UNECE Ministerial Conference, Astana, Kazakhstan

June 14, 2017

The role of Waste-to-energy (WTE) in a circular economy society

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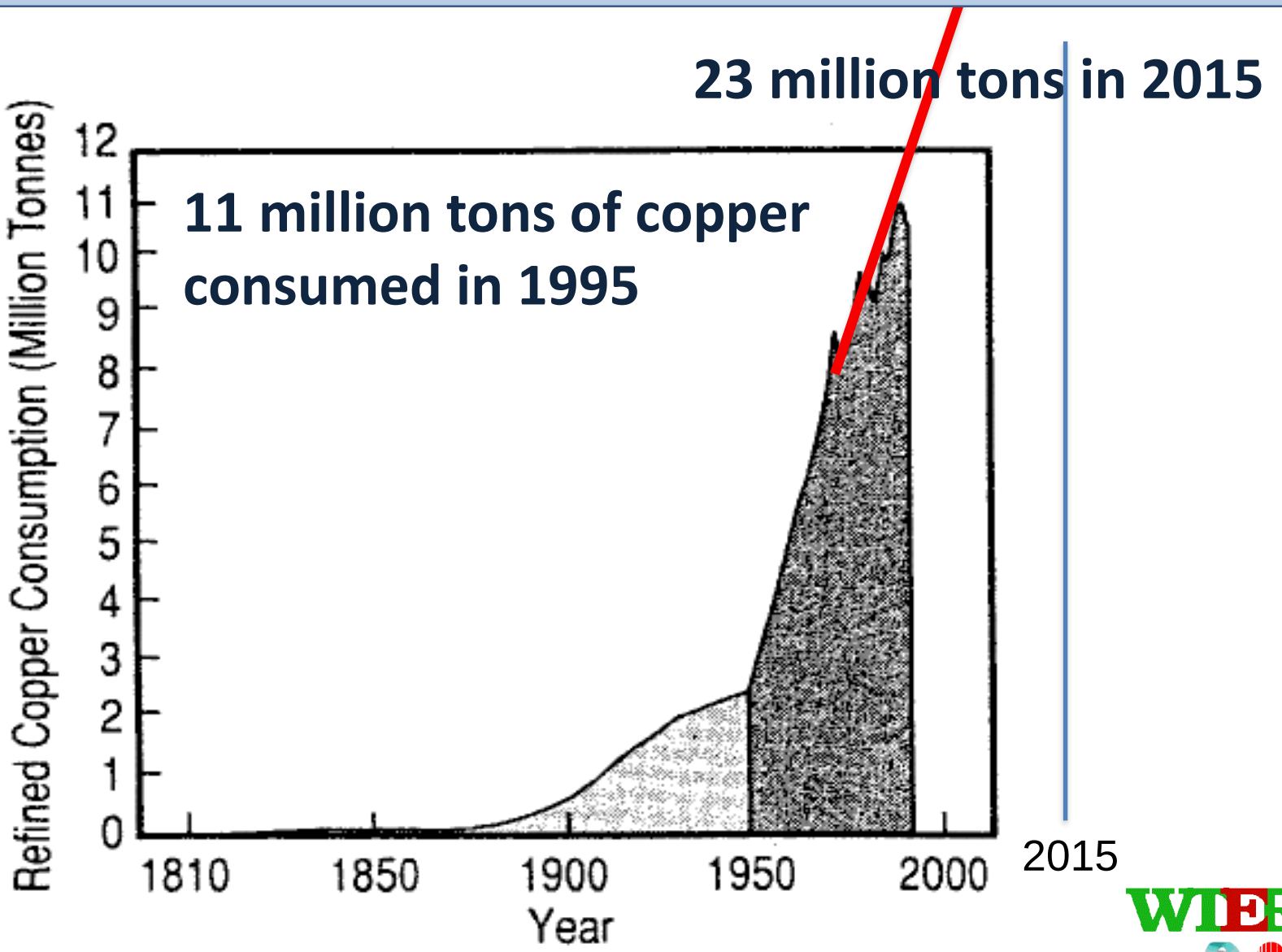
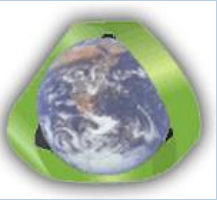
EARTH ENGINEERING CENTER

Importance of resource recovery for the sustainability of the planet:



Themelis' lecture to Metallurgical Society of Finland (1996)



Some conclusions from the previous slide:

- 1996: Humanity used much more copper in the period of 1950-1995, than it had been used in 6,000 years before that
- 2016: Consumption of copper has nearly doubled from 1995 to 2015
- 2016: If it had not been for recycling of copper, the world would have run out of copper and copper would have become very expensive

