Outline

● Circular economy in the face of unsustainable resource consumption

● Singapore’s Zero Waste Vision
  ○ Waste Minimization
  ○ Waste Management

● Applicability to other urban centers
1.7 Earths

take-make-waste

extractive industrial economy
Circular Economy
Circular Economy

Sustainable economic model
Replace current take-make-waste extractive industrial model

Principles
● Design out waste and pollution
● Keep products and materials in use
● Regenerate natural systems

...waste minimization and management are essential elements of a circular economy
Singapore: Zero Waste Vision
Singapore

Island city-state

Population: 5.6 million

Total area: 722.5 km$^2$ (278.6 mi$^2$)

...land-scarcity is of great concern to Singapore
Semakau Landfill

Singapore’s landfill

Originally intended to last until 2045, but is predicted to be filled by 2035

2018: 7.7 million tons of solid waste generated
Zero Waste Vision

Singapore intends to become a zero waste nation.

Waste minimization and waste management.
Waste Minimization
Waste Minimization

Electrical & Electronic Waste
Producers of electrical and electronic equipment held responsible for end-of-life collection and treatment thereof.

Packaging Waste
Producers of packaging and packaged products must report on the type and amount of packaging produced and outline plans to reduce, reuse, and recycle these.

Food Waste
Commercial and industrial food waste generators must segregate food waste for treatment and new developments must allocate space for on-site food waste treatment.

Zero Waste Masterplan
Waste Minimization

The 3Rs

**REDUCE**
Use only what you need

**RECYCLE**
Convert waste into useful products

**REUSE**
Re-use things for the same or new purpose

3R Campaign
Singapore Packaging Agreement
SS 587
Waste Management
Waste Management

The National Environmental Agency plans, develops, and administers waste management systems

Integrated Waste Management Facility
Tuas Water Reclamation Plant
Waste Streams

- Incinerable Waste
- Recyclables
- Food Waste
- Sludge
- Used Water
Incinerable Waste

THE EXCITING JOURNEY OF TRASH

Waste-to-Energy Incineration Plants

Heat from combustion generates superheated steam, which drives turbogenerators, producing electricity.

Provides 3% of national energy.
Wet Flue Gas Treatment

Flue gas is the material produced during incineration, typically containing toxic matter.

Flue gas treatment effectively reduces toxic matter in flue gas.

“Wet” flue gas treatment refers to use of wet scrubbers, which may be alkaline sorbents.
Semakau Landfill

Rock bund, lined with impermeable membrane and marine clay, encloses tipping cells

Tipping cells sealed off from sea when activated

Filled tipping cell covered with layer of earth, where greenscape is then planted
Recyclables

Recycled and returned to industry

Dewatered

Joins incinerable waste

Food Waste & Sludge
Used Water

Treated and reclaimed as NEWater

NEWater is ultra-clean reclaimed water, its quality is consistent with WHO and USEPA standards for drinking water

Used especially for industrial purposes
NEWater

**NEWater Reclamation Plant**
Collection and treatment of used water in accordance to international standards.

**Reverse Osmosis**
Undesirable contaminants are removed here. The water after this stage is high-grade water.

**Treated Used Water**
High-grade reclaimed water used by the industries. During dry periods, NEWater is added to our reservoirs to blend with raw water.

**Microfiltration**
Microscopic particles including some bacteria are filtered out in this stage.

**Ultraviolet Disinfection**
The water passes through ultraviolet light to ensure that any remaining organism is eradicated. Chemicals are then added to restore pH balance. The NEWater is now ready for use.
## Waste Streams

<table>
<thead>
<tr>
<th>Incinerable Waste (37%)</th>
<th>Recyclables (60%)</th>
<th>Food Waste &amp; Sludge</th>
<th>Used Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Incinerated, volume reduced &amp; energy produced</td>
<td>- Recycled</td>
<td>- Dewatered ... continues as incinerable waste</td>
<td>- NEWater</td>
</tr>
<tr>
<td>- Dumped into Semakau Landfill</td>
<td>- Sold into industry</td>
<td></td>
<td>- Returned to potable water supply</td>
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</tbody>
</table>
Applicability to Other Urban Centers
Urban centers across the globe are implementing plans for a sustainable future.

Example: OneNYC 2050
Singaporean Context

Island city-state

Total area:
722.5 km² (278.6 mi²)

GDP per capita:
$64,581

Priority:
land conservation
Conclusion

the Zero Waste Vision was born from concern over land-scarcity
Thank You!