PIETER POT

CARBON FOOTPRINT COMPARISON

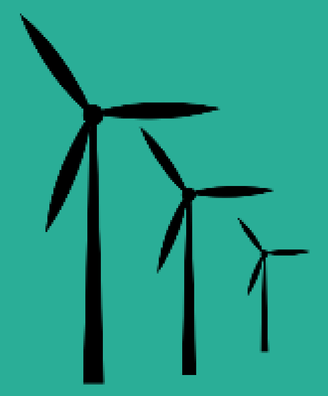
Goal

Compare carbon footprint of
Reusing glass jars
With
Recycling plastic packaging

Key takeaways

Reusing glass jars for 40 times[1]
Saves 4 kg – 455 kg CO2 eq.
Per household[2], per year compared to recycling plastic
At current energy mix and plastic from fossil fuels

Reusing glass jars for 40 times[1]
Saves 12 kg – 198 kg CO2 eq.
Per household[2], per year compared to recycling bioplastic
At 100% renewable energy and plastic from sugarcane



[1] Glass of 500 grams, compared to plastic of 10-60 grams
[2] Reference case of 2.600 products per household per year

Scope

IN

Emissions from material sourcing
Emissions from packaging production, cleaning and recycling
Emissions from transport of packaging, with and without product

OUT

Emissions from transport of bulk food
Emissions from production of food
Emissions from warehouse
Emissions from production of transport vehicles

Reference case

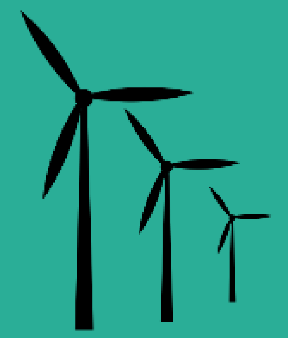
One household using
50 Products per week
2.600 Products per year

Package material per product
10-60 grams of plastic
500 grams of glass
1.000 grams of product

Scenarios

1. Status quo
13% of energy from renewable energy sources[1]
Plastic from fossil fuels

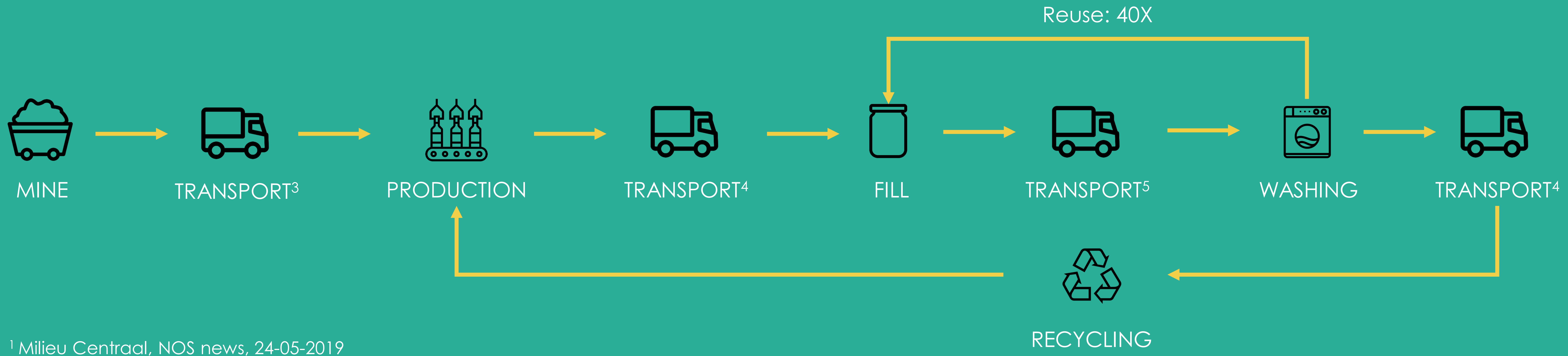
2. Outlook 2050
100% renewable energy[2]
100% bioplastics



[1] RVO, 2017, National Energy Outlook, 77-gram CO_2/kWh
[2] Ministerie van Economische Zaken, 2016, Energieagenda

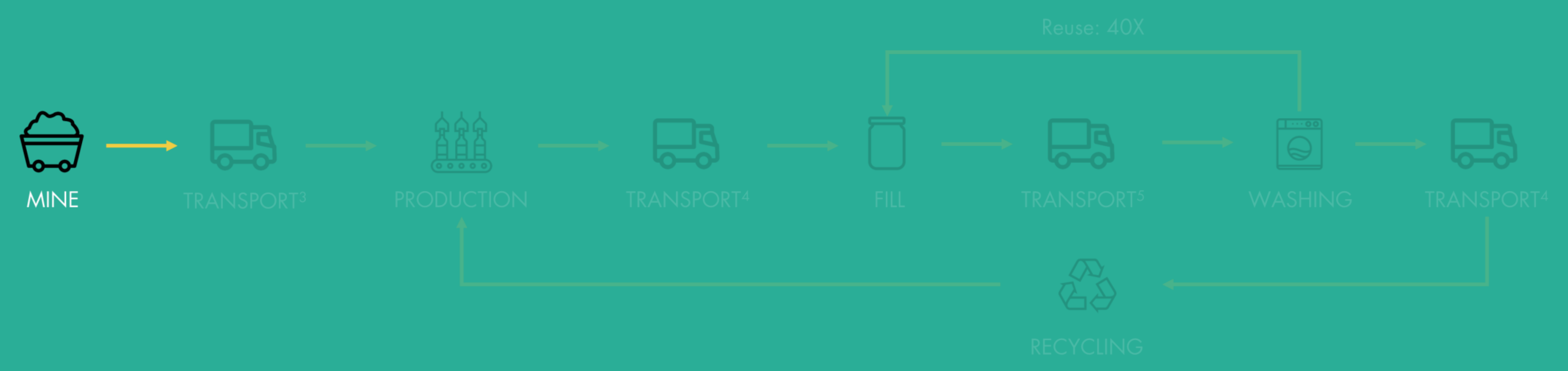
Lifecycle

Reuse glass jars
Typical reuse in beer breweries: 40 times[1]
Recycling times: indefinitely[2]



[1] Milieu Centraal, NOS news, 24-05-2019
[2] Victoria State Government, 2013
[3] Distance from mine:100 km
[4] Distance from production facility:100 km
[5] Distance from distribution center: 100 km

Glass



Scenario 1

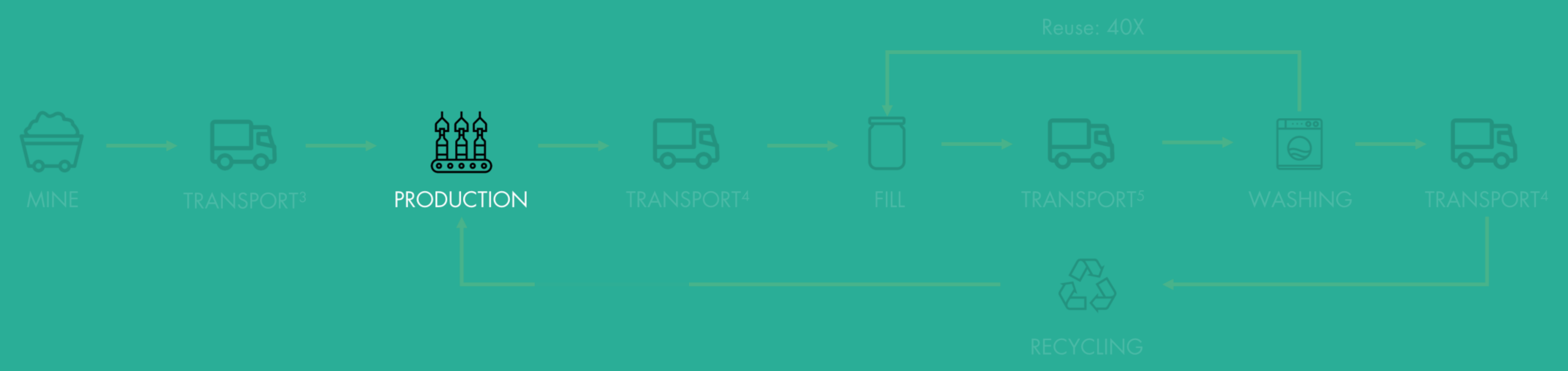
Sourcing the raw materials for glass
Emits 0,07 kg CO_2 eq. per kg glass[1].
At feedstock mix with 50% recycled cullets[2].

Scenario 2

Sourcing the raw materials for glass
Emits 0,07 kg CO2 eq. per kg glass[1].
At feedstock mix with 50% recycled cullets[2].