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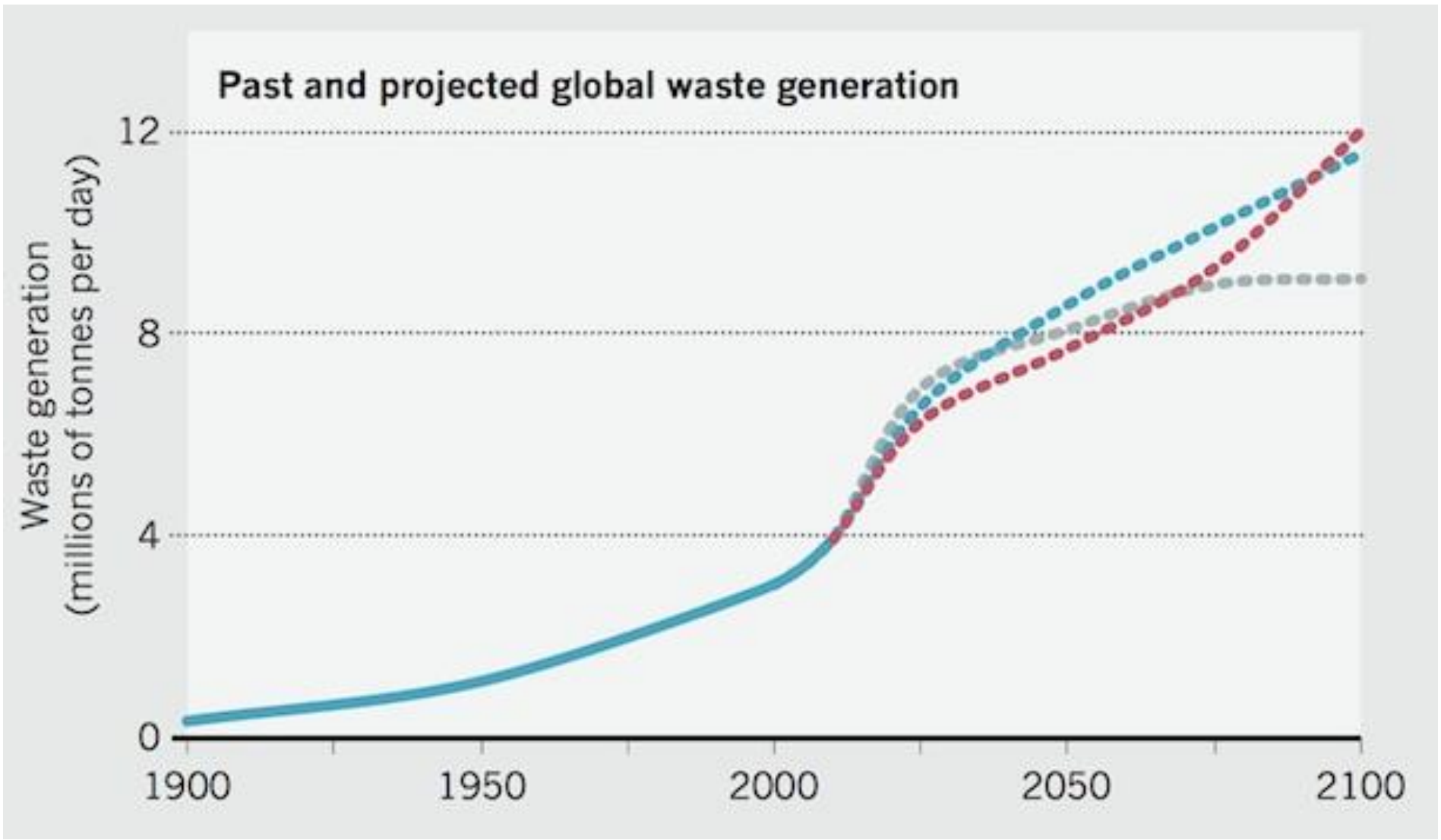
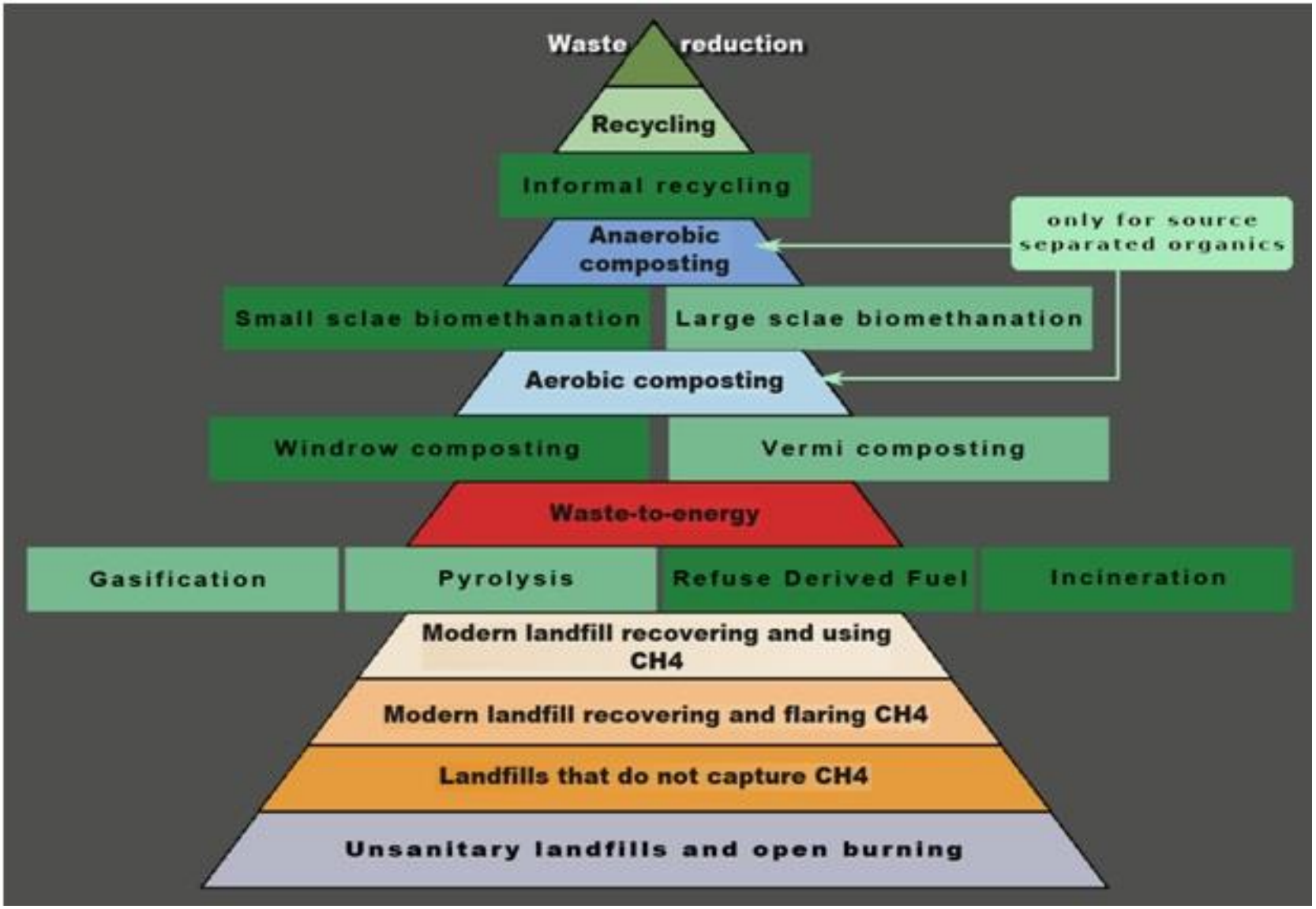
Global Waste Generation



Global waste generation predictions (Hoornweg, Bhada-Tata and Kennedy, 2013)

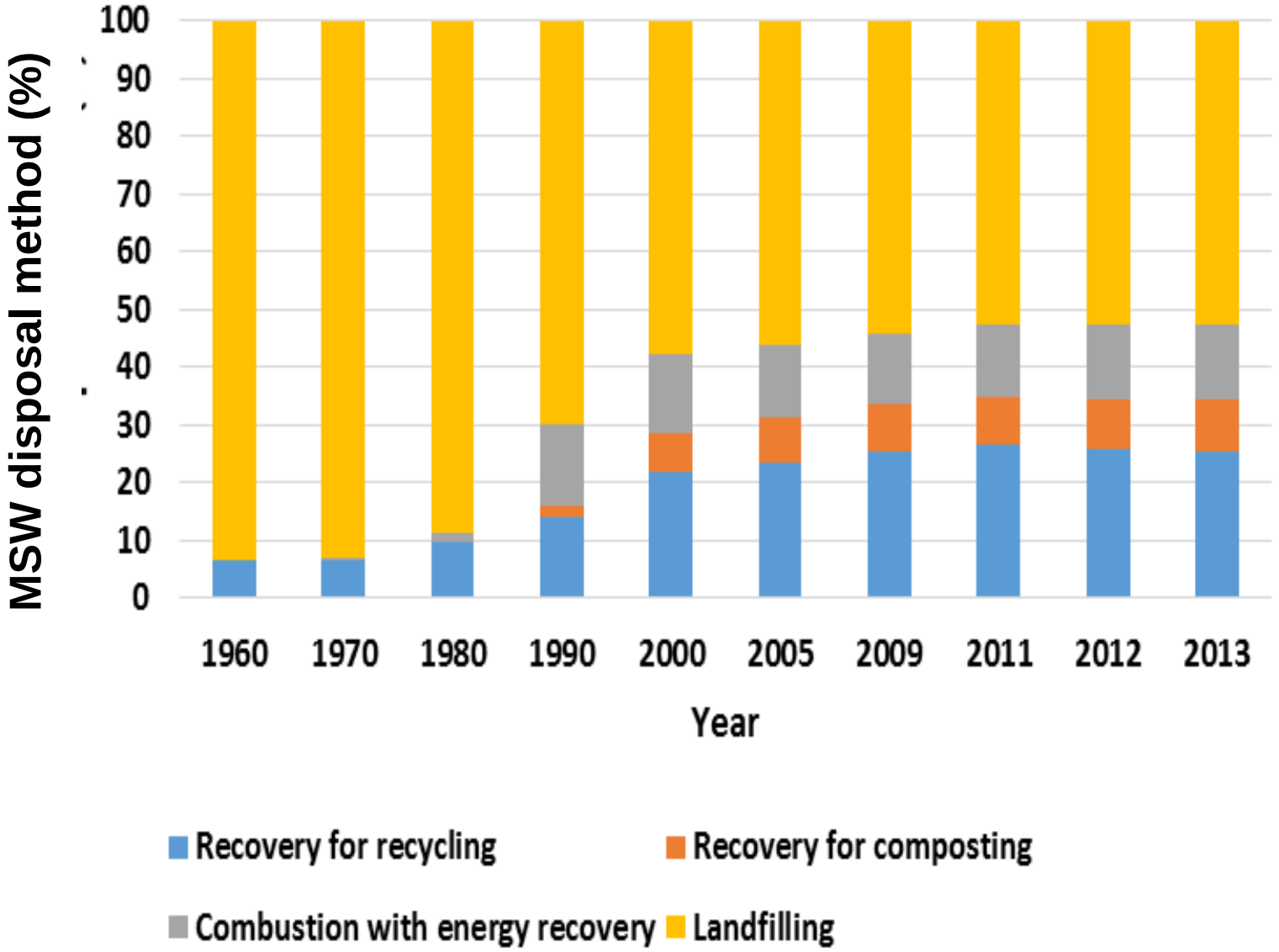
The EEC Hierarchy of Sustainable Waste Management



