

WECoS

Waste & Energy in Sweden's circular economy:
Collaborative system dynamics and choice modelling



**ÖRESUNDS
KRAFT**



RI.
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Vi är Sveriges
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RISE Research Institutes of Sweden

RISE is an independent government research institute. As an innovation partner for all of society, we help to develop technologies, products, services and processes that contribute to a sustainable world and a competitive business sector. We do this in collaboration with and on behalf of industry, academia and the public sector. We also have a special focus on supporting small and medium-sized enterprises in their innovation processes.

Our focus for a sustainable future

- Climate and environment
- Health and welfare
- Digitalization
- Democratic and resilient society

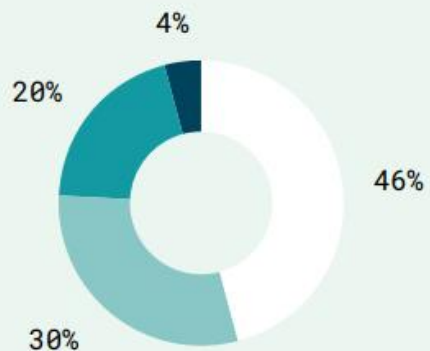


3,993

SEK million, net sales

Operating results: 22 MSEK

Operating margin: 0,6%



Distribution of net sales

Business sector	1,831 MSEK
Public funds	1,179 MSEK
Basic state funding	812 MSEK
EU funds	171 MSEK

36%

Turnover from interdisciplinary projects in relation to total turnover from the RISE project portfolio

130+

Testbeds and demonstration environments

3,094

employees

79

Innovation Partnership Index

40%

women

77

Customer Satisfaction Index

What is the role of WtE in Sweden under a changing EU policy landscape?



Projektid

Mars, 2023 - November, 2025



Projektbudget

7.058.948 SEK



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WECOS: Waste-to-Energy (WtE) in Sweden's circular economy – Collaborative system dynamics modelling

Beteendeförändring

Dialog

Energisystem

Hushåll

Klimat

Lokalt

Negativa utsläpp

Samverkan

Scenarier

Simulering

WtE in Sweden

- The Swedish Environmental Protection Agency estimates 80% of plastic waste generated is incinerated.
- Energy recovery from waste meets the heating needs of more than 1,470,000 apartments and the electricity needs of more than 940,000 apartments.
- The EU Packaging Directive (94/62/EC) sets targets for recycling of all material types to reach 70 % by 2030.
- Currently aprox. 25 % of the municipal solid waste going to WtE is paper and plastic packaging materials.

