Waste-to-energy
(W-t-E)
or
energy-from-waste
(e-f-w)
technologies

Presented by
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Solid Waste as a Green Fuel

- Solid Waste, it is meant to be :-

  - Municipal Solid Waste (MSW)

- By definition MSW is more commonly known as trash or garbage

"consists of everyday items we use and then throw away, such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. This comes from our homes, schools, hospitals, and businesses."-EPA

Energy recovery from MSW

A unique sustainable way for materials management

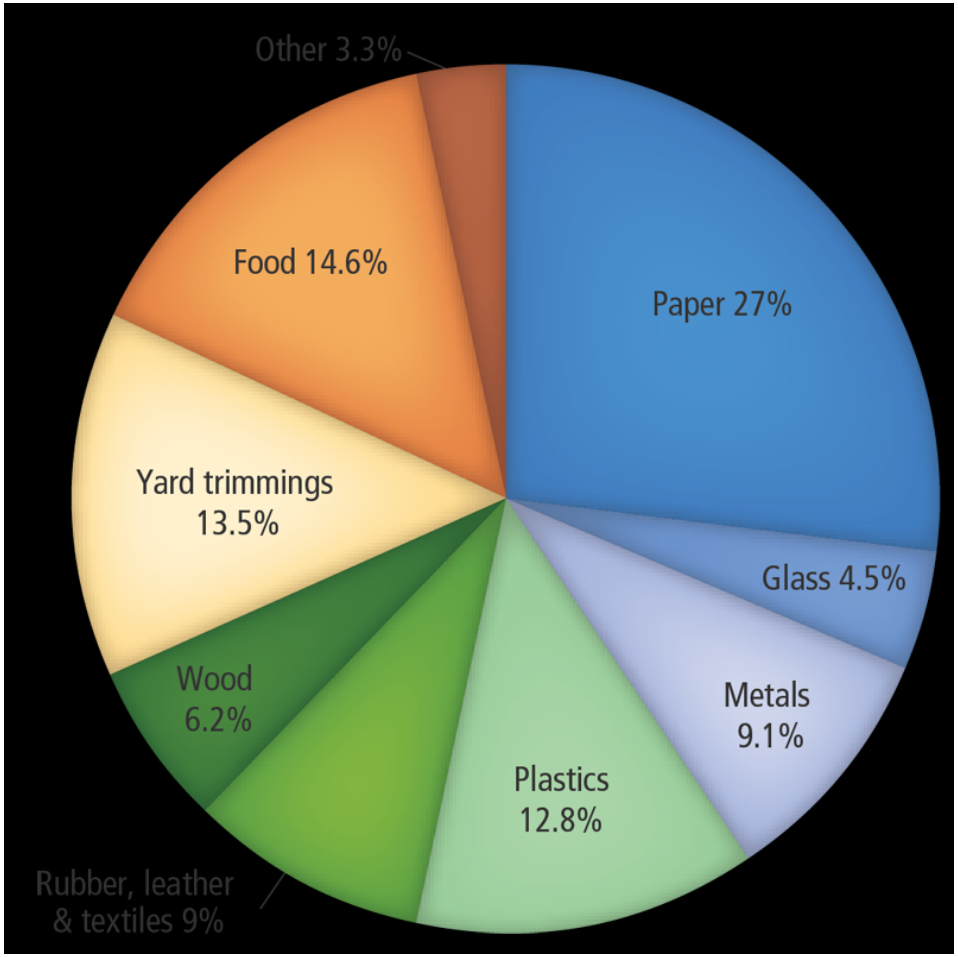
- Sustainable Materials Management (SMM) –

- Refers to the use and reuse of materials in the most productive and sustainable ways across their entire life cycle.

- SMM practices conserve resources, reduce wastes, slow climate change and minimize the environmental impacts of the materials we use.

- Energy recovery from waste is an important part of SMM, besides Source Reduction, Recycling and Composting

Composition of Waste: US EPA, 2013



Each person in America generates

30 Pounds (4.5 Kg) of Waste **Weekly**

Trash Can

Trash Truck

What we can do with waste that we generate

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Two Primary choices for waste management

WIERT
Waste-To-Energy Research and Technology Council

249 Million tons of trash (MSW) goes to landfills

Landfills

Renewable Energy Generated from Landfills - 5 billion kWh

Up to 100 kilowatt hours of electricity per ton of waste

Waste to Energy

Renewable energy generated from WTE Facilities - 15 billion kWh

Up to 700 kilowatt hours of electricity per ton of waste

29 Million tons of trash goes to EfW

These two options must co-exist for the foreseeable future

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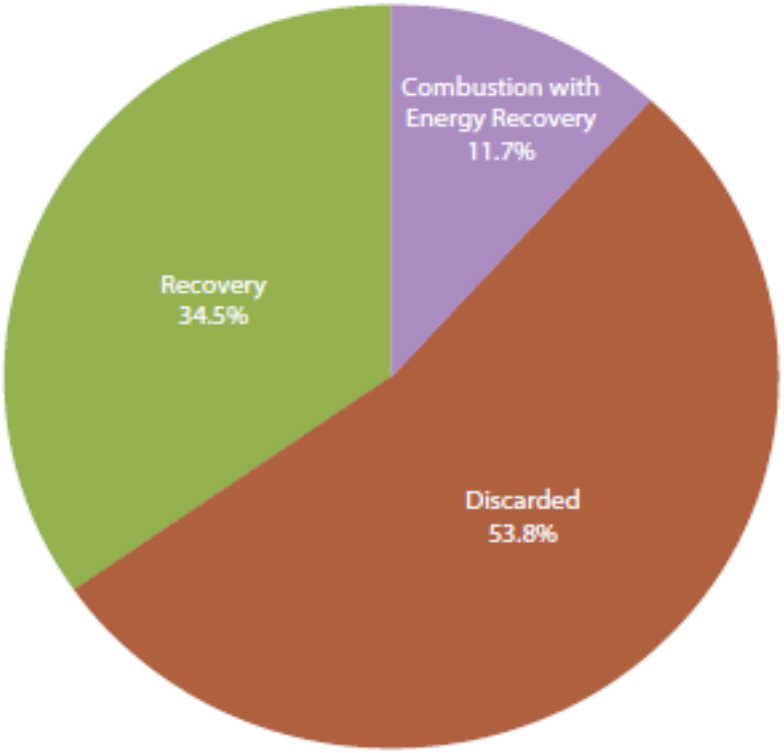
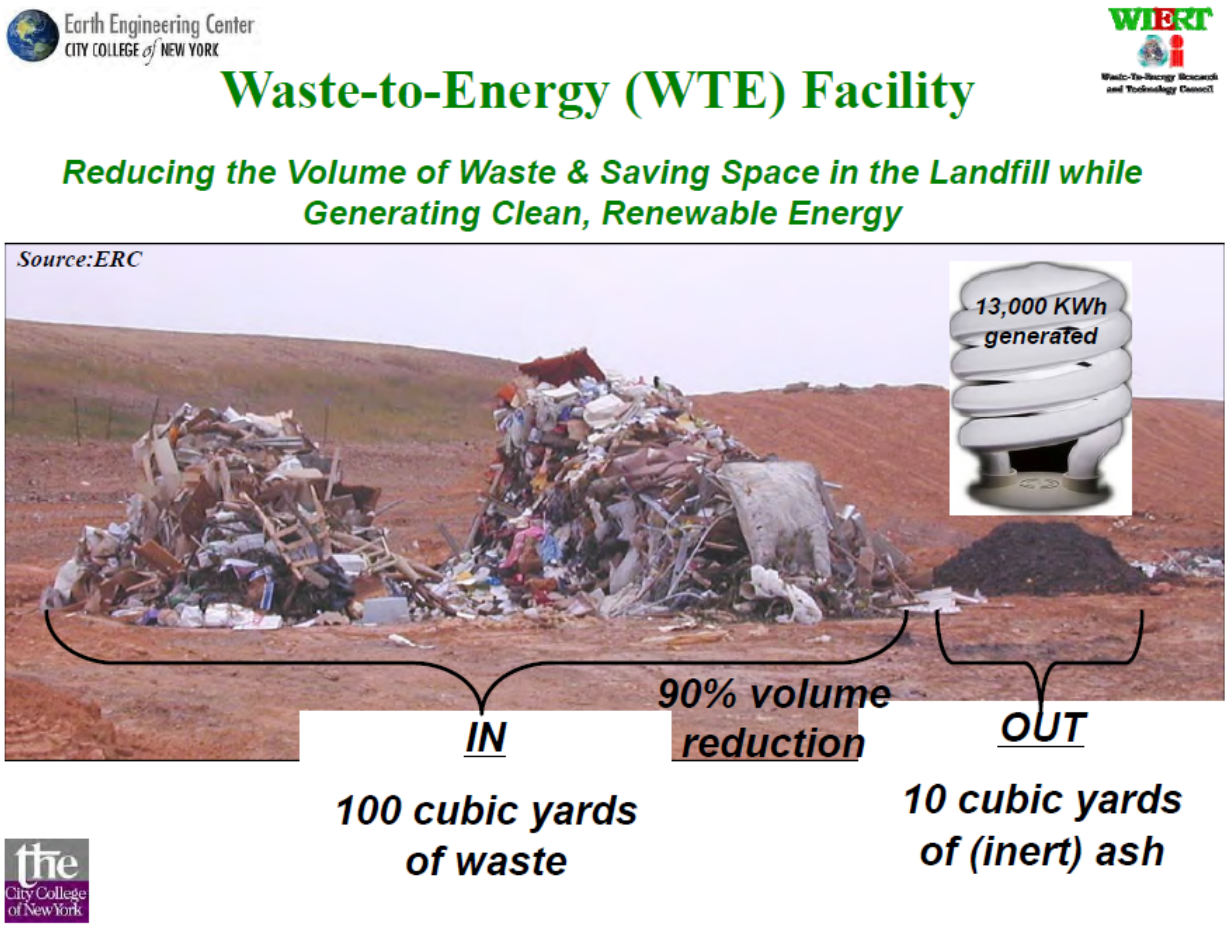
Less than **12%** is used for combustion for **energy recovery**: US EPA, 2013