Necessary ingredients for successful recycling

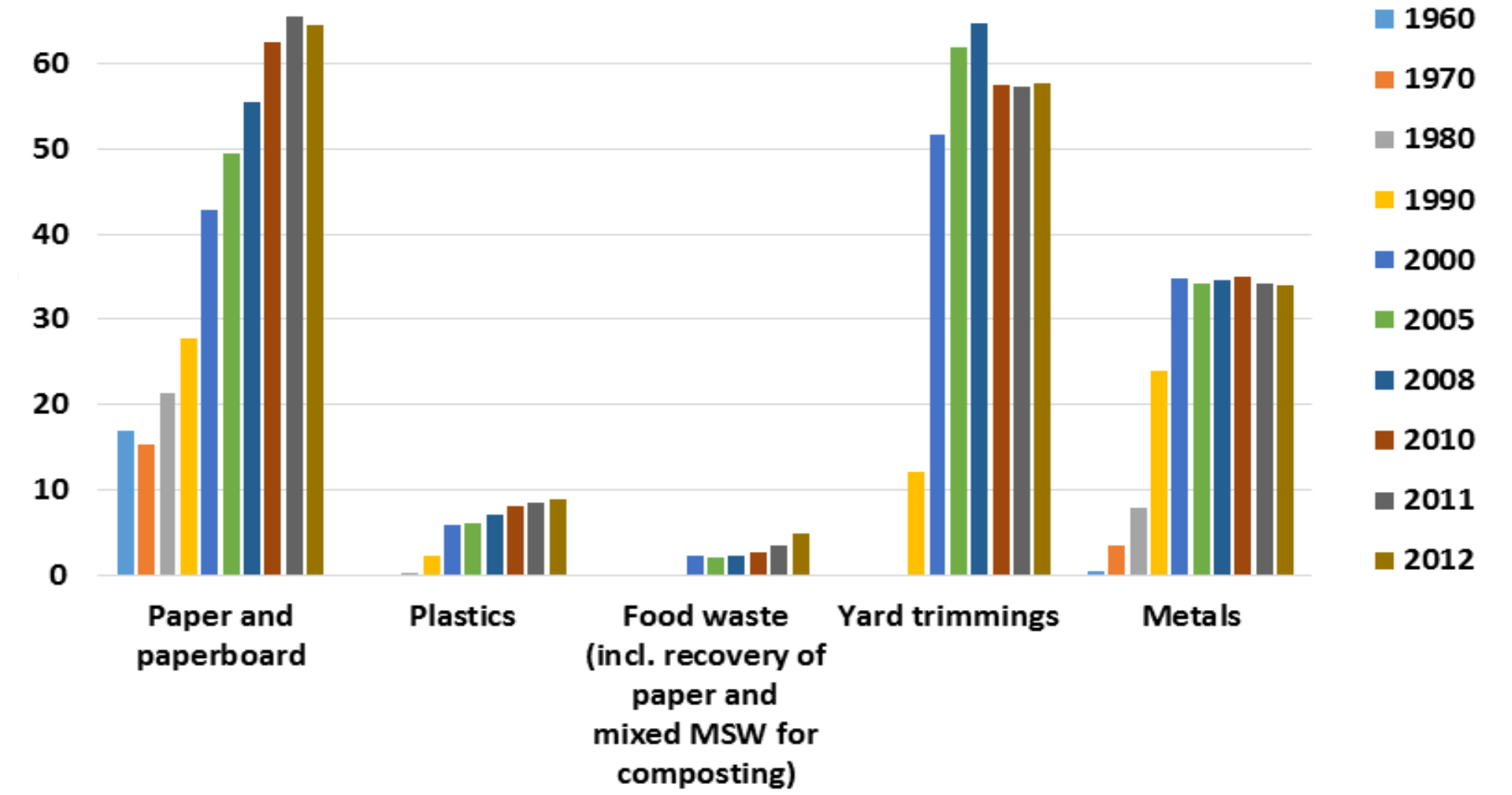
- **Communities** with **separate collection** of recyclable materials (principally metals, paper/ cardboard, green wastes)
- **Citizens** who **separate** recyclables at the source
- **Markets** that can use/make profit from the recyclable materials (e.g. metal smelters, secondary paper mills)

In developed countries recycling and composting have reached their limit: E.g., U.S.(1960-2013)



Some materials are much easier to recycle than others (e.g., U.S., 1960-2012)

Paper> green wastes> metals> plastics> food wastes



Managing post-recycling wastes

Only two options to manage post-recycling wastes:

- **Sanitary landfills**
- **Waste to Energy (WTE)**

WTE advantages over sanitary landfilling:

- **Destruction of pathogens**
- **Conservation of land near cities (LF=1 m2/10 tons MSW)**
- **Electricity production: >0.5 MW over sanitary LF**
- **GHG emission reduction: 0.5 -1 ton per ton MSW to WTE**
- **Metal recovery**

