

Waste-to-Energy (WTE) is much better than Landfilling for Ontario and Canada

WHY???

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Ways to manage Urban Wastes

- **“Recycling”**: Source-separated wastes that can be used as materials or composted and used as soil conditioner
- **“Post-recycling”**: Materials that remain after all possible “recycling”
- After nearly 100 years of R&D efforts, there are two ways of dealing with “post-recycling” wastes:
 - **Sanitary landfilling (LF)**
 - Thermal processing with energy and materials recovery (**Waste to Energy or WTE**)

The Milano example of maximum “recycling”

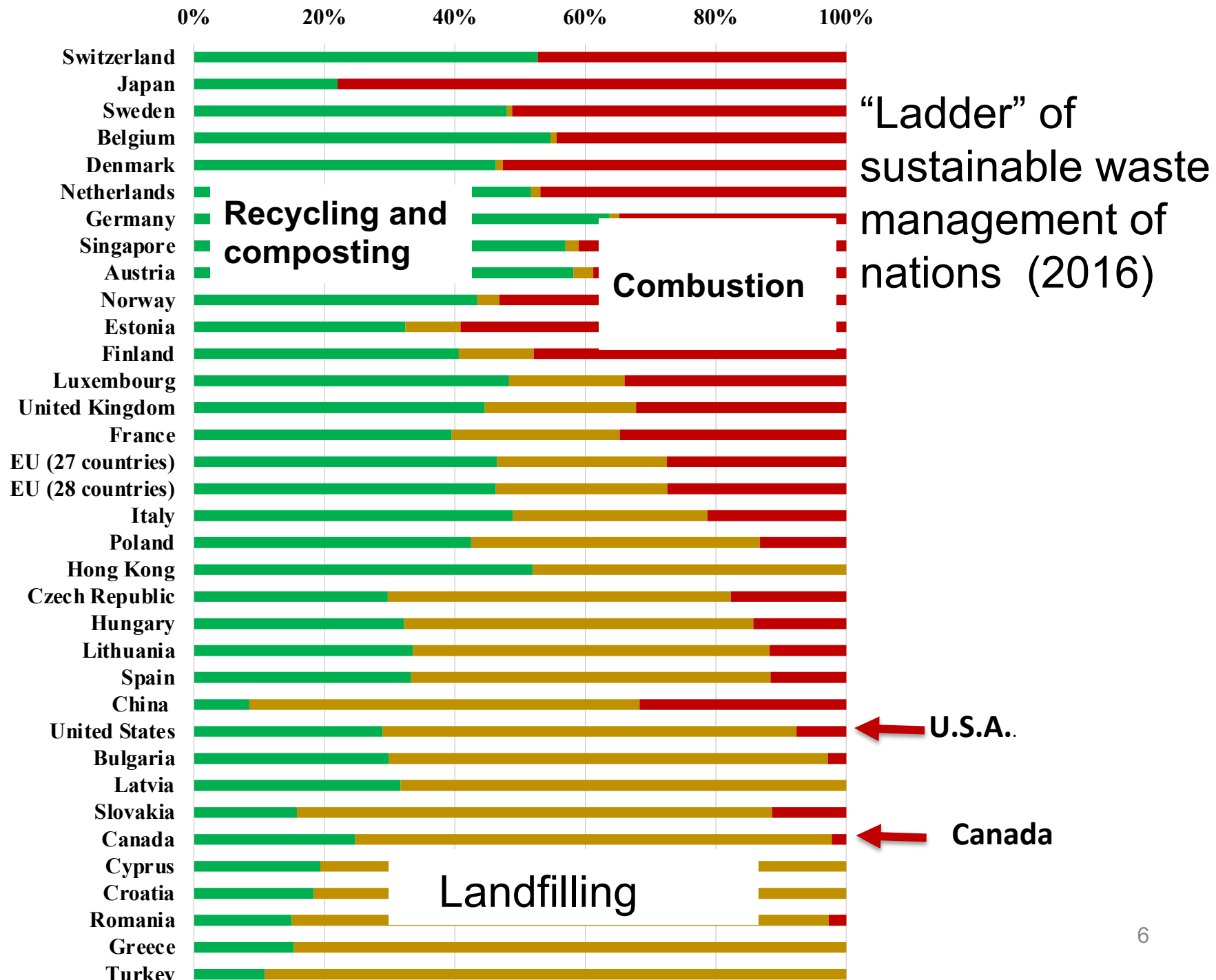
- The city of Milano, Italy, is a good example of intensive recycling and composting (EEC study).
- The city collects five separate streams:
 - (1) paper,
 - (2) glass,
 - (3) metals plus some types of plastics,
 - (4) compostable organics,
 - (5) All other, “POST-RECYCLING”, wastes go to the WTE power plant of Milano.

