

RECYCLING & UPCYCLING OF PLASTICS

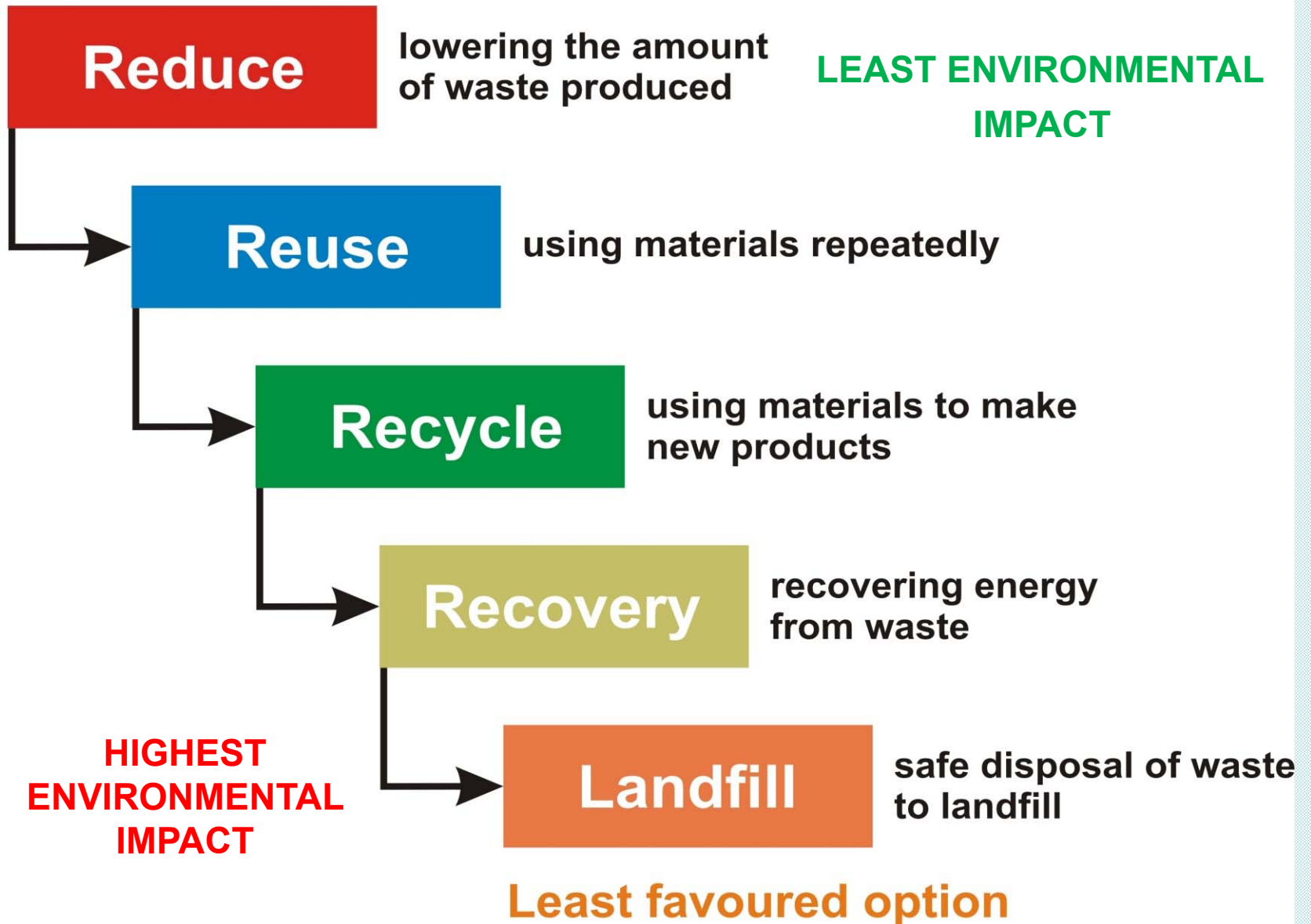
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KPS CONSULTANTS & IMPEX PVT. LTD.**

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WASTE HEIRARCHY & ENVIRONMENTAL IMPACT