Still Majority of MSW is discarded in landfills (53.8%)



Waste-to-Energy: an integral part of Waste Management hierarchy

Waste-to-Energy: an integral part of Waste management hierarchy



3 Types of MSW Combustion Technologies

1. Mass burn – by far the most popular

- Mass burn units are designed to burn MSW in a single combustion chamber under conditions of excess air.
- In combustion systems, excess air must be used to promote mixing and turbulence to ensure that air can reach all parts of the waste. This is necessary because of the inconsistent nature of solid waste.
- Most mass-burn facilities burn MSW on a sloping, moving grate that is vibrated or otherwise moved to agitate the waste and mix it with air.

The other 2 lesser used technologies

2. Modular - they are much smaller and are portable. They can be moved from site to site.

3. Refuse Derived Fuel (RDF) - use mechanical methods to shred incoming MSW, separate out non-combustible materials, and produce a better combustible mixture.

- The RDF technology increases the heating value of MSW by about 25%
- But is much costlier to install and operate than Mass Burn and requires larger footprint

Mass Burn facility procedures

- At an MSW combustion facility, MSW is unloaded from collection trucks and placed in a trash storage bunker.
- An overhead crane is used to sort the waste and then lift it into a combustion chamber to be burned.
- The heat released from burning is used to convert water to steam. The steam is then sent to a turbine generator to produce electricity.
- The remaining ash is collected and taken to a landfill.

Trash unloaded from collection trucks

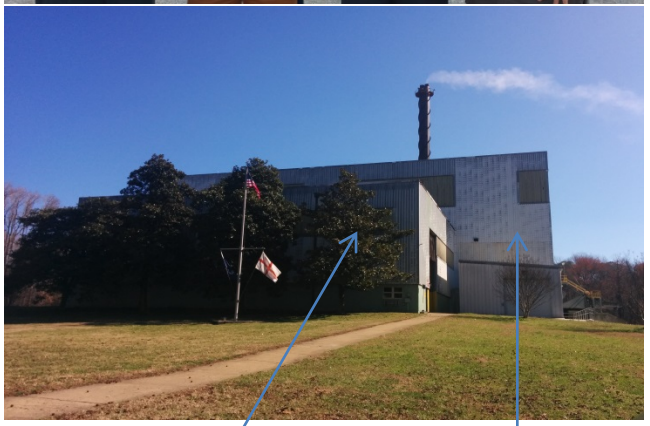
Truck bed is raised to directly dump the trash in the pit

Visitors in front of the typical trash pile

Trash burning plant Hampton, Virginia, USA

- Trucks bring trash to the Plant
- Trash is fed to boilers by cranes
- Boilers burn trash to produce steam
- Steam is sent to NASA for Space Research

Engineers work at Plant which is run round the clock



Trash Area

Boiler House

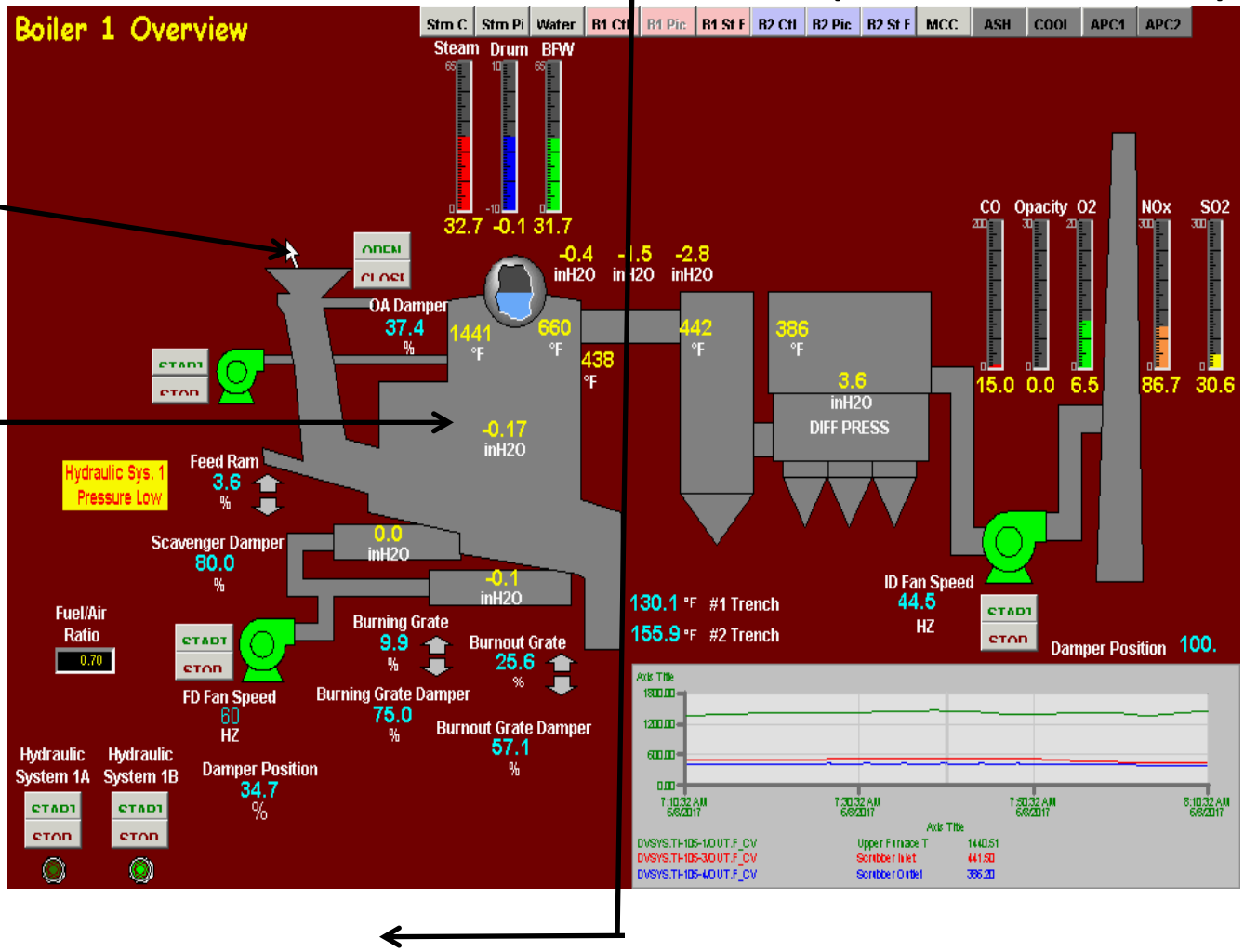
Combustion process

Downstream: Flue gas cleaning
(next slide for details)

