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THE ROLE OF ENERGY RECOVERY IN SUSTAINABLE WASTE MANAGEMENT

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EARTH ENGINEERING CENTER

Earth Engineering Center of Columbia University:

- WTERT Waste-to-Energy Research & Technology Council

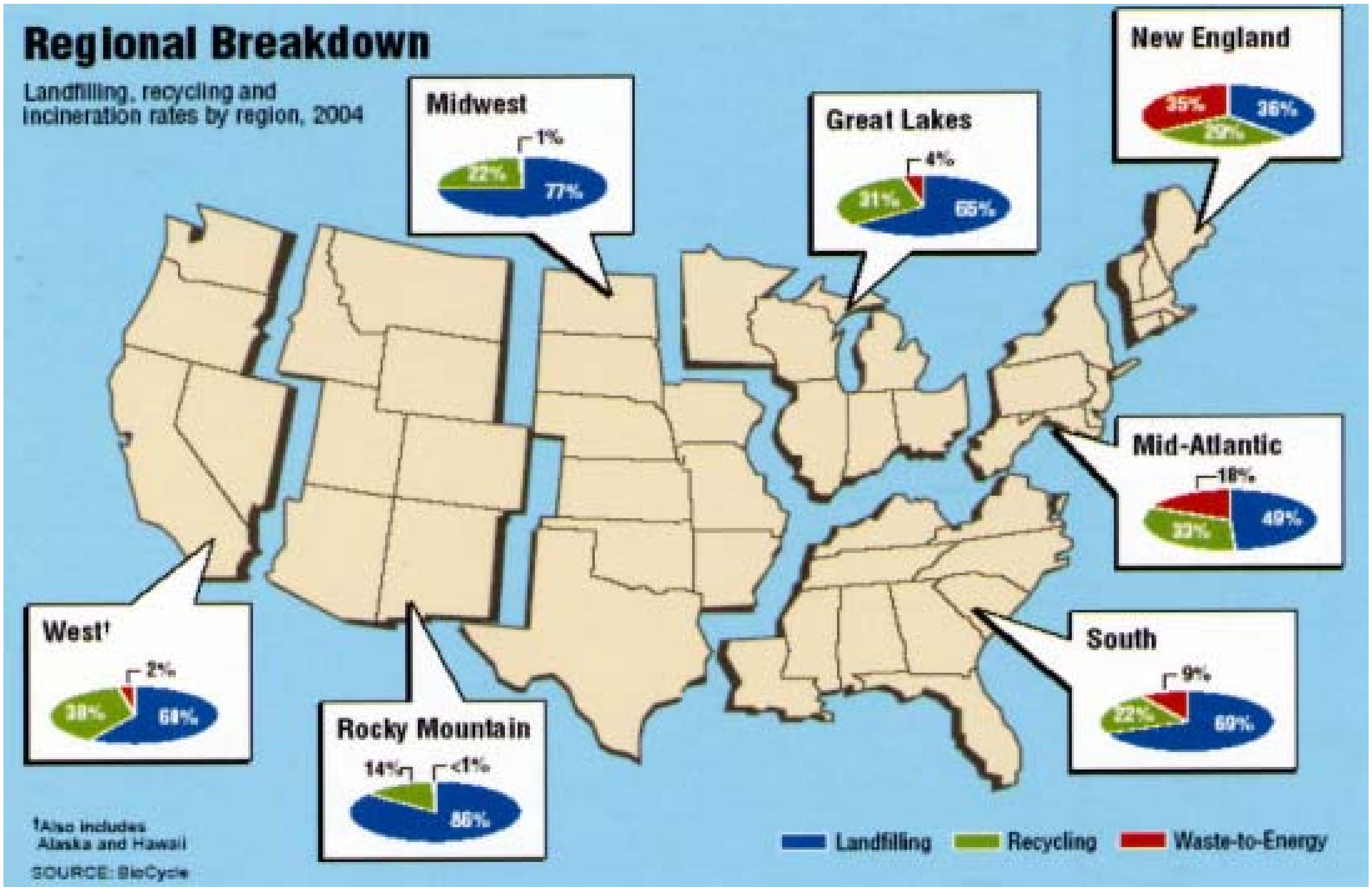
Sister organizations:

- **WtERT-Germany (www.wtert.eu)**
- **WTERT-China (www.wtert.cn)**
- **WTERT-Canada (CEFWC, www.wtert.ca)**
- **WTERT-Greece (SYNERGIA, www.wtert.gr**

- SUR Council for Sustainable Use of Resources

SUR is a university-industry consortium concerned with reducing the "carbon footprint" of all means of waste management and resource conservation.

The Earth Engineering Center conducts a bi-annual survey of waste generation and disposition in the U.S. U.S. EPA uses the results for estimating climate change (GHG) impacts



Summary of presentation

- Sustainable Development and Waste Management
- The Hierarchy of Waste Management
- Recycling of materials and composting: What is possible?
- The carbon chemistry of “post-recycling” wastes
- Recovery of energy: Waste to Energy (WTE)
- Global use of Landfilling (LF) and WTE
- WTE as a renewable and local energy source
- Environmental and economic impacts of WTE vs LF
- Regulations and policies for enabling WTE
- WTE and the host communities
- Grate combustion and novel WTE technologies

Sustainable Development <u>and</u> Waste Management

U.N. Definition of sustainability:

Meeting the needs of the present generation…..