Most favoured option



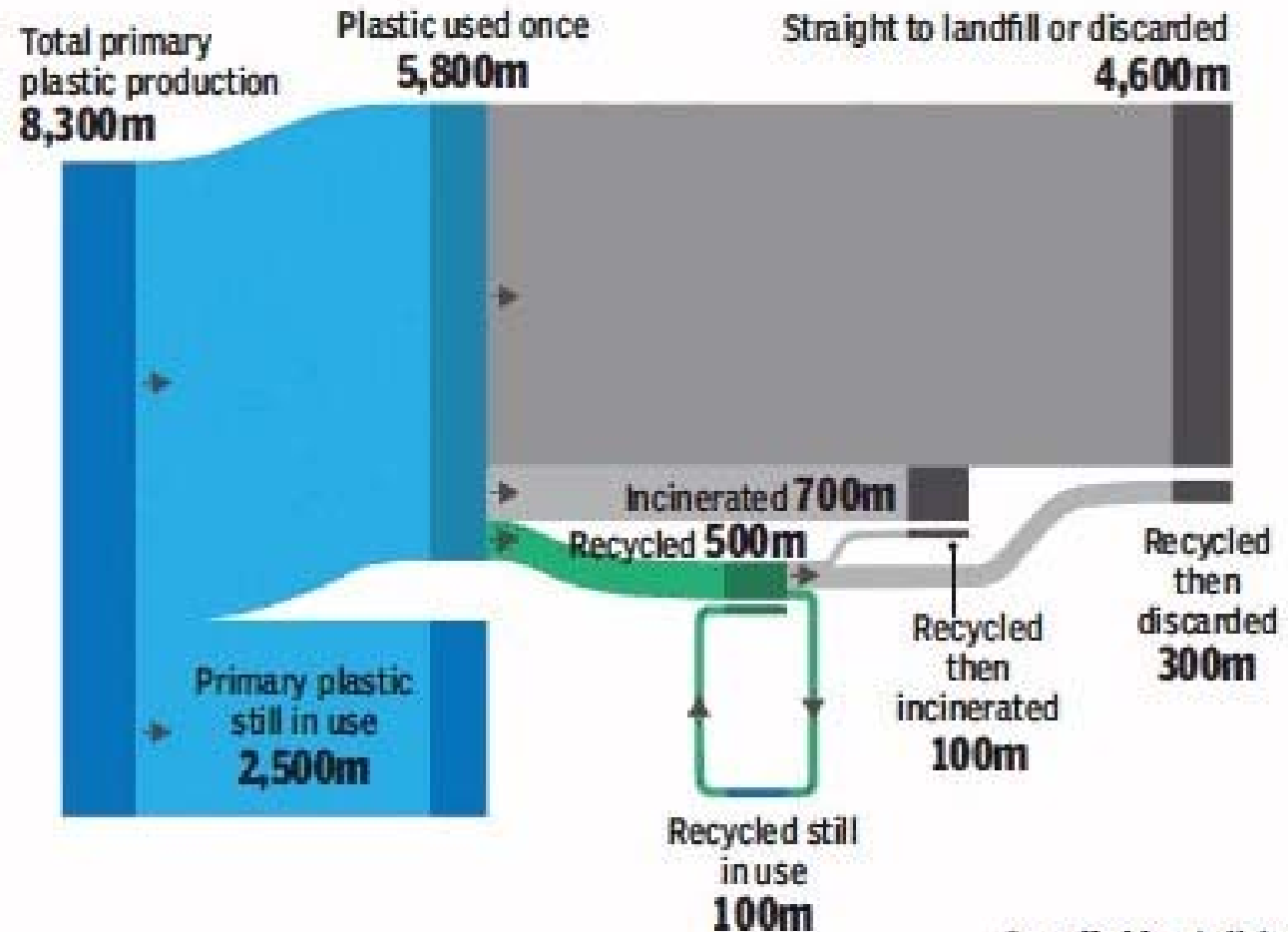
But almost 80% of all plastic remains in the environment

450 years to forever is how long plastic endures in the environment

40% of plastic produced is packaging used once and then discarded

79% Of all plastic produced since 1950 is still in the environment

GLOBAL PLASTIC PRODUCTION AND ITS FATE (1950-2015) (Measured in tonnes)




