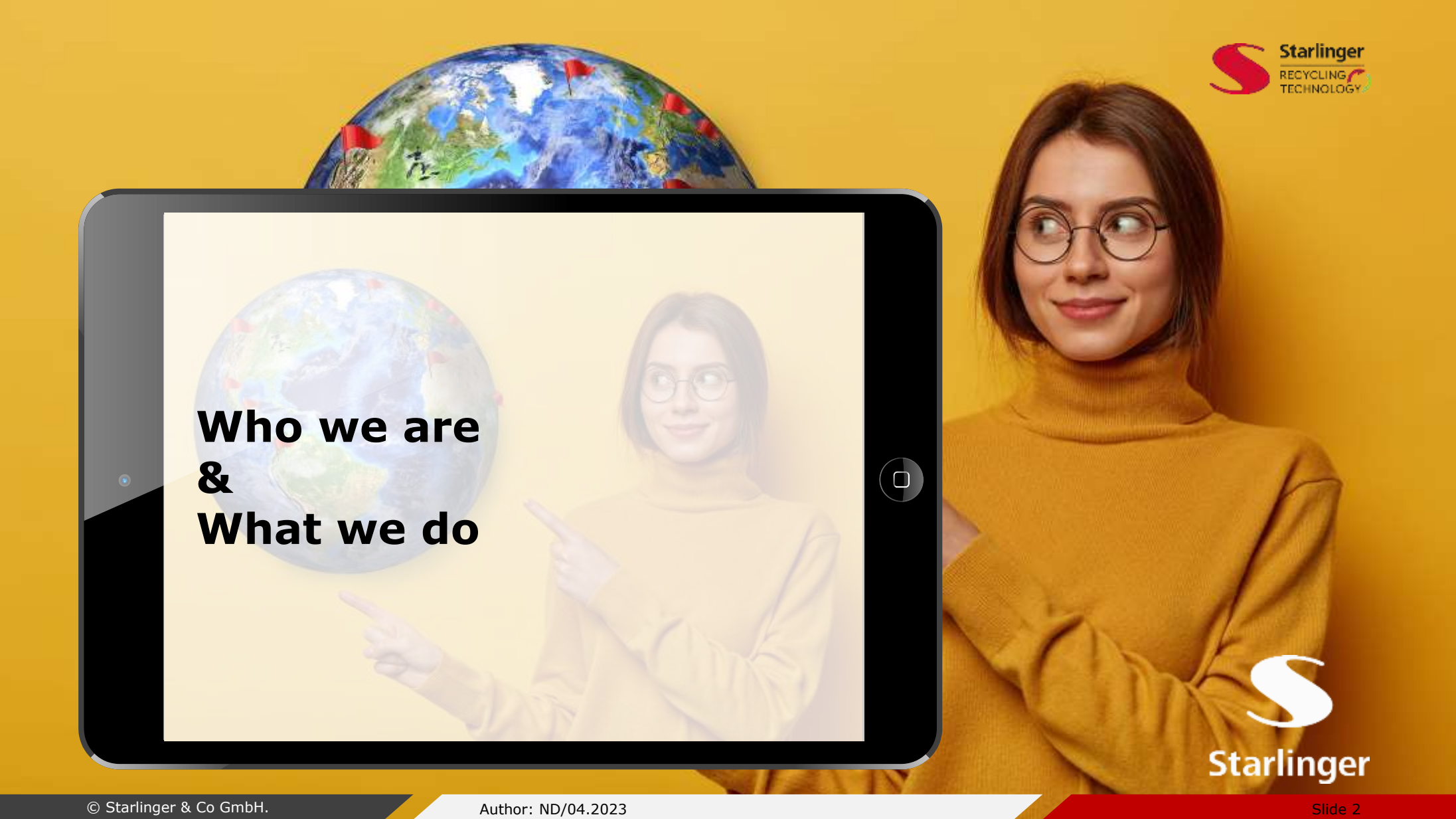
# The art of PET recycling

PETinar 2023



# Starlinger recycling technology

Division of Starlinger & Co GmbH, Austria
Family owned business founded in 1835

Recycling machines for thermoplastics
Production scrap & Post-Consumer plastics

Recycling lines since 1987
Division/Business Unit since 2002

Per 01/2023 > 2 Million tpa installed
PET btb & Polyester recycling capacity

First FDA LNO 2004
Numeruous FDA LNOs, EFSA positive opinions & brand owner approvals

# Solutions for Food-Grade and non Food-Grade rPET

## Flake to Sheet

Up to 100% rPET, inhouse flakes and pellets can be processed at guaranteed iV levels. viscoSHEET installations are highly automated with customized and flexible configuration.