[1] Larsen, A., Merrild, H. and Christenen, T., 2009, Recycling of glass: accounting of greenhouse gases and global warming contributions
[2] EU Average, EU, 2010, JRC Reference Report, Best Available Techniques (BAT) Reference Document for the Manufacture of Glass

Glass



Scenario 1

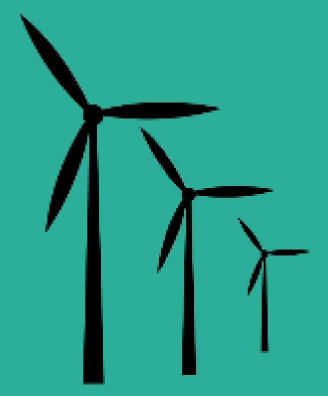
Production of glass with conventional fossil fuels

Emits 0,52 kg CO2 eq./kg glass[1]

Scenario 2

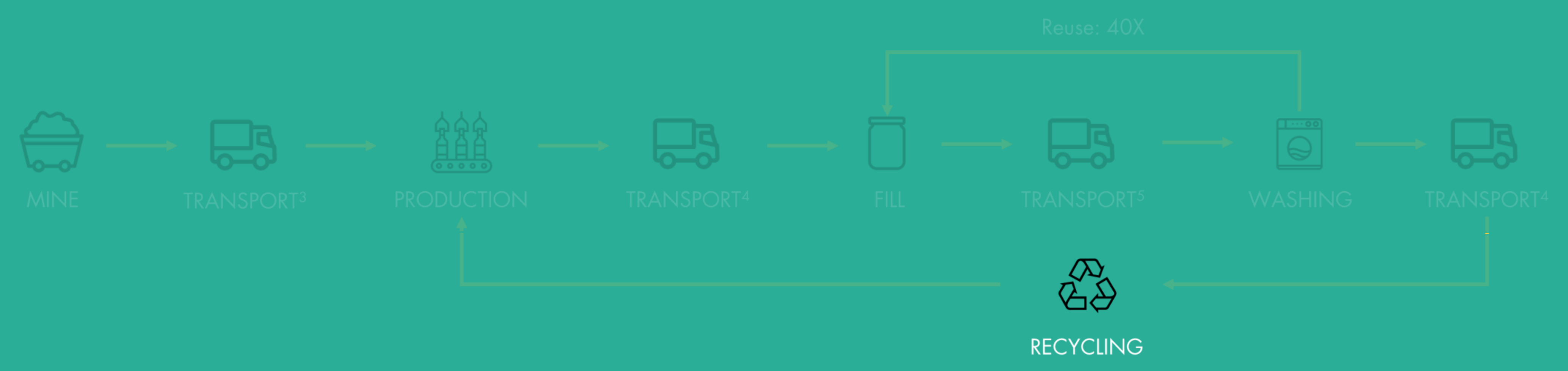
Production of glass with 100% renewable energy

Emits 0,08 kg CO2 eq./kg glass[1]



[1]Ecofys, 2018, Methodology for the free allocation of emission allowances in the EU ETS

Glass



Scenario 1

Recycling glass to cullets requires 14 kWh/t glass[1] which

Emits 0,001 kg CO_2 eq./kg glass

Scenario 2

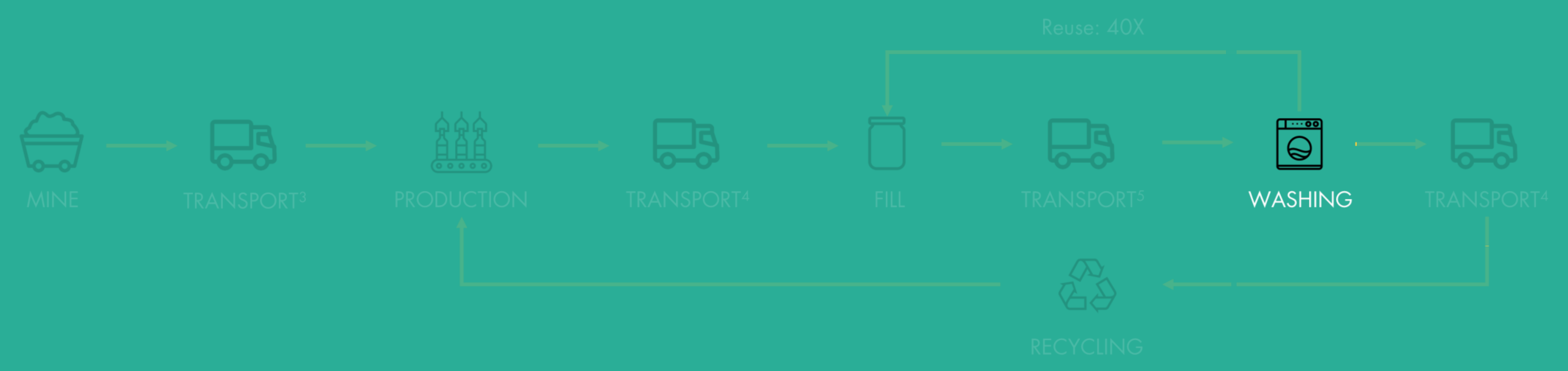
Recycling glass to cullets with 100% renewable energy

Emits 0 kg CO_2 eq./kg glass[2]

[1]Larsen, A., Merrild, H. and Christenen, T., 2009, Recycling of glass: accounting of greenhouse gases and global warming contributions

2 Given a fully electric recycling process

Glass

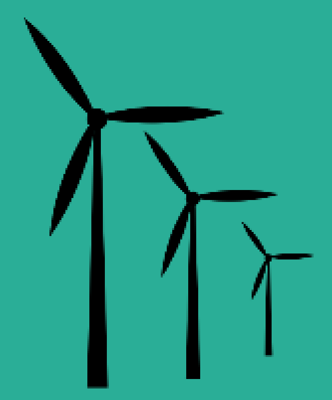


Scenario 1

Washing one glass container
Emits 4,9g CO_2 eq[1].
Including carbon footprint of washing, drying, water and chemicals.

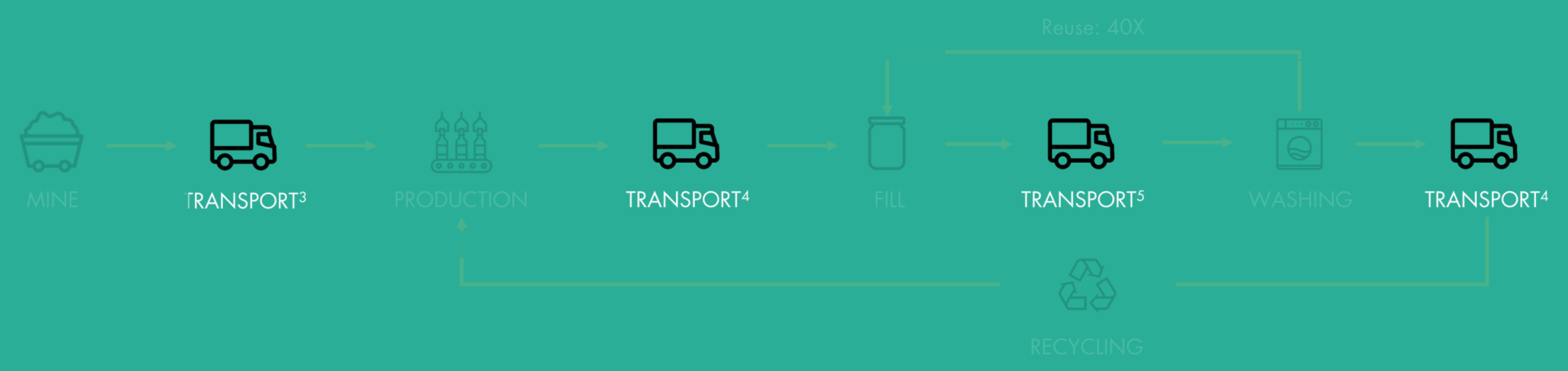
Scenario 2

Washing one glass container
Emits 0,2g CO2 eq[1].
Including carbon footprint of water and chemicals.



