Informational Meeting Session No. 2

February 28, 2017

King County Council Chamber

Introduction

Kathy Lambert, King County Councilmember

Integrated Solid Waste Management Systems Anchored by Modern Waste-to-Energy

A Review of Recent Installations and Existing Facility Operations from Around the World

Sustainable Waste Management Solutions for the 21st Century

CDM Smith

Presentation to:

King County and Regional Public /Private Organizations

February 28, 2017

Seattle, WA

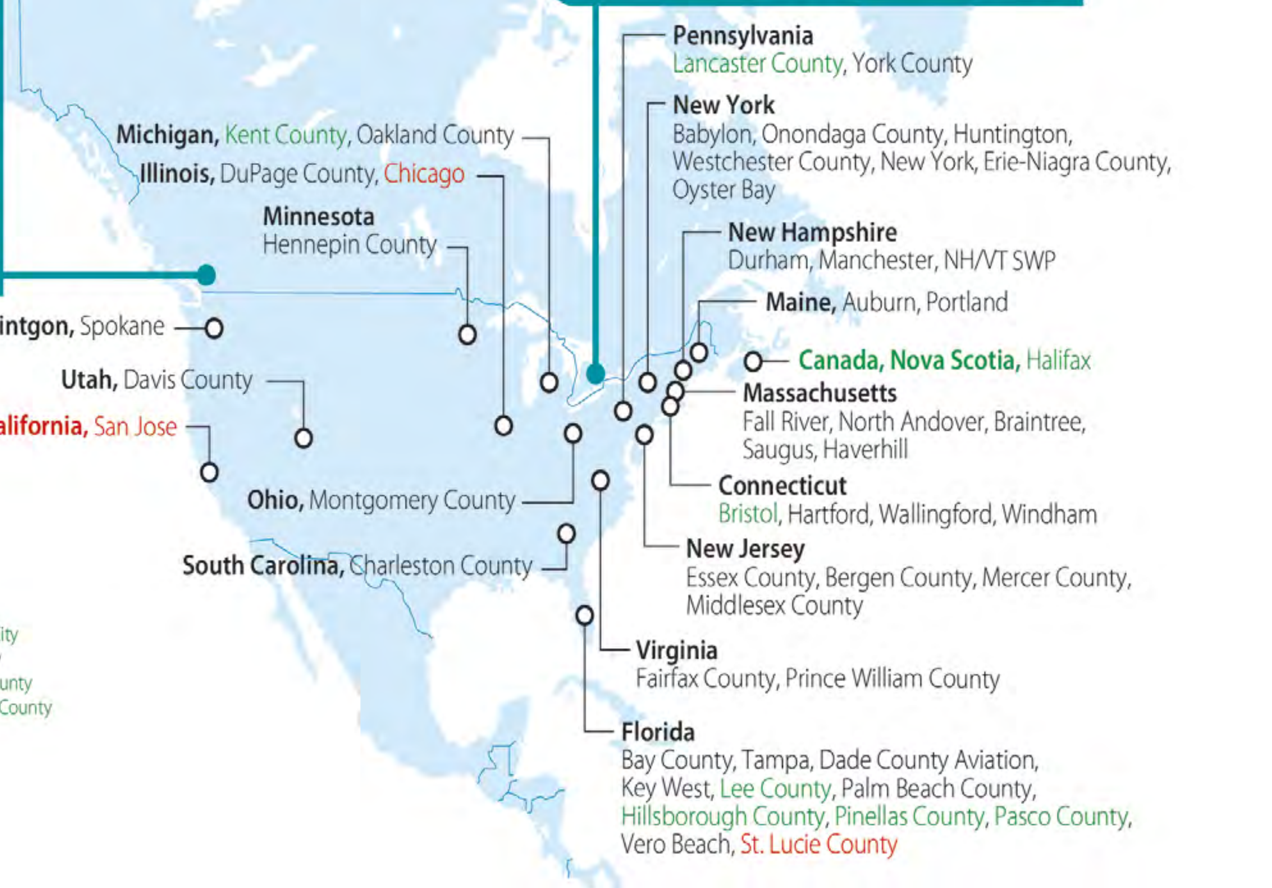
Paul Hauck, P.E.

CDM Smith's World Waste-to-Energy Experience

DB/DBO Vendor Procurement
Technology Evaluation
Other WTE Projects

British Columbia, Canada, Vancouver

Ontario, Canada, Brampton



International Experience

Presentation Outline

- Evolution of the WTE into the Resource Recovery Industry
- Capital and O&M Cost of WTE Facilities
- Revenue Streams from WTE Facilities
- Options for Enhanced Revenues
- Economic and Environmental Benefits of WTE
- Greenhouse Gases and Carbon Offset Potential of WTE
- Case Studies of Several Florida WTE Projects
- Conclusion

U.S. / Europe Waste Management Hierarchy

- Waste Prevention
- Re-use
- Recycling
- Maximize Recovery of Energy and Materials
- Minimize Landfill Waste Disposal

WTE Benefits Include Waste Sterilization, along with 90% Volume and 75% Weight Reduction

Input

Output

Waste in, stabilized and inert ash out!

Modern WTE Trends…Improved Efficiency and Sustainability, Yet Lower Power Payments!

Increasing Trends

- Advanced ferrous and non-ferrous metal recovery
- Advanced combustion controls
- Higher boiler/TG availability and gross/net electric generation
- Use of reclaimed water for cooling
- Higher Heating Value (HHV) of MSW
- Compliance with stringent emission limits & GHG reporting
- WTE facility expansions and attention to aesthetics/LEED®/innovation
- Evolution of integrated solid waste management/eco-campus

Trends Decreasing

- Air pollution emissions
- Chemical reagent consumption
- Water consumption
- Lower payments for electricity sold to electric grid

Evolution of WTE Technology

Element	Incineration	1st Generation WTE	2nd Generation Modern WTE	3rd Generation Advanced RR
Year	1910-1970	1970-1985	1985-1995	2011-2017
Aesthetics	Industrial	Industrial	Enhanced	Enhanced Plus
Steam Conditions	None	600 psi	835/ 1350 psi	850 / 1400 psi
Net Electrical Generation	0	475	570/ 725	575-600/ 750
Combustion Control	Basic	Computer Based	Advanced	Optimized
Air Pollution Control	None	Electrostatic Precipitators	Scrubber / Fabric Filters with Activated Carbon	Scrubber / Fabric Filters with Activated Carbon, Very Low NOx
Ferrous Recovery	None	Electromagnets 2.0 – 2.5%	Permanent Magnets 2.5%	Rare Earth Magnets 3.5%
Non-ferrous Recovery	None	None	Eddy Current Separators (ECS)	High Strength ECS (90% recovery)
Beneficial Reuse of Ash Residue	None	None	Within Landfill Campus	Multiple Uses

Examples of Enhanced Architectural Design

Palm Beach County FL

Hamburg, Germany

Copenhagen Denmark

Focus on Good Housekeeping…
Top Floor of Refuse Storage Building

Focus on Good Housekeeping…
Middle Deck Level of Boiler Building

Metals "Liberated" by Combustion and Recovered by Stronger Magnets and ECS – 2nd Generation

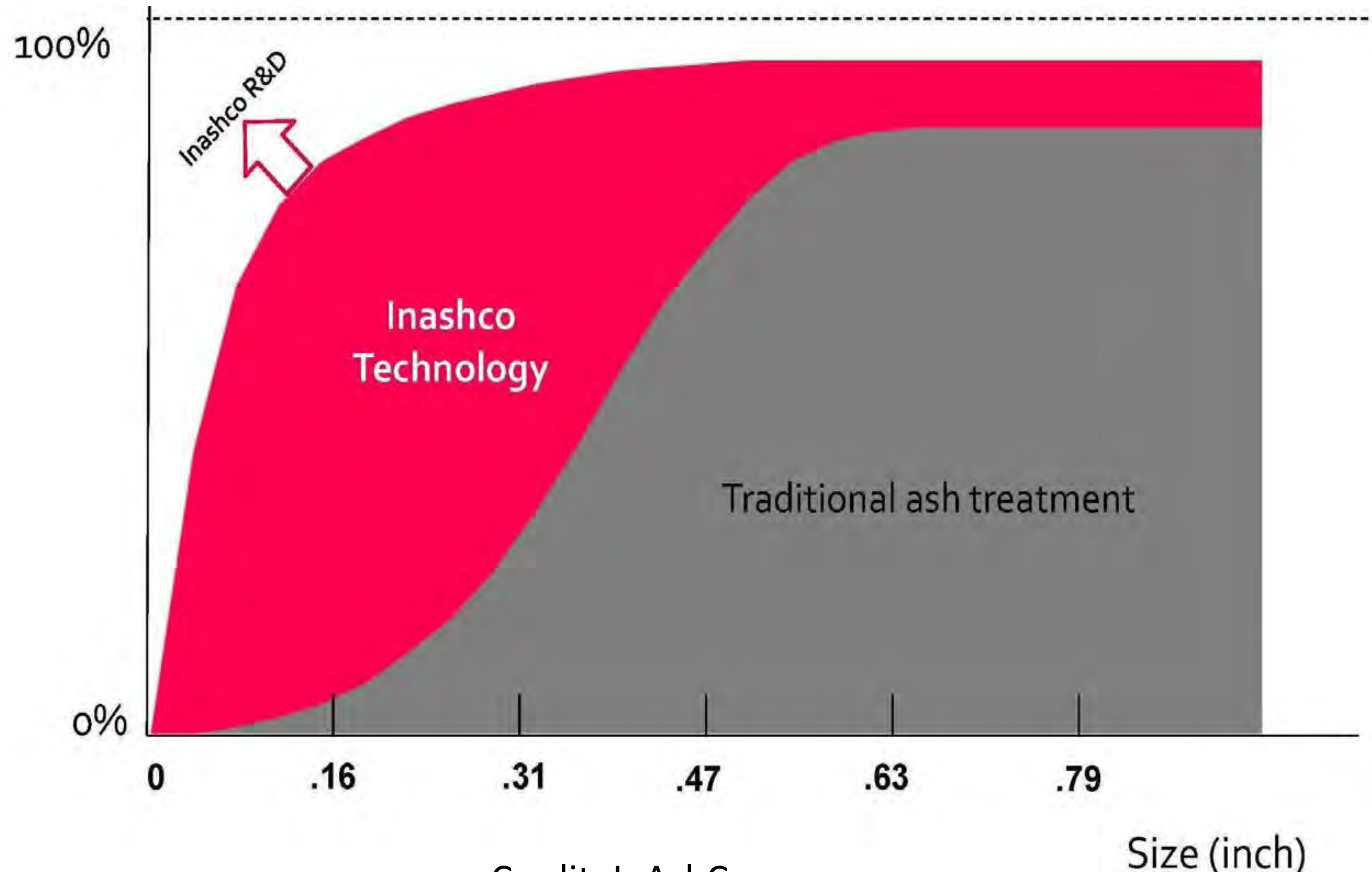
Plus 6" Ferrous Metals

Minus 6" Ferrous Metals

+3/8" Non-ferrous Metals

Close-up of Non-ferrous Metals

Advanced Metal Recovery Goal is to Recover the "Fine Fractions" of Metals and Minerals



Credit: InAshCo

Samples of "Fine" Minerals and Metals from Ash

Fine minerals
(< 0.07 inch)

Mineral aggregates
(> 0.07 inch)

Non-ferrous concentrate

Ferrous concentrate

Credit: InAshCo

Percent of Estimated Value of Non-Ferrous Metals in Ash

Aluminum 34%

Gold 28%

Copper 23%

Iron 10%

Silver 3%

Zinc 2%

Lead 1%

3rd Generation Resource Recovery can Help Communities Achieve Future "Zero Waste" Goal

- **MSW to Landfill**

WTE without Metal Recovery

WTE with Metal Recovery

WTE with Metal Recovery and Bottom Ash Recycling

Major Elements of WTE Capital and O&M Cost

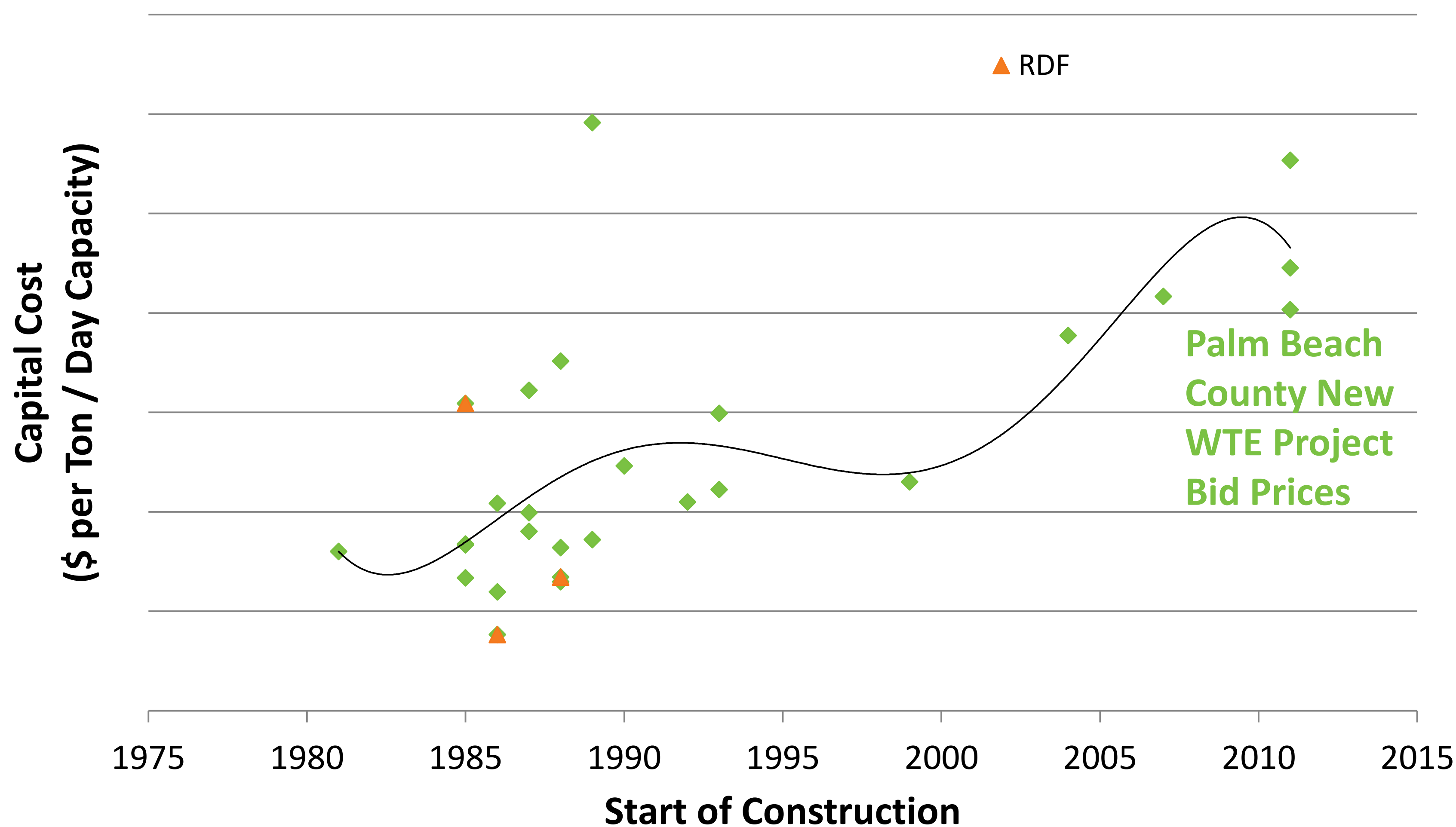
Capital Costs

- Cost of land
- Project development cost
  - Engineering
  - Permitting
  - Procurement
  - Legal
- WTE facility / process cost (including spare parts)
- Financing cost
  - Interest rate
  - Term of loan

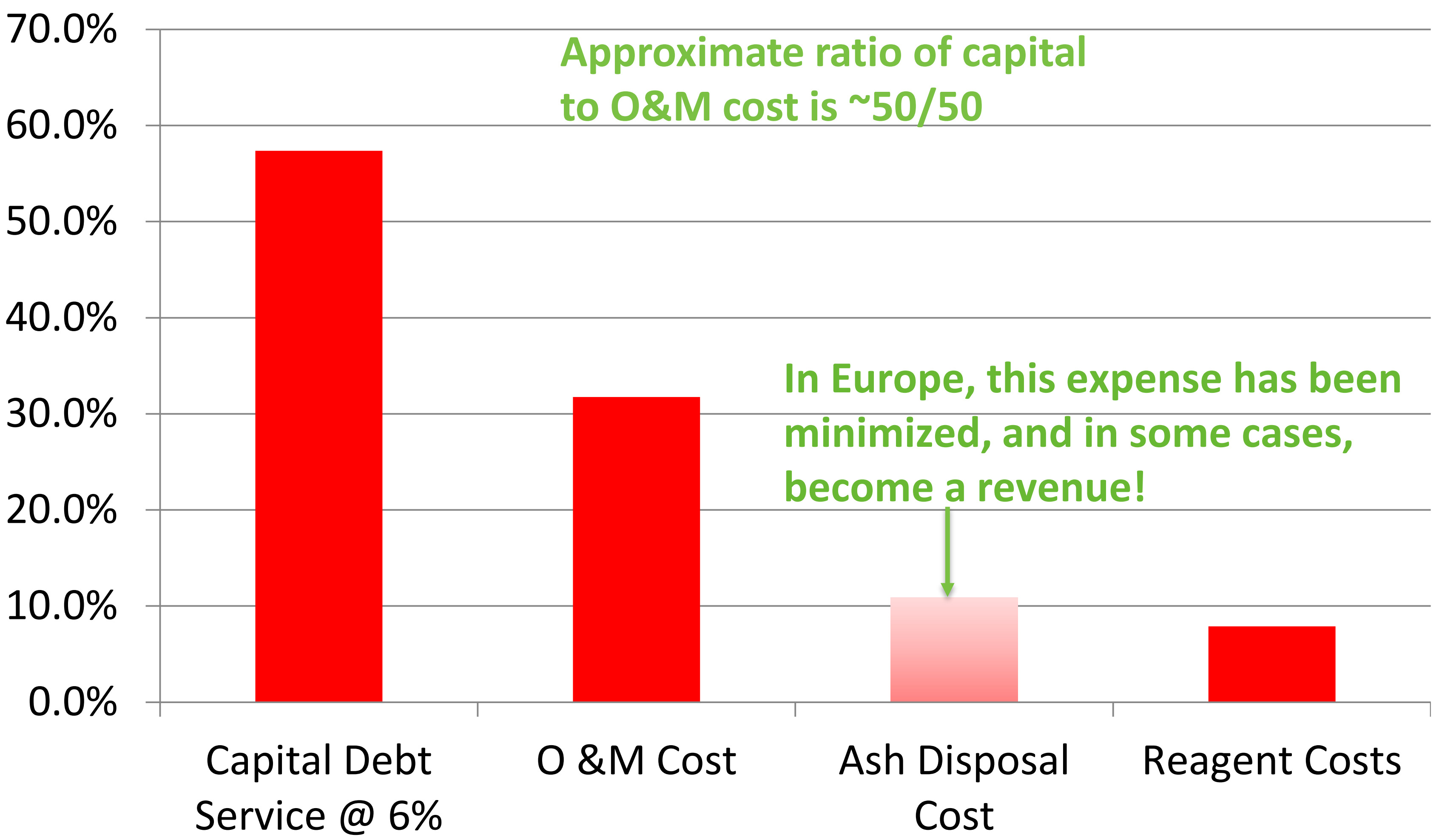
O&M Costs

- Contractor labor and service fee (includes profit)
- Air pollution control system chemical reagents (carbon, lime, urea, ammonia)
- Water treatment reagents (acid, caustic)
- Utilities (natural gas, electricity, potable water, raw water, reclaimed water, sanitary sewer)
- Disposal of bypassed or non-processible waste
- Disposal of ash residue

U.S. Massburn WTE Capital Cost History Upward Trend, or has it Turned the Corner?