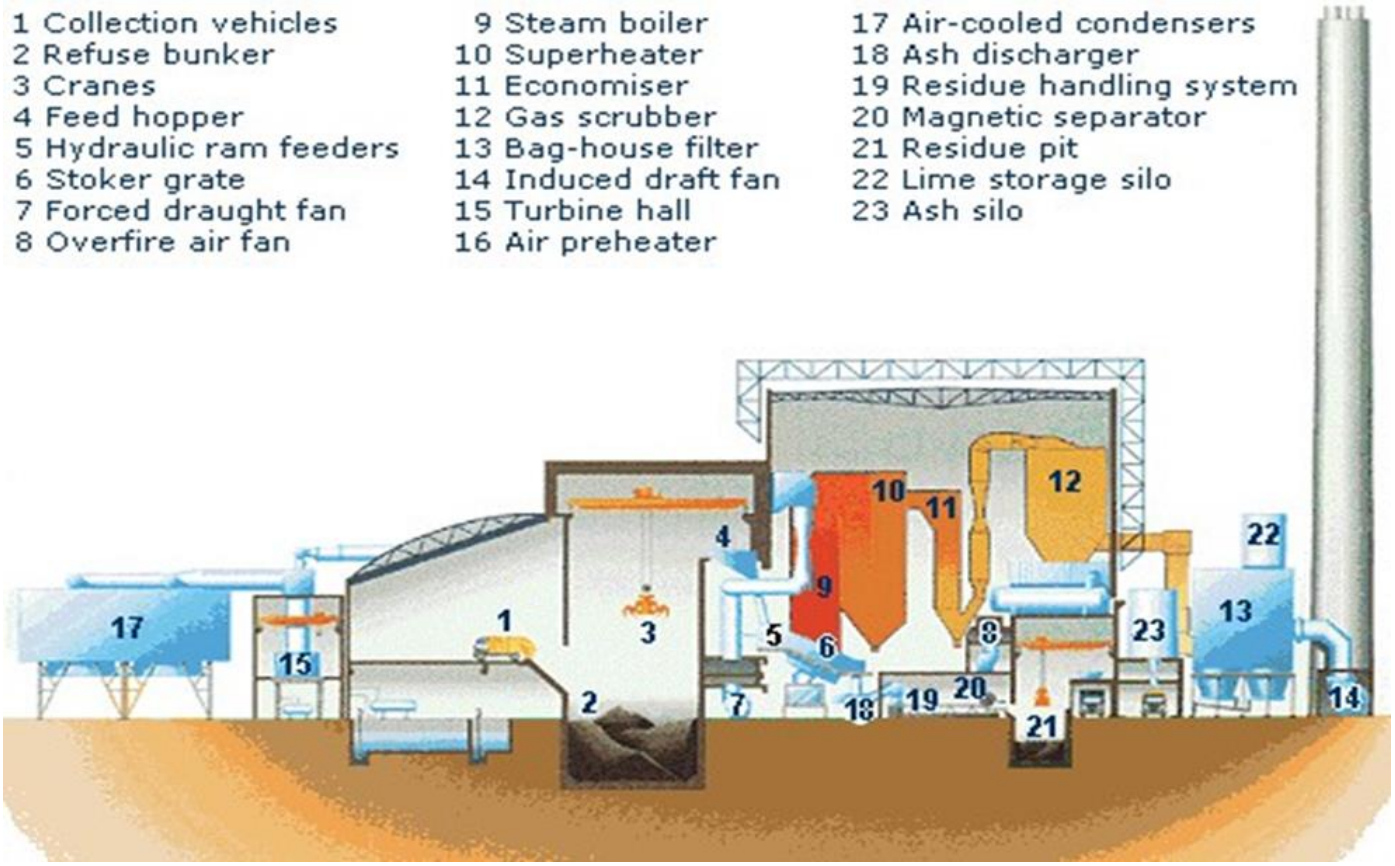
Global use of land for landfilling in one year

Estimated average ultimate use of land for proper (sanitary) landfilling of MSW: One square meter gone for ever, for every 10 tons of MSW landfilled

- Current global landfilling converts an estimated 100 square kilometers of greenfields to landfills
- If it were done at one landfill it would use up a land surface equal to that of metropolitan Paris
- At present rate of MSW generation, continued landfilling would use up 10,000 square kilometers in this century

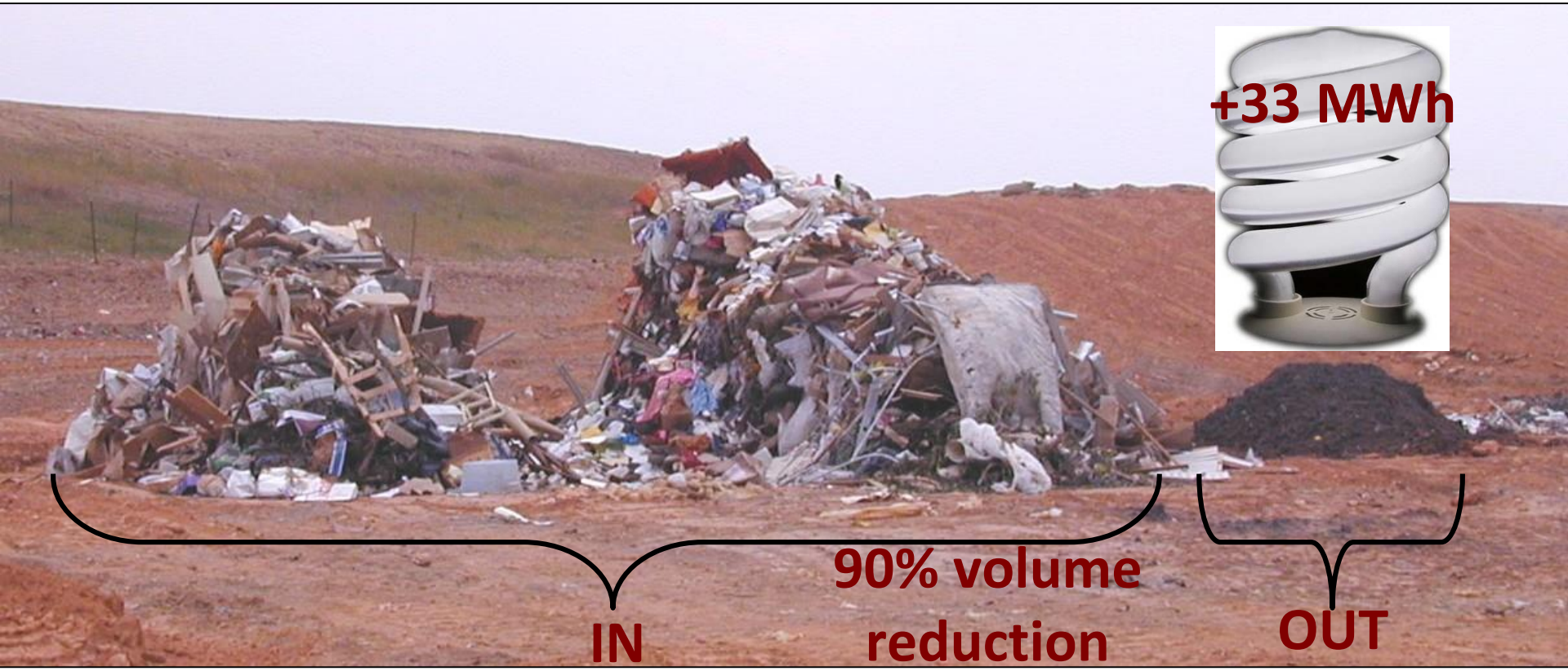
A typical moving grate WTE plant

1 Collection vehicles
2 Refuse bunker
3 Cranes
4 Feed hopper
5 Hydraulic ram feeders
6 Stoker grate
7 Forced draught fan
8 Overfire air fan
9 Steam boiler
10 Superheater
11 Economiser
12 Gas scrubber
13 Bag-house filter
14 Induced draft fan
15 Turbine hall
16 Air preheater
17 Air-cooled condensers
18 Ash discharger
19 Residue handling system
20 Magnetic separator
21 Residue pit
22 Lime storage silo
23 Ash silo



CHP: electricity (> 0.6 MWh per tonne of MSW) and district heating/cooling (> 0.5 MWh per tonne of MSW).

WTE reduces volume of MSW by 90%
Bottom ash is reusable



100 cubic meters of MSW

10 cubic meters of WTE ash

Waste to Energy bottom ash recycling plant

Coarse fraction, 10- 15%

MAGNETS, ECS → SCREEN → Medium fraction, 40-70 %

Fine fraction, 15- 45 %

Public acceptance of WTE: Need to inform the public

- In some countries, there is continuing **opposition** to WTE based on the **early history of incineration.**

- For example, any **new proposal for WTE** is **opposed** by people who claim that a new WTE plant will emit **dioxins** harmful to public health.