…without affecting the ability of future generations to meet their needs

How far ahead: Is 100 years too long for a nation?
100 years for Australia: 1,500,000,000 tons of municipal solid wastes (MSW) – More than the global MSW in 2008.

The carbon chemistry of municipal sold wastes (MSW)

MSW contains about 30% carbon. Two thirds of this carbon is biogenic and one third is fossil-based. The average composition of combustible materials in MSW (i.e., excluding water, metals, and glass) can be expressed by the formula:

$C_6H_{10}O_4$ (there are ten such organic compounds!)

How this compound reacts in WTE furnaces:

$$C_6H_{10}O_4 + 6.5O_2 = 6CO_2 + 5H_2O$$

+ 23 MJ/kg

How the organic fraction of MSW reacts in landfills:

$$C_6H_{10}O_4 + 1.5H_2O = 3.25CH_4 + 2.75CO_2$$

+very small amount of heat

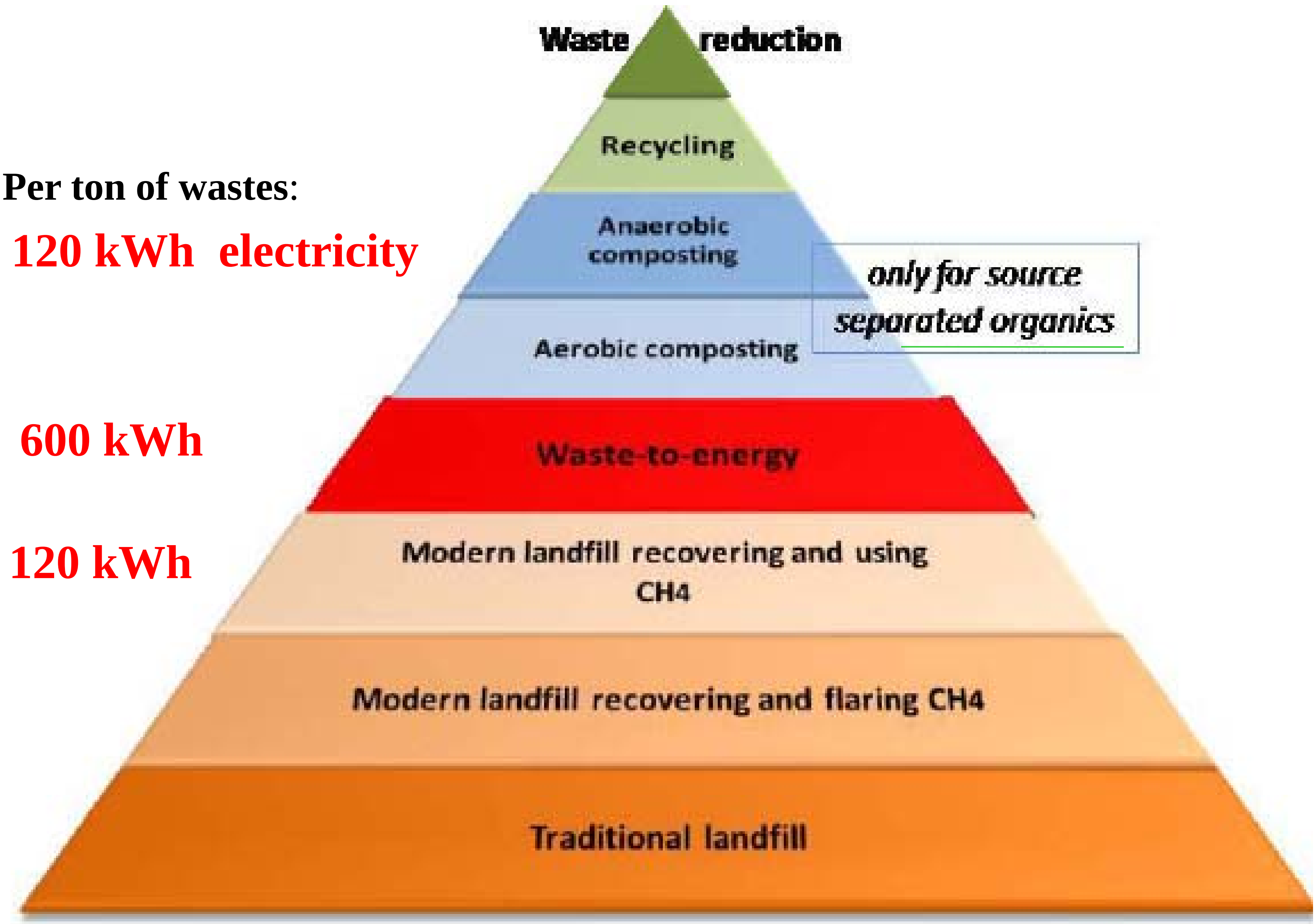
The Hierarchy of Waste Management (EEC)

Per ton of wastes:

+ 120 kWh electricity

+ 600 kWh

+ 120 kWh



Recycling of materials and composting: What is possible?

- Communities who can provide collection of source-separated <u>recyclables</u> (metals, clean paper fiber, green wastes).

- Citizens who are willing to spend some effort in separating recyclables at the source.

- Markets that can use the recyclable materials at a profit to the recyclers (e.g. metal smelters; secondary paper mills).