Compiled by: Anjishnu D

(Ref: The Times of India, 23rd August 2019)





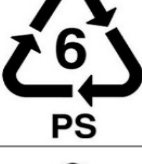

WASTE SIDE STORY

Total municipal solid and plastic waste (tonnes per day)- 2010-11

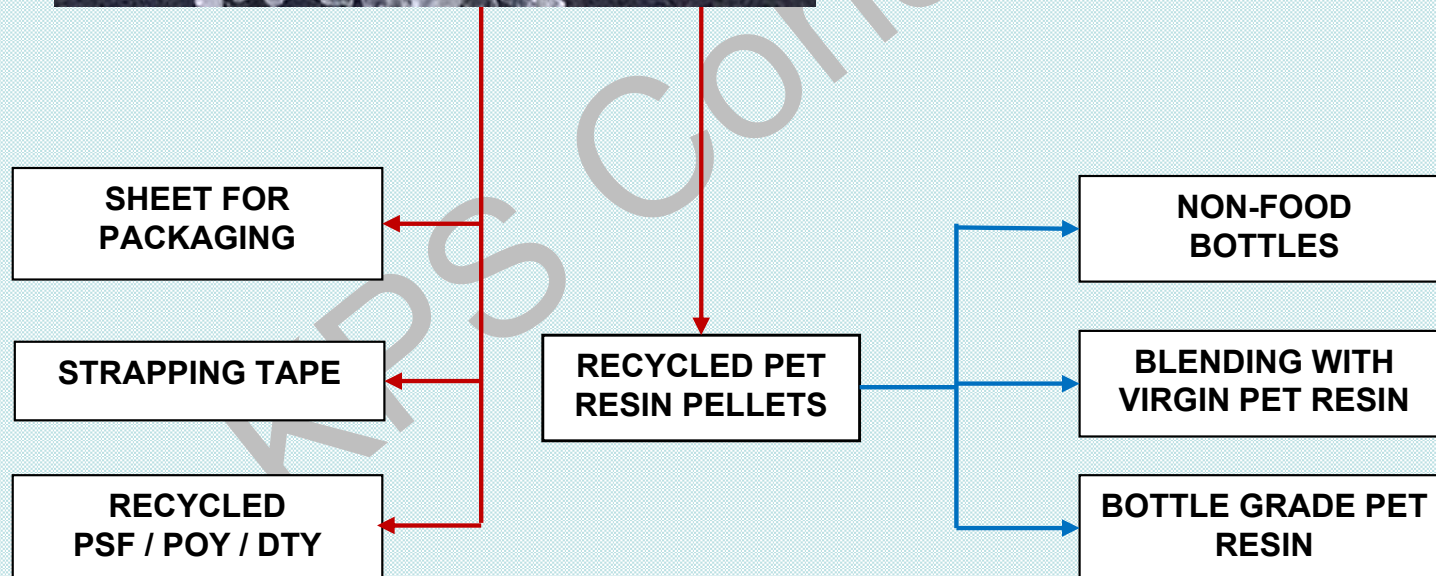
| City | Municipal Solid Waste | Plastic Waste | Plastic Waste as % of total  |
|-----------|-----------------------|---------------|---|
| Delhi | 6,800 | 690 | 10.1 |
| Chennai | 4,500 | 429 | 9.5 |
| Kolkata | 3,670 | 426 | 11.6 |
| Mumbai | 6,500 | 408 | 6.3 |
| Bangalore | 3,700 | 314 | 8.5 |
| Ahmedabad | 2,300 | 242 | 10.5 |
| Hyderabad | 4,200 | 199 | 4.8 |
| Surat | 1,200 | 150 | 12.5 |
| Kanpur | 1,600 | 107 | 6.7 |
| Pune | 1,300 | 101 | 7.8 |

Source: CPCB

Delhi tops in generating plastic waste
(Ref: The Times of India, 17th August 2019)

