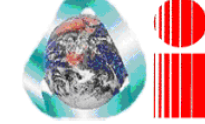


A LOOK INTO THE FUTURE OF THE GLOBAL WTE INDUSTRY

Nickolas J. Themelis,

Director, Earth Engineering Center, Columbia University,

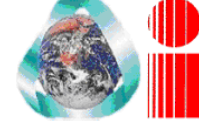
Chair, Global WTER Council (GWC)



Estimated global disposition of urban post-recycling municipal solid wastes (total: 1.2 billion tons; 2012)

- Thermal treatment (WTE): 200 mill. tons
- Sanitary landfill, partial CH₄ recovery: 200 mill. tons
- Landfilled without CH₄ recovery: >800 mill. Tons

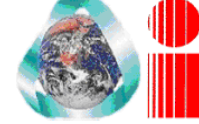
All numbers are expected to double by 2030



Text

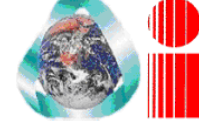
- Destruction of pathogens
- Volume reduction
- Environmental protection
- Mineralization and immobilization of hazardous substances
- Resource conservation
- **Public acceptance**
- **Affordable capital cost**

WTE meets these criteria, except the last two



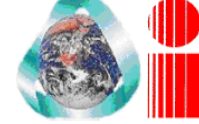
- The results of early waste incineration were an environmental disaster (Brunner and Zobrist, 1983).
- It has taken a new generation of science, technology, and legislation to perform the quantum leap that was necessary to improve incineration to the point that it has become WTE and an integral part of sustainable waste management
- However, In the U.S., Canada, and Australia, there is still opposition based on past history.
- It is necessary for industry to use the media and the universities to inform the public and through the public the legislators (“bottom up” approach)

What is affordable cost of WTE?



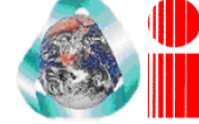
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and Technology Council

- Depending on their economic capacity and culture, countries spend between 0.2% and 0.4% of their GDP on MSW management (Brunner and Fellner, 2007).
- Since the per capita GDP ranges from \$200-\$100,000, there is no uniform solution for all countries when attempting to reach the goals of waste management.



- With regard to sustainable waste management, South Korea is ahead of the U.S., although the ROK GDP per capita = 63% of the U.S. GDP

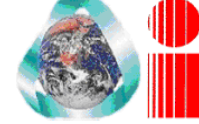
How South Korea has done it?



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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



Only two options to manage post-recycling wastes: Thermal treatment (WTE) or Sanitary landfill

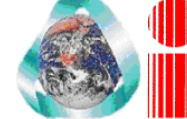
WTE advantages:

- Destruction of pathogens**
- Conservation of land near cities**
- Electricity production (>0.5 MW over sanitary LF)**
- Reduction of GHG emission (0.5-1 ton per ton MSW to WTE)**

WTE disadvantage: Higher gate fee needed (EEC study on Latin America)

RESULTS OF THREE LA CASE STUDIES

STUDIES-2

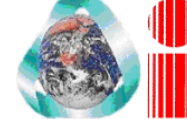


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Case Study	Toluca, Mexico	Valparaiso, Chile	Metro. Buenos Aires, Argentina
Landfilled MSW, tons/year	227,000	360,000	2,900,000
WTE plant capacity, tons/day	480	1,000	3,000
WTE plant annual capacity, tons/year	158,000	336,000	990,000
Electricity production, kWh/ton MSW	600	540	600
Electricity to the grid, MWh/year	96,000	182,000	600,000
Electricity price, US\$/MWh	62	90	102

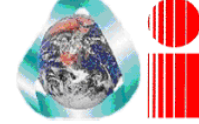
COMPARISON OF THREE CASE STUDIES

STUDIES-2

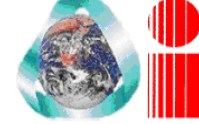


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Case Study	Toluca, Mexico	Valparaiso, Chile	Metro. Buenos Aires, Argentina
WTE plant capacity, tons/year	158,000	336,000	990,000
CAPEX, \$ million	120	225	600
CAPEX, \$/ton MSW	750	670	595
OPEX, \$ million	7.6	13.1	32
OPEX, \$/ton MSW	47.5	39	31.8
Current gate fee, \$/ton MSW	13	14	20
Electricity rev., \$/ton MSW	37.2	46	61
Metal recovery, \$/ton MSW	0.93	3.9	0.96
Carbon Credits, \$/ton MSW	5	5	7.7