The results of intensive recycling of Milano

| Materials collected | Tonnes Ter year | % |
|---|--------------------|--------------|
| Paper | 78,000 | 9.6% |
| Plastics & metal | 44,000 | 5.4% |
| Glass | 65,000 | 8.0% |
| Total recycled | 187,000 | 23.1% |
| Composted | 141,000 | 17.4% |
| Total recycled and composted | 328,000 | 40.4% |
| Post-recycling waste to WTE power plants | 483,000 | 59.6% |
| Total MSW, tonnes/year | 811,000 | 100.0% |

How urban wastes are managed in various countries?

- We call the following graph :
“The Ladder of sustainable waste management”
- The nations higher up the “Ladder” are doing less or no landfilling



Comparison of landfilling and WTE

(all \$ in Canadian \$; all tons in metric tons)

- Be your own judge: a) Visit the landfill serving your city;
- b) Visit the WTE plant of Durham County in Ontario (let me know at njt1@Columbia.edu) and I will arrange)
- In 2019, Ontario landfilled 0.82 tons MSW per person (OWMA Report)
- A landfill to serve a city of 300,000 over a 40-year period requires a land area of about 150 acres
- At current cost of rural land in Ontario, the land investment for this landfill would be **\$1.5 million**

Comparison of landfilling and WTE options (cont.)

- The WTE power plant requires much higher capital investment than a sanitary landfill; for new plans, roughly estimated at \$600 per annual ton of WTE plant capacity
- A WTE plant for city of 300,000 would require annual capacity of 200,000 tons.
- Therefore, the capital investment would be \$126 million
- The major cost item of the WTE plant will be the capital charge of about \$50/ton of MSW
- The WTE will have a revenue from sale of electricity produced, estimated at \$55 per ton of MSW in Ontario.
- The WTE will require the city to provide a gate fee of \$50 per ton of MSW delivered to the plant. \

Preliminary conclusion

- With municipal government committing to provide waste and pay the gate fee of \$50/ton and a utility to purchase the electricity produced, a private-public partnership can build and operate a WTE plant that would repay the capital investment at an appropriate interest, over a period of 20 years.
- After this period, the municipality will own this plant (some US WTE plants are still operating after 50 years)

Environmental benefits of WTE over sanitary landfilling

Doing away with “external” costs of landfilling:

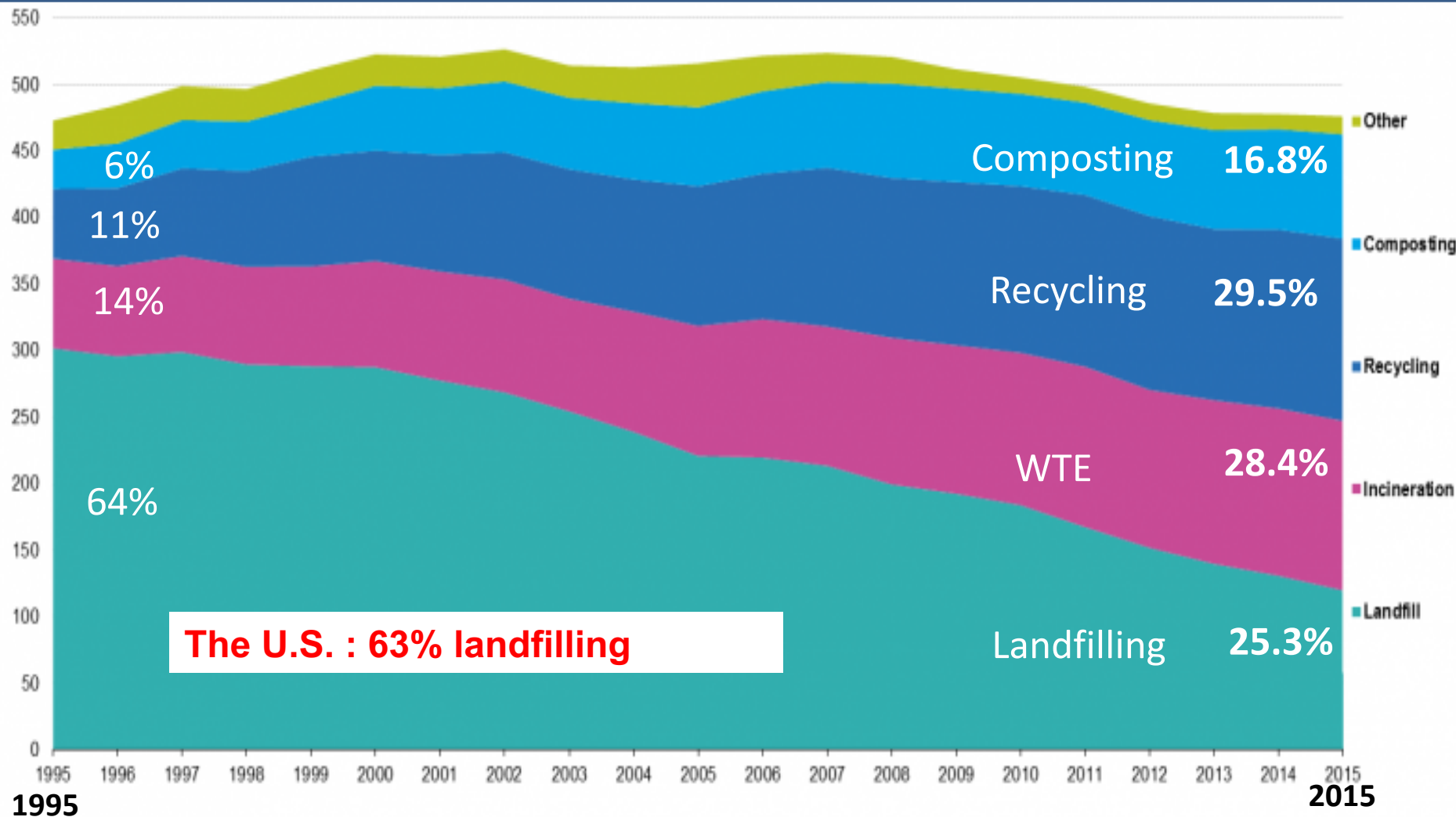
- **Virgin land transformation** (estimated at about 4 acres of land annually for a city of 300,000.
- **Methane emissions** of landfilling gas (LFG), estimated at ≤ 0.05 ton CH₄/ton MSW (*Themelis and Bourtsalas, 2021*)
- **Dioxin and mercury emissions** during unintentional landfill fires (over one thousand landfill fires annually, in the U.S.; *Dwyer and Themelis, in Waste Management*)
- Ontario has 805 operating landfills (12 million tons; projected lifetime of existing landfills: 15 years (OWMA))

Progress made in European Union (EU)

- E.U. directive** to phase out landfilling in the first half of this century. Some E.U. members have already phased out landfilling, as shown earlier