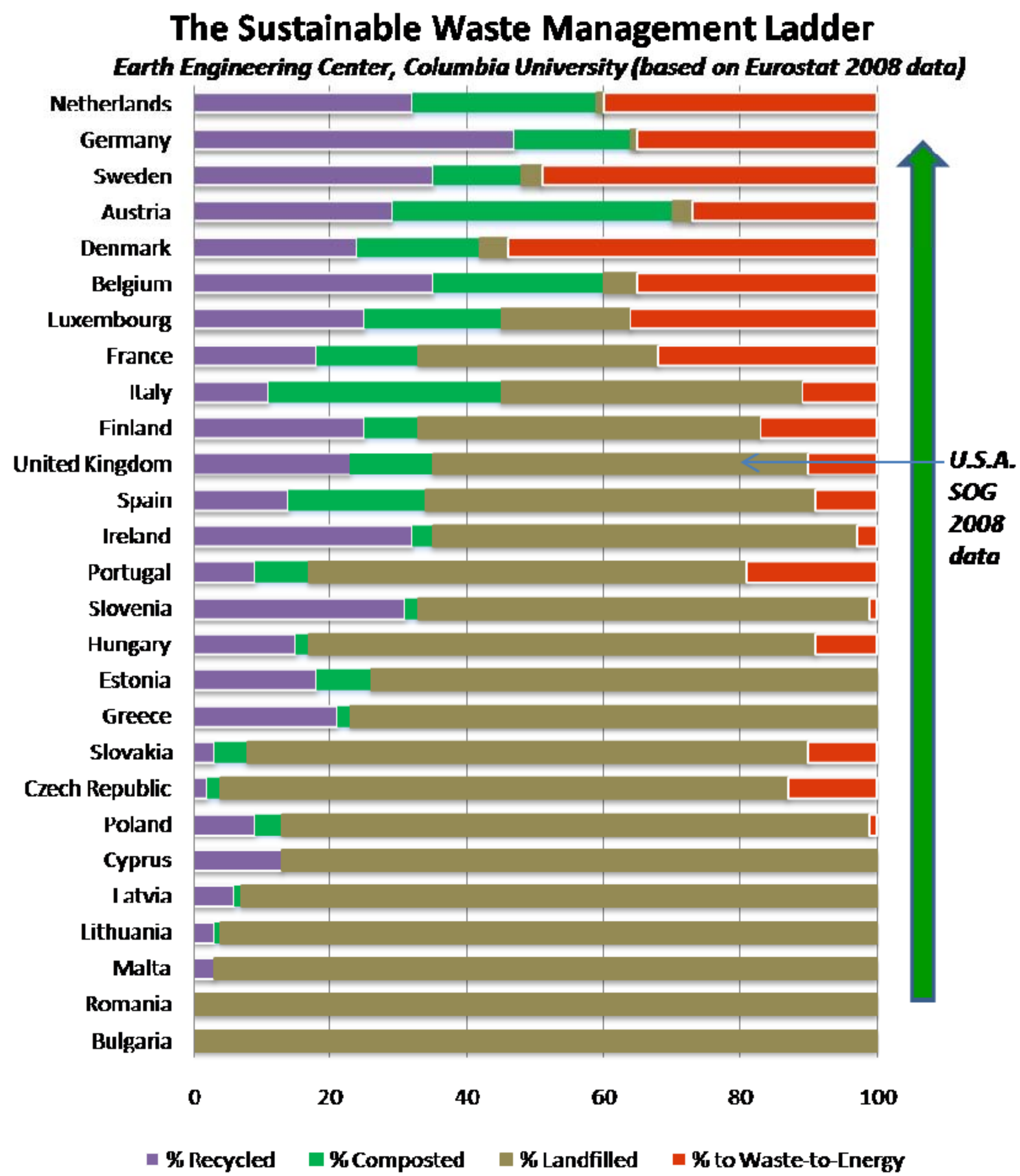
All three have their practical limits (e.g., only 10% of U.S. plastic wastes are recycled). Government edicts that a community must recycle X% of their solid wastes may end up in questionable statistics and waste of money and energy

Sustainable Waste Management: The global experience

- There are only two alternatives to manage post-recycling MSW: a) by landfilling, or b) by comnbustion with energy and metals recovery: Waste-to-Energy (WTE; also called energy from waste or EfW).

- All countries that use WTE also have strong recycling efforts.

Recycling/composting and Waste to Energy are complementary



Estimated global disposition of post-recycling MSW

- **Combustion with energy recovery: 190 mill. tons**
- **Landfilled, partial methane recovery: 200 mill. tons**
- **Landfilled without methane recovery: >800 mill. tons**

