Trash as Treasure

or the dirt on how not to trash refuse wastefully

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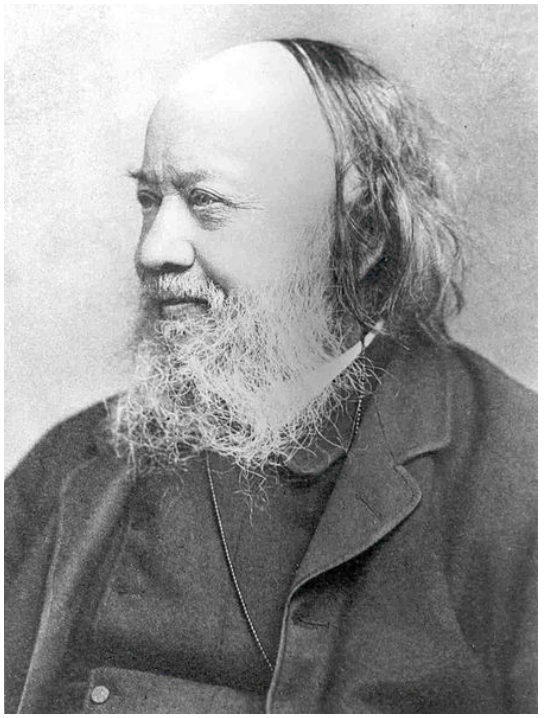
Which view is waste?

Waste is Public Health

- Public Health Act 1875: Compulsory to put your waste into a bin to be collected.

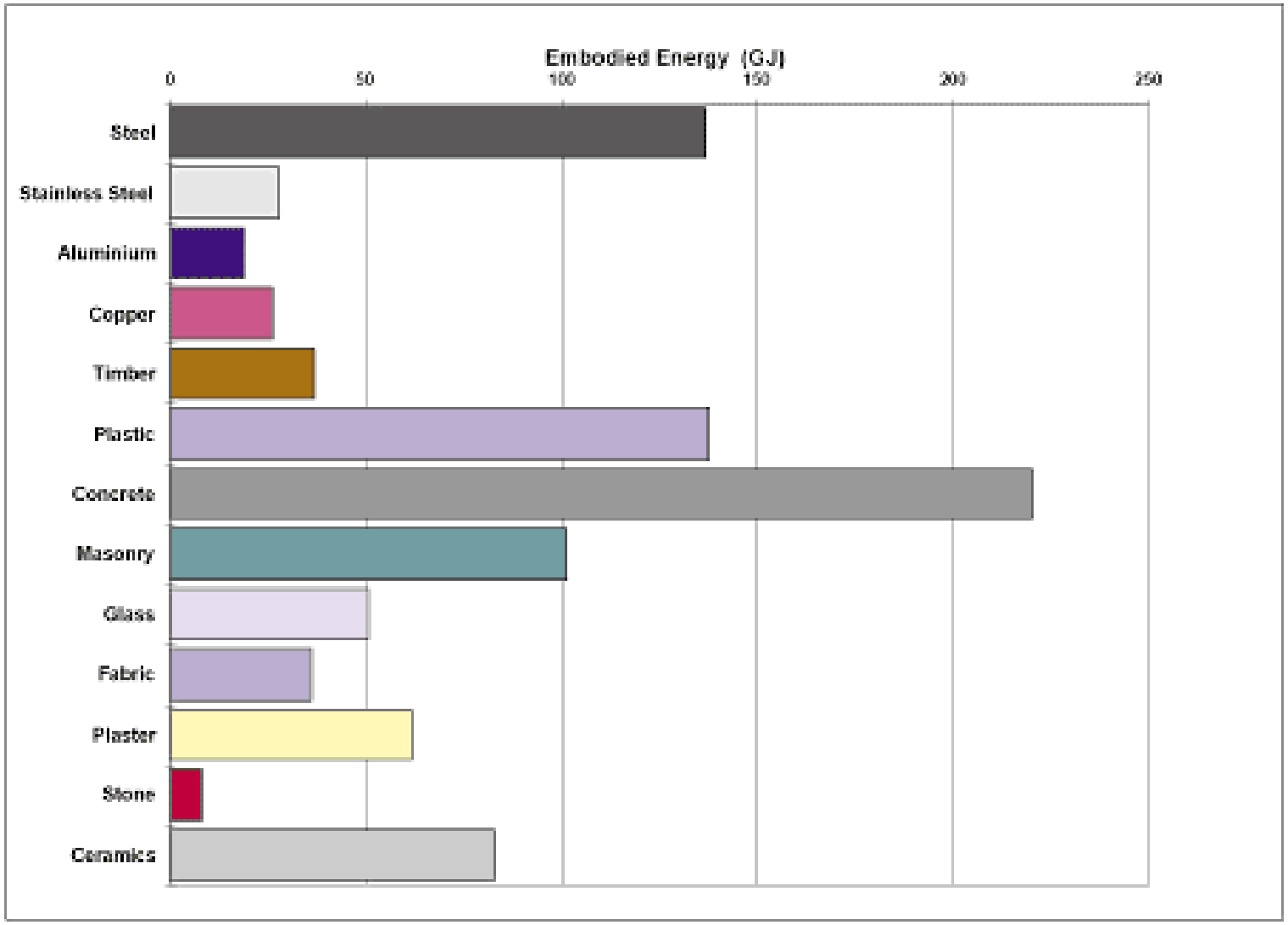


Sir Edwin Chadwick.

What is embodied energy?

Embodied energy is the sum of all the energy required to produce any goods or services, considered as if that energy was incorporated or 'embodied' in the product itself

Embodied energy of a house



http://www.epa.vic.gov.au/agc/r_emissions.html#page-4/!

Some other forms of waste

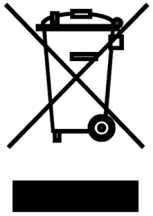
We've discussed:

- Municipal Solid Waste
- Food / Biomass
- Metals / Plastics

Other categories include

- Electronic Waste
- Industrial Waste
- Hazardous Waste
- Sewage

Waste electrical and electronic equipment (WEEE)



- Televisions / PCs
- Hard copy computer peripherals (including printers, etc)
- Cell phones

20 million computers discarded in 2008 alone

Computer Sales	2011	2010	2000	1975
Number of computers sold in the U.S.	95.4 M	93 M	46 M	40,000
Number of computers sold globally	355.2 M	346.2 M	134.7 M	50,000

Electronic Waste Solutions

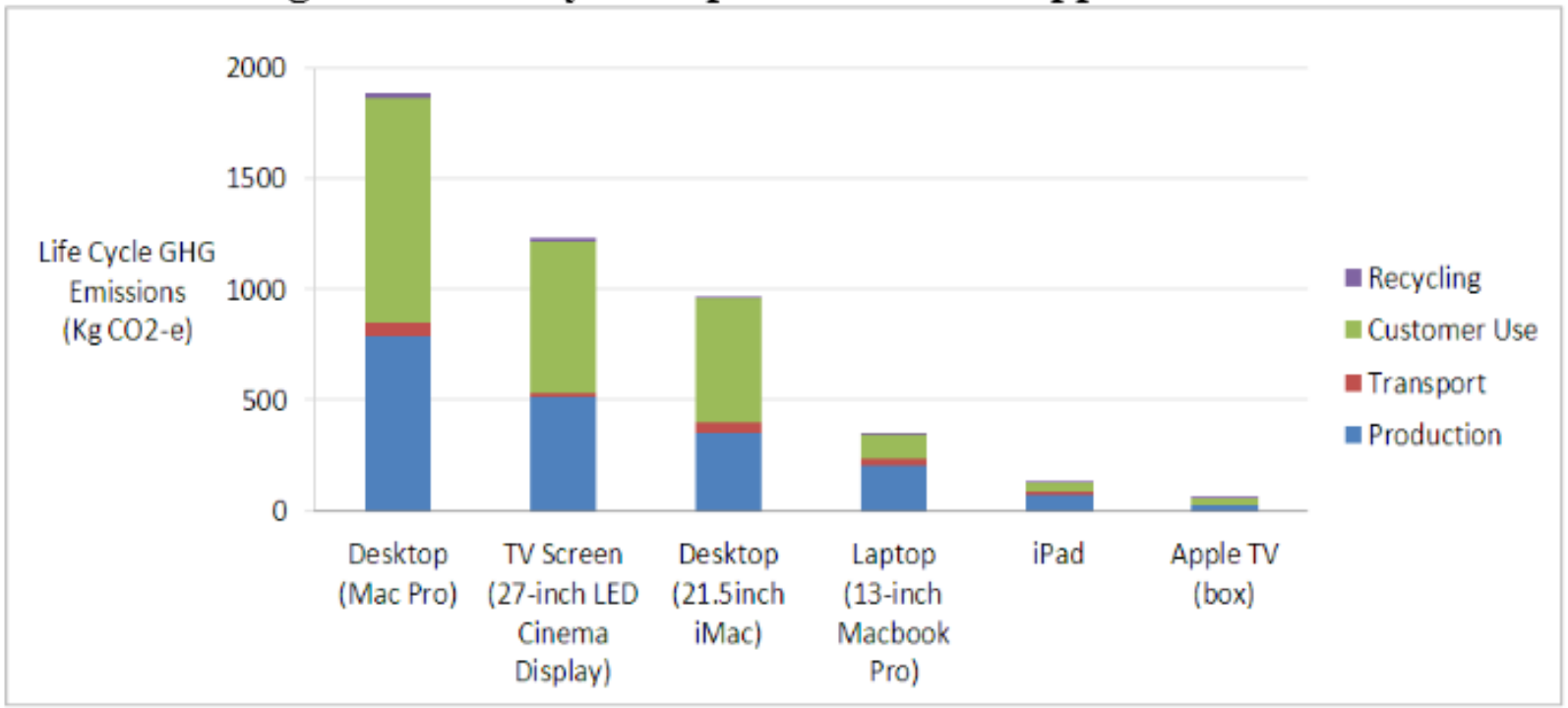
RoHS

- Recycle it
- RoHS (Restriction of Hazardous Substance, in the EU)
  - Limits Lead, Mercury, Cadmium, Chromium, and others.

- California has passed the Electronic Waste Recycling Act of 2003 (EWRA)
  - No Federal policy, outside of EPA guidelines on heavy metals as hazardous waste.