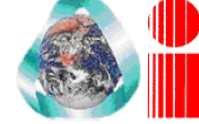


- The EEC study in Latin America showed that the total cost ("gate fee") of semi-sanitary landfills is about \$20 per ton MSW
- By coincidence, this is more than the average difference between WTE and LF gate fees in the U.S. (Columbia Survey of 2011 data)
- At current CAPEX, for a WTE plant to be economic, it needs a gate fee of at least \$40 per ton MSW, plus the electricity revenue.
- **The \$20/ton difference in gate fee would disappear if the CAPEX of WTE plants can be reduced by \$200 per annual ton of capacity**

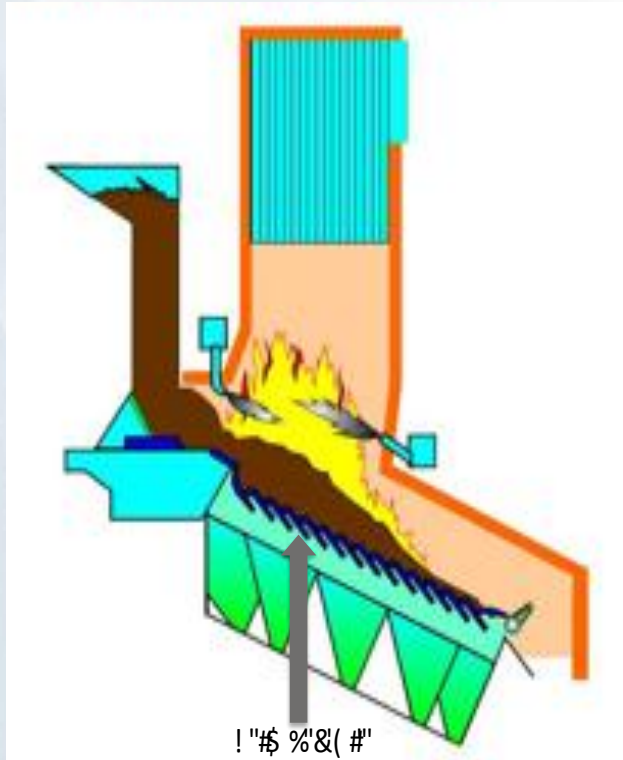


- Mass-burn combustion is the oldest and still leading technology for WTE.
- However, its CAPEX per ton MSW has not decreased since the nineties (“learning curve” of industrial experience). More R&D?
- Fluidized bed WTE is coming strong. (Very large investment in R&D by China)
 - 5.8% of the global capacity of WTE plants built since 2000
 - 45% of plants built from 2001 to 2005 in China (over 40 WTE plants)

Moving grate and CFB WTE



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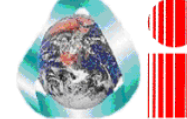