Changes in E.U. generation & disposition of MSW, 1995-2015

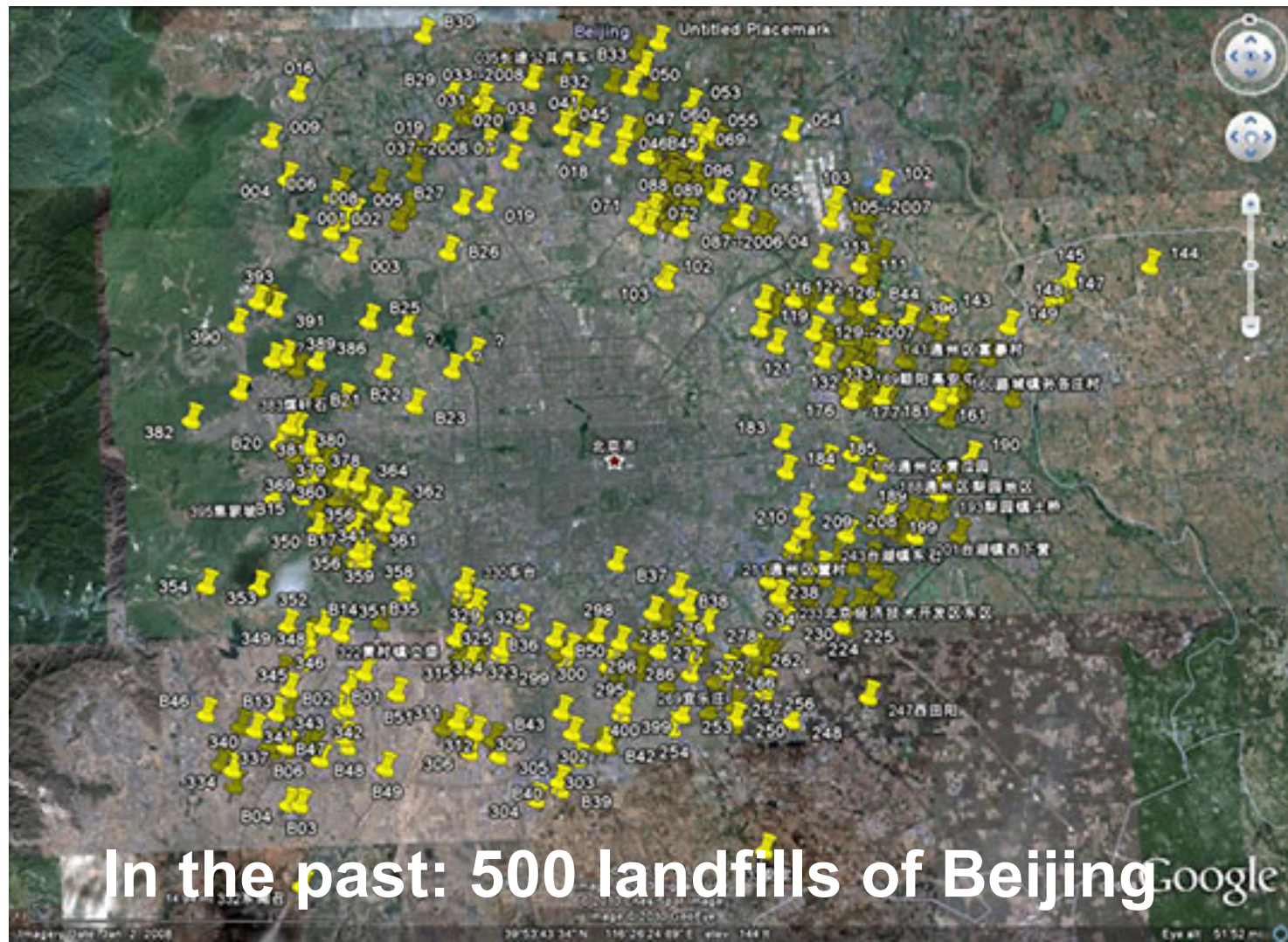
(Eurostat data, August 2017)



2015 EU MSW generation: 243 million tons 2015 EU population: 510 million

y-axis: kg per capita

China has gone a long way since the Wang Juliang film “Beijing besieged by landfills”



Over the last 20 years, China has become a major player in the global WTE industry