Embodied vs. Operational

Figure 3. Life Cycle Impact of Selected Apple Products



Sources: Adapted from Apple (2010a); Apple (2010c); Apple (2010b); Apple (2010f); Apple (2010e); Apple (2010d)

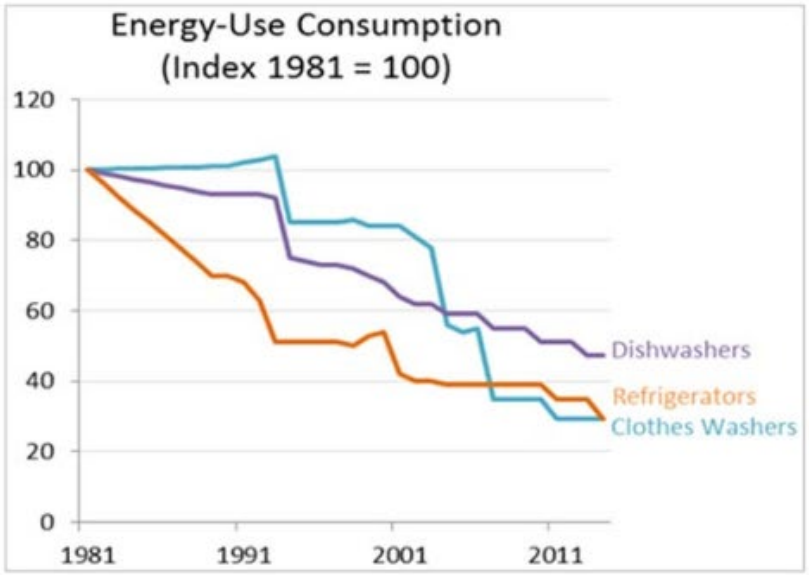
~ 12 kilograms of fuel for 1 kilogram of computer

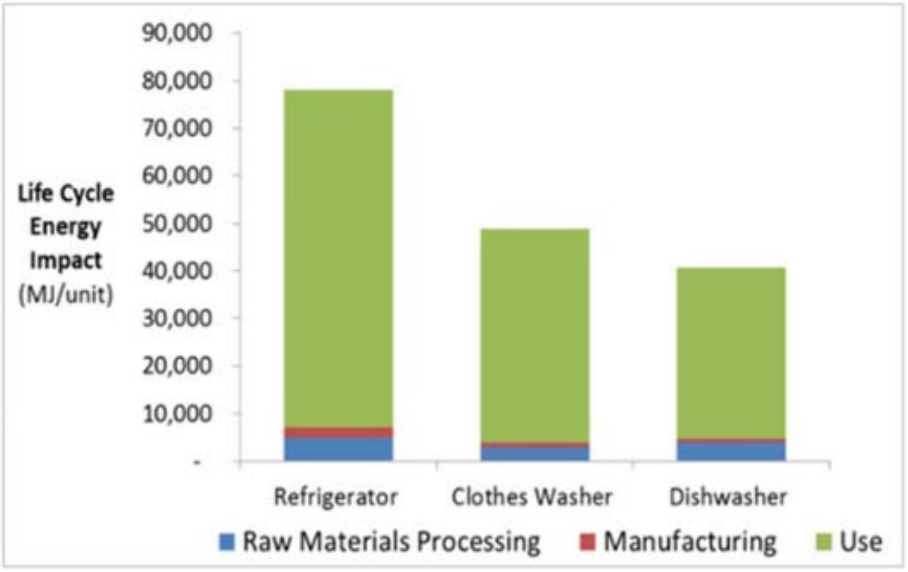
http://www.lowtechmagazine.com/2009/06/embodied-energy-of-digital-technology.html

Amanda Gonzalez, Alex Chase and Noah Horowitz, *What We Know and Don't Know about Embodied Energy and Greenhouse Gases for Electronics, Appliances, and Light Bulbs* 2012 ACEEE Summer Study on Energy Efficiency in Buildings

Appliances are Operations-driven

Figure 5. End-Use Energy Improvements and LCA Impacts for White Goods[6]





Sources: End-use energy consumption adapted from Boustani et al. 2010; Life cycle energy impact adapted from Boustani, Graves & Gutowski 2010

Amanda Gonzalez, Alex Chase and Noah Horowitz, *What We Know and Don't Know about Embodied Energy and Greenhouse Gases for Electronics, Appliances, and Light Bulbs* 2012 ACEEE Summer Study on Energy Efficiency in Buildings

Hazardous Waste

- Listed as requiring special disposal

- Dry cleaner
- Auto repair shop
- Hospitals
- Paints
- Refrigerants

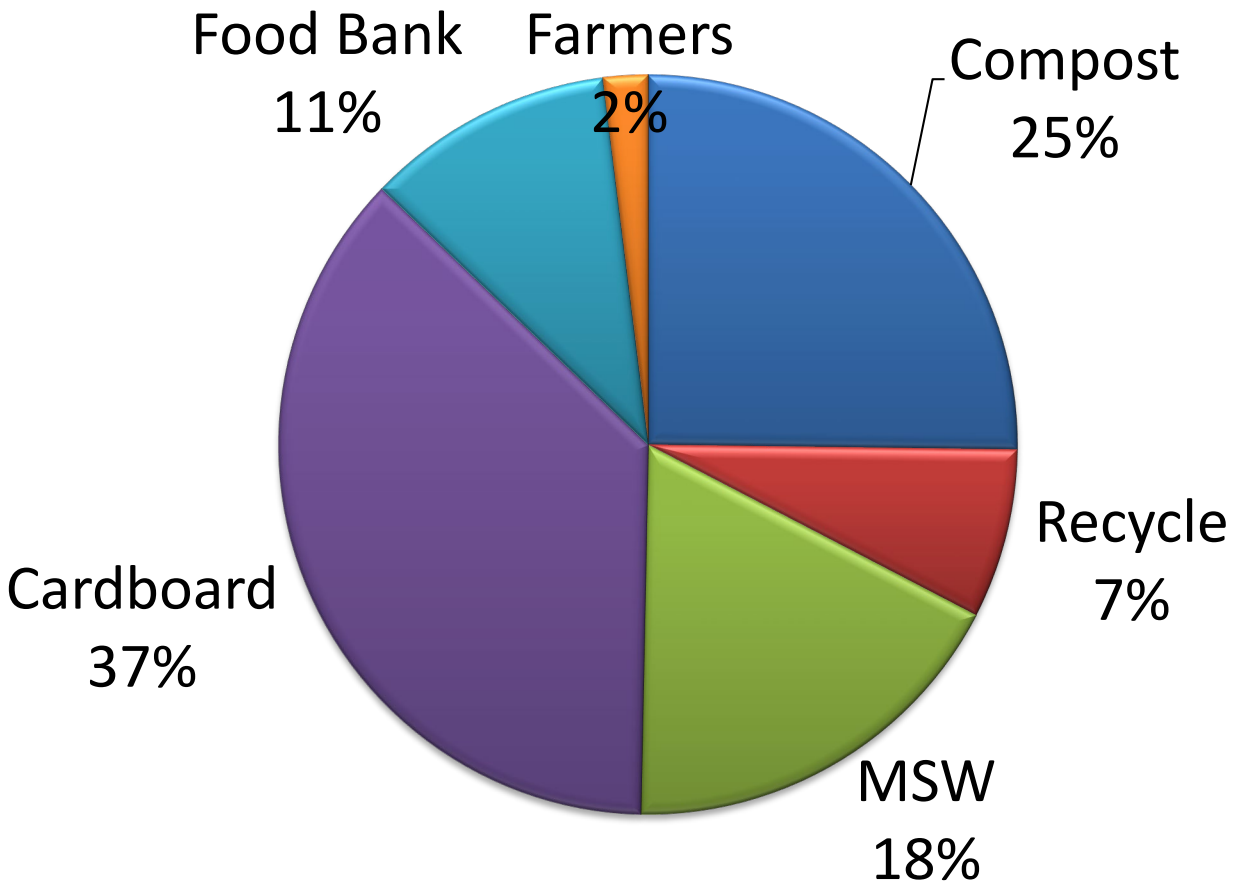
Disposal:

- Incineration
- Pyrolysis
- Portland Cement
- *Any method to make chemically inert*

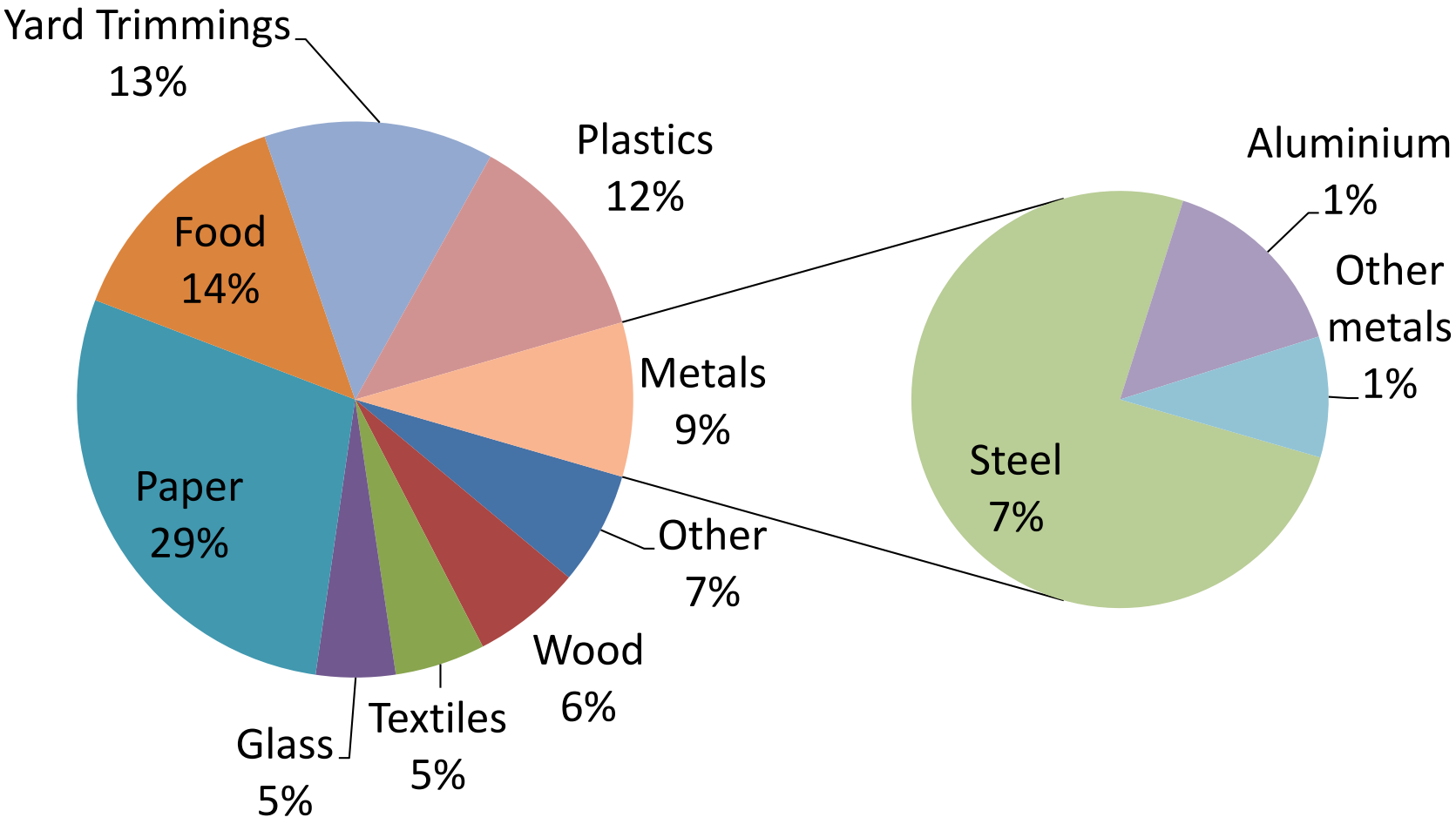
Sewage

- Primarily liquid or transported by using liquid technologies.
- Sewage Treatment is the process of separating liquid and solid waste.
- Solid waste can become fertilizer.
- Poorly managed causes diseases.