Moving grate WTE

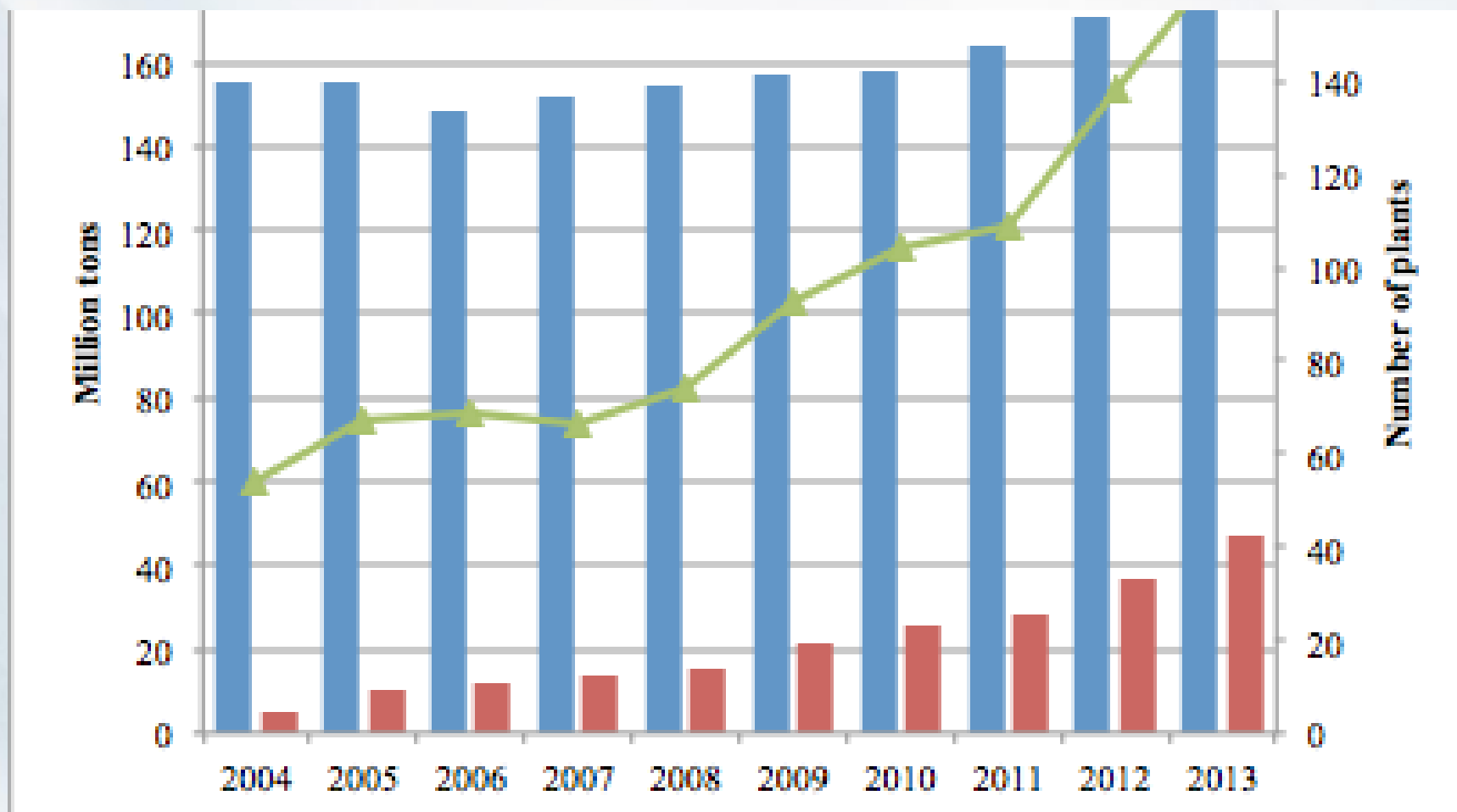


Circulating fluid bed WTE

Phenomenal growth of WTE in China

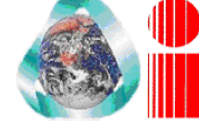


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China is now number 1 user of WTE

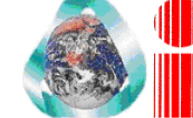
Difference MSW/biomass and fossil fuels



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Fuel	% Carbon	% Hydrogen	% Oxygen
Dry wood	47%	5%	40 %
Dry MSW	30%	4.5%	27%
Fossil fuels	80-85%	7-12 %	0%

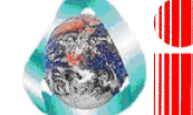
Comparison of fossil and "waste" solid fuels