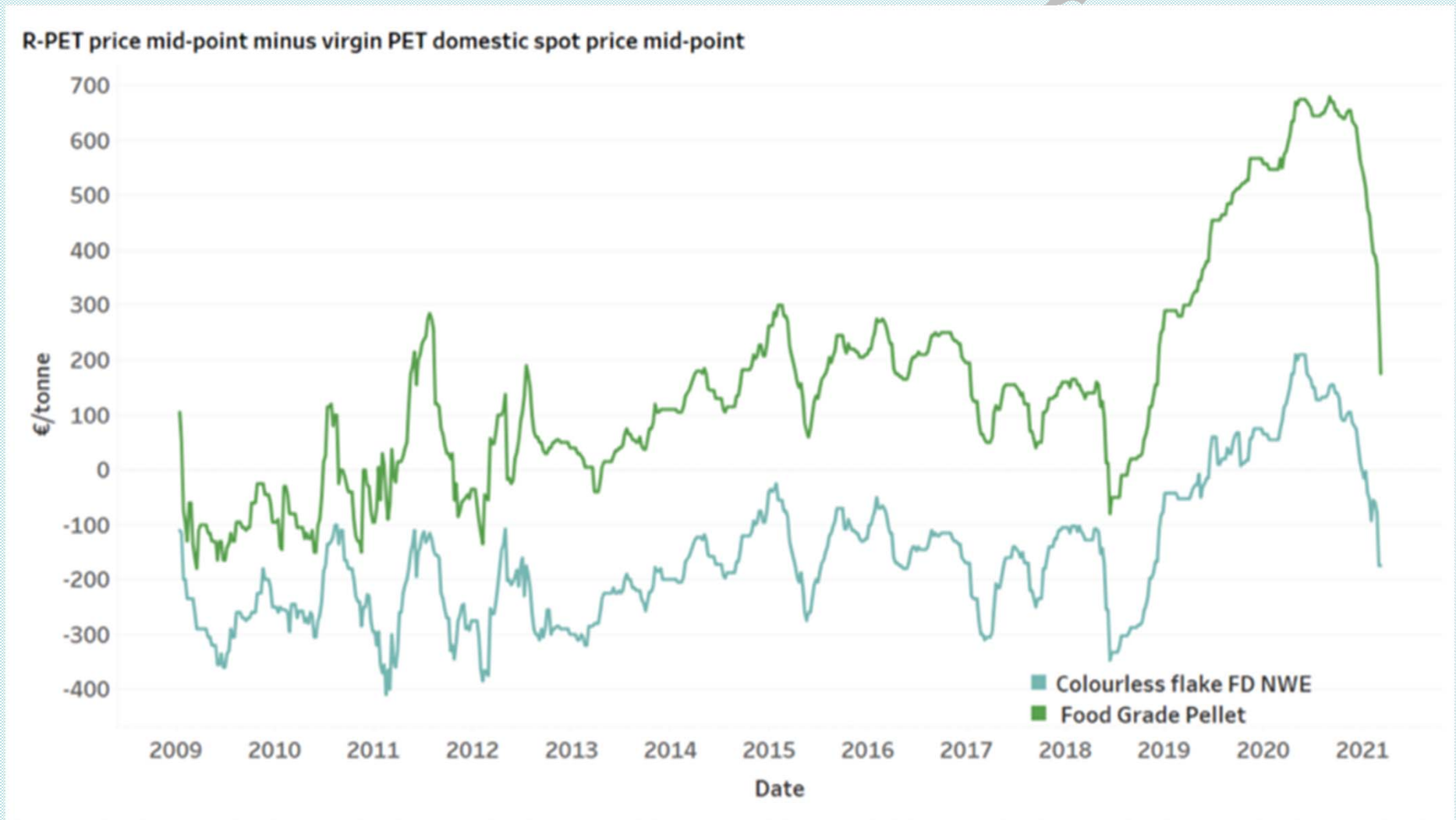
| Symbol | Polymer Name | Product Examples | |
|--|--|--|---|
|  PETE | Polyethylene Terephthalate (PETE or PET) | <ul style="list-style-type: none"> • Soft drink bottles • Water bottles • Sports drink bottles • Salad dressing bottles • Vegetable oil bottles | <ul style="list-style-type: none"> • Peanut butter jars • Pickle jars • Jelly jars • Prepared food trays • Mouthwash bottles  |
|  HDPE | High-density Polyethylene (HDPE) | <ul style="list-style-type: none"> • Milk jugs • Juice bottles • Yogurt tubs • Butter tubs • Cereal box liners | <ul style="list-style-type: none"> • Shampoo bottles • Motor oil bottles • Bleach/detergent bottles • Household cleaner bottles • Grocery bags  |
|  V | Polyvinyl Chloride (PVC or V) | <ul style="list-style-type: none"> • Clear food packaging • Wire/cable insulation • Pipes/fittings • Siding • Flooring | <ul style="list-style-type: none"> • Fencing • Window frames • Shower curtains • Lawn chairs • Children's toys  |