Boiler House

Waste Feed

Combustion Furnace

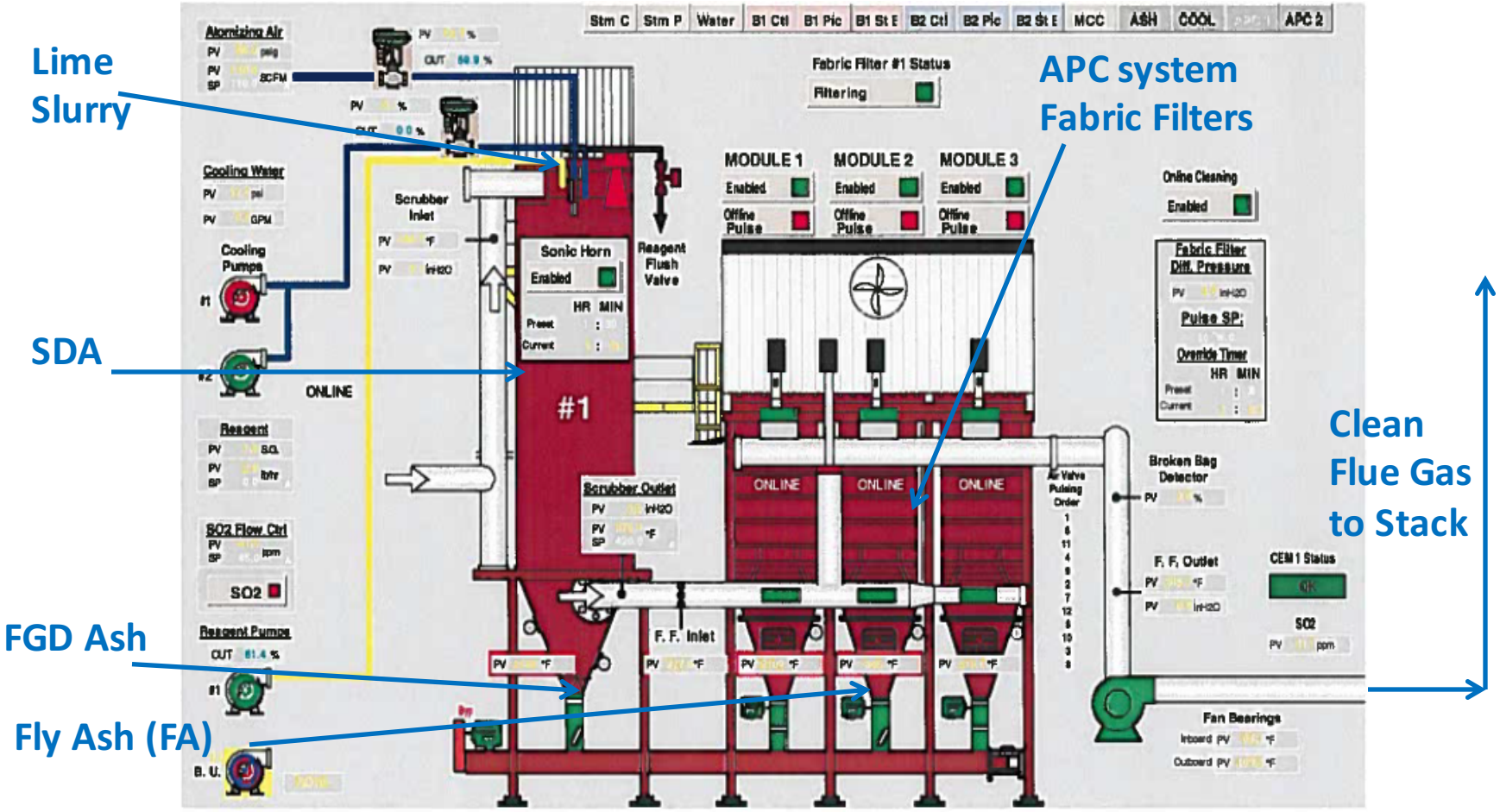


FLUE GAS CLEANING

- First acid gases in boiler flue gas are neutralized in Scrubber Dryer Absorber (SDA)
- Particulates are then captured by a high-efficiency baghouse (a filtering system).
- As the gas stream travels through these filters, more than 99 percent of particulate matter is removed.
- Captured fly ash particles fall into hoppers (funnel-shaped receptacles) and are transported by an enclosed conveyor system to the ash discharger where they are wetted to prevent dust and mixed with the bottom ash from the grate.

Calcium hydrated lime slurry sprayed in Scrubber (SDA)

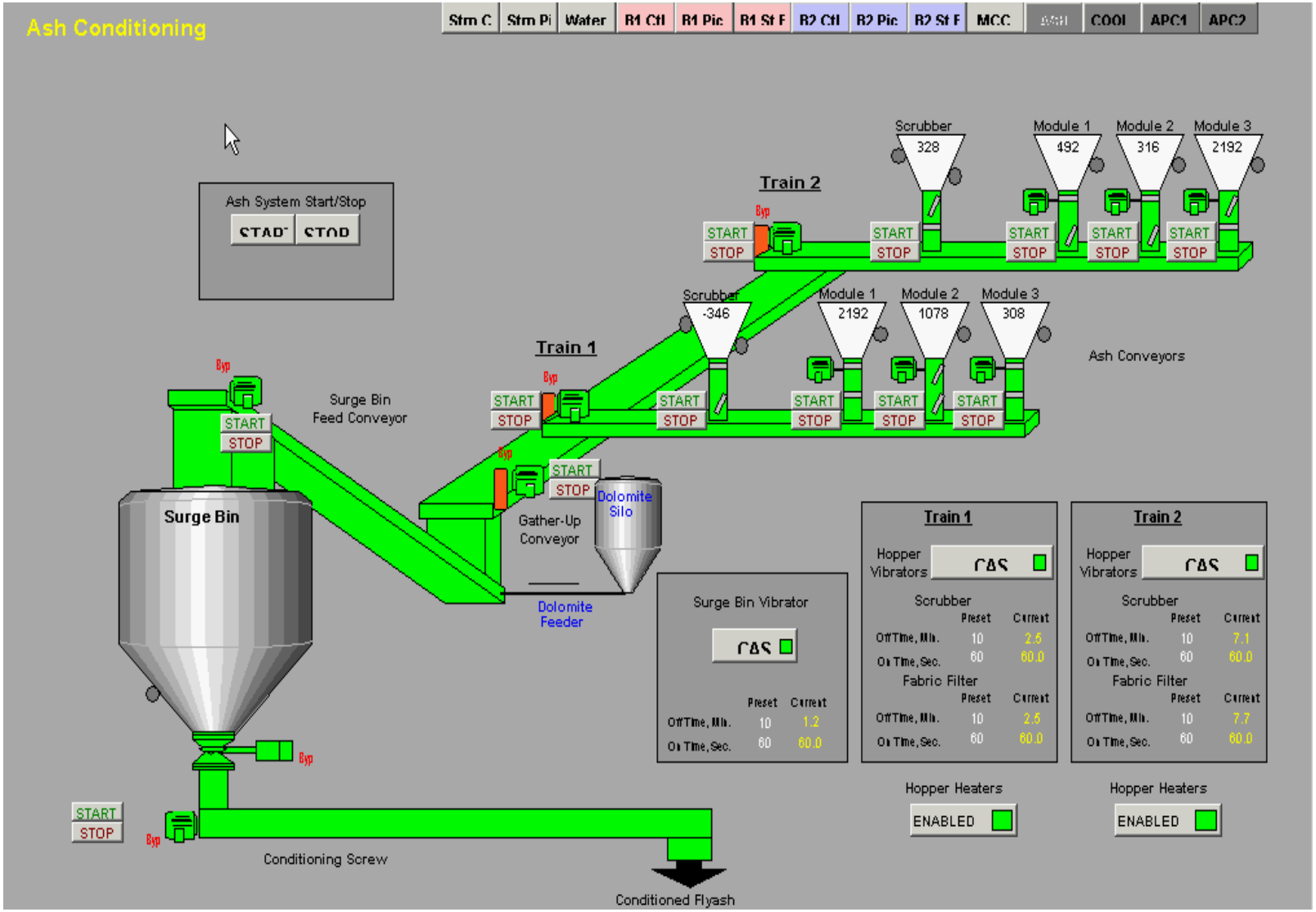
1. FGD (Flue Gas Desulfurization) ash collected in SDA hopper
2. Fly Ash (FA) collected in APC system Fabric Filter bags



Ash Generated from the MSW Combustion Process

- The amount of ash generated ranges from 15-25 percent by weight of the MSW processed and from 5-15 percent of the volume of the MSW processed.
- The ash residue is conveyed to an enclosed building where it is loaded into covered, leak-proof trucks and taken to a landfill designed to protect against groundwater contamination.