Case study- Helsingborg SE

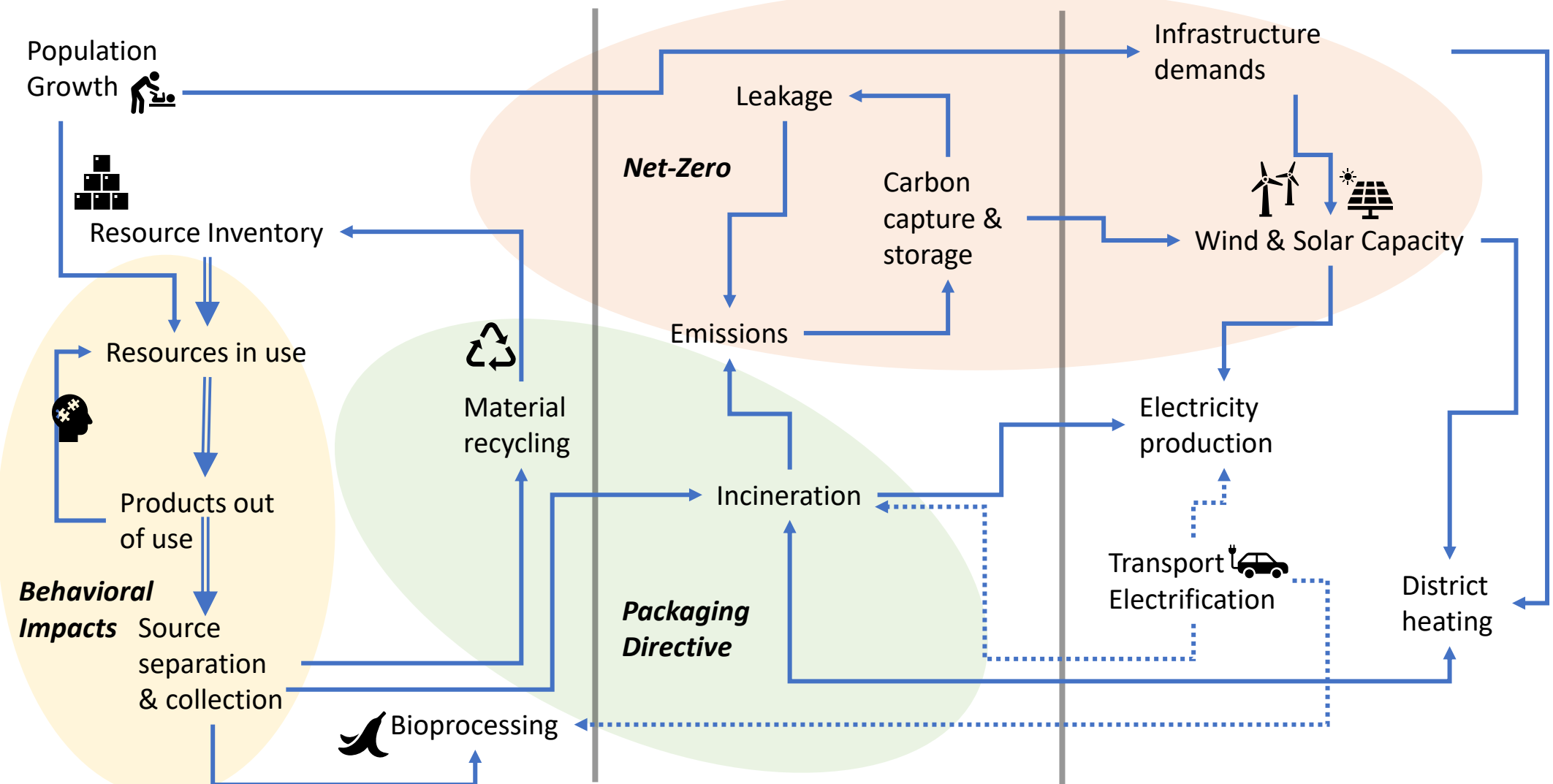
- €163 M has been invested in WtE more than a decade ago in 2012 (Filbornaverket, pictured)
- Ambitious climate goals – Net Zero by 2035
- CCS and negative emissions key to this strategy



SUSTAINABILITY

Helsingborg Becomes First City to List a Sustainability-Linked Bond, Supporting Efforts to Reach Net-Zero Emissions by 2035

Initial System Boundary – Policy Implications



Project Organisation

WP1: Collaborative Project Management

- Identify and gather key partners.
- Agile project management and evaluation of model development.
- Recruiting additional partners as dictated by findings in WP1, 2.

WP3: Model Development and Quantification

- Quantitative model development of WP2 results.
- Choice modelling to integrate behavioural aspects in SD model.
- Iterations with WP1 to prioritise model focus and validate findings.
- Custom dashboards and uncertainty analysis.

WP4: Political and Economic Implementation

- Validated model used to drive interactive workshops to drive management strategy consensus at multiple levels.

WP2: Conceptualising System Boundary

- Data collection from consortium
- Interviews with project management team to identify KPIs.
- Mapping of initial system including complex feedbacks, delays and human behavioural influence.

WP5: Dissemination

- Workshops with additional regions and policymakers.
- Webinars and website
- Academic publications.

Goals

- 1) Co-development of SD model to assess policy alternatives related to the entire waste-energy system
- 2) Develop improved methods for integrating behavioral aspects into modeling assessments
- 3) Drive implementation of partner-prioritized policy alternatives at the municipal level.

