SUSTAINABLE URBAN SYSTEMS AND CIRCULAR CITIES OF THE FUTURE: LEARNINGS FROM THREE CITIES

MND Auditorium - 1.30pm to 3.00pm (Registration & Networking starts 1.00pm)

Speaker
Ms Eva Gladek
Founder and CEO of Metabolic

Moderator
Ms Jessica Cheam
Managing Editor Eco-Business
Adjunct Research Associate
Centre for Liveable Cities
OUTLINE

• Introduction

• Urgency: Global Challenges

• What is the Circular Economy?

• Learnings from three cities:
  • Amsterdam (NL)
  • Rotterdam (NL)
  • Charlotte (US)

• Conclusions
ABOUT METABOLIC
Metabolic is a consulting and venture building company that uses systems thinking to tackle global sustainability challenges.

We work towards our mission in three main ways:

1. INSIGHTS:
   We provide influential organisations and individuals with the knowledge and tools to understand the global metabolism and support improved decision-making.

2. IMPLEMENTATION:
   We develop transformative ventures and technologies, and support existing networks that can address sustainability challenges at scale.

3. ACTIVATION:
   We are inspiring a new generation of changemakers by breaking down complex information and by providing actionable resources.
We help businesses, governments, and non-profits thrive in the circular economy through our knowledge and tools.
IMPLEMENTATION

We develop transformative innovations and ventures to shift the way we live and work to a sustainable state.
ACTIVATION

We inspire through education and actionable ideas, and our Foundation helps us reach underserved communities.
WHY I CHOSE THIS PATH
FATAL FEEDBACK LOOPS

E. coli Growth Curve

- Lag phase
- Exponential growth
- Stationary phase
- Death phase

Time (hrs) vs. No. Viable cells
SUSTAINABILITY CHALLENGES
PLANETARY BOUNDARIES

Planetary Boundaries. Source: Rockstrom et al, Stockholm Resilience Centre
A PATHWAY FORWARD
EXPONENTIAL SOLUTIONS

Global renewable energy consumption
Excluding hydropower. In million tons of oil equivalent.

- 40 years ahead of expected forecasts in many countries, like the United States.
- Over half of new power capacity installed in 2015 was renewable
- Already in 2017, renewables hit 25% percent of global power supply

Source: BP Statistical Review of World Energy 2014
BUILDING A CIRCULAR ECONOMY

Since 2012, Metabolic has completed over 350 projects for companies, cities, and governments, with a large focus on the Circular Economy.
“Based on detailed product level modelling, the report estimates that the circular economy represents a net material cost saving opportunity of USD 340 to 380 billion p.a. at EU level for a ‘transition scenario’ and USD 520 to 630 billion p.a. for an ‘advanced scenario’”
CIRCULAR ECONOMY BUSINESS MODELS

Power of the inner circle:
- Pay per use and leasing
- Repair
- Waste reduction
- Sharing platforms

The power of circling longer:
- Performance based contracting
- Takeback guarantees
- Through-sales
- Refurbishment

Power of cascaded use:
- Upcycling
- Recycling
- Supply chain collaboration

The power of pure inputs:
- Monomaterials
- Certified materials
- Circular procurement and sourcing

Finished products are worth much more than the raw materials inside them.

JOB CREATION POTENTIAL per 10,000 tonnes of used goods

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>£8,940</th>
<th>£940</th>
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<tbody>
<tr>
<td>MATERIAL</td>
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<td>PARTS</td>
<td>£5,900</td>
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</table>

Source: US EPA (2002) and the Institute for Local Self Reliance
IS THIS CIRCULAR?
7 Pillars of the Circular Economy:

- Human society and culture are preserved.
- Human activities generate value in measures beyond just financial.
- Materials in the economy are cycled at continuous high value.
- Biodiversity is structurally supported and enhanced.
- Water is extracted at a sustainable rate and resource recovery is maximized.
- All energy is based on renewable sources.
- The health and wellbeing of humans and other species is structurally supported.
THE GLOBAL MATERIAL FLOW: 2010

This is how linear the global economy actually is:

The Global Metabolism Flow that was conducted by Metabolic in 2010 shows that we have extracted an estimated 71.8 billion tonnes of material from the Earth to fuel the global economy. These include: biomass (food, feed, forestry, and other), fossil fuels (coal, gas, oil, and other), ores, minerals (industrial and construction).