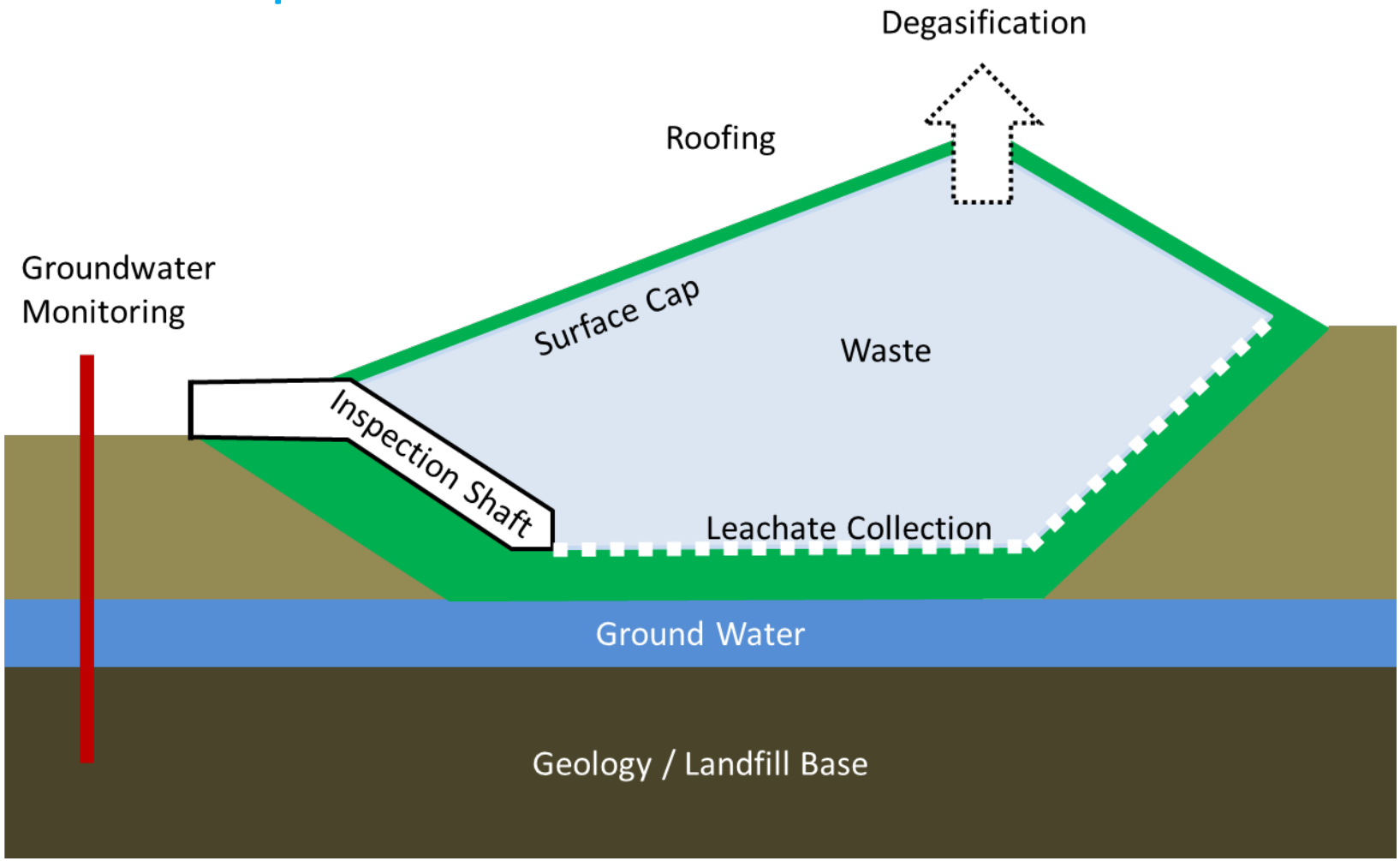
The Case


Food Bank
11%
Farmers
2%
Compost
25%
Recycle
7%
MSW
18%
Cardboard
37%

Composition of Waste in the USA



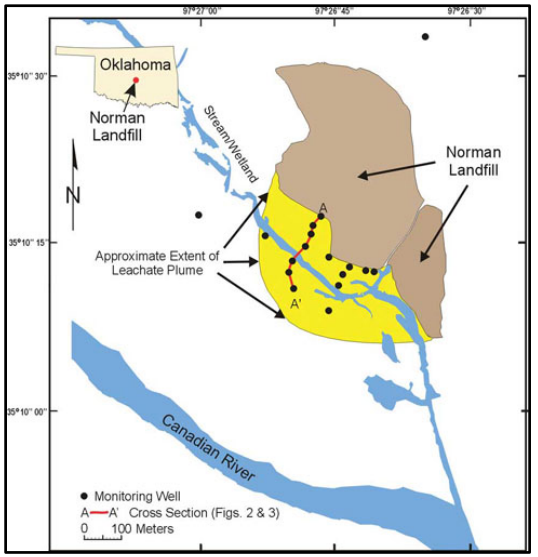
Landfill Option



Example side effects

8000 landfill fires in the USA alone

Leachate leaks



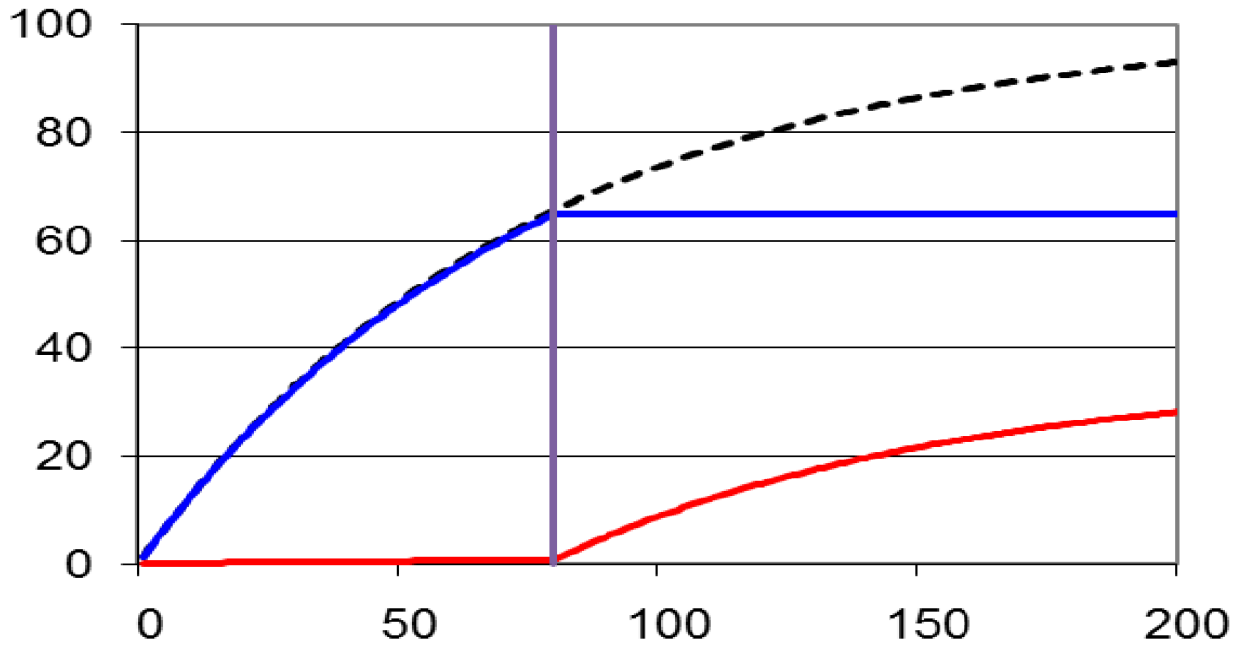
$2 million per year in King County (Where Seattle is located) to maintain closed landfills

Middens

Oldest ~140,000 years old (mid Paleolithic era)

http://www.cnn.com/2011/10/04/world/europe/archaeology-ancient-trash/

Leachate Containment



Element Breakouts

Element	Breakpoint L/S (l/kg)[1]	Net infiltration 2009 158 mm/year H = 10 m	Net infiltration 2010 658 mm/year H = 10 m
Cd	3,00	100 years	24 years
Cu	3,75	130 years	30 years
Hg	1,17	40 years	9 years
Ni	7,98	270 years	65
Pb	2,42	80 years	20 years
Zn	11,0	370 years	90 years

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1991: German consensus that Landfills are bad

Regulatory Compliance

- Germany 1991: Ordinance on the Avoidance and Recovery of Packaging Waste
- Required producers to take back the packaging associated with their products after consumption and ensure that a specified percentage of it is recycled each year.

