City of Oslo
Agency for Waste Management

Impact on the recycling rate

John E. Nilssen & Maren A. Sylthe

13.02.2017

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1. Background

- The target in Oslo is 50% recycling – is it possible?
  - 38% in 2012 (includes reuse)
  - 40% in 2016 – roughly 2 % increase……..
  - 46% in 2032?
- The report “How to increase the recycling rate” (Virkemiddelpakke) gave a set of recommendations, such as;
  - Number of waste fractions from curbside collection schemes have to increase as much as possible.
  - Collection frequency and/or volume of source separated waste containers have to be optimized to avoid overfilling
  - Collection frequency and/or volume of residual waste containers have to be reduced
  - Communication has to boost positive and reduce negative findings in the report
  - Incentives have to be designed to support desired changes in the waste service
- What is the potential in recycling if these recommendations are implemented in Oslo?

1. Intention and purpose

- The intention is to clarify the reports recommendations and quantify these effects on the recycling rate.

- Purpose:
  1. Calculate recycling rates from different curbside collection schemes, including the current scheme
  2. Develop a system dynamic simulation model for these schemes
  3. Cost calculate the collection schemes to make recommendations based on cost- efficiency criteria.
  4. Recommend curbside collection scheme

2. Curbside collection schemes

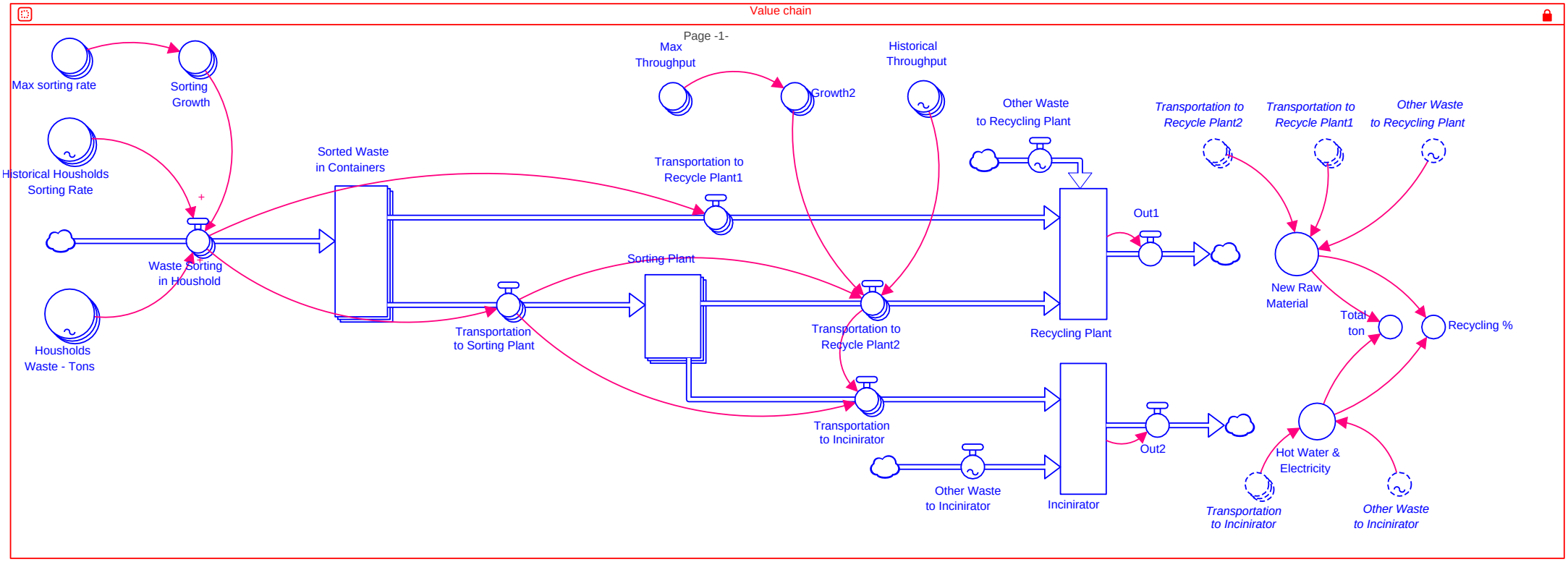
Curbside Collection Scheme	Bin System	Residual waste	Plastic waste	Food waste	Papir waste	Glass/ metal waste	Garden waste
1	2						
	3						
	4						
2	2						
	3						
	4						
3	2						
	3						
	4						
4	2						
	3						
	4						
5	2						
	3						
	4						