Columbia detailed studies of four nations annual WTE dioxin emissions

Country	Year of study	MSW processed (million tons)	Average Dioxin Emissions (ng TEQ/Nm3)	Total Dioxins Emitted (g TEQ/year)
USA	2012	25.9	0.027	2.90
France	2010	13.8	0.013	0.79
South Korea	2010	3.9	0.007	0.11
China	2015	61.8	0.1*	24.7

*Assumed average; Everbright average: 0.019 ng TEQ/Nm3

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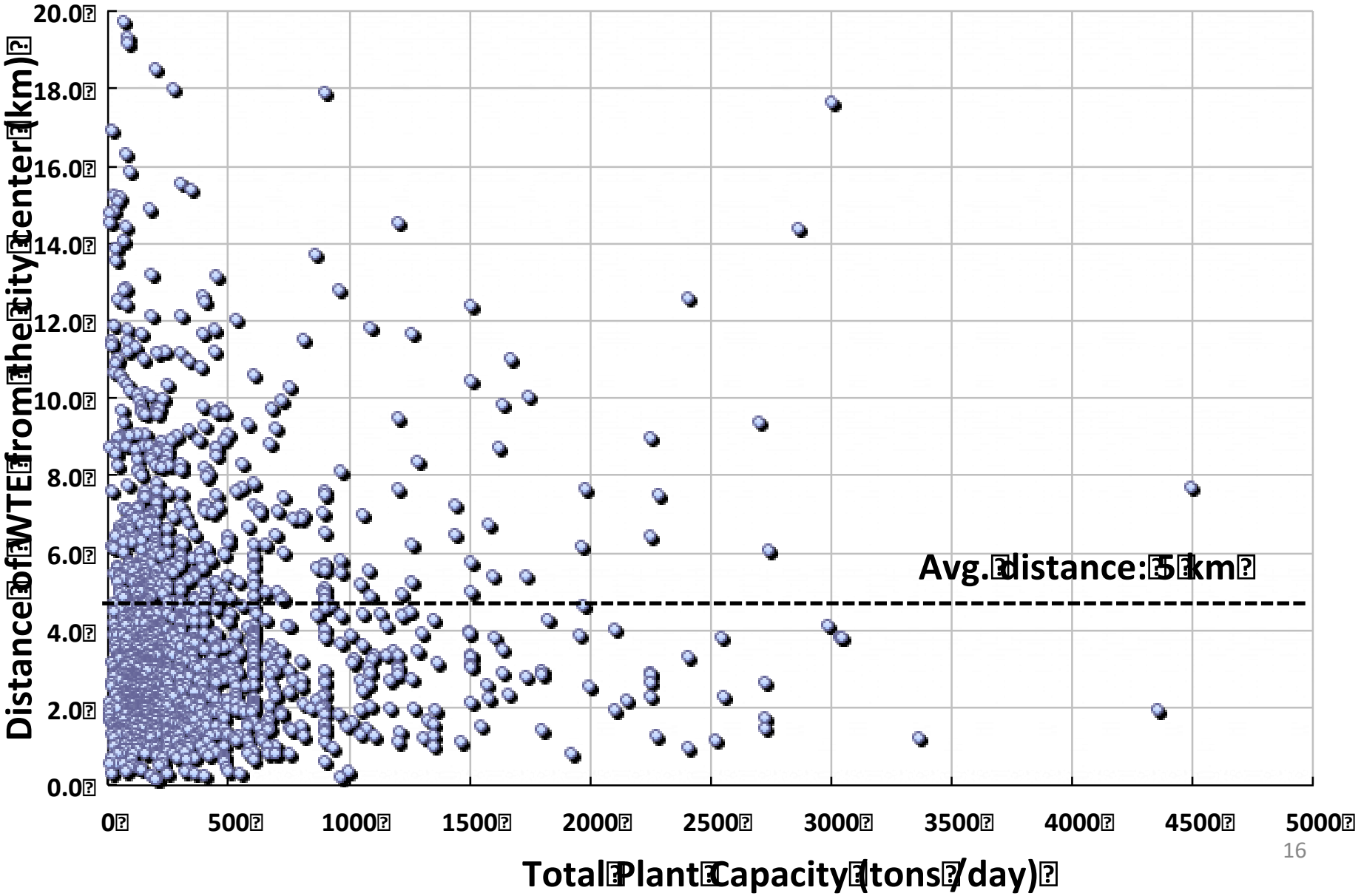
Distance of global WTEs from center of city