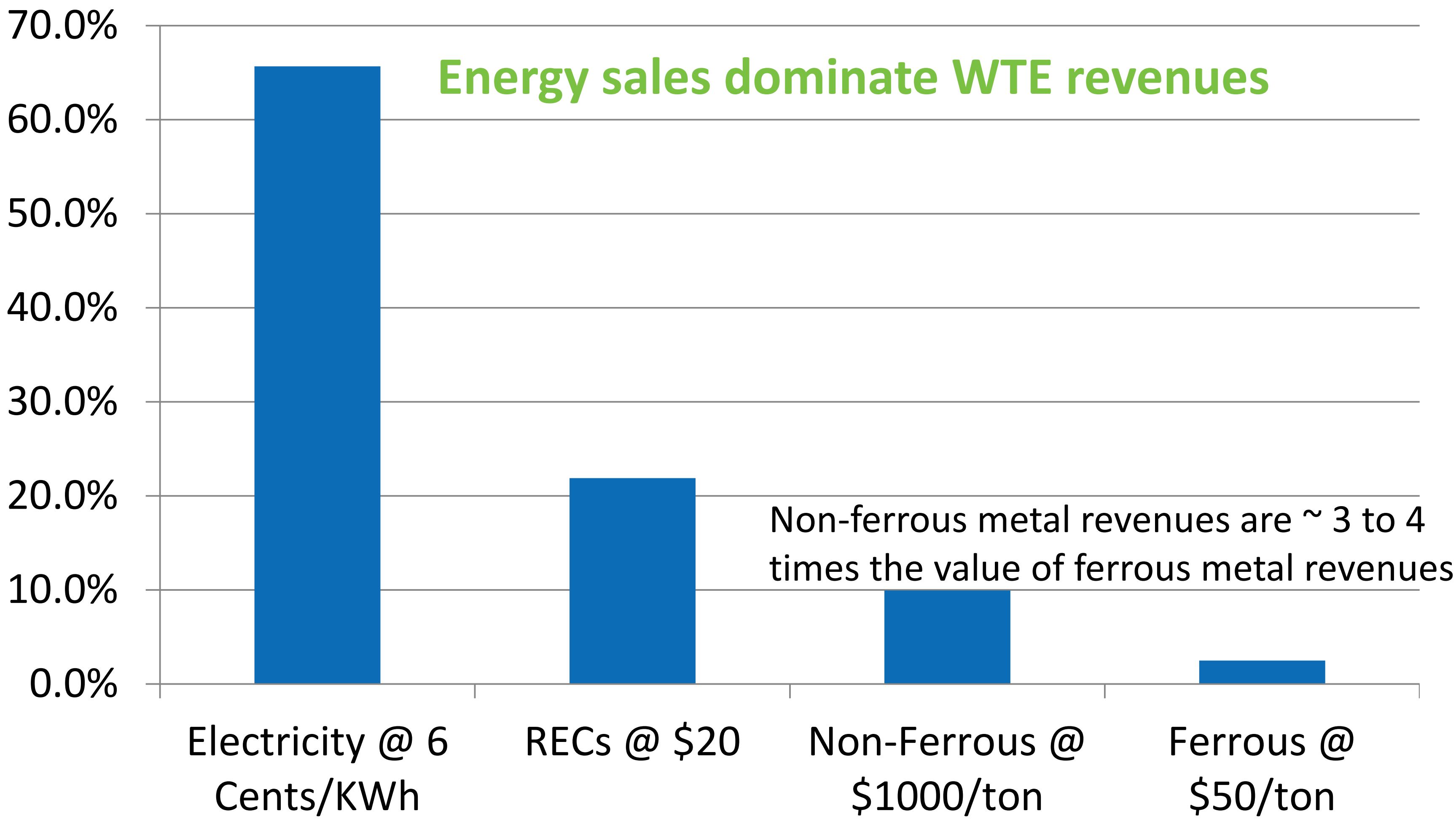
Representative Massburn WTE **Annual Expenses**
Illustrative Purposes Only, from Prior Project Analysis



Major Revenue Streams from Modern WTE (Listed in Approximate Order of Value)

- Value of power used internally (behind the meter)
  - Allows owner to realize full retail value
- Net electricity sold to grid
  - Percentage of electrical revenues shared with operator (10%)
- Steam / hot water sales (CH&P)
- Ferrous and non-ferrous metals
  - Percentage of electrical revenues shared with operator (50%)
- Special Waste Programs
  - Liquid and solid wastes
- Attributes of renewable energy generation
  - Renewable Energy Credits (RECS)
  - Carbon offsets (CO_{2e} - Currently sold on voluntary markets)

Representative Massburn WTE **Annual Revenues**
Illustrative Purposes Only, from Prior Project Analysis



WTE Capacity Factor is the Highest Among Renewable/Fossil Energy Options (Base Load)

Nuclear……………………………………………………………	90-92%
Waste-to-Energy (WTE)…………………………………………	**88-95%**
Baseload Coal……………………………………………………….	80-90%
Landfill Gas………………………………………………………….	80-95%
Biomass……………………………………………………………….	60-85%
Natural Gas Combined Cycle……………………………………	60-80%
Thermal solar (parabolic trough)……………………………	40%
Wind……………………………………………………………………	20-35%
Photovoltaic solar (southern latitudes)…………………	18-20%
Photovoltaic solar (northern latitudes)…………………	12-15%

WTE helps provide fuel diversity and resiliency for base load power production on the regional electrical grid!

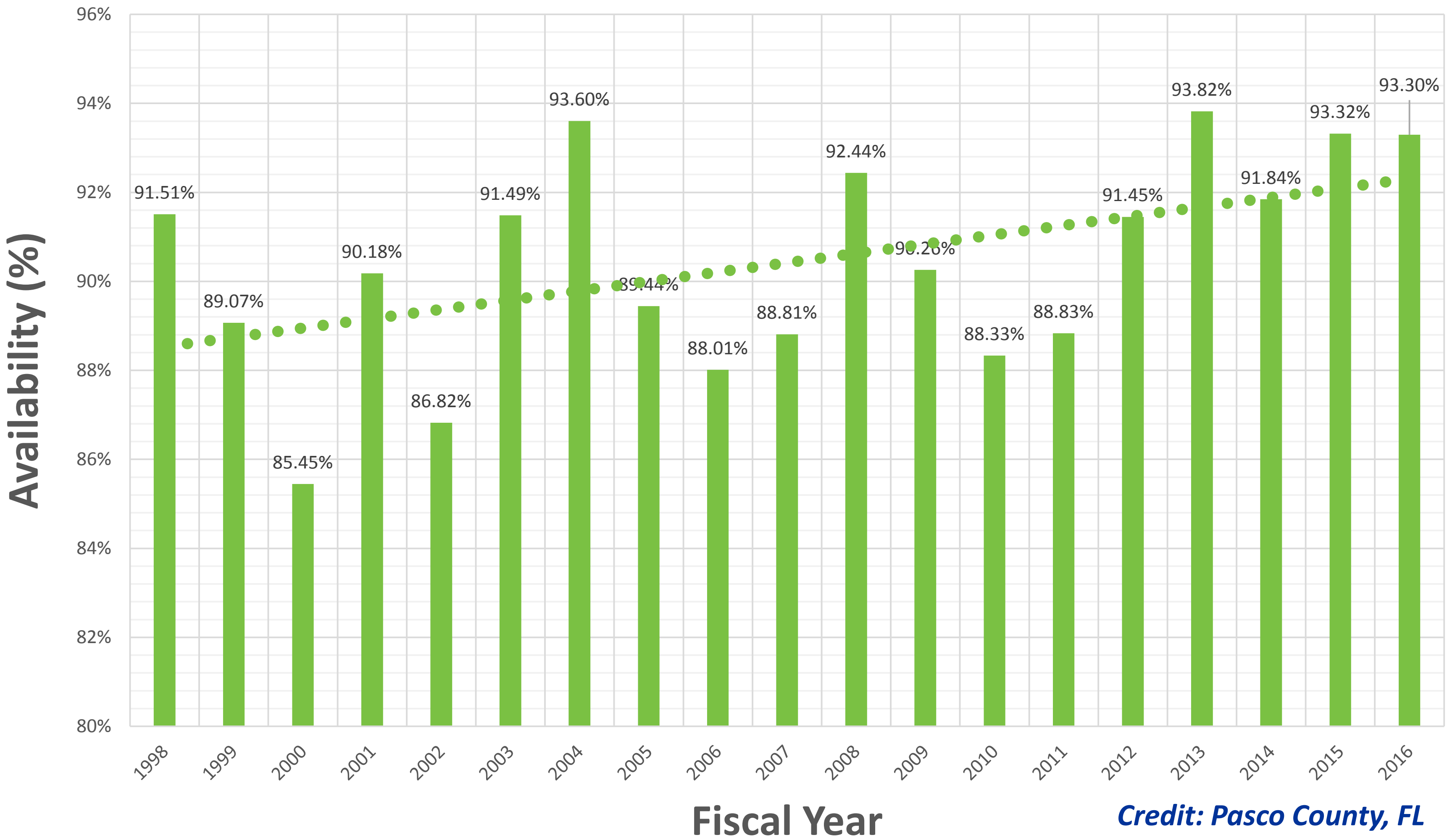
Benefits of WTE to Regional Electrical Grid

- Centrally located distributed energy
  - Typically located in close proximity to urban electrical demand
  - Distributed source of generation, with minimal line losses
- Reliable base load source of renewable energy
  - Supports proper operating voltages on local electrical grid
- Delays need to permit and construct new units as aging and uneconomical large fossil units are retired
- Improves “fuel” diversity to local electrical grid for reliability during interruptions in fuel or hydro water supply
- Compatible with Microgrid Concept
  - Improves resiliency of critical municipal infrastructure (power, water, wastewater, public works, emergency and disaster management, etc.)

Opportunities for Enhanced WTE Revenues

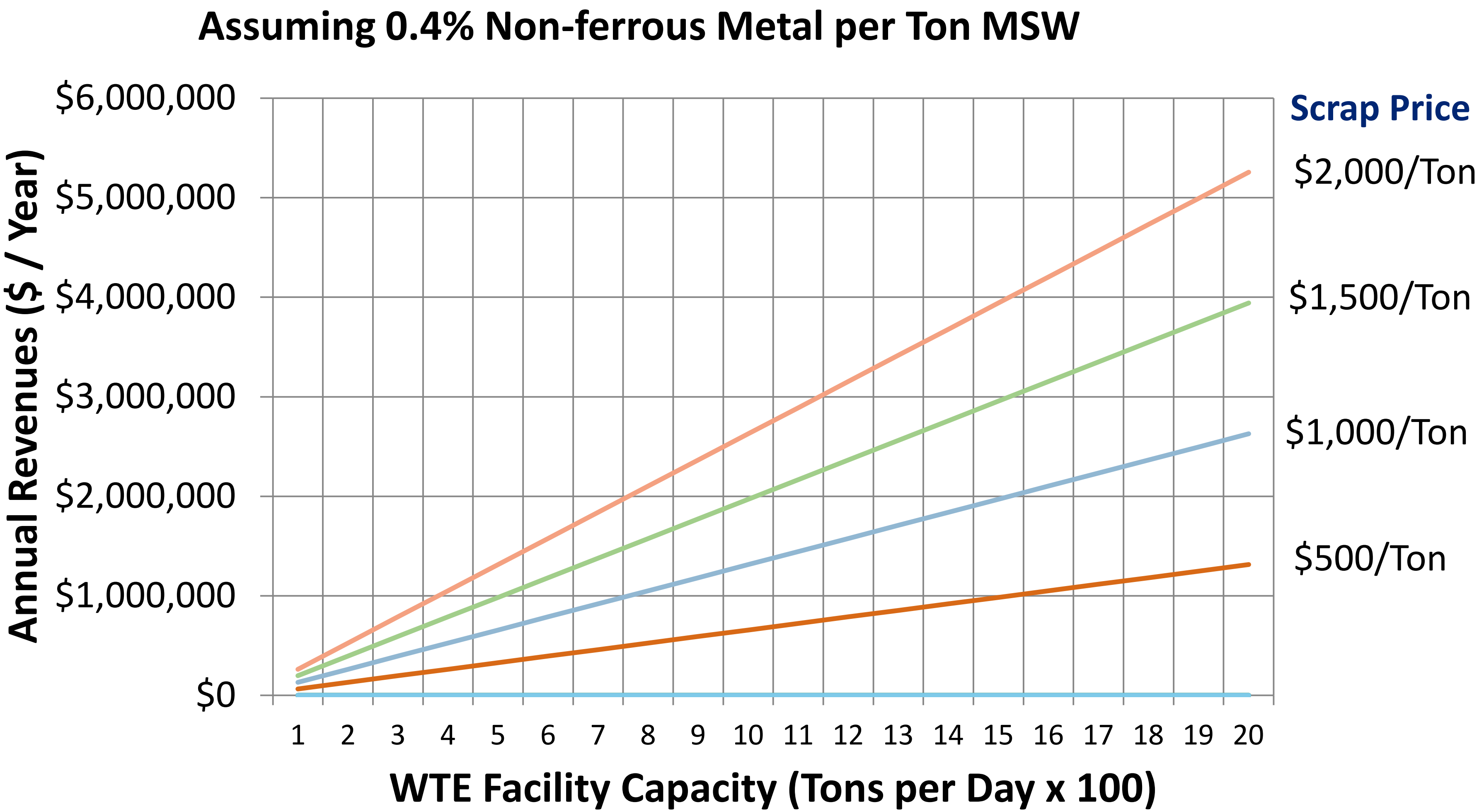
- Maximize availability
- Maximize energy production
- Internal use of energy
  - Treatment of water and/or wastewater
  - Drying and processing WWTP biosolids
  - Other “behind the meter” uses (Public Works, recycling facilities)
- Combustion of special wastes in need of assured destruction
- Advanced recovery of metals and minerals
- Sale of bottom ash
  - Aggregates for use in asphalt or concrete pavements / products
  - Feedstock for manufacturing of Portland cement
- Recover and use of waste heat (municipal and industrial uses, **host community benefits**)

Pasco County Florida WTE Facility (26 years old)
Continuous Improvement in Facility Availability

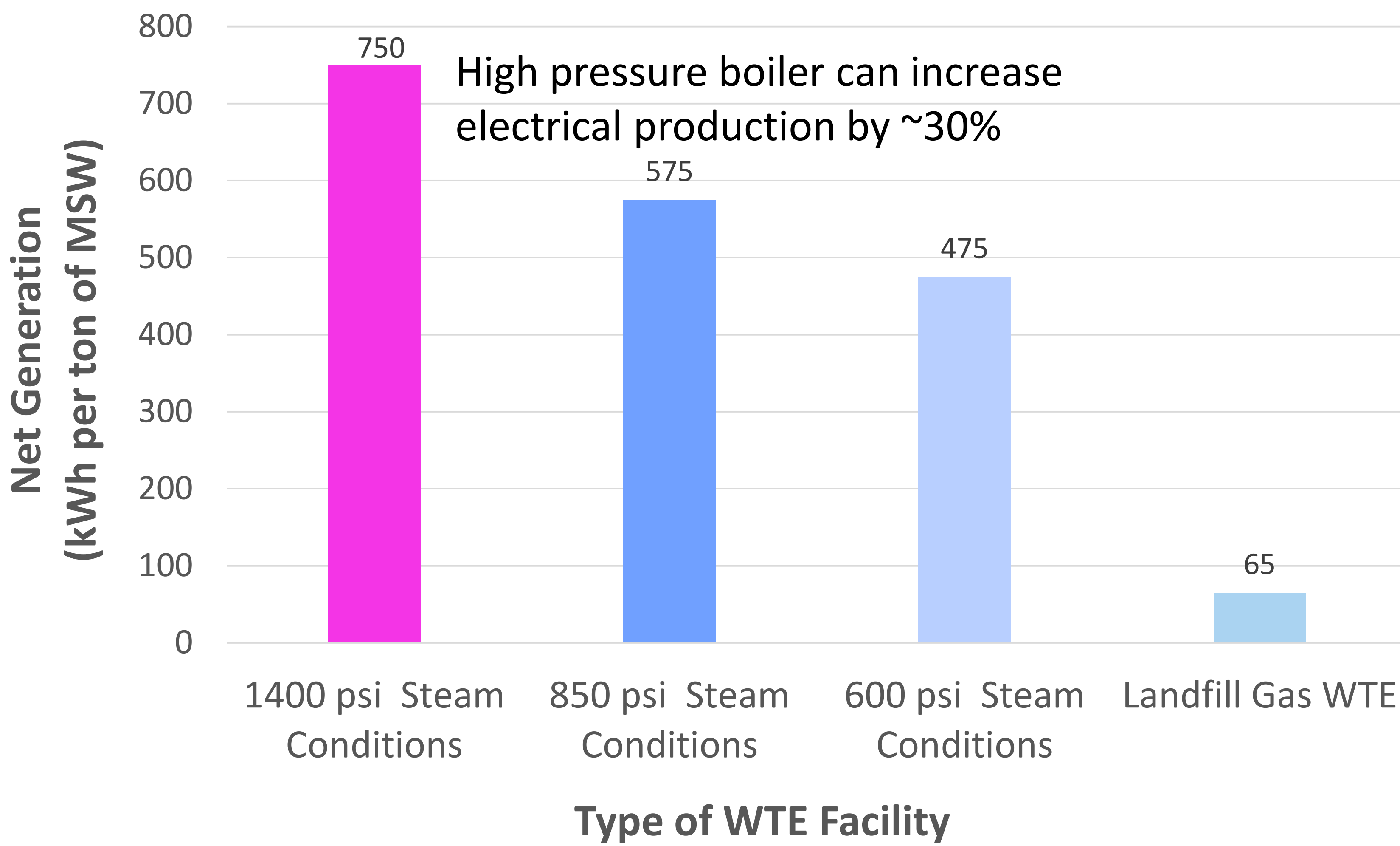


Credit: Pasco County, FL

Current Value of Recovered Non-Ferrous Metals in Bottom Ash is ~60% of Total Recoverable Value



Net Electrical Generation Rates for Proven WTE (not including Emerging Technologies)



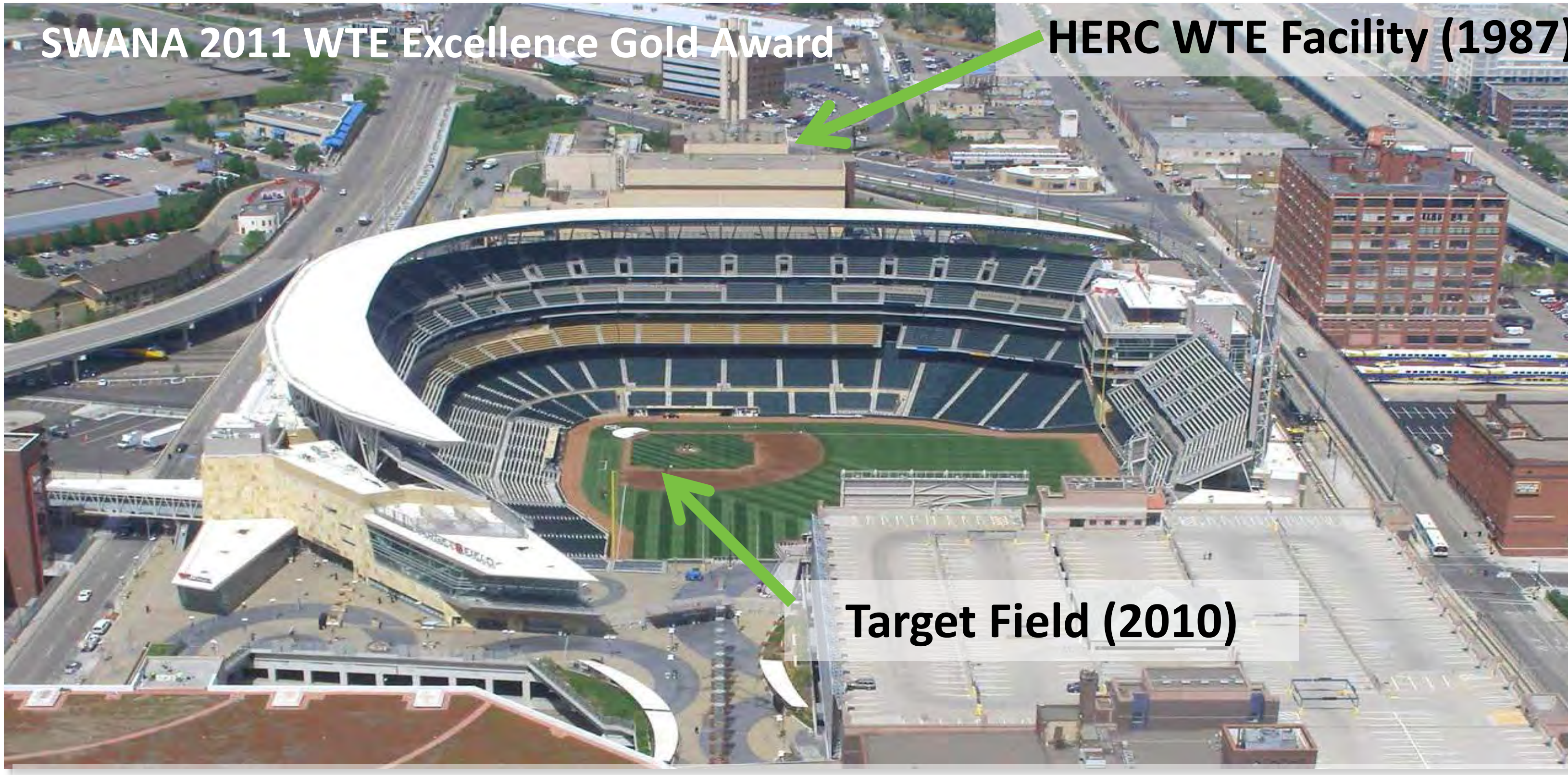
World's Largest WTE Facility (2020) in China to include Desalination Water Plant and Solar PV

Using power internally allows owner to realize full retail value of electricity!

- 5,000 mtpd (5,600 tpd)
- 125 MW nameplate electrical
- **132 mgd water production**
- Shenzhen,China (population of 20 Million)

Credit: Schmidt Hammer Lassen Architects and Gottlieb Paludan Architects

Hennepin County, MN WTE Facility
CH&P and Compatible with Urban Redevelopment



Low pressure steam used for heating of grassed areas for early greening in spring, along with space heating and hot water needs. **Steam also delivered to local district heating system, significantly increasing net thermal efficiency!**

Special Wastes in Need of Secure Means of Disposal!