Business Response:

- Creation of the Green Dot program that operates in parallel to the normal waste collection.
- Companies pay a fee to affix the label; product is collected and recycled separate from the waste stream

Managing Food Waste

Diagram of Composting

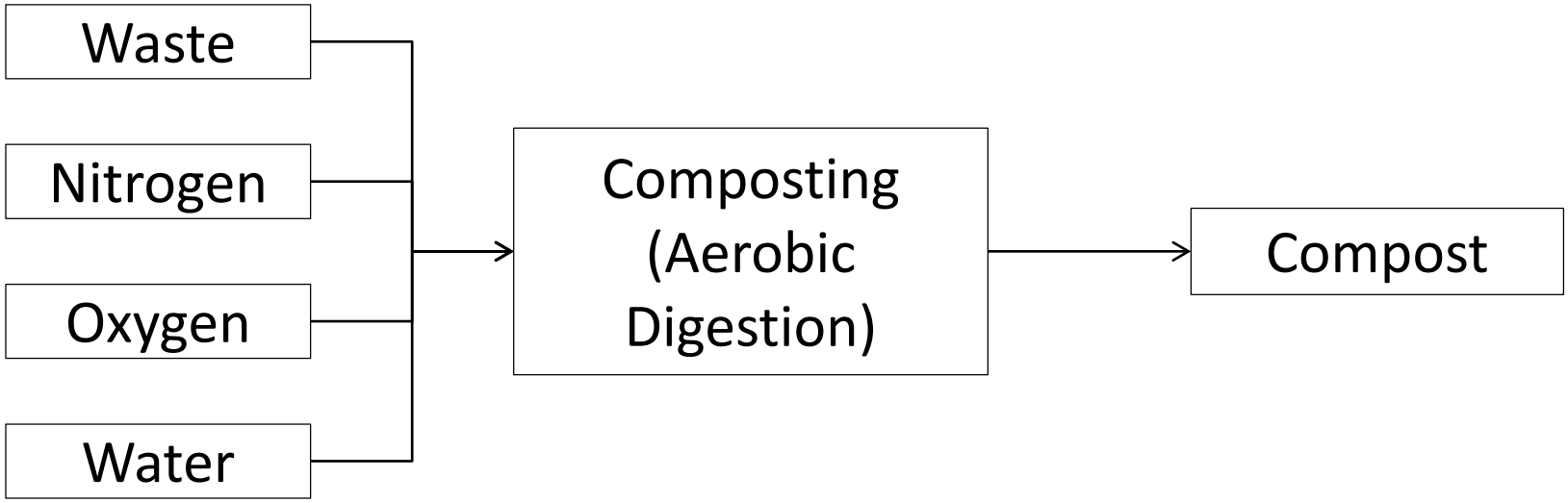
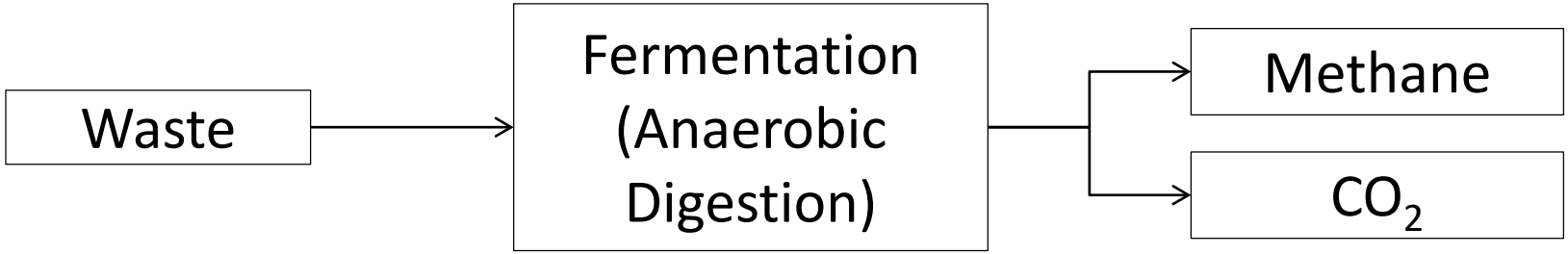


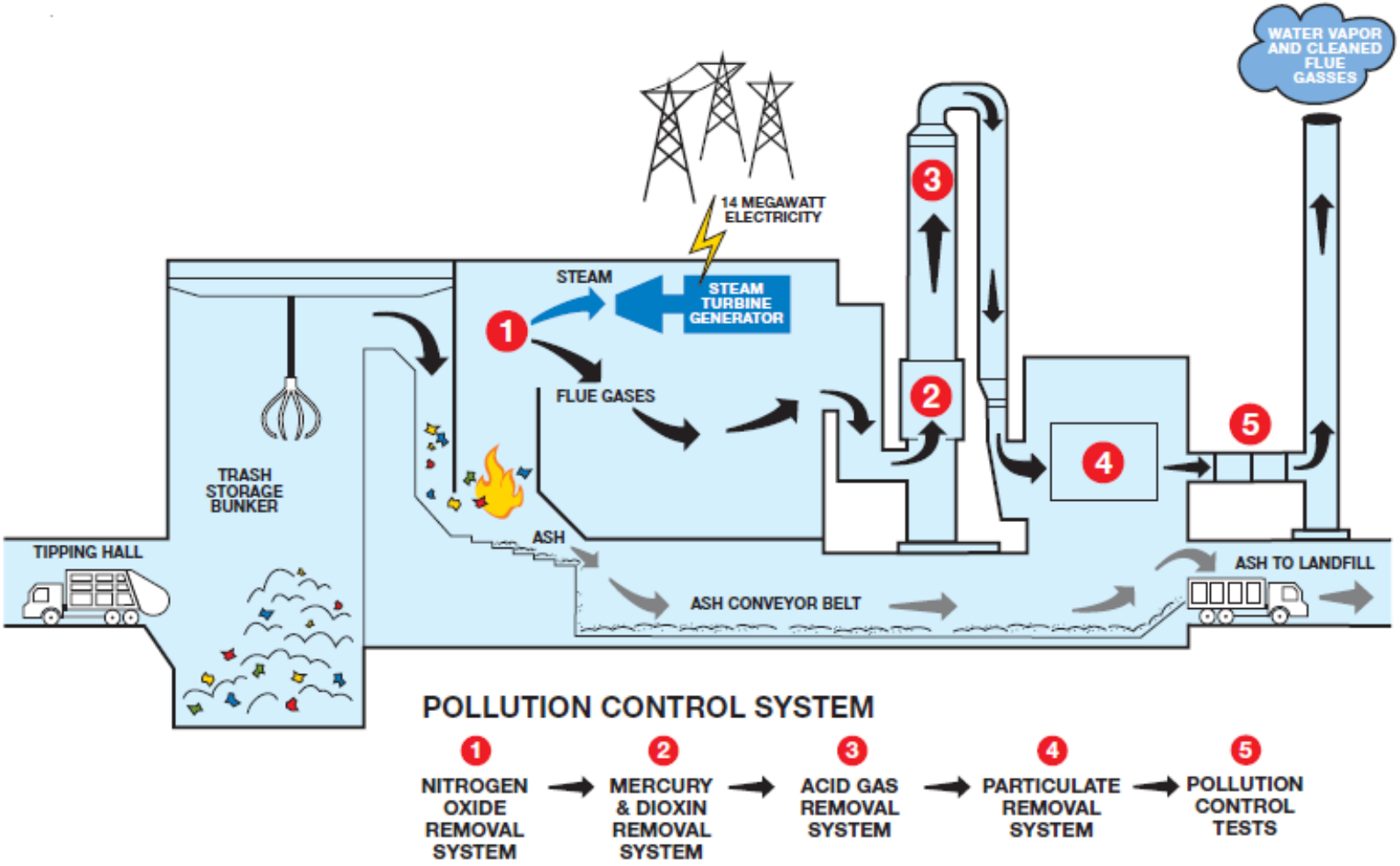
Diagram of Fermentation



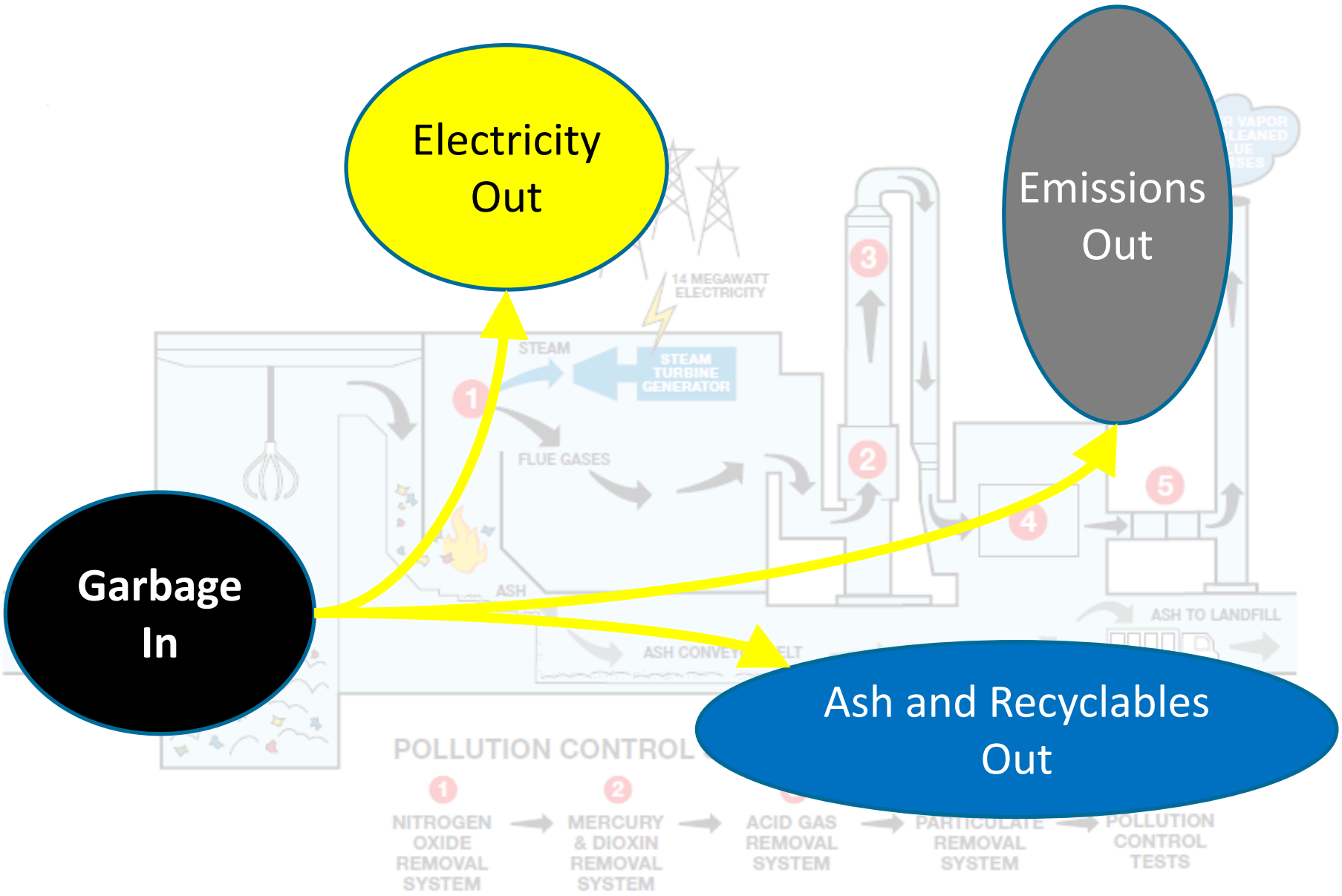
Energy Use of Recycled Material vs. Raw Ore

Reduction of:	Aluminum	Steel	Glass	Paper	Plastics
Energy Use	95%	60%	20%	50%	60%
Air Pollution	95%	85%	20%	74%	-
Water Pollution	97%	76%	-	35%	-
Water Use	-	49%	50%	58%	-
Recyclable Number of times	Many	Many	Many	5-7	1-2

