized
- Using life-cycle analysis, USEPA's solid waste management planning methodology addresses the 3 ways in which WTE reduces GHG emissions:
  - Generating electricity and/or steam without having to use fossil fuels
  - Avoiding the potential methane emissions that would result if the same waste was landfilled, and
  - Recovering ferrous and nonferrous metals, which avoids the additional energy consumption that would be required to produce the same metals from virgin ores

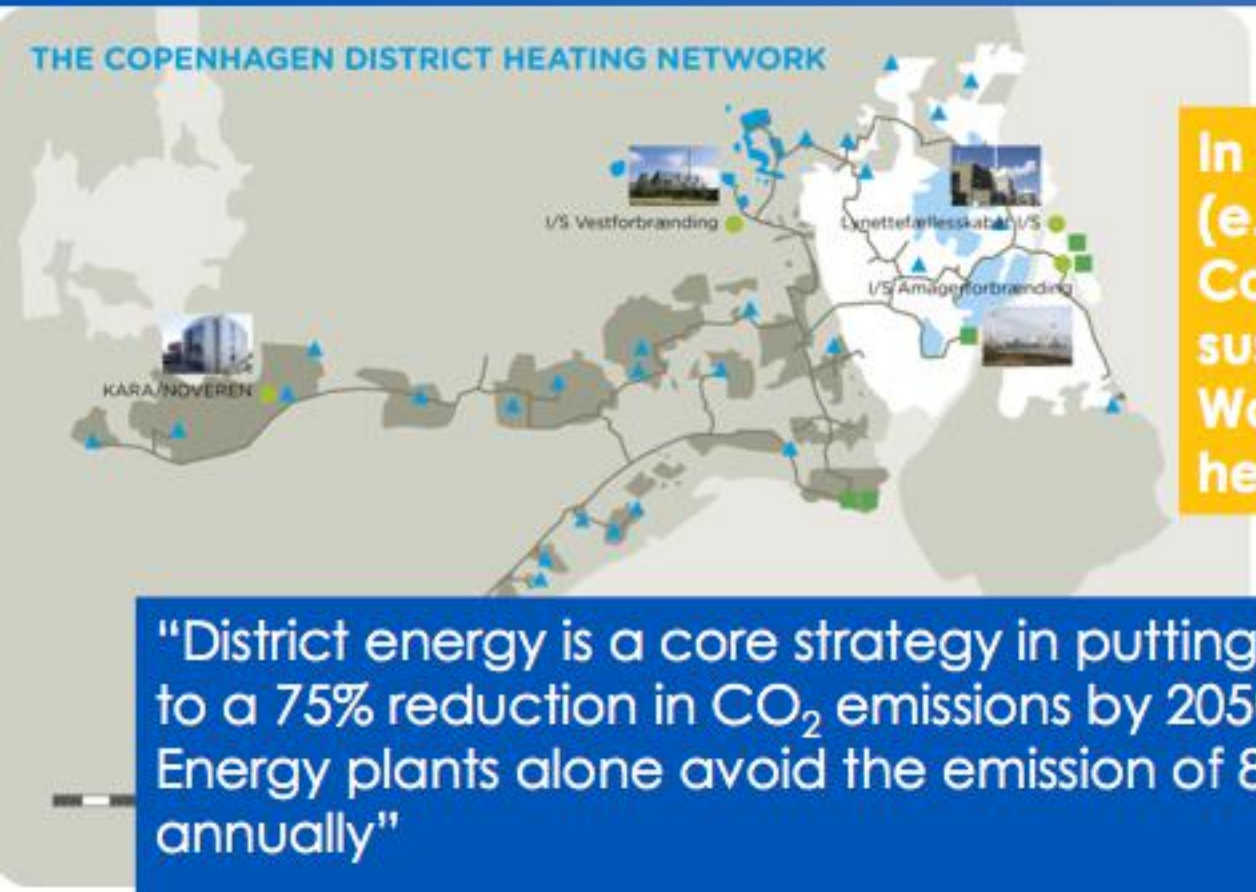
Mitigation of Climate Change

- EPA analysis also shows that WTE yields the best results (compared to landfills) in terms of maximum energy recovery and lowest GHG and criteria pollutant emissions
- One ton of CO2e (carbon dioxide and equivalent emissions) is widely recognized as being avoided for every ton of MSW that is processed at a WTE rather than landfilled (comparison based on a modern landfill with methane recovery and reuse)
- The Intergovernmental Panel on Climate Change emphasizes WTE's dual benefits of (i) offsetting fossil fuel combustion and (ii) avoided landfill methane emissions