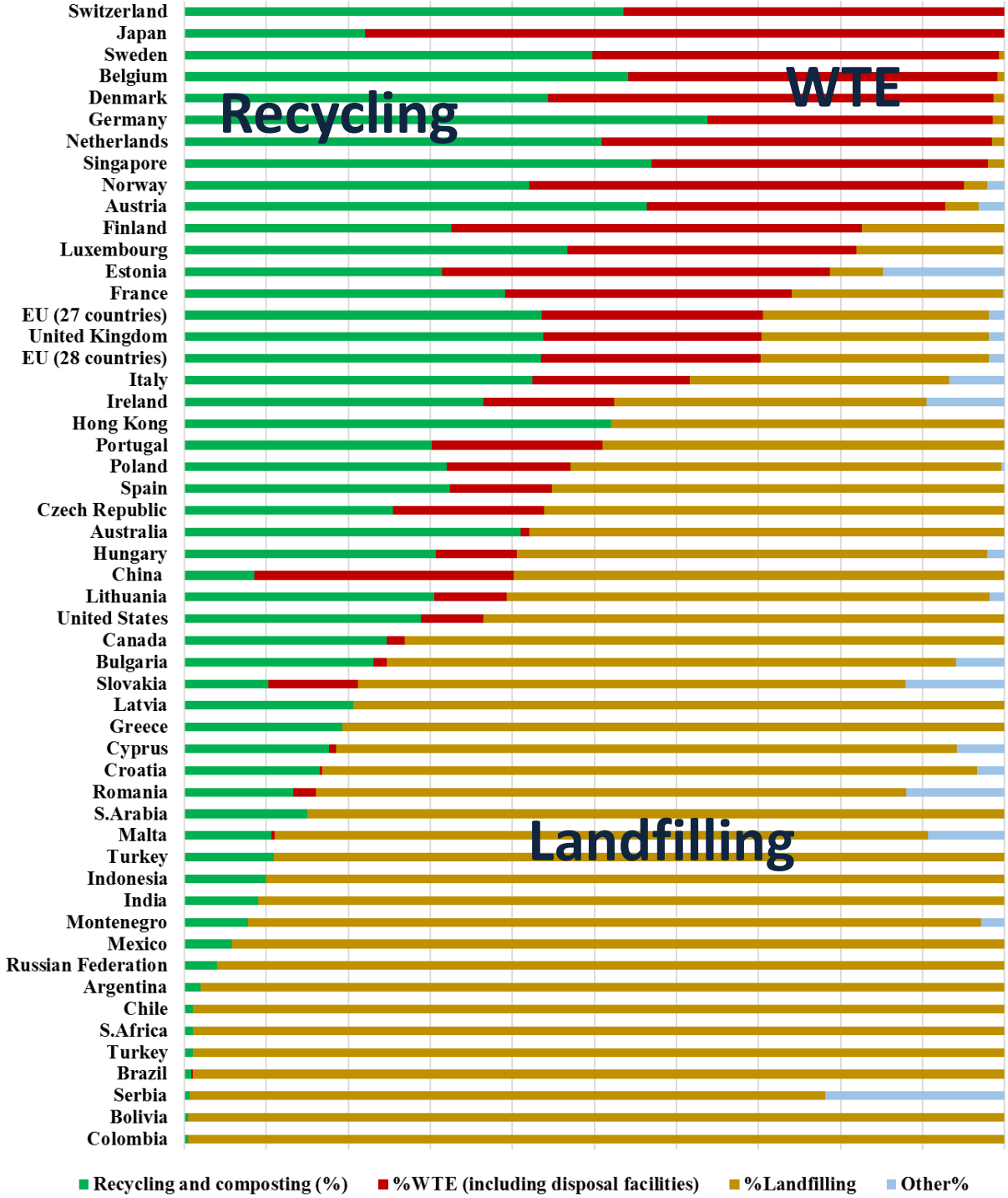
The Global picture of waste management

Global generation and disposition of MSW

Estimated global disposition of urban post-recycling MSW

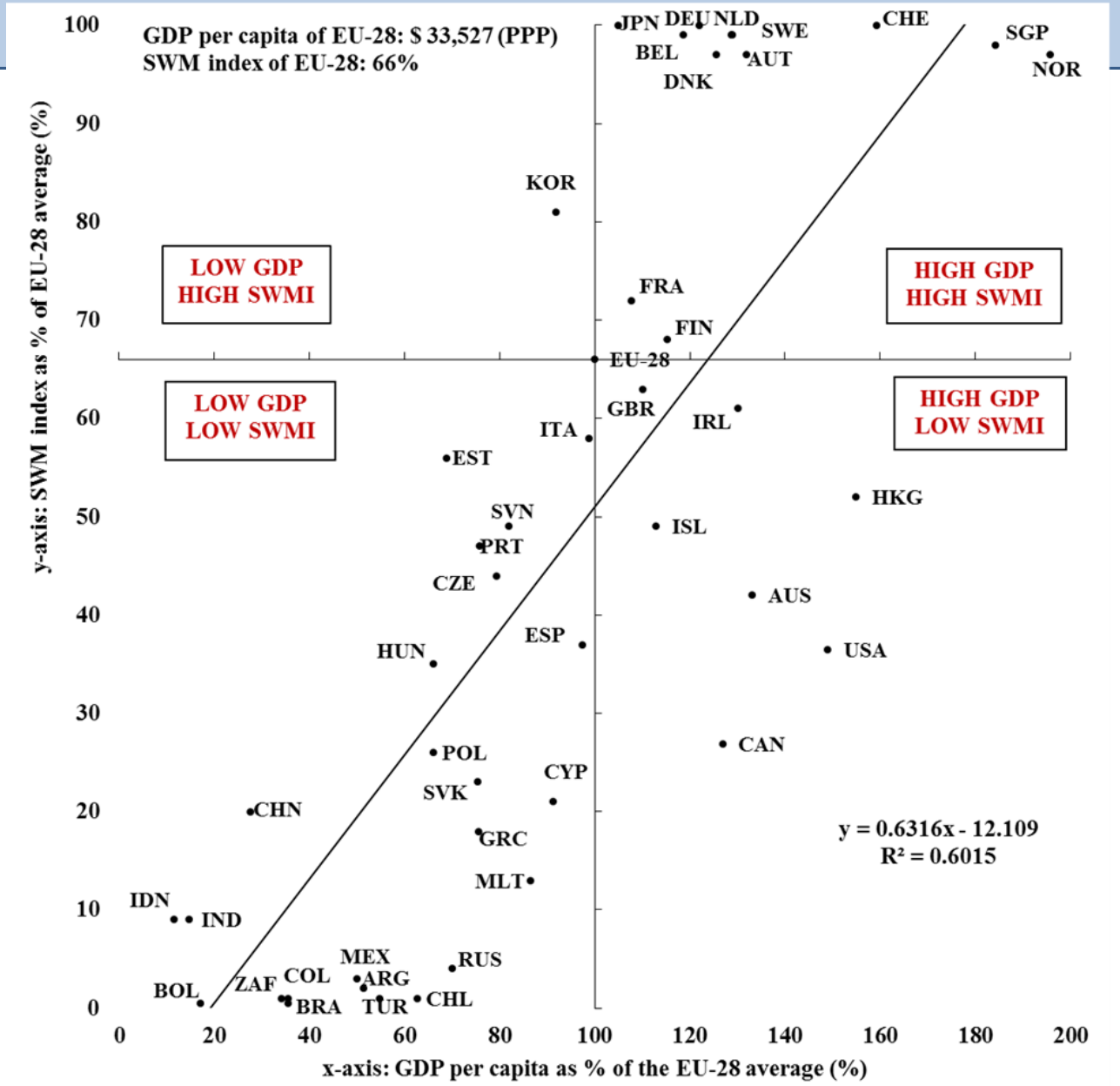
- Thermal treatment (WTE): 230 mill. tons
- Sanitary landfill, partial CH4 recovery: 250 mill. tons
- Landfilled without CH4 recovery: >800 mill. tons

- MSW generation has tripled since 1950 and is expected to be six times greater by 2030