Waste-to-Energy



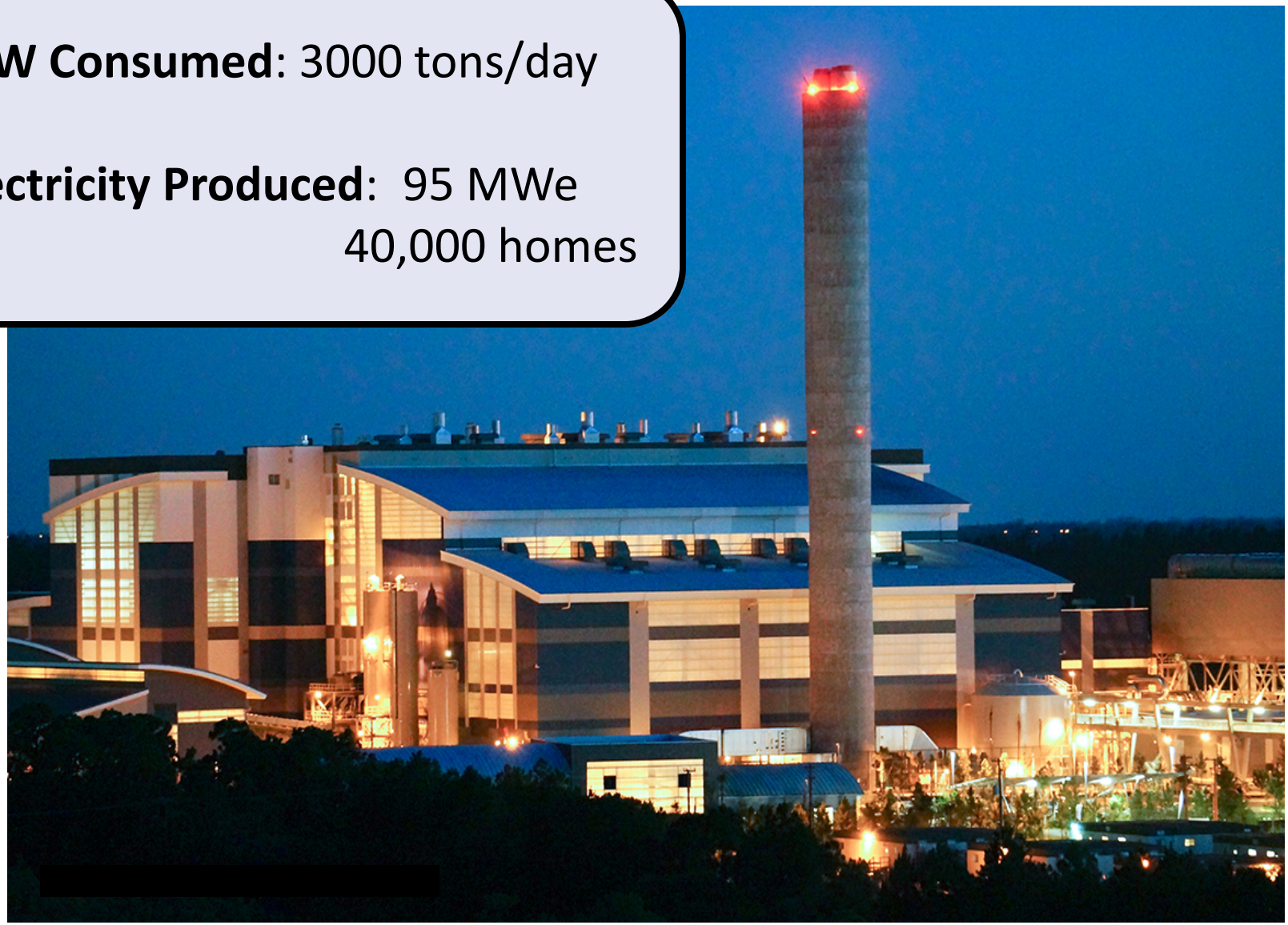
Waste-to-Energy



2015 Project in the USA

MSW Consumed: 3000 tons/day

Electricity Produced: 95 MWe
40,000 homes



USA Project Permit vs. Actual Emissions

Pollutant	Emissions Permit	Actual Emissions Test**
NOx	<50 PPM	< 35 PPM
Carbon Monoxide	<100 PPM	< 30 PPM
SOx	<24 PPM	< 21 PPM
Unburned Hydrocarbons	< 7 PPM	< 3 PPM
Particulate Matter	12 MG/DSCM	< 3 MG/DSCM

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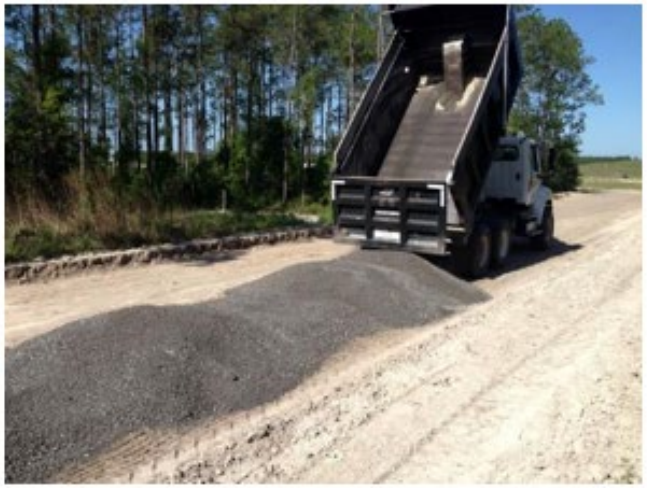
Less than 40 cars

Less than 3 cars

Pasco County Ash Reuse - First in Florida to Receive FDEP Authorization for Beneficial Reuse



FDEP approved beneficial reuse in December 2014 for three applications

1. Bottom ash as road base
2. Bottom ash as aggregate in asphalt
3. Bottom ash as aggregate in concrete

High Tech Magnets for Optimized Recovery of Ferrous and Non-ferrous Metals

High Strength Drum Magnet for Ferrous Metals

Samples of Non-ferrous Metals Recovered by Eddy Current Separator

Aluminum, brass, bronze, copper… even gold and silver!

Dense aluminum "nuggets"

Is incineration the same technology?

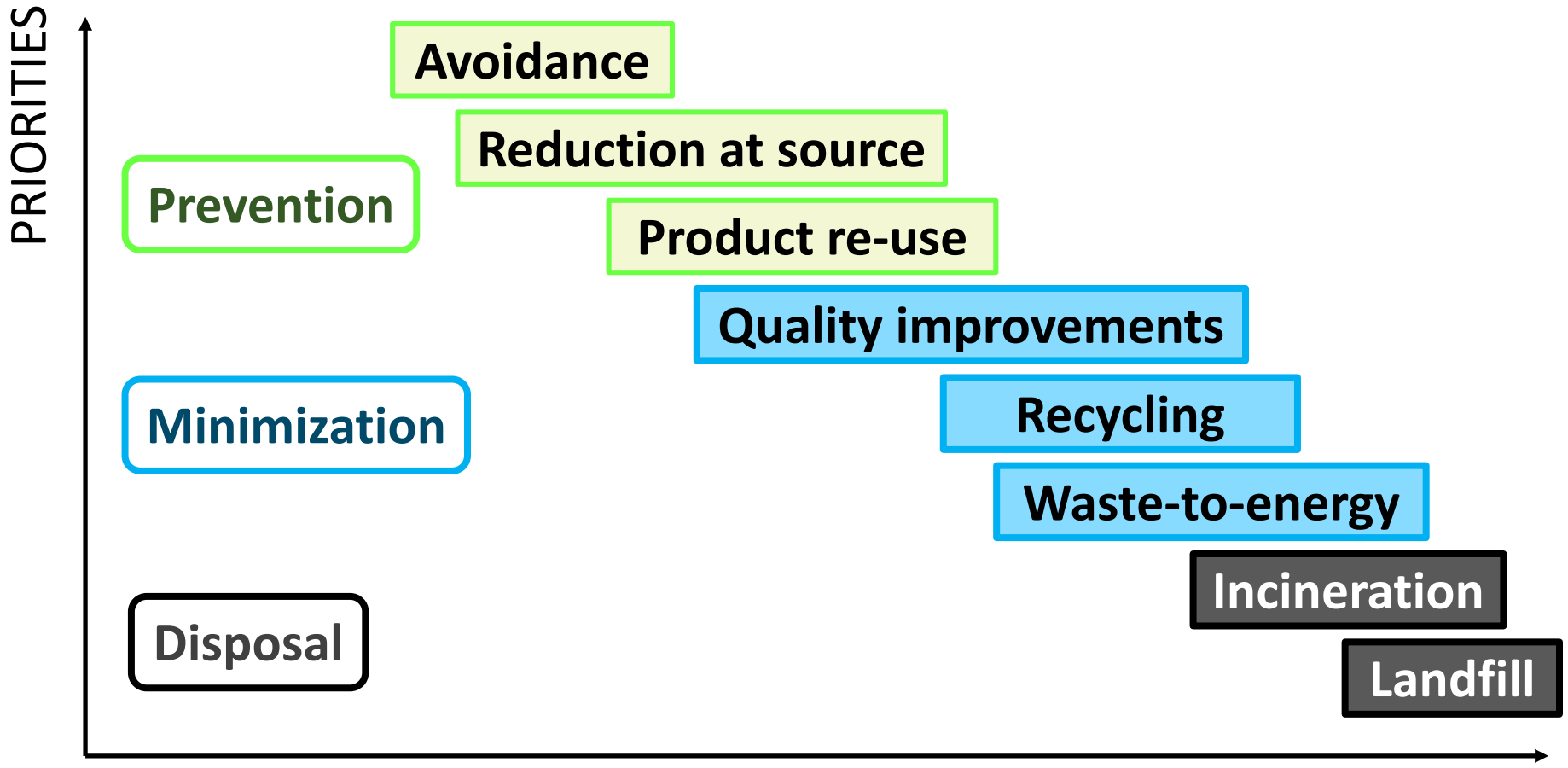
Waste In → **Waste-to-Energy** → **Goal**: Maximize Energy Conversion

More economical to maintain a high-temperature fire
- Breaks down toxic chemicals.
- Self-sustaining fire.
- Better sorting of waste: Only want to burn plastics, wood and paper. All else should be removed.
- Materials recovery of metals and ash

Waste In → **Incineration** → **Goal**: Volume Reduction

More economical to maintain a low-temperature fire
- Toxins are not burned completely.
- Burn natural gas to maintain fire.
- No ability to recover recyclables from embers.
- No feedback into the economy