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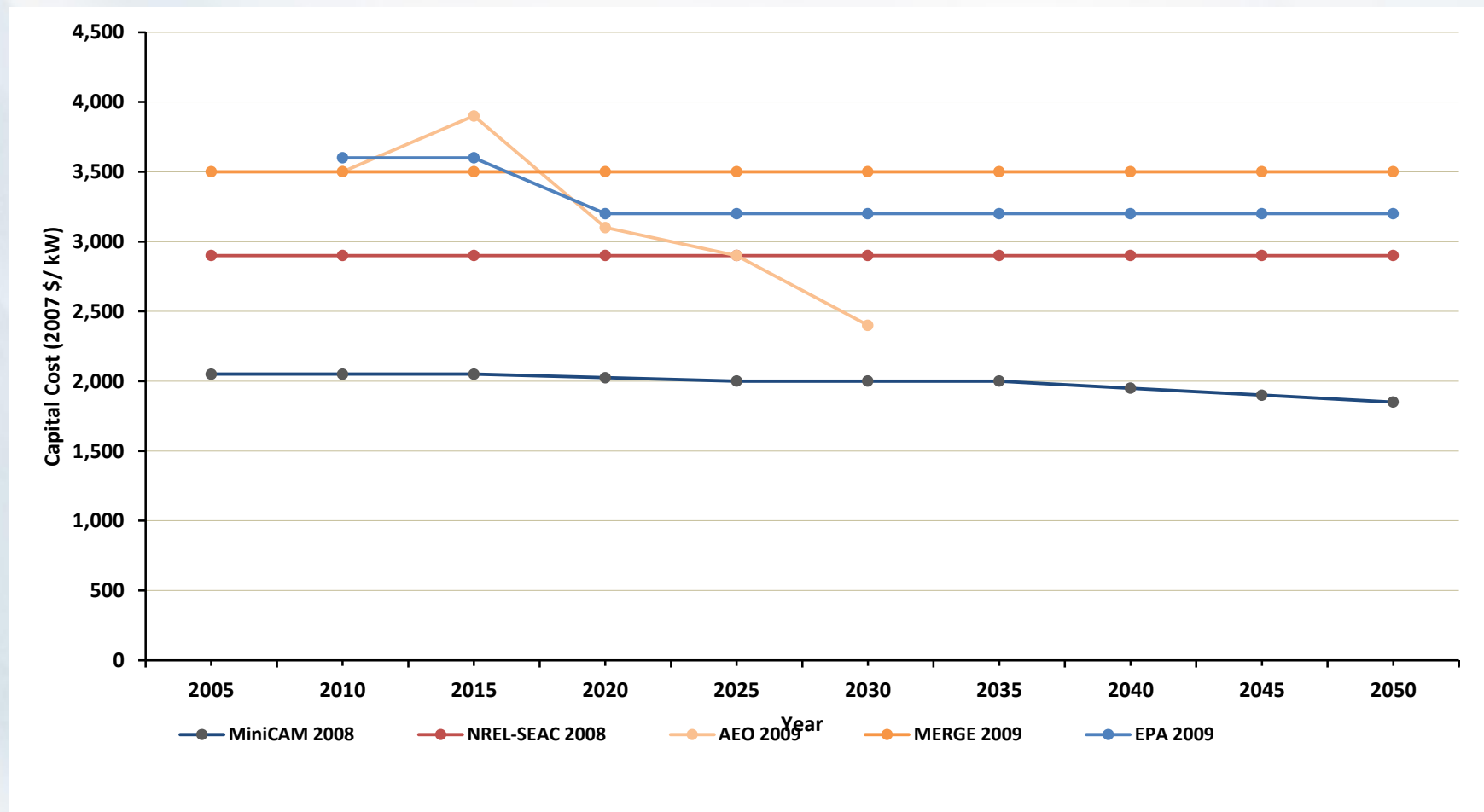
	% C	N g/kg	S g/kg	Cl g/kg	Cd mg/kg	Hg mg/kg	Pb mg/kg	Zn mg/kg	HV MJ/kg
Fuel oil	85%	3	15	0.01	<1	0.01	10	20	41
Anthracite coal	85%	12	10	1.5	1	0.5	80	85	30
Sawdust/wo od	47%	0.3	1	0.6	0.8	0.02	3	30	17
Non- recycled plastics	64%	7.9	0.7	17	73	1.3	390	550	35
U.S. MSW	30%	7	4	8.7	11	2	810	1100	11