- WTE's efficiency and reliability are clear as well:
  - WTE recovers approximately 600 kWh of electricity per ton of waste, i.e., approximately 10 times the electric energy recoverable from a ton of landfilled waste



Warmth from Waste
WtE for smart cities



In some European cities (e.g. Paris, Brescia, Copenhagen, Malmö) sustainable Energy from Waste covers > 50% of heat demand.

"District energy is a core strategy in putting **Paris** on the pathway to a 75% reduction in CO_2 emissions by 2050; the city's Waste-to-Energy plants alone avoid the emission of 800,000 tons of CO_2 annually"

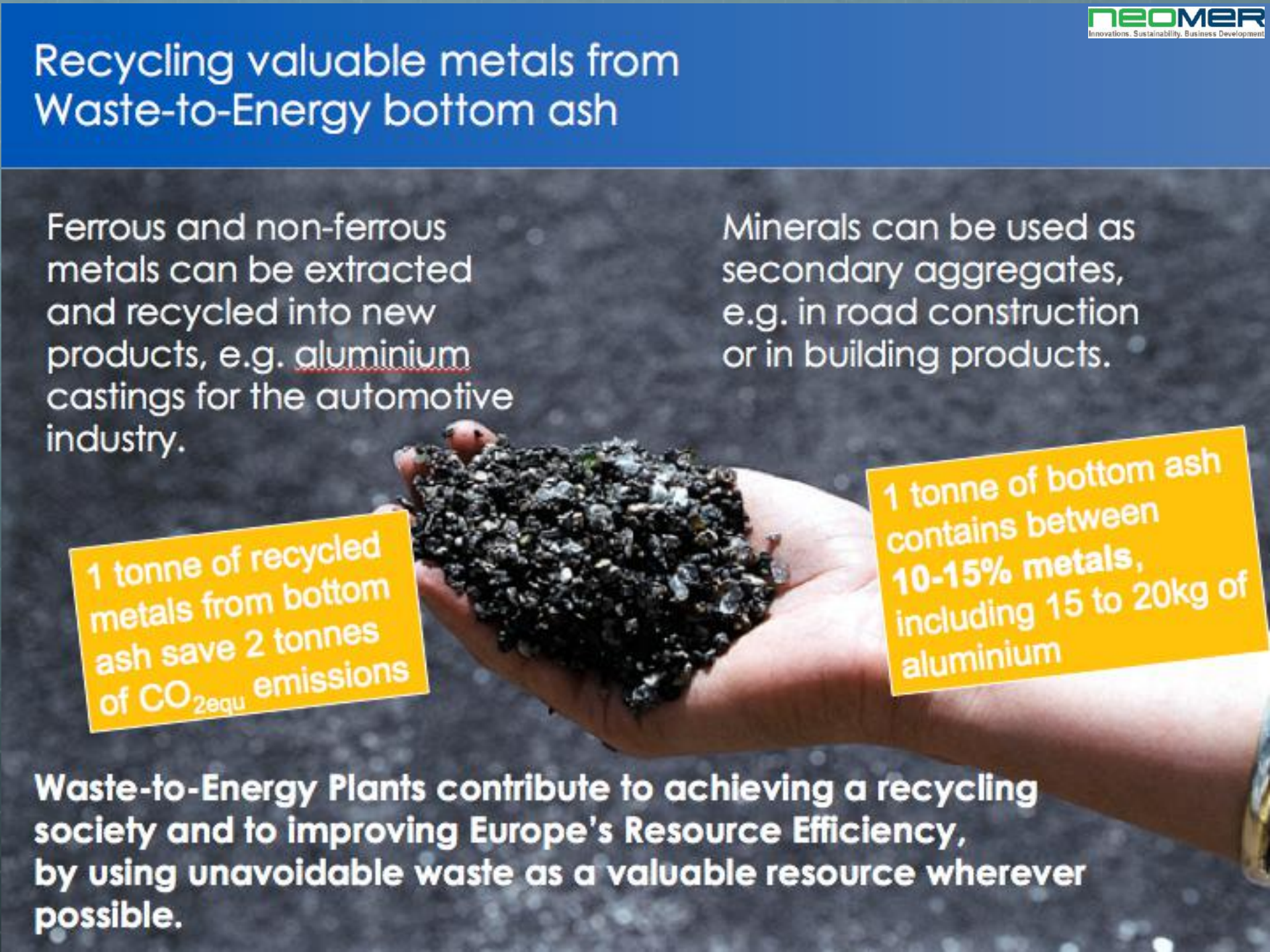
"In **Copenhagen**, recycling waste heat results in 655,000 tons of CO_2 emissions reductions and displaces 1.4 million barrels of oil annually."