German Waste Prioritization Hierarchy

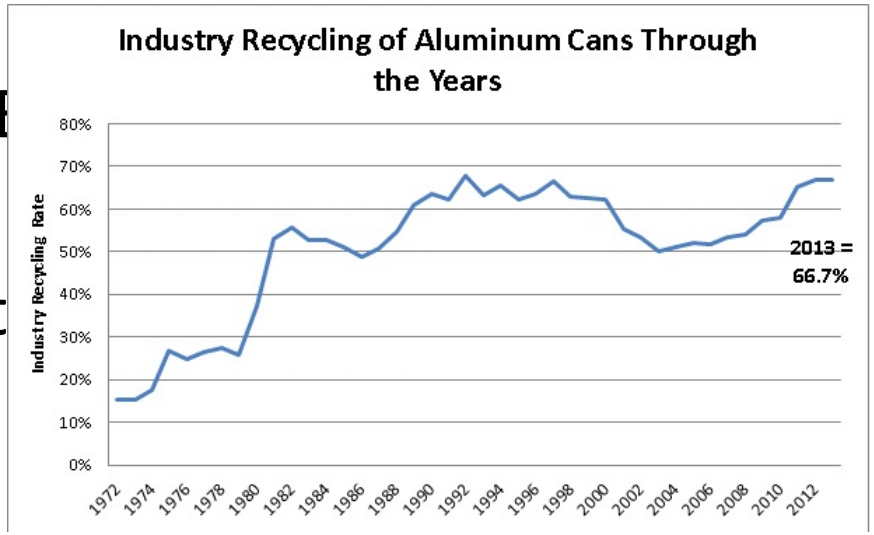


Deposit-Refund Model

- Combines ***a tax*** on product consumption with ***a rebate*** when the product is returned for recycling or appropriate disposal.
- Batteries, tires, cans and bottles, motor oil, electronic equipment etc.
- Oregon: bottle bill in 1971

Deposit-Refund Model

- Taxes the point where it's easy to administer then refund based on positive activities that is hard to monitor.
- Tax evasion is also harder because you don't just avoid the tax but you get a refund if you do follow the tax.
- Only 10 states with “Bottle B
rates as high as 90%.
- USA Average is 31% for bott



http://www.aluminum.org/news/aluminum-can-continues-leadership-sustainable-packaging-most-recycled-beverage-container

Consumer Pays Model

- Person throwing trash away pays for the pickup.
- Collection companies charge consumers a fee for the collection
- Landfill charge trucks a ‘tipping fee’ to deposit their trash
- Landfills are financed via a cost recovery model
  - Economics is a “feed the beast” model. Not “sustainable”

Which Policy?

Consumer Pays

- Waste Management driven by tipping fees
- Landfills are driven by a cost-recovery business model
- WA State spends $2 million per year maintaining closed landfills

Polluter Pays

- Waste collection driven by manufacturers (green dot)
- Waste treated as a resource and put back into the manufacturing system.
- Has created a huge economic boost with manufacturing jobs.

Economic:

Germany:

- Created 200,000 jobs to manage waste
- Generates €75 Billion contribution to GDP

USA Equivalent:

- “Bury” $250-375 Billion in economic value in landfills every year (GDP Opportunity cost)

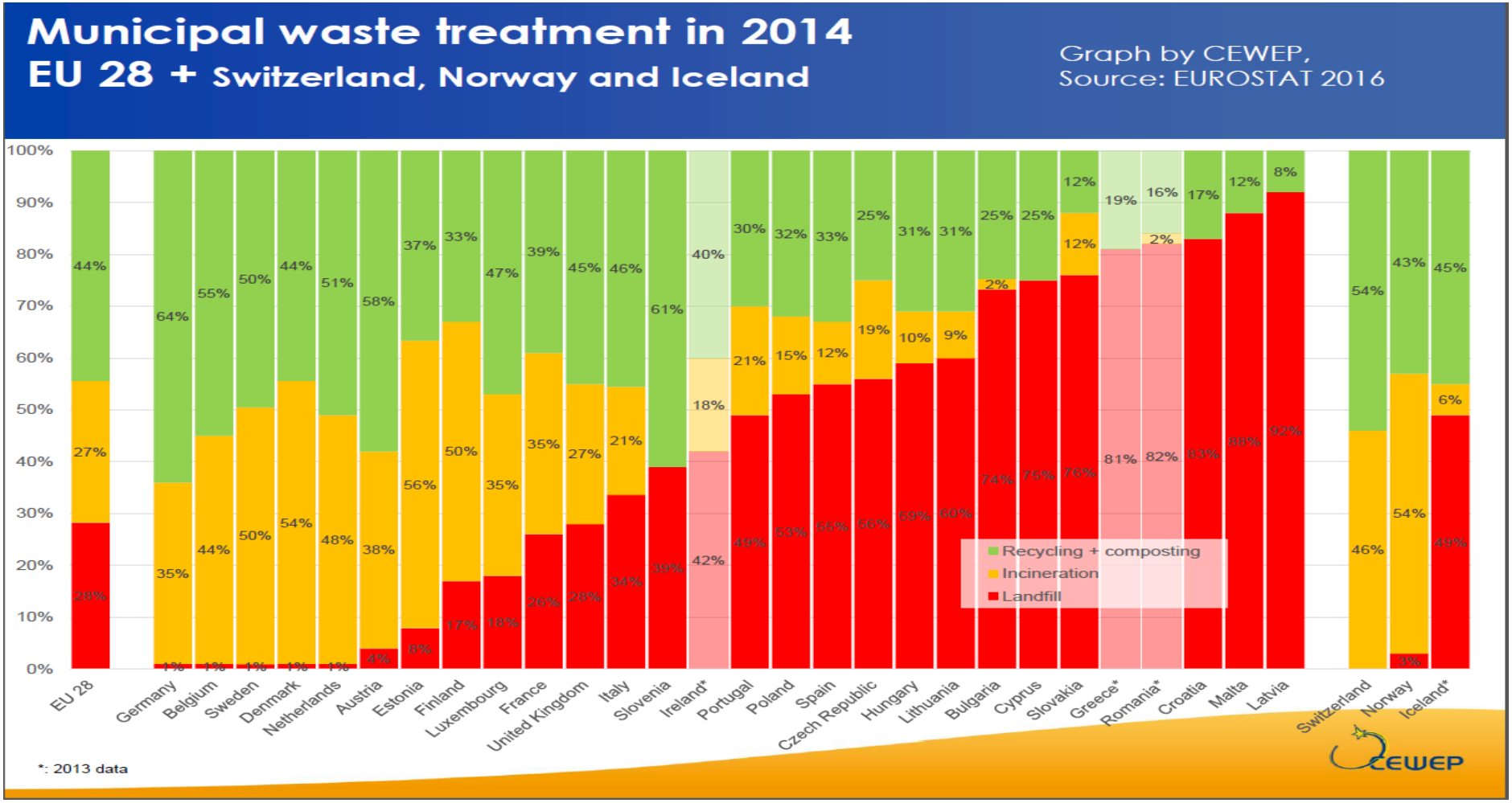
Outcomes

Germany:
Disposal Cost:
$294: 4 Person Household

USA - King County:
Disposal Cost:
$300: 4 Person Household

	1990's	**2010**
MSW Generation	50.9 M Tons	49.2 M Tons
Composting	13 %	17 %
Recycling	26 %	46 %
Waste-to-Energy	18 %	37 %
Landfill	**43 %** →	**0.4 %**
MSW Generation	208 M Tons	250 M Tons
Composting	2 %	8.1 %
Recycling	14 %	26 %
Waste-to-Energy	14 %	12 %
Landfill	70 % →	54 %