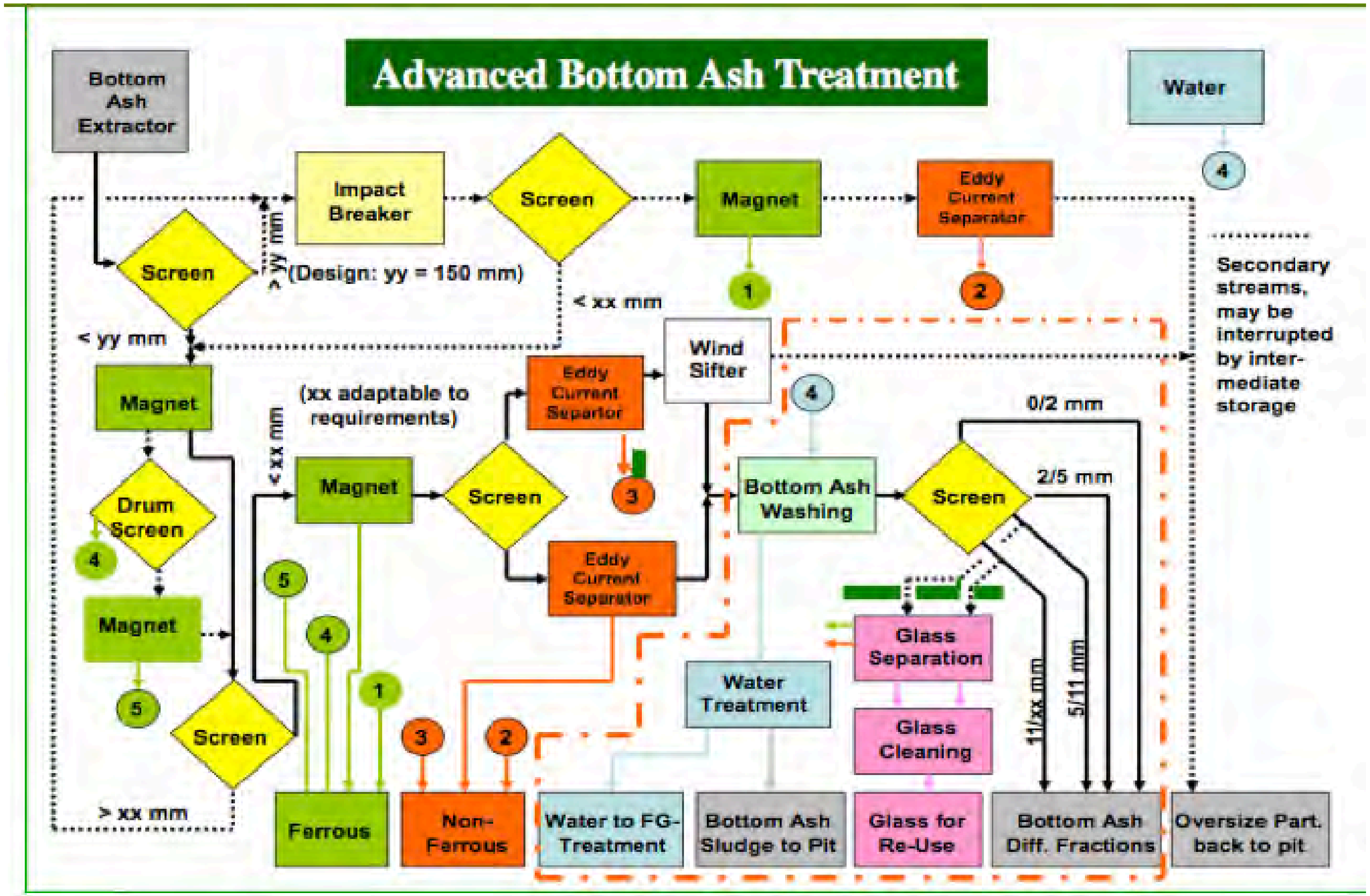
- **Wastewater treatment plant residuals and biosolids**
  - Discarded fats, oils and grease (FOG)
- **Local and regional wastes in need of "secure means of disposal "**
  - Unsalable manufactured products
  - Out-of-spec or out-of-date
  - Discarded pharmaceuticals
  - Industrial liquid and solid wastes
  - International wastes (USDA regulated garbage)
  - Auto shredder residue (ASR)
- **Construction and demolition wastes**
- **Recycling facility residues**
- **Bulky Wastes, used tires, used motor oils and lubricants**

Significant Annual Revenues from Supplemental Waste Program in Lancaster County Pennsylvania

Opportunities for Local Ash Recycling

- Beneficial use of bottom ash
  - Construction aggregate
    - Road base
    - Structural fill
    - Flowable fill
    - Asphalt and concrete pavements
  - Feedstock for manufacture of Portland cement
    - Source of alumina, ferric oxide, lime and silica (primary ingredients)
- Beneficial use of combined ash
  - Construction aggregate
    - Road base
    - Structural fill
    - Flowable fill

Europe Continues to Advance the Art and Science of Enhanced Recovery of Metal and Minerals, along with Beneficial Reuse of Ash



©Philipp Schmidt-Pathmann, Dr. Heiner Zwahr – Banff, April 20th, 2010

Advanced screening technology for various size ranges of ash

Multiple magnets and eddy current separators

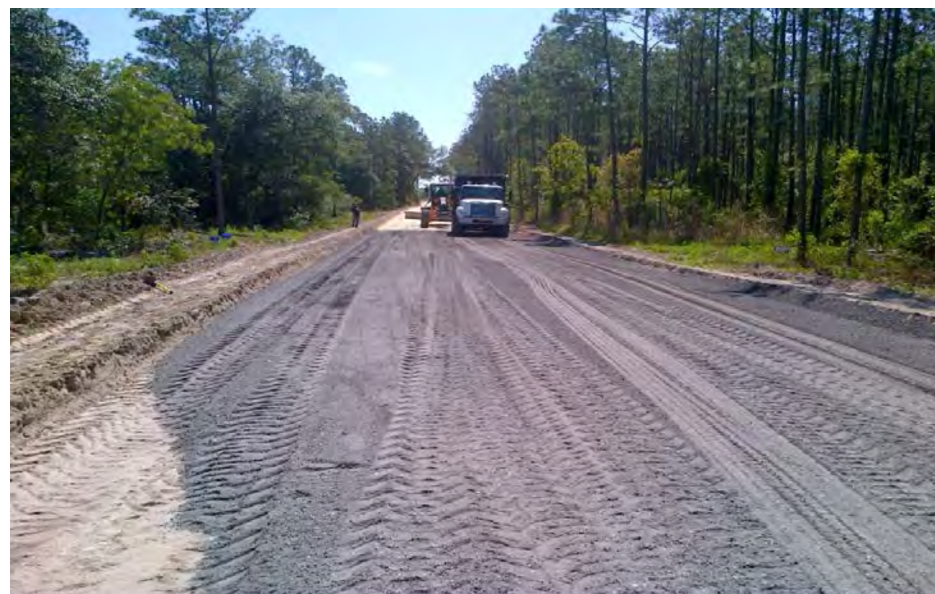
Impact breaker for large clinkers, ash washing

This is What Fresh Bottom Ash Looks Like

Pasco County Ash Reuse - First in Florida to Receive FDEP Authorization for Beneficial Reuse Beyond the Limits of the Solid Waste Campus

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



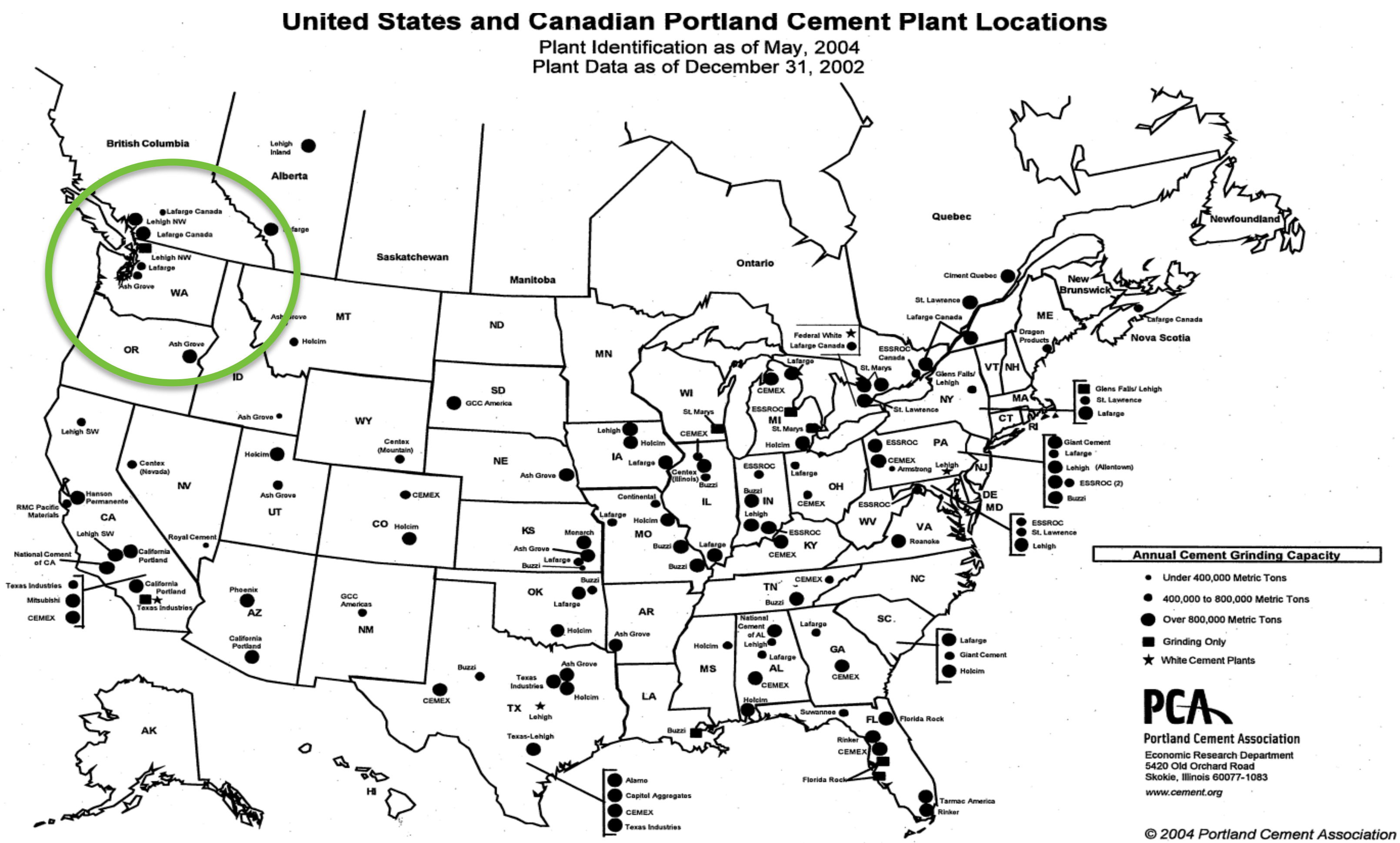
WTE Bottom Ash Recycling Opportunity as a Raw Material for Production of Portland Cement

WTE Bottom Ash is a good match to provide the four primary ingredients

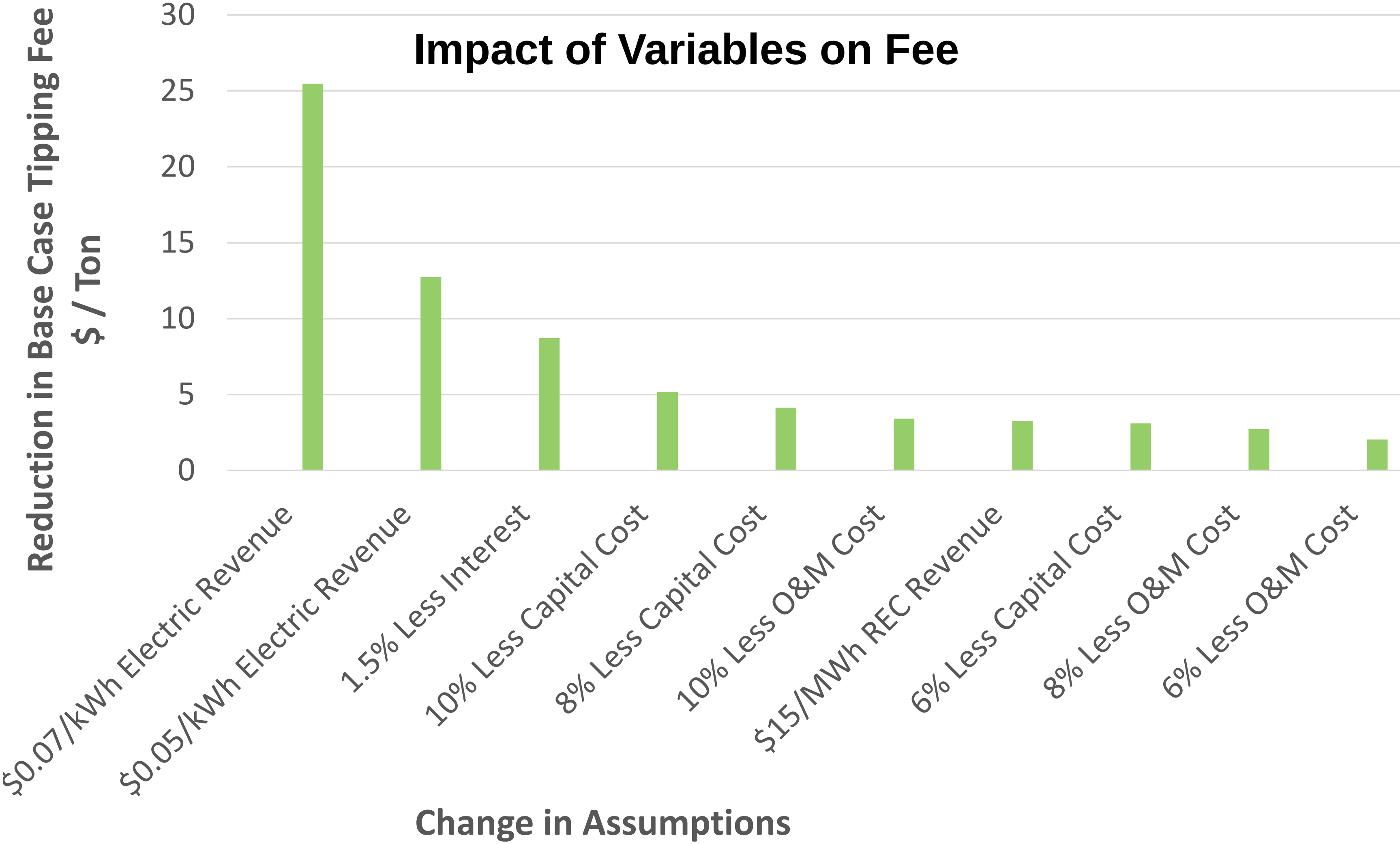
Component	Portland Cement	Clinker	Typical WTE Ash
Silica (SiO_2)	18-24	22-24	24
Aluminia (Al_2O_3)	4-8	5	6
Ferric Oxide (Fe_2O_3)	2-5	0-3	3
Lime (CaO)	62-67	68-71	37

Source: Defending the Character of Ash, Richard W. Goodwin, 1992

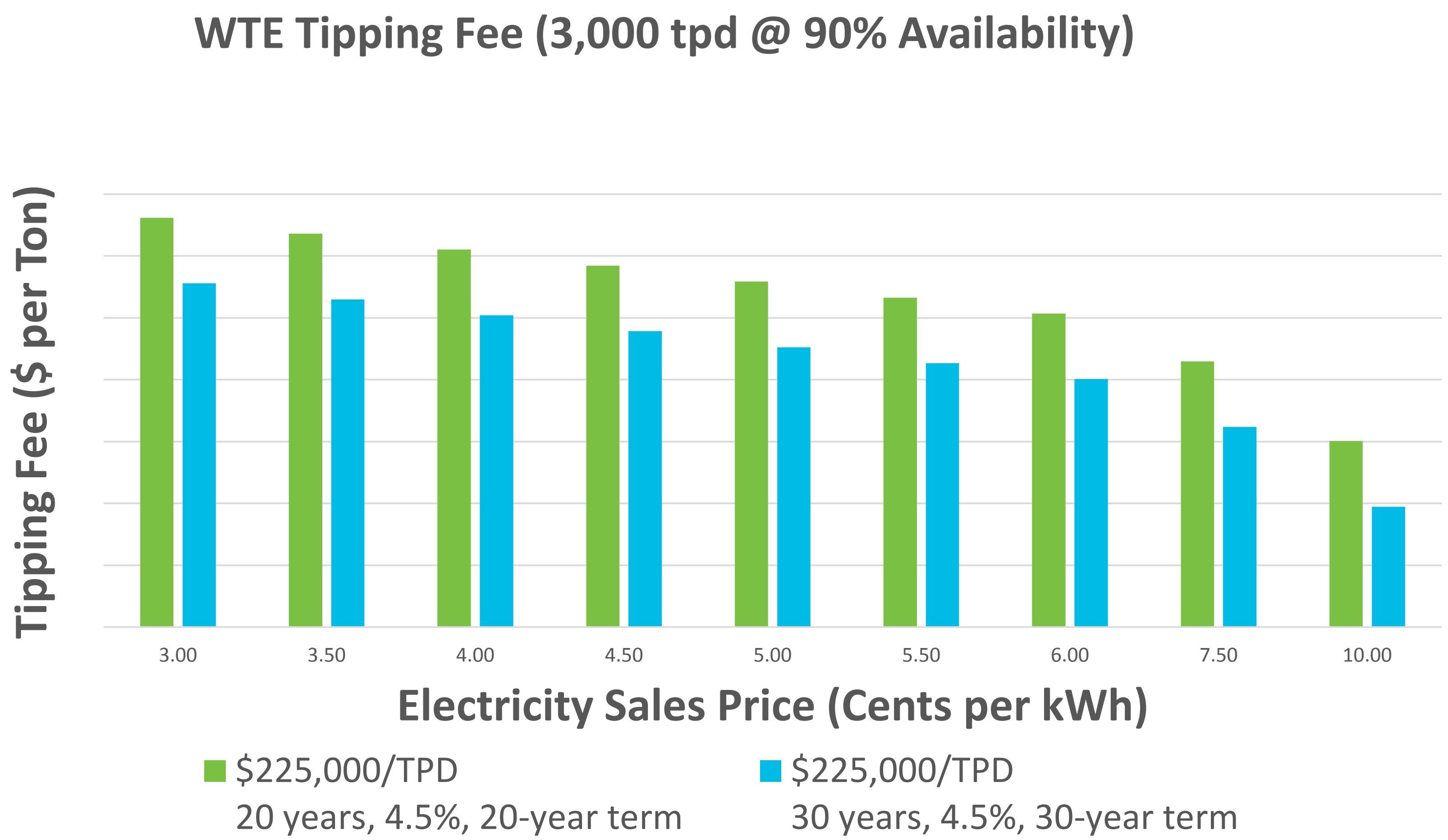
Explore Opportunities for Recycling Bottom Ash at Local Cement Kilns



Sensitivity Analysis (2,400 TPD, 3 Cents/kWh, Project Financed at 4.5% for 30 Years)
Illustrative Purposes Only, from Prior Project Analysis



Extending Financing Term from 20 to 30 Years Reduces Tipping Fee by ~ $10.60 per Ton
Illustrative Purposes Only, from Prior Project Analysis

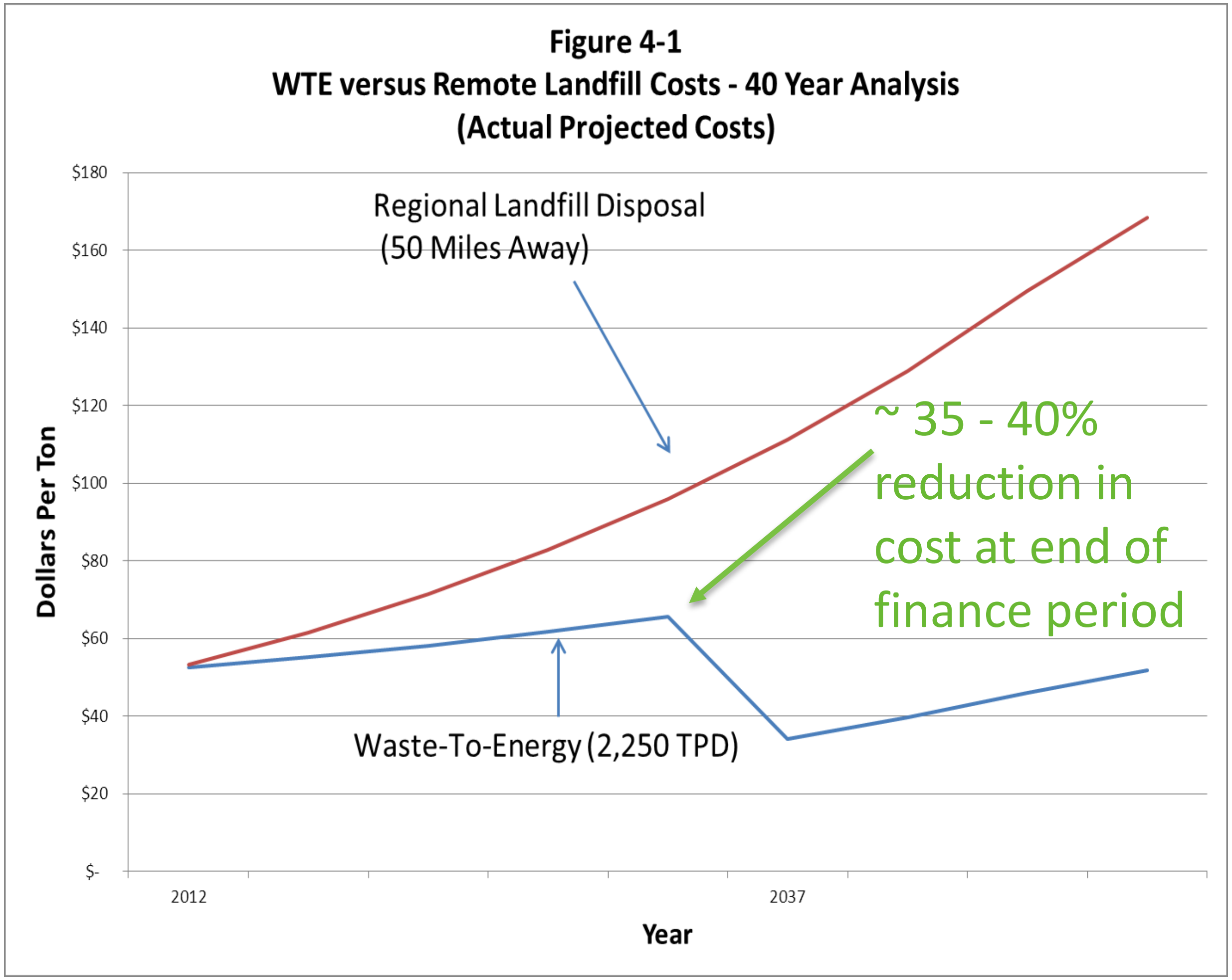


Reason to Finance Infrastructure Debt over Longer Periods of Time

- WTE technology has proven 45-50 service life when properly operated and maintained
- Reduces annual financing costs by a meaningful amount (~$10.60 per ton)
- Attractive for bond financing of investment grade "PPP infrastructure projects"
- **Users of the system pay their fair share over the longer finance period!**

Long-term Benefit of WTE…
Cost Stabilization and Local Economic Development

- Long-term tipping fee savings and rate stabilization
- Economic development via procurement of goods and services from local vendors
- Creation of **high quality jobs** during design, construction, operation, and maintenance period