The global landfilling picture

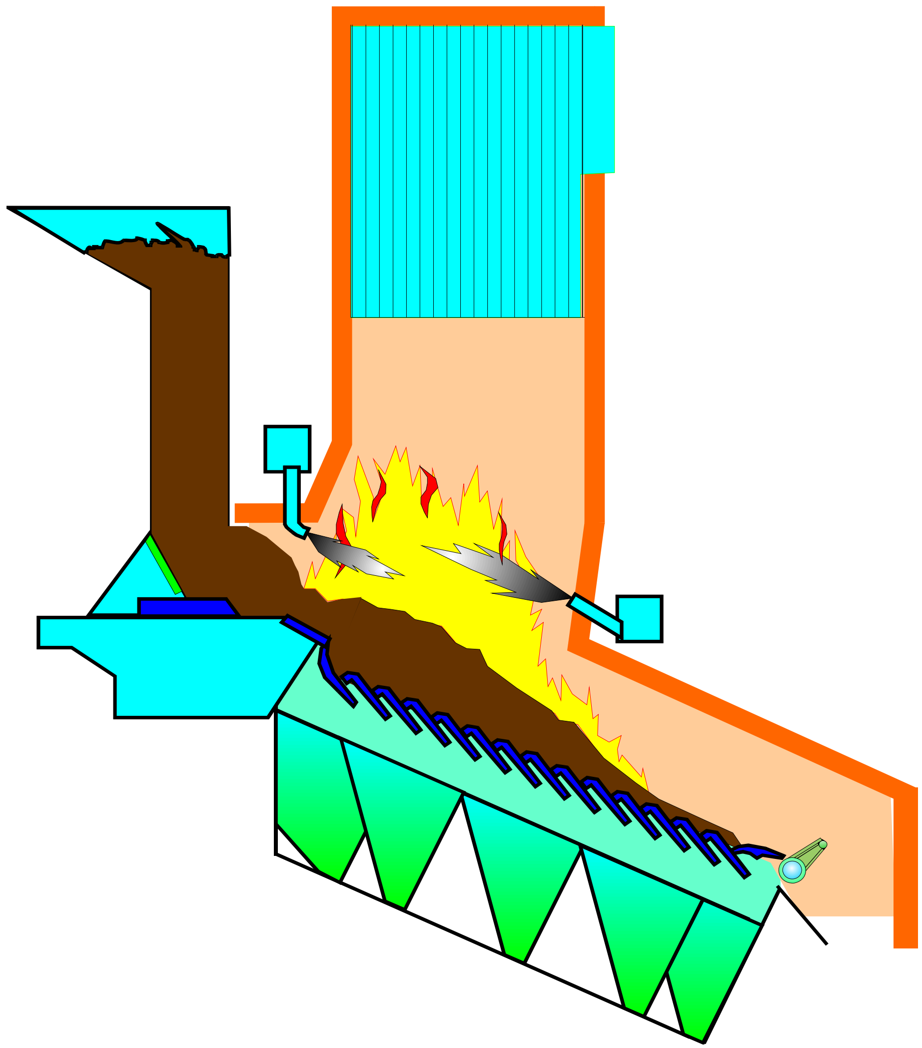
(N.J. Themelis and P. Ulloa, "Methane generation in landfills", Renewable Energy 32 (2007) 1243-1257

• MSW to global landfills:	**1 billion tons/y**
•Landfill Gas (LFG) generation:	**50 million tonnes CH_4**
• LFG collected and used or flared:	**6 million tonnes CH_4**
• LFG emitted globally:	**44 million tonnes CH_4** *