## Flake to Fiber

Various solutions for PES recycling including hybrid lines flake/fiber, ultra-fine filtration with sleeve/candle filter and IV increase in melt phase or solid state

## Flake to Fabric


Woven bags made of 100% rPET flakes: higher fabric strength, high creep resistance, long term form stability (compared to PP)

# Solutions for Food-Grade rPET

Flake to Food-Grade Flake

**deCON 20**
Decontamination dryer for production of food grade flakes (and/or pellets or skeleton waste) directly in front of the production extruder
Food-grade acc. to EFSA, FDA

Flake to Food-Grade Flake

**viscoSTAR**
Solid-state polycondensation
Consistent and adjustable IV
Excellent colour values
Low AA-values
Food-grade acc. to EFSA, FDA,

Flake to Food-Grade Melt

**viscoZERO**
Melt- phase decontamination
Food-grade PS, PP and HDPE
IV increase of polyester
spin finish removal
odour removal
FDA pending

Flake to Pellet (btb)

**recoSTAR PET art**
Single stage drying, extrusion without degassing, melt filtration, pelletizing,
IV increase of pellets
Decontamination
Food-grade acc. to EFSA, FDA

# Market dynamics

# Minimum recycled content mandates

- EU SUP directive (national law since 07/2021): 25% rPET in bottles by 2025 (2018 was 17%), 30% r-plastic in all bottles by 2030
- EU PPWR revision: mandate for all plastic in packaging, expected vote 2024/Q2 in EP
- California: 2022 min. 15% r-plastic in beverage bottles (25% by 2025, 50% by 2050)
  More to come in USA: WA/NJ bill by 2023/24 also CT and MD
- India: Flexible packaging 10% content and rigid 30% by 2025
- UAE: 35% rPET in bottles by 2025 expected

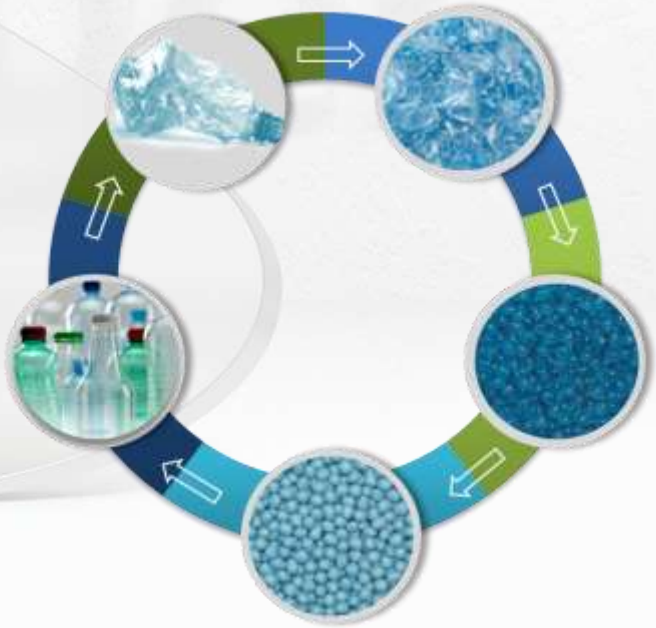
# Industry and Brand owner recycled content pledges

EU industry (CPA, not only brand owner): 10 million tonnes of r-plastic uptake in new products by 2025, FMCG brand owners see table below

| | Coca Cola | PepsiCo | Nestlé | Danone |
|---|---|---|---|---|
| **Total Plastics usage** | 2.96 mio metric tonnes | 2.5 mio metric tonnes | 1 mio metric tonnes | 716,500 metric tonnes |
| **PET share in total usage** | 97% for bottles | 31% | Unknown | 45% for bottles |
| **Recycling Targets** | 25% by 2025<br>50% by 2030 | 25% by 2025<br>100% by 2030 (for USA) | unknown | By 2025<br>25% for packaging<br>50% for water & beverages<br>100% for Evian bottles |
| **Reduced use of virgin material** | 5 year goal of 3 mio metric tonnes (2020-2025) | 35% by 2025<br>50% by 2030 | 1/3rd by 2025 | 33% by 2025 |