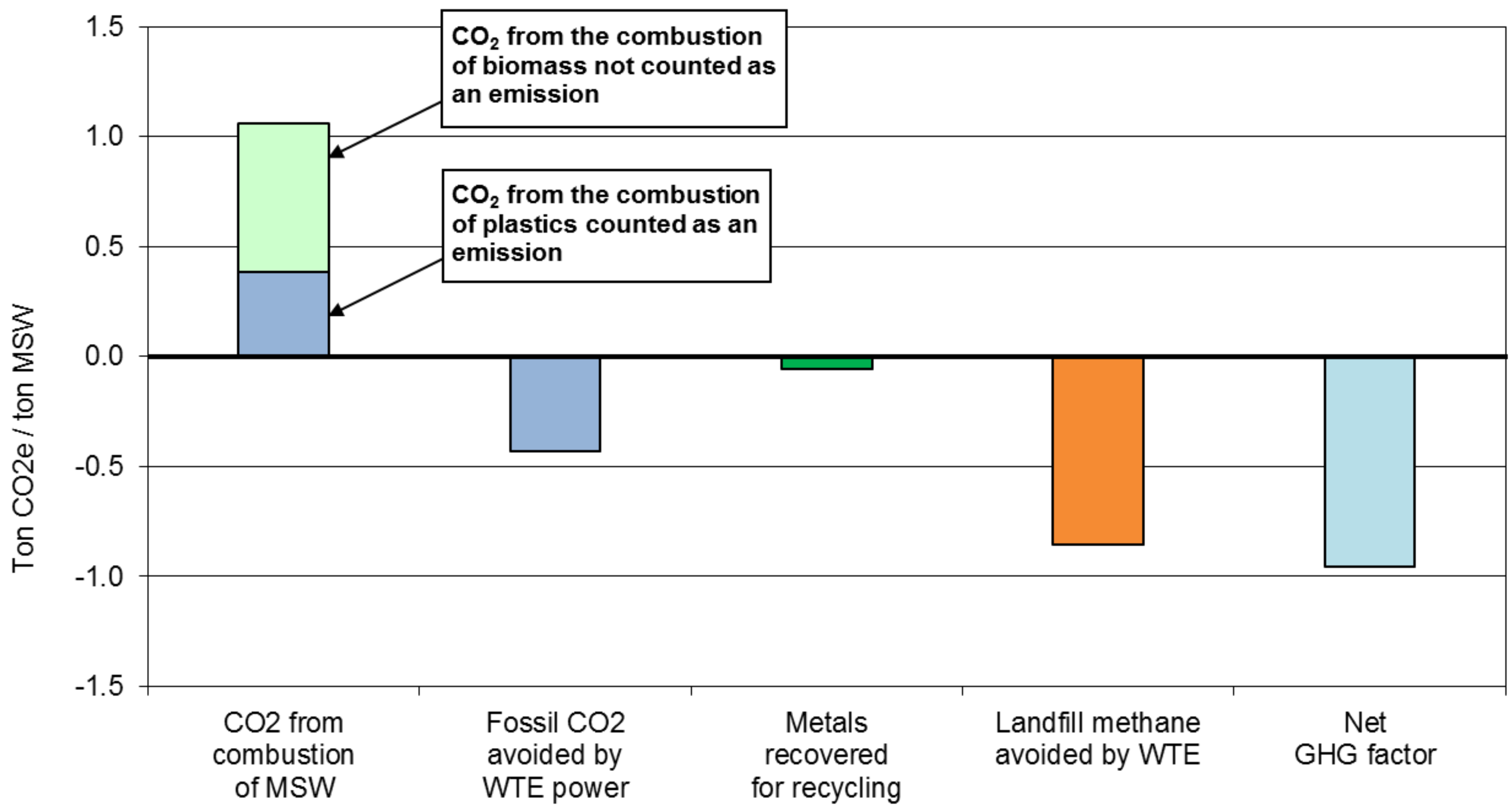
Credit: Economic benefits of WTE: Jobs Creation and Community Development, SWANA Advanced Research Foundation, Dec. 2012

WTE & Greenhouse Gas Avoidance

- **Avoided methane emissions from landfills.** When a ton of solid waste is delivered to a waste-to-energy facility, the methane that would have been generated if it were sent to a landfill is avoided. While some of this methane could be collected and used to generate electricity, some would not be captured and would be emitted to the atmosphere.
- **Avoided CO_2 emissions from fossil fuel combustion.** When a megawatt of electricity is generated by a waste-to-energy facility, an increase in carbon dioxide emissions that would have been generated by a fossil-fuel fired power plant is avoided.
- **Avoided CO_2 emissions from metal recycling.** Waste-to-energy plants recover more than 700,000 tons of ferrous metal for recycling annually. Recycling metals saves energy and avoids CO_2 emissions that would have been emitted if virgin materials were mine and new metals were manufactured, such as steel.
- **Waste-to-energy plants are tremendously valuable contributors in the fight against global warming**. According to the U.S. EPA MSW Decision Support Tool, **nearly one ton of CO_2 equivalent emissions are avoided for every ton of municipal solid waste handled by a waste-to-energy facility.**

Credit: Ted Michaels, President Energy Recovery Council, March 17, 2011

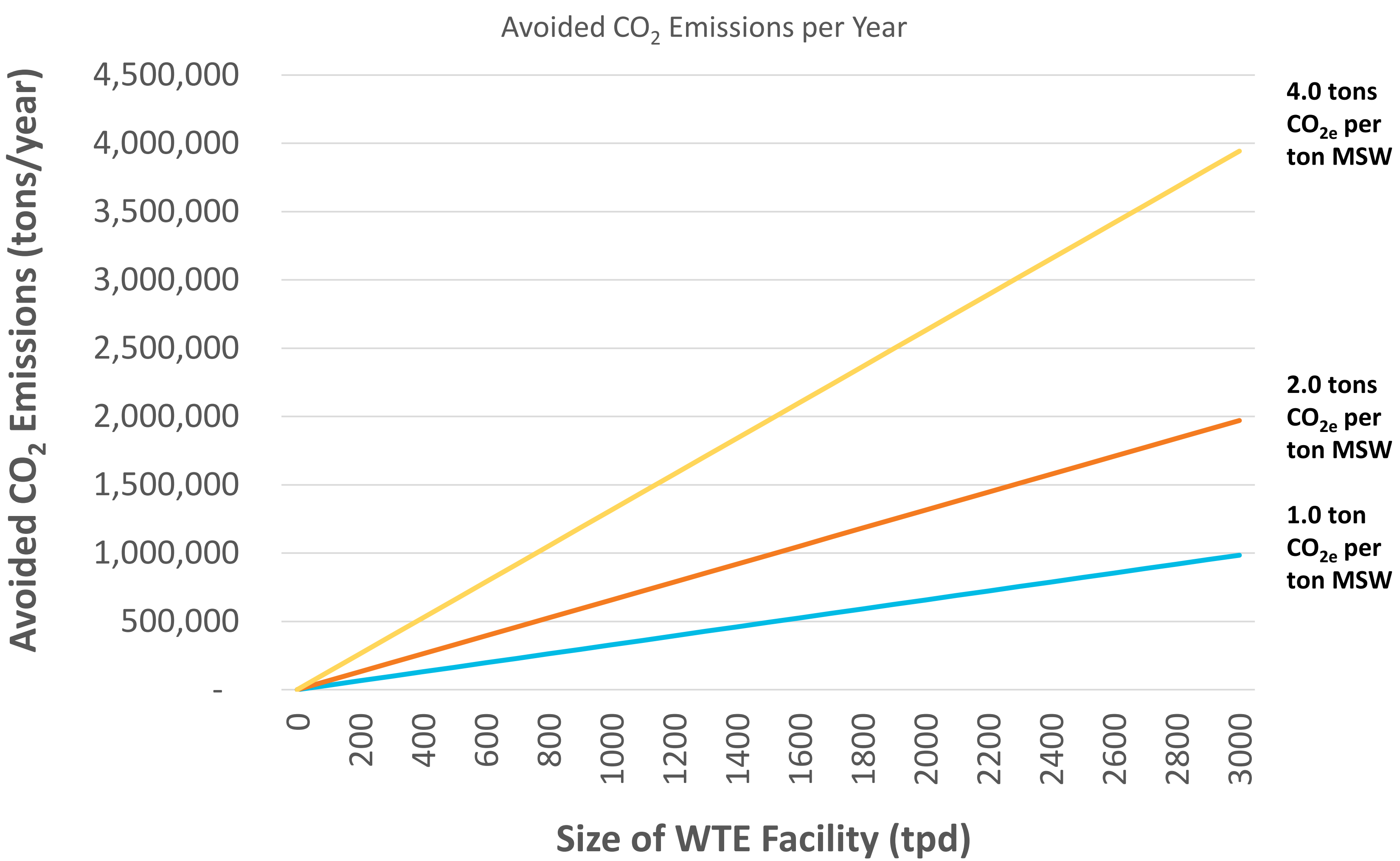
Potential Carbon Offsets Attributable to Modern WTE Facilities – Avoided Methane is the Largest



Nearly one ton of CO2 equivalent emissions are avoided for every ton of municipal solid waste processed by a modern WTE facility

Credit: Ted Michaels, President Energy Recovery Council, March 17, 2011

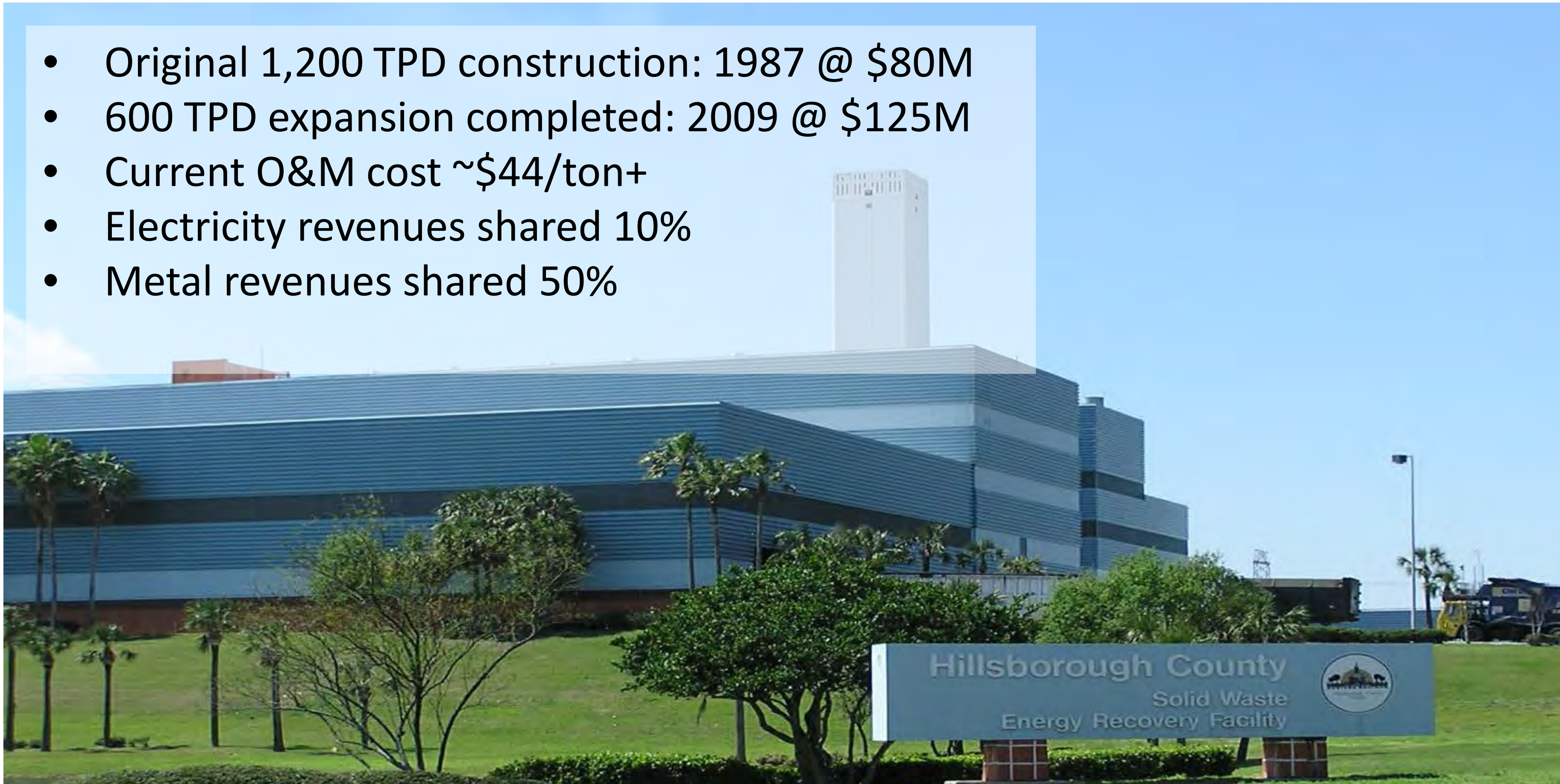
Annual Avoided CO_2 Emissions from WTE (May be 4 times than first reported by EPA)



Case Study Pasco County, Florida WTE
1,050 TPD Massburn – 30 MW Net Electrical Output
(serving average needs of 17,000 households)

Case Study - Hillsborough County Florida WTE
1,800 TPD Massburn – 46 MW Net Electrical Output (serving the average needs of 25,000 households)

- Original 1,200 TPD construction: 1987 @ $80M
- 600 TPD expansion completed: 2009 @ $125M
- Current O&M cost ~$44/ton+
- Electricity revenues shared 10%
- Metal revenues shared 50%

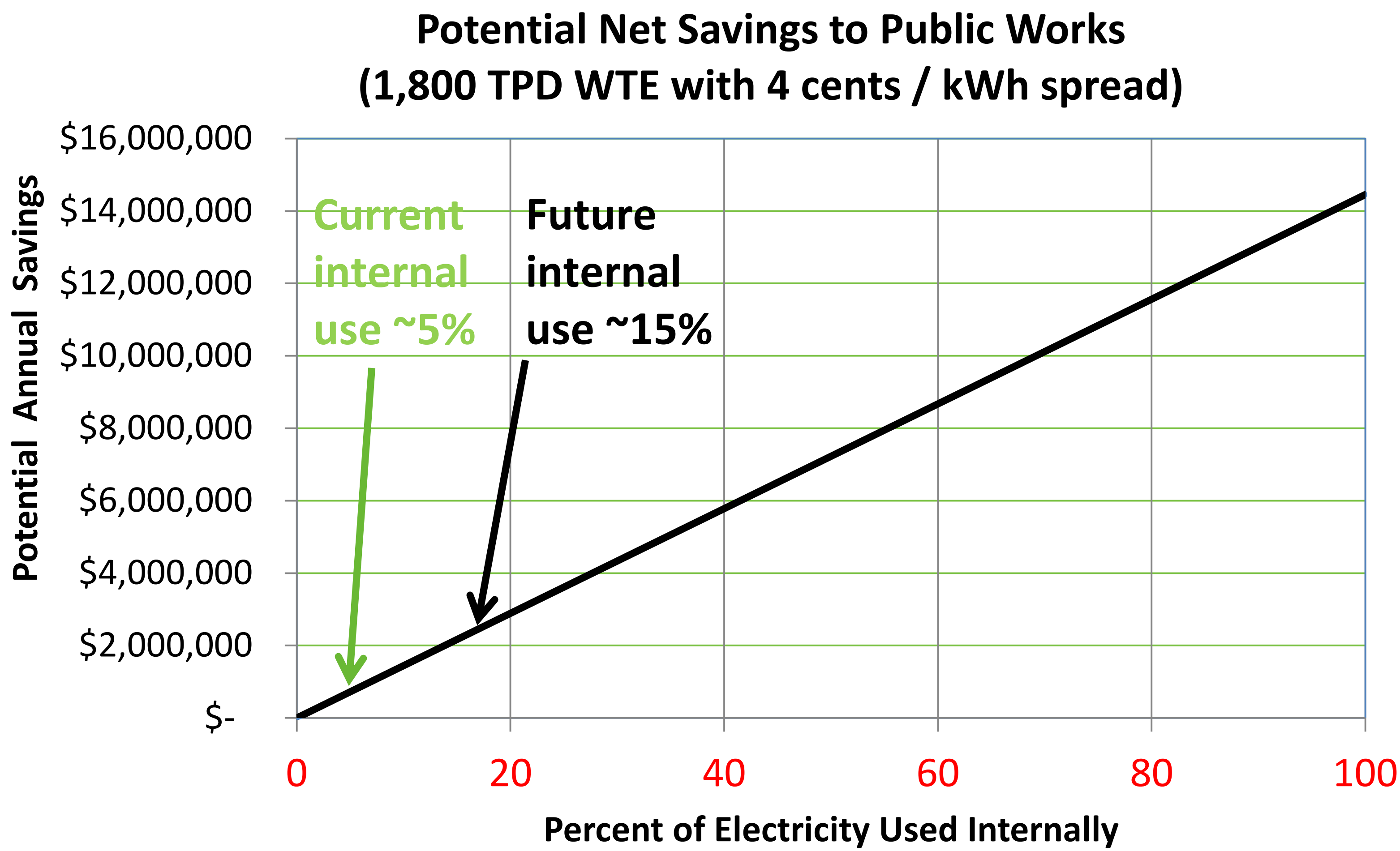


Compatible with the urban landscape

Commercial/industrial development has occurred around facility over the past 30 years!

Hillsborough County Florida WTE
First to Internally Power Water Resource Facilities

Significant Potential Savings to Public Works by Internally Using Electricity from WTE Facility



Case Study - Pinellas County Florida WTE
3,000 TPD Massburn – 75 MW Net Electrical Output
(serving average needs of 40,000 households)

Summary of Tampa Area Annual Solid Waste Rates with ISWM Systems Anchored by WTE Facilities

County	Population	Collections per Week	Tipping Fee ($/ton)	Collection ($/HH/Yr)	Disposal ($/HH/Yr)	Overall Cost ($/HH/Yr)
Pasco (1,050 tpd)	470,000	2 Trash 1 Recycling No Separate Yard Waste Pickup	$56.70	Open Market ($150 max)	$62.00	$212.00
Hillsborough (1,800 tpd)	950,000	2 Trash 1 Recycling 1 Yard Waste	$68.16	$131.43 (Franchise System)	$91.32	$222.75
Pinellas (3,000 tpd)	925,000	2 Trash EOW Recycling No Yard Waste (St. Petersburg)	$37.50	$208.00 Varies among 27 cities	$95.40	$303
				Data for City of St. Petersburg		

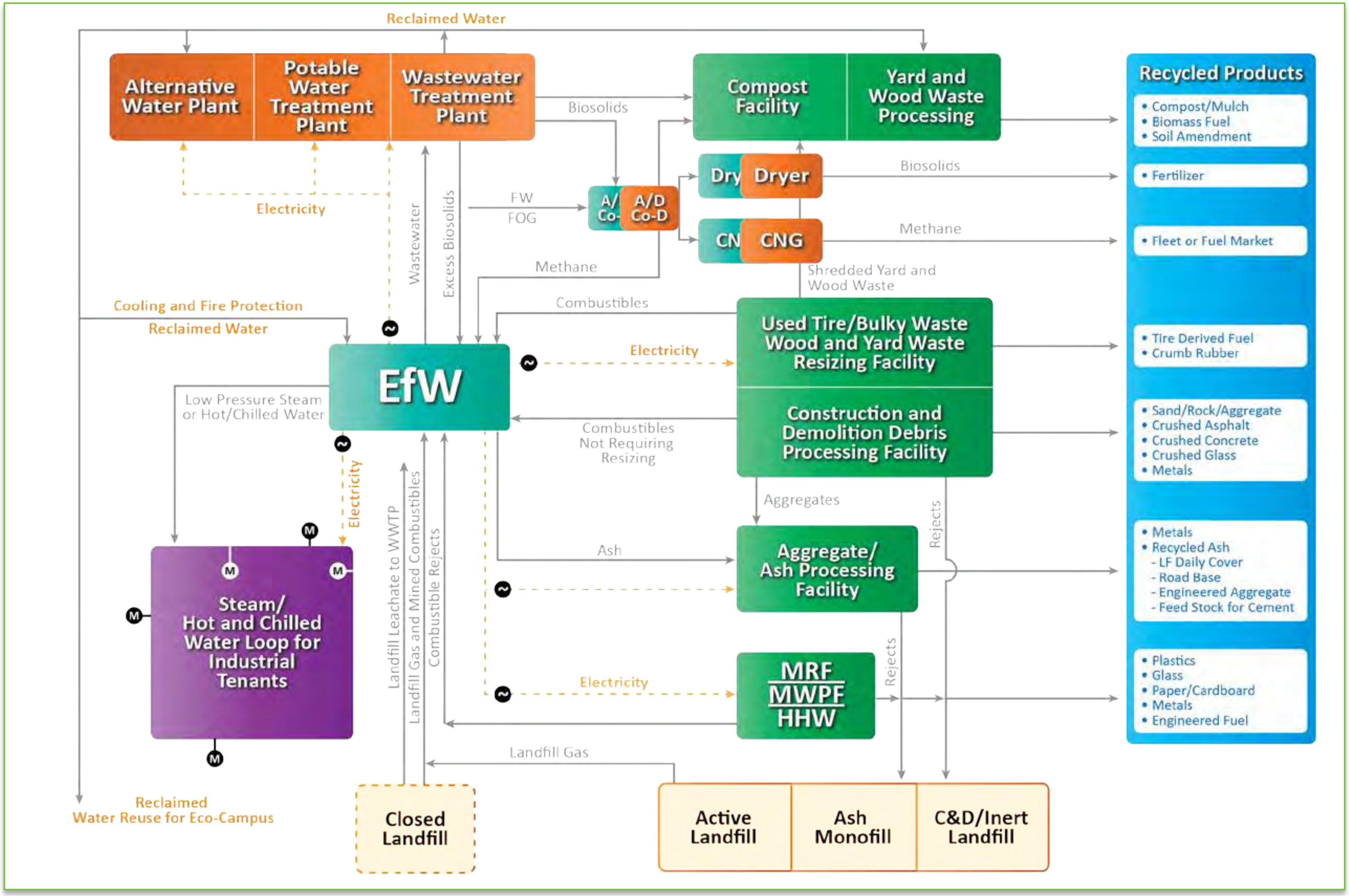
HH: Household

Benefits Realized by the Florida Communities with ISWM Systems Anchored by WTE

- **Maximizes production of renewable energy**
  - 575 kWh/ton of MSW processed
  - Higher thermal efficiency with Combined Heat and Power (CHP)
- **Significantly lower environmental impacts than landfills**
  - Less CO_2 and greenhouse gas emissions
  - Stabilized and inert ash disposal volume is minimized (90% volume reduction and 75% weight reduction)
  - Opportunities for recycling ash as aggregates and feedstock for cement
- **Greatest economic impact to local economy**
  - Long-term careers and high quality jobs
  - Significant impact during construction and long-term operation for purchase of goods and services
- **Minimal land use impacts**
  - Can meet the current and future needs of a community on 15-45 acres

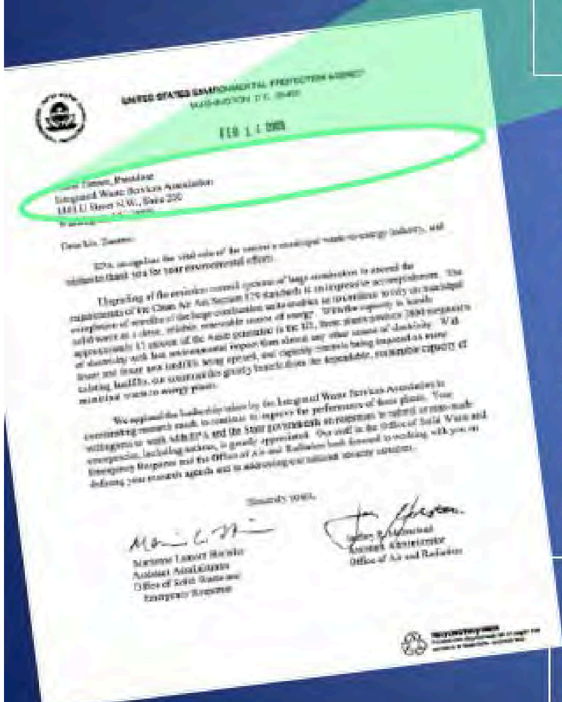
- **ISWM Systems anchored by WTE allowed each community to responsibly manage their waste, within their jurisdiction!**

My Vision of an Integrated Campus for Management of Municipal Resources



Benefits of Waste to Energy

- Least environmental impact for power plants according to EPA (February 2003)
- Converts 4 million tons of Florida garbage/year to 534 megawatts of Power/day
- NCRRF has processed 13M tons of waste since the 1980's – saving 13M barrels of oil
- Reduces expended landfill volume by 60%
- More favorable than landfills for greenhouse gas emissions according to EPA (September 2006)



Evaluating the Feasibility of Waste Conversion Technologies Requires a Serious Commitment

- High-Impact Decisions:
  - Capacity – target/max/min tpd, MSW source(s), etc.
  - Location – in region/out-of-region, transportation, etc.
  - Technology – massburn, gasification, emerging technologies, anaerobic or co-digestion, waste-to-biofuels, etc.
  - Procurement – funding, transparency, equitable comparison, etc.
  - Triple-Bottom-Line (TBL) Baseline – what is WTE being compared to?