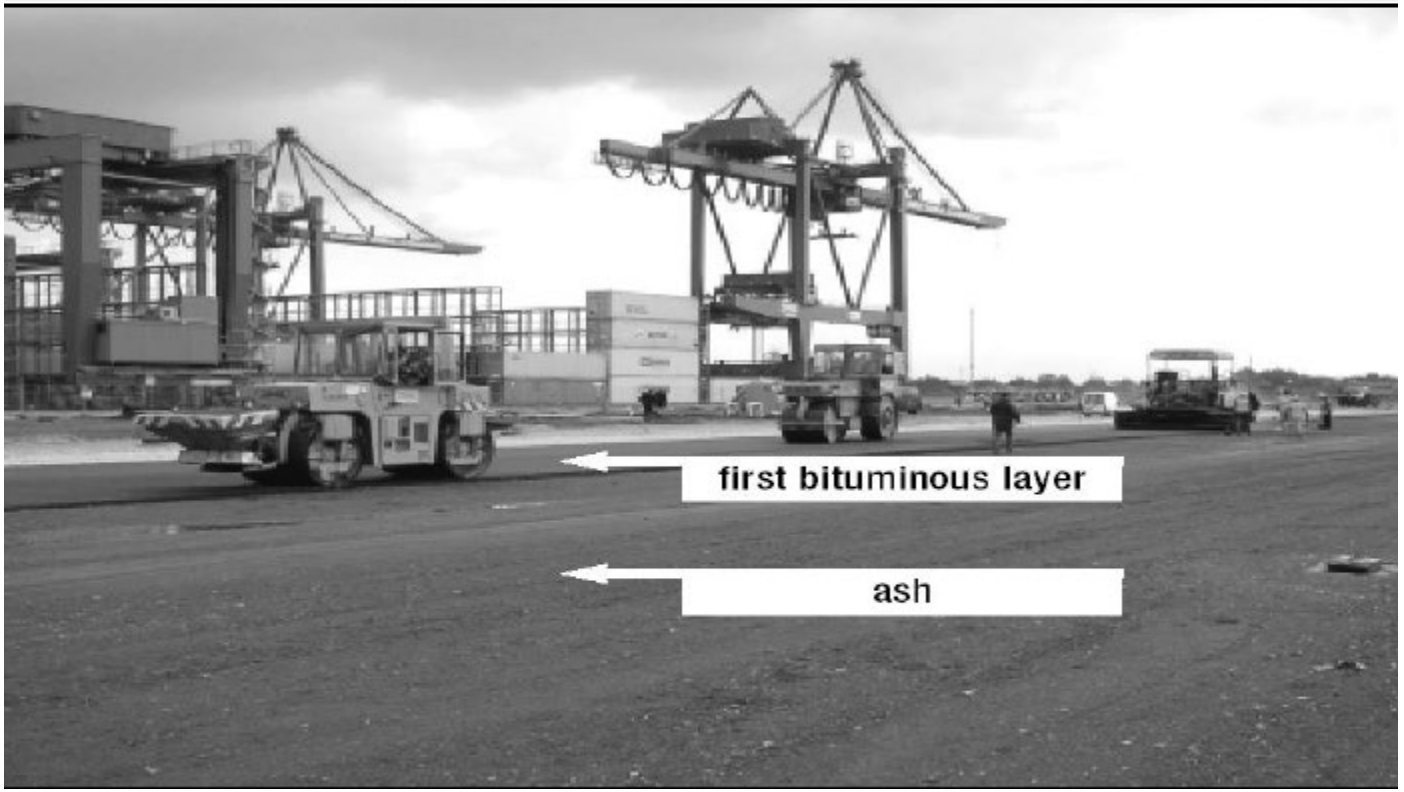
W2E encourages Recycling



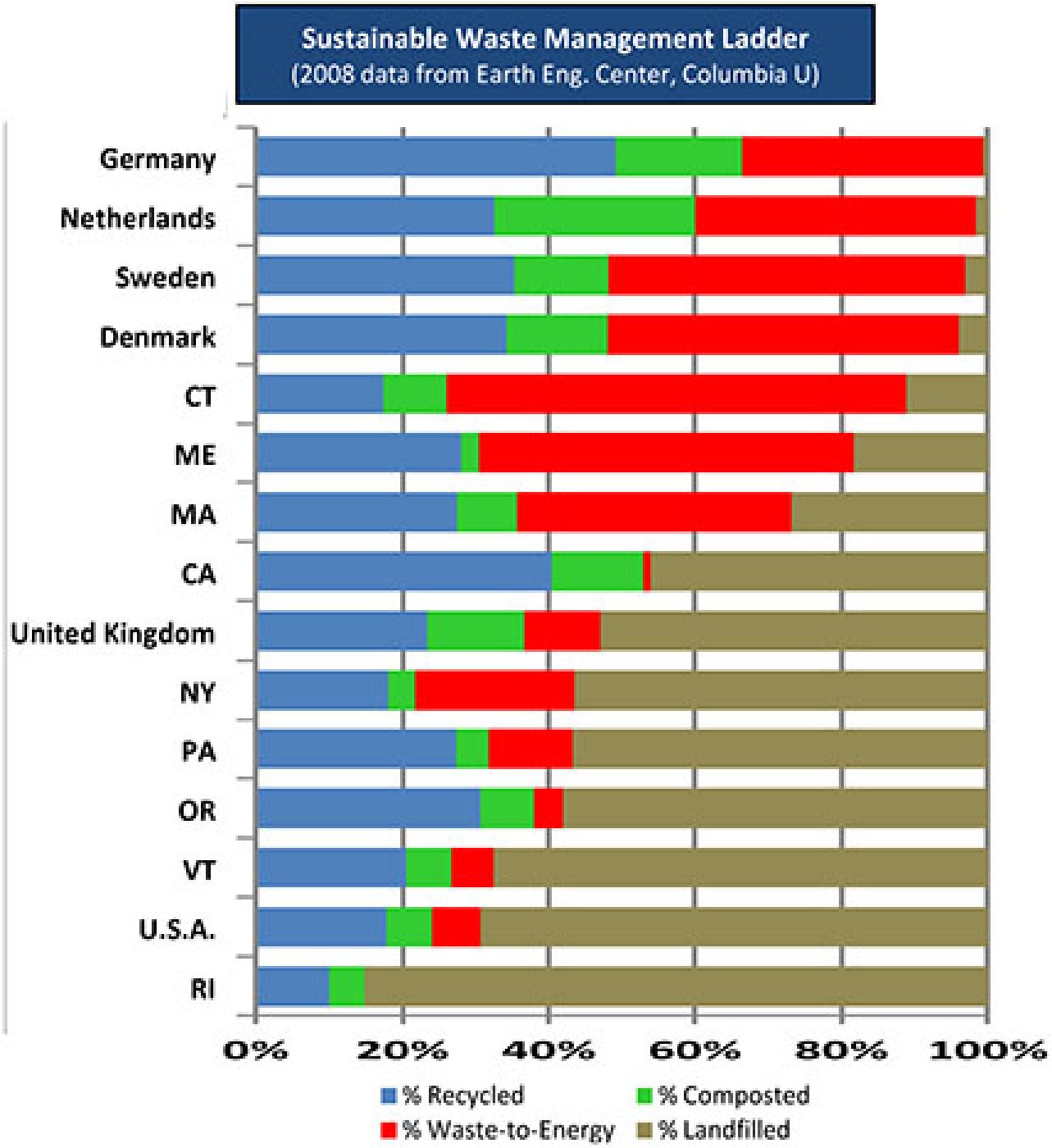
Example Facility, MVR, Hamburg, Germany:

Container-Terminal Altenwerder, Hamburg (3 million TEUs annually)

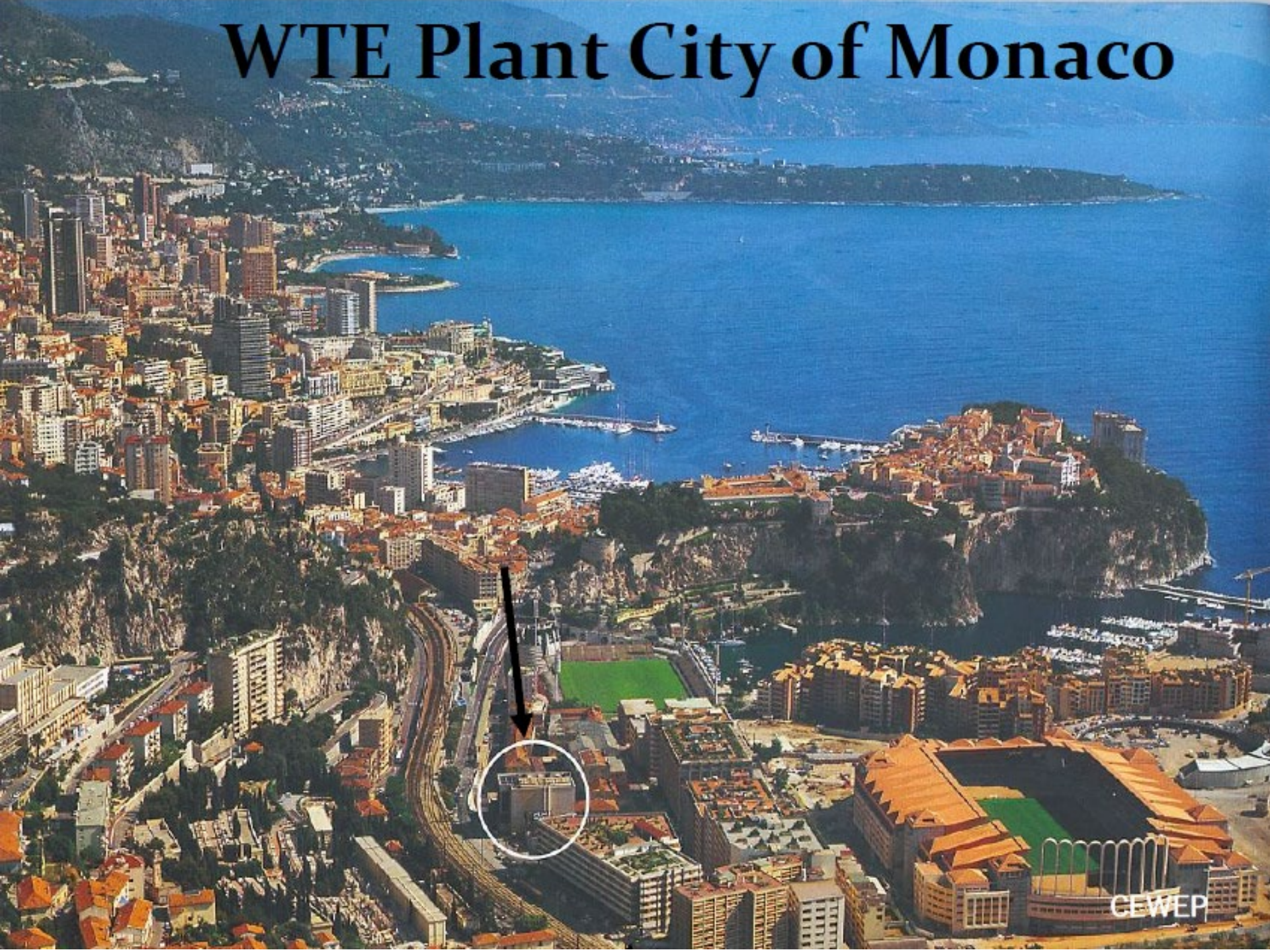
Application of ash (450,000 metric tons) utilized

