Transformation of Waste Management in Oman
ISWA Energy Recovery WG Meeting
25th May 2016 – West Palm Beach, FL
Area: 309,500 km² (120,000 sq. miles)

Population: 4.24 million*

Density: 13.71 capita/km²

Source: National Center for Statistics and Information

*Sep 2015
Waste Management in Oman: Situation Analysis
Oman: Waste Management Framework Structure

Waste Management & Cleaning Services Providers

- Willayat Sohar
  - Sohar Municipality
- Muscat Governorate
  - Muscat Municipality
- Most of Oman
  - Ministry of Regional Municipalities & Water Resources
- Dhofar Governorate
  - Dhofar Municipality

Environmental Legislator & Regulator

- Ministry Of Environment & Climate Affairs
- Healthcare Waste Permits
  - Ministry Of Health
Oman: Municipal Solid Waste Generation*

Over 1.7 million tons in 2014

Over 300 Dumpsites in Oman

*Internal estimates 2014. Does not include industrial waste, healthcare waste, ELT, ELV, C&D, WEEE
Oman: Municipal Solid Waste Generation*

Oman average 1.2 kg / person / day

Around 4,714 tons per day of in 2014

Waste Generation (Tons per Day)

<table>
<thead>
<tr>
<th>Region</th>
<th>Waste Generation (Tons per Day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscat</td>
<td>1.38</td>
</tr>
<tr>
<td>North Al-Batinah</td>
<td>1.26</td>
</tr>
<tr>
<td>Al-Dakhiliya</td>
<td>0.75</td>
</tr>
<tr>
<td>Dhofar</td>
<td>1.05</td>
</tr>
<tr>
<td>South Al-Batinah</td>
<td>0.91</td>
</tr>
<tr>
<td>South Al-Sharqiya</td>
<td>0.81</td>
</tr>
<tr>
<td>North Al-Sharqiya</td>
<td>0.52</td>
</tr>
<tr>
<td>Al-Dhahirah</td>
<td>0.58</td>
</tr>
<tr>
<td>Al-Buraiymi</td>
<td>0.95</td>
</tr>
<tr>
<td>Al-Wusta</td>
<td></td>
</tr>
<tr>
<td>Musandam</td>
<td></td>
</tr>
</tbody>
</table>

Waste Generation (Kg per Capita per Day)

*Internal estimates 2014. Does not include industrial waste, Healthcare waste, ELT, ELV, C&D, WEEE
Oman: Other Waste Streams: Quantities in Tons

*** 2014 “ELT Feasibility Study in 2011”
***** 2009 Muscat Governorate Field estimate

- **WEEE**: Electrical & Electronic
  - Quantities: 45,000*

- **Healthcare**
  - Quantities: 4,500**

- **ELT**: Tires
  - Quantities: 35,000***

- **LAB**: Lead Acid batteries
  - Quantities: 14,000****

- **Hazardous**
  - Quantities: 1,469,835****

- **C&D**: Construction & Demolition
  - Quantities: 735,341*****
Oman: Current Infrastructure

Dumpsites in Oman

- 317 Dumpsites
- 4 Landfills
- 9 Transfer Stations
- 1 Healthcare Treatment Facility
- 6,466 Workers*
- 1,284 Pcs of Equipment*

* 2009 estimates
Oman: Waste Management Hierarchy

Current Waste Management Practice in Oman

- Reduce
- Reuse
- Recycle
- Disposal
be’ah: Integrated Waste Management Strategy
Oman Environmental Services Holding Company “be’ah” Established

July ‘06

Draft Strategy Report: National Solid Waste Management Project

July ‘07

Royal Decree 46/2009

Aug ’09

Takeover Healthcare Treatment

2011

Budget Approved by Ministry of Finance

Jul ’12
be’ah: Strategic Goals

1. Damage Control
2. Restructure WM Services
3. Develop WM Sector
4. Support Oman’s Economy
Sector Building Stages

- **Closure of Dumpsites**
- **0 CO₂ Emissions from Dumpsites**
- **60% Diversion Rate**
  - Integrated Industrial waste handling and treatment facility
- **80% Diversion Rate**
- **Less than 1 kg/capita/day**

