International Market Developments in the Sewage Sludge Treatment Industry

Sewage Sludge Treatment
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# About A. Vaccani & Partner (AVP)

AVP is an independent international management consulting company located in Switzerland, founded 25 years ago.

AVP has a well proven and renown track record in Renewable Energy & Environment (RE&E) and a well-qualified practice team.

- **Member of the ICFG international M&A network with over 40 offices worldwide**
- **Key activities include**
  - Strategy Consulting
  - Mergers & Acquisitions, Project Financing
  - Strategic Partnering
  - Specialized Research
- **Unique combination of transaction orientation, management consulting competence and business experience**
- **AVP team located on three continents with complementary skills and business experience, highest standards with regards to professionalism and quality**
- **Long experience in working with national and international clients on cross border mandates**

- **Strong domain experts and dedicated research in three practice areas:**
  - Sustainability, Waste Management
  - Energy
  - Water
- **Executed over**
  - 250 M&A and partnering mandates
  - 150 consulting mandates
- **Extensive network of industry contacts, large international network of specialists**
- **Excellent references and partner network in Europe, Asia, USA**
- **Established toolbox (and database) for market research and industry analysis**
- **Unique knowledge of what is happening in the most attractive market segments**

- **CEO ABB worldwide Business Area Resource Recovery**
- **CEO W+E Umwelttechnik AG**
- **Various Board / Advisory Board positions**

**Specialties**

- Practice leader for AVP’s waste, biomass, multi-fuel business
- Extensive experience with all aspects of international business development:
  - Strategy development and implementation
  - Mergers & Acquisitions (M&A)
  - Strategic Partnering and Licensing
  - Project development
- Personal access to many decision makers of global and regional leading market players
Key Points for Today’s Discussion

- Market drivers and sewage sludge volumes
- Disposal / treatment options
- Selected Technologies
- Market – Business Outlook
Global Need for Safe Management of Sewage Sludge is Growing Rapidly

- World population 7.5 billion and growing at rate of 1.13% (~226'000 per day)
- Urban population is 4 billion and expected to grow up to 4.7 billion by 2025
- 31 megacities out of 512 cities with population over 1 million
- Waste water treatment has high priority in environmental protection with high importance in large and small urban context.
- Sewage sludge production is proportional to waste water treatment volume
- Total sewage sludge generated world wide is approximately 75 million tons per year 2013 growing to approximately 103 million tons (+37%) by 2025
- Sewage Sludge related regulations are very sketchy
- Statistics are very inconsistent or often inexistent
- Actual sewage sludge treatment is not well documented

Source: Winnipeg Free Press
## Factors Impacting the Market Development in Europe

### Market Drivers

- **National and EU Regulation**
  - EU regulation (water/waste)
  - National frameworks for implementation

- **Increasing disposal costs**
  - Leading to an effective sludge management strategy

- **Potential revenue stream**
  - Energy recovery
  - Recycled phosphorus from sewage can cover 20% of Europe’s demand

- **Circular Economy**
  - Shift to reducing and reusing waste

### Market Challenges

- **Impact**
  - High cost of treatment technology & O&M
  - High transportation cost
  - Lack of strong & effective governance
  - Shortfall in funding for treatment

- **Impact**
  - Cheaper to reduce sludge volume than to treat it for reuse
  - Transportation of sewage sludge to treatment facility may be uneconomical
  - Lack of expertise and human capacities
  - Low implementation priority
  - Need for a more established new financing models

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**Circular Economy**

- Energy recovery
- Recycled phosphorus from sewage can cover 20% of Europe’s demand
Per Capita Sewage Sludge Generation in Europe

Kg per capita per year

Source: Eurostat, 2013 Data
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# Sewage Sludge Treatment Options

## Options

### Land Use
- Agriculture
- Reclamation
- Silviculture
- Forestry
- Amenity
- Horticulture

### Fuel Use
- Incineration
- Supplementary fuel for power and processes
- Gasification

### Disposal Option (until 2020)
- Landfill – mono
- Landfill – co-disposal

## Benefits

### Land Use
- Established policy
- Nutrients
- Organic matter
- Low cost/low technology

### Fuel Use
- Renewable energy
- Low transport costs (if on site)
- Continuous process

### Disposal Option
- Low cost
- Low technology
- Fill and forget
- Enhanced CH₄ recovery

## Constraints

### Land Use
- Voluntary
- Vulnerable
- Variable demand
- Quality
- Impacts
- Competition

### Fuel Use
- Public perception
- Planning controls
- Costs
- Emissions
- Ash disposal

### Disposal Option
- Gas emissions
- Leachate
- Legacy
- Resource loss
- Void loss
Disposal / Treatment Methods of Sewage Sludge in Europe
Possible Impact of Legislative Changes in Europe