[1] See Appendix for detailed calculations

Glass



Scenario 1

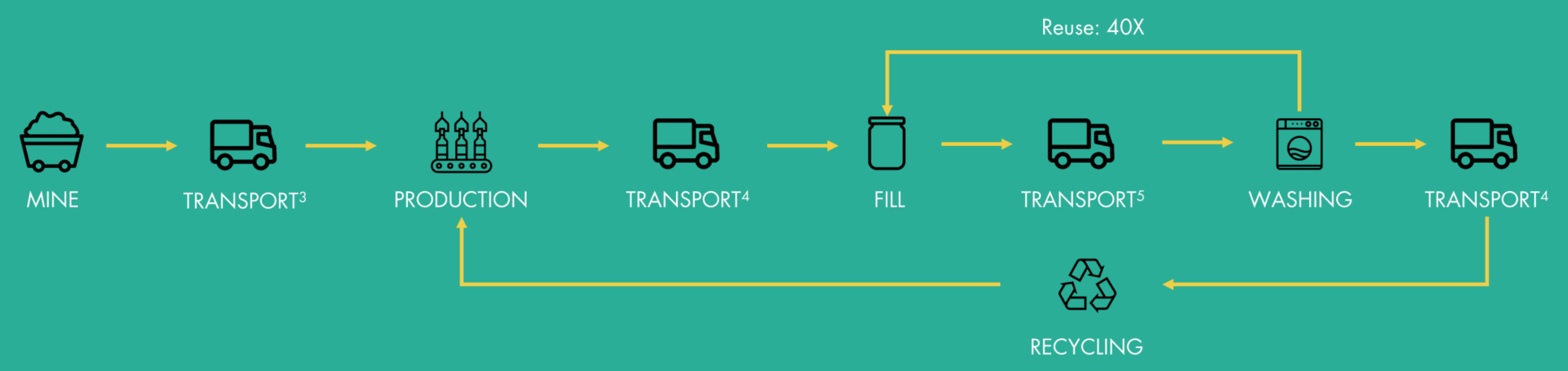
Transport 2.600 products per year
Emits 24,8 kg CO_2 eq[1].
Using a diesel truck

Scenario 2

Transport 2.600 products per year
Emits of 0 kg CO2 eq[2].
Using electric truck

[1]See Appendix for calculation
[2]Based on 100% renewable energy scenario

Total

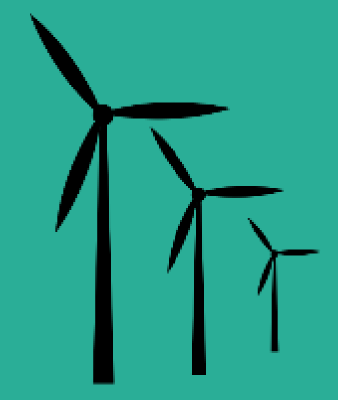


Scenario 1

Reusing 2.600 glass jars
Emits 56,5 kg CO_2 eq.
Per year.

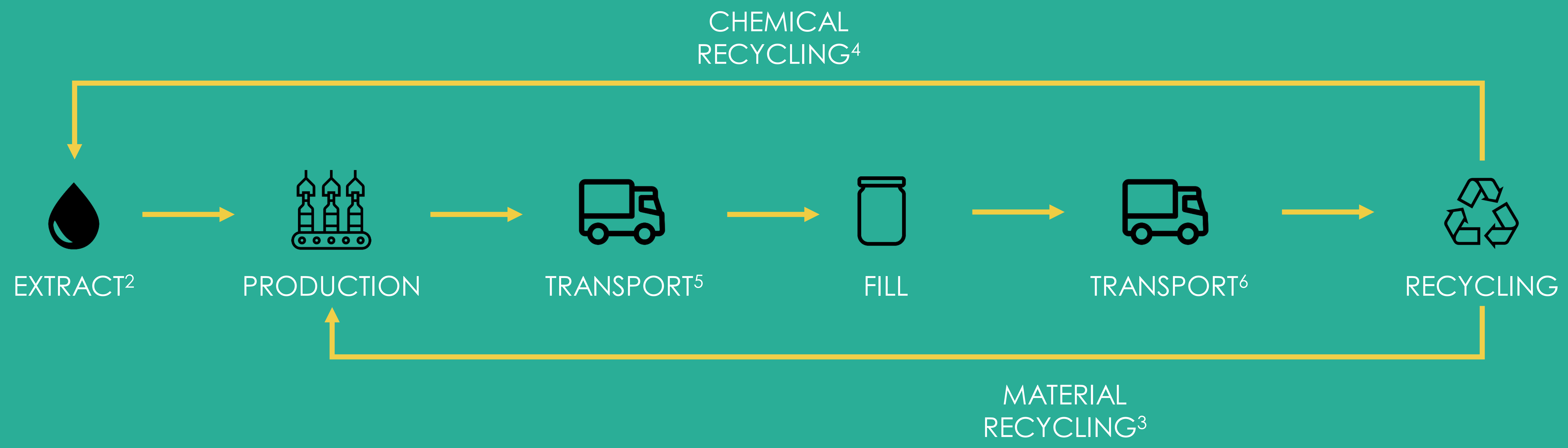
Scenario 2

Reusing 2.600 glass jars
Emits 5 kg CO2 eq.
Per year.



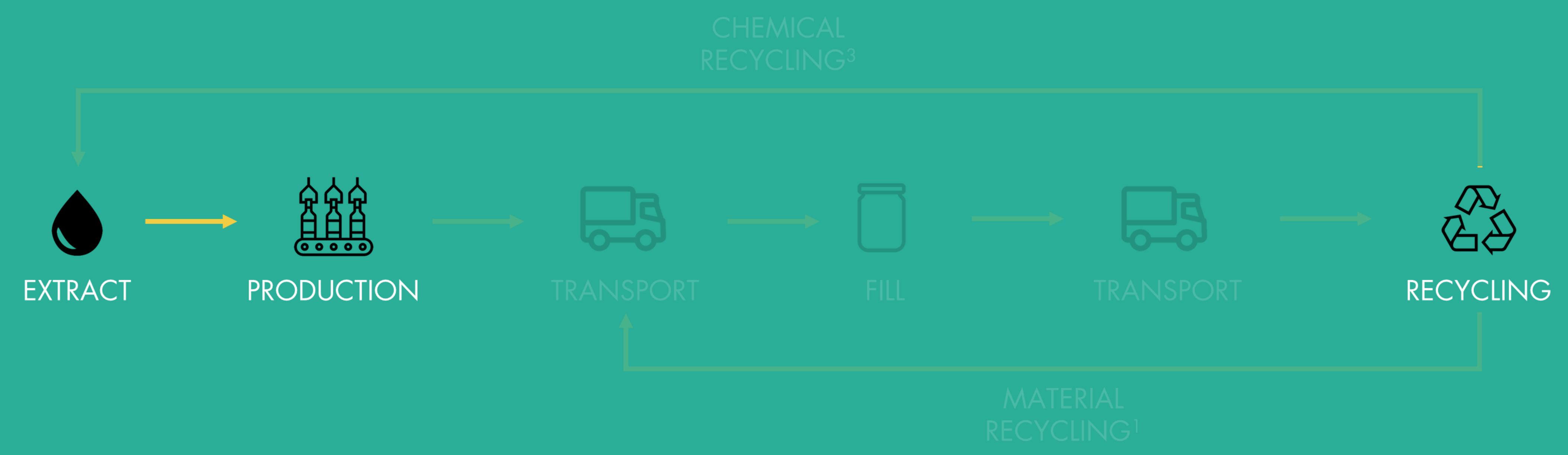
Lifecycle

Recycle plastic
Recycling times:1-2[1]



[1] Material recycling without altering the chemical structure
[2] Including shipment to production facility
[3] Recycled plastic for food packaging always contains a layer of virgin plastic to prevent contaminations
[4] Produces syngas, which can be used as a raw material to produce plastic
[5] Distance to Dutch production facility: 100km
[6] Distance from distribution center: 100 km

Plastic



Scenario 1

Production and recycling of plastic[3]

Emits 3,15 kg CO_2 eq./kg plastic[1,2]

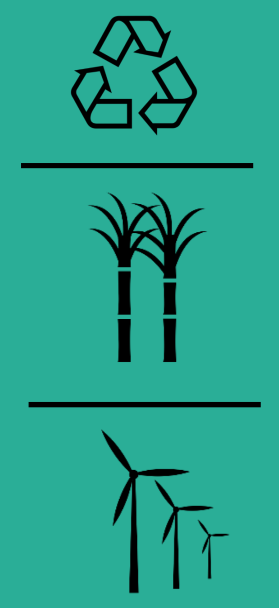
Using fossil fuels.