Methods

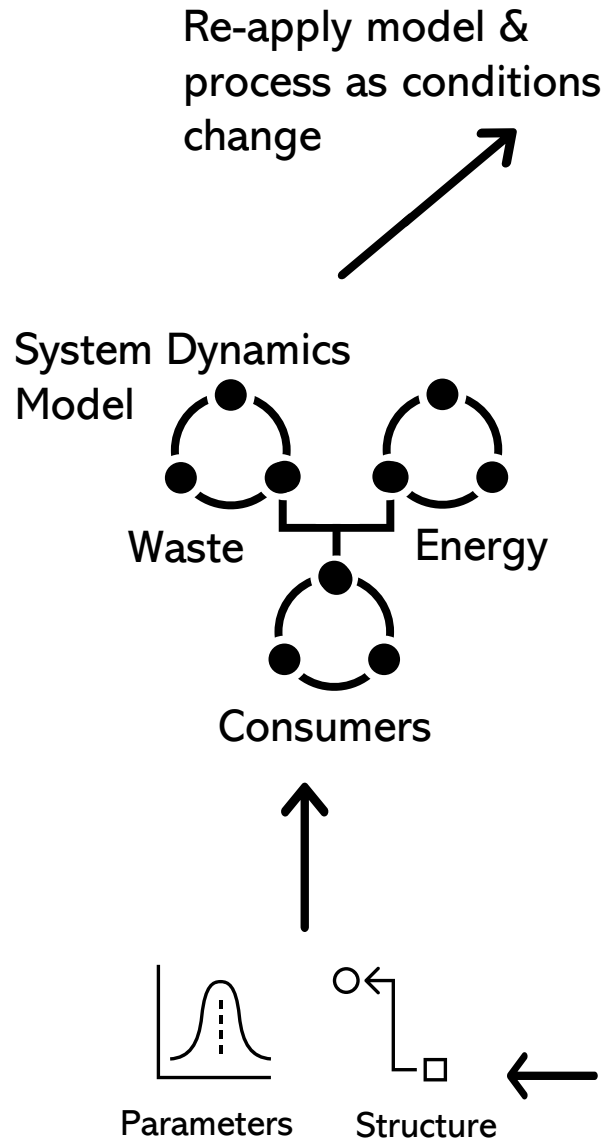
- 1) Participatory modelling of waste, energy and consumer aspects of system
- 2) Iterative development and delivery of dashboards within interactive process
- 3) Choice modelling used to refine assumptions regarding waste sorting behaviour in response to novel policies

Expected Outcomes

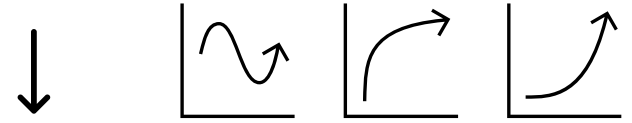
- 1) Shared understanding of systemic impacts of individual actor decisions
- 2) Model dashboards aligned with partners' decision-making processes
- 3) Plausible future scenarios for waste & WtE and shared strategies.

Modelling work-flow

- 1) Iterative development of the workflow seeks to transfer ownership of model to user dashboards.
- 2) Parallel evaluation process using questionnaire at multiple points throughout process.



1. Identify problem behaviour



2. Co-develop policy intentions



3. Policy design and assumption identification
(Identify Choice Delimmas under Rational DM Assumption)

4. Simulate Policy Impact



5. Develop and conduct choice experiment

6. Refine assumptions

Parallel Evaluation

System Understanding

- How well do you understand the system?
- How well do you understand others' perspectives?

- 1) Focus on **boundary object** function of user dashboards.
- 2) Based upon existing literature and frameworks for evaluation regarding both boundary objects and the function of model emulators in participatory work.
- 3) Legitimacy, saliency and credibility initial categories, developed further through iterative process with evaluation experts in project.

Model Usage

- Do you use the model?
- Do you understand how the model works?

Effect of Model Usage

- Does the model ease your communication with other partners?
- New insights using the model?

Black, L. et al. *System Dynamics Review* 29, no. 2 (April 2013): 70–86.

Black, L. et al. *Systems Research and Behavioral Science* 29, no. 2 (March 2012): 194–208.