- One collection scheme consist of 3 different «bin systems»
- One bin system consist of 2, 3 or 4 containers for source separated and residual waste
- Available space at the physical location point determines which bin system to use
- One color equals one container in the bin system
- The selected waste fractions have a recycling potential of > 2200 tons which give a net increase >= Δ+ 1% recycling rate

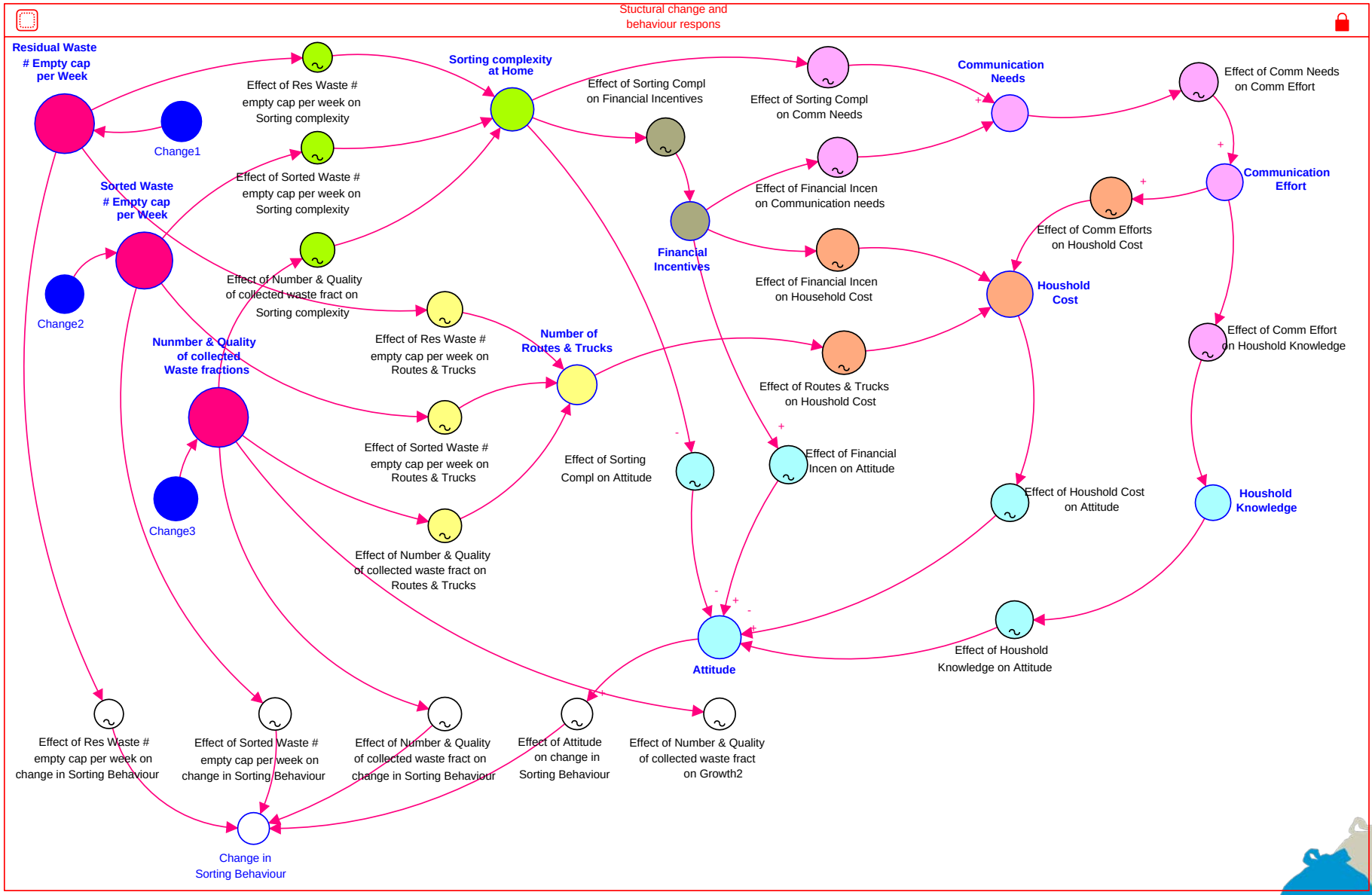
3 Simulation model

- The model consists of three main parts
  - Value chain includes historical quantity of household waste and sorting behavior. In addition the model has maximum values for sorting behavior and throughput
  - Decision variables that changes the infrastructure (input data posted here)
  - Behavioral response on attitude as a function of changes in the infrastructure.
- Reference mode, year 2010-2015 – «calibrates» the model
- Simulation period, year 2016-2031 – clarifies the possible effects of the infrastructural changes
- Multiplicative model. Input «1» reflects todays situation
- DNV/GL v/Senior Principal Scientist Bent Erik Bakken has supported the task to develop and use the simulation model

3 Simulation model – Value Chain



3 Simulation model – Structure and Behavior



4 Input to simulation model

- Decision variables are changes in infrastructure. Input will have different numeric values depending on collection scheme and bin system. Decision variables are:
  - Residual waste capacity per week, volume x collection frequency (decrease)
  - Source sorted waste capacity per week (increase)
  - Quality consists of three parts (increase)
    - Number of source sorted waste fractions
    - The collection schemes ability to improve throughput of plastic and food waste (reduce loss in value chain)
    - The collection schemes influence on throughput for paper and cardboard
- Waste weight ratio per bin system is common to all collection schemes and is used to calculate the model input.

4 Input data simulation – numeric values

Bin system	Stand ratio per bin system	Weight ratio per bin system
2-bin	27 %	14 %
3-bin	38 %	74 %
4-bin	35 %	12 %

Curbside Collection Scheme	Bin System	Weight ratio	Average residual waste cap.	Average source sorted waste cap.	Basis input Quality
1	2	14 %	0,97	1,09	1,00
	3	74 %	0,60	1,50	1,26
	4	12 %	0,54	1,58	1,68
		Weighted average:	**0,64**	**1,45**	**1,27**
2	2	14 %	0,97	1,09	1,00
	3	74 %	0,79	1,29	1,49
	4	12 %	0,73	1,38	2,00
		Weighted average:	**0,81**	**1,27**	**1,48**
3	2	14 %	0,97	1,09	1,00
	3	74 %	0,74	1,38	1,21
	4	12 %	0,68	1,47	1,69
		Weighted average:	**0,76**	**1,35**	**1,24**
4	2	14 %	0,97	1,09	1,00
	3	74 %	0,93	1,17	1,50
	4	12 %	0,90	1,29	1,87
		Weighted average:	**0,93**	**1,18**	**1,47**
5	2	14 %	0,74	1,38	1,01
	3	74 %	0,57	1,63	1,34
	4	12 %	0,51	1,72	1,78
		Weighted average:	**0,58**	**1,60**	**1,35**