Scenario 2

Production and recycling of plastic[3]

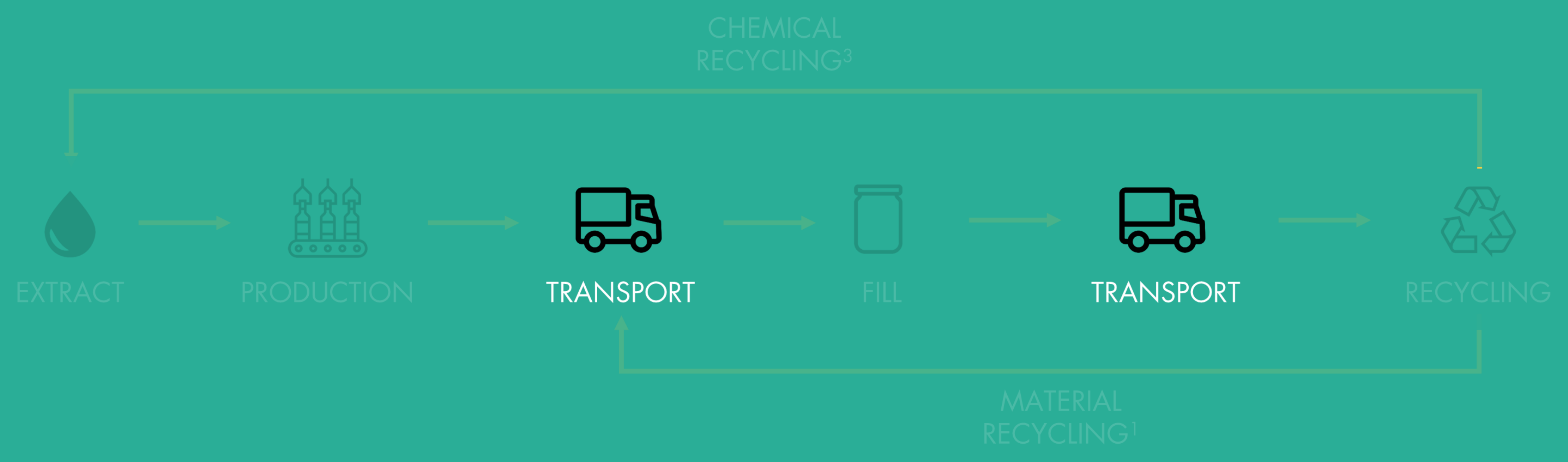
Emits 1,3 kg CO_2 eq./kg plastic[1]

Using 100% renewable energy and 100% bioplastics.



[1] Nature Journal of Climate Change, 2019, Strategies to reduce the global carbon footprint of plastics
[2] Including emissions from transport for recycling
[3] Combination of material and chemical recycling

Plastic



Scenario 1

Transport of 2.600 products per year

Emits 19,4 kg – 20,5 kg CO_2 eq[1 2].

Using diesel trucks.

Scenario 2

Transport of 2.600 products per year

Emits 0 kg CO2 eq[3].

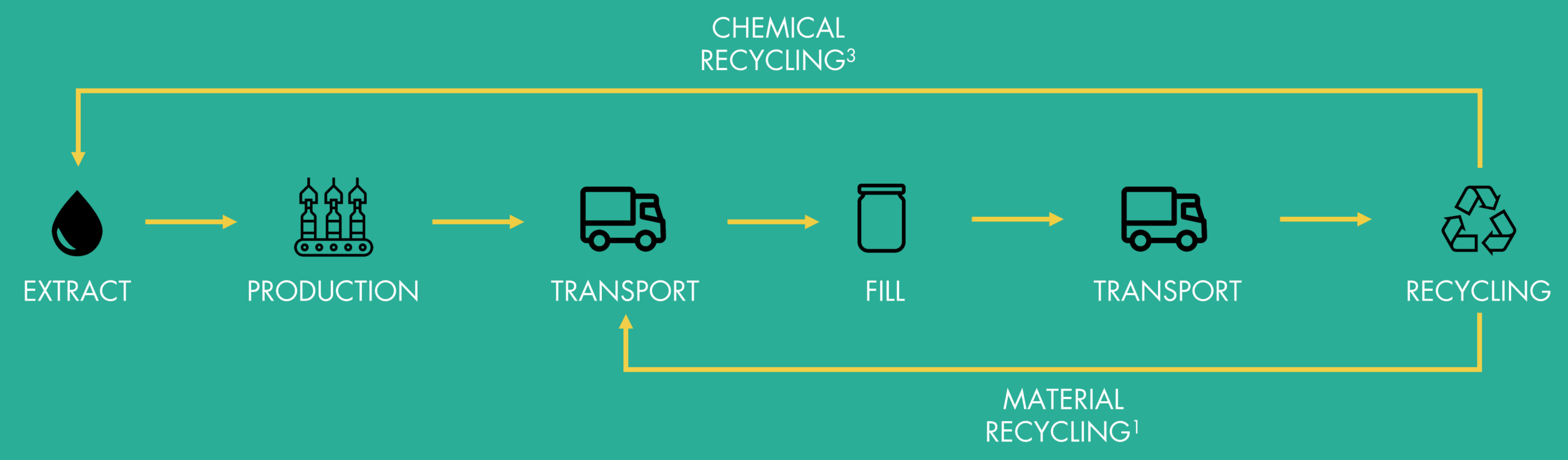
Using electric trucks

[1]Excluding transportation for recycling since this is already included in the plastic emissions for the recycling

[2]See Appendix for calculation

[3]Based on 100% renewable energy scenario

Total



Scenario 1

Using 2.600 plastic containers

Emits 60 kg - 512 kg CO_2 eq.

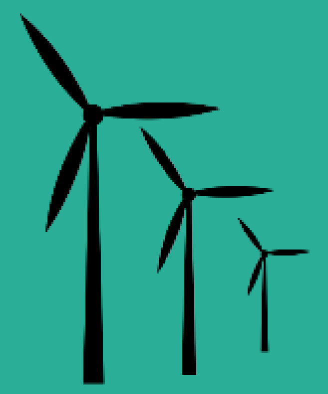
Per year.

Scenario 2

Using 2.600 bioplastic containers

Emits 17 kg – 203 kg CO2 eq.

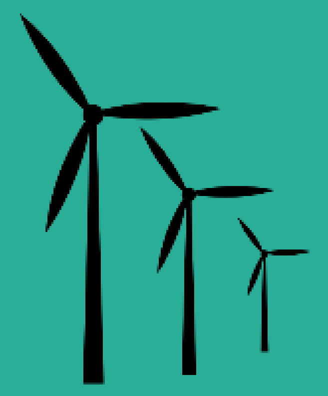
Per year.



Glass versus plastic

Reusing glass jars for 40 times[1]
Saves 4 kg – 455 kg CO_2 eq.
Per household[2], per year compared to recycling plastic
At current energy mix and plastic from fossil fuels

Reusing glass jars for 40 times[1]
Saves 12 kg – 198 kg CO_2 eq.
Per household[2], per year compared to recycling bioplastic
At 100% renewable energy and plastic from sugarcane



[1] Glass of 500 grams, compared to plastic of 5-60 grams
[2] Reference case of 2.600 products per household per year

Reusable glass saves on average

230 kg CO_2

per year, per household*

*Based on 50 products per week, at current energy mix

Reusable glass saves on average

1% CO_2

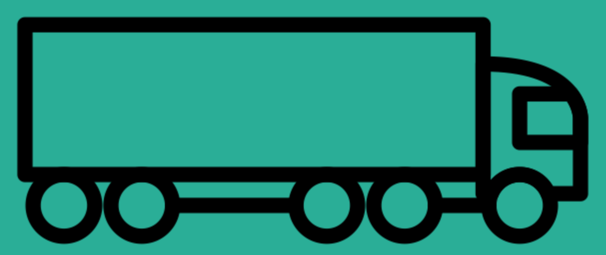
per year, per household*

*Based on 50 products per week, at current energy mix
Average carbon footprint per capita of 11.500 kg CO_2 eq./year [EEA 2016]
household size 2.2

APPENDIX

Transport

Volume: 80 m^3
Maximum payload: 25t
Emissions[1]: 62-gram CO_2/ton-km



GLASS

Ship raw material[3] for glass production

Raw material[2]:	1,2 kg/kg glass
Total mass:	25t
Amount of containers:	41.666
Distance:	100 km
Emissions:	129 kg CO_2
Relative emissions:	3,1 g CO_2/container

65 containers/year at reuse of 40 times
0,20 kg CO_2 /year

Ship glass retrieval for recycling

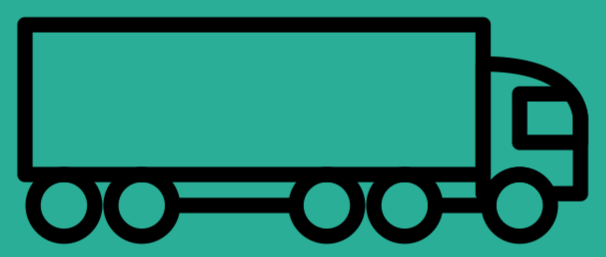
Weight per container:	0,5 kg
Total mass:	25t
Amount of containers:	50.000
Distance:	100 km
Emissions:	155 kg CO_2
Relative emissions:	3,1 g CO_2/container

65 containers/year at reuse of 40 times
0,20 kg CO_2 /year

[1] ECTA, 2011, Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations
[2] Larsen, A., Merrild, H. and Christenen, T., 2009, Recycling of glass: accounting of greenhouse gases and global warming contributions
[3] Includes both raw materials and recycled cullets. Assumes that recycle plant is at the same location as the production facility

Transport

Volume: 80 m^3
Maximum payload: 25t
Emissions[1]: 62-gram CO_2/ton-km



GLASS

Ship empty glass containers to warehouse

Weight per container:	0.5 kg
Total mass:	25t
Amount of containers:	50.000
Distance:	100 km
Emissions:	155 kg CO_2
Relative emissions:	3.1 g CO_2/container