Source: District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable, UNEP 2015

Recycling valuable metals from Waste-to-Energy bottom ash

Ferrous and non-ferrous metals can be extracted and recycled into new products, e.g. aluminium castings for the automotive industry.

Minerals can be used as secondary aggregates, e.g. in road construction or in building products.



1 tonne of recycled metals from bottom ash save 2 tonnes of CO_{2equ} emissions

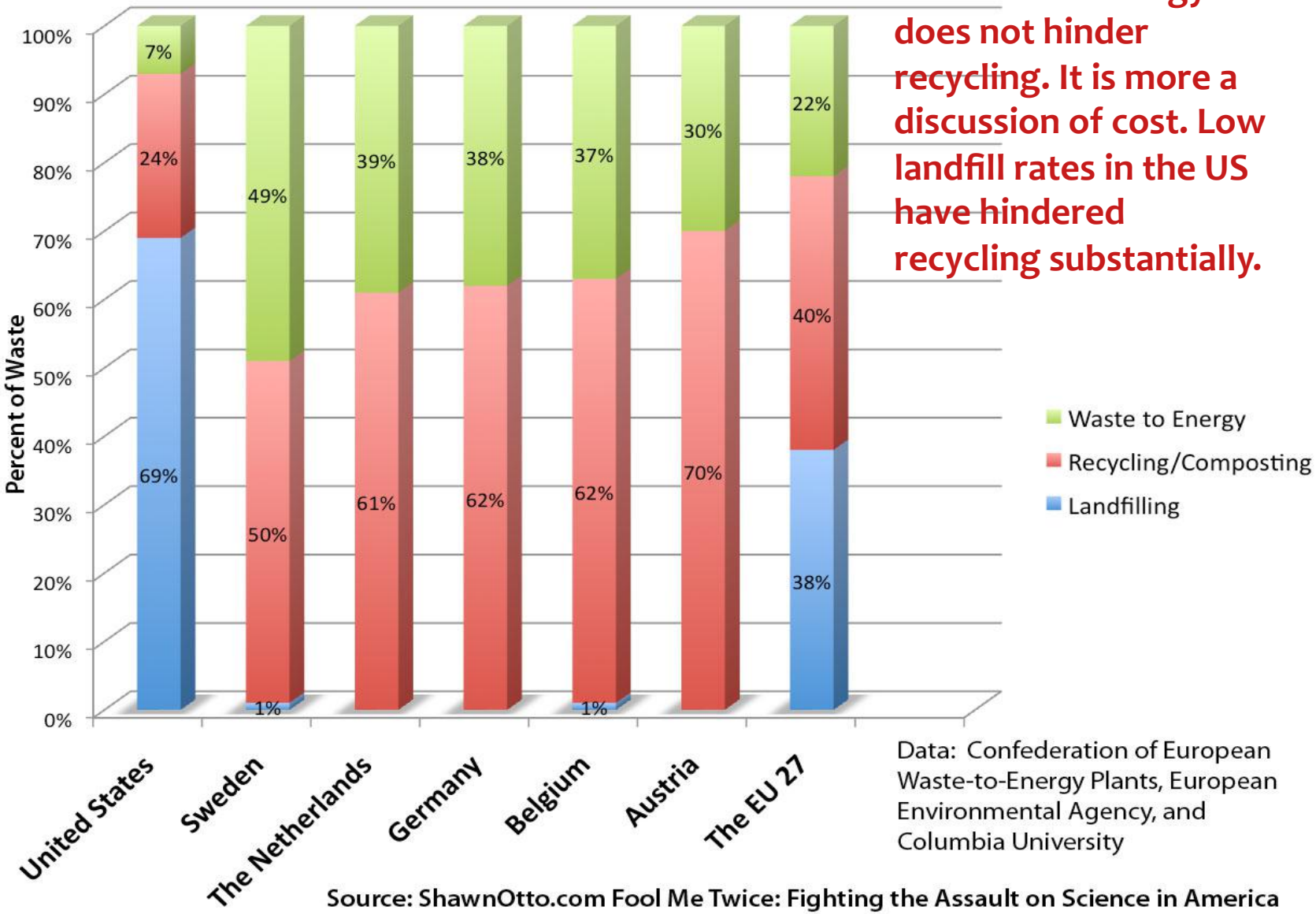
1 tonne of bottom ash contains between **10-15% metals**, including 15 to 20kg of aluminium