# Challenges

- Where do the bales/flakes are coming from and in which quality?
- Washing quality is important, machine configuration to match the input stream
- Flake quality influences following processes (extrusion/SSP)
- Technology selection depending on the application
  - IV increase
  - AA reduction
  - Colour values L, a, b
  - Decontamination values
- Food contact regulations
  (national rules vs. brand owner approvals)
  (super cleaning vs. closed loop approach)
- Economy (bale prices, production costs, vPET price)



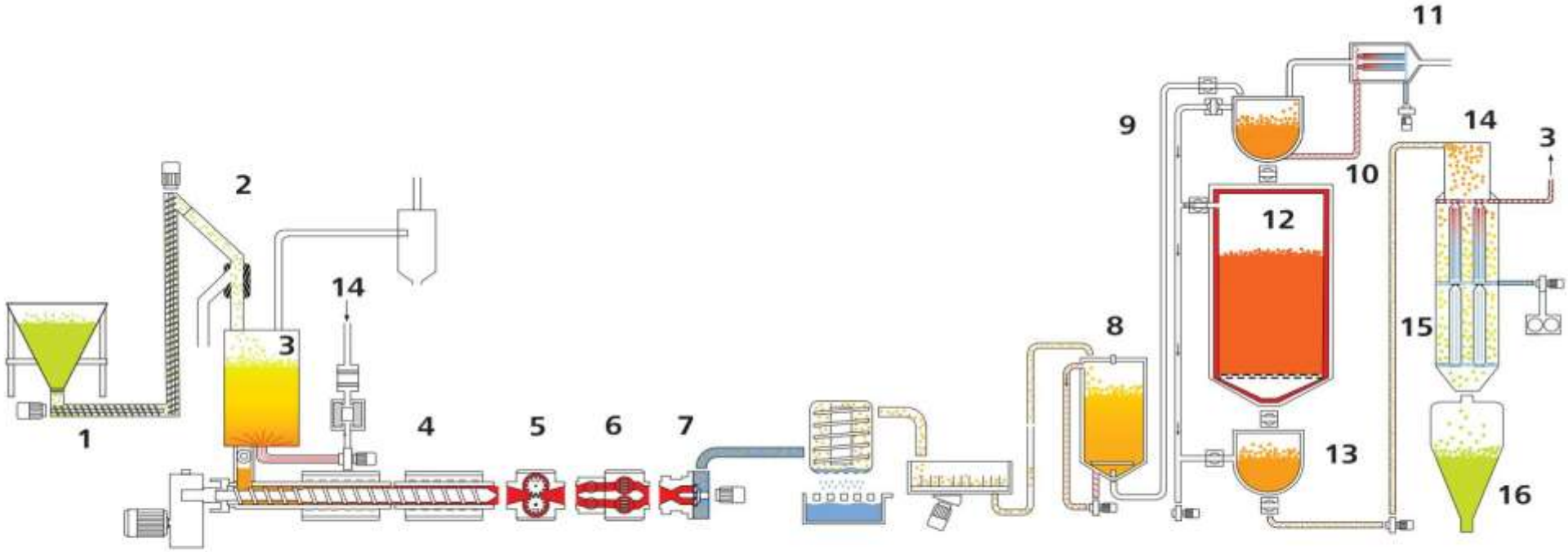
# Food Contact Evaluation

- Countries allow / prohibit / or neither of both rPET in food contact materials
- National rules vs. brand owner approvals
- Super cleaning vs. chain of custody/closed loop
- US FDA : PET from food- and non-food containers (excl. industrial containers)
- EU EFSA: PET which has already been food-safe, max. 5% non-food-safe PET in the stream
- Percentage of rPET in direct food contact → large differences (Starlinger: 100%)
- US FDA LNO (was) seen as the "gold standard", was therefore taken over by other countries

