



## “ WASTES TO ENERGY AND PRODUCTS”

### KNOWLEDGE EXCHANGE CONFERENCE

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### ENERGY&PRODUCTS FROM WASTES CONTENTS

*Opportunities with Wastes – Case Studies*

- HK Municipal Solid Waste, MSW, to Energy and Cement - 9300t/day
- Construction Waste, Reprocessing and Re-Use – 6000t/day
- HK Sewage Sludge, SS, Applications – 2000t/day
- E-Waste; Metals, Fuels and Plastics Recovery, Better Products – 70,000t/year
- Fuel Oils and Active Carbons from Waste Tyre Pyrolysis
- Activated Carbons from Bamboo Scaffolding/Wood/Husk Wastes
- Chitin and Chitosan from Seafood Shell Waste
- Activated Carbons/Adsorbents from Biomass Wastes (bagasse/seaweed/others)
- Waste Incineration Ashes Utilisation
- Others (Vehicle Oils, Restaurant Fats/Grease, Hazardous Wastes/Chemical Wastes)
- Landfill Linings & Remediation
- Integrated Waste Treatments

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### ENERGY&PRODUCTS FROM WASTES - Not in HK Thank You



Waste on the streets of Naples, Italy

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### ENERGY&PRODUCTS FROM WASTES 1. HK MSW to Energy & Cement




Spittelau incineration plant in Vienna



Former incineration plant in Kwai Chung

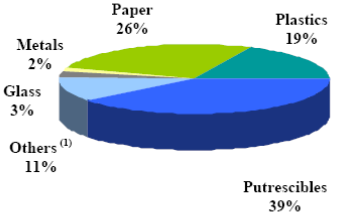
Photo of MSW Incinerator

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ENERGY&PRODUCTS FROM WASTES 1. HK MSW to Energy & Cement

1. Characterisation of HK Wastes



**Total quantity: 9,279 tonnes per day**  
 MSW feed materials defined by HKEPD (2006)

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ENERGY&PRODUCTS FROM WASTES 1. HK MSW to Energy & Cement

Characterisation of HK Wastes: Elemental Analysis (% w/w) dry

C	45.0
H	6.78
N	1.15
O	25.8
S	0.092
Cl	0.927
Calorific Value	25.1 MJ/kg
Ash	20.3 % w/w

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ENERGY&PRODUCTS FROM WASTES 1. HK MSW to Energy & Cement

R & D at HKUST – Co-Combustion Project



Materials Recovery & Recycling Facility  
 Co-combustion facility

Photograph of the Pilot Plant

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R & D at HKUST – Co-Combustion Project




Waste Reception

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ENERGY&PRODUCTS FROM WASTES 1. HK MSW to Energy & Cement




Architects Impression "Energy, Cement and Electricity"

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**Mitchell Tseng**  
IELM

2. Environment: Construction Waste Management

**Formation of Hong Kong SAR Construction Waste Eco-system**



**Key solutions**

- Partners with construction companies, government and third-party for waste treatment
- Applying Supply Chain Management Methodology to Coordinate material flow, information flow and financial flow of construction waste processing

**Impacts to Environment**

- Reduce consumption of natural resource
  - 50% of sands and gravels are imported in HK
- Substantially reduce construction waste
  - 23 % of HK solid waste disposal is construction waste (~10+ million tons/year)
- Reduce truck transportation of construction waste and materials in busy streets
  - 1200+ trip per day for waste disposal, costing at least 270 million on transportation cost

◇ Primary processor  
+ Recycler  
X Secondary processor  
■ Public landfill

ENERGY&PRODUCTS FROM WASTES 3. HK Sewage Sludge

**SEWAGE SLUDGE POTENTIAL USES**

- Fertilizer( N, P, K)
- Sea Dumping - disposal
- Landfill - disposal
- Low Grade Fuel for Energy-Mass Burn WTE
- High Grade Fuel for Energy (SDF)
- Fats and Grease Recovery for Biofuel
- Biodigestion for Methane Production
- Ash Utilisation

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ENERGY&PRODUCTS FROM WASTES 3. HK Sewage Sludge



**Sewage Sludge Incineration Plant**

**Sewage Sludge Drying System (Shanghai Shidongkou Sewage Treatment Plant)**

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### ENERGY&PRODUCTS FROM WASTES 3. HK Sewage Sludge

The CHNOS of Sludge Cake

	N	C	S	H	O
	2.8%	39.9%	2.4%	4.8%	21.6%

CHNOS in Sludge Cake in Different Sampling Days (Silo)

Source: ERM

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### 4. Environment: Processing E-Waste CBME