Out of these:

- Almost 11% is wasted prior to use (food and industrial waste).
- An estimated 18% of approximately 3.4 billion tonnes of global Municipal Solid Waste is recycled or composted. An additional 10% is incinerated. The remainder is lost.

Reducing material throughput, increasing efficiency gains, and extending the useful lifespan of materials and products (both within a single product’s life cycle and across product cascades), and closing resource loops is essential for fixing the global metabolism and changing the way the current economic system is functioning.

- 117 billion tonnes extracted
- 71.8 billion tonnes “used”
KEY INTERVENTION AREAS FOR ACHIEVING A CIRCULAR ECONOMY

- agriculture
- cities & the built environment
- wastewater
- mobility & transport
- electronics
- chemicals
- construction & demolition waste
CITIES AS LEVERAGE POINTS

Cities occupy 3% of global land surface but consume 75% of global resources & produce 60-80% of global greenhouse gas emissions.
FUTURE CITIES must engineer an ECONOMY that is REGENERATIVE and WASTE-FREE by design.

A CIRCULAR APPROACH to urban development unlocks INTEGRATED OPPORTUNITIES for RESOURCE SAVINGS, JOB CREATION, capacity building, CIVIC ENGAGEMENT, healthy and INCLUSIVE ENVIRONMENTS, and RESILIENCE TO EXTERNAL SHOCKS.
TOWARDS CIRCULAR CITIES: THREE CASE STUDIES
CASE 1: AMSTERDAM
DE CEUVEL: BACKGROUND

- Polluted piece of industrial land
- 5000m² / 1.2 acres
- Tender put out by municipality
- 10 year land lease - temporary development
- Plan submitted for creative eco-office park
- Total budget 0.5 million euro
- High ambitions of circularity
Brede Waterpest

Ruwe Smele

Fonteinkruid

Kahlwirg
SCALING UP TO CITY LEVEL
OUR SYSTEMS TRANSFORMATION METHOD

CURRENT STATE ANALYSIS

01 DEFINE THE SYSTEM
02 MAP & ORGANIZE IMPACTS
03 IDENTIFY KEY BEHAVIOURS DRIVING IMPACTS
04 ROOT CAUSE ANALYSIS
05 DEFINE SYSTEM LEVEL GOALS
06 SET KEY PERFORMANCE INDICATORS
07 IDENTIFY AREAS FOR INTERVENTION
08 SELECT POSSIBLE INTERVENTION POINTS
09 EVALUATE LEVERAGE
10 FORMULATE PROJECTS

VISIONING & GOALSETTING

INTERVENTION ANALYSIS
BUIKSLOTERHAM

CLIENTS:

TEAM:

DELVA Landscape Architects

SEPTEMBER 2018
VISION & GOALS

• **Energy**: Buiksloterham is energy self-sufficient with a fully renewable energy supply

• **Materials & products**: Buiksloterham is a zero waste neighbourhood that with a near 100% circular material

• **Water**: Buiksloterham is rainproof and has near 100% resource recovery from wastewater

• **Goals on smart infrastructure, economy, society, mobility, resilience.**
“Verbonden door de ambitie om te bouwen aan een duurzame toekomst voor de stad”

DURVEN HET AAN EN SPREKEN ZICH UIT IN EEN MANIFEST VOOR DE CIRCULARE ONTWIKKELING VAN BUIKSLOTERHAM
SCHOONSCHIP: SUSTAINABLE HOUSING
“AMSTERDAM IS THE FIRST TO SHAPE TENDERING PROCEDURES TO TAKE CIRCULARITY INTO ACCOUNT IN THE EVALUATION OF BUILDING DESIGN AND DEVELOPMENT PLANS.”
CASE 2: ROTTERDAM
IMPACT ANALYSIS