‘Ladder’ of Sustainable Waste Management of nations

Sustainable waste management (SWM) index vs per capita GDP

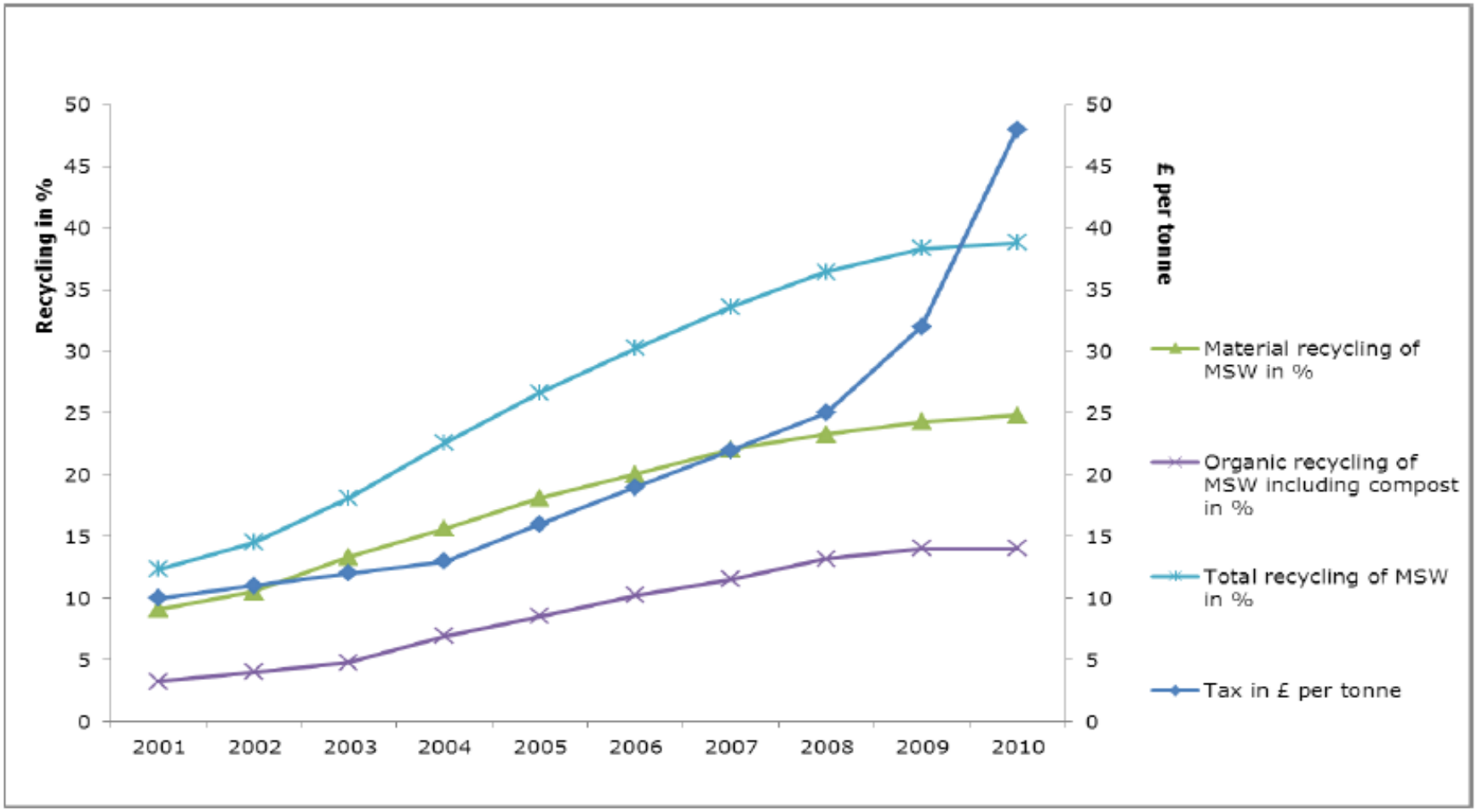


How S. Korea has done it?

Very high levels of recycling, composting and WTE, achieved in less than 20 years, by means of:

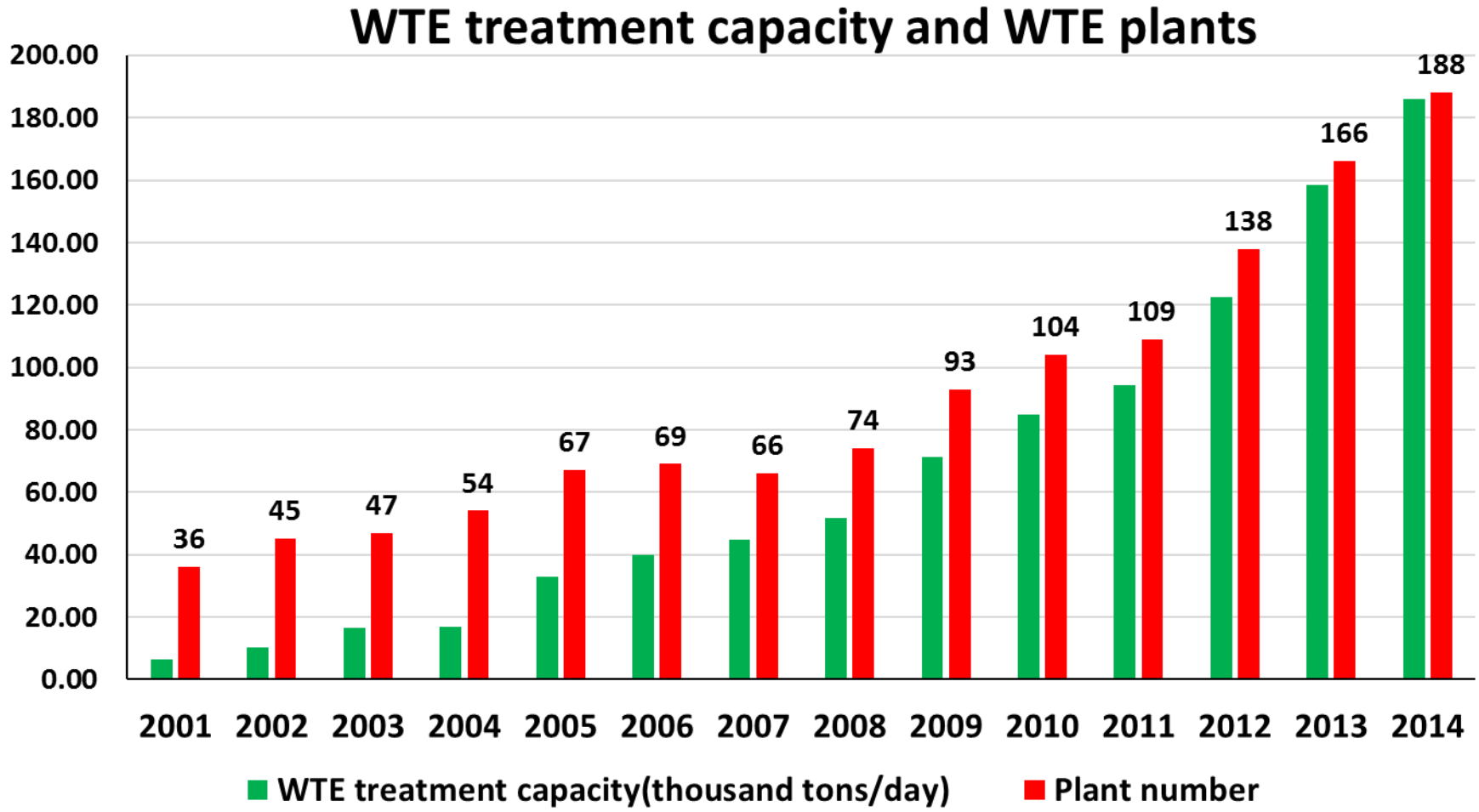
- **Planning, policy, regulations, and public education at national level**
- **Implementation at municipal level**
- **Assistance by national/regional agencies to municipalities in implementing regulations**
- **Citizen compliance and participation**

Successful case in recycling and composting: UK through increase in landfill tax



Source: ETC/SCP, 2012 and Eurostat, 2012. Note : landfill tax is shown for active waste – for inactive waste it lies at GBP 2.50/tonne

Successful case in conversion of open dumps to WTE: China Growth in number and average capacity of WTE in China



Yating Yu, EEC/Columbia 2016

Reducing the initial capital investment in WTE plants makes WTE plants competitive with sanitary landfills

- China has demonstrated that it is possible to reduce the capital cost of WTE plants by means of
  - Industrial and academic **R&D**
  - **Mass production**, Instead of one plant at the time
- Incentives to WTE: **Credit for renewable energy production** ($30/MWh of electricity produced by WTE vs coal-fired power plants)