Economic	Environmental	Social
• Capital • Annual O&M • Total Lifecycle • Offsets • Revenues	• Regulations • Permitting • Carbon Impacts • Health & Human Risk Assessment	• Job Creation • Community Integration • Being a Good Neighbor

Thank You for the Opportunity to Share!

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Question and Answer Session

Resources

- Scott DuBoff - GSB
- Paul Hauck – CDM Smith
- Jimmy Jia - DEM
- Philipp Schmidt-Pathmann - Neomer
- Curt Thalken - Normandeau
- Tay Yoshitani

Thank you!

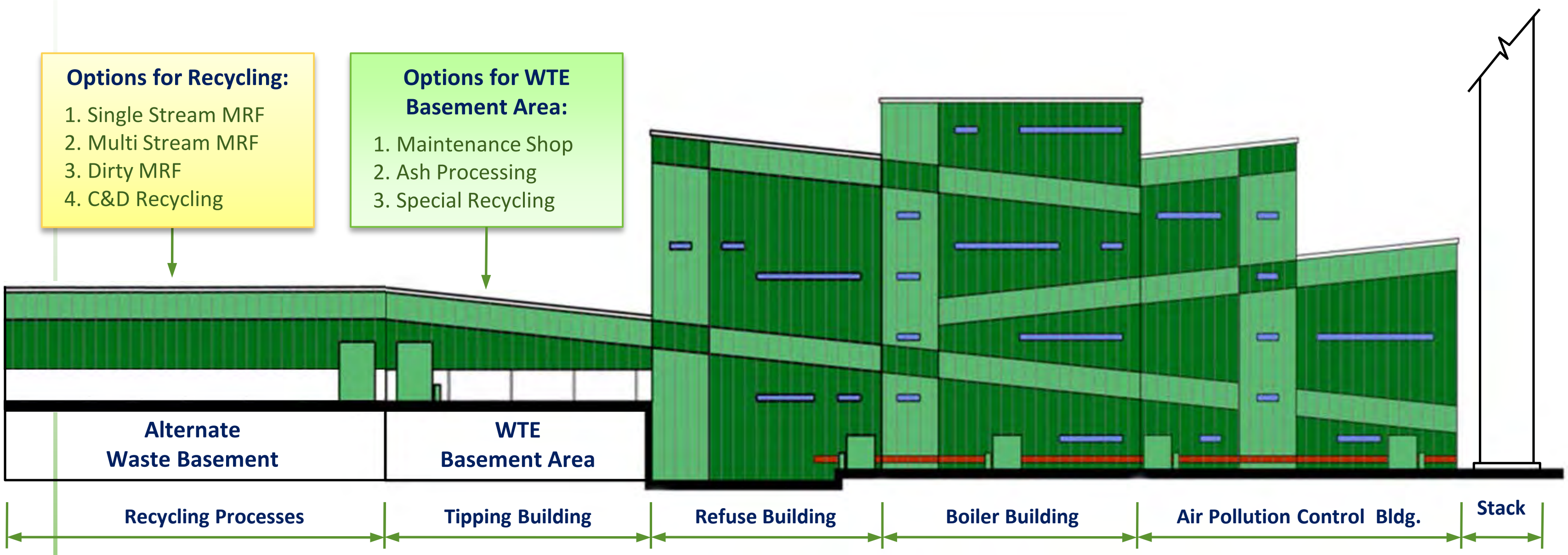
Additional Slides for Q&A

- Options for Integrated Resource Management Systems
- Photos of WTE Plants from Around the Globe
- Advanced Recovery of Metals
- Economic Benefits of WTE to Local Community

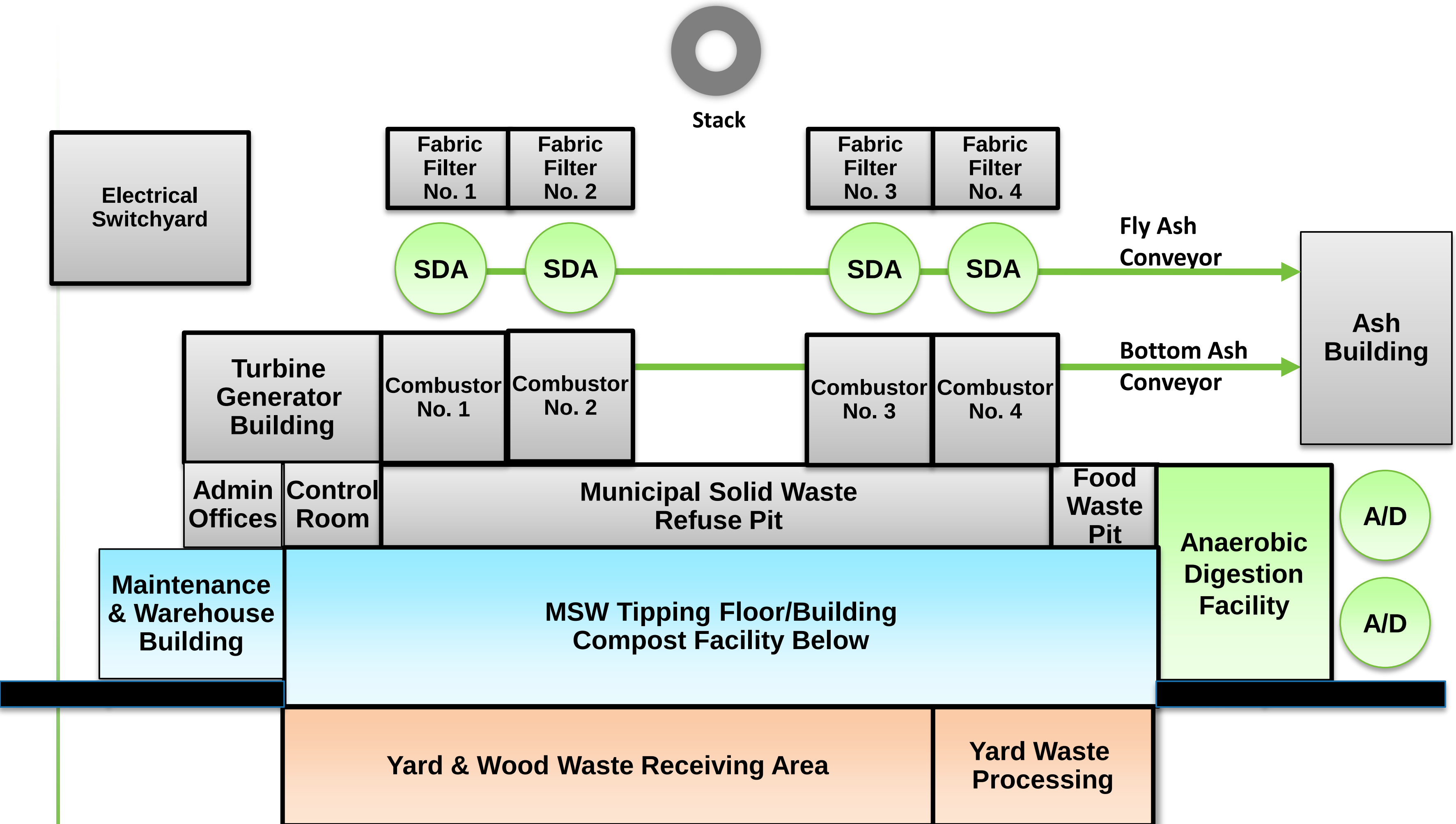
Options for Integrated Resource Management Systems

- Representative Slides

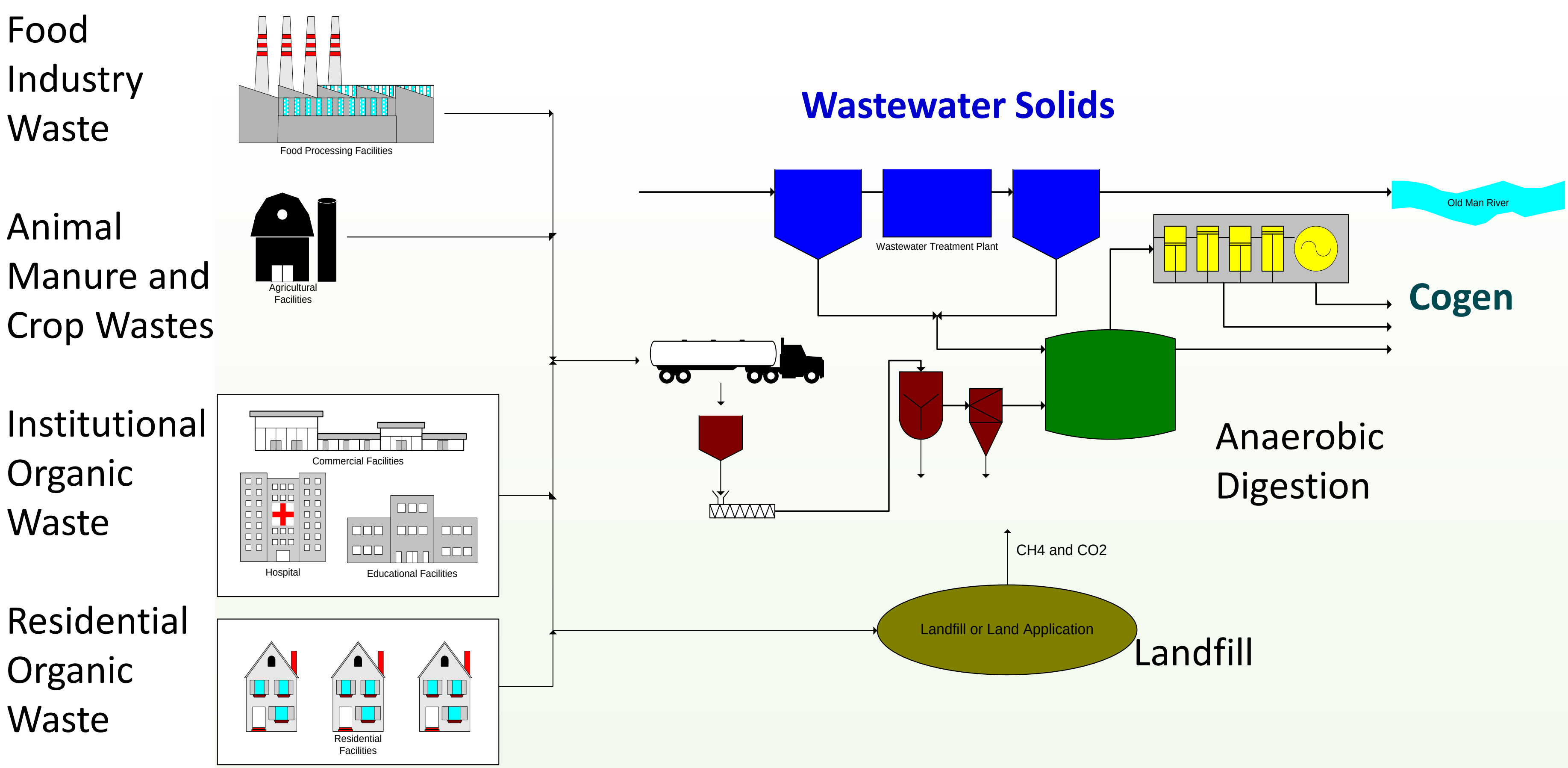
Future WTE Projects Could Include Material Recovery, Advanced Recycling, and Emerging Waste Conversion Processes



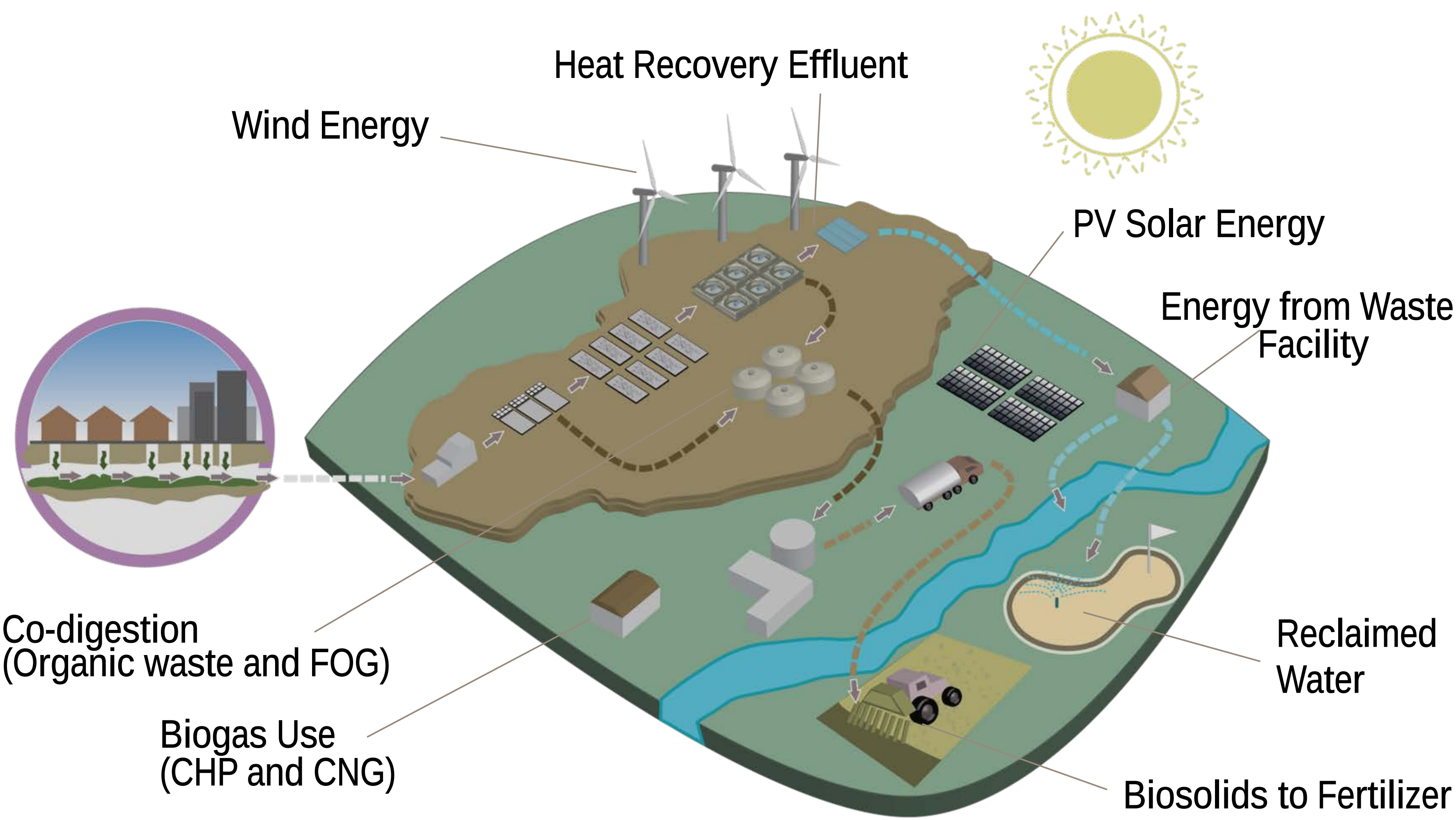
Massburn WTE Integrated with Anaerobic Digestion and Composting



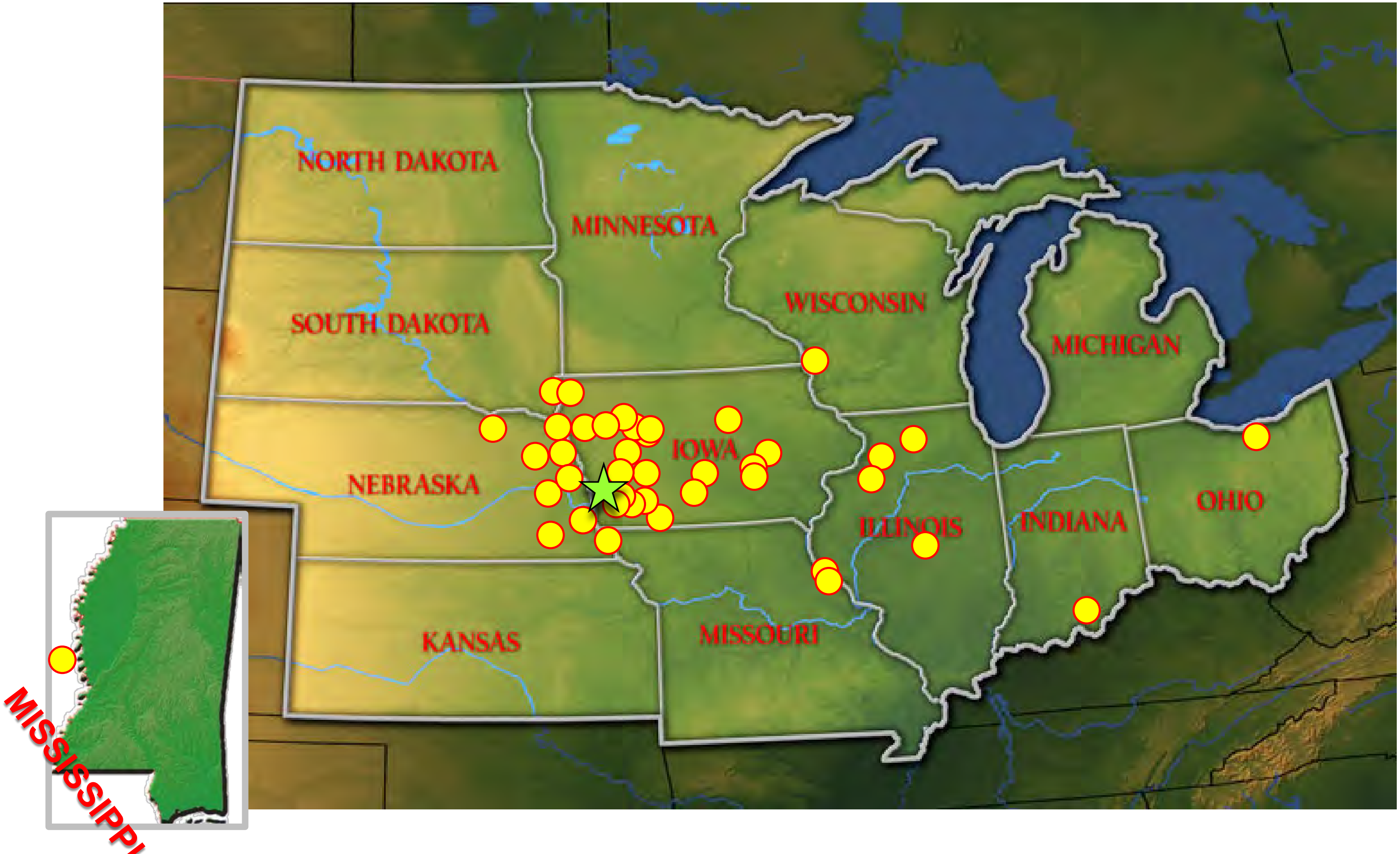
Co-digestion of Organic Waste with Wastewater Biosolids for Generation of Biomethane Gas