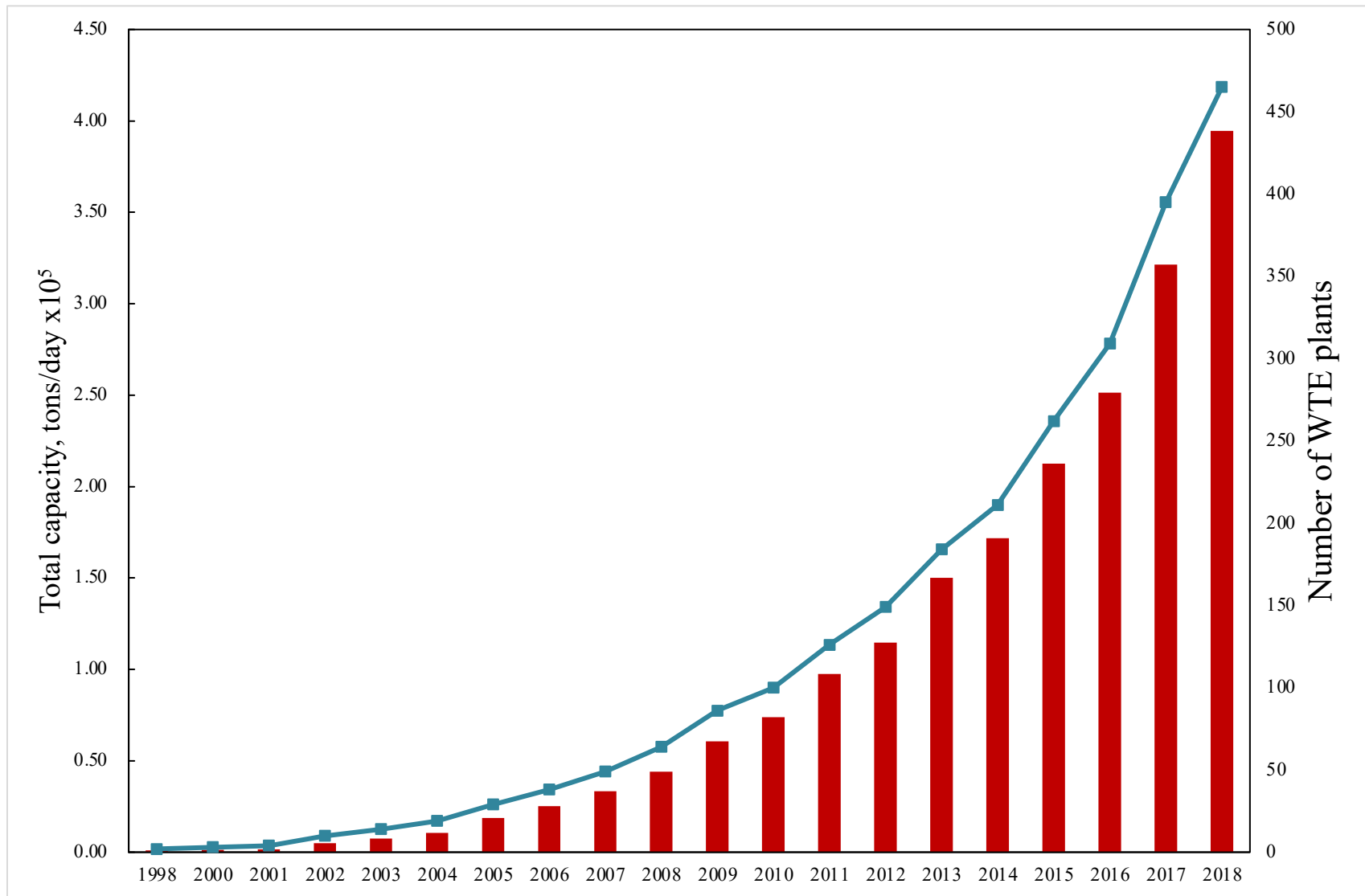
China has reduced the capital cost of WTE plants by means of :

- Dedicated Industrial and academic R&D (e.g., at Zhejiang University- WtERT China),
- Rapid growth of industry, instead of custom building one plant at the time,
- Assembly line fabrication of WTE equipment,
- Favorable national policy (e.g., \$30/MWh credit for WTE electricity).