# THE ART OF RECYCLING

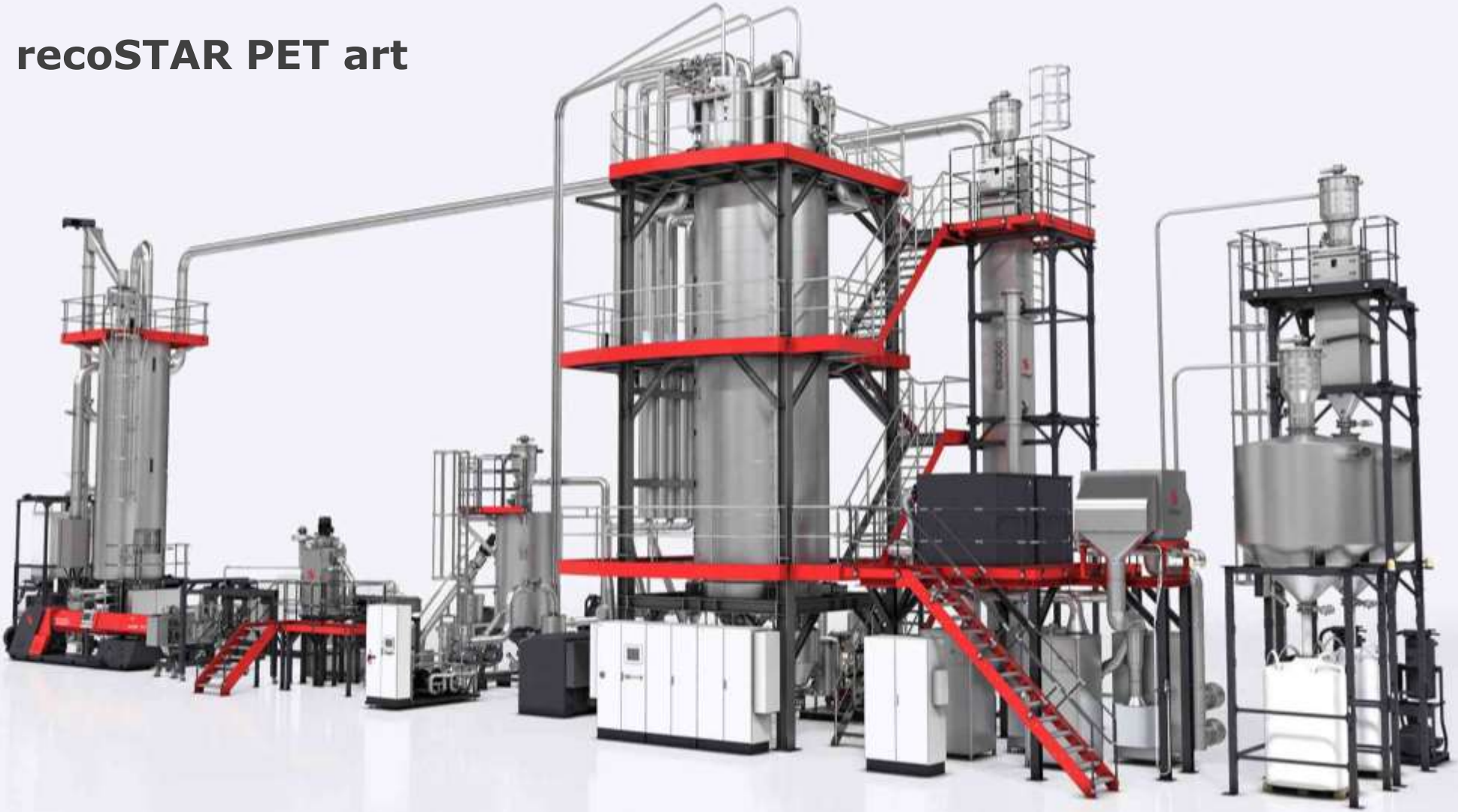
# recoSTAR PETart

# Process Flow Description bottle-to-bottle recycling recoSTAR PET art




1. Feeding screw
2. Metal separator
3. Combined drying unit
4. Extruder
5. Melt pump
6. Melt filter with backflush
7. Underwater pelletiser with inline crystallisation
8. Post-cristallisation unit
9. Separat vacuum feeding system
10. SSP preheater
11. Heat exchanger for preheater
12. SSP reactor
13. Cooling unit/vacuum sluice
14. Energy recovery kit
15. Pellet water cooler
16. Storage silo

# recoSTAR PET art



# Description of rPET pellets

- **intrinsic viscosity: adjustable**
- **acetaldehyde (AA): less than 1 ppm**
- physical status: crystalline > 40 %
- **colour b-value: depending on input material, usually < 2**
- colour L-value: depending on input material, usually > 70
- melting point: approx. 245°C
- bulk density: approx. 850 kg/m³ (spherical pellets)
- specific density (crystalline): about 1.39 g/cm³
- **pellet weight: adjustable, normally 50-60 pcs/gr**
- **dust content: max. 500 ppm (like resin)**
- humidity: max. 0.1 %
- **decontamination:** FDA non objection letter, EFSA requirements achieved

# HMI

- preventive maintenance notification
- RFID technology for personalized access authorization (different levels)
- traceability
- data logger for up to 40 parameters (e.g. for EFSA sampling / data validation)
- 15” display
- remote access/online support
- VNC viewer read only access to HMI for live browsing

# Online Quality Monitoring

## Online Viscosity Rheometer

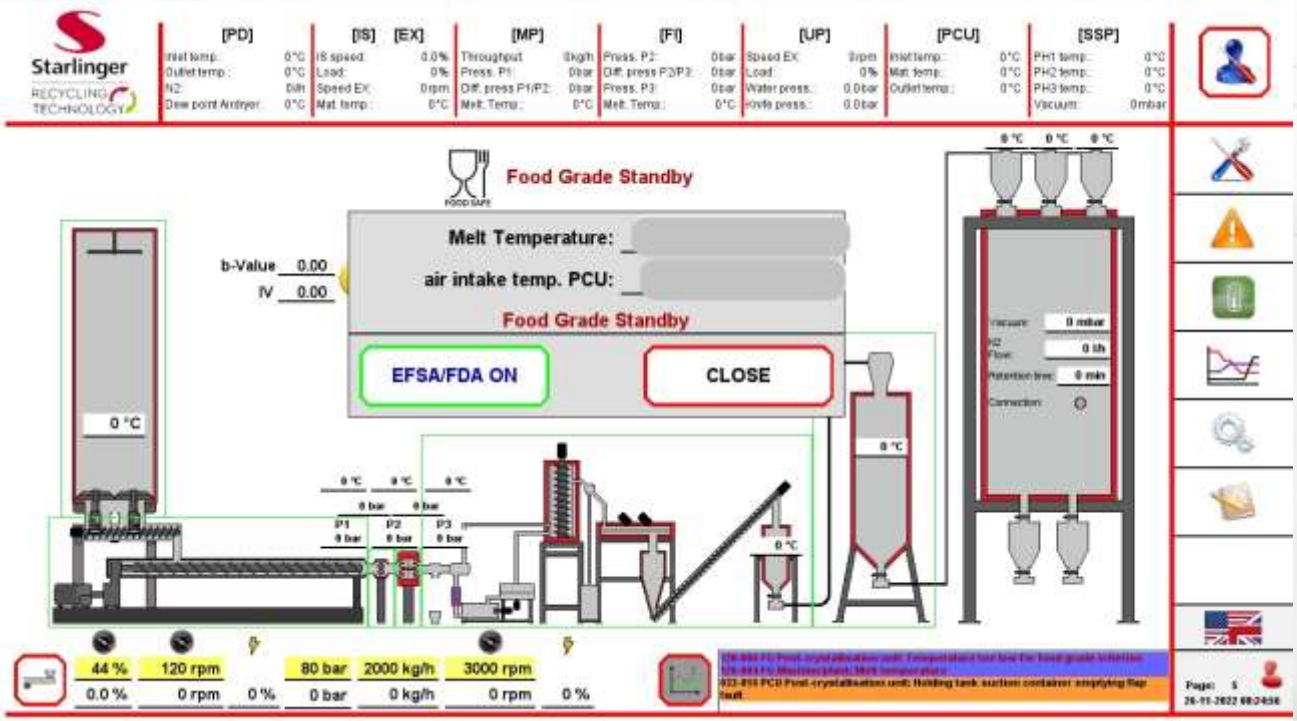
- real time IV measurement allows quick parameter adaption
- delivered plug & play
- software played directly into the plc
- data transfer on the customer's own USB available

# Online Quality Monitoring


## Online Colour Measurement

- real time color measurement allows quick parameter adaption
- placed after in-line crystallisation for L*a*b*measurement of the partly crystalline pellets
- feedback loop to control liquid additive e.g. color toner / anti-yellow dosing rate based on the measured color values of the pellets

# Online Quality Monitoring




## Food-Grade Monitoring

- automatic monitoring of food-safety relevant process parameters
- automatic separation of non-FG material

# Achievements

# recoSTAR PET art
# Increased Output

# recoSTAR PET art
# Reduced maintenance requirements

Indicator

Availability

Performance

Quality

**–46%**

Losses

**Unscheduled stops**

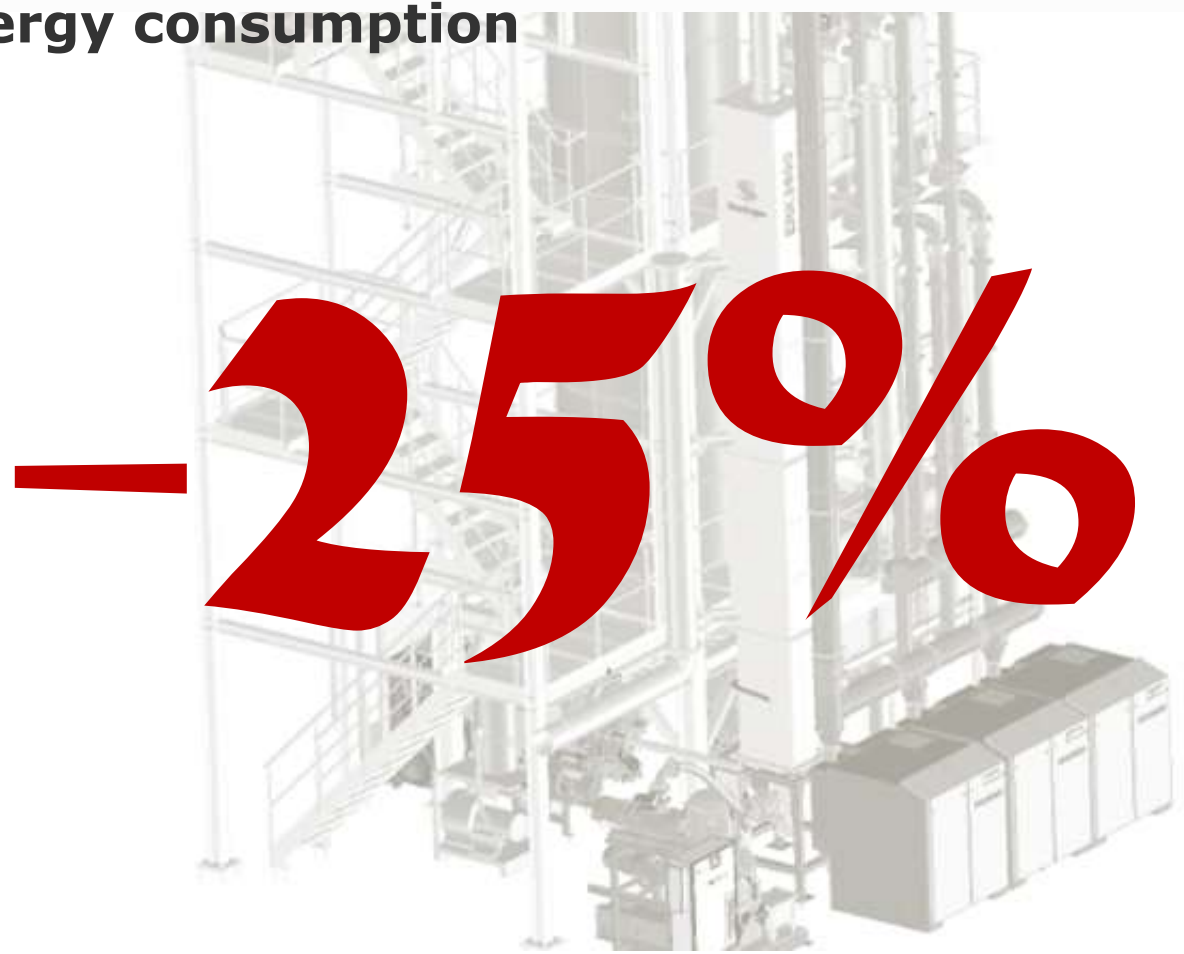
**Scheduled stops**

Reduced speed

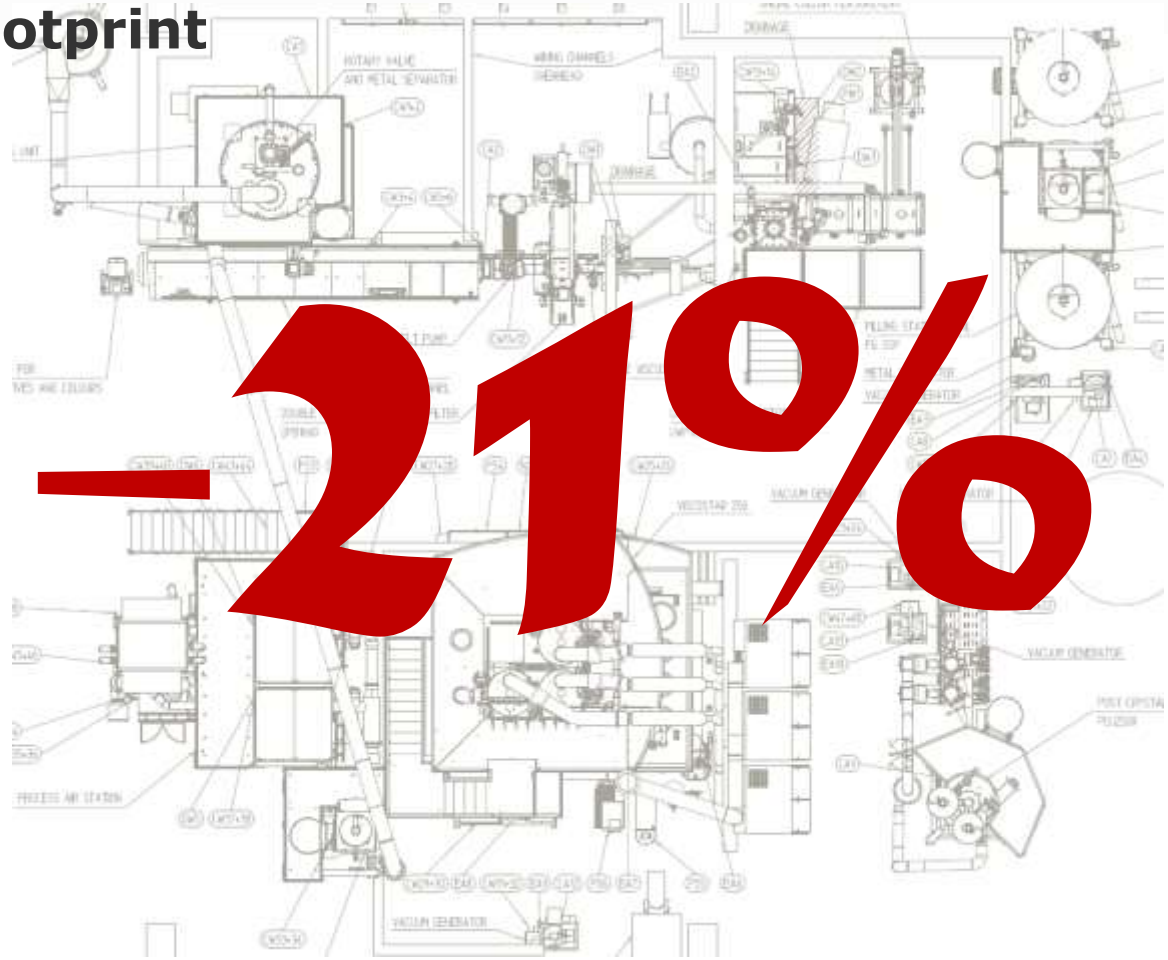
Production rejects

Start-up rejects

# recoSTAR PET art
## Reduced energy consumption



# recoSTAR PET art
# Reduced Footprint



# recoSTAR PET art
# Steady rPET bottle-to-bottle quality

| Technology | IV [dl/g] | L* | a* | b* |
|---|---|---|---|---|
| recoSTAR PET art | 0.82 | 70.45 | -2.83 | -1.26<br>without anti-yellow |
| recoSTAR PET iV+ | 0.82 | 70.69 | -2.85 | -0.22<br>with anti-yellow |

# recoSTAR PET art
# Steady rPET bottle-to-bottle quality