***Equivalent to 920 million tons of CO2**

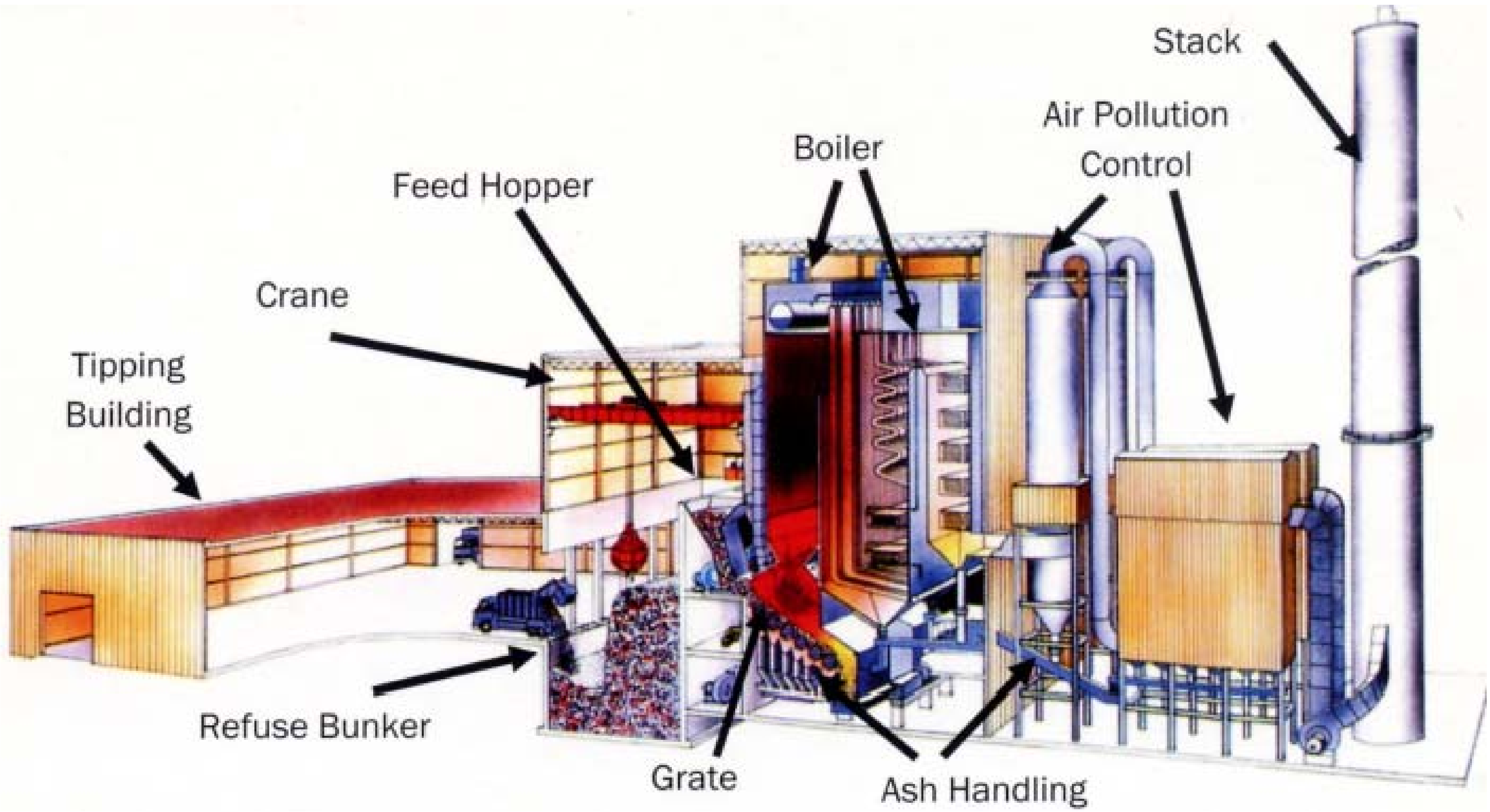
About 4% of Global CO2 emission

Combustion with energy recovery on an inclined grate



Recovery of energy: Waste to Energy (WTE)

The dominant WTE technology (600 plants worldwide): Grate combustion of as received MSW



Tons of New WTE Global Capacity, 2001-2007

Year	Martin	Von Roll	Keppel Seghers	Total of three technologies
2001	2,156,220	1,228,867	267,630	3,652,717
2002	1,197,900	252,965	183,480	1,634,345
2003	923,340	750,974	424,380	2,098,694
2004	2,084,940	557,726	721,380	3,364,046
2005	2,040,390	1,322,482	-	3,362,872
2006	818,400	606,830	564,300	1,989,530
2007	1,756,260	1,635,559		3,391,819
Total Stoker:	**10,977,450**	**6,355,404**	**2,161,170**	**19,494,024**
All other thermal treatment technologies				**5 million tons**

Estimated total global growth: 3.5 million tonnes/year

China???

WTE as a renewable and local energy source in the U.S. (avoiding transmission loss)

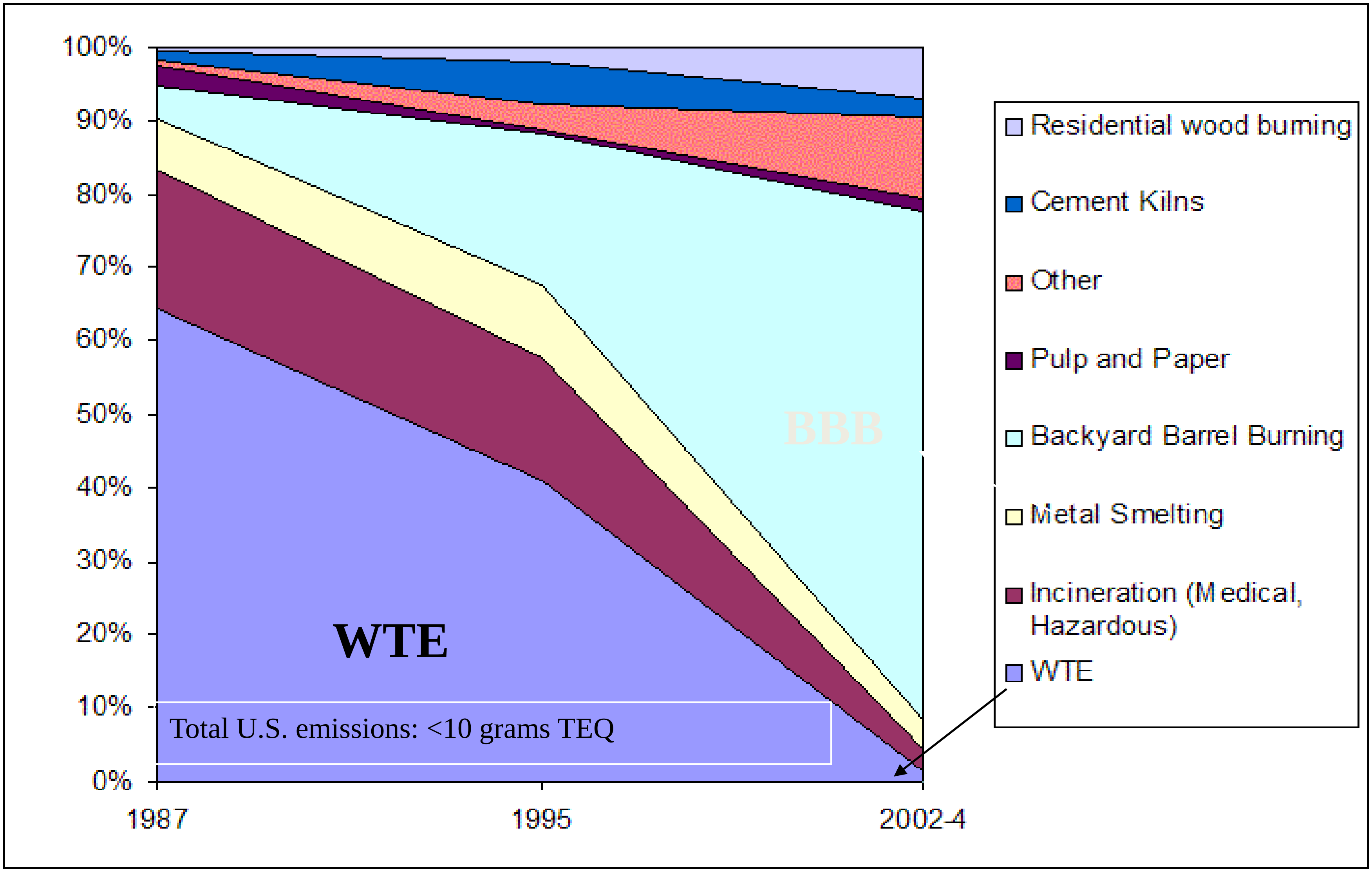
Energy source	Billion kWh generated	% of total renewable energy
Geothermal	13.52	28.0%
WTE (from 7.4% of the MSW)	13.50	28.0%
Landfill gas (from 64.1% of the MSW)	6.65	13.8%
Wood/other biomass	8.37	17.4%
Solar thermal	0.87	1.8%
Solar photovoltaic	0.01	0.0%
Wind	5.3	11.0%
Total	48.22	100.0%