Scrubber Ash (FGD) and Fly Ash (FA) conveying system

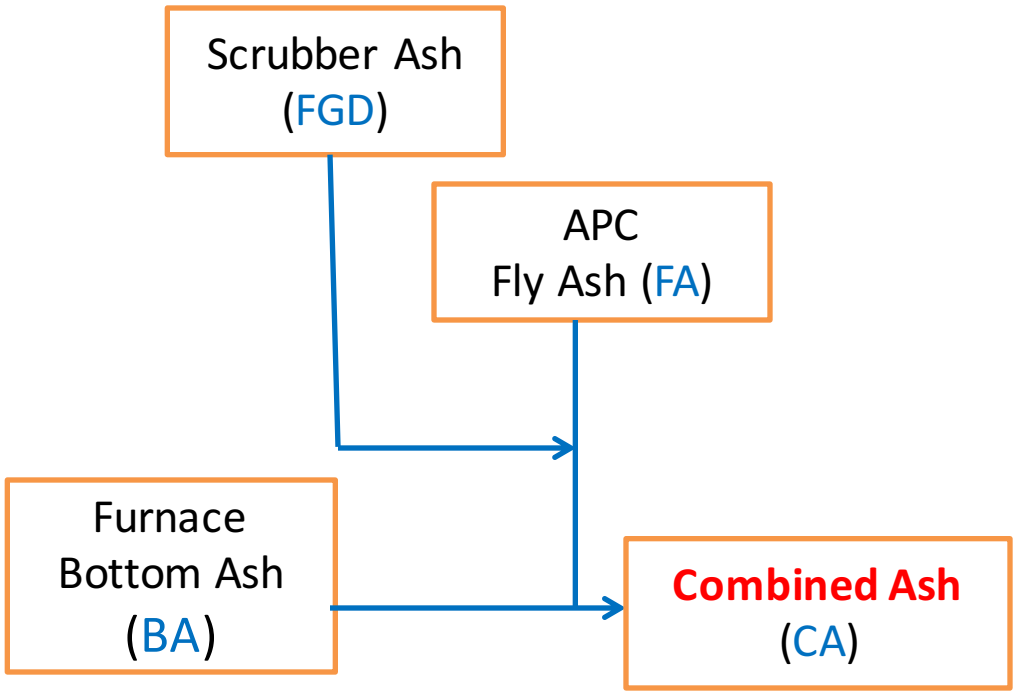


The furnace bottom ash

- The rest of the MSW combustion ash is called bottom ash (80-90 percent by weight).
- The main chemical components of bottom ash are silica (sand and quartz), calcium, iron oxide, and aluminum oxide.
- Bottom ash usually has a moisture content of 22-62 percent by dry weight.
- The chemical composition of the ash varies depending on the original MSW feedstock and the combustion process. The ash that remains from the MSW combustion process is sent to landfills.

Various streams of ashes are combined before disposal

Combined Ash components



BA + (FGD + FA) ⟶ CA

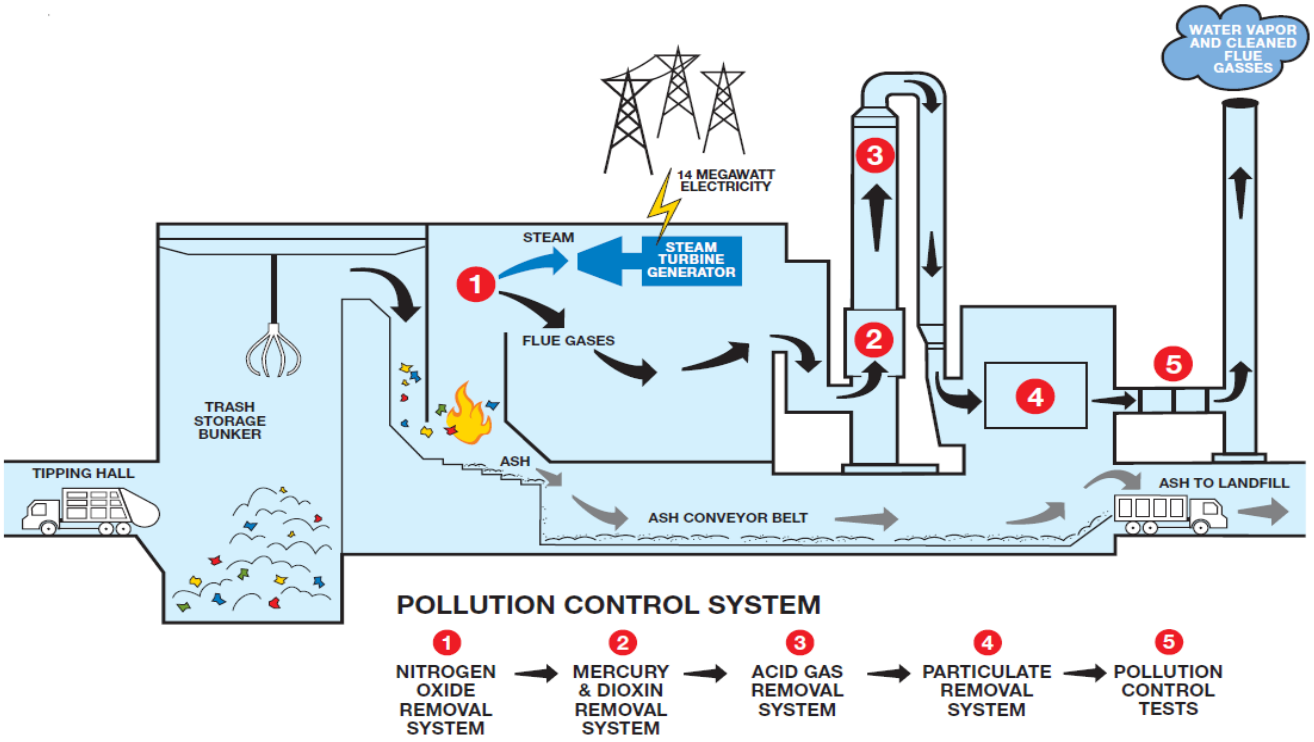
Combined Ash (CA) collection

Recovery of metals from ash and transportation to landfills

Ash residue from the furnace can be processed for removal of recyclable scrap metals

Ash after recovery of metals loaded in trucks for transportation to landfills

Steam generated in boiler is used to run a Turbine-generator to produce electricity