Capex \$/kW of biomass power plants



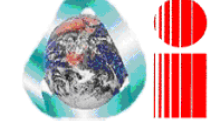
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Tidball R., Bluestein J., Rodriguez N., and Knoke S., 2010. Cost and Performance Assumptions for Modeling Electricity Generation Technologies. National Renewable Energy Laboratory report, pp. 26



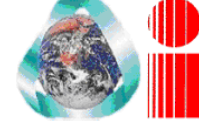
- **CAPEX of biomass power plants: \$2,000-\$3000/kW**
- **CAPEX of recently built WTE in N.A.: \$8,200/kW**

Comparison of power plants



Waste-To-Energy Research

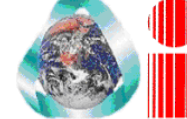
	SEMASS WTE, pre-shredding	Brescia WTE moving grate	Union County WTE, moving grate	Essex Co. WTE, roller grate	Archangelsk wood, fluid bed
Starting year	1988	1998	1994	1990	2001
Capacity, tons/day	910	792	480	845	1584
Heat value of fuel, MJ/kg	11.6	11.3	11.0	11.0	8.7
Height, m	30	22	19	20.42	16.2
Length x width of grate, m2	6 x 11=66	8*12.8=102	7.5*7.8=58	10.7*6=66	6.4*5.8=37
Process gas volume, Nm3/hour	219917	135003	125280	205532	247500
Flue gas flow, Nm3/ton	5800	4091	5653	5200	3750
Gas velocity through chamber, m/s	3.95	2.60	3.91	7.62	7.91
Average minimum residence time, s	7.59	8.45	4.86	2.68	2.05
Heat release, MW/m2	1.86	1.01	1.05	12.9	42.7
Electricity to the grid, MW	23	23	11	18	NA
Net electricity, kWh/ton	610	682	550	513	NA
Thermal efficiency	18.9%	21.7%	18.0%	16.8%	NA