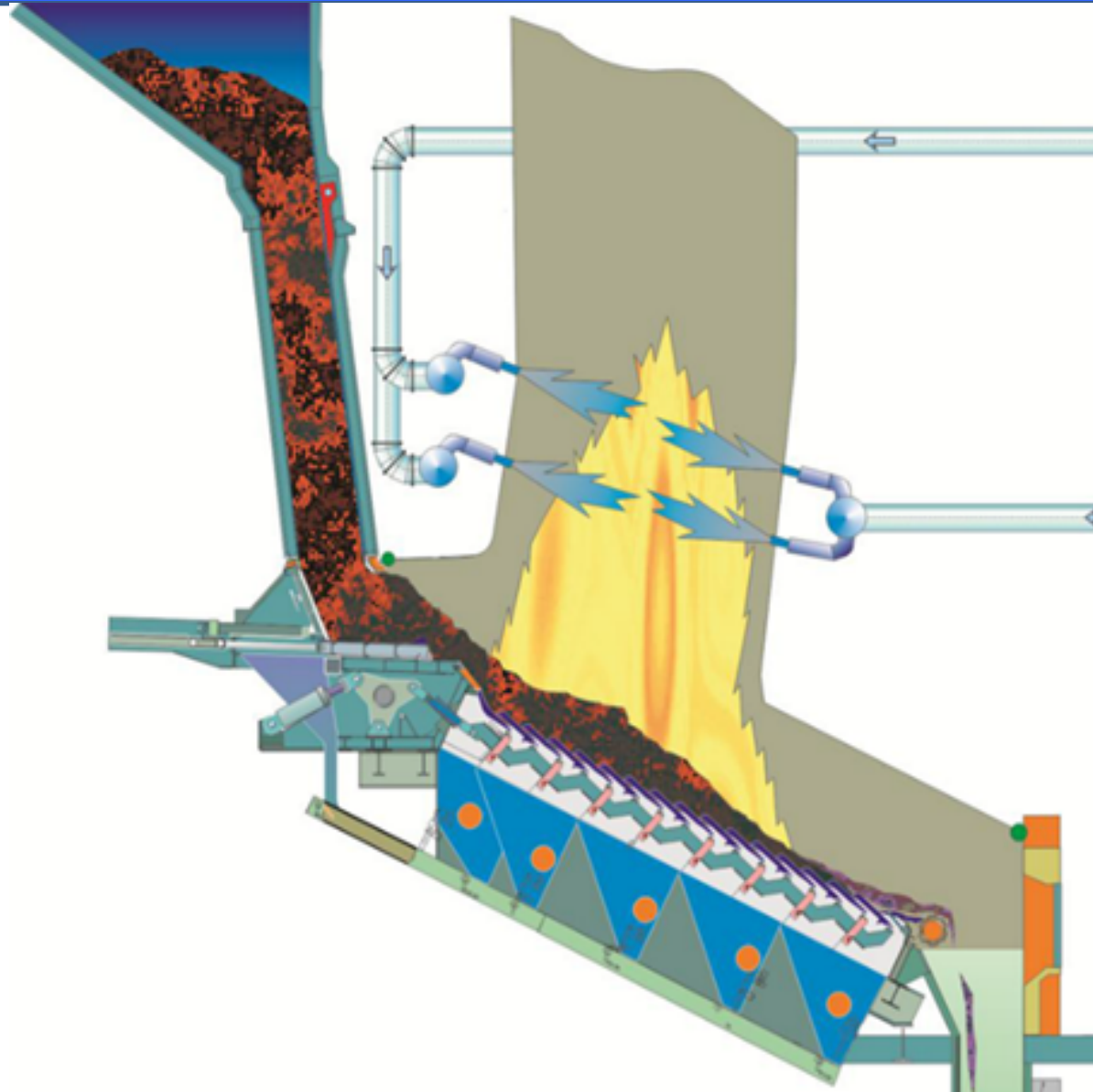
From latecomer to front runner

- The Chinese WTE capacity is now greater than that of the EU, plus US, plus Japan