Synergies for EfW on Wastewater Sites…Similar Opportunities may exist on Power Plant Sites

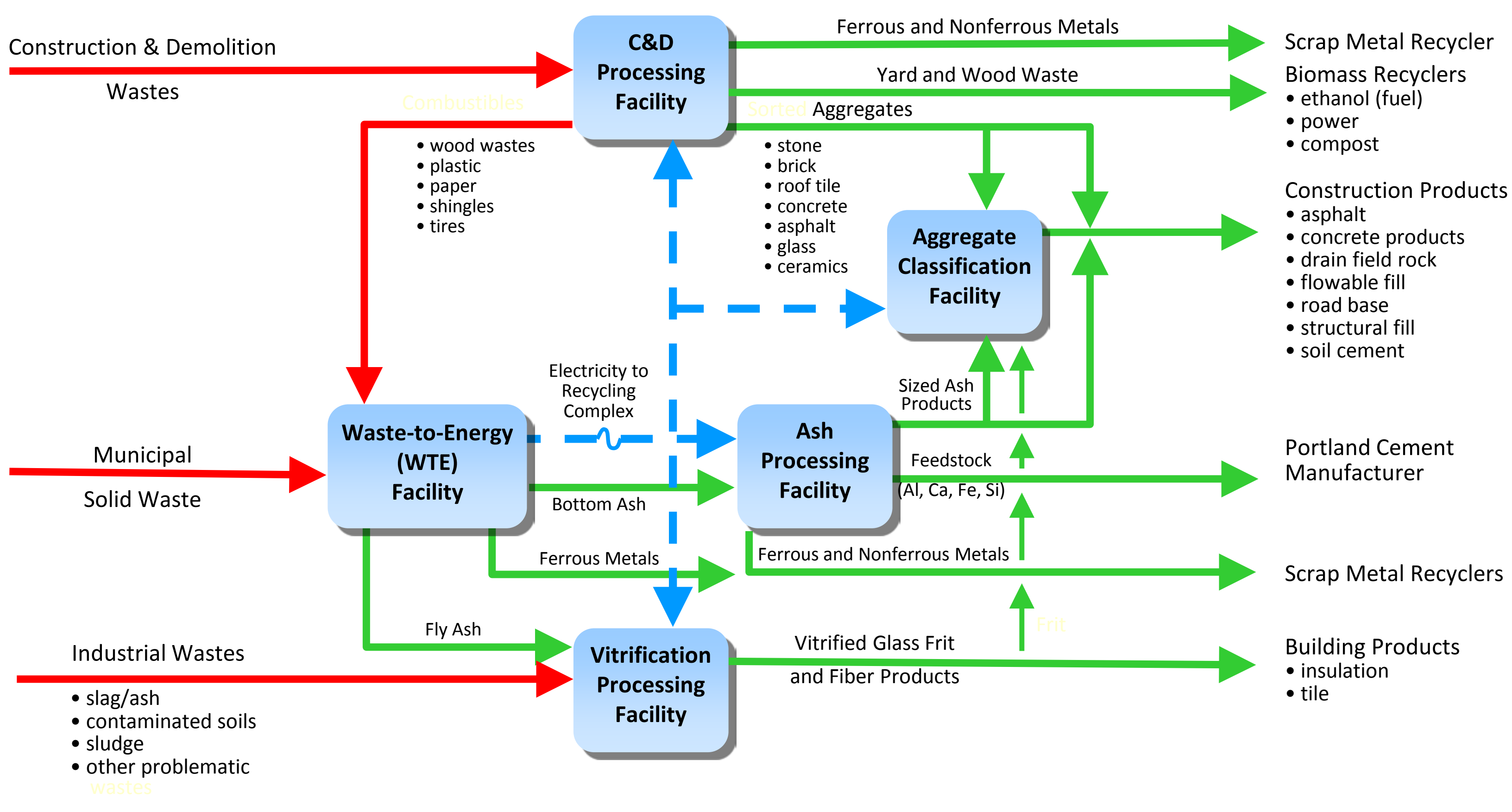


Co-Digestion
Des Moines Wastewater Reclamation Authority
Hauled Waste - Regional

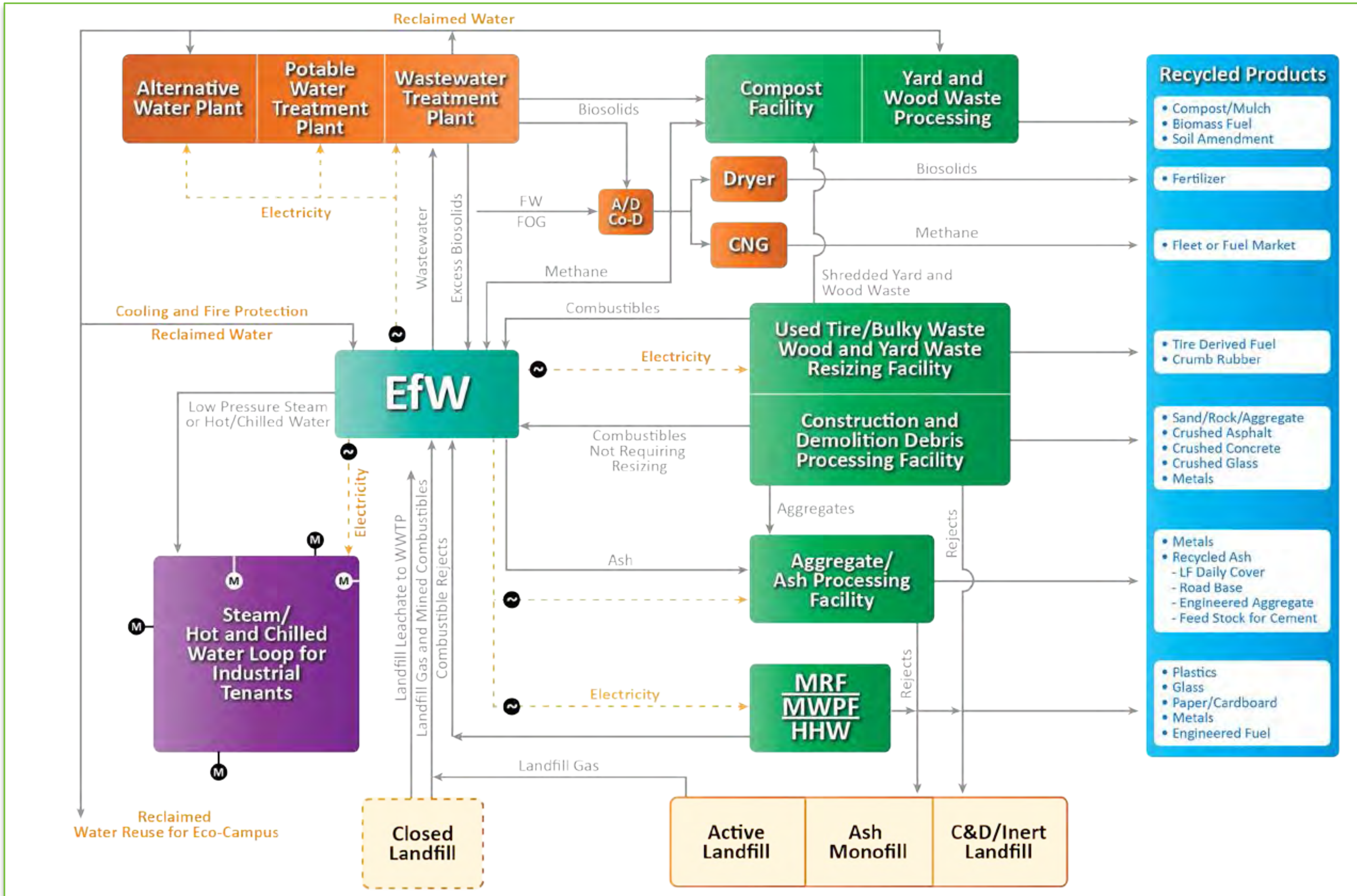


Integrated Campus can Include C&D Recycling for Commodities and "Engineered Aggregates"

Public Works Recycling Complex



Integrated Campus for Management of Municipal Waste Can Include Water Resources



World's Largest EfW Facility (2020) in China to include Desalination Water Plant and Solar PV

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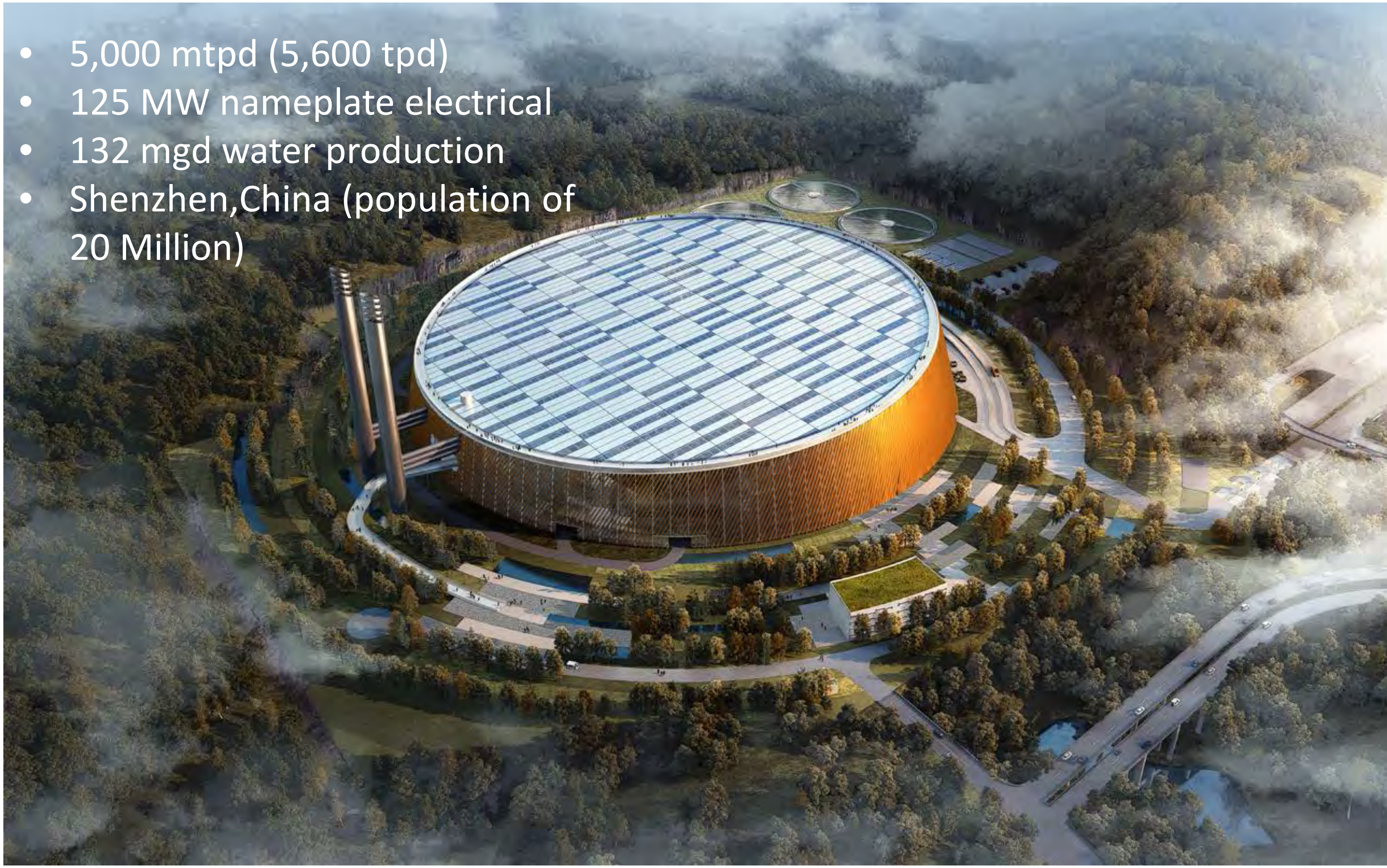
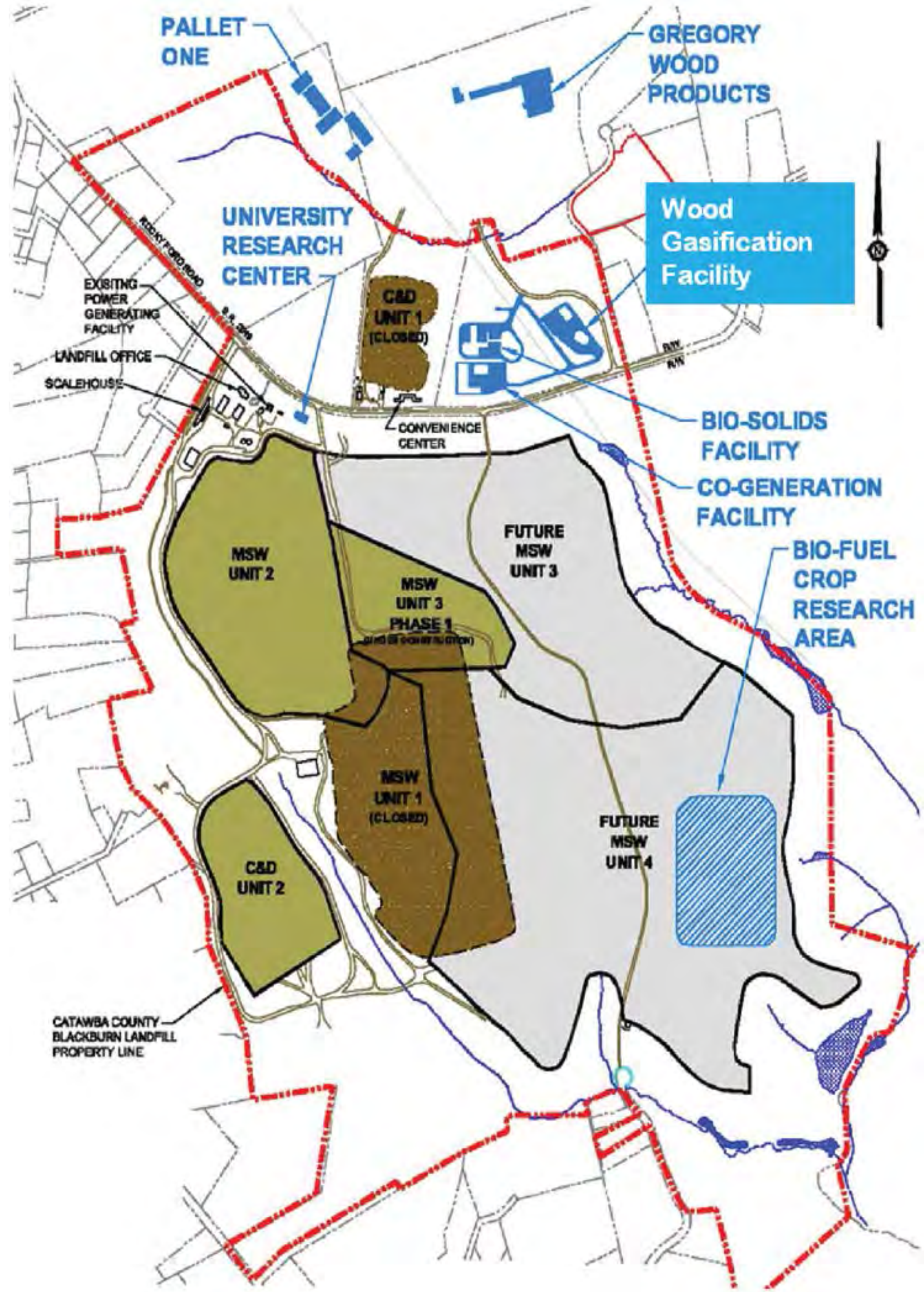
- Shenzhen,China (population of 20 Million)



Schmidt Hammer Lassen Architects and Gottlieb Paludan Architects

Catawba County, NC Resource Recovery Park
Site Layout

- Lumber & Pallet Partners
- Wood Gasification
- Research Center
- Biosolids Processing Facility
- Digesters for Sludge, Animal and Food Waste for Energy
- Biofuel Research- Algae and Fuel Crops
- Total Project Cost- $20.7 Million



Palm Beach County, FL
Regional Biosolids Palletization Facility (600 wtpd)

Palm Beach County Florida
Regional Biosolids Processing Facility on ISWM Campus

Photos of WTE Plants from Around the Globe

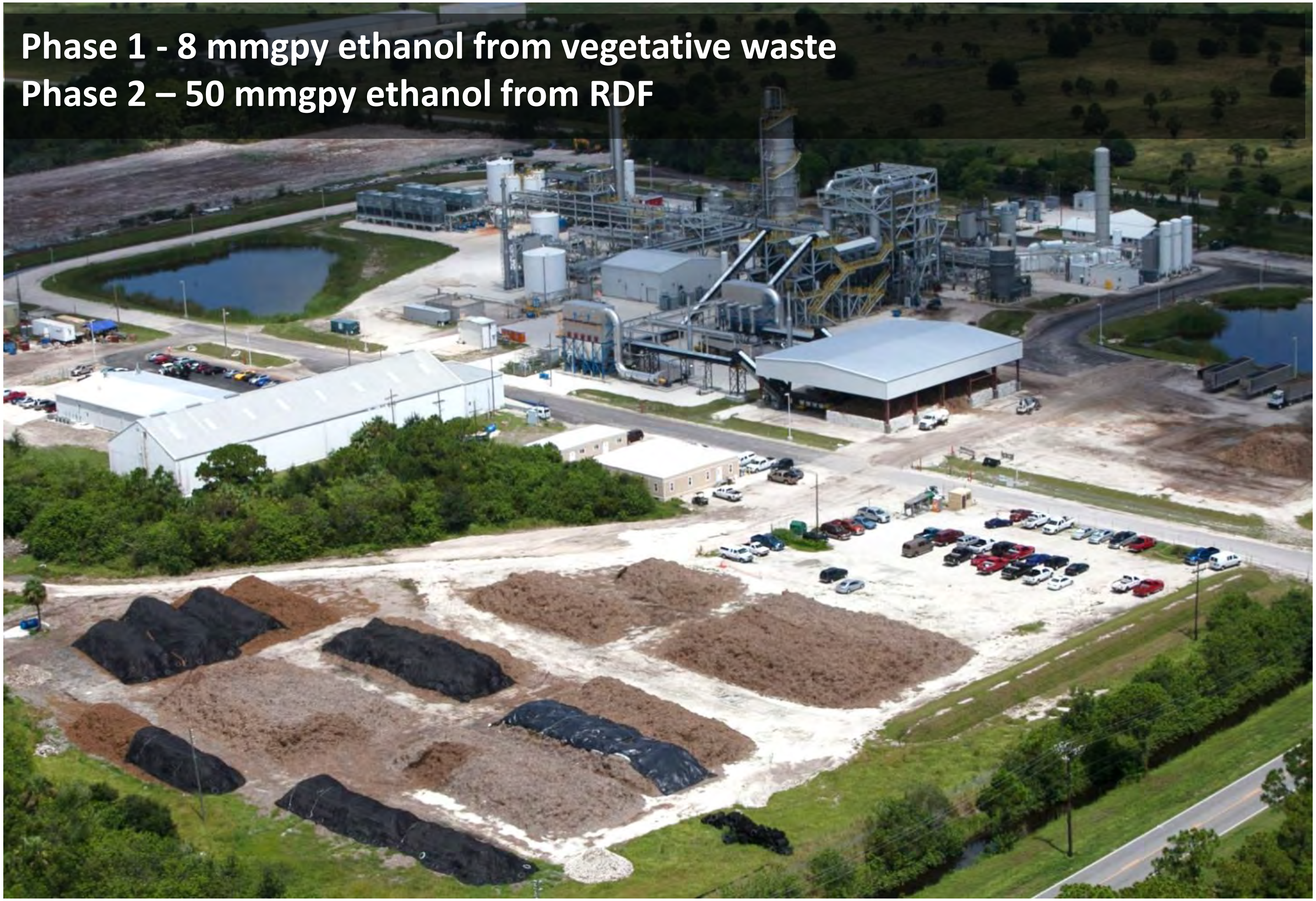
Supplemental Waste Program Lancaster County Pennsylvania

Copenhagen Denmark WTE (under construction) with Public Ski Slope around Stack

If an EfW Facility Can be Located in the Center of Paris, It Can be Located Anywhere!