65 containers/year at reuse of 40 times
0,2 kg CO_2 /year

Ship filled glass containers to customers

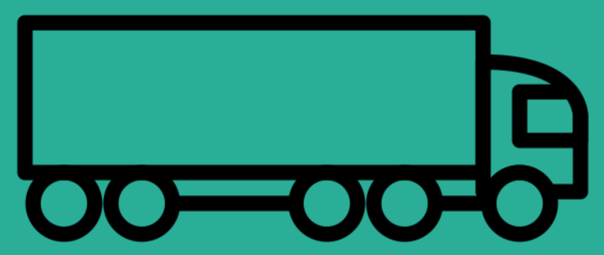
Weight per container:	1.5 kg
Total mass:	25t
Amount of containers:	16.666
Distance:	100 km
Emissions :	155 kg CO_2
Relative emissions :	9.3 g CO_2/container

2.600 containers/year
24 kg CO_2 /year

[1] ECTA, 2011, Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations

Transport

Volume: 80 m^3
Maximum payload: 25t
Emissions[1]: 62-gram CO_2/ton-km



PLASTIC

Empty plastic containers

- Included in carbon footprint of plastic recycling

Filled glass containers

Weight per container:	1.005-1.06 kg
Total mass:	25t
Amount of containers:	23.584 – 24.875
Distance:	100 km
Emissions :	186 kg CO_2
Relative emissions :	7.47 – 7.88 g CO_2/container

2.600 containers/year
19 – 20 kg CO_2 /year

[1] ECTA, 2011, Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations

Washing

Containers/wash: 9[1]

GLASS

Variables

- Electricity consumption[2]: 40 kWh/t glass
- Natural gas consumption (drying)[2]: 25 m3/t glass
- Soda hydroxide consumption[1]: 0,9 g/wash
- Water consumption per wash[1]: 3,1 L/wash

Emissions

- Electricity[3]: 77 g CO_2/kWh
- Soda hydroxide production[2]: 1,12 kg CO_2 /kg
- Water production and cleaning[2]: 0,32 kg CO_2 /m3
- Natural gas incineration[4]: 0,25 kg CO_2/m3

SCENARIO 1 [Fossil fuels]
2.600 containers/year
12,7 kg CO_2 /year

SCENARIO 2 [100% Renewable energy]
2.600 containers/year
0,6 kg CO2 /year[5]

[1] Based on current operation at Pieter Pot
[2] Larsen, A., Merrild, H. and Christenen, T., 2009, Recycling of glass: accounting of greenhouse gases and global warming contributions
[3] RVO, 2017, National Energy Outlook
[4] Fruergaard, T., Ekvall, T. & Astrup, T. (2009) Energy use and recovery in waste management and implications for accounting of greenhouse gases and global warming contributions.
[5] Only including emissions from sodium hydroxide production and water treatment

PIETER POT

CARBON FOOTPRINT COMPARISON

Goal

Compare carbon footprint of
Reusing glass jars
With
Recycling carton packaging

Key takeaways

Reusing glass jars for 40 times[1]
Saves 16 kg – 111 kg CO2 eq[2].
Per household[3], per year compared to recycling cardboard
At current energy mix

[1] Milieu Centraal, NOS news, 24-05-2019
[2] Glass of 500 grams, compared to cardboard of 15 - 40 grams
[3] Reference case of 2.600 products per household per year

Scope

IN

Emissions from material sourcing
Emissions from packaging production, cleaning and recycling
Emissions from transport of packaging, with and without product

OUT

Emissions from transport of food from supplier to distribution center[1]
Emissions from production of food[2]
Carbon sequestration from forests[3]

[1] Assuming similar emissions from transport of bulk and single packaged products from supplier to distribution center
[2] Assuming similar production process and emissions for bulk and single packaged product
[3] See slide 5 for a detailed explanation

Sequestration

Background

Forests capture and store carbon – this process is called sequestration

Some carbon footprint analysis assign this carbon sink to cardboard products, with a reference forest of zero sequestration[1].

This comparison excludes carbon sequestration

To assign carbon sequestration to cardboard would be misleading, since 1) these product have a significantly shorter carbon decay time compared to the natural decomposition of biomass in forests[2,3,4] 2) managed forests may contain 25%-50% less carbon than natural forests[5].

1. Swedish Environmental Research Institute, 2010, Carbon Footprint of Cartons in Europe.
2. Natural decomposition of biomass takes over 200 years to decay 95% of the carbon, while cardboard products take less than 8 years to decay 95% of the carbon.
3. Klein, D. Hollerl, S., Blaschke, M. and Schulz, C. 2013, The Contribution of Managed and Unmanaged Forests to Climate Change Mitigation—A Model Approach at Stand Level for the Main Tree Species in Bavaria
4. Pukkala, T. 2017, Does management improve the carbon balance of forestry?
5. Ontario Ministry of Natural Resources, 2010, The effects of forest management on carbon storage in Ontario's forests.

Reference case

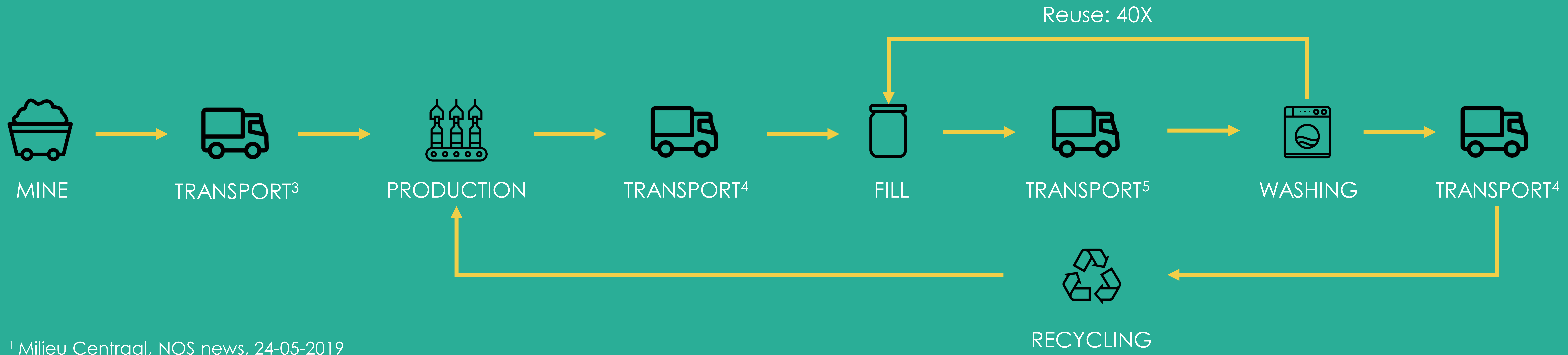
One household using
50 Products per week
2.600 Products per year

Package material per product
15 - 40 grams[1] of White Lined Chipboard carton[2]
500 grams of glass[3]
1.000 grams of product

[1] A range of weights is taken to compare the impact for different products
[2] Cardboard without plastic layers
[3] Average weight of current glass packaging (1L), assuming all type of products can be stored in this size

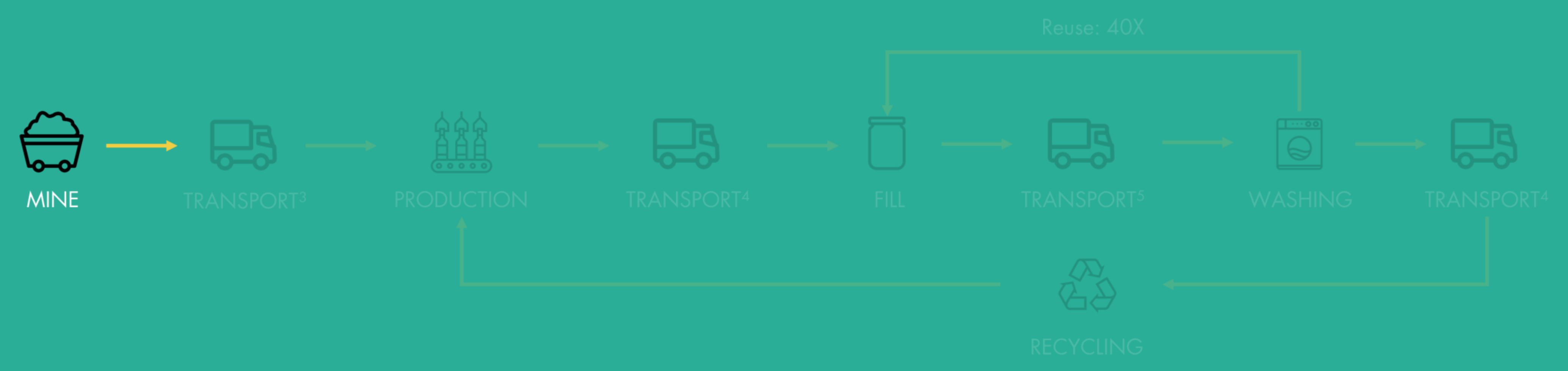
Lifecycle

Reuse glass jars
Typical reuse in beer breweries: 40 times[1]
Recycling times: indefinitely[2]