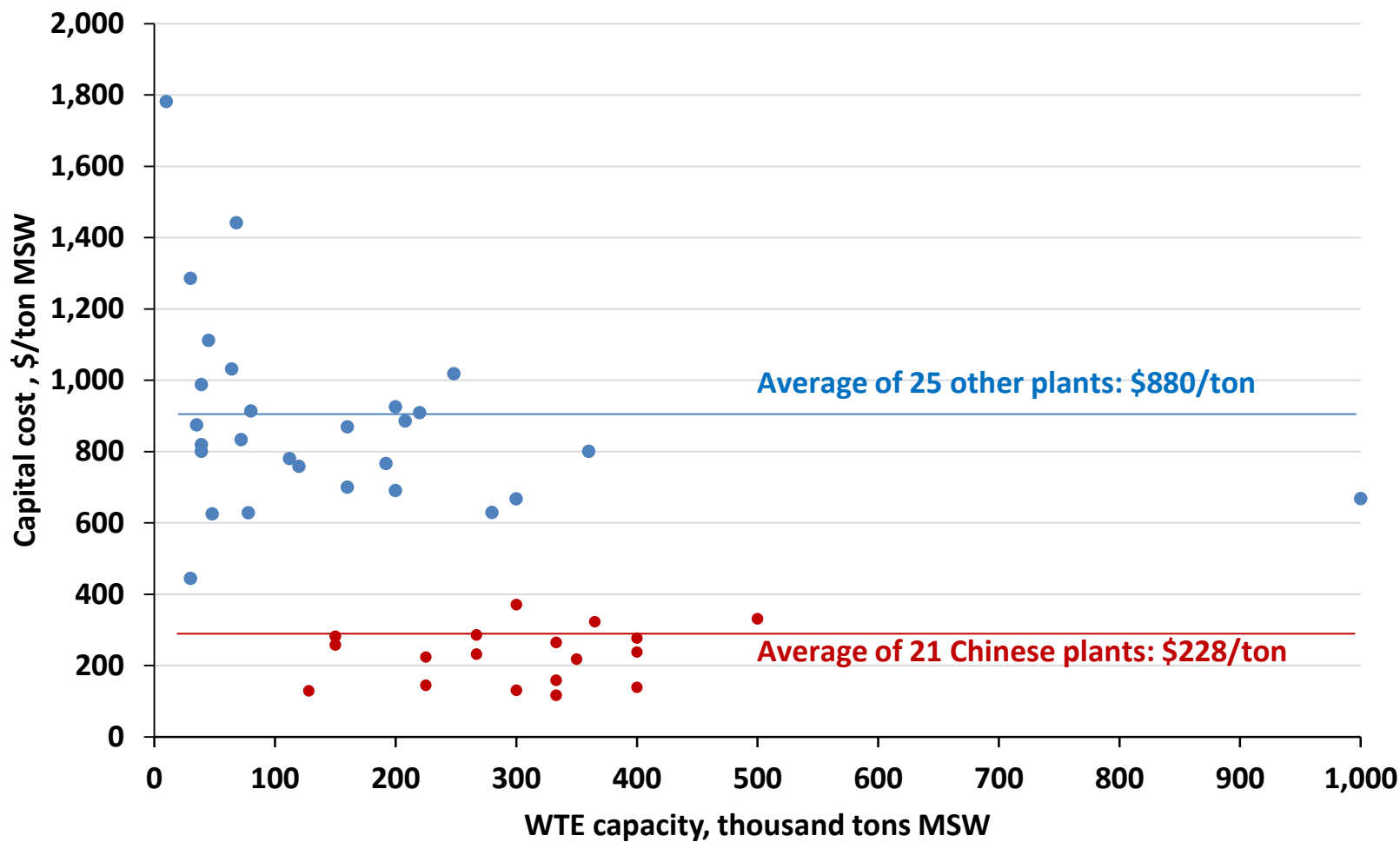
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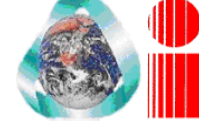
Plant	Brescia, Italy	Zhejiang University, Cixi
Reactor type	MG	CFB
Starting year	1998	2012
Capacity, tons/day	792	800
Heat value of fuel, MJ/kg	11.3	3.98
Height, m	22	16.8
Grate area, m ²	102.4	21.8
Combustion chamber cross section area, m ²	62	21.8
Volume of combustion chamber, m ³	1,210	366
Process gas volume, Nm ³ /hour	135,003	85,000
Flue gas flow, Nm ³ /ton	4,091	2,553
Velocity of gas in main section of chamber, m/s	2.5	4.5
Gas average minimum residence time, s	8.79	3.8
Grate combustion intensity, tons/day/m ²	7.73	36.7
Net electricity (kWh/Ton)	682	279
Net electricity generation, MW	23	9.3
Heat release rate, MJ/(h m ²)	3,139	6,085
Heat release, MW/m ²	1.01	1.69
Net electricity generation, MW/m ²	0.22	0.43
Thermal efficiency (heat to electricity)	21.7%	25.2%

CAPEX per ton of annual capacity



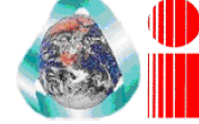
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- APC residues are rich in heavy metals and are more hazardous.
- They are disposed of in underground storages (EU) or mixed with bottom ash (US).
- The latest development in Europe is to extract secondary resources such as iron, aluminum, copper, zinc and other metals from these residues.
- In the future, incineration is likely to become a means to conserve resources by both utilizing energy and recycling materials.