- **2012**
  - Establish Infrastructure
  - Sector Takeover

- **2016**

- **2020**
  - Rehabilitation of Dumpsites
  - Establish sustainability principles pillars
  - Establish the required recycling mechanisms and waste value recovery

- **2030**
  - Sustainability awareness programs designed as the services needs

- **2040**

*MSW (Household excluding HW, WEEE, ELT, ELV, LAB...etc.)
be’ah: Municipal Solid Waste
## be’ah: Core Infrastructure for Municipal Waste

<table>
<thead>
<tr>
<th></th>
<th>Past</th>
<th>2015</th>
<th>2016</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dumpsites</strong></td>
<td>317</td>
<td>&gt;300</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Engineered landfills</strong></td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td><strong>Transfer Stations</strong></td>
<td>0</td>
<td>9</td>
<td>25</td>
<td>25-34</td>
</tr>
</tbody>
</table>
be’ah: Municipal Solid Waste (MSW) Infrastructure
be’ah: Municipal Solid Waste (MSW) Infrastructure

Tahwa Landfill
be’ah: Municipal Solid Waste (MSW) Infrastructure

Izz Landfill
be’ah: Municipal Solid Waste (MSW) Infrastructure

Barka Landfill
be’ah: Municipal Solid Waste (MSW) Infrastructure

Thamrait Landfill
be’ah: Municipal Solid Waste (MSW) Infrastructure
be’ah: Municipal Solid Waste (MSW) Infrastructure
Be’ah: Sector Takeover Outsourcing Contract

Collection

Transportation

Transfer Stations

Transportation

Recyclables

Landfills

Management

Management

Pre-collection

Household

Commercial
## be’ah: Sector Takeover

<table>
<thead>
<tr>
<th>Governorate</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Al-Sharqiyyah &amp; Mahut</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>South Al-Batinah</td>
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<td>Dhofar</td>
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<td></td>
</tr>
<tr>
<td>Al-Dahirah &amp; Al-Buraimi</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>North Al-Batinah &amp; Musandam</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Muscat (2 contracts)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Al-Sharqiyyah</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Al-Wusta</td>
<td></td>
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</tr>
</tbody>
</table>

- Float, evaluate, and award
- Mobilize
- Operate

South Al-Sharqiyyah & Mahut Awarded: Mar ’15
South Al-Batinah Awarded: May ’15
Al-Dakhiliyyah Award: Jun ’15
Dhofar Award: Q3 ’15
Al-Dahirah & Al-Buraimi Award: Q3 ’15
be’ah: Industrial (Hazardous) Waste
be’ah: Healthcare Waste (HCW) Infrastructure*

Remote areas

Liwa
In 2015

Barka
In 2017

Thamrait
In 2017

Al-Multaqa
98% of Muscat’s HCW treated

*Fully financed by be’ah
Integrated Industrial HW Handling & Treatment Plant

Sohar Free Zone (Liwa)

- 240 Ha
- 90% of all hazardous waste in Oman is generated in Sohar
- Good infrastructure with roads, railway, port …etc.
- Location approved by:
  - Sohar Industrial Port Company
  - Supreme Council of Planning
Integrated Industrial HW Handling & Treatment Plant

Central Facility
- Storage Facilities
- Pretreatment Units
- Solidification (100,000 t/annum)
- Physical / Chemical Treatment (1,000 t/annum)
- Thermal Treatment (50,000 t/annum)

Slag Reclamation
28 million m³

Hazardous waste landfill
3 million m³
Duqm Landfill and storage operational Q3 2016

Solidification plant operational in Sohar, Q4 2017

Liquid Waste reception facility in Duqm 2019

Incinerator in Sohar operational 2020
- Slag Landfills
- Hazardous Waste Landfill
- Storage Facilities
- Pretreatment
- Solidification
- Physical / Chemical Treatment
- Thermal treatment

Waste for landfill and solid waste for storage is accepted

Waste from Duqm needing solidification is transferred to Sohar for treatment

Liquid Waste is received on site, weighed, inspected stored and transferred to Sohar