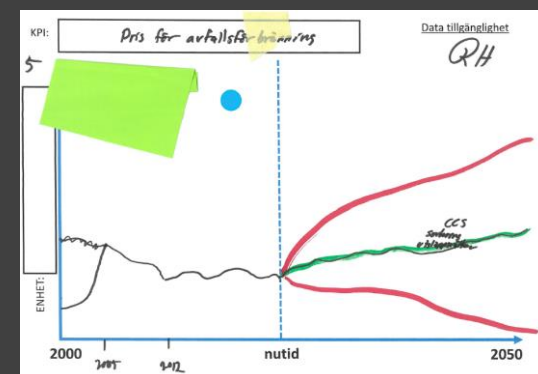
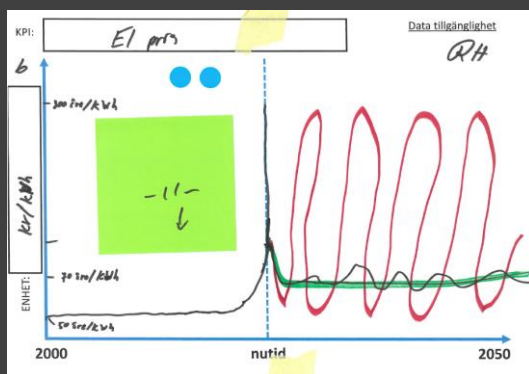
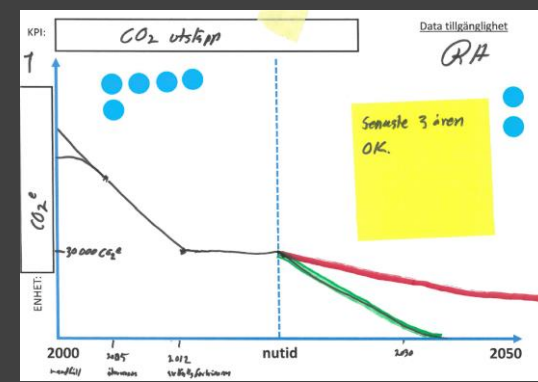
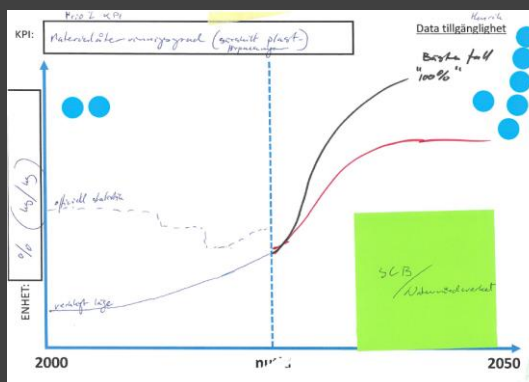
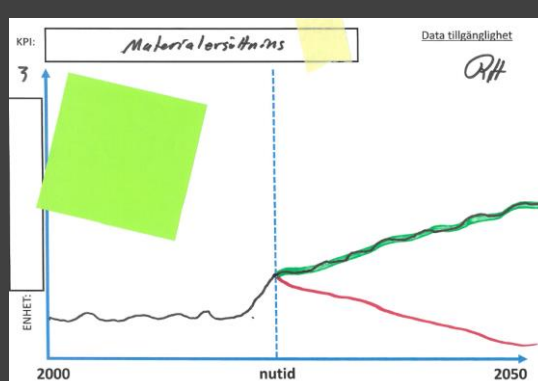
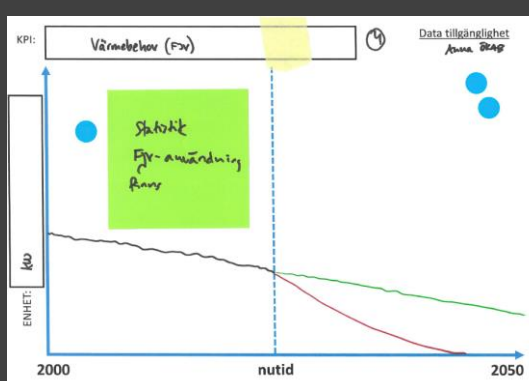
Bouw, K. et al. *Sustainability* 15, no. 3 (January 19, 2023): 1937.

Falconi, S. et al. *Water Resources Research* 53, no. 2 (February 2017): 1625–45.

Lee, G.Y. et al. *PLOS ONE* 17, no. 4 (April 22, 2022): e0266125.

Lim, T.C. *Environmental Modelling & Software* 135 (January 2021): 104928.