Concentration of metals in fly ash**



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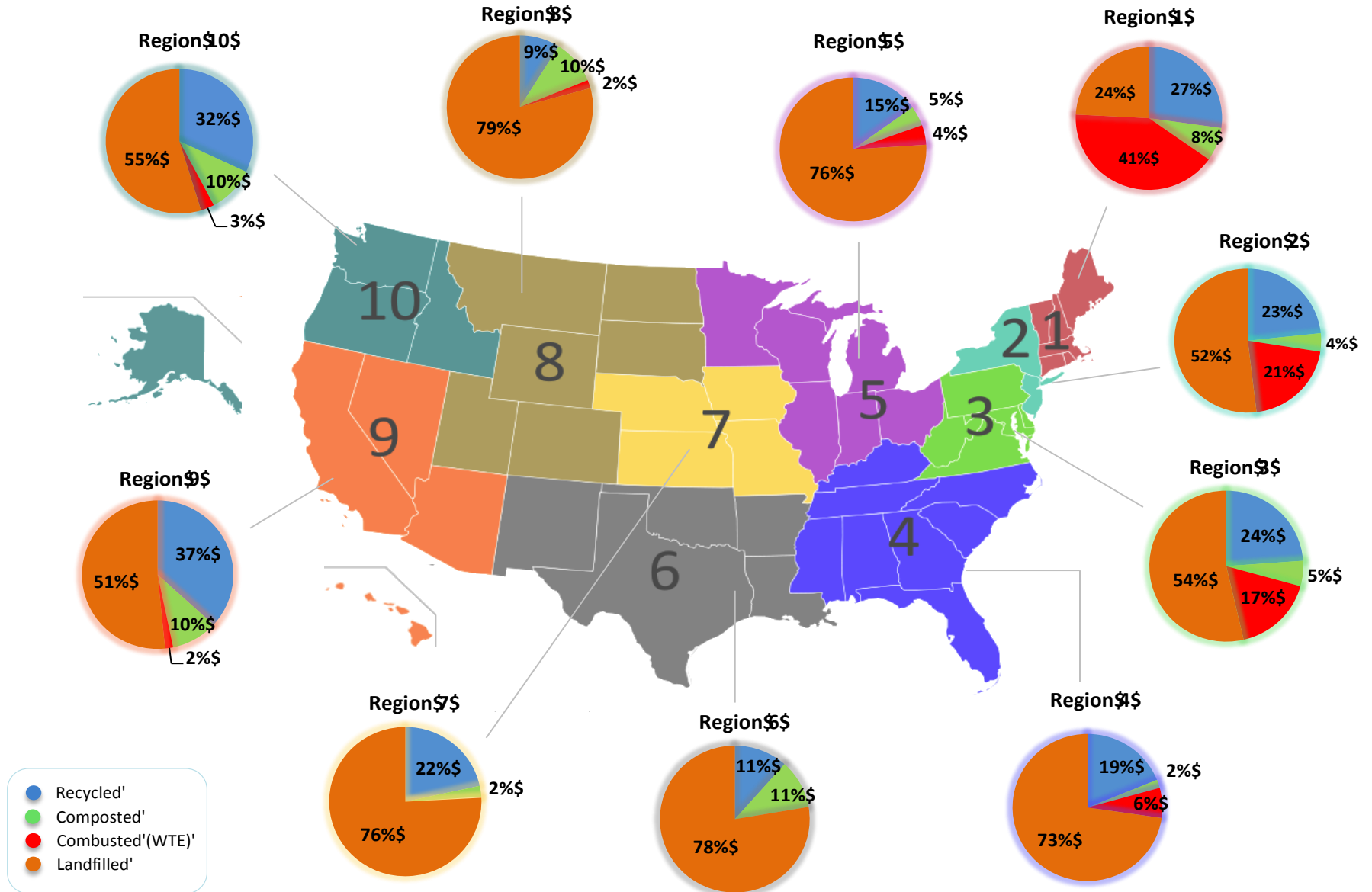
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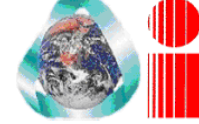
Metal	Concentration, ppm		Metal	Concentration, ppm	
	Min	Max		Min	Max
Aluminum	25,000	45,000	Copper	1500	5000
Antimony	700	5000	Magnesium	6000	18,000
Arsenic	20	120	Manganese	400	900
Barium	50	200	Sodium	25,000	70,000
Lead	7000	25,000	Nickel	60	300
Cadmium	150	1000	Mercury	0	3
Calcium	100,000	250,000	Silver	30	60
Chrome	100	500	Silicon	50,000	100,000
Cobalt	20	100	Titan	2500	5000
Iron	18,000	55,000	Zinc	20,000	120,000
Potassium	30,000	60,000	Tin	800	3000

*Brunner and Rechtberger

Breakdown by EPA Regions

Recycling, composting, combusting, and landfilling rates by regions





...will be published in SWANA's
"MSW Management" this fall

Thank you for attending this lecture!

www.wtert.org