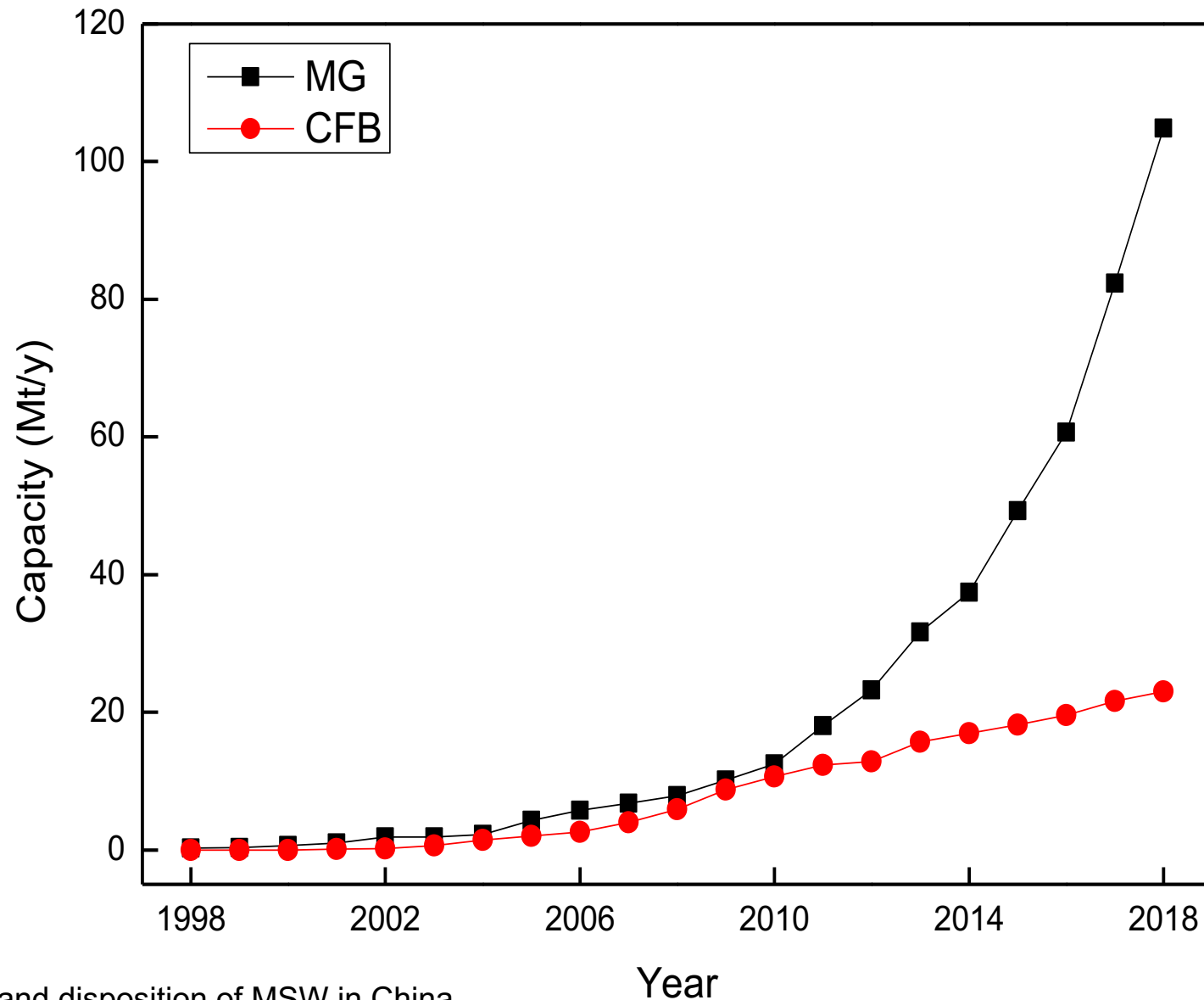
21st century growth of WTE industry in China; By 2019, WTE plants in operation and under construction



The dominant WTE technology, globally: Combustion on a Moving Grate



Historical development of moving grate (MG) and fluid bed (CFB) technologies in China



| Company | Chinese name | Tons/day |
|--|-----------------------|---------------|
| Anhui Shengyun Group (ASEPG) | 盛运环保集团 | 7,300 |
| Beijing Enterprises BEHET | 北京控股集团有限公司 | 13,525 |
| CSET | 中科能环 | 7,000 |
| Canvest Env. Protection | 粤丰环保电力有限公司 | 13,940 |
| China Energy Conservation, CECEP | 中国环境保护集团有限公司 | 19,950 |
| China TIANYING Inc. | 中国天楹股份有限公司 | 9,200 |
| Dynagreen | 绿色动力 | 14,710 |
| Everbright International | 光大国际 | 49,060 |
| Grandblue | 瀚蓝 | 10,800 |
| GZEPIC | 广州环保 | 13,290 |
| Jinjiang Environment | 锦江环境 | 28,170 |
| Sanfeng Environment | 三峰环境 | 22,050 |
| Shanghai Chengtou | 上海城投/上海环境集团股 份有限公司 | 15,250 |
| Shengyuan Env. Protection Co. | 圣元环保 | 6,675 |
| SUS Environment | 康恒环境 | 6,150 |
| TEDA | 泰达环保 | 6,550 |
| TUS-EST | 启迪环境 | 9,900 |
| Wangneng Environment | 旺能环境 | 10,850 |
| Total WTE capacity, tons/day | | 402,415 |
| Estimated annual capacity, tons MSW: | | 128 mill tons |

Important “fallout” from WTE progress in China: Lower CAPEX has made the WTE technology cost-competitive with sanitary landfilling

- The 21st century progress of WTE in China will encourage developed countries (e.g., U.S., Canada and Australia) to re-evaluate WTE vs sanitary landfilling, especially in view of the greenhouse effect of landfill methane emission
- Cities in the developing world can now skip the sanitary landfill stage and move directly from **waste dumps** to **WTE power plants** (as in Azerbaijan, Ethiopia, Vietnam, Turkey (Istanbul), Serbia (Belgrade)).

China Everbright factory of WTE equipment (Changzhou, China)



From “one-of” to Ford mass production of cars

Ningbo WTE plant, China (SUS Environment)



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