Bubble Size: Total CO2 Emissions (tonnes)
# Agrifood Interventions

<table>
<thead>
<tr>
<th>No.</th>
<th>Impact Addressed</th>
<th>Impact Size</th>
<th>Intervention Name</th>
<th>Type</th>
<th>Feasibility</th>
<th>Impact Reduction Potential % (Low)</th>
<th>Impact Reduction Potential % (High)</th>
<th>Average Possible Impact Savings (tonnes)</th>
<th>Local Job Creation</th>
<th>Local Job Destruction</th>
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<tr>
<td>A1</td>
<td>Water voor gewassen - import (m3)</td>
<td>4182942</td>
<td>Incentives for low-impact urban agriculture</td>
<td>Supply</td>
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<td>2081471</td>
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<td>A2</td>
<td>Mixed Organic Waste (tonnes)</td>
<td>85062</td>
<td>Door-to-Door Biowaste Collection</td>
<td>Synergize</td>
<td>Medium</td>
<td>20%</td>
<td>75%</td>
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<td>Pay-As-You-Throw scheme</td>
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<td>80%</td>
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<td>Waste-to-Chemical Processing</td>
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<td>95%</td>
<td>74429.25</td>
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<td>Voedselverspilling - algemeen (tonnes)</td>
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<td>Subsidy for food waste avoidance projects</td>
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<td>20%</td>
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<td>A6</td>
<td>Stb bij bedrijven (tonnes)</td>
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<td>Waste-to-Chemical Processing</td>
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<td>50%</td>
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<td>16030</td>
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<td>Mest (tonnes)</td>
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<td>Vermi-composting</td>
<td>Synergize</td>
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<td>70%</td>
<td>80%</td>
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<td>Bio-digestion</td>
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<td>90%</td>
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<td>A9</td>
<td>Dienlijk &amp; Planten Afal bij bedrijven (tonnes)</td>
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<td>Waste-to-Chemical Processing</td>
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<td>90%</td>
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<td>Voedselverspilling bij consumenten (tonnes)</td>
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<td>Shopping, Cooking, Storage Education</td>
<td>Reduce</td>
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<td>10%</td>
<td>30%</td>
<td>3600</td>
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<td>A11</td>
<td>GHG-dieren - import &amp; local (tonnes)</td>
<td>139341</td>
<td>Public procurement of low-impact food</td>
<td>Supply</td>
<td>High</td>
<td>2%</td>
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<td>R&amp;D investment in bioprocessing tech</td>
<td>Synergize</td>
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<td>N/A</td>
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<td>Voedselverspilling bij retail (tonnes)</td>
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<td>Adoption of apps. e.g., FoodCloud</td>
<td>Reduce</td>
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<td>10%</td>
<td>20%</td>
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<td>Adoption of apps. e.g., Winnow, ToolGoodToGo</td>
<td>Reduce</td>
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<td>Ban on Retail Food Waste</td>
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<td>10%</td>
<td>30%</td>
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<td>Voedselverspilling bij retail (tonnes)</td>
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<td>Adoption apps. e.g., NoFoodWasted</td>
<td>Reduce</td>
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<td>25%</td>
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<td>Family-bag policy</td>
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<td>10%</td>
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<td>Incentives for GFT separation in offices</td>
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<td>40%</td>
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<td>Mixed Organic Waste (tonnes)</td>
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<td>Organic Mono-Material Collection</td>
<td>Synergize</td>
<td>Low</td>
<td>5%</td>
<td>15%</td>
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<td>A21</td>
<td>GHG-dieren - import &amp; local (tonnes)</td>
<td>139341</td>
<td>Campaign on sustainable, healthy diets</td>
<td>Reduce</td>
<td>High</td>
<td>5%</td>
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<td>Voedselverspilling bij consumenten (tonnes)</td>
<td>18000</td>
<td>Incentives for animal product replacements</td>
<td>Supply</td>
<td>Medium</td>
<td>10%</td>
<td>30%</td>
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<td>A23</td>
<td>Mixed Organic Waste (tonnes)</td>
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<td>Monitoring of organic waste generation</td>
<td>Manage</td>
<td>Low</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Low</td>
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**Metabolic**
EXAMPLE: REDUCING FOOD WASTE

At home store below 5°C

Suitable for freezing
BEYOND MONOCULTURE
EXAMPLE: PROTIX

The BLACK SOLDIER FLY
King of the upcyclers

Fly
The flies need light and the right climate to mate and lay eggs.

Eggs
A batch of 500 to 1000 eggs is laid in crocks & prawn so they are safe.

Larvae
When larvae are 6-8 days old, they grow very intense and fast. It's here where they build up all the nutrients for the rest of their lifecycle.

Pupa
A complex transformation happens. The larva dissolves and regenerates into a fly.

Pre-pupa
When larvae are ready to become flies, they turn dark and migrate to find a nice place to transform into flies.

Protein meal
Insect proteins are of the highest quality and vital for all animals.

Soil nutrients
Insect oils & lipids are high in lauric acid and offer great health benefits.