Waste-to-Energy Plants contribute to achieving a recycling society and to improving Europe's Resource Efficiency, by using unavoidable waste as a valuable resource wherever possible.

What about the myth that Waste to Energy prohibits/lessens/bypass recycling:

United States is Far Behind Europe on Recycling and Waste to Energy

=> Waste to Energy does not hinder recycling. It is more a discussion of cost. Low landfill rates in the US have hindered recycling substantially.



Data: Confederation of European Waste-to-Energy Plants, European Environmental Agency, and Columbia University

Source: ShawnOtto.com Fool Me Twice: Fighting the Assault on Science in America

US Perspective: More about Recycling and WTE

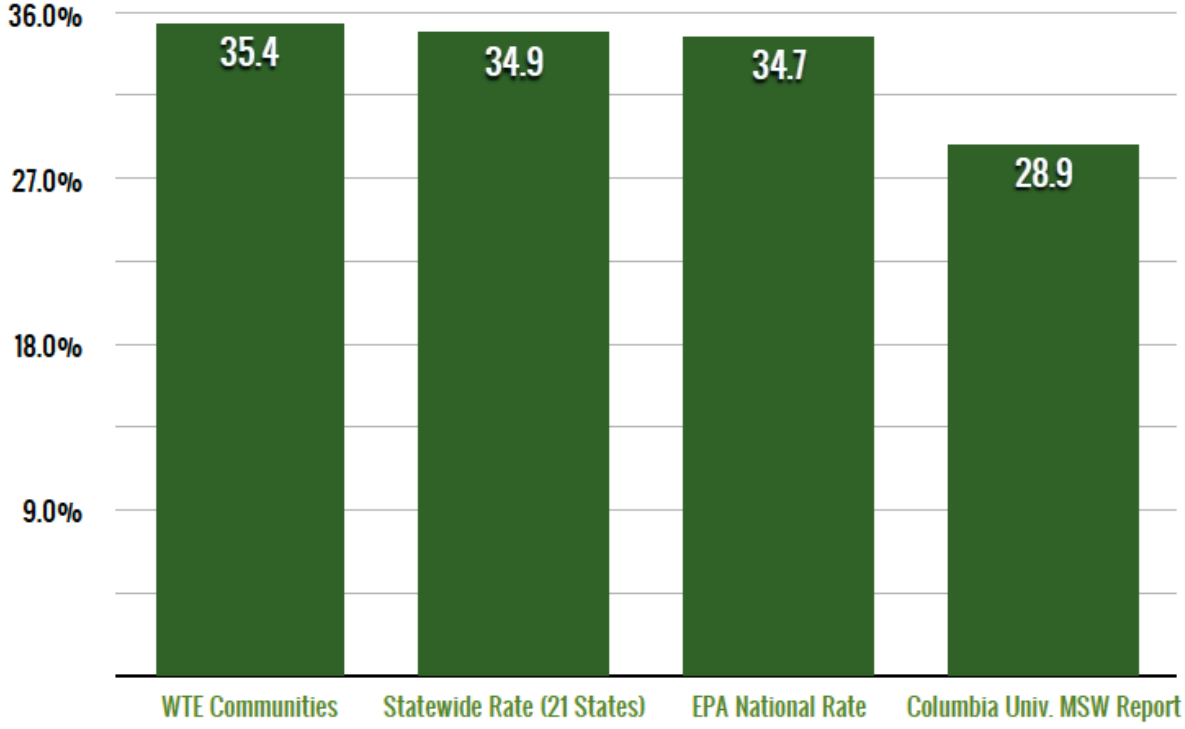
2014 UPDATE

A Compatibility Study: Recycling and Waste-to-Energy Work in Concert

EILEEN BRETTLER BERENYI, Ph.D

Governmental Advisory Associates, Inc.
599 Riverside Avenue, Suite 1
Westport, CT 06880

FIGURE 2: BENCHMARK COMPARISONS



CONCLUSION

As shown by the data, waste-to-energy does not have an adverse impact on recycling rates. The most influential factors that affect these rates appear to be state policies and the proactive stance of a municipality. Communities using waste-to-energy have recycling rates that are slightly above the national average and above the aggregate recycling rate of the states in which they operate. Therefore, it can be concluded that recycling and waste-to-energy are compatible waste management strategies. They form part of a successful, integrated waste management approach in many communities across the United States.

Another Side by Side:

	WTE	Landfilling	Composting
Regulations - current North America	**One of the most regulated overall**	**Very limited – Slow process (Lobby efforts)**	**Very limited – Slow process (green perception)**
Cost	**Can not compete with current low priced landfilling rates**	**Artificial low cost**	**Can not compete with current low priced landfilling rates**