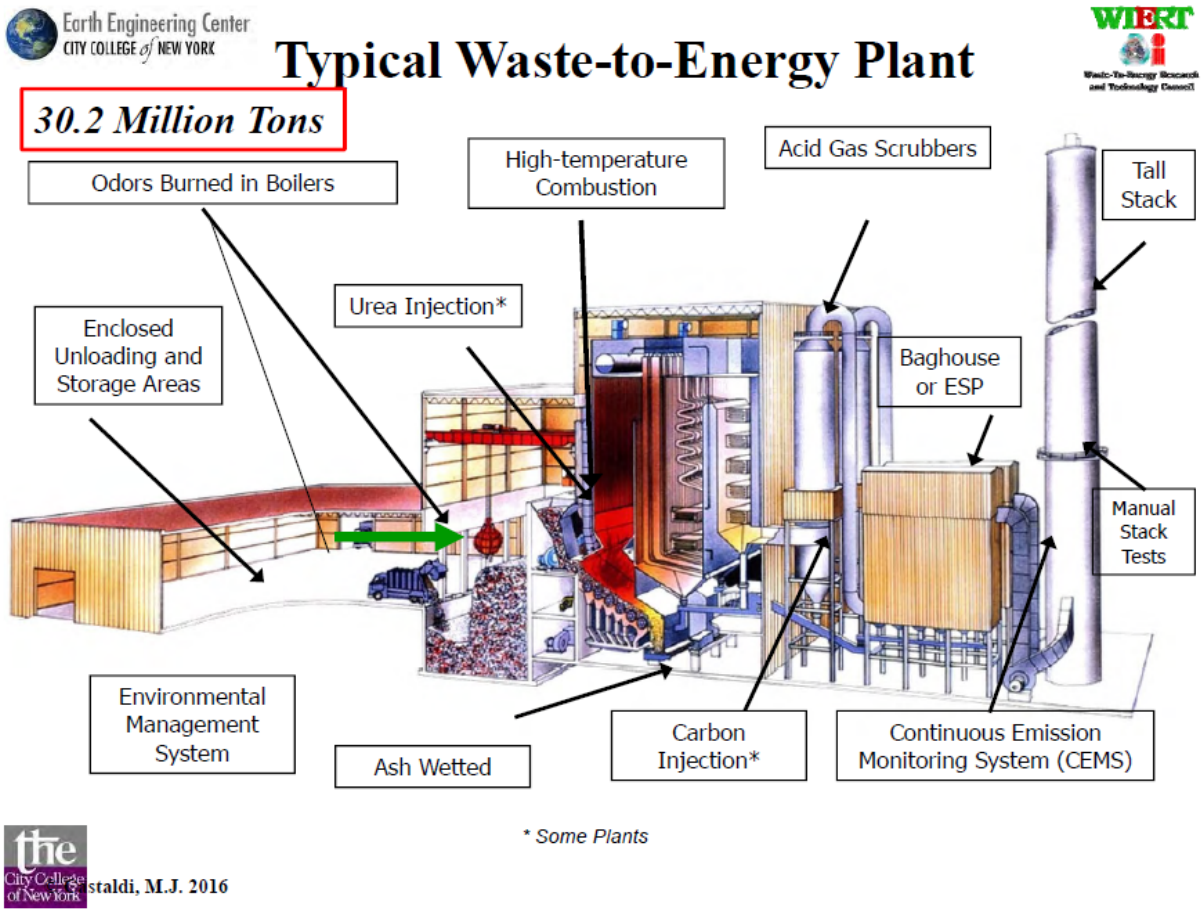


Waste-to-Energy

- 90% reduction of trash volume
- Power generation
- Pollution control

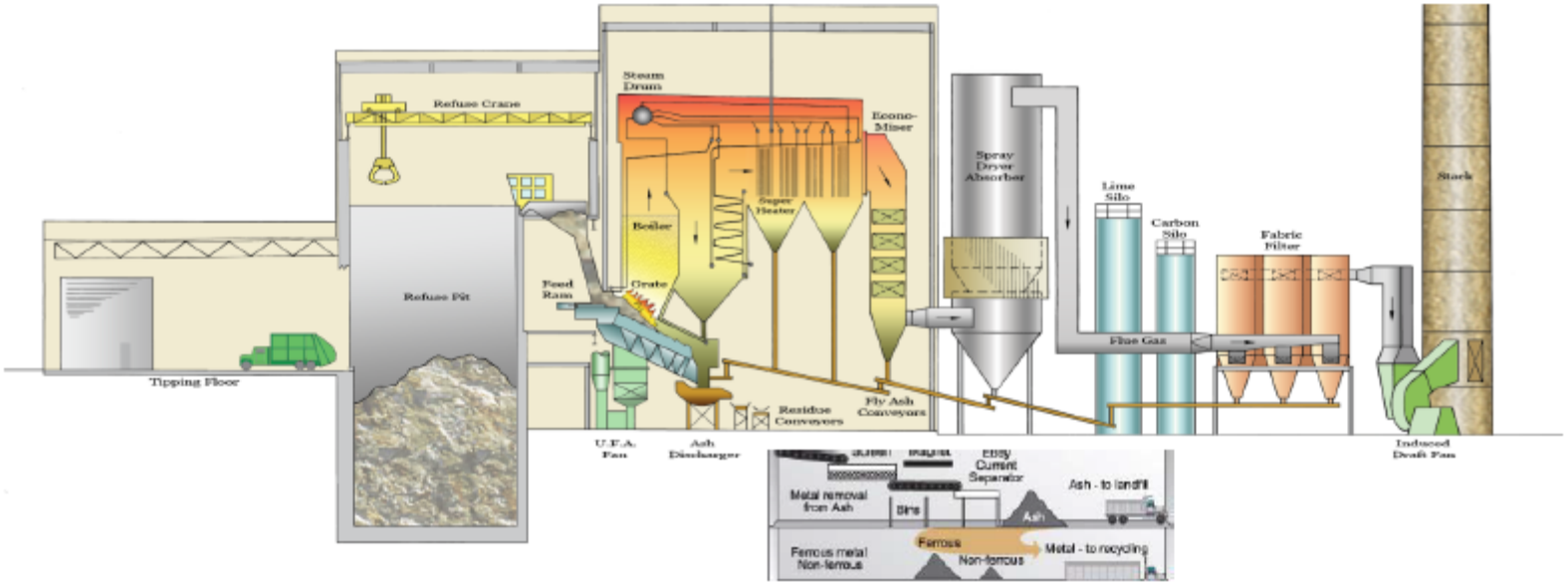
ecomaine
the future of regional waste systems
www.ecomaine.org

Functional components of W-t-E Plants



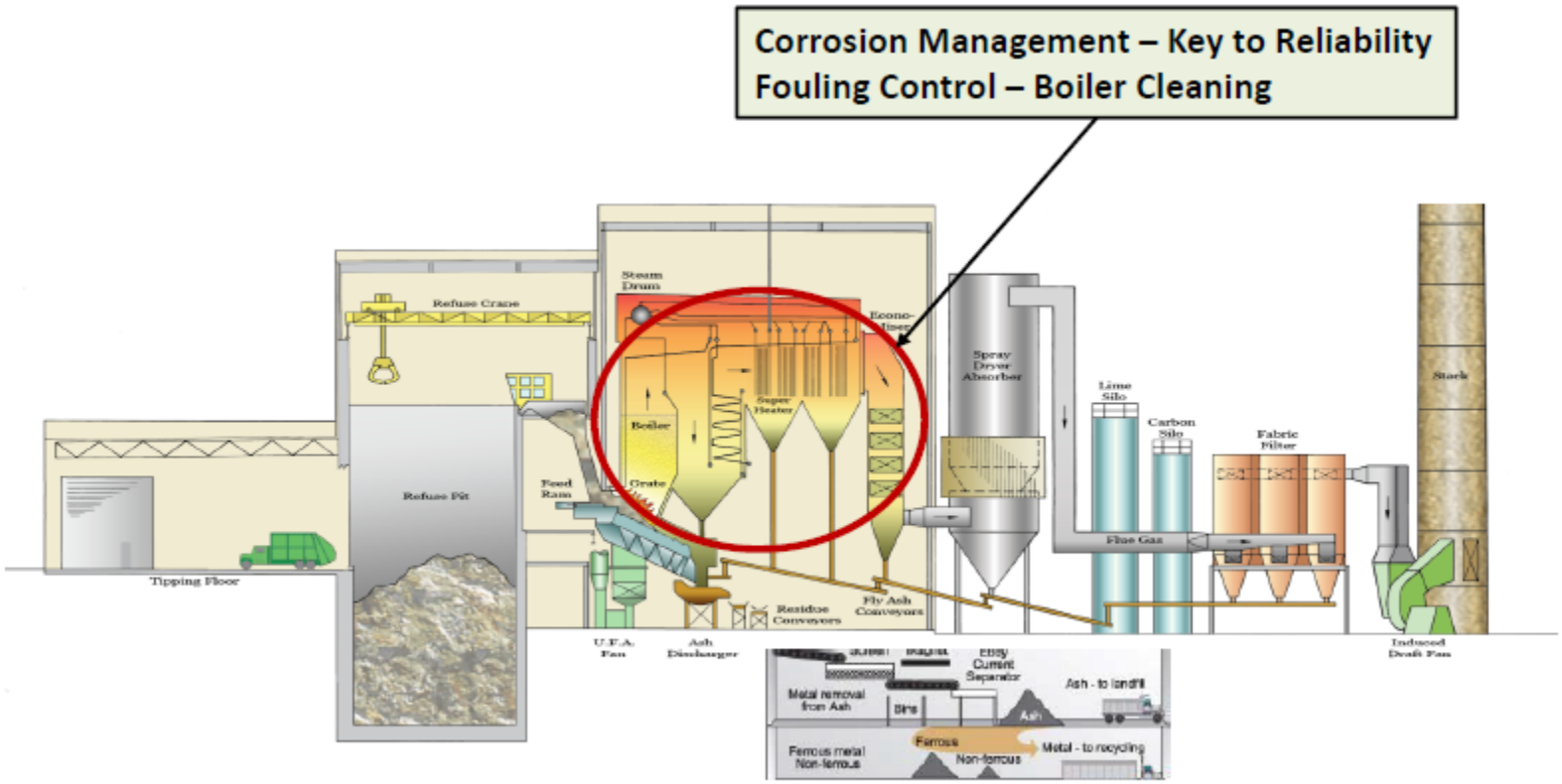
Typical modern waste-to-energy plant

(various functional stages shown in subsequent slides)



