City of Sydney Gasification Project

Master Planning Energy from Waste

Mark McKenzie
Senior Policy Officer – Waste
Local Government NSW
mark.mckenzie@lgnsw.org.au
(former Manager – Waste Strategy, City of Sydney)
City of Sydney
206,000 residents
40,000 businesses
26 km²
Ambitious GHG targets set in 2009

- 2006 Emissions
- BAU 2030 Emissions
- 2030 Target

70% reduction on 2006 levels
Integrated master plans reinforcing GHG reduction through complementary energy contributions (oh, and water too)
80% emissions come from coal

GHG and solid waste environmental impacts integral to solution

87 tonnes of ash waste for every gigawatt of electricity
Municipal (household) Solid Waste collected 2012/13

Garbage = 41,000t
Kerbside Recycling = 15,000t
Garden Organics = 800t

Plus bulky waste, other minor streams

Kerbside MSW collection
2 - 3 bin system
City Annual Waste
Municipal (household) 43,000 tonnes
Commercial 320,000 tonnes
Municipal Operations 6,500 tonnes
Landfilled 158,000 t
Three critical steps that transform choices. . .
2011 – Step 1 Strategy

• Push for recycling increase
• Clean up waste stream (lowering hazardous & problem waste)
• Final strategy awaiting Energy from Waste Master Plan
• Target to provide a waste solution for all waste types in City
Step 2 - Critical characterisation studies
Step 3 - Mindset change
Precise understanding of feedstock values rather than focus on waste levels

Waste fractions MSW 2030 (by weight)

Calorific fractions MSW 2030 (by weight)

MSW Energy Values
Higher Heating Value

- High Calorific
- Mid Calorific
- Low Calorific
- Inert
- Hazardous

- Moisture 32%

 MJ/Kg (as received)
Gasification plus upgrade to substitute natural gas
Advanced Waste Treatment Objectives:

• Cost effective – Recovery efficiency first, treatment of residual
• Minimises the environmental impact of waste disposal
• Significantly reduce greenhouse gas emissions arising from waste
• Integrate with other City Energy Master Plans
• Significantly divert waste from landfill
• Capable of handling increasing waste volumes and variability over the longer term
• Able to treat full material and calorific range of MSW, recycling where feasible
• Facility sized to treat municipal, commercial and industrial waste

[MAXIMISE RENEWABLE ENERGY CONTENT]
Evaluating Advanced Waste Treatment Options

Mechanical-Biological Treatment

Bioreactor Landfill

Anaerobic Digestion

Thermal Combustion (Incineration)

Thermal Conversion (Gasification)
## HIGH LEVEL RISK EVALUATION

<table>
<thead>
<tr>
<th>Initial Assessment</th>
<th>Mechanical Biological Treatment</th>
<th>Bioreactor Landfill</th>
<th>Anaerobic Digestion</th>
<th>Grate Incineration</th>
<th>Fluidised Bed Incineration</th>
<th>Gasification (two stage)</th>
<th>Pyrolysis</th>
<th>Plasma Arc Gasification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significantly reduces GHG emissions load</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>?</td>
<td>?</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Generates renewable/ non-fossil fuel gas for end use energy supply</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>Waste diversion target</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tbody>
</table>
Multi-criteria and Life Cycle Analysis

- Technical 30%
- Environmental 30%
- Financial 20%
- Social 20%

- Feedstock Flexibility
- Modularity
- Process Control
- Waste Diversion
- Reliability
- Project Capacity
- Waste Strategy
- Staffing
- Proven Technology
- Meets 2030 Plan
- Energy Export

- Climate Change
- Air Emissions
- Water Emissions
- Water Resource
- Energy Resource

- Capital
- Revenue
- Waste Levy
- Cost per tonne
- Transportation
- Supply Risk
- Cost Volatility