- **Waste framework directive (2008/98/EC)**
  - According to this Directive sewage sludge is a waste and has to be treated, recycled, reused and/or disposed off accordingly
  - Waste legislation (risk management) does not favour use of sludge in agriculture
  - Waste management is a business and accordingly the legislation is strongly addressing private initiative and favours market economy
  - There is no provision for the relationship between WWT and sludge treatment/disposal
  - Waste legislation is very different form water legislation for several reasons (causes conflicts)

- **Hygienic aspects get more relevant again**
  - Infection transfer at farm level (MCD, etc.),
  - Transfer of antibiotic resistance, legionella?
  - Even there is no report on hygienic problems with sludge application in agriculture over the last decennia.

- **Increasing trend to recognize sludge (and WW) as valuable resources. (Water, P, N, org. C,..)**
  - 80 to 90 % P- removal at most of the treatment plants in central Europe (having no P- ores)
  - P- recycling is a matter of intensive research in EU.
  - EU commission is preparing a P-policy
Other Markets: China – 28 million Tons of Sewage Sludge Annually

- Total sewage production is 71 billion tons, of which 20 billion tons - industrial wastewater and 51 billion tons municipal sewage. The top ten provinces account for 44 billion tons.
- The industrial waste water declined since 2008, while the municipal sewage grew annually by average 5%.
- More than 60% of all Chinese are now living in cities.
- In 2014, Chinese sewage plants produced 28 million tons sewage sludge. 56% were treated by “professional” qualified companies, via landfill (37%), incineration (8%), conversion to fertilisers and building materials. Another 1/3 was treated “temporarily”. Remaining disappeared without clear explanation.
- Landfill remains the cheapest method, followed by fertilisation. The drying process before incineration is the most expensive.
- Many companies are fighting for the fat cake, collecting the fees for "treatment".

### STPs, 2014

<table>
<thead>
<tr>
<th></th>
<th>Prefectural Level</th>
<th>County Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cities</td>
<td>287</td>
<td>374</td>
</tr>
<tr>
<td>Urban sewage</td>
<td>~ 40 bln m³</td>
<td></td>
</tr>
<tr>
<td>Number of STPs</td>
<td>1 808</td>
<td>1 554</td>
</tr>
<tr>
<td>Sewage produced</td>
<td>28 mln tons</td>
<td></td>
</tr>
<tr>
<td>Treated Sewage Capacity per day, m³</td>
<td>131 mln m³</td>
<td>~29 mln m³</td>
</tr>
<tr>
<td>Annual growth of treated capacity</td>
<td>5.1%</td>
<td>7%</td>
</tr>
<tr>
<td>Total Sewage treated</td>
<td>90%</td>
<td>82%</td>
</tr>
</tbody>
</table>

Only about 18% of Sewage Sludge Actually Treated

Source: AVP Analysis
Other Markets: India – Only About 30% of Sewage Treated

- 62,000 MLD (22.6 billion tons per year) sewage generated by Urban India
- Treatment capacity is 23,277 MLD (8.5 billion tons per year) i.e. 37%
- 816 Municipal STPs are “commissioned”, of which only 522 in operation
- Thus, only 18,883 MLD (6.8 billion tons per year) sewage is treated and 70% of sewage is left untreated
- Class I cities (population 100k+ and Class II cities (50k+)
  - Generate: 38,255 MLD
  - Treat: 11,787 MLD (30%)
- Approximately 6 million tons of sewage sludge is generated annually. We have no information about its treatment and/or disposal.

### STPs per State - one Third of STPs Not Operational

<table>
<thead>
<tr>
<th>State/UT</th>
<th>Punjab</th>
<th>Maharashtra</th>
<th>Tamil Nadu</th>
<th>Uttar Pradesh</th>
<th>Himachal Pradesh</th>
<th>All India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity of Municipal STPs (MLD)</td>
<td>1 245</td>
<td>5 160</td>
<td>1 800</td>
<td>2 647</td>
<td>115</td>
<td>23 277</td>
</tr>
<tr>
<td>Total Municipal STPs</td>
<td>86</td>
<td>76</td>
<td>73</td>
<td>73</td>
<td>66</td>
<td>816</td>
</tr>
<tr>
<td>Operational Capacity (MLD)</td>
<td>921</td>
<td>4 684</td>
<td>1 141</td>
<td>2 372</td>
<td>80</td>
<td>18 883</td>
</tr>
<tr>
<td>STPs Operational</td>
<td>38</td>
<td>60</td>
<td>33</td>
<td>62</td>
<td>36</td>
<td>522</td>
</tr>
<tr>
<td>Non-Operational STPs</td>
<td>4</td>
<td>10</td>
<td>1</td>
<td>7</td>
<td>30</td>
<td>79</td>
</tr>
<tr>
<td>Under Construction STPs</td>
<td>31</td>
<td>6</td>
<td>28</td>
<td>3</td>
<td>-</td>
<td>145</td>
</tr>
<tr>
<td>Proposed STPs</td>
<td>13</td>
<td>-</td>
<td>11</td>
<td>1</td>
<td>-</td>
<td>70</td>
</tr>
</tbody>
</table>