|  LDPE | Low-density Polyethylene (LDPE) | <ul style="list-style-type: none"> • Dry cleaning bags • Bread bags • Frozen food bags • Squeezable bottles • Wash bottles | <ul style="list-style-type: none"> • Dispensing bottles • 6 pack rings • Various molded laboratory equipment  |
|  PP | Polypropylene (PP) | <ul style="list-style-type: none"> • Ketchup bottles • Most yogurt tubs • Syrup bottles • Bottle caps • Straws | <ul style="list-style-type: none"> • Dishware • Medicine bottles • Some auto parts • Pails • Packing tape  |
|  PS | Polystyrene (PS) | <ul style="list-style-type: none"> • Disposable plates • Disposable cutlery • Cafeteria trays • Meat trays • Egg cartons | <ul style="list-style-type: none"> • Carry out containers • Aspirin bottles • CD/video cases • Packaging peanuts • Other Styrofoam products  |
|  OTHER | Other Plastics (OTHER or O) | <ul style="list-style-type: none"> • 3/5 gallon water jugs • Citrus juice bottles • Plastic lumber • Headlight lenses • Safety glasses | <ul style="list-style-type: none"> • Gas containers • Bullet proof materials • Acrylic, nylon, polycarbonate • Polylactic acid (a bioplastic) • Combinations of different plastics  |