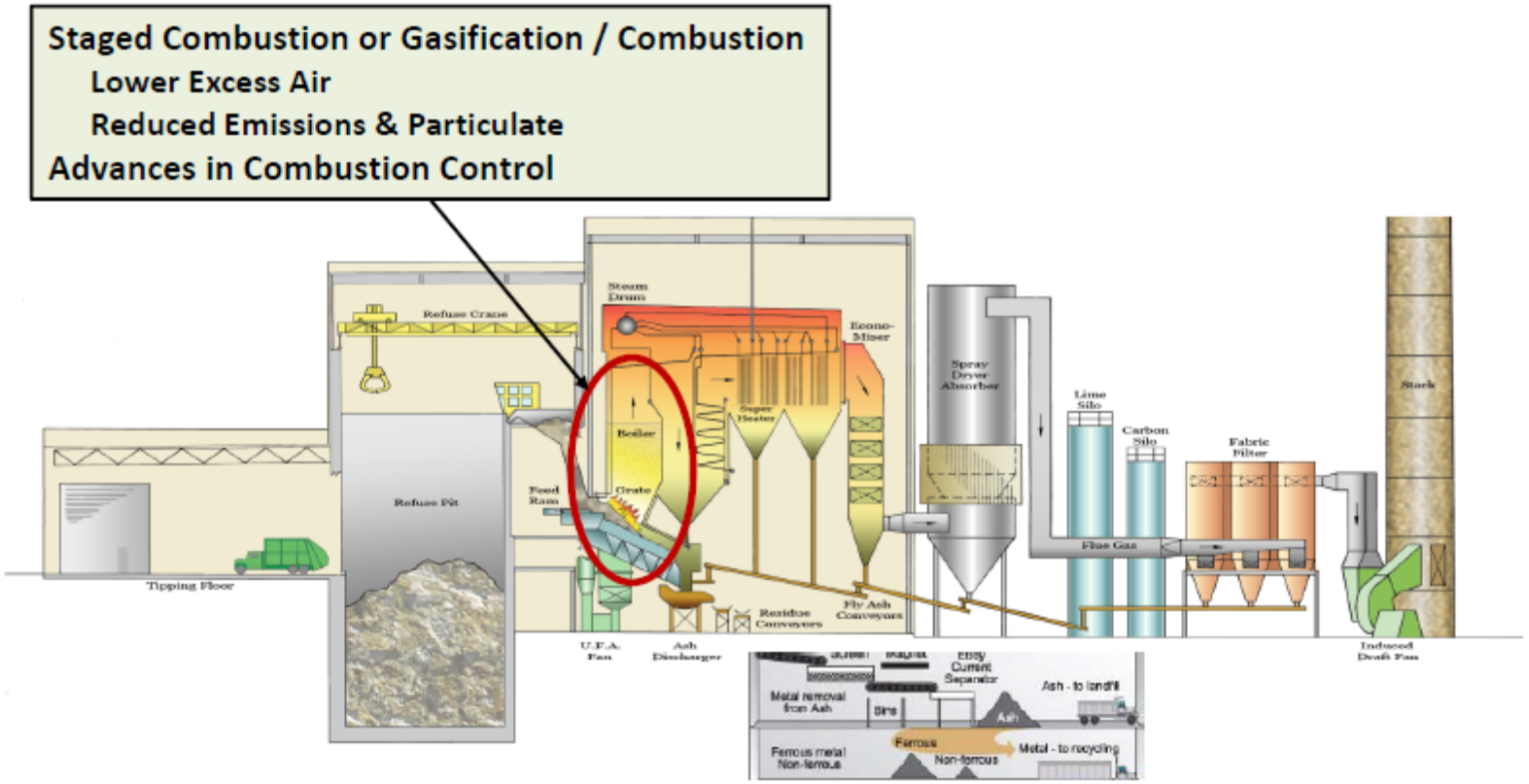
Courtesy: COVANTA, USA

Boiler design for heat recovery and reliability



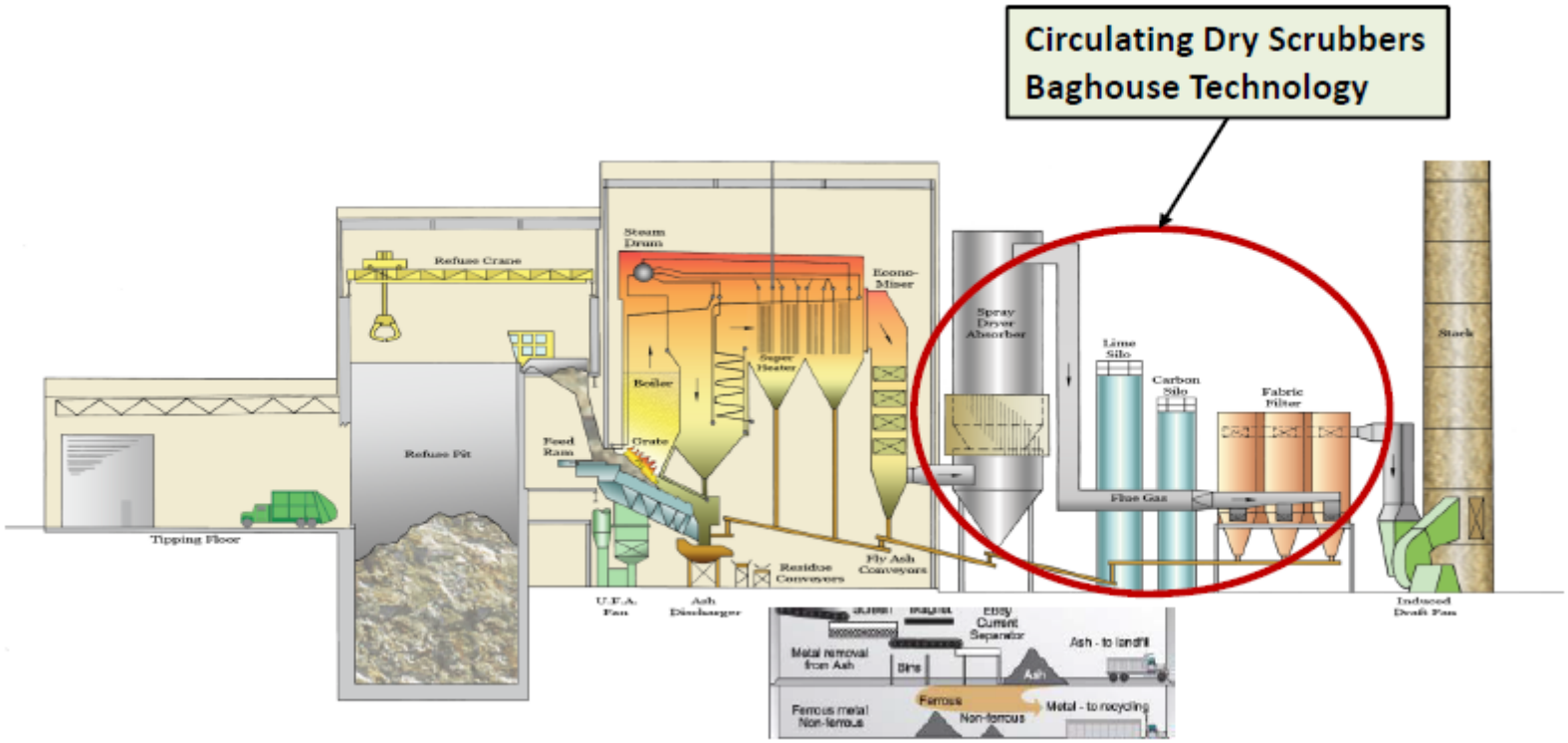
Courtesy: COVANTA, USA

A typical 3-stage combustion



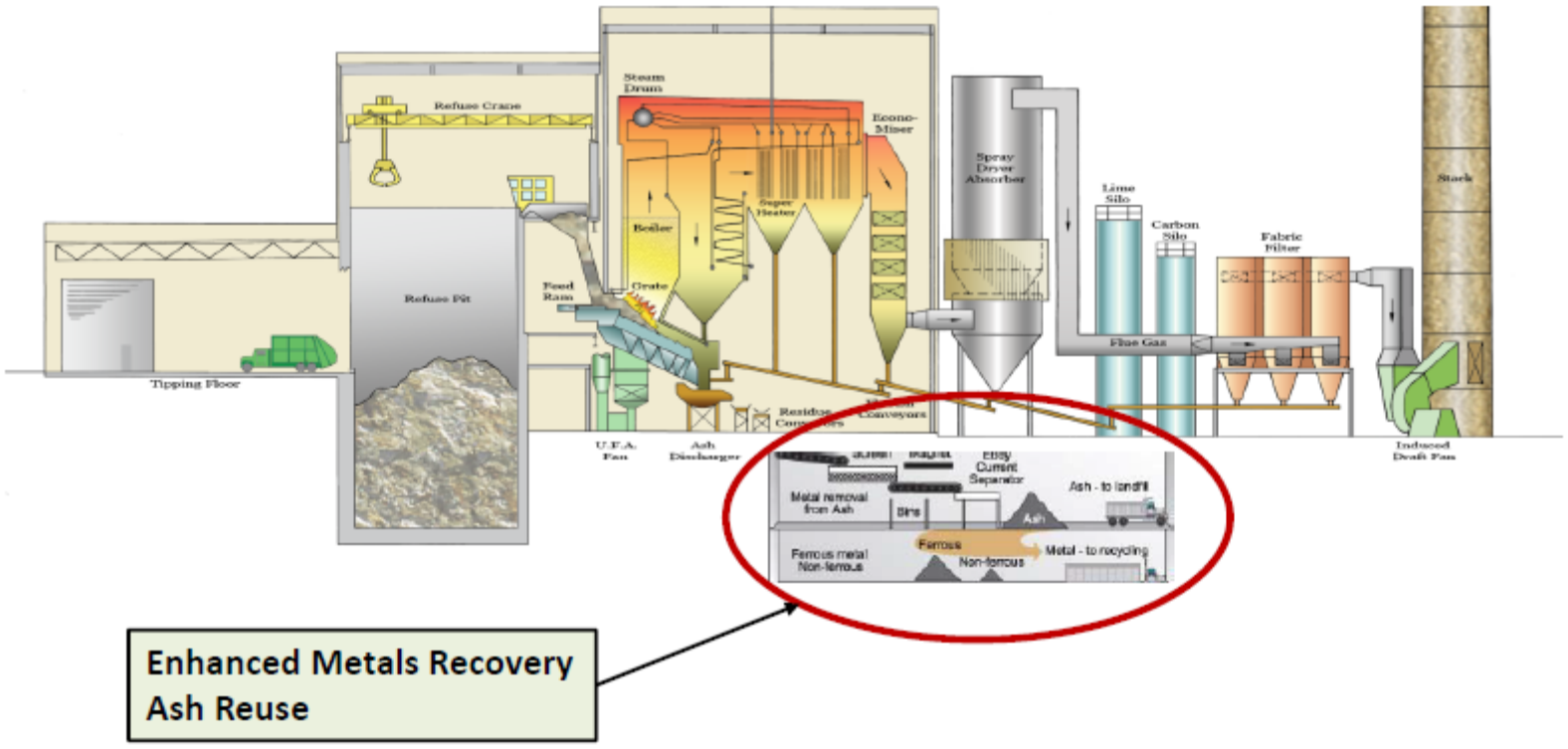
Courtesy: COVANTA, USA

Flue gas cleaning and Particulate Matter (PM) collection



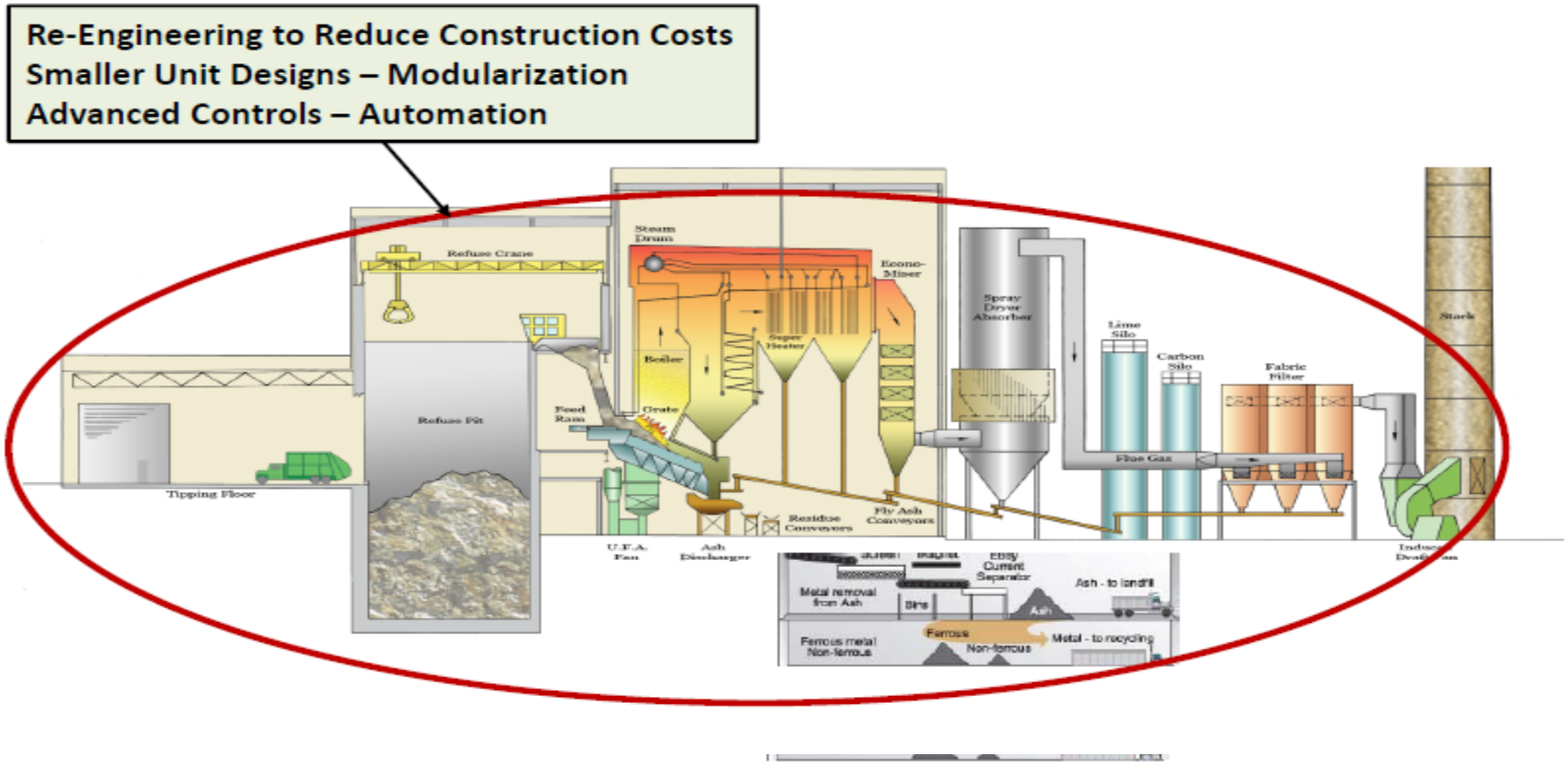
Courtesy: COVANTA, USA

Metal recovery before ash disposal



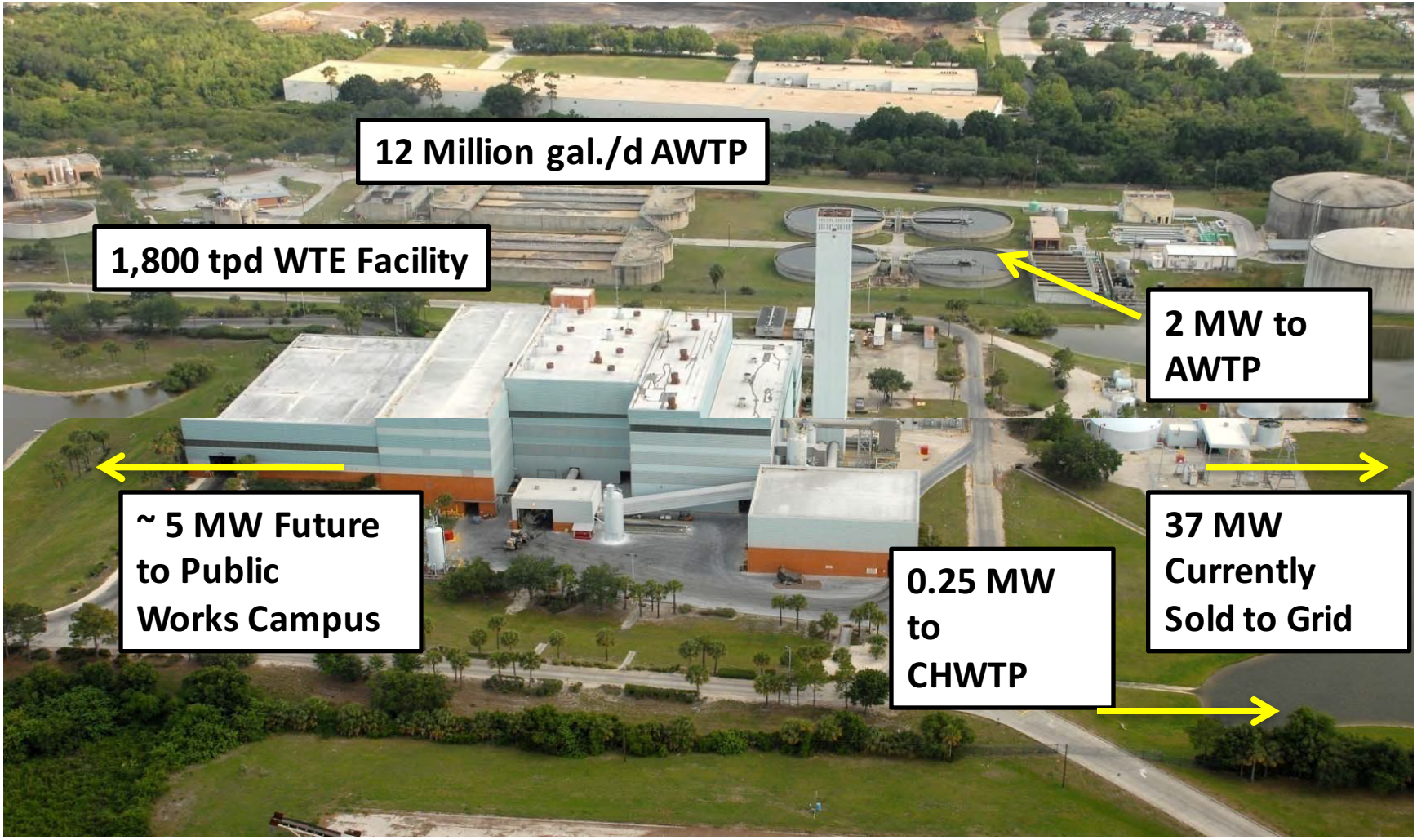
Courtesy: COVANTA, USA

Modern plants are fully automated with Dedicated Digital Control (DDC) technology



Courtesy: COVANTA, USA

Hillsborough County, Florida
WTE and Water Resources Synergy



Consulting

- Technology Evaluation
- Initial Feasibility Study and Economic Analysis
- Procurement & Vendor Negotiations
- Financing Activities Assistance
- Construction and Commercial Operations Monitoring

Consulting

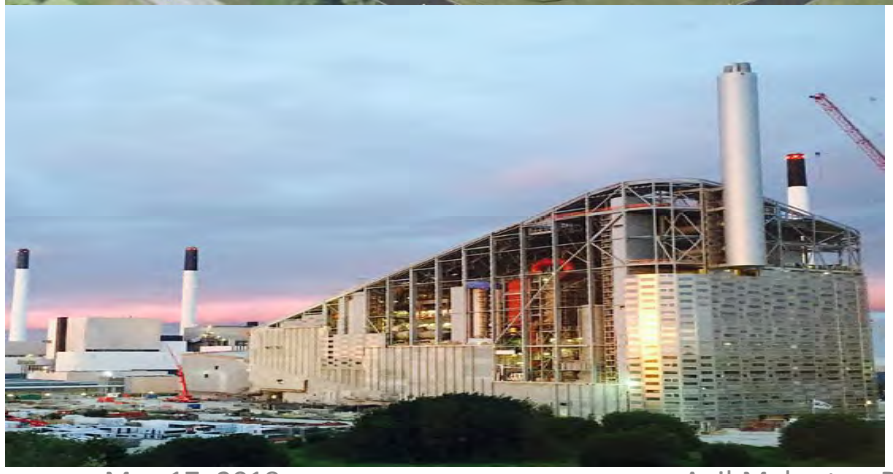
- Solid Waste Management Techniques
- Solid Waste Fuel Characteristics
- Solid Waste Safety Precautions
- Air Pollution Controls
- Emissions Testing & Monitoring
- Ash Considerations

Facilities' architecture is state-of-the-art to look modern and clean

Illustrating 3 Modern Plants

Palm Beach County, Florida, USA

Hamburg, Germany



Copenhagen, Denmark

Why consider waste as fuel?

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Extraction of value from wastes is sustainable

- ***Conserves fossil fuels by generating electricity.*** ***(Energy)***
  - 1 ton of waste combusted = 45 gallons of oil or 0.28 tons of coal
  - Most WTE facilities in U.S. process between 500 and 3,000 tons of waste per day
  - Electricity for 2.8 million homes
- **WTE facilities process 14% of the MSW in the United States. (Health)**
  - Trash-disposal needs about than 37 million people
- ***Reduce greenhouse gas emissions.*** ***(Climate, global)***
  - EPA estimates :WTE facilities prevent 33 million metric tons of CO_2 per year avoided
- ***Compatible with recycling.*** ***(Resource Minimization)***
  - Communities served by WTE recycle 35% of their trash, compared to 30% for the general population.