1 U.S. ton of MSW = 500 kWh = 1 barrel of oil

Emissions of Thermal Treatment Technologies are no longer an issue: WTE Facilities competing for 2006 Columbia/WTERT Industry Award

Emissions, mg/Nm3	Average of 10 WTEs	E.U. standard	WTEs as % of E.U. standard
Particulates	3.06	10	31%
SO2	12.2	50	24%
NOx	123	200	61%
HCl	7.88	10	79%
CO	26.3	50	53%
Mercury	0.01	0.05	20%
TOC	0.92	10	9%
Dioxins, ng TEQ/m3	0.02	0.10	21%

Advances in emission control of WTEs: Change in dioxin emissions from U.S. WTEs between 1987 (10,000 g TEQ) and 2002 (<10g TEQ)



ANNUAL DIOXIN/FURAN EMISSIONS FROM COMBUSTING 100,000 TONS OF SOLID WASTES IN A WTE POWER PLANT AT THE EU STANDARD (0.1 nanogram TEQ per cubic meter of stack gas):

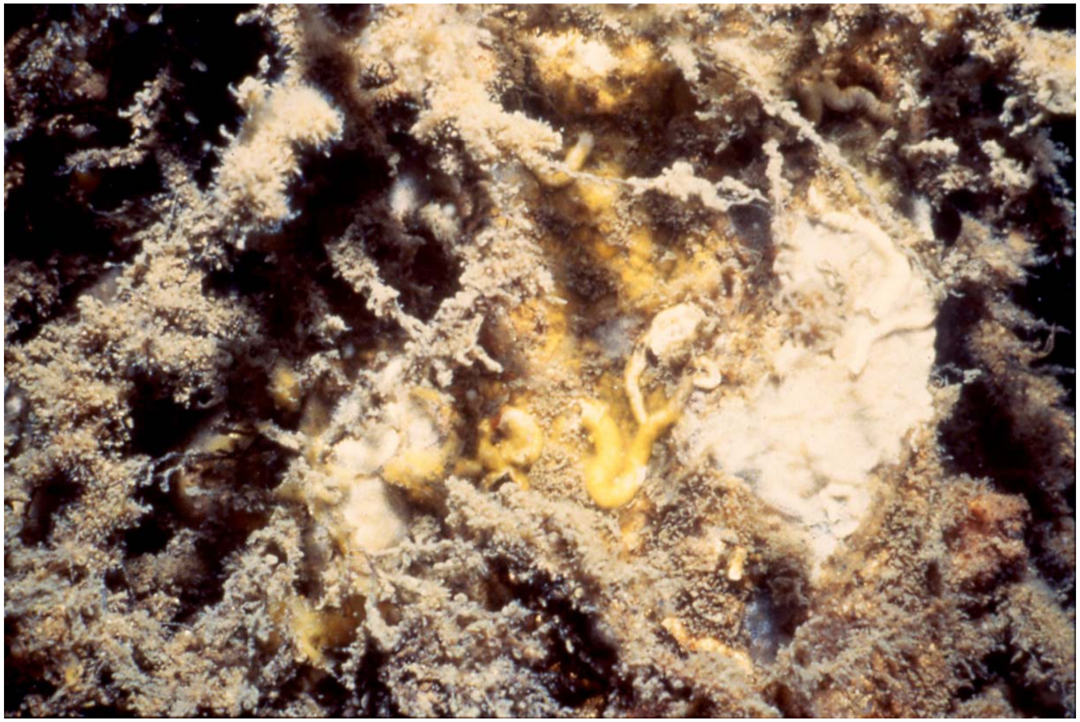
100,000 tons x 5000 Nm3/ton x 0.1 ng TEQ = 0.05 grams TEQ in one year

WTE bottom ash can be used beneficially

- Ferrous and non-ferrous metal recovery
- As Alternative Daily Cover (ADC) in landfills
- For road and other construction
- Shore protection, land creation

