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NEXTEK Ltd - What we do

- Recycling plant design and Feasibility studies
- Strategic advice to Multi-National Corporations and Recycling Co's
- Food grade recycling of post consumer plastics – process development
- Research and development of novel materials and processes including plastics and bioplastics
- Business support, productivity improvement and problem solving
- Ground breaking projects for governments and major commercial organisations in the EU, UK, India, Malaysia, USA, South America, Middle East, North Africa and Australia/NZ
- Strong ties to Universities and Scientific Centres of Excellence in the UK and Europe

nextek recent awards





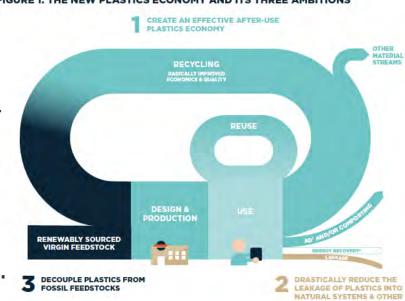
Creating a Circular Destiny for Plastics with Whole Cycle Product Thinking

- Principles of efficient plastics recycling
 - What recycling plants see as ideal operations
- The importance of Design in Recycling
 - Recycling impact of products, Whole cycle product thinking
- Case studies in recycling of mixed rigid and flexible plastics
 - Sleeves, PET trays, PP, Black Plastics, mixed films
- Strategies for Brand Owners and Retailers
 - Labels and Standard Design Guidelines
- An Action Agenda for the future Taking Responsibility.



Principles of Circular Economy Plastics Recycling

- The best value is obtained for high quality resins that can replace virgin resins.
- The plant has high yields/low losses based on input >75% (some can be <50% generating more waste than product)
- The separation of plastics is into mono polymer types to a high quality >99.9%
- The plant can output >2 t/hr of the major plastics
- The plant is simple to run with stable continuous processes that are simple to control.
- There is a steady supply of a consistent infeed material for the plant.
- Where possible, the plastics are clear
- Every possible contaminant can be removed in an efficient, safe way inc inks
- By products (caps, labels) can be sold



Source: The New Plastics Economy - Rethinking the future of plastics

Products and Resins must be designed to be recycled into a defined destination replacing virgin resin



Key Steps in the Plastics Recycling Process

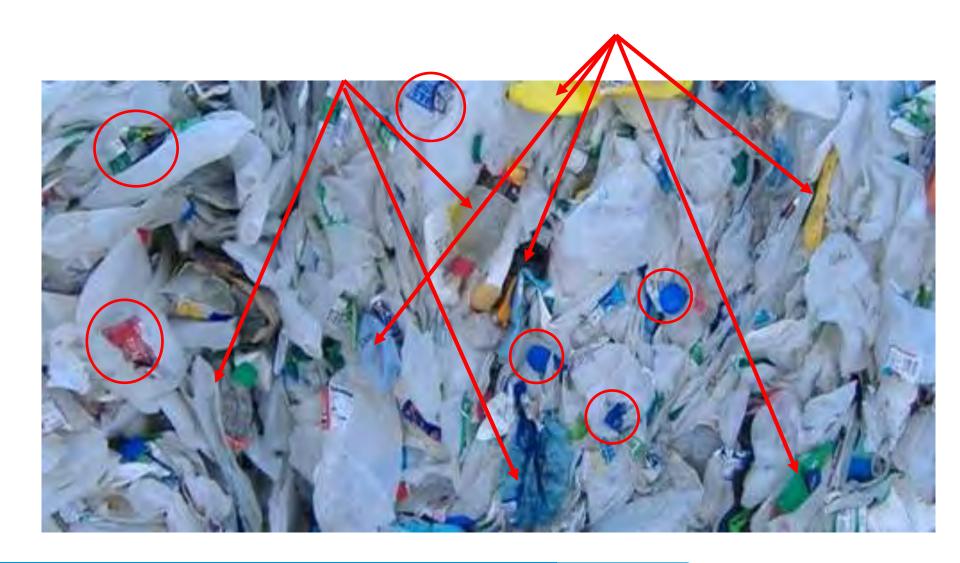
- Accept material in Bales
- 2. Debale into single bottles
- 3. Remove glass and sand (trommel)
- Remove loose labels and metal
- 5. Sort into plastic type
- Cut bottle into flakes
- 7. Wash flakes with detergents, rinse, dry
- 8. Remove loose labels
- 9. Sort out coloured particles
- 10. Remove traces of metal
- 11. Decontaminate the flakes
- 12. Extrude flakes into clear and clean granules.
- 13. Test plastic for conformance to standards
 - 1. Physical, colour, food grade, odour,







HDPE Bottles Plus contaminants in bales



PET Bottles Plus









Recycled HDPE for A CIRCULAR ECONOMY

- The key requirements are
- 1. CONSISTENCY IN ALL PROPERTIES
- 2. NEUTRAL COLOUR THAT CAN BE USED IN ALL PRODUCTS
- 3. CONSTANT COMPOSITION (CONSTANT MELT FLOW INDEX AND COLOUR)
- 4. CONSTANT MECHANICAL PROPERTIES
- 5. LOW ODOUR
- 6. **PRICE comparable to VIRGIN RESIN** (but not necessarily much lower!)
- (rHDPE for other markets such as pipes will only reach approx 2/3 of virgin resin)
- CAN WE DO IT RIGHT NOW ????
- No for Food grade, but, YES Non-Food grade



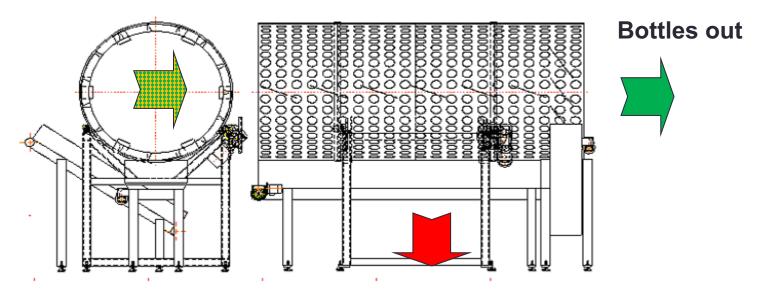
PCR HDPE in Laundry Bottles



Key recycling steps

Trommel to remove glass and sand – holes are ~ 40 mm

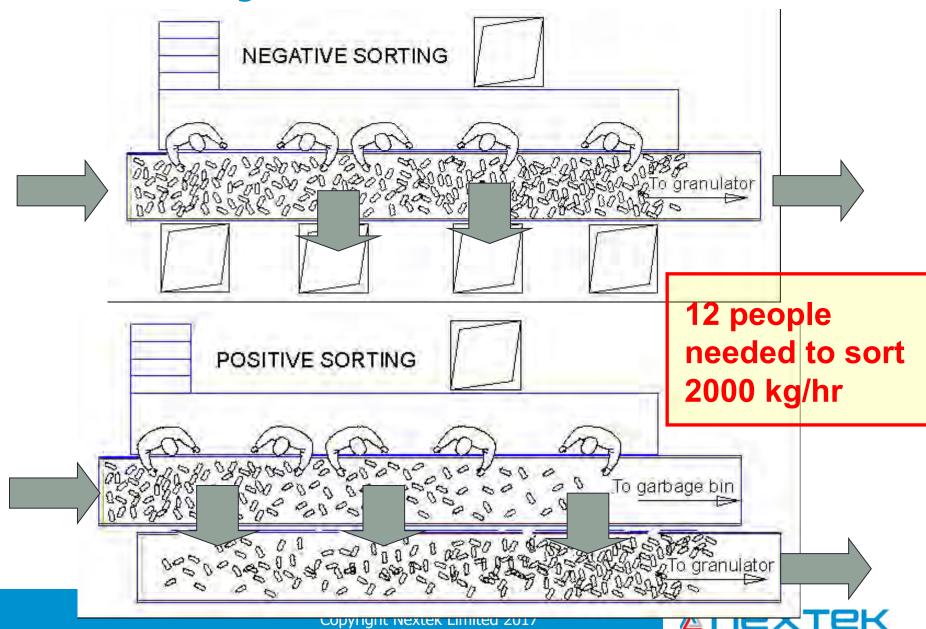
Bottles and dirt in



Dirt and Glass falls out Caps and Small Bottles as well



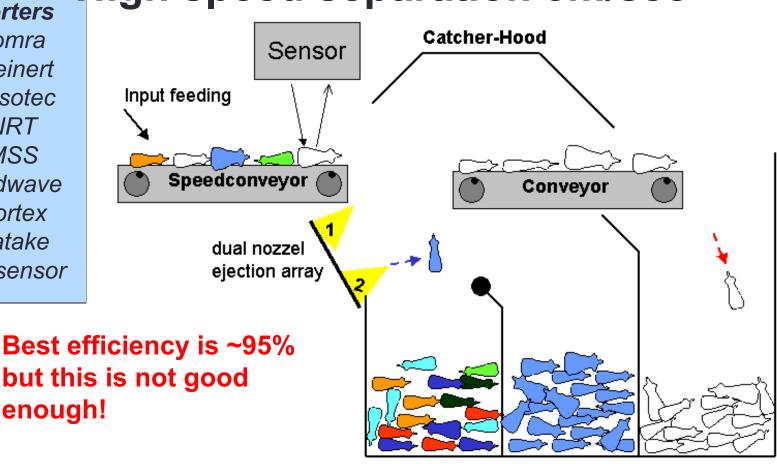
Manual Sorting



Near Infra Red Automatic sorting

High speed separation 3m/sec

Sorters Tomra Steinert Sesotec NRT MSS Redwave Sortex Satake Unisensor



UNISORT Triple Sorting Modul

Flowpath Sorted Fraction e.q.: HDPE

Sorted Fraction e.g.: PET



Sink / Float Separation

Polypropylene	(PP)	(0.90 g/m ³
Poly(Ethylene-co- Vinyl Acetate)	(EVA)	(0.92. g/cm ³)
Low-Density Polyethylene	(LDPE)	(0.92.g/m ³)
High-Density Polyethylene	(HDPE)	(0.96. g/m ³)
Water		(1.00. g/m ³)
Styrenics	ABS	(1.05. g/m ³)
Orientated Polystyrene	(OPS)	(1.06. g/m ³)
Poly Vinyl Chloride	(PVC)	(1.35. g/m ³)
Polyethylene Terephthalate	(PET)	(1.38. g/m ³)



PET bottle with PVC sleeves

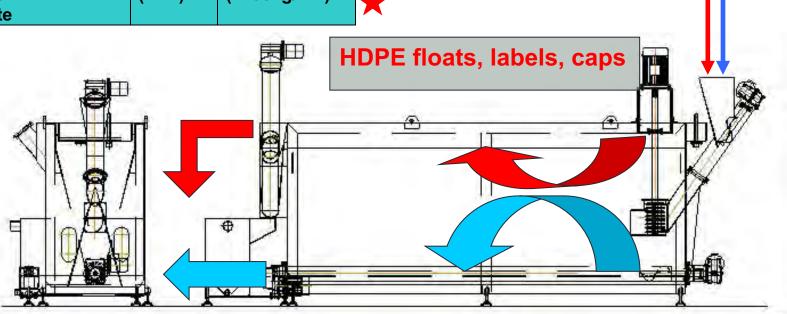


Sports Caps with silicon seal



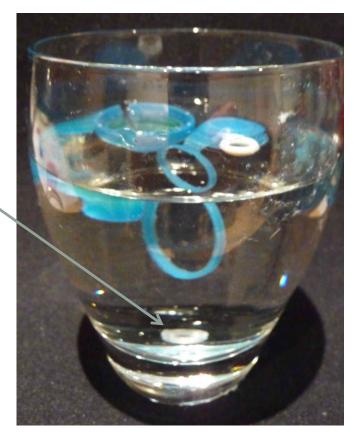
Trigger packs

Mixed flake in



Separation issues created by choice of materials Silicone rubber seals in Sports caps contaminate RPET





Better design is the key to greater recycled quality







Trigger Pack made from 100% polyolefins (PP and TPE)





Difficult to recycle plastics products -OPAQUE white PET



White PET dramatically increases haze in clear PET and looks like crystallised PET and is very difficult to separate the two.



Multi Layer UHT Milk (inc. black) Opaque HDPE and PET











2/3 Layer PET



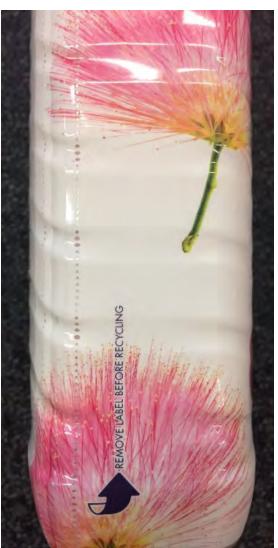
HDPE 3 Layer





Full Body sleeves (with zip) – on an opaque PET bottle









Meat packaging and Trays

Vacuum

 packaging can
 increase the life
 of meat by 50%

•

 Vacuum skin packed Sirloin.
 Shelf life increase from 6 to 16 days.

 Food waste reduction: from 34% to 18%.







Flow pack Vacuum



APET Thermoforms – 700,000 t/yr Europe

Many Thermoforms are laminated with PE for sealability making recycling problematic

Rigid PET

Sheet

3 Layers: A. 5-10% Virgin B. 90-80% Bottle flakes A. 5-10% Virgin

Also with laminated layer for seal-ability

Riaid PET

Sheet

3 Layers: A. 5-10% Virgin B. 90-80% Bottle flakes

A. 5-10% Virgin Plus laminated layer for seal-ability

Rigid PET Sheet Mono layer 100% Bottle flakes

Colored Rigid PET Sheet

3 Layers:

A. 5-10% Virgin

B. 90-80% Bottle flakes

A. 5-10% Virgin

Also with laminated layer for seal-ability



Rigid PET Sheet 3 Layers:

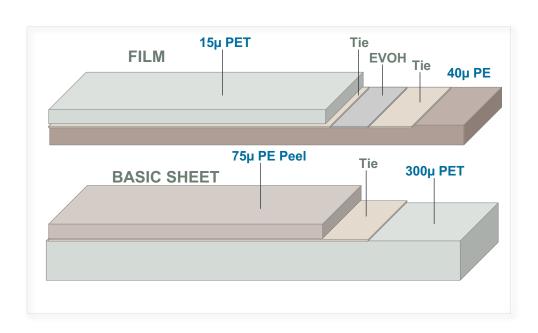
A. 5-10% Virgin **B. 90-80% Bottle** flakes

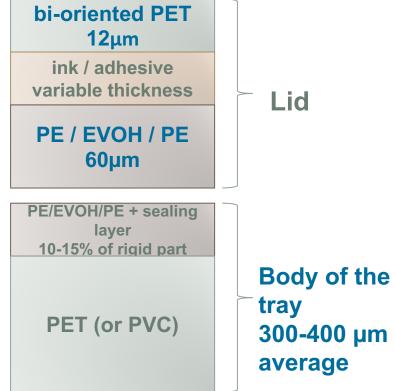
A. 5-10% Virgin

Multilayer Thermoform trays

Multilayer Thermoforms trays:

Most of the multilayer trays are rigid for the base with a PET base (bottom) & flexible lids for the top with PE/PET





Recycling Process impact

APET MONOLAYER

- Difference in IV versus PET bottle
- APET crystallises during hot washing stage and becomes brittle during the flake processing steps and up to 50% is lost as fines less than 2 mm.
- NO/LOW impact on color properties

APET + MULTILAYER

- High impact on color properties due to barrier layers decomposing
- Multilayer trays can be sorted with NIR
- Application in colored sheet



Oven test low level of multilayer



Oven test high level of multilayer



Rigid Black Tray Packaging in Mixed Plastics MRF Residue Streams – 70,000 t/yr in UK





Black pots, tubs and trays are typically colored with carbon black masterbatch based pigments. Carbon black readily absorbs visible and infra-red light.

Majority of the sorting systems around the world use NIR (Near-Infra Red) to identify and sort plastic packaging by polymer type. So black trays are invisible.



NIR Detection of Commercially Available Detectable Black Plastic Trays in the UK



Commercial carbon black trays from UK retailers were tested using NIR, MIR and Laser based Spectroscopy

• rPET, APET, CPET, HIPS, PP, Starch material black trays tested

 Extensive tests performed at several leading sorting equipment suppliers in





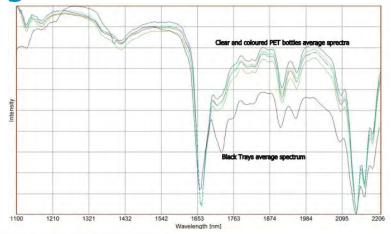






CPET (for ready meals) sorting trials

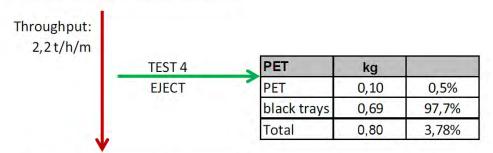
Detectable black trays could also be identified as CPET by NIR making it possible to separate CPET into its own stream for closed loop recycling of detectable black CPET materials.





Spectra and Pixel map of APET bottle and black tray

Input	kg	
Total	21,10	100,00%



Drop	kg	
PET	20,28	99,49%
black trays	0,02	2,25%
Total	20,30	96,22%

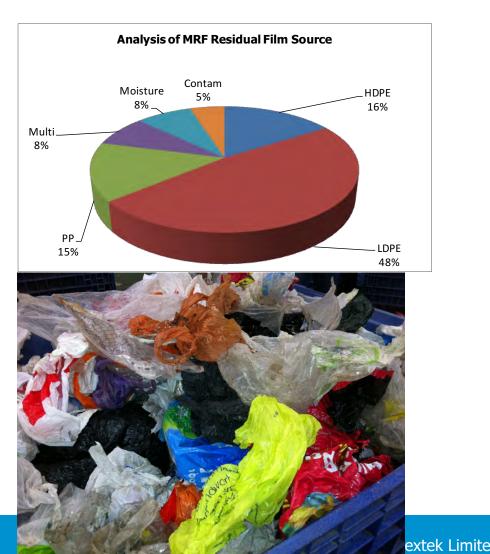
Recovery:	
PET	99,5%
black trays	97,7%

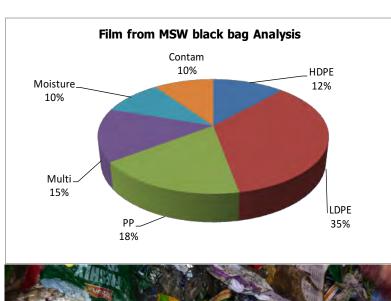
Quantitative +ve separation of black trays (TITECH)



Recycling of Mixed Films

MRF waste film $(\pm £0/t)$ and Black Bag waste (-£75/t) film







Problems with recycling mixed plastic films

- Polyethylene (LD+HD) is typically 45%-65%
- PP content is 15% 18%
- Multi Layer is 8% -15%
- Contaminants are 5% -10% (paper, rigid plastics, metals)
- Moisture is 8% -10%
- Yields will be low typically 50% at best lots of waste
- Throughputs rates low due to low bulk density
- Multilayer and PP content needs to be minimised by NIR sorting
- Contaminants are stuck to film (paper, organics)
- Strong odour to recovered films and pellets
- Moisture and volatiles need to be removed energy cost

Pouch made from Polyolefin materials replacing a multi layer construction.

REFLEX PROJECT







High Performance devolatilisation can address printing

inks and volatiles







EXTRICOM



100% recycled film



MAS





GNEUSS





EREMA





Using invisible markers on labels for auto detectors!

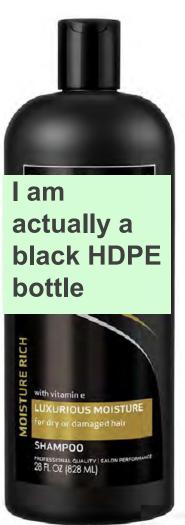


I am actually a clear PET bottle (or a multilayer bottle or a bioplastic)





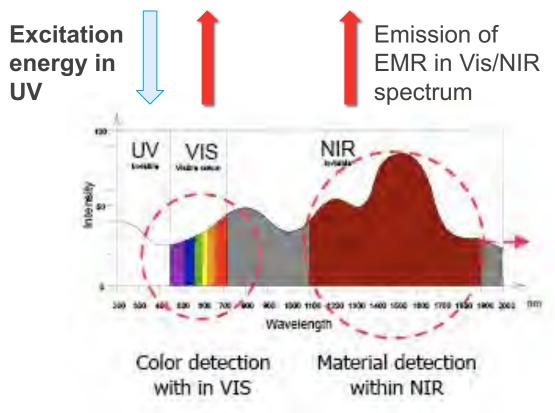






New sorting technology -Fluorescence Markers

- Organic or inorganic compounds
- Emit light (fluorescence) in the visible or Near Infra-red spectrum when excited with UV laser





Sorting of plastics Packaging in Plastics Recycling Facility

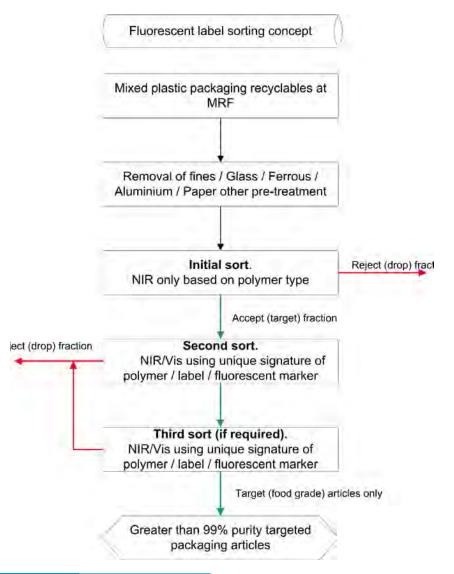
 Current - Mixed bottles are sorted by polymer type and colour







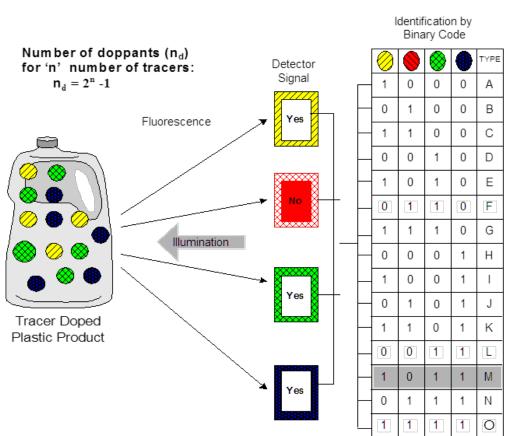
 Future - Fluorescent markers could be used for sorting either at the initial stage (mixed polymers) or at the latter stages of sorting (mono polymer stream) to confirm recent use of the pack eg food contact or use with noxious substances





The Protocol

- •The use of multiple markers allows additional coding opportunities.
- •The number of combinations is given by Number=2ⁿ-1
- •Three markers = 7 coding sets per type of plastic
- •Four markers = 15 coding sets per type of plastics





The Protocol for the PRISM project

- coding of packs by polymer-type AND RECENT APPLICATION





Protocol for Sorting Plastics

Package type	Food Grade Natural and Full length sleeve	Food grade natural Pots, Tubs and Trays	Food Grade Coloured and Full length sleeve	Non-Food Grade Natural or Coloured and Full length sleeve
PET	RED-1	RED-1 & Yellow -1	RED-1 & Cyan-1	Yellow -1
HDPE	RED-1	RED-1 & Yellow -1	RED-1 & Cyan-1	Yellow -1
PP	RED-1	RED-1 & Yellow -1	RED-1 & Cyan-1	Yellow -1
Other Polymers	RED-1	RED-1 & Yellow -1	RED-1 & Cyan-1	Yellow -1



Video Sorting food grade sleeve selected from mixed plastics



Strategies for Brand Owners and Retailers for a Circular Economy

- Identify All packaging they use as "Recyclable" or "Not Recyclable"
- Educate and encourage consumers to recover and recycle
- Ensure all packaging is approved for recyclability by recycling industry groups like EPBP, APR, PRE using guidelines such as RecyClass.
- Eliminate non recyclable packaging
- Use only PP, HDPE and PET
- Develop "mono-material compatible" clear packaging for high performance recycling
- Investigate marker technology for advanced sorting for difficult to recycle packaging
- Decoration minimal/removable inks
- Labels easy to remove and recyclable









On Pack Recycling Label



Recycling Guidelines Plastics Recyclers Europe

Clear PET Thermoforms

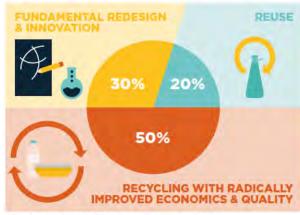
4	VES	CONDITIONAL	NO
	Full compatibility — materials that passed the testing protocols with no negative impact OR materials that have not been tested (yet), but are known to be acceptable in PET recycling	Limited compatibility – materials that passed the testing protocols if certain conditions are met OR materials that have not been tested (yet), but pose a low risk of interfering with PET recycling	Low compatibility – materials that failed the testing protocols OR materials that have not been tested (yet), but pose a high risk of interfering with PET recycling
Container	PET		C-PET , PETG, PET+PE, any multilayer film (PET/PE/EVOH, PT/PE/PA, etc.).
Colours	Clear,	light transparent colours	Opaque, dark colours, Metallized, Black
<u>Barrier</u>		Oxygen scavenger (PET based)	EVOH, PA
<u>Additives</u>	Antiblocking masterbatch (< 0.5%)		Any other additive affecting colour and density of PET
Coatings			Any other coating affecting colour and density of PET
<u>Closure</u> Systems	same material as body (clear)	Material with density < 1 kg./cm3 & Light transparent colours	Any other material and/or colour except transparent or light transparent colour
<u>Lid</u>	same material as body (clear)	Multilayers sealed with glue detaching at 60°C-80°C, Material with density < 1 kg./cm3 & Light transparent colours	Any other lid
Pads			Every pad
<u>Labels</u>	PET transparent/Light colours/non-covering colours. Labels that must be completely removed before opening the tray		Any other labels/sleeves. Metallised materials; non-detaching or welded labels
<u>Adhesives</u>	water or alkali soluble in 60-80°C	hot-melts	pressure-sensitive labels; self-adhesive labels; not water soluble
<u>Inks</u>	non-toxic; follow EUPIA Guidelines		inks that bleed; toxic or hazardous inks
<u>Direct</u> Printing	laser marked	production or expiry date	any other direct printing



An action Agenda for the Future Taking Resposibility

- To reach the ambitious APC Goals, the packaging supply chain must link up and
 - Create real consumer engagement to recover packaging
 - Boost recycling efficiency for recyclers
 - Directly create the pull for recycled material content for all products as standard practice every day, every year
- Recycling operations for the big three resins should be on a big scale to gain economies (100,000 tonnes/yr). The total level of recycling activity should be at least 70% of packaging production.
- Resin companies and Brand Owners should have a stake in recycling operations to close the circle on their products and ensure longevity of recyclers.
- All products will be made with credible end of life scenario(s) in mind

FIGURE 2: THREE DISTINCT TRANSITIONS STRATEGIES TO ACCELERATE THE SHIFT TOWARDS THE NEW PLASTICS ECONOMY (SHARE OF PLASTIC PACKAGING MARKET BY WEIGHT)



Source: New Plastics Economy Initiative analysis (see Appendix for details