Marchwood England 2007
500 TPD WTE Facility Under Dome

Ineos Bio-Energy Center (2012) Indian River County, FL



What does a Co-Digestion Facility Look Like?
Courtesy of Harvest Power Orlando

- 120,000 tpy capacity processing food waste and WWTP biosolids into biomethane
- 3.2 MWe plus heat for drying granular biosolids product (5,000 mt/year)
- Facility commissioned in December 2013

Spittelau WTE facility in Austria

Resource Recovery Nuremberg, Germany

- Compact layout, close to the city
- Heat for district heating and industrial purposes
- Transport of waste by truck and rail
- Modern architecture

Lee County Florida
Integrated Campus with Regional Landfill

Advanced Recovery of Metals

- High strength magnets for recovery of ferrous metals
  - Large, medium and fine fractions
- Eddy Current Separators for recovery of non-ferrous metals
  - Large, medium and fine fractions
  - Separation of aluminum, brass, bronze, copper and stainless steel
  - Recovery of precious (gold, silver) and rare-earth metals

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

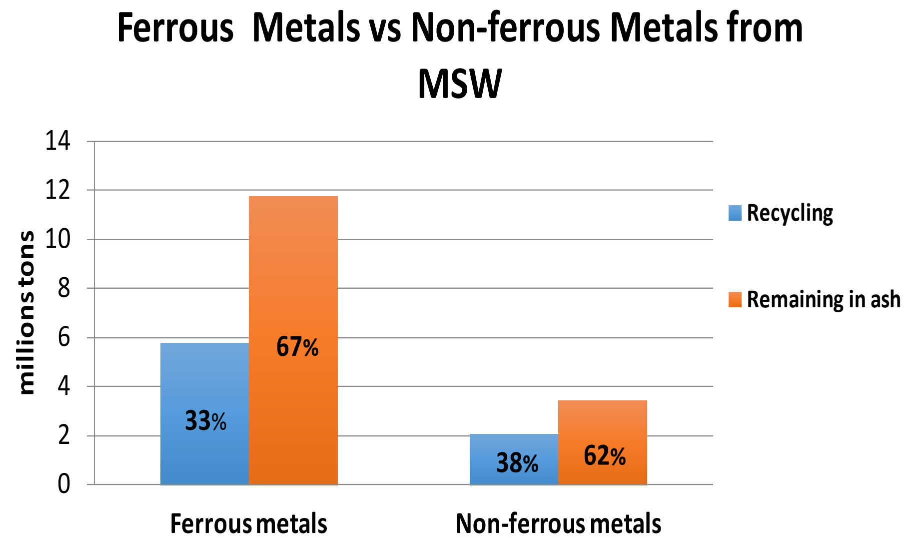
High Strength Drum Magnet for Ferrous Metals

Samples of Non-ferrous Metals Recovered by Eddy Current Separator

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

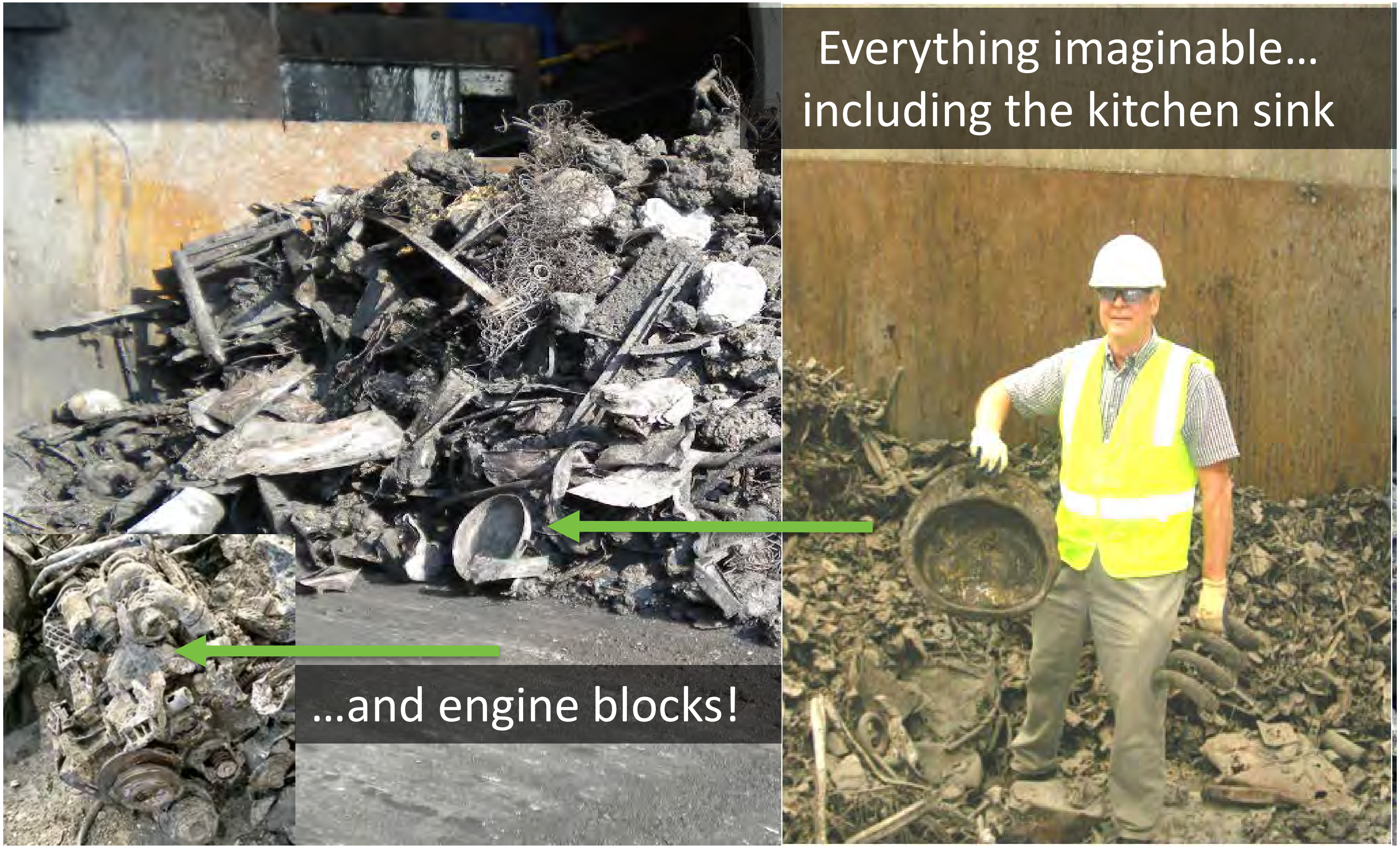
Recovery of Metals from WTE Bottom Ash can Play a Significant Role in Community's Recycling Program

- Two thirds of metals generated by residential households end up in the mixed waste mainly because they are not targeted for recycling in source-separation recycling programs.



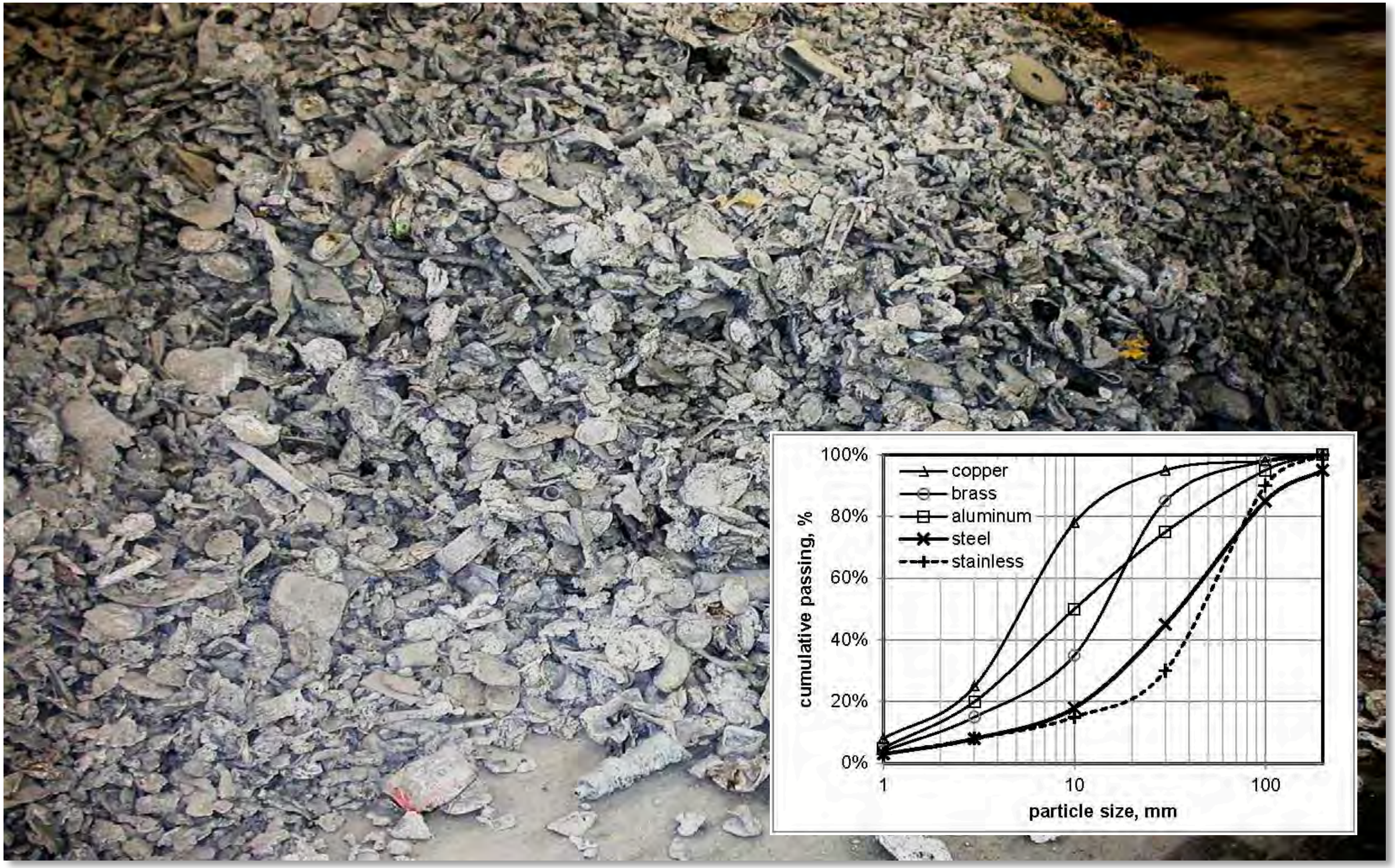
- Recycling of metals from WTE bottom ash can account for more recycling tonnages than typically diverted via source separation recycling programs.
- Conventional EfW ash processing systems typically target the recovery of native metals greater than 12 millimeters (0.47 inches) in size.
- Advanced metal recovery systems utilizing recently developed new technologies improve the metal recovery rates by targeting metals less than 12 millimeters (0.47 inches) in size.

Initial Metal Recovery Operation
Bulky Ferrous Metals Greater than 5-6" in Size



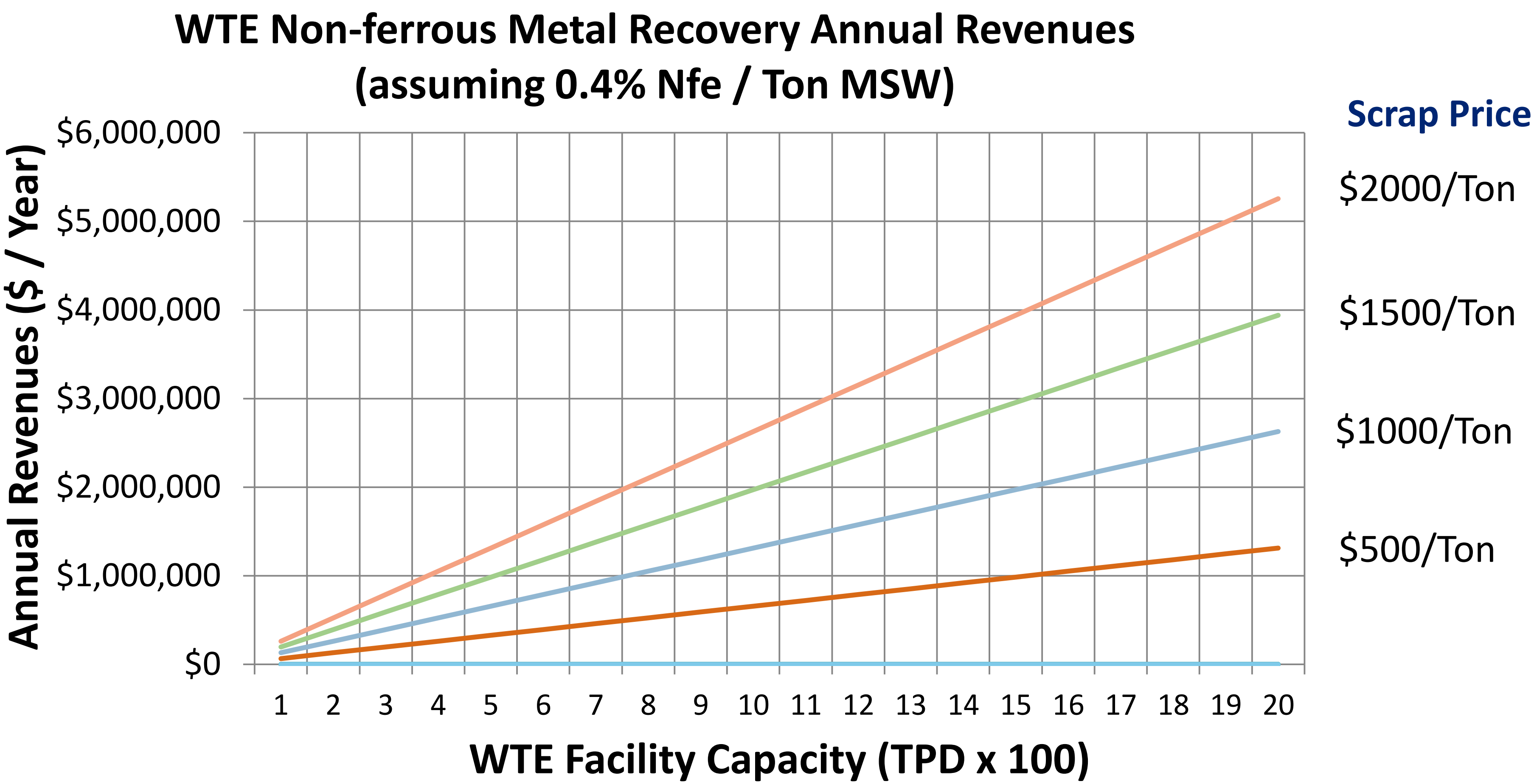
Second Metal Recovery Operation Ferrous Metals Less than 5-6" in Size

Third Metal Recovery Operation
Non-ferrous Metals "Liberated" by Combustion



Non-ferrous Metals Liberated by Combustion and Recovered by Eddy Current Separator

Value of Non-Ferrous Metal Recovered from WTE Bottom Ash



Coins Separated from Recovered Non-ferrous Metals in Palm Beach County, FL

Europe Continues WTE Advancements with Recovery of "Fine" Recyclables from Bottom Ash

Fine minerals
(< 0.07 inch)

Mineral aggregates
(> 0.07 inch)

Non-ferrous concentrate

Ferrous concentrate

Recovered Aluminum Products
Light Non-ferrous Metals from WTE Bottom Ash

Aluminium scrap product (fine)

- 0.04 – 0.14 inch
- 70 - 75% pure metal scrap

Aluminium scrap product (middle)

- 0.14 – 0.4 inch
- 75 - 80 % pure metal scrap

Aluminium scrap product (coarse)

- 0.4 – 0.75 inch
- 85 - 90 % pure metal scrap

Heavy Non-ferrous Metals from WTE Bottom Ash

Primarily brass and copper

Heavy non ferrous scrap

- 0.04 – 0.75 inch
- 95-99 % pure metal scrap

Inashco Centralized Upgrading Facility (Belgium)

Central Upgrading Facility located in Sluiskil, the Netherlands, where non-ferrous recovered metals are processed into high value heavy and light non-ferrous metal scrap products

Economic Benefits for 1,000 tpd WTE Facility

Economic Benefits During Construction for 1,000 tpd WTE Facility

- Over $200M in total construction cost
- $60M construction payroll
- 300 total jobs over 2 year construction period
- Procurement of $40-50 M in local goods and services
- Increased demand for local business

Economic Benefits During WTE Operation Period (45-50 years)

- High quality jobs/careers
  - 30-35 full-time permanent jobs
- Payroll dollars increase
  - Over $2M in annual payroll
- Retail sales increase
  - Local procurement of Operations and Maintenance supplies
  - Bank deposits increase
  - Local tax base expands
- Oversight of waste disposal operations and management
- Protection from out-of-county surcharges

Typical Goods and Services Procured During Operation and Maintenance Period (45-50 years)

Office and Plant Supplies

- Calibration gasses
- Carpentry services
- Chemical reagents (lime, carbon, urea, water chemicals)
- Electrical supplies
- Fire protection
- Fuel (gasoline, diesel, propane)
- Janitorial supplies
- Lab supplies
- Lubricants
- Mechanical supplies
- Mobile equipment
- Office equipment and supplies
- Safety and first aid
- Tools
- Welding supplies

Environmental Testing

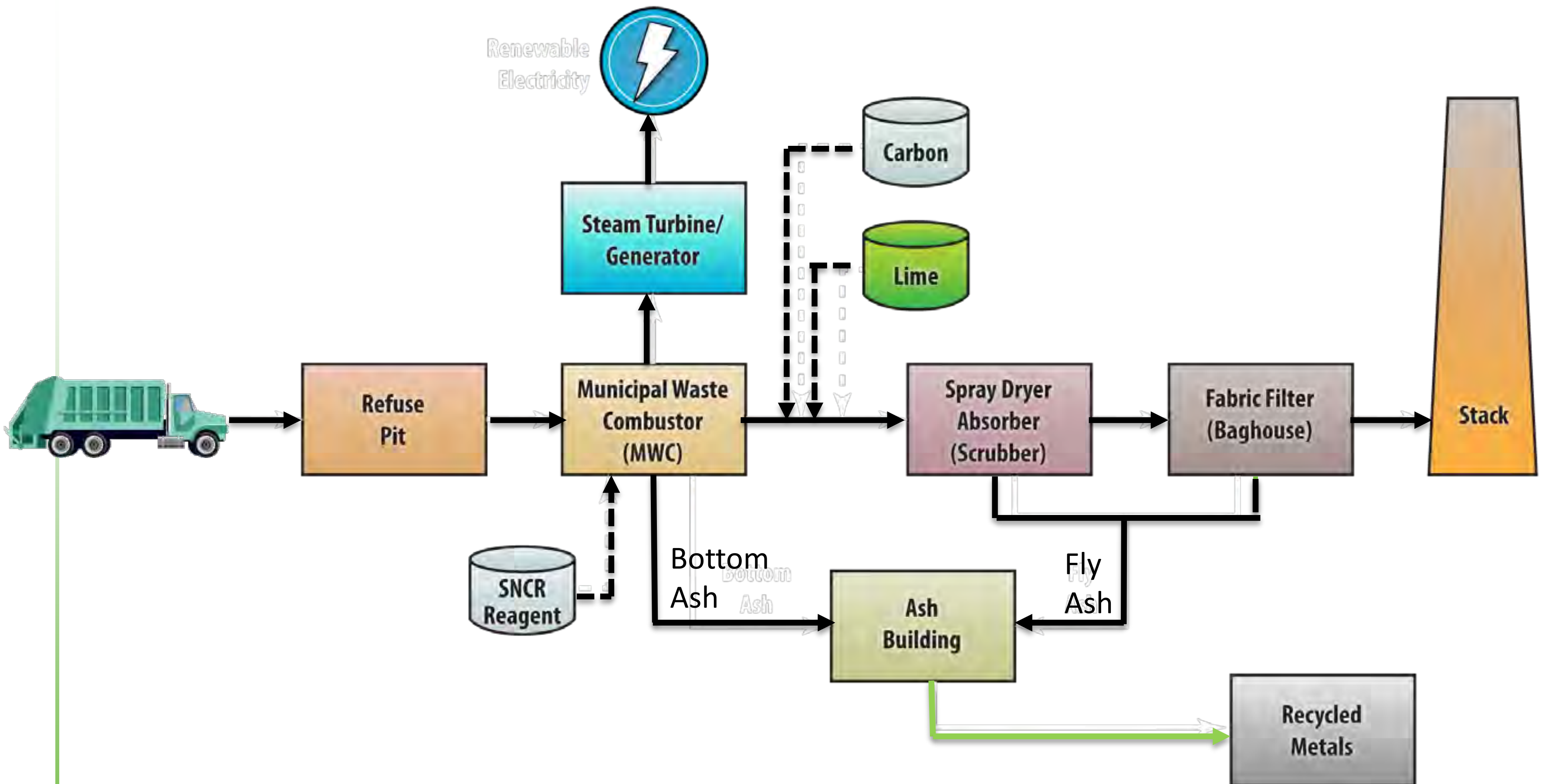
- Air emission testing
- Ash residue testing
- CEM maintenance / troubleshooting
- Water quality testing

Sub-contracted Services

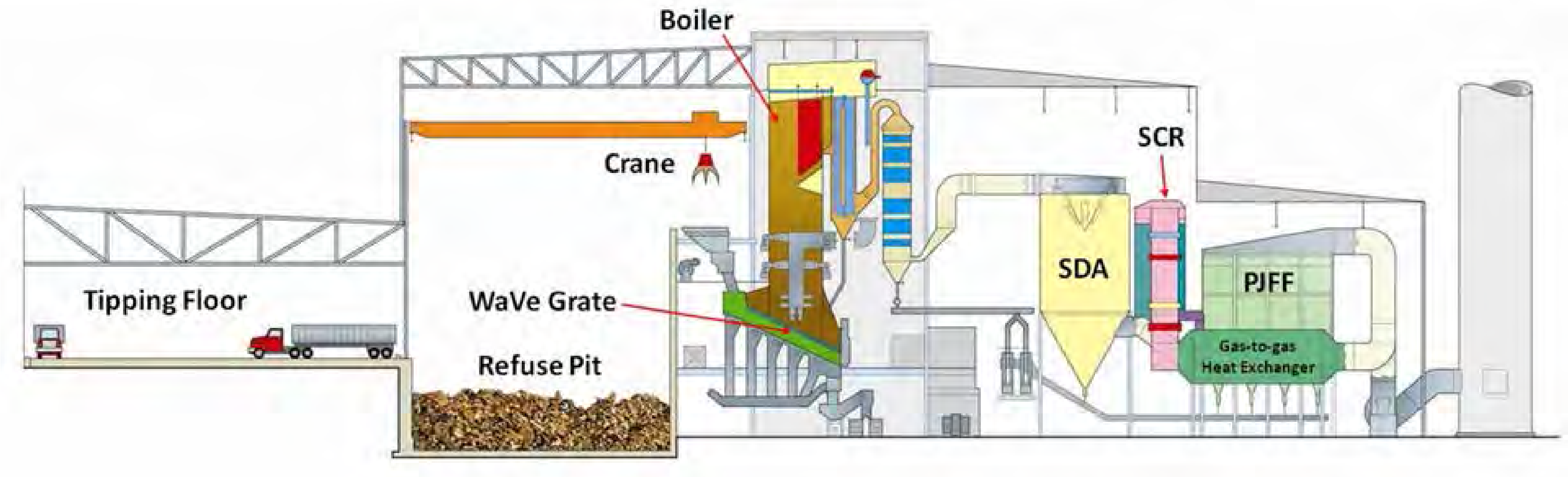
- Boiler water treatment monitoring
- Building services
- Catering services
- Cooling tower water treatment monitoring
- Electrical testing
- Janitorial / cleanup services
- Landscaping maintenance
- Medical testing
- Mobile equipment maintenance Residue hauling
- Pest and vector control
- Plant equipment rental
- Printing services
- Refractory repair
- Scaffolding rental
- Specialty cleaning
- Temporary labor
- Uniform services
- Welding repairs and Non-destructive testing