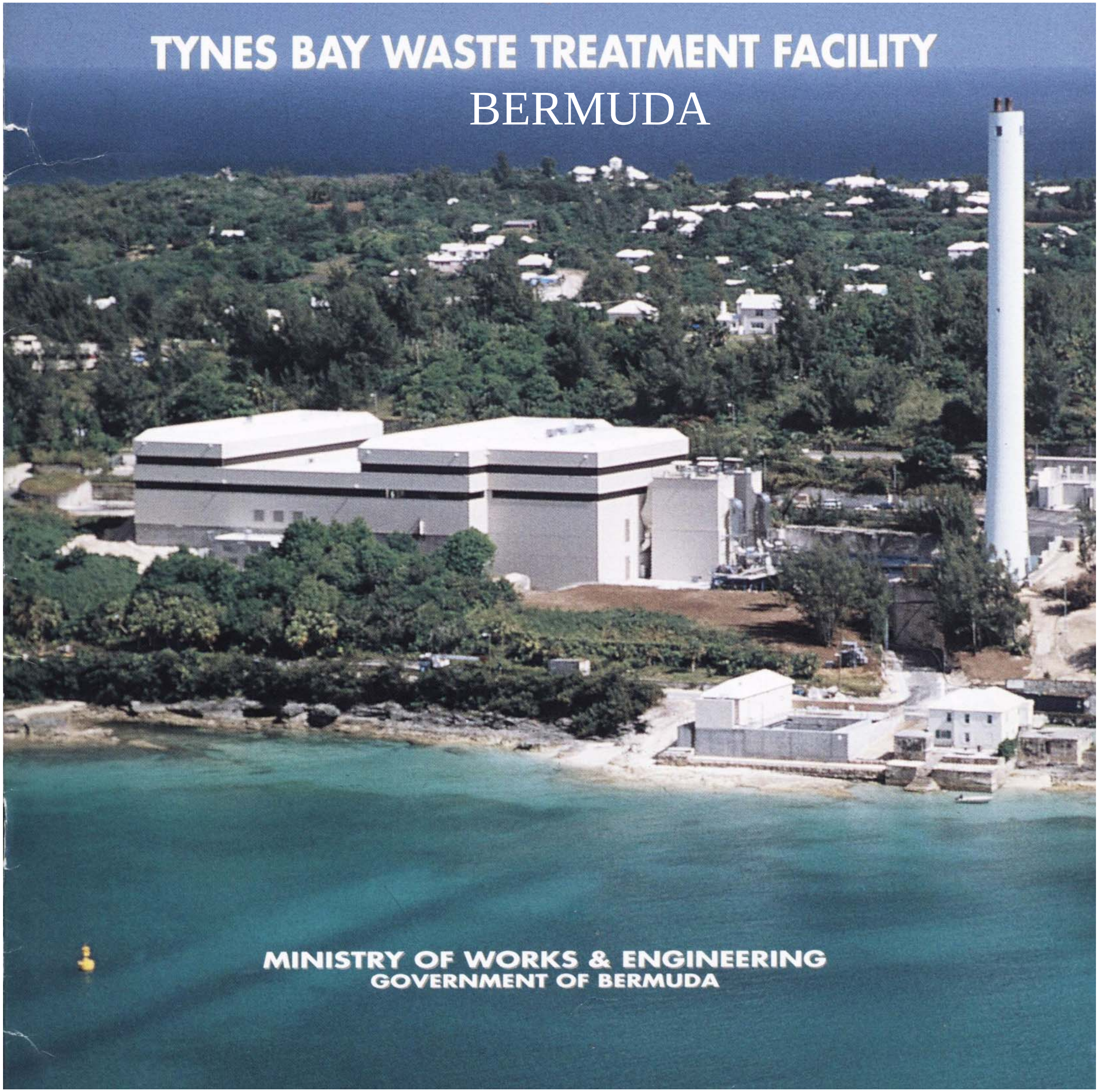
Artificial Reefs

- Metals didn’t leach from the Ash Blocks
- Dioxins/Furans also retained within the blocks
- Biological Community was diverse and identical to that found on Control Structures