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### 4. Environment: Processing E-Waste CBME

Metal	Unit Price <sup>1</sup>	Revenue <sup>2</sup>	Revenue <sup>3</sup>
Ag	US\$ 17.39/ozt (0.56/g)	197,120	394,211
Au	US\$ 1137/ozt (36.56/g)	7,732,331	6,443,609
Pd	US\$ 477/ozt (15.34/g)	1,081,302	1,189,432
<b>Total</b>		<b>US\$ 9,010,753</b>	<b>US\$ 8,027,252</b>
		<b>HK\$ 70,283,873</b>	<b>HK\$ 62,612,565</b>

<sup>1</sup> Goodsey & Kettner, 2003  
<sup>2</sup> Chancere et al., 2009.  
<sup>3</sup> <http://www.mines.com/money/controller/sagegoldprices> (Dated 8 Mar 2010).

**Jiang Xu/ECE**

### 4. Green Electronic Systems

- A Growing Challenge**
  - 82% become toxic e-waste\*
  - 4.3 million tones to landfill in US in 2007\*
  - 10-20% computers to landfill in HK\*\*
  - 12.3 million tones in EU in 2020\*\*\*
- Why?**
  - New devices are incompatible with old devices
  - Short life cycle
- Improve compatibility**
  - Unified interconnected electronic systems
- Increase life cycle**
  - Resilient electronic systems
- Easier to reuse and recycle**
  - Hardware/software codesign


\*US EPA \*\*Greenpeace \*\*\*EU Commission

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ENERGY&PRODUCTS FROM WASTES 5. Waste Tyres

**FUEL OILS AND ACTIVE CARBONS FROM WASTE TYRE PYROLYSIS**

- Retread
- Fuel Oil
- Fuel Gas
- Tyre Char
- Activated Carbon
- Tyre Rubber (Mats, Pellets to Export)
- Construction Products



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5. Use of Waste-Derived Paste (Tire Chips + Paper Sludge) as Daily Cover Materials

Landfill daily cover material



- Objectives: improve mechanical properties and minimize environmental impact
- **Tire Chips (TC)**
  - Obtained from a local private company
  - Particle size ranging from 2 – 40 mm
- **Paper Sludge (PS)**
  - Obtained from a recycled paper factory
  - Which is the residual from the manufacturing process and the engineering properties are similar to soil.

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ENERGY&PRODUCTS FROM WASTES 6. Bamboo/Wood/Husk

**ACTIVATED CARBONS FROM BAMBOO SCAFFOLDING WASTE**

1. Wood Fuel
2. BBQ Char
3. Activated Carbon



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ENERGY&PRODUCTS FROM WASTES 6. Bamboo/Wood/Husk



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ENERGY&PRODUCTS FROM WASTES 6. Bamboo/Wood/Husk ACTIVATED CARBONS

- The surface area of product is over 2000 m<sup>2</sup>/g (commercial carbons 500 – 1500 m<sup>2</sup>/g).
- Excellent adsorbent for wastewater treatment.
- Promising future - potential applications include microelectronics, hydrogen storage, gas purification, composite material, etc.

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6. Colour Removal from Wastewaters by Waste Activated Carbon

1 3 5 10 15 20 25 minutes

1 3 5 10 15 20 25 minutes

Powdered Activated Carbon Derived from Wood Waste

Commercial Activated Carbon: Calgon F-400

Possess high adsorption capacity and short adsorption time compared to commercial activated carbon

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Zongjin Li/CIVL

6. Utilization of Industry By-products: Extruded Door Frame with Waste Wood Particles and Honeycomb sectioned Panel with Fly Ash

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6. Environment: Use of Solid Waste in Pollutant Control and Recycling

Research Accomplishment/ Sub topics

- Use of the Fly Ash Products (FAP) from Rice Husk and Coal Co-combustion as low-cost adsorbents in gaseous VOC adsorption and Catalytic Ozonation
- Recycling Fly Ash into Zeolite Materials for both gaseous contaminant control and heavy metal removal in wastewater
- C.W. Kwong and C.Y.H. Chao, Fly Ash Products from Biomass Co-Combustion for VOC Control, *Bioresour. Technology*, **104**, pp. 1075-1081, 2010.
- K.S. Hui and C.Y.H. Chao, Methane Emissions Abatement by Multi-ion-exchanged Zeolite A Prepared from Both Commercial-grade Zeolite and Coal Fly Ash, *Environmental Science and Technology*, **42**, pp. 7392-7397, 2008.
- K.S. Hui and C.Y.H. Chao, Synthesis of MCM-41 from Coal Fly Ash by a Green Approach: Influence of Synthesis pH, *Journal of Hazardous Materials*, **137**, pp. 1135-1145, 2006.
- K.S. Hui, C.Y.H. Chao and S.C. Kot, Removal of Mixed Heavy Metal Ions in Waste Water by Zeolite 4A and Residual Products from Recycled Coal Fly Ash, *Journal of Hazardous Materials*, **127** (1-3), pp. 89-101, 2005.