Duqm IW situation revised to check feasibility for local treatment.
be’ah: Waste Diversion Strategy
Municipal Waste Diversion Process

- Wet waste
  - Transfer Stations
    - MRF or MBT
      - W2W
      - Compost Facilities
    - Recycling Facilities
- Dry waste
  - Landfills
Recycling System: Value Chain

Objectives:
- Reduce Environment Impact from wrong practices
- Maximize in country value
- Retain valuable resources
- Achieve diversion targets

Success Factors:
- Integration with be’ah strategies
- Financial Funding & Support
- Sustainability
- Policy Support

Opportunities for SME Development
Waste composition*

Average energy content: 10 MJ/kg

*Waste Characterization and Quantification study, be’ah 2013
Waste to Energy in Oman

Possible Energy Uses

- **POWER**
  - relatively low cost of conventional energy production in the GCC

- **Hot Water District Heating**
  - No economy of scale (small scale industrial clusters)

- **District Cooling**
  - horizontal residential expansion, and high cost of logistics

All above mentioned options are not feasible
Oman: Fresh Water Shortage

- Low rainfall levels
- Dependence on sea water desalination
- Most desalination plants run on subsided gas
- Further desalination capacity is required in the near future
Waste to Energy to Water Concept

Business Case:
Waste to Energy with RO & MED (Thermal) based only on selling fresh water
Waste to Energy to Water Concept

Plant Capacity: 2,100 t/day or 700’000 t/annum

1 ton Waste = 104.5 tons Distillate Water

- Incineration & Boiler
- Backpressure Turbine
- Condensate
- Cleaned Flue Gas

- Stea 266 t/h
- 33.3 MW
- 47.16 MW "Gross"

- Thermal Desalination Plant MED-Conv.
  2,307 tons/h

- Reverse Osmosis “RO”
  6,842 tons/h

- Total Distillate Water:
  9,149 tons/h
  73,192,000 tons/a

- Waste 3x29.2 t/h = 87.5 t/h
  8.5 MJ/Kg

- 104.5 tons Distillate Water
W2E: Mechanical Biological Treatment (MBT) – Dhofar Project

- Municipal Solid Waste (MSW)
  - Inert Waste
  - Organic Waste
  - Metals
    - Engineered Landfills
    - Compost or Digestion Facilities
    - Recycling Facilities
      - Refuse Derived Fuel (RDF)
        - Cement Industry
Waste to Steam

Oil business require around additional 45,000 tons/day of steam.
Business Plan

Multiple RDF Facilities*

<table>
<thead>
<tr>
<th>Daily MSW Input</th>
<th>Location</th>
<th>Daily RDF Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>116 tons</td>
<td>Ad Dhahrah</td>
<td>77 tons</td>
</tr>
<tr>
<td>386 tons</td>
<td>Al Dhakhiliyah</td>
<td>256 tons</td>
</tr>
<tr>
<td>2075 tons</td>
<td>Muscat</td>
<td>1375 tons</td>
</tr>
<tr>
<td>250 tons</td>
<td>N Sharqiyah</td>
<td>160 tons</td>
</tr>
<tr>
<td>303 tons</td>
<td>S Sharqiyah</td>
<td>200 tons</td>
</tr>
</tbody>
</table>

Waste collected and transport

- Insure MSW quantity of RDF through “Supply Agreement with RDF Plant”
- Assuming no gate fees

RDF Management

- Insure quantity and quality of RDF through “Supply Agreement with Plant”
- Transport from RDF generation Site to Plant
- Can source out material and/or RDF from other places

Steam Generation

- BOO Model with a developer
- Energy purchase agreement
- Guarantee steam specs

• RDF material flow
• steam
• Cash flow

3120 tons

* Calculation based on waste generated in 2020 with growth rate of 3.28% and population growth of 2.28%
be’ah: Potential Waste Recovery Facilities

South Al-Batinah
2,100 T/Day
Waste to Energy to Water

North Al-Batinah
500-1,000 T/Day
Waste to Energy to Water

South Al-Sharqiyyah
500-1,000 T/Day
Waste to Energy to Water

Dhofar
400-500 T/Day
MBT Facility
Conserving our Beautiful Oman

THANK YOU

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