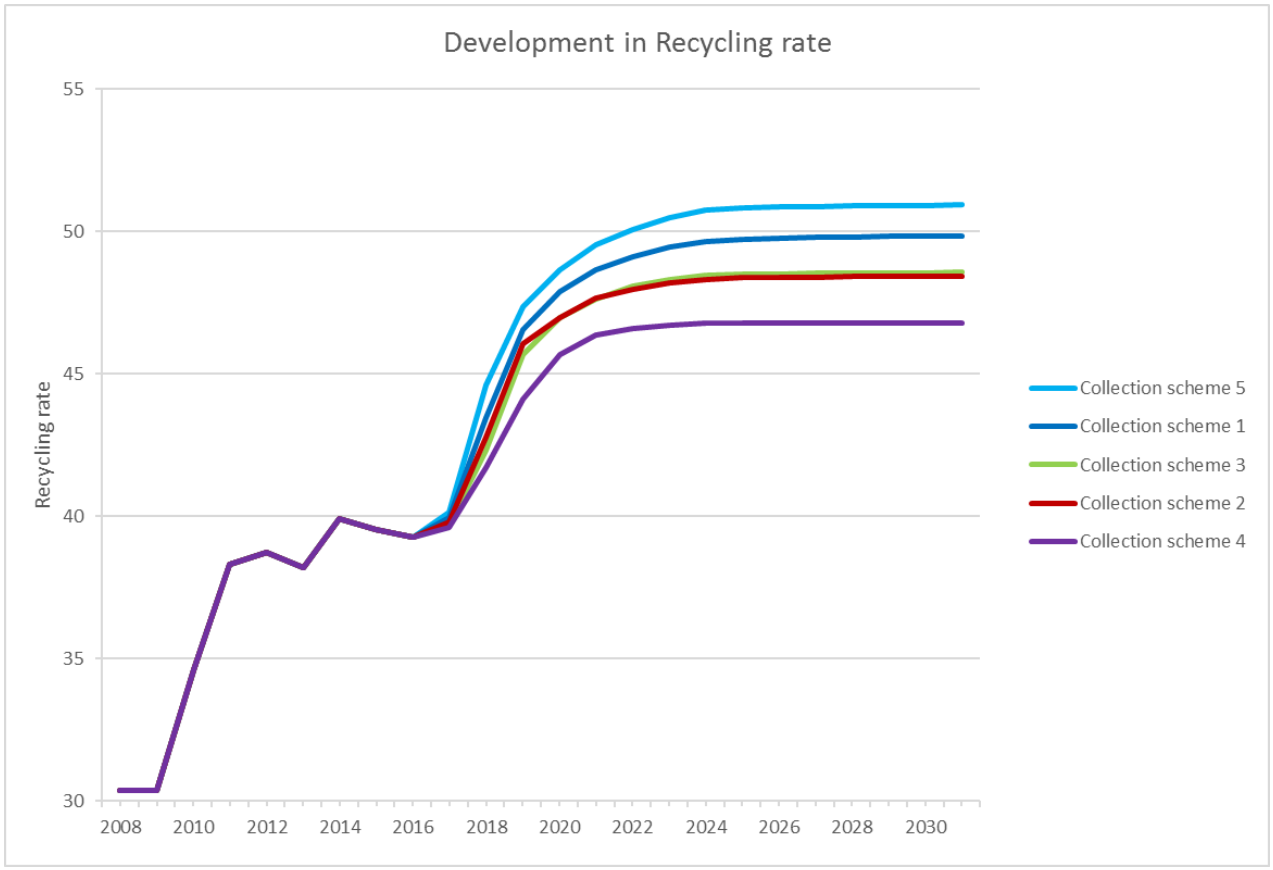
5 Cost calculation assumptions

- Cost and income drivers are directly influenced by the collection schemes
- There is identified and estimated a cost/income base in 2015 for 11 drivers
- The cost base is extrapolated until 2031 with a real growth of 1.7% per year – forming a "Baseline“
- The baseline reflects future net expenditure for the drivers with an activity level unchanged from 2015
- Simulation results are used as input in the cost calculation
- The collection schemes annual net expense => NPV => Annual annuity