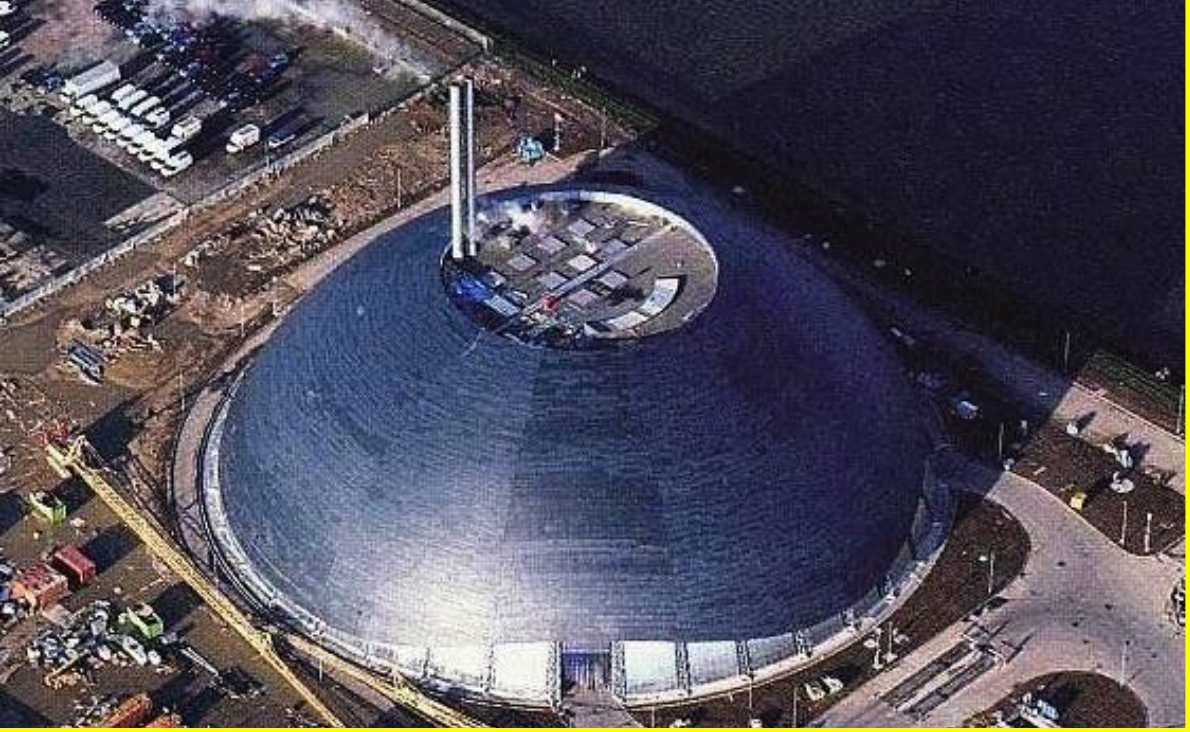


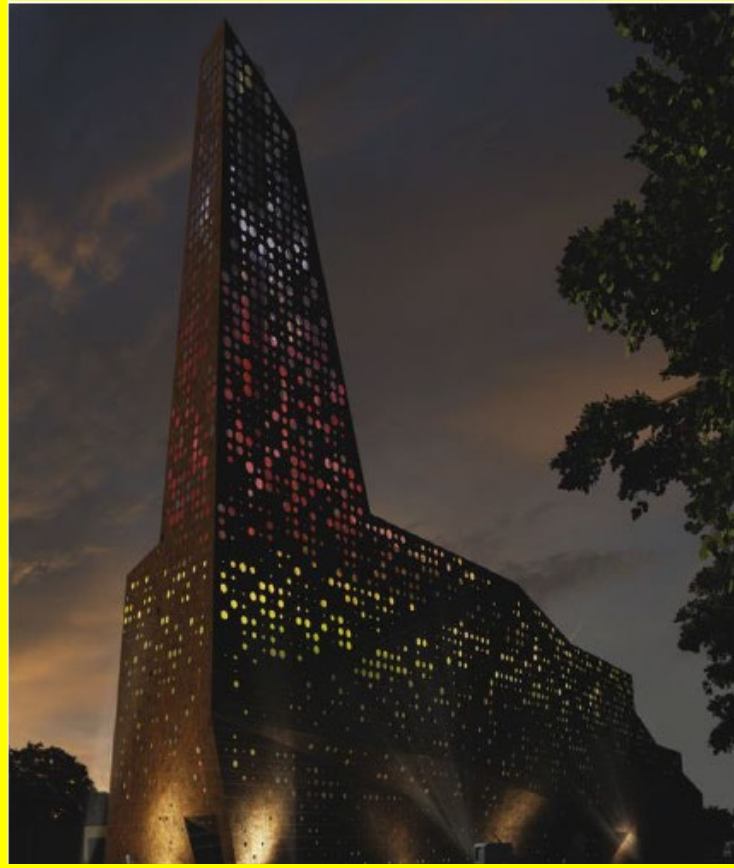
Disposal of WTE Ash Residue from 25+ Years of Operation in Four Lined Ash Monofill Cells


Sustainable Waste Management Ladder
(2008 data from Earth Eng. Center, Columbia U)
Germany
Netherlands
Sweden
Denmark
CT
ME
MA
CA
United Kingdom
NY
PA
OR
VT
U.S.A.
RI
0%
20%
40%
60%
80%
100%
% Recycled
% Composted
% Waste-to-Energy
% Landfilled

WTE Plant City of Monaco

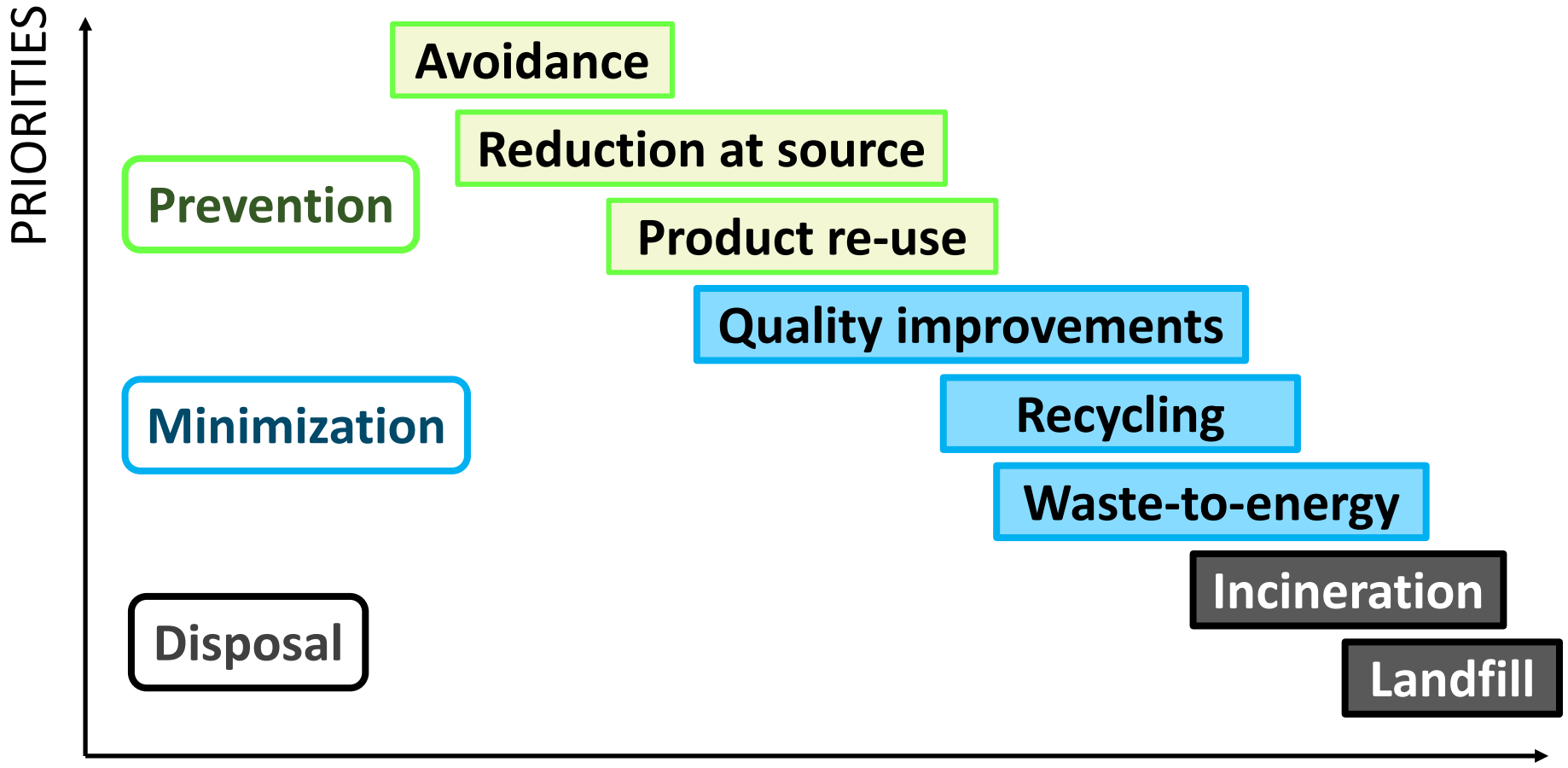




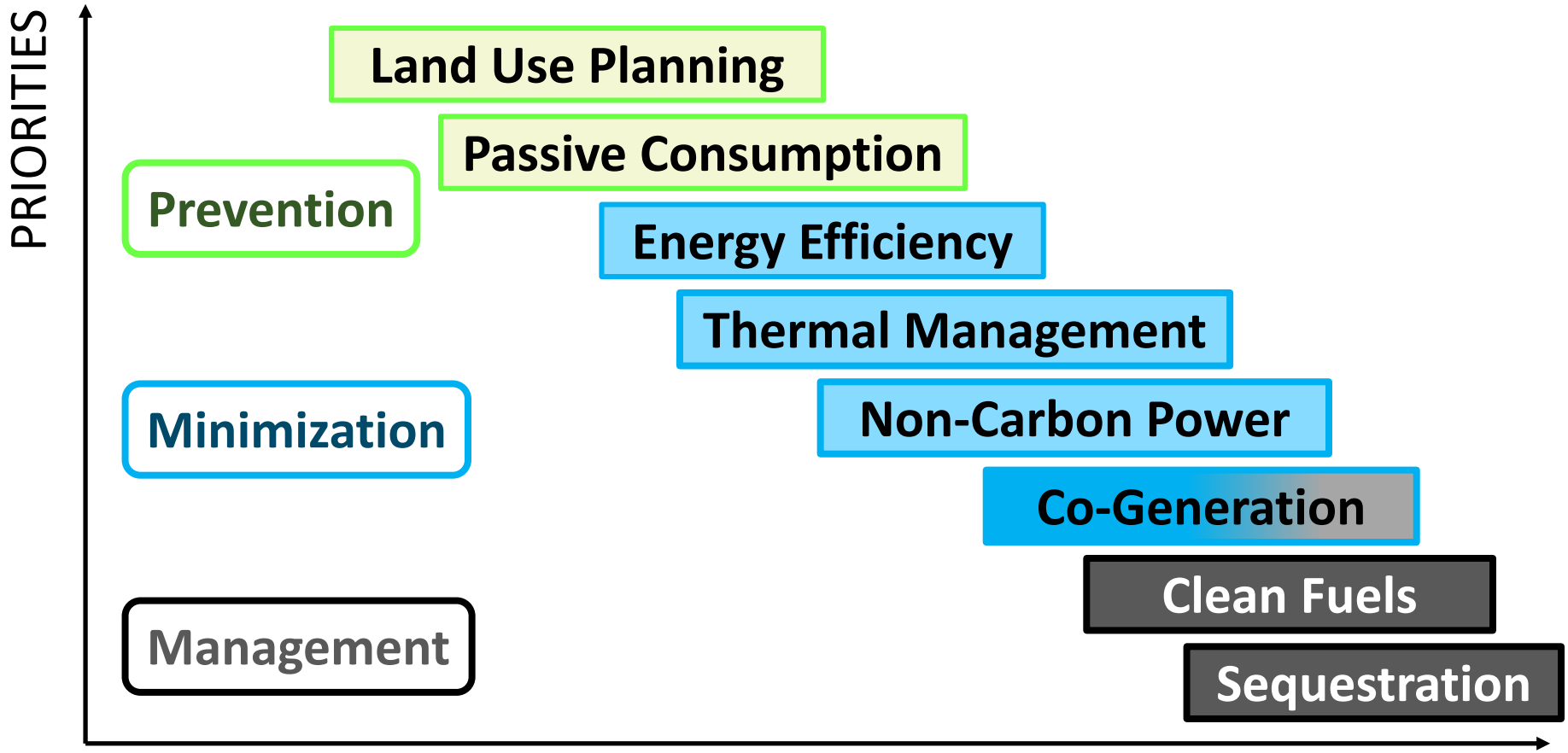



SYSAV

Waste Prioritization Hierarchy



Carbon Resource Prioritization



Tradeoffs vs. Priorities

A ***tradeoff*** is a balance achieved between two desirable but incompatible features; a compromise.

A ***priority*** is "a thing that is regarded as more important than another."

Tradeoffs imply that the two outcomes are equal.
Priorities imply that the two outcomes are unequal.

Within energy and waste, should we measure ***tradeoffs*** or ***priorities***?

Irony of the developed world

We set up a huge delivery supply chain.

We then create a huge waste collection chain.

Then we complain about polluting the earth.

For what purpose?

Thoughts?