[1] Milieu Centraal, NOS news, 24-05-2019
[2] Victoria State Government, 2013
[3] Distance from mine:100 km
[4] Distance from production facility:100 km
[5] Distance from distribution center: 100 km

Glass



Sourcing

Sourcing the raw materials for glass

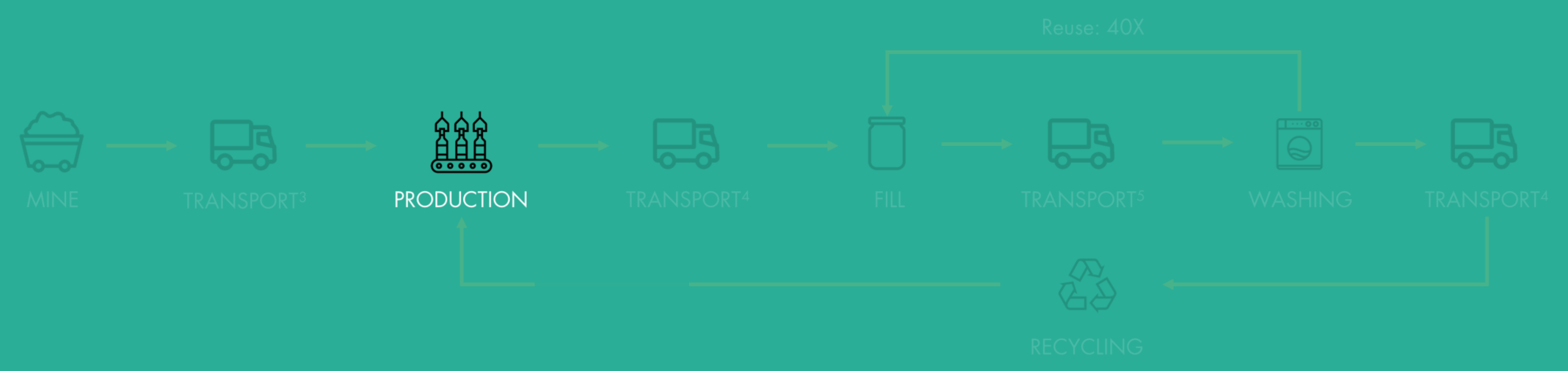
Emits 0,07 kg CO_2 eq. per kg glass[1].

At feedstock mix with 50% recycled cullets[2].

[1] Larsen, A., Merrild, H. and Christenen, T., 2009, Recycling of glass: accounting of greenhouse gases and global warming contributions

[2] EU Average, EU, 2010, JRC Reference Report, Best Available Techniques (BAT) Reference Document for the Manufacture of Glass

Glass



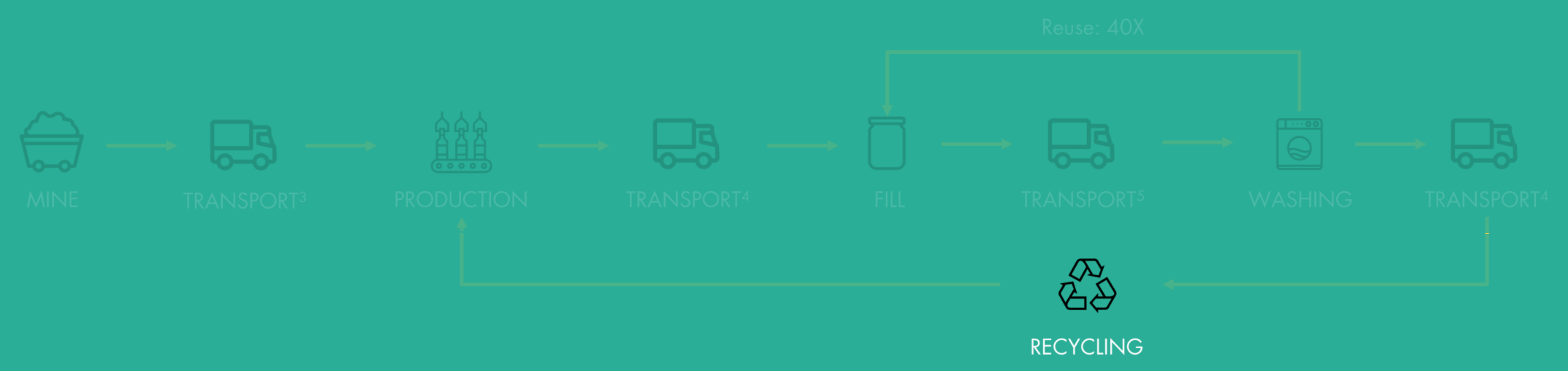
Production

Production of glass with conventional fossil fuels

Emits 0,52 kg CO_2 eq./kg glass[1]

[1]Ecofys, 2018, Methodology for the free allocation of emission allowances in the EU ETS

Glass

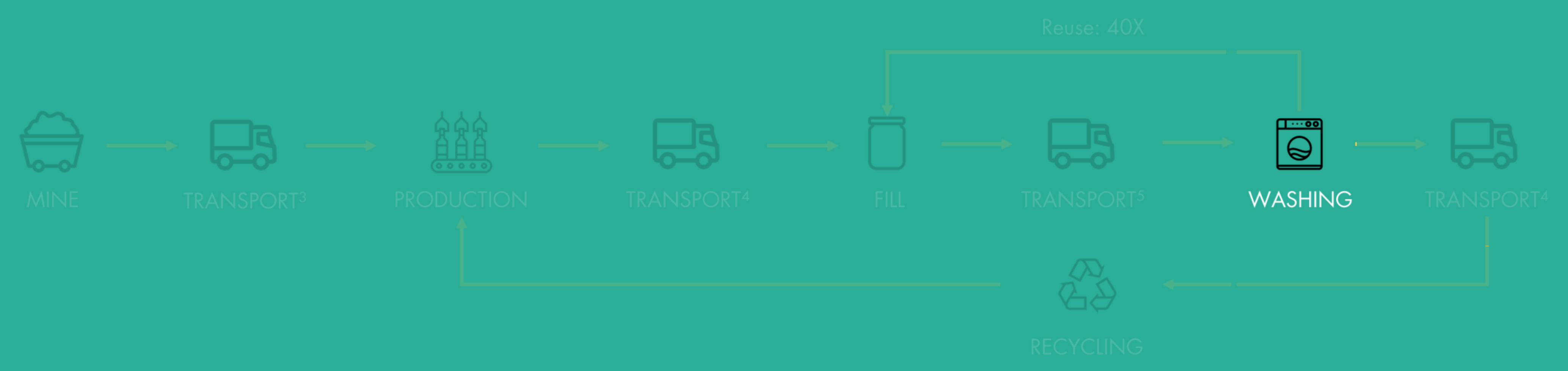


Recycling

Recycling glass to cullets requires 14 kWh/t glass[1] which
Emits 0,001 kg CO2 eq./kg glass

[1]Larsen, A., Merrild, H. and Christenen, T., 2009, Recycling of glass: accounting of greenhouse gases and global warming contributions
2 Given a fully electric recycling process

Glass



Washing

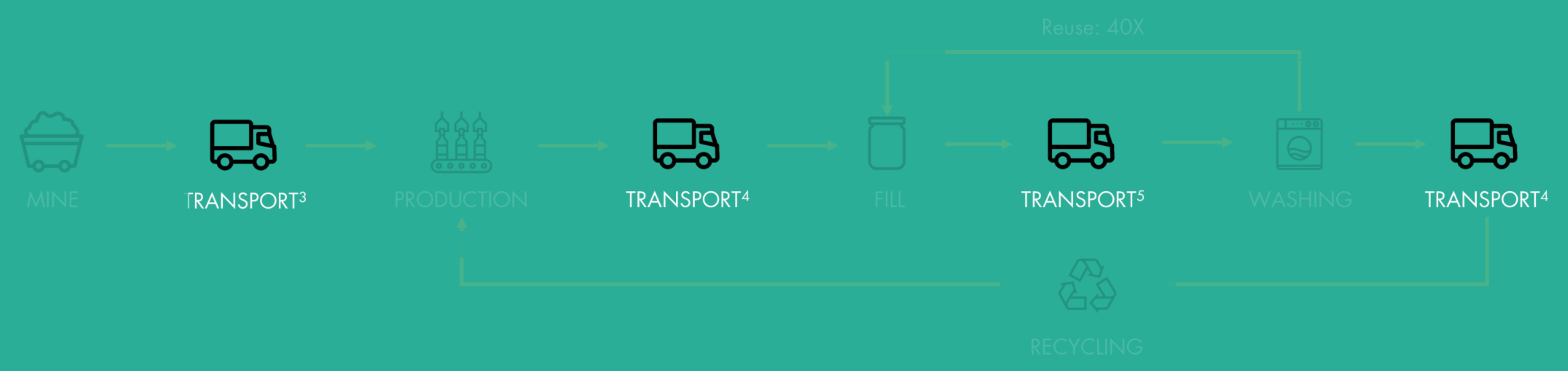
Washing one glass container

Emits 4,9g CO_2 eq[1].