6 Results

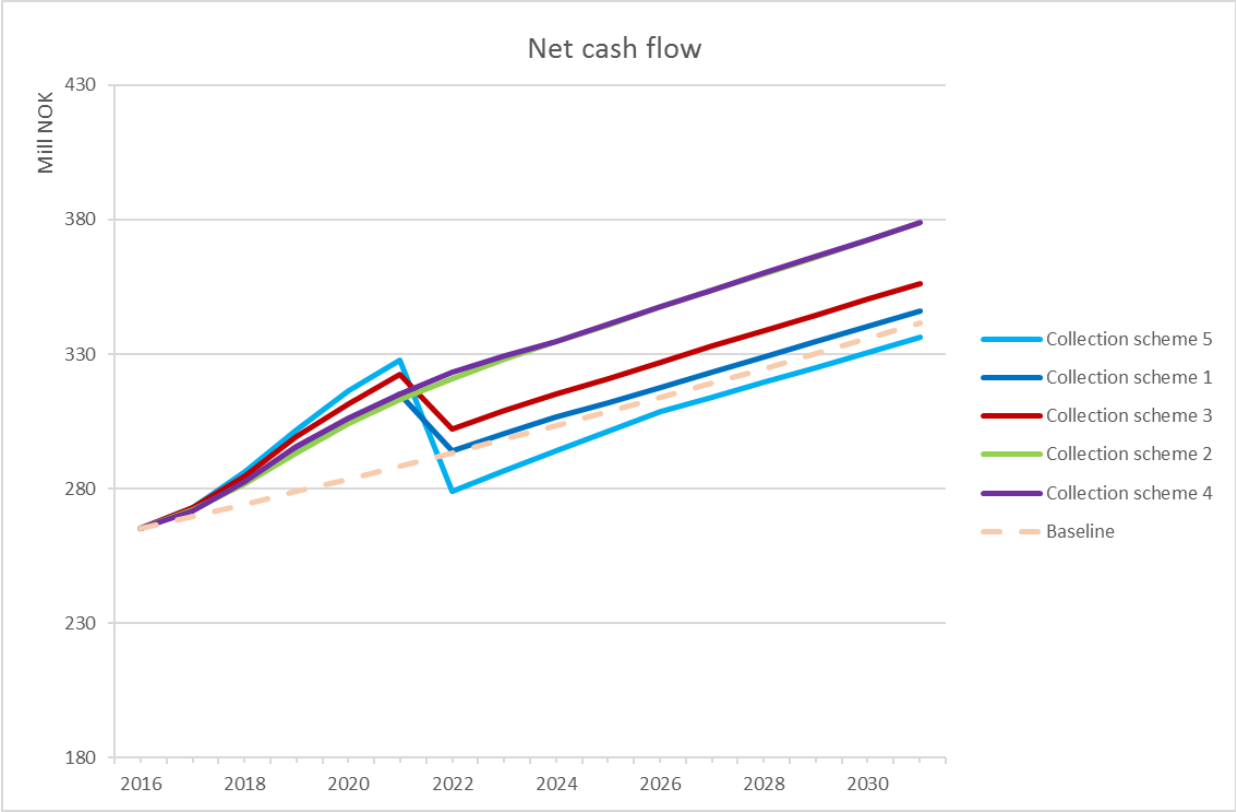
Curbside Collection Scheme	Bin System	Residual waste	Plastic waste	Food waste	Papir waste	Glass/ metal waste	Garden waste	Recycling rate 2031	Ranking recycling	Annuity in mill NOK	Ranking annuity
1	2							49,8 %	2	295,2	2
	3										
	4										
2	2							48,4 %	4	301,7	3
	3										
	4										
3	2							48,6 %	3	311,0	4
	3										
	4										
4	2							46,8 %	5	311,7	5
	3										
	4										
5	2							50,9 %	1	291,6	1
	3										
	4										

6 Results – Simulation recycling rate



- All changes are implemented from 2017
- The increase in the recycling rate stops in 2025
- The time period 2017-2025 visualizes a window of opportunities, given effects before 2032

6 Results – Cost calculation



- In 2021/2022 the curves shifts due to less need for optical sorting of food and plastic waste
- Collection scheme 5 – needs only one optical sorting line
- Collection scheme 1+3 – needs two optical sorting lines
- Collection scheme 3 – has higher transportation costs than scheme1
- Collection scheme 2+4 – needs three optical sorting lines

6 Results – Cost-efficiency

SUMMARY COST - EFFICIENCY					PERIOD 2016 - 2031
	Collection scheme 1	Collection scheme 2	Collection scheme 3	Collection scheme 4	Collection scheme 5
Cost-efficiency 1 (max)	1,11	1,06	1,03	0,99	1,15
Cost-efficiency 2 (min)	5 924 044	6 228 587	6 403 587	6 662 099	5 724 390
Yearly Annuity (NOK)	295 245 026	301 657 368	310 988 747	311 749 365	291 563 360
Yearly Additional Cost (NOK)	34 478 485	40 890 826	50 222 206	50 982 823	30 796 819
Cost/income base 2015 (NOK)	260 766 541	260 766 541	260 766 541	260 766 541	260 766 541
Recycling rate 2031	49,84 %	48,43 %	48,56 %	46,79 %	50,93 %
Add. recycling rate 2015 til 2031	10,31 %	8,90 %	9,03 %	7,26 %	11,40 %
Recycling rate 2015	39,53 %	39,53 %	39,53 %	39,53 %	39,53 %