Going in versus Coming out	Measurable to <1ng; High Energy & Material recovery; 100% landfill diversion possible RR (Resource Recovery); Works more efficient with Composting; Compliments Recycling	CH_4 recovery <50%; High risk of leaks up and down; 2000+ toxic chemicals in air; Dioxins are found in ground water; Some energy recovery possible	$NO_{2:}$ 298 times CO_2; CH_4: >25 times CO_2; water, air (smell), noise; Proper housing needed (not yet required); Complements WTE;

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IPCC (International Panel on Climate Change) weighs in:

Updating ARP4 to ARP5 numbers

Submitted by the Local Government Collation for Renewable Energy to US EPA

Docket ID No. EPA-HQ-OAR-2014-0451

- Currently, the US EPA uses the ARP4 (Fourth Annual Assessment Report) of the International Panel on Climate Change (IPCC), the leading international body for the assessment of climate change. The ARP4 from 2007 uses the Global Warming Potential (GWP) of Methane of 25 times that of carbon dioxide.
- The latest Assessment by IPPC regarding GWP, ARP5 was finalized in 2014 and has not been considered in current EPA calculations despite EPA stating that AR5 GWPs "are the most up-to-date and accurate available".
- Under ARP5 the GWP of methane on a 100 year scale is 34 times that of CO_2 and 86 times on a 20 year scale. IPCC advises that lifetime methane recovery efficiencies of methane from landfills may be as low as 20%.
- Currently, under ARP4, EPA states that WTE reduces the amount of CO_2 per ton of waste landfilled + landfill gas recovery by 1 ton of CO_2.
- Under ARP5 this amount would increase for a 20 year period to over 3, possibly as much as 4 tons of avoided CO_2 per ton of waste going to WTE instead of being landfilled.

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Landfilling of waste needs to be assigned to the past!

Designing for the Future

- At Neomer we develop sustainable business practices for our clients
- We innovate without having to ‘re-invent the wheel’
- We identify common denominators to solve ecologic-economic equations
- We inspire, guide and assist companies and municipalities to implement solutions with the future in mind
- We are teaming up with leading companies offering proven know how and experience

Thank You for Your Attention

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