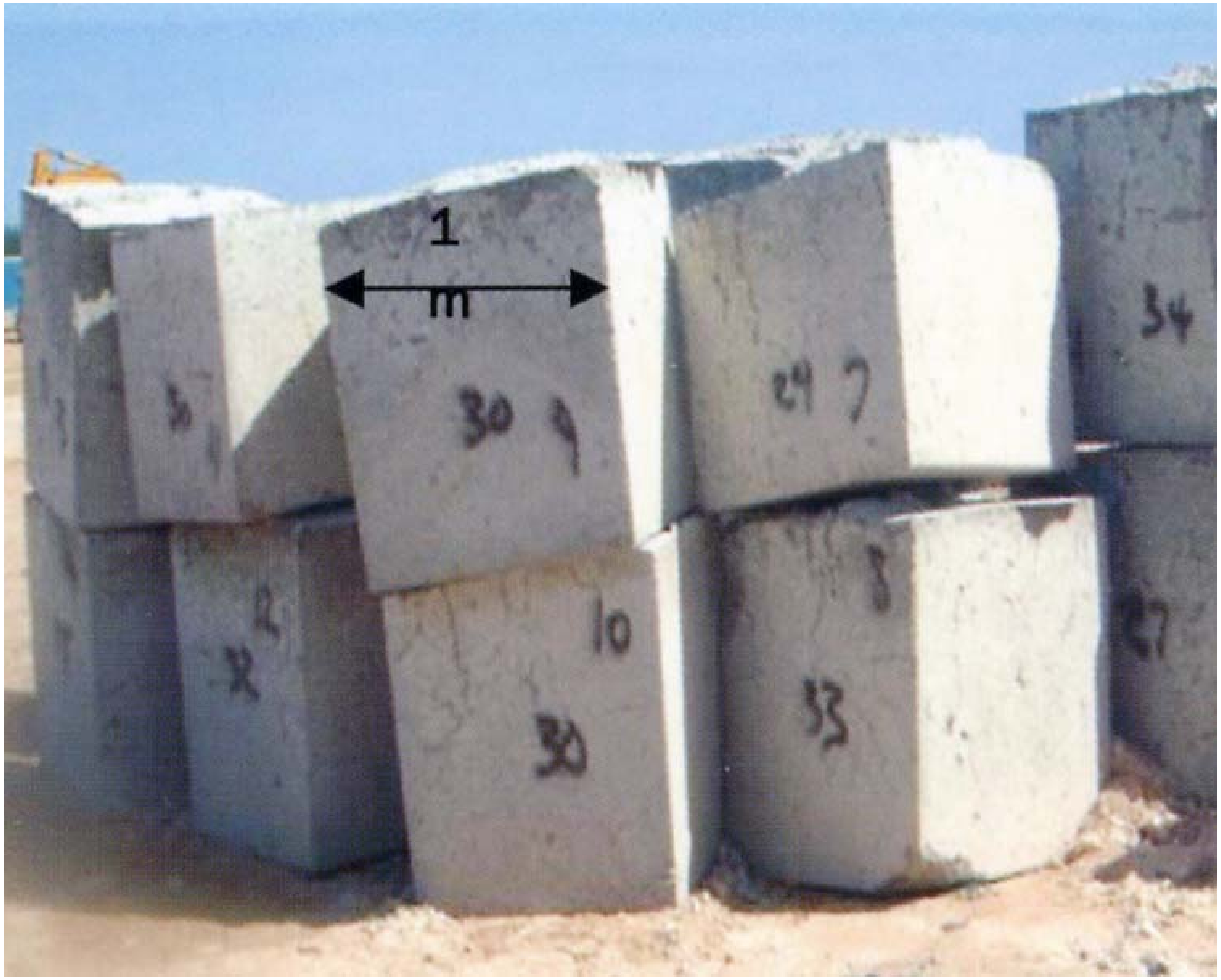
TYNES BAY WASTE TREATMENT FACILITY

BERMUDA



MINISTRY OF WORKS & ENGINEERING
GOVERNMENT OF BERMUDA

Use of WTE ash to make cement blocks for expanding runways in Bermuda



Shore Protection Applications

- James River, VA Demonstration Project

- Concrete blocks possess the durability to withstand the impact of the ocean

WTE Potential in Australia

- Population 21.4 million
- Estimated non-C&D landfilling (2003): 18 million tons
- Assumed 50% overall capture of landfill gas (LFG)
- Replacing landfilling by WTE will result in:

  - Electricity generation of 12.8 million kWh (needs of one million people; World Bank 2006-Australia)

  - Low pressure steam energy of 10 million kWh,th for commercial/industrial use

  - Reduction of greenhouse gas (GHG) emissions by 16 mill tons CO_2

  -Avoiding the use of 1.8 million square meters for landfilling each year

Policies to help WTE: The China example

• Only 20% of China's MSW goes to sanitary landfills at this time. The rest is deposited at rudimentary landfills without liner, gas collection, or leachate treatment system.

•China is the world's largest emitter of landfill methane.

•However, China is rapidly increasing WTE capacity; it has over 60 WTE plants and plans to have one hundred by 2012. Present capacity: 14.3 million tons of MSW.

PRC provides a credit of $30 per MWh of electricity produced by WTE power plants

China GDP per capita:	**$ 6.800**
Australia GDP per capita	**$37,000**

Economics of WTE vs landfilling

- WTE is more costly to build than a sanitary landfill equipped for controlling liquid emissions and collecting 50% of methane generated

- Landfiling is more costly to operate because of the revenues of WTE electricity.

- In contrast to a sanitary landfill that must be replaced within 10-20 years, the WTE plant can continue to serve future generations at a very low cost, after the first 20 years when the initial investment has been paid off.
- WTE may benefit from carbon or other credits for Renewable Energy Sources.
- WTE may benefit from sale of low-pressure steam for industrial or district heating

How to engage the community in new WTE plant

- Information as to environmental impacts and benefits of WTE
- Transparency as to actual emissions of plant
- Select a location that will be enhanced by the plant and not the other way around
- Expenditure on esthetic appearance of plant (5% of capital cost), educational facilities for visitors, pride of ownership
- Arranging for community share in economic benefits

Grate combustion and novel WTE technologies

- Japan is the only nation that has both conventional and novel WTE technologies. Both types of plants are much costlier than those used in the U.S. and E.U. because they are funded by government and government does not allow landfilling.

- For a novel technology to be selected over grate combustion in the U.S. and the E.U., it has to demonstrate on a fairly large scale lower capital cost per ton of capacity and/or higher electricity generation per ton MSW.

Engaging the community: Select a site where the WTE plant will esthetically and functionally improve the lives of the neighbors

Winner of Columbia/WTERT 2006 Industry Award: ASM Brescia, Italy

...thank you!

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