Workshops



Workshop – Nov '23 Reference Modes and KPIs

- Partners introduced to CLD diagramming.
- Elicitation of KPIs via NGT
- Reference mode hopes and fears for KPIs
- Dots exercise to prioritise KPIs
- Data availability
- Cause-effect written exercise

Workshop – March '24

Choice Modelling

- Choice modelling method introduced – revealed and stated preference methods
 - Partners test a prototype experiment and suggest attributes
- Virtual tour of WtE facility
- Model structure and example dashboard presentation
- Scheduling work "sprint" with partners: 4x 2 hour online meetings with focus on model structure & behaviour as well as dashboards



Choice modelling

Choice models, as the name implies, are mathematical approximations of people's decisions. All decisions in our lives require that we choose one course of action from the set of all alternatives available to us at the given moment. Many (all!) of these decisions can be modelled.

Stated Preferences

- Uses existing data - existing decision determinants (policy/decision levers)
- Relationships among existing data are a "decision trail" which can be evaluated statistically.
- Relationships between previously collected data can be used to extrapolate future preferences.

Revealed Preferences

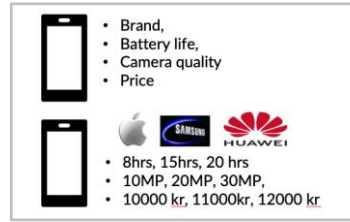
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Our Approach – Step by step



Scope of study

Define scope in terms of product or service, key user groups, geographical markets and any potential limitations in availability of data. Define sample size and combinatorics.



Experimental design

Design experiment:

- Discrete choice experiments (DCE)
- Best-worst scaling (BWS)

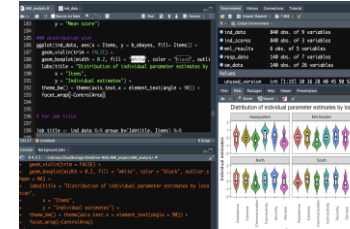
Combine levels of features to form choice options between which decision makers choose.



Data generation

Construct survey and run pilot study with a small sample.

Field survey to generate data from key user groups in key markets.



Choice analytics

Using discrete choice models and best-worst scaling approaches to explain choices and make predictions about future behaviour.



Insight report

Documentation of research findings and communication of recommendations.

Report on insights on market acceptance/performance, price differentiation, willingness-to-pay, market/policy acceptance.

Why?

Understanding behaviour

Everyone has wishes, needs, preferences and values wrt. offers or services. Disregarding them leads to products, offers and services not being used

We can answer **WHAT IF** questions, such as:

What happens if we change the price, packaging, or any other feature of the offer?

We can test services that do not exist yet or products that cannot be easily tested, such as preferences for medical treatment

Who is going to engage?

We can discover customer segments and customer profiles

Revealed preference

- Revealed preference is based on the actual choices individuals/households make when disposing of waste in real-world situations.
- This data could include records from waste management facilities, surveys on waste disposal habits.






Stated Preference – Co-design of Choice Experiments

- Participants divided into groups with representation from each partner group
- Tasked with developing additional attributes of interest
- **A second iteration of attribute elicitation planned for June '24**

Attributes

Alternatives

	Scenario 1	Scenario 2	Scenario 3
Information on sorting food waste	 <p>Detailed example</p>	 <p>Matavfall</p> <p>Detailed picture</p>	 <p>MATAV FALL Food waste</p> <p>Simple symbol</p>
Separate bins	Separate bin for food waste	Food waste goes into your own compost	Separate bin for food waste
Information on sorting results	No information	No information	Information on your household results compared to neighbourhood
Information on savings	Emissions reduced by sorting food waste	Costs and emissions reduced by sorting food waste	Costs reduced by sorting food waste
Payment model	Pay per number of pickups	Pay per kilo of residual waste	Pay per number of pickups
Which would you choose?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Levels