Including carbon footprint of washing, drying, water and chemicals.

[1] See Appendix for detailed calculations

Glass



Transport

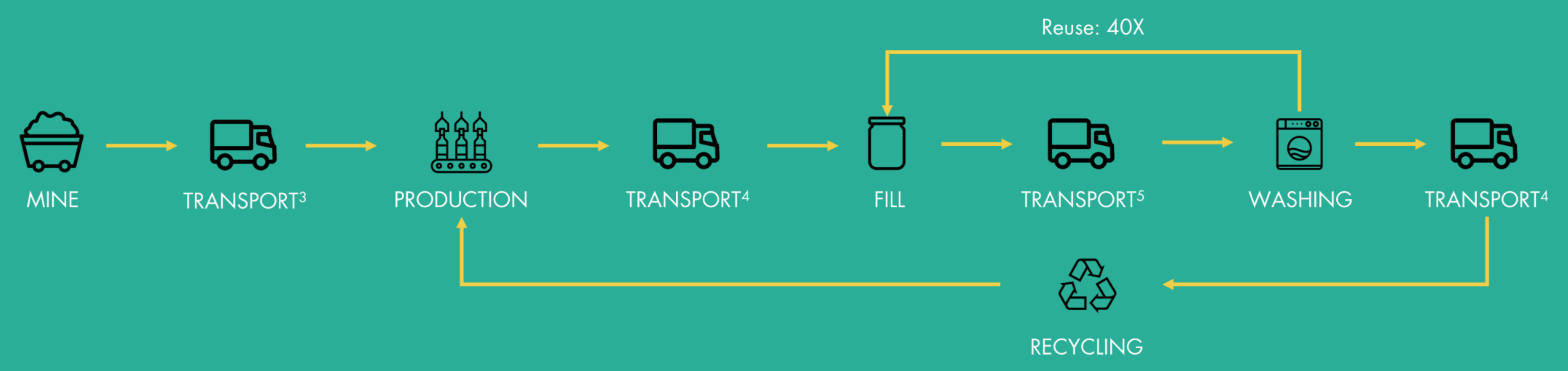
Transport 2.600 products per year

Emits 24,8 kg CO_2 eq[1].

Using diesel truck

[1]See Appendix for calculation

Total



Reference case

Reusing 2.600 glass jars

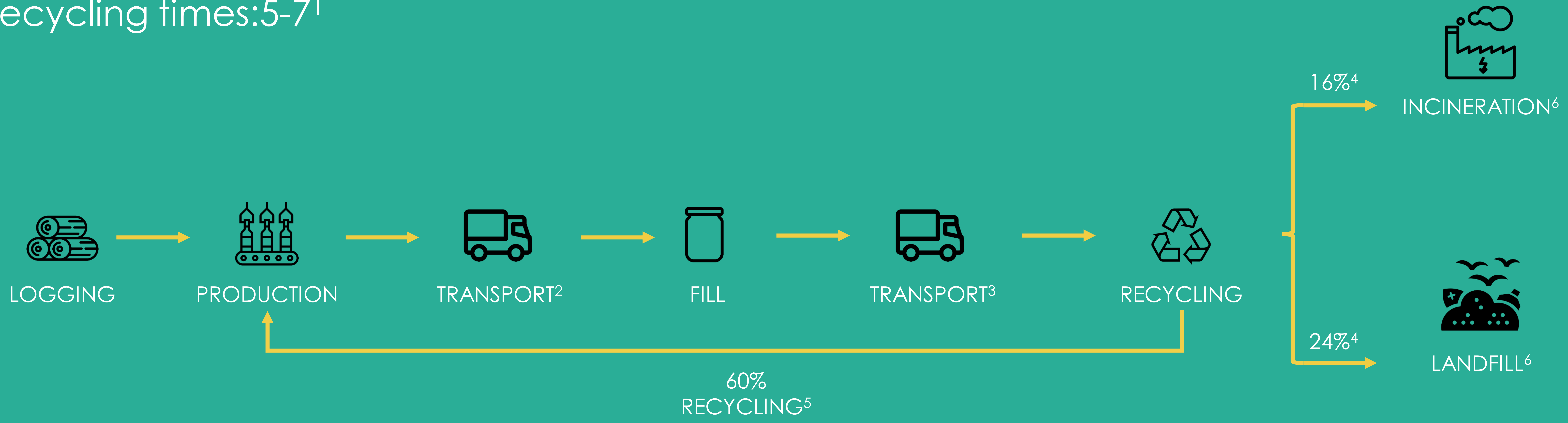
Emits 56,5 kg CO_2 eq.

Per year.

Lifecycle

Recycle cardboard

Recycling times:5-7[1]



[1] Pro Carton, Carbon Footprint
[2] Distance to Dutch production facility: 100km
[3] Distance from distribution center: 100 km
[4] Swedish Environmental Research Institute, 2010, Carbon Footprint of Carton in Europe
[5] Assuming recycling and production is done at one location
[6] Transport from recycling plant to landfill/incinerator is neglected

Cardboard

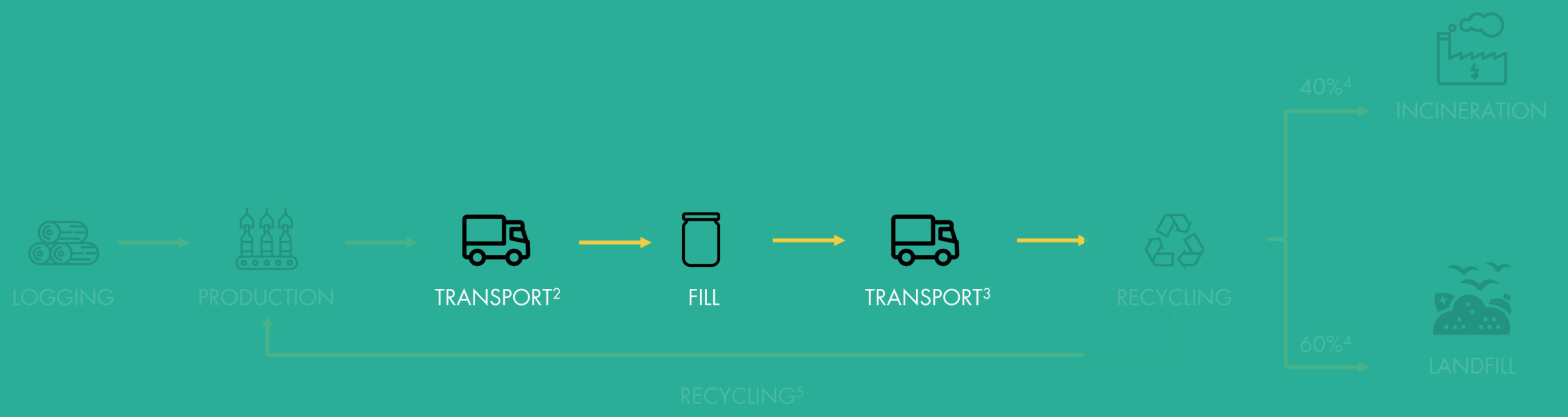
Production

Production and recycling of cardboard

Emits 0,96 kg CO_2 eq./kg cardboard[1 2]

[1] Swedish Environmental Research Institute, 2010, Carbon Footprint of Carton in Europe
[2] Including emissions from transport of raw materials

Cardboard

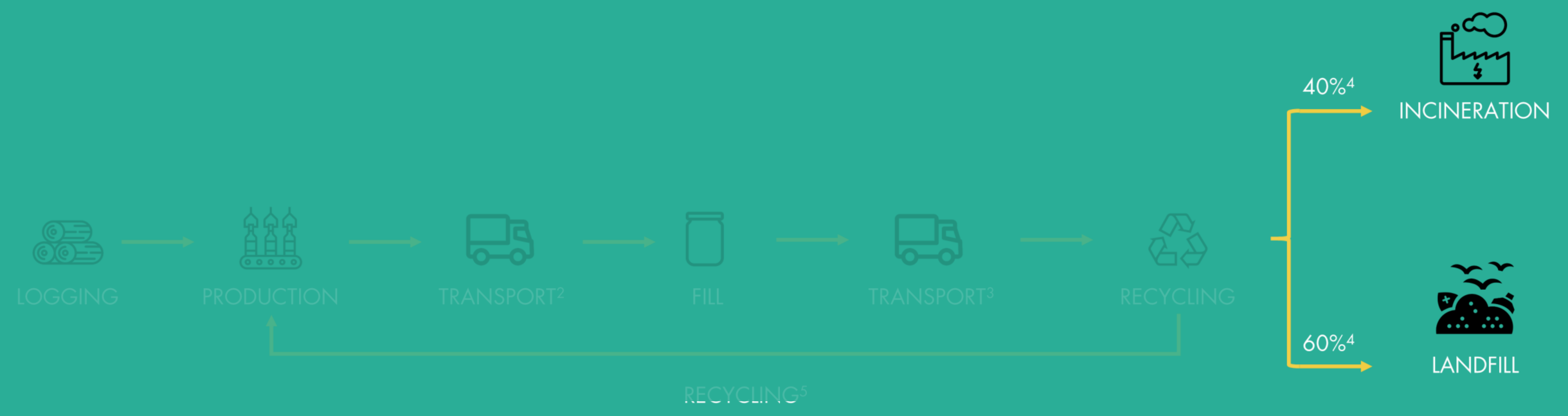


Transport

Transport of 2.600 products per year
Emits 16,6 kg – 17,7 kg CO_2 eq[1].
Using diesel trucks.