  - Annually removes more than 700,000 tons of ferrous materials
  - ~ 3 million tons of WTE ash reused as landfill cover, roadbed, or building material.

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Energy contents in wastes

Heat contents in MSW

4,500 BTU (British thermal units) per pound, or 2,500 Kcal. (Kilo calories) per kg

Energy potential in MSW 600 - 700 Kwh/ton of waste

Conserves fossil fuels by generating electricity. (Energy)

- 1 ton of waste combusted = 45 gallons of oil
  or = 0.28 tons of coal
- Most WTE facilities in U.S. process between:
  500 to 3,000 tons of waste/day
- Provide electricity for 2.8 million (28 lakh) homes

Heat contents of Waste is low – but "Do not let waste go waste"

- Calorific values of various fuels:

Coal	3,350 – 4,700 Kcal/Kg
Fuel oil	9,600 Kcal/Kg
Natural gas	8,000 - 9,500 Kcal/Kg
Cow dung	3,200 Kcal/Kg
Solid waste (MSW)	2,500 Kcal/kg

Major considerations in W-t-E

- Money needed to build an MSW combustion facility can be significant and economic benefits may take several years to be fully realized.
- A moderate size plant (500 – 1000 MT/day) typically requires at least 100 million dollars to finance the construction
- Larger plants (1000 – 3000 MT/day) may require double to triple that amount.
- Long-term contracts (generally 30 years) are often developed between the facility and municipality to secure a guaranteed waste stream.

W-t-E is a Renewable energy source

Waste-to-Energy (W-t-E) meets the two basic criteria for establishing and meeting the definition of what a renewable energy source

1. It is sustainable as a fuel source (trash)
2. It is indigenous

Waste-to-Energy facilities generate clean renewable energy and deserve the same treatment as any other renewable energy source

Major Socio-economic functions

Waste-to-Energy sector serves these main functions

1. It manages post-recycled waste
2. Recycles post-consumer metals
3. Produces GREEN ENERGY
4. In addition these facilities generate indirect and induced impacts like employment and wage earnings

Main constraints to W-t-E:
Lack of Awareness and Management

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Specific Issues Driving Technology

WTERT

Country Drivers

- *Economic/Market*
- *Environment*
- *Environment / land constrained*
- *Land Constrained*
- *Management*

US/Canada – Market driven, compete with landfills

Japan – Prefecture structure (no waste across boundaries) landfill inert material

Europe – Landfill directive (no organics), R1 formula → renewable status, environment

China – Management, co-fired with coal, lack of sanitary landfill infrastructure

India – Awareness, management

South America – Management, lack of sanitary landfills

Taiwan (island nations) – Land constrained – mining of existing landfills to process via thermal treatment enabling land reclamation

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Conclusion
W-t-E: a Green source of Revenue

- MSW Combustion facilities typically collect a tipping fee from the independent contractors that drop the waste off on a daily basis to recover costs.
- The facilities also receive income from utilities after the electricity generated from the waste is sold to the grid.
- A possible third stream of revenue for the facilities comes from the sale of both ferrous (iron) and non-ferrous scrap metal collected from the post-combusted ash stream.

Conclusion (contd.)

- The Waste-to-Energy sector provides significant economic value to the communities it serves.
- In addition to the revenues generated by this sector, waste-to-energy facilities provide stable, well-paying jobs
- Provides indirect revenues to the local economies through the purchase of local goods and services and by way of payments of fees and taxes

Conclusion (contd.)

- It enhances the capacity of providing **base load renewable** electricity generation, recover valuable metals for recycling, and reduce **green house gas (GHG)** emissions.
- W-t-E facilities thus contribute significantly towards the **green economy** in the communities which they serve and in which they operate.

Acknowledgments: US Environmental Protection Agency (EPA) and Others