Fig. SEM analysis of FAP from biomass co-combustion with coal (Ash<sub>30</sub>)

Fig. Toluene conversion efficiencies and outlet ozone concentrations over various FAP at 25°C

Fig. Toluene ozonation characteristics with zeolite13X, MCM-41, Ash<sub>100</sub> and Ash<sub>30</sub>

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PRODUCTS FROM WASTES 7. Chitosan from Seafood

### CHITIN AND CHITOSAN FROM SEAFOOD SHELL WASTE

Eg. Prawns, shrimps, lobsters, crabs


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PRODUCTS FROM WASTES 7. Chitosan from Seafood

### Chitosan and Its Uses

- Adsorbent for pollutant removal e.g. dyes, proteins, metals,
- Flocculant e.g. for use in wastewater dairies, textiles,
- Clarifier e.g. for use in wine making,
- Thickening agent,
- Fibre e.g. can be spun into fibre form,
- Film/membrane forming material,
- Affinity chromatography column matrix support,
- Plant disease resistance promoter,
- Anti-cancer agent,
- Wound healing promoting agent – medical stitches,
- Antimicrobial agent e.g. Veterinary applications
- Waterproof properties e.g. clothing, building applications
- Slimming fat reducing products




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**BIOFUELS and BIOMASS**

PRODUCTS FROM WASTES 8. Activated Carbons/Adsorbents from Biomass

### Uses of Biomass Wastes

Sugar Cane/Peat	<ul style="list-style-type: none"> <li>• Biofuel</li> <li>• Active Carbon/ BBQ Fuel/ WDF</li> </ul>
Residue Jatropha	<ul style="list-style-type: none"> <li>• Active Carbon/ BBQ Fuel/ WDF</li> <li>• Biofuel</li> </ul>
Residue Algae	<ul style="list-style-type: none"> <li>• Active Carbon/ BBQ Fuel/ WDF</li> <li>• Biofuel</li> </ul>
Residue	<ul style="list-style-type: none"> <li>• Active Carbon/ BBQ Fuel/ WDF</li> </ul>
Animal Feed Cakes	




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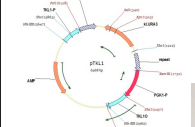
**BIOTECH APPLICATIONS**

Green Products Development - Biotechnology Application


**Waste biomass**



**Modified gene for enzymes**



**Fermentation for alcohol production**



**Research Accomplishment/ Sub topics**


- Two stains successfully obtained.
- They perform better than the commercially available enzymes
- An integrated process has been tested
- A pilot plant study is planned.

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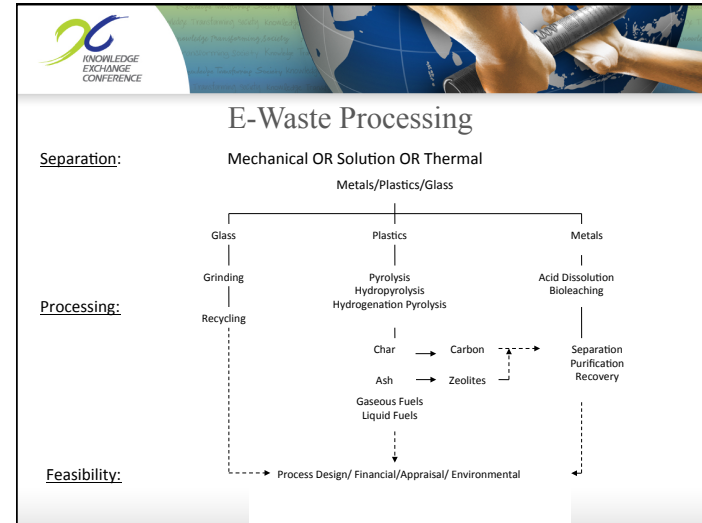
PRODUCTS FROM WASTES 9. Waste Incineration Ashes Utilisation

### Uses of Incineration Ashes

- Cement
- Concrete
- Tiles-Ceramic - Glass
- Aggregate
- Agriculture NPK
- Adsorbents
- Zeolites



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Thank you!

Q & A

Prof Gordon McKay

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