Key figures	Explanation
Cost-efficiency 1 (max)	Cost-effeciency 1 use the relative increase in material recycling ratio (efficiency component) divided by the relative increase in costs (cost component). The most cost-effective collection scheme is the one who comes out with the highest numerical value.
Cost-efficiency 2 (min)	The cost-effeciency 2 shows how much one percentage in recycling rate costs on average per year. The most cost-effective collection scheme is the one that comes out with the lowest costs.

6 Results – Sensitivity

Collection Scheme	Data Combination	Yearly Annuity	Recycling rate 2031	Cost-eff.1	Cost-eff.2
1	Combination 1	308 202 758	52,4 %	1,12	5 880 725
	Combination 2	306 599 584	51,9 %	1,12	5 905 222
	Sim. Result	295 245 026	49,8 %	1,11	5 924 044
	Combination 3	256 187 429	43,8 %	1,13	5 842 960
	Combination 4	229 748 141	25,9 %	0,74	8 877 896
2	Combination 1	310 909 302	52,4 %	1,11	5 936 754
	Combination 2	311 661 419	51,2 %	1,08	6 089 348
	Sim. Result	301 657 368	48,4 %	1,06	6 228 587
	Combination 3	294 489 000	39,2 %	0,88	7 512 271
	Combination 4	267 479 723	19,9 %	0,49	13 445 082
3	Combination 1	326 047 201	52,4 %	1,06	6 223 917
	Combination 2	324 058 124	51,4 %	1,05	6 307 917
	Sim. Result	310 988 747	48,6 %	1,03	6 403 587
	Combination 3	285 577 785	38,0 %	0,88	7 517 937
	Combination 4	261 429 146	20,5 %	0,52	12 732 377
4	Combination 1	322 135 940	52,0 %	1,07	6 192 586
	Combination 2	322 143 504	50,1 %	1,03	6 424 980
	Sim. Result	311 749 365	46,8 %	0,99	6 662 099
	Combination 3	291 382 579	31,2 %	0,71	9 347 306
	Combination 4	266 353 324	16,9 %	0,42	15 789 513
5	Combination 1	300 445 169	52,4 %	1,15	5 731 221
	Combination 2	300 044 442	52,2 %	1,15	5 744 038
	Sim. Result	291 563 360	50,9 %	1,15	5 724 390
	Combination 3	266 635 704	45,6 %	1,13	5 843 727
	Combination 4	233 422 827	29,3 %	0,83	7 968 574

- The purpose is to investigate how sensitive the results are to changes in the assumptions
- Change +/- 25% and 50% - on input data
- Input data organized in 4 combinations
- Combinations 1 + 2 – increase recycling rate
- Combinations 3 + 4 – decrease recycling rate
- The increase and decrease are compared with the simulation results
- Sensitivity results: There is no change in the ranking order compered to simulation results

6 Results – Managerial information

Need of additional information may be crucial for an implementation of a new curbside collection scheme:

- *Stands*. Which location point can accommodate a 2, 3 or 4 bin system? Unique registration of bin system, waste fractions and quality criteria per stand is necessary
- *Segments of Households*. An appropriate segmentation model who ensures that the right message hits the right recipient, is needed. Segmentation should take into account the findings in the report and combine these with the stand information in the first bullet point
- *Incentives*. It should be developed a model for economic incentives that combines full cost estimates and budgets with stand information from the first bullet point
- *Pilot*. Suitable areas to test bullet points above should be identified. The pilot serves to give feedback on possible changes that should be retested.

7 Recommendation

- Based on these results, the Agency should make a decision on whether it finds it relevant to change its current collection scheme. If this is desired then it should;
- Investigate further with the aim to implement, primary, curbside collection scheme 5, secondary collection scheme 1
- Start the work to collect and record the lack of management information
- Start the work on developing an appropriate and effective package of means and measures taking into account Oslo's needs
- Start the work of planning and identifying areas to test the selected collection scheme with accompanying means and measures