MSW – Ash – Recovered Metal Photos

Typical Mass Burn WTE Flow Diagram



Typical Massburn EfW Facility Cross-Section



Based upon B&W Volund technology employed at the newest EfW facility in US (Palm Beach County, FL)

Massburn is the Dominant EfW Technology in the US (~75%)

Minimizing Landfill Disposal of EfW Ash Residue

~ 90% volume and 75% weight reduction, plus ~3% metal recovery

Initial Metal Recovery Operation
Bulky Ferrous Metals Greater than 5 – 6 Inches

Second Metal Recovery Operation Ferrous Metals Less than 5 – 6 Inches

Third Metal Recovery Operation
Non-ferrous Metals "Liberated" by Combustion

Sample of Non-ferrous Metals Recovered from Bottom Ash by Eddy Current Separator

Enhanced Recovery of Recyclable Products from Bottom Ash "Fines" (European Experience)

Fine minerals
(< 0.07 inch)

Mineral aggregates
(> 0.07 inch)

Non-ferrous concentrate

Ferrous concentrate

Enhanced Recovery of Aluminum Metals from Bottom Ash "Fines"

Aluminium scrap product (fine)

- 0.04 – 0.14 inch
- 70 - 75% pure metal scrap

Aluminium scrap product (middle)

- 0.14 – 0.4 inch
- 75 - 80 % pure metal scrap

Aluminium scrap product (coarse)

- 0.4 – 0.75 inch
- 85 - 90 % pure metal scrap

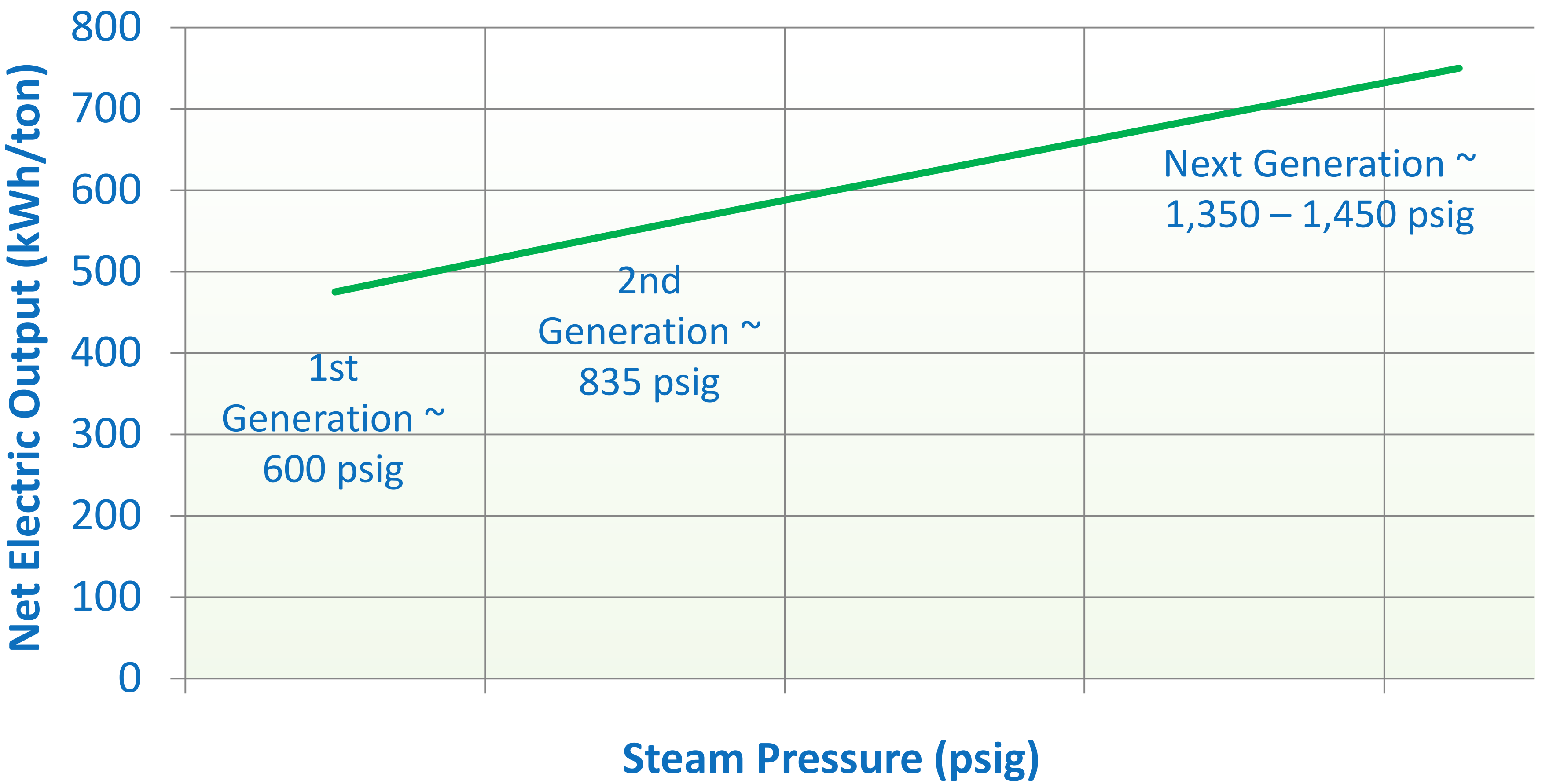
Heavy Non-ferrous Metals Separated from Non-ferrous Metals Recovered from Bottom Ash Fines

Primarily brass and copper

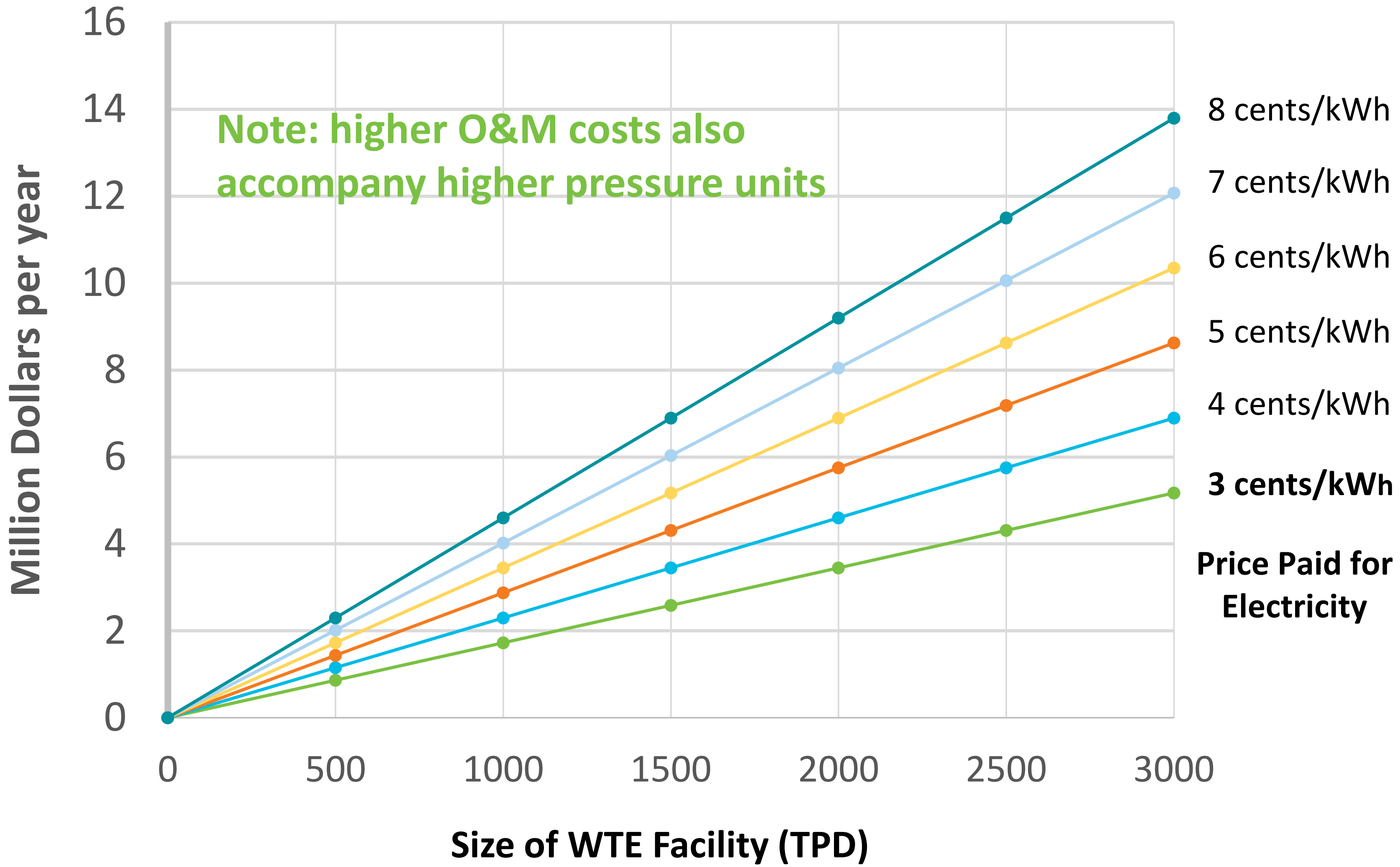
Heavy non ferrous scrap

- 0.04 – 0.75 inch
- 95-99 % pure metal scrap

Massburn WTE Trends
Higher Steam Pressures and Net Electric Generation



Increase in Annual Electrical Payments with High Pressure Boilers



Options for Improved Benefits from WTE

- Process and recycle leachate from local landfill(s) for use as WTE process water
- Process WWTP biosolids for beneficial Reuse
  - Low pressure steam for drying biosolids
  - Electricity for microwave drying of WWTP biosolids
- Capture rain water from facility roofs for use as process makeup water
- Mine existing unlined landfill(s) and process combustibles in WTE
- Use of steam or hot water in local recreational / fitness center (host community benefit often employed in Europe and Asia)

Palm Beach County Florida New WTE Facility

Incorporating Gravity Rainwater Harvest

First 2" of Rain Provides ~16% of Annual Water Demand

Machine for "Halving" Tires on Rims Supplemental Fuel for Pasco County Florida WTE

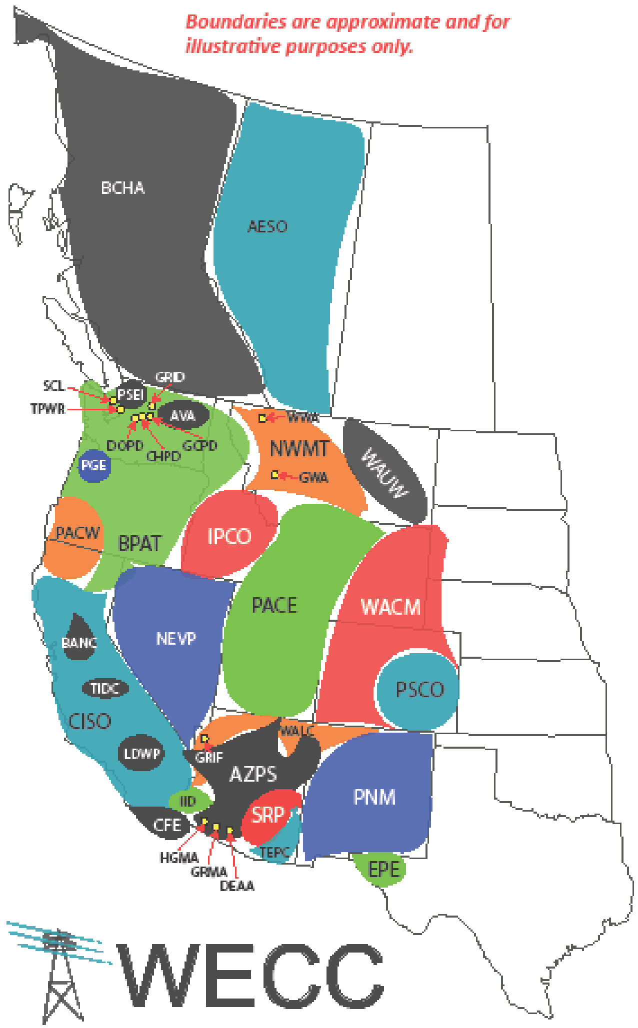
Chipped Tires - Supplemental Fuel for Pasco County Florida WTE Facility

Note: One ton of tires displaces three tons of MSW due to higher heating value of rubber

Explore Incentives / Needs of Regional Electric Grid

North American Electric Reliability Corporation (NERC) Regions

Western Electricity Coordinating Council (WECC)

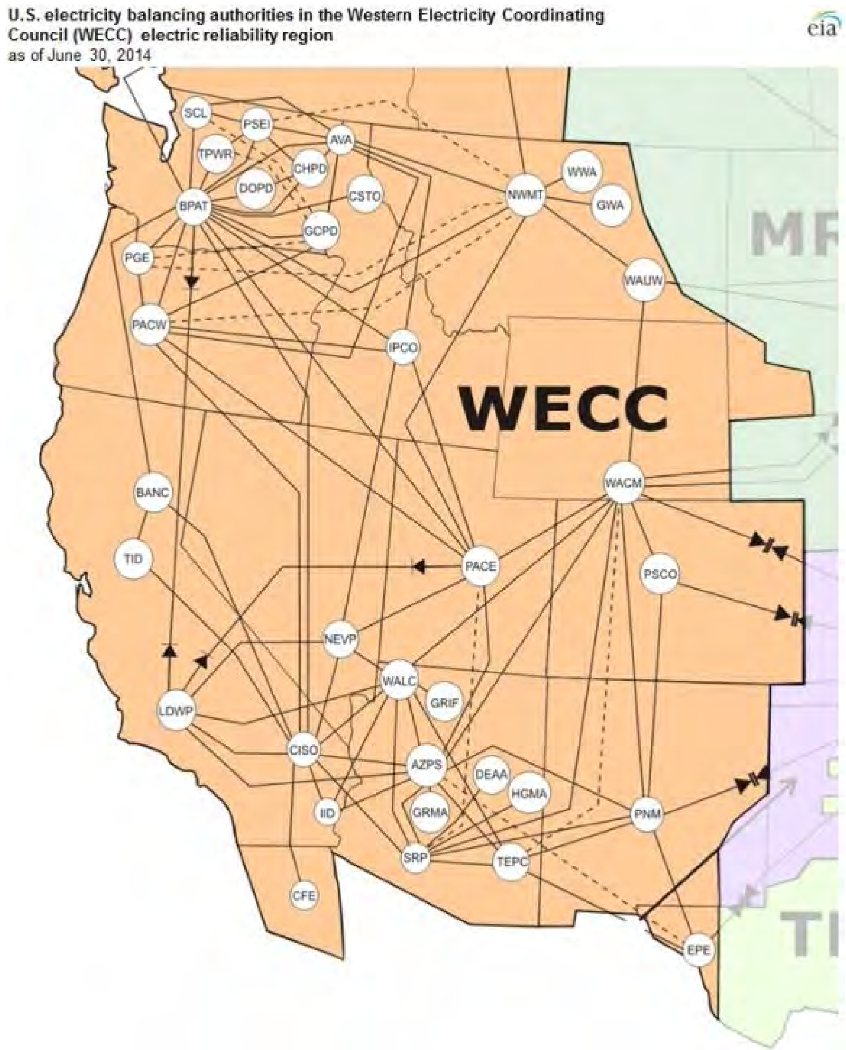


Western Interconnection Balancing Authorities (38)

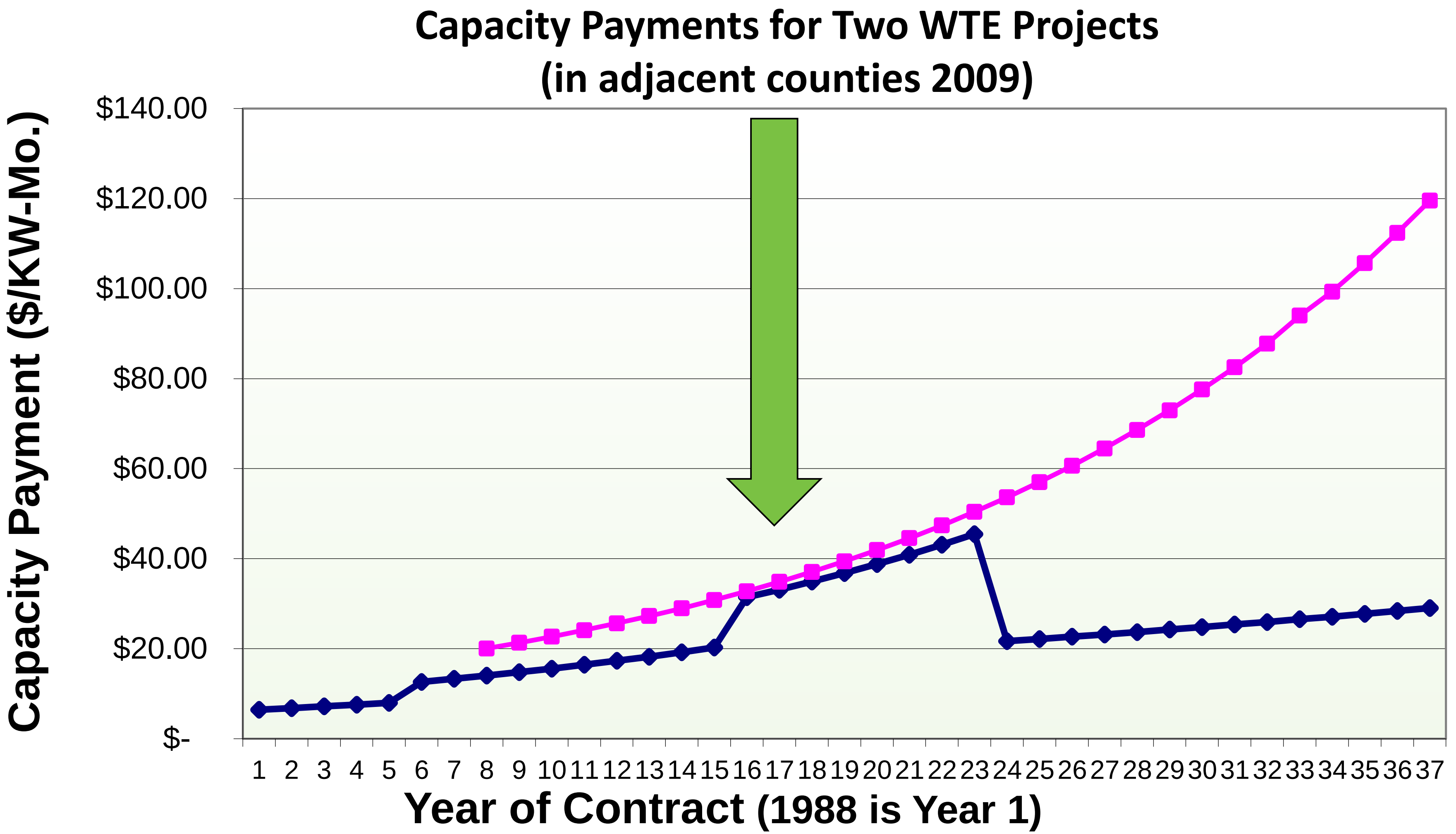
AESO - Alberta Electric System Operator
AVA - Avista Corporation
AZPS - Arizona Public Service Company
BANC - Balancing Authority of Northern California
BCHA - British Columbia Hydro Authority
BPAT - Bonneville Power Administration - Transmission
CFE - Comision Federal de Electricidad
CHPD - PUD No. 1 of Chelan County
CISO - California Independent System Operator
DEAA - Arlington Valley, LLC
DOPD - PUD No. 1 of Douglas County
EPE - El Paso Electric Company
GCPD - PUD No. 2 of Grant County
GRID - Gridforce
GRIF - Griffith Energy, LLC
GRMA - Sun Devil Power Holdings, LLC
GWA - NaturEner Power Watch, LLC
HGMA - New Harquahala Generating Company, LLC
IID - Imperial Irrigation District
IPCO - Idaho Power Company
LDWP - Los Angeles Department of Water and Power
NEVP - Nevada Power Company
NWMT - NorthWestern Energy
PACE - PacifiCorp East
PACW - PacifiCorp West
PGE - Portland General Electric Company
PNM - Public Service Company of New Mexico
PSCO - Public Service Company of Colorado
PSEI - Puget Sound Energy
SCL - Seattle City Light
SRP - Salt River Project
TEPC - Tucson Electric Power Company
TIDC - Turlock Irrigation District
TPWR - City of Tacoma, Department of Public Utilities
WACM - Western Area Power Administration, Colorado-Missouri Region
WALC - Western Area Power Administration, Lower Colorado Region
WAUW - Western Area Power Administration, Upper Great Plains West
WWA - NaturEner Wind Watch, LLC

Explore Opportunities for Regional Electrical Generation with Western Electricity Coordinating Council (WECC)

- Reactive power advantages for electrical generation in urban areas
- Fuel diversity for improved resiliency
- Grid balancing needs



Small Power Purchase Agreements (PPA) in Florida …Timing is Everything, but the Trend is Downward!



Opportunities to Reduce Cost of Modern WTE

- Optimization of the combustion process
- Value Engineering and optimization of facility and processes for balance of plant
  - Processing of ash for advanced recycling of metals at a remote location
  - Appropriately sized refuse receiving and storage areas
  - Need for redundancy of critical systems
  - Reduce parasitic load
    - High efficiency motors and systems
    - Variable frequency drives
  - High efficiency ceramic based thermal insulation

Optimization of the Combustion Process

- Expert systems to optimize the combustion process
- Improve Boiler efficiency
  - Reduction of excess air
  - Reduction of flue gas temperature at boiler outlet
  - Installation of an external superheater
  - Steam production at higher pressure and temperature
  - Design of boilers to allow intermediate steam reheating
  - Supplementary gas turbine to preheat combustion air
  - Additional superheater located above lower end of combustion grates (B&W Steam Boost)