Lipids

Feedstock
Nearly all organic leftovers can be used as feed for insects. There is no need for stabilisation.

The Black soldier fly lifecycle

Young larvae
The right environment ensures high hatch rates. The health of the larvae is determined in the first days.

SecureFeed
GMP+
EXAMPLE: SYMBIOCULTURE
CASE 3: CHARLOTTE
CHARLOTTE’S STRENGTHS

• 7th on Forbes list of Places for Business and Career *(Forbes, 2018)*

• Unemployment below state average at 4.2% *(Bureau of Labor Statistics, 2017)*

• $53,000 GMP per capita 61st wealthiest metro *(Parilla, 2016)*

• 26th most livable city in US *(24/7 Wall St., 2017)*

• Number one choice for millennials in 2015 *(Abadi, 2017)*

• Among the least polluted cities in US *(American Lung Association)*
CHARLOTTE’S CHALLENGES

• Prosperity of the city is not accessible to everyone

• Lowest social mobility among the 50 biggest cities in the US (Deruy & Boschma, 2016)

• More than 148,000 people living in poverty (DATA USA, 2018)

• Shrinking middle class (Mecklenburg County Community, 2018)
VISION FOR A CIRCULAR CHARLOTTE

1. Zero Waste City
2. Innovative City of the Future
3. Resilient and Healthy City
4. City with Opportunities for All
CHARLOTTE AS A CIRCULAR CITY

Charlotte terminates all use of landfills by 2040
Charlotte improves its virgin resource efficiency
Charlotte minimizes GHG emissions and achieves net zero emissions by 2040
Charlotte recovers maximum value from waste streams
Charlotte maintains material quality (complexity) of non-biotic resources
Charlotte ensures that nutrients from all biotic wastes are returned to natural cycles
Charlotte reduces its reliance on critical (scarce) materials
Charlotte improves information flows on waste between stakeholders and the City
Circular companies can thrive in Charlotte

Highlighted KPI

Tons of waste going to landfill annually per capita = WL/C

Charlotte: 1.12
Austin: 1.05

Source: Envision Charlotte, 2017
Source: Austin Resource Recovery Master Plan, 2011
The CHW recycling program only costs $7/ton, compared to $30/ton for landfill.

26.3% of content could be recycled with existing programs

31% of MSW is organics, which creates both a loss of value and increased methane emissions.
CIRCULAR JOB CREATION

Total mass to landfill (tons)

- C&D
- Paper
- Textiles
- Plastics
- Other
- Hazardous waste
- Metals
- Electronics
- Glass
- Organics

Total potential revenue (£)

- 0
- 25,000
- 50,000
- 75,000
- 100,000
- 125,000
- 150,000
- 175,000
- 200,000
- 225,000
- 250,000
- 275,000
- 300,000

Potential job creation (# of jobs)

- 0
- 50
- 100
- 250
- 500
- 1,000
- 1,500

Bubble size: Potential job creation (# of jobs)
IF ALL PLASTICS LANDFILLED IN CHARLOTTE ARE RECYCLED, THIS SAVES 936,329 BARRELS OF OIL PER YEAR & CREATES REVENUES & JOBS

144,403 TONS PLASTICS LANDFILLED

936,329 BARRELS OF OIL AVOIDED

35 MILLION REVENUES POSSIBLE

1,343 JOBS CREATED
Selection of five promising business cases to investigate in detail:

- Closed loop textiles
- Upcycling food waste into feed
- Materials innovation lab
- Tokenized reverse logistics for plastics
- Concrete recycling chain
CLOSED-LOOP TEXTILES CHAIN

- Textiles are historically important for Charlotte and innovation in this sector fits the local context
- Charlotte still ranks 2nd in U.S. for employment in textiles sector
- 57,000 tons of textiles ending up in the landfill per year
- Limited closed-loop textiles project (uniforms, linens) can be a starting point for a fully circular chain
- Local companies like Unifi and Recover Brands show the right pieces are in place in Charlotte

<table>
<thead>
<tr>
<th>OPPORTUNITY</th>
<th>VALUE</th>
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<tbody>
<tr>
<td>Total waste diverted from landfill (lbs/year)</td>
<td>210,000 lbs/year</td>
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<tr>
<td>Potential profits from case ($/year)</td>
<td>$201,800</td>
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<td>Total jobs created (#)</td>
<td>9</td>
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<tr>
<td>CO₂,e emissions saved (tons)</td>
<td>1,226</td>
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<tr>
<td>Water use avoided (gallons)</td>
<td>345,341</td>
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<tr>
<td>Land use prevented (acres)</td>
<td>79</td>
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</table>
UPCYCLING FOOD WASTE INTO FEED