### Technologies in Use in India

- ASP: 38%
- UASB: 20%
- WSP: 28%
- Others: 14%

Source: Encito Advisors
Key Points for Today’s Discussion

- Market drivers and sewage sludge volumes
- Disposal / treatment options

Selected Technologies

- Market – Business Outlook
Co-incineration of Sewage Sludge in MSW Plant (Germany)

**Obvious energy recovery choice in line with Waste Legislation and “reasonable marginal cost”**

**Some operational benefits with MSW plants (e.g. RdF, SRF)**

**P recovery difficult because of “diluted” incineration ash**

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**Example of Bamberg EfW Plant**

- Co-incineration of 12-13'000 tpa of sewage sludge with app 30% DS together with household, commercial, and bulky waste
- Three process lines with total capacity of approximately 144,000 tpa
- The sewage sludge is scattered into the waste pit, mixed with the other waste, and incinerated together with the MSW on the grate
- Other co-incineration options:
  - Spreading on the grate
  - Spreading on the feeding hopper

*Source: Hitachi Zosen Inova*
Mono-incineration of Sewage Sludge (Switzerland)

Prevalent energy recovery choice in markets that avoid/ban agricultural use, in line with EU waste legislation
High cost – requiring large plants with regional reach
Mid term goal to recover P from incineration ash (considered feasible because of high P concentration in bottom ash)

Example of Zürich Sewage Sludge Incineration Plant
- Fluidized bed incinerator for 100'000 tpa sewage sludge with DS of 22-30%
- Steam boiler 450C, 60 bar
- Steam turbine 900kWel for internal consumption
- Supply of app 5MW of heat to district heating network

Source: Outotec
Mono-incineration of Sewage Sludge (Switzerland)

Source: Outotec

KSV Zürich Verfahrenstechnisches Prozessschema

Outotec

Stadt Zürich
Entsorgung + Recycling

A. Vaccani & Partner AG | 2017 | Page 17
Kubota Surface Melting System (Japan)

Key technology for separation and purification from wide variety of wastes

- Wide variety of wastes are acceptable.
  - Wet / Dry
  - Combustible / Incombustible
  - Bulky wastes: after treatment (< 30mm)
- Continuous and stable feed:
  - The wastes are fed into the furnace by continuous outer cylinder rotation.
- High temperature treatment: 1250-1350°C
  - Organic hazardous substances such as DXNs, PCBs, POPs are decomposed in the furnace.
- Recovery of Resources
  - Separation of heavy metals from slag:
    - Heavy metals such as Pb, Cd, Zn, HG are separated from slag and condensed into fly ash.
  - Immobilization of phosphorus in slag with high recovery rate (>80%).
  - 40 years history, more than 30 track records

Source: Kubota
Advances in Digestion Lead to Reduction of Sewage Sludge Amount

<table>
<thead>
<tr>
<th>Aerobic Digestion</th>
<th>Anaerobic Digestion (Mesophilic)</th>
<th>Advanced Anaerobic Digestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Low CAPEX for plants under 5 MGD (220 L/s)</td>
<td>▪ High Methane content can be used for heat and power</td>
<td>▪ Thermophilic Anaerobic Digestions (TDA)</td>
</tr>
<tr>
<td>▪ Relatively easy to operate</td>
<td>▪ Approximately 25-45% (weight basis) of the influent sludge solids are destroyed</td>
<td>▪ Two-phased and temperature-phased (TPAD)</td>
</tr>
<tr>
<td>▪ Minimal unpleasant odors</td>
<td>▪ Digested sludge is soil conditioner containing N and P, other nutrient and stable organic matter</td>
<td>▪ Digestion pre-processes, e.g. Thermal Hydrolysis (TH)</td>
</tr>
<tr>
<td>▪ Volatile solids destruction is approximately equal to that observed in anaerobic digestion as long as the ratio of primary solids to biological solids is less than 0.50.</td>
<td>▪ Pathogens and parasite ova associated with the raw sludge are inactivated</td>
<td></td>
</tr>
<tr>
<td>▪ Poor mechanical dewatering characteristics of the aerobically digested sludge.</td>
<td>▪ High CAPEX due to large covered tanks, pumps, heat exchanges and gas compressors</td>
<td>▪ Two decades of development</td>
</tr>
<tr>
<td>▪ High power costs to supply oxygen, even for very small plants.</td>
<td>▪ Hydraulic detention time typically 15 days</td>
<td>▪ Some winners, some losers</td>
</tr>
<tr>
<td>▪ Performance is affected by type of sludge, temperature, location, and type of tank material.</td>
<td></td>
<td>▪ Extended/staged thermophilic (TPAD) operated in some places with success, in other places not so much</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ TH – highly concentrated recycle stream</td>
</tr>
</tbody>
</table>
Cambi – Thermal Hydrolysis Process (Norway)