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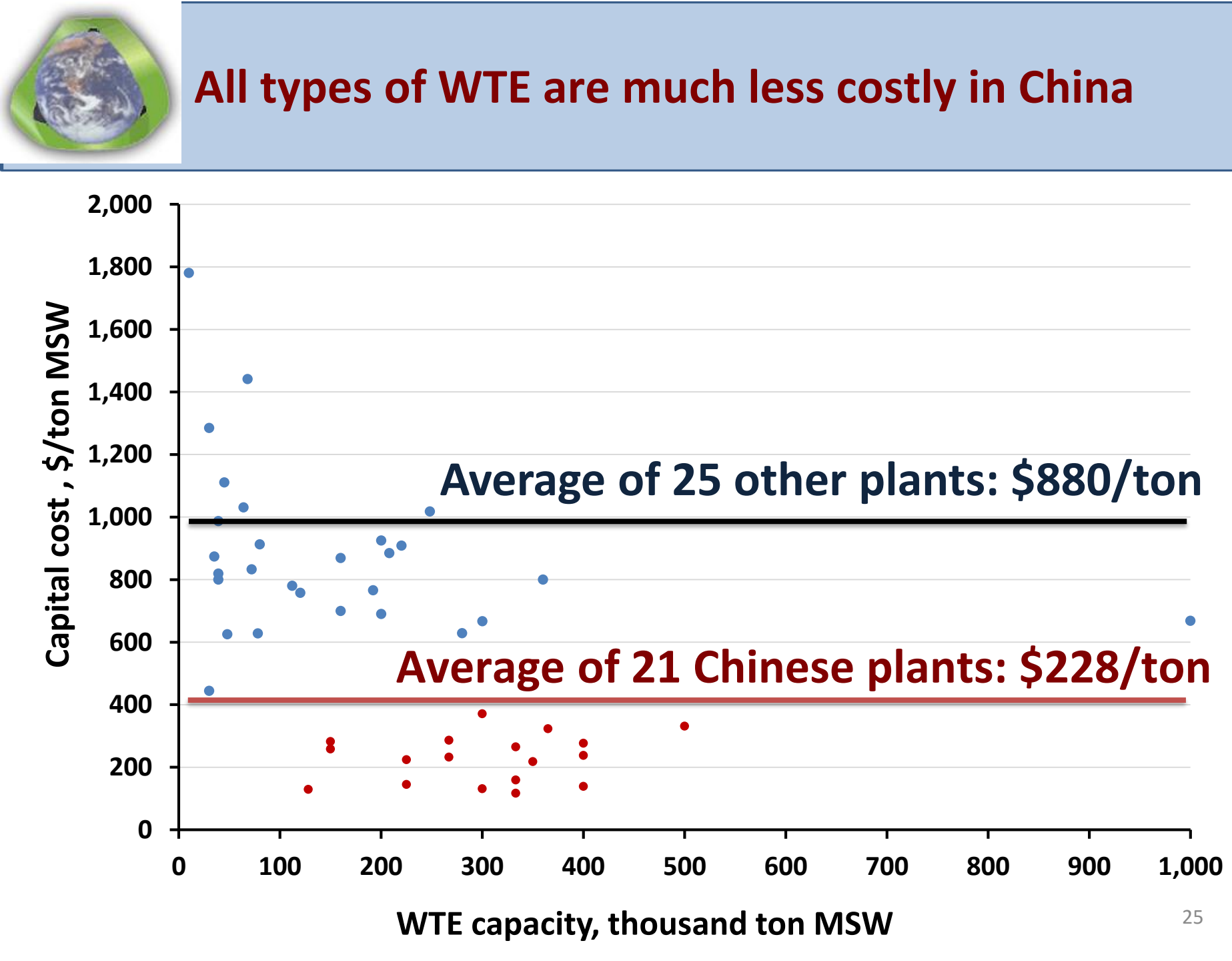
All types of WTE are much less costly in China



Why all this talk about China becoming a world leader in WTE in about ten years?

- China should be a good example to other countries
- Developed nations took several decades to reach their present state of development and achievement in sustainable waste management
- Developing nations can use Chinese know-how and capital to accelerate the application of WTE technology and the phasing out of landfilling

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Worldwide examples: Copenhagen, Denmark

CEI WTE plant in Nanjing, China

The Global WtERT Council (GWC)

- WtERT-U.S. was founded by the Earth Engineering Center of Columbia University with the aid of the U.S. WTE industry in 2002
- At the end of 2011, GWC was incorporated as a non-profit organization under the laws of the state of New York and the U.S.A.
- By 2017, 12 national plus one regional (WtERT-Asia) organizations

The mission of the Global WTERT Council (GWC):

- Bring together universities, industry and government concerned with sustainable waste management
- Identify the best available technologies for the recovery of materials and energy from all types of "wastes"
- Disseminate this information by means of publications, the multilingual WTERT web pages, and national/international conferences.

Role of universities in disseminating credible information on major environmental problems

- People generally resist change, even when change is for the good.
- The first central systems for potable water, for wastewater treatment, for management of solid wastes were resisted for lack of adequate information.
- Some people acquire “fame” by leading movements against beneficial change.
- It is therefore necessary for universities to lead the effort for sustainable development.

How universities can fulfill their role:

- Through educational programs
- Through academic research
- Through the dissemination of credible information (publications, the web, public meetings)

Universities need industry and government support!

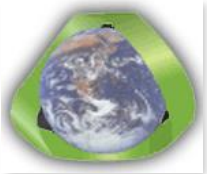
Sponsored by:

IDB Inter-American Development Bank

GUIDEBOOK

FOR THE APPLICATION OF WASTE TO ENERGY TECHNOLOGIES IN LATIN AMERICA AND THE CARIBBEAN

NICKOLAS J. THEMELIS, MARIA ELENA DIAZ BARRIGA,
PAULA ESTEVEZ, AND MARIA GAVIOTA VELASCO



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MARCH 2012

WTERT "wte guidebook"

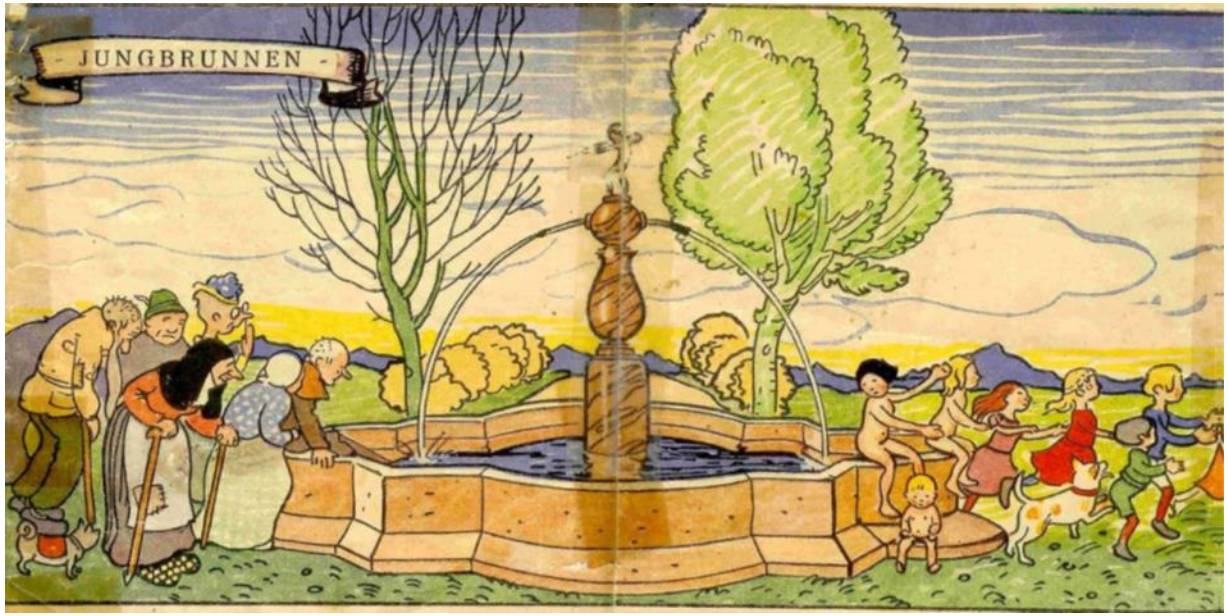
- Already available In English, Portuguese, Spanish.
- Chinese edition underway by WTERT-Asia

Waste to Energy providing new material resources

Waste → Resource opportunity

Research

The best opportunities need research to make them happen



Thank you very much for your attention!

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Appendix: U.S. dioxin emissions from all industrial and from area sources (forest and landfill fires, flaring of LFG), in grams TEQ

	1987	1995	2000	2012
Total industrial sources	13,833	2,634	998	511
Total ind'l plus area sources	16,125	4,925	3,827	3,808
WTE dioxins as % of total U.S. dioxins	58.9%	24.4%	2.0%	0.08%

Dioxins from unintended landfill fires in the U.S. in 2012:
1,300 grams TEQ vs. 3.0 gramsTEQ from WTE