• 150,000 tons of food waste to landfill per year in Charlotte

• Companies like Crown Town and Earth Farm collecting organic waste, but still on a small scale

• Cost of collection is high while value of compost is low

• Upcycling this waste into feed can create a high-value product at a commercial scale and link to local initiatives around aquaponics production

• Legislative barriers still stand in the way

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<tr>
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<td>Total waste diverted from landfill</td>
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<td>(lbs/year)</td>
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<td>Potential profits from case ($/year)</td>
<td>1,200,000</td>
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<td>Total jobs created (#)</td>
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<td>CO₂e emissions saved (tons)</td>
<td>97,000</td>
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<td>Water use avoided (gallons)</td>
<td>41,000</td>
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<td>Land use prevented (acres)</td>
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• 31% of waste to landfill is organic

• Currently there is a lot of interest in innovation in biobased products made from specific waste streams

• Many interesting new innovations in waste-based products exist

• Supporting a materials innovation lab can encourage local innovation and entrepreneurship

• Provides an invaluable experience for local students and entrepreneurs that adds additional value to education
One of the largest barriers is getting people to recycle

Tokenized system gamifies recycling and provides incentives to households

Clean and source-separated recyclables --> Vouchers for local business (also encourage shopping locally)

Once critical mass is reached, case can be very profitable

Break-even point is around 10% participation with a 10% rate of recycling of materials by those households

**TOKENIZED REVERSE LOGISTICS SYSTEM**

<table>
<thead>
<tr>
<th>OPPORTUNITY</th>
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<tr>
<td>Total waste diverted from landfill (lbs/year)</td>
<td>ST: 3.6 mln lbs, LT: 88.2 mln lbs</td>
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<tr>
<td>Potential profits from case ($/year)</td>
<td>ST: N/A, LT: min. 3 mln per year</td>
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<tr>
<td>Total jobs created (#)</td>
<td>ST: 35, LT: 130</td>
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<tr>
<td>CO₂e emissions saved (tons)</td>
<td>ST: 10,310, LT: 237,003</td>
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<tr>
<td>Water use avoided (gallons)</td>
<td>ST: 675 mln gallons, LT: 18 bln gallons</td>
</tr>
<tr>
<td>Land use prevented (acres)</td>
<td>ST: 1,317 acres, LT: 34,404 acres</td>
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*ST is short-term, LT is long term
• Charlotte is a fast-growing city with 12,000 new apartments being built

• 50,000 tons of concrete ends up in the landfill per year, ~6% of total

• Up to 20% of aggregate and 20% of cement can be replaced by recycled aggregate and glass in new cement

• In total, all of Charlotte’s concrete could become 16% recycled

• Local concrete recyclers already have the equipment for recycling aggregate, but this is currently being used primarily as backfill

### CONCRETE RECYCLING CHAIN

<table>
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<tr>
<th>OPPORTUNITY</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total waste diverted from landfill (lbs/year)</td>
<td>100 million lbs</td>
</tr>
<tr>
<td>Potential profits from case ($/year)</td>
<td>$2 million after first year</td>
</tr>
<tr>
<td>Total jobs created (#)</td>
<td>5</td>
</tr>
<tr>
<td>CO₂e emissions saved (tons)</td>
<td>41,186</td>
</tr>
<tr>
<td>Water use avoided (gallons)</td>
<td>183 million</td>
</tr>
<tr>
<td>Land use prevented (acres)</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
BUSINESS CASES: KEY TAKEAWAYS

- In total, ~100,000 - 150,000 tons of waste to landfill can be prevented with the five business cases.
- An estimated 290-492 jobs can be created with these cases.
- CO₂ emissions can be reduced by 379,000 tons/year.
- Each business case improves 13-19 of the 29 Key Performance Indicators (KPIs).
- $22 - $34 million USD per year in revenue.
CONCLUDING THOUGHTS
UPCOMING LECTURES 2018

4 OCT THU

REALIZING 3PS IN REAL ESTATE

URA Function Hall
4.00pm to 5.30pm

Dr Seek Ngee Huat
Chairman, IRES

More details available on the website soon

THANK YOU AND SEE YOU AGAIN