Typical Cambi™ Integration with WWTP

Typical Benefits Thermal Hydrolysis

- Increased biogas yield and methane content
- Up to 60% volatile solids are destroyed
- Improved dewaterability (dewatered cake approx. 35% DS vs. 24% for mesophilic)
- Improved biodegradability
Cambi – Thermal Hydrolysis Process (Norway)

Main Components of a Cambi™ System

- PULPER
- REACTOR
- FLASH TANK

Dewatered solids (16-18%)

Recycled Steam

Fresh Steam

Hydrolyzed biosolids to digestion

<table>
<thead>
<tr>
<th>B – 2 (2 m³ reactor)</th>
<th>B – 6 (6 m³ reactor)</th>
<th>B – 12 (12 m³ reactor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small size projects</td>
<td>Medium-large size projects</td>
<td>Extra large size projects</td>
</tr>
<tr>
<td>▪ Standardized package unit</td>
<td>▪ Standardized package unit</td>
<td>▪ Custom-made</td>
</tr>
<tr>
<td>▪ Pre-assembled &amp; pre-tested</td>
<td>▪ Pre-assembled skids</td>
<td>▪ On-site construction</td>
</tr>
<tr>
<td>Containerized unit</td>
<td>Containerized unit</td>
<td>Containerized unit</td>
</tr>
<tr>
<td>5 – 20 tDS/day</td>
<td>20 – 80 tDS/day</td>
<td>60 – 500 tDS/day</td>
</tr>
</tbody>
</table>

Source: Cambi and AVP internet research
Key Points for Today’s Discussion

▪ Market drivers and sewage sludge volumes

▪ Disposal / treatment options

▪ Selected Technologies

▪ Market – Business Outlook
Market Outlook Europe

- 86% of EU 15 and 71% of EU 27 connected to sewage system
- Total sewage sludge production is about 10 million tons per year (DS) – expected to remain stable for the next 10 years
- Impact of Waste Directive favouring energy recovery vs agricultural usage and P recovery will create some market opportunities
- Dry nutrients as a treated sludge product
- Sludge dewatering technology is likely to grow in the medium term
- Commercial sludge trading market in 2020 in the UK
- Production of electricity from AD is expected to grow

European sludge treatment equipment market

<table>
<thead>
<tr>
<th>Sludge Disposal Method</th>
<th>2016 Revenue (bln Euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sludge thickening</td>
<td>~1.1</td>
</tr>
<tr>
<td>Sludge dewatering</td>
<td>~1.5</td>
</tr>
<tr>
<td>Sludge incineration</td>
<td>~0.5</td>
</tr>
<tr>
<td>Sludge drying</td>
<td>~0.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>~3.7</strong></td>
</tr>
</tbody>
</table>

Source: Frost & Sullivan, 2016

Sludge disposal and treatment in Europe, 2014

Source: Eurostat
Most attractive growth markets:
- South East Asia: Thailand, Malaysia, Indonesia
- Japan: 80% incineration moving to P recovery
- MENA
- Latin America and Caribbean

Contract models:
- "Service model"
- PPP
- EPC

- Only about 30% of sewage sludge “orderly” treated
- Thereof 1/3 landfilled
- Strong market growth
- Likely via “service model” and/or PPP schemes
- Actual market growth dependent on “political preference”

- Urban growth
- Utilization of “existing/planned” capacity
- Capacity build up
- Likely via PPP schemes

- Focus on minimizing sludge volume (adv. AD)
- Transition to more energy recovery, less agriculture
Key Strategies for International Business Development

- Technology/know-how base in Europe, US/Cd, Japan – with no significant market growth
- Growing markets: China, India, SEA, Latin America, others
- Strategic approach
  - Selection of strategic target markets / strategic growth plan
  - M&A
  - Strategic partnering (with localization)
  - (Licensing)
- Key success factors
  - Project development
  - CAPEX in line with market affordability
  - Localisation/globalization of supply chain
  - Maintain control of core know-how
Thank you for your attention – QUESTIONS?

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