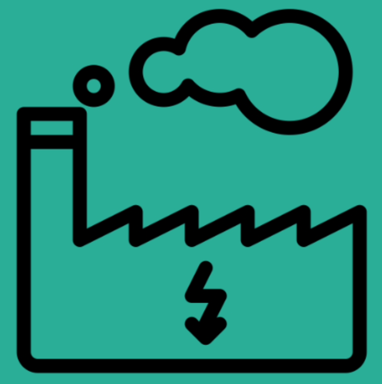
[1]See Appendix for calculation

Cardboard



Incineration

Incinerating end-of-life cardboard
Emits 1,1 kg CO_2 eq/kg cardboard[1].
16% of the cardboard ends here[1].

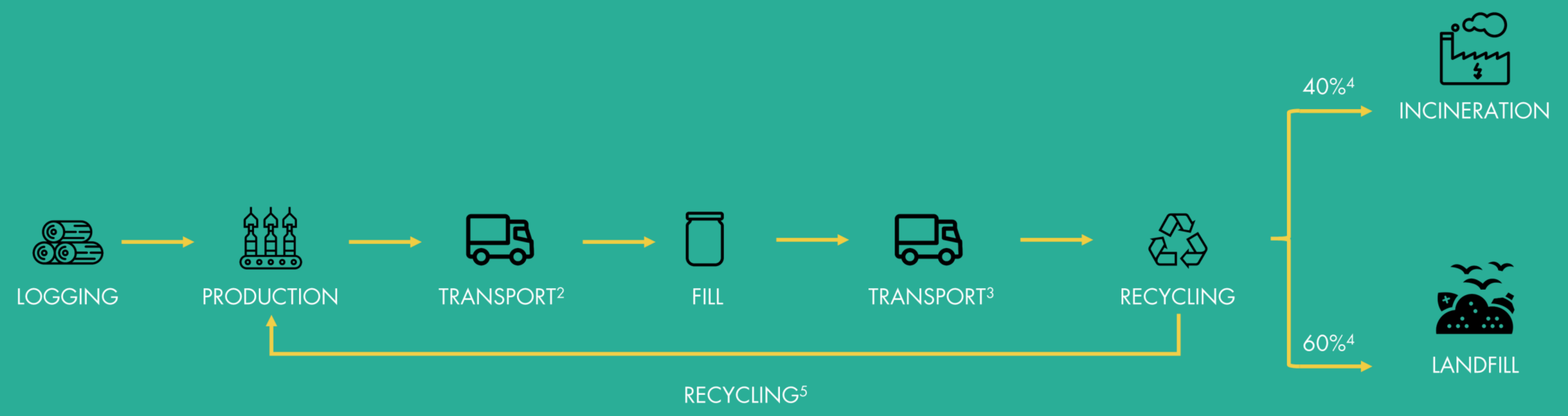


Landfill

Landfill of end-of-life cardboard
Emits 1,3 kg CO2 eq/kg cardboard[1].
24% of the cardboard ends here[1]

[1] Swedish Environmental Research Institute, 2010, Carbon Footprint of Carton in Europe

Total



Cardboard

Using 2.600 cardboard containers

Emits 73 kg - 168 kg CO_2 eq.

Per year.

Glass versus cardboard

Reusing glass jars for 40 times[1]
Saves 16 kg – 111 kg CO2 eq.
Per household[2], per year compared to recycling cardboard
At current energy mix

[1] Glass of 500 grams, compared to cardboard of 15 - 40 grams
[2] Reference case of 2.600 products per household per year

Reusable glass saves on average

64 kg CO_2

per year, per household*

compared to cardboard packaging

*Based on 50 products per week, at current energy mix

Reusable glass saves on average

0,3% CO_2

per year, per household*

compared to cardboard packaging

*Based on 50 products per week, at current energy mix
Average carbon footprint per capita of 11.500 kg CO_2 eq./year [EEA 2016]
household size 2.2

APPENDIX

Transport

Volume: 80 m^3
Maximum payload: 25t
Emissions[1]: 62-gram CO_2/ton-km

GLASS

Ship raw material[3] for glass production

Raw material[2]:	1,2 kg/kg glass
Total mass:	25t
Amount of containers:	41.666
Distance:	100 km
Emissions:	129 kg CO_2
Relative emissions:	3,1 g CO_2/container

65 containers/year at reuse of 40 times
0,2 kg CO_2 /year

Ship glass retrieval for recycling

Weight per container:	0,5 kg
Total mass:	25t
Amount of containers:	50.000
Distance:	100 km
Emissions:	155 kg CO_2
Relative emissions:	3,1 g CO_2/container

65 containers/year at reuse of 40 times
0,2 kg CO_2 /year

[1] ECTA, 2011, Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations
[2] Larsen, A., Merrild, H. and Christenen, T., 2009, Recycling of glass: accounting of greenhouse gases and global warming contributions
[3] Includes both raw materials and recycled cullets. Assumes that recycle plant is at the same location as the production facility

Transport

Volume: 80 m^3
Maximum payload: 25t
Emissions[1]: 62-gram CO_2/ton-km

GLASS

Ship empty glass containers to warehouse

Weight per container:	0.5 kg
Total mass:	25t
Amount of containers:	50.000
Distance:	100 km
Emissions:	155 kg CO_2
Relative emissions:	3.1 g CO_2/container

65 containers/year at reuse of 40 times
0,2 kg CO_2 /year

Ship filled glass containers to customers

Weight per container:	1.5 kg
Total mass:	25t
Amount of containers:	16.666
Distance:	100 km
Emissions :	155 kg CO_2
Relative emissions :	0.93 g CO_2/container

2.600 containers/year
24 kg CO_2 /year

[1] ECTA, 2011, Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations

Transport

Volume: 80 m^3
Maximum payload: 25t
Emissions[1]: 62-gram CO_2/ton-km

CARDBOARD

Empty cardboard containers

Weight per container:	0,015 - 0,035 kg
Total mass:	12t
Amount of containers:	80.000 – 62.500
Distance:	100 km
Emissions :	74 - 232 kg CO2
Relative emissions :	0,1 – 0,37 g CO2/container

Filled glass containers

Weight per container:	1.005-1.06 kg
Total mass:	25t
Amount of containers:	23.584 – 24.875
Distance:	100 km
Emissions :	155 kg CO_2
Relative emissions :	6,29 – 6,45 g CO_2/container

2.600 containers/year
16,6 – 17,7 kg CO_2 /year

EMPTY
15 – 40 gram
0,1L (compressed)

FILLED
1015 – 1040 gram
1L

[1] ECTA, 2011, Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations

Washing

Containers/wash: 9[1]

GLASS

Variables

Electricity consumption[2]:	40 kWh/t glass
Natural gas consumption (drying)[2]:	25 m3/t glass
Soda hydroxide consumption[1]:	0,9 g/wash
Water consumption per wash[1]:	3,1 L/wash

Emissions

Electricity[3]:	77 g CO_2/kWh
Soda hydroxide production[2]:	1,12 kg CO_2 /kg
Water production and cleaning[2]:	0,32 kg CO_2 /m3
Natural gas incineration[4]:	0,25 kg CO_2/m3

SCENARIO 1 [Fossil fuels]
2.600 containers/year
12,7 kg CO_2 /year

SCENARIO 2 [100% Renewable energy]
2.600 containers/year
0,6 kg CO2 /year[5]

[1] Based on current operation at Pieter Pot
[2] Larsen, A., Merrild, H. and Christenen, T., 2009, Recycling of glass: accounting of greenhouse gases and global warming contributions
[3] RVO, 2017, National Energy Outlook
[4] Fruergaard, T., Ekvall, T. & Astrup, T. (2009) Energy use and recovery in waste management and implications for accounting of greenhouse gases and global warming contributions.
[5] Only including emissions from sodium hydroxide production and water treatment