Next Steps

Process plan

INITIAL MODEL RESULTS AND DASHBOARDS TO BE PRESENTED AT ISDC 2024

2024

March 5 – Choice Modelling
& Model Structure

Samverkande
process



Enkät



Övriga möter:
e.g. data



Modell
användning



June 11 – Model
analysis – policy options



Övriga möter:
e.g. data



Modell
användning



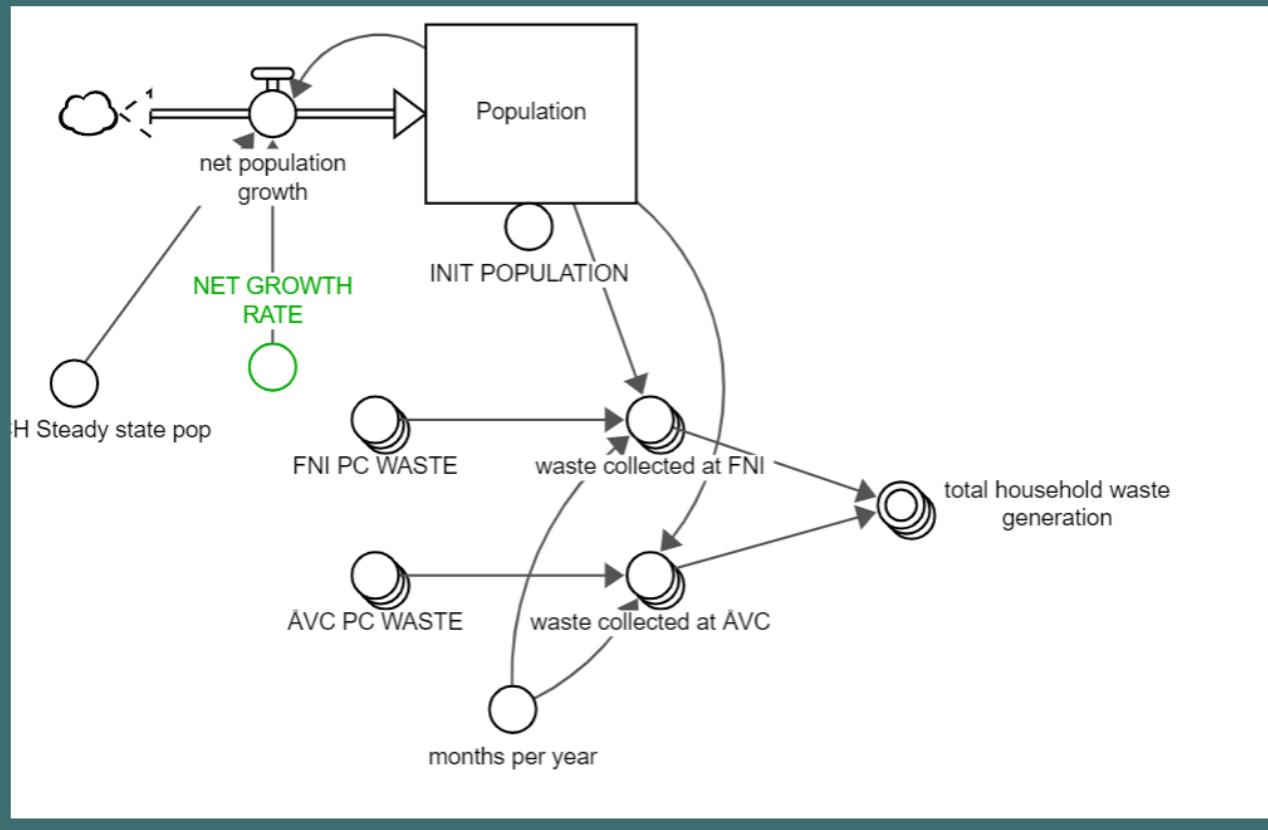
Okt. 23– Model analysis
scenario development



Användning
internt



Structure – population and behaviour



Ex. Introduktion till model logik

De som är nya i projektet kan ha nytta av att få en förståelse för hur en systemdynamisk modell fungerar genom enkla exempel på struktur.

Denna funktion kan användas för att utöka användbarheten för andra inom era organisationer som inte har varit en del av modellutvecklingen genom projektet.