- Family Impacts
- Amenity
- Employment
- Heritage Impacts
- Health and Safety

LIFE CYCLE OF STUFF

1. MATERIALS EXTRACTION
2. MANUFACTURING
3. DISTRIBUTION
4. USAGE
5. END-OF-LIFE MANAGEMENT
Five Key Criteria:

1) Commercial Maturity
2) Plant Throughput
3) Feedstock handles MSW
4) Syngas Generation
5) Best Available Emissions Performance

16 technologies available to review
Most suitable technology

Hi temperature Gasification plus ash melting
<table>
<thead>
<tr>
<th>Conversion Method</th>
<th>Renewable Syngas</th>
<th>Total Syngas</th>
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</thead>
<tbody>
<tr>
<td>Plasma gasification</td>
<td>0.33</td>
<td>0.50</td>
</tr>
<tr>
<td>Fluid-bed gasification + melting</td>
<td>0.29</td>
<td>0.49</td>
</tr>
<tr>
<td>Pyro-gasification + melting</td>
<td>0.26</td>
<td>0.42</td>
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<tr>
<td>Fluid-bed gasification</td>
<td>0.27</td>
<td>0.45</td>
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<tr>
<td>Pyro-gasification</td>
<td>0.25</td>
<td>0.40</td>
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<tr>
<td>Fixed-bed gasification</td>
<td>0.24</td>
<td>0.37</td>
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<tr>
<td>Pyro-combustion</td>
<td>0.25</td>
<td>0.40</td>
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<tr>
<td>Slow pyrolysis</td>
<td>0.23</td>
<td>0.36</td>
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</tbody>
</table>

66% renewable from MSW
STAKEHOLDER PARTNERS of MASTER PLANNING

• Regional Municipal Partners for viable levels (~120,000 tonnes per year)
  • Renewable Energy Master Plan identified regional waste levels
  • Regional Strategy developed included Energy from Waste led by City
  • Regional partnering was a weakness, slowly improved

• Biosolids noted within Renewable Energy Master Plan
  • Strong consideration of both anaerobic digestion & Gasification (with upgrade) to a common gas pipeline feed
  • Sydney Water controls local biosolids & sought partnering at public consultation
  • Biosolids provide excellent renewable energy content in mix with gasification
  • Up to 35% moisture without issues

• Community Workshops - Social licence to operate
Financial assumptions based on Master Plan analysis

• Assumptions for indicative costs
  • 100,000 tpy
  • 5 hectare site purchased
  • 35 year life of equipment
  • All construction, licencing and operational costs included
  • Direct capital cost $120 mil
  • Master Plan included additional $10 mil methanation plant
  • Discount rate 9.5%
  • CPI 3%
  • Capital overhaul at 20 years

• Estimated Gate fee cost to City of $A242 per tonne NPV (2013 figures)
Estimates from financial analysis

CAPITAL COSTS
• Land - $A35 million
• Facility - $A120 million + $A35 million overhaul in Year 20
• Engineering, licences, contingency - $A30 million

OPERATING COSTS (inc landfill residual)
• ~ $A12 million per year

REVENUES
• Commercial gate fees (inc regional partners)
• Large-scale generation certificates
• Direct energy sales
• Avoided disposal/treatment costs
TOTAL~ $A28 million per year (rising)

Positive financial return after year 9 for a zero net result at end of life
Planning for Implementing

1. IMPLEMENTATION RISK ASSESSMENT
2. SITE ACQUISITION STRATEGY
3. REVIEW of REGULATORY IMPACTS
4. PLANNING APPROVALS REPORT
5. COMMUNITY and STAKEHOLDER ENGAGEMENT PLAN
6. PROCUREMENT PLAN and CONTRACTING MODEL
7. FINANCIAL PLAN (and Budget)
8. CONTINGENCY PLAN (& exit strategy)
9. TIMETABLE
10. COMMITMENT
Challenges that could prove fatal

- Changes in critical staff
- Political cycle & council futures
- Competing priorities at critical junctures
- Challenging Regulatory context – changing policy basis for both EfW and GHG
- PLUS the City took a very very cutting edge technical approach and therefore a hard sell

“I think you should be more explicit here in step two.”
Thank you