Value added products from recycled pet bottles



Recycled resin prices rise in Europe even as virgin resin prices drop

02-Aug-2022 — In June, clear food-grade recycled PET pellet prices were **€650 per tonne higher than virgin PET** prices, compared to €270 per tonne in January. (source *Plastics News*)

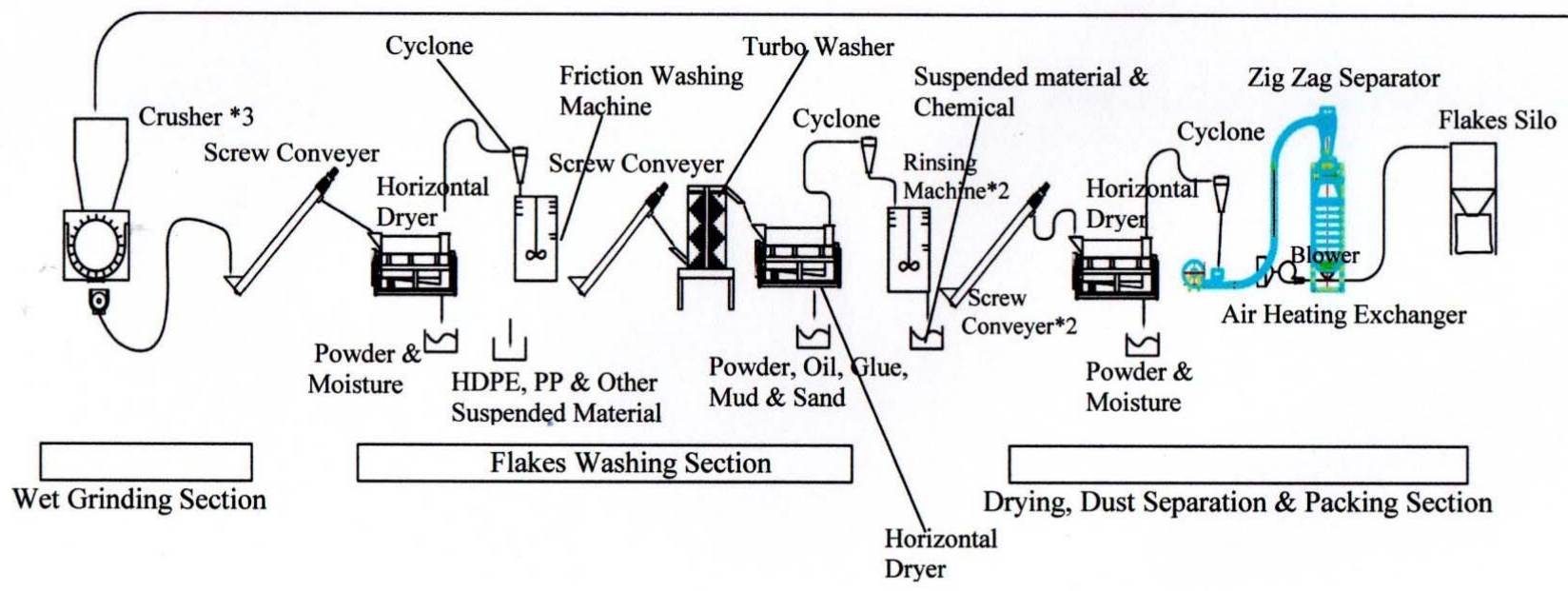
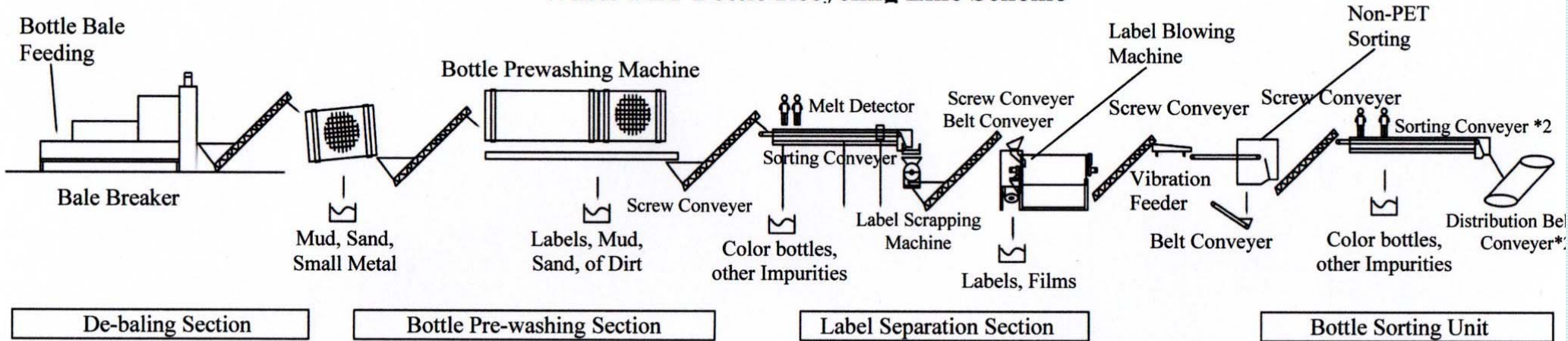


Source: *Sustainable Plastics*

Indicative Intrinsic Viscosity levels for different applications

| INDUSTRY / APPLICATION | Desired I.V. (dL / gm) |
|--|------------------------|
| Virgin PET from resin producers | 0.76 – 0.88 |
| Filled bottles by marketers | 0.76 – 0.88 |
| Sheets for thermoformed packaging | 0.70 – 0.80 |
| Strapping bands | 0.84 – 0.92 |
| Monofilaments | 0.66 – 0.76 |
| Master batch | 0.76 – 0.84 |
| Injection moulded articles | 0.80 – 0.84 |
| Industrial Yarns (Tire Cord / Conveyor Belt / Sewing Thread) | 0.92 – 1.00 |
| Polyester Staple Fiber | 0.60 – 0.65 |
| Polyester Oriented Yarn | 0.60 – 0.65 |
| Non-Woven fabric | 0.60 – 0.65 |
| Fully Drawn Yarn / Drawn Textured Yarn | 0.60 – 0.65 |

Waste PET Bottle Recycling Line Scheme



Source: Borotech