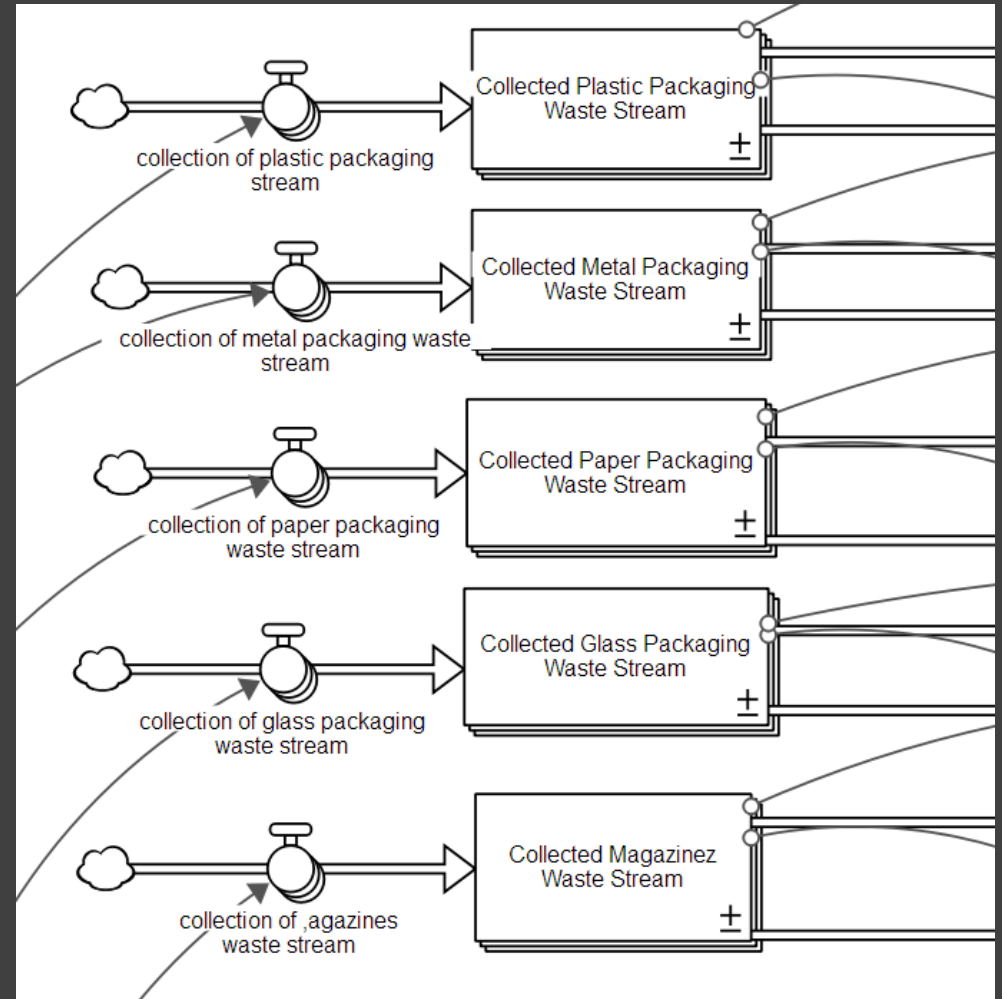


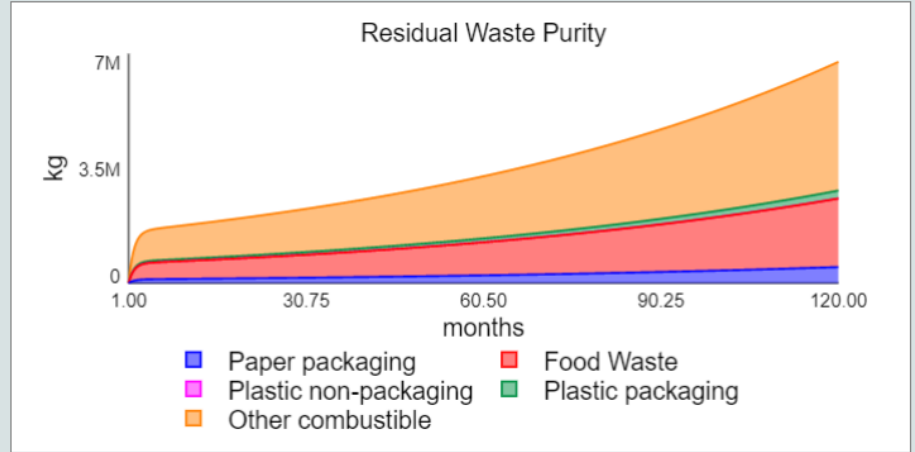
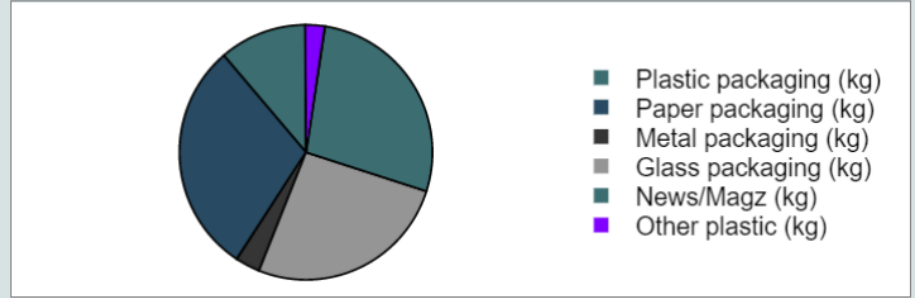
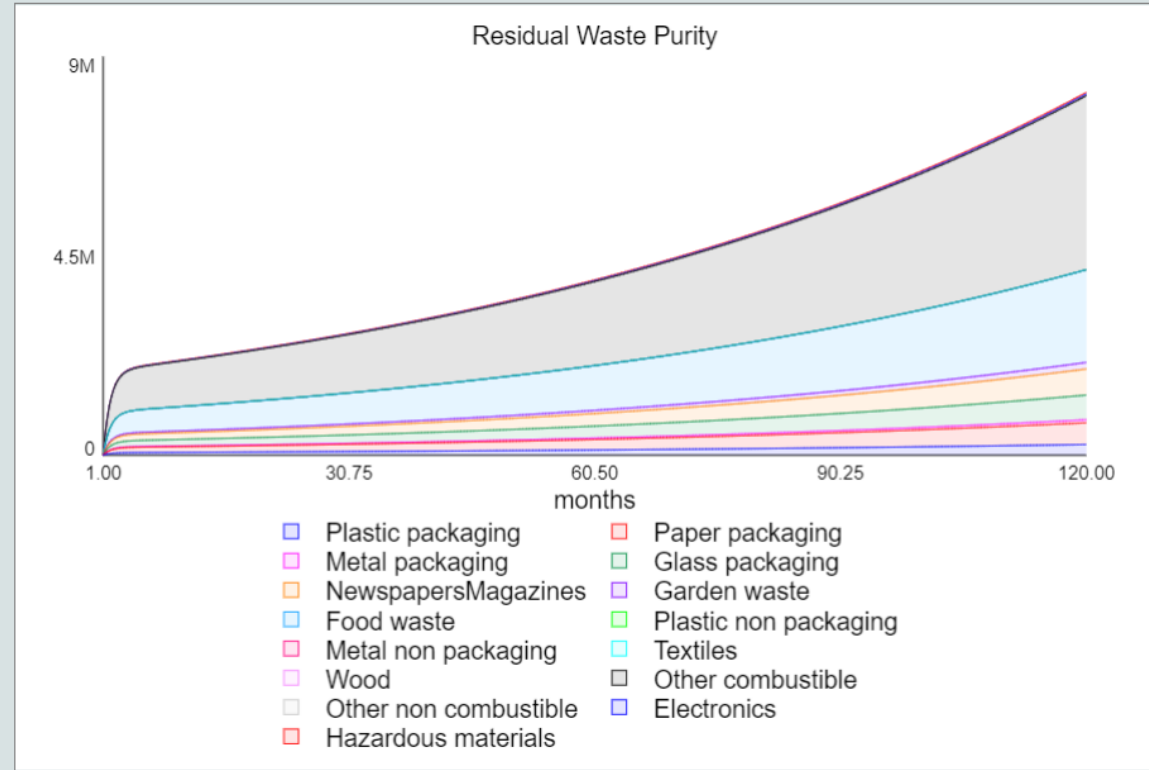
Revealed preference

- Data collection ongoing at household level – villas and apartments in coordination with NSR- the regional waste-handling partner.
- Used in combination with year-end reports from NSR to ascertain determinants of sorting behaviour
- Will provide input to model structure i.e. to develop and test cause-effect hypotheses in the model.

Structure - waste

- The waste module is currently the most developed
- It contains 3 array dimensions:
 - Collected recycling
 - Material Type
 - Collected waste
- **Structure validated with partners in March 5th workshop** – necessary to capture material composition and develop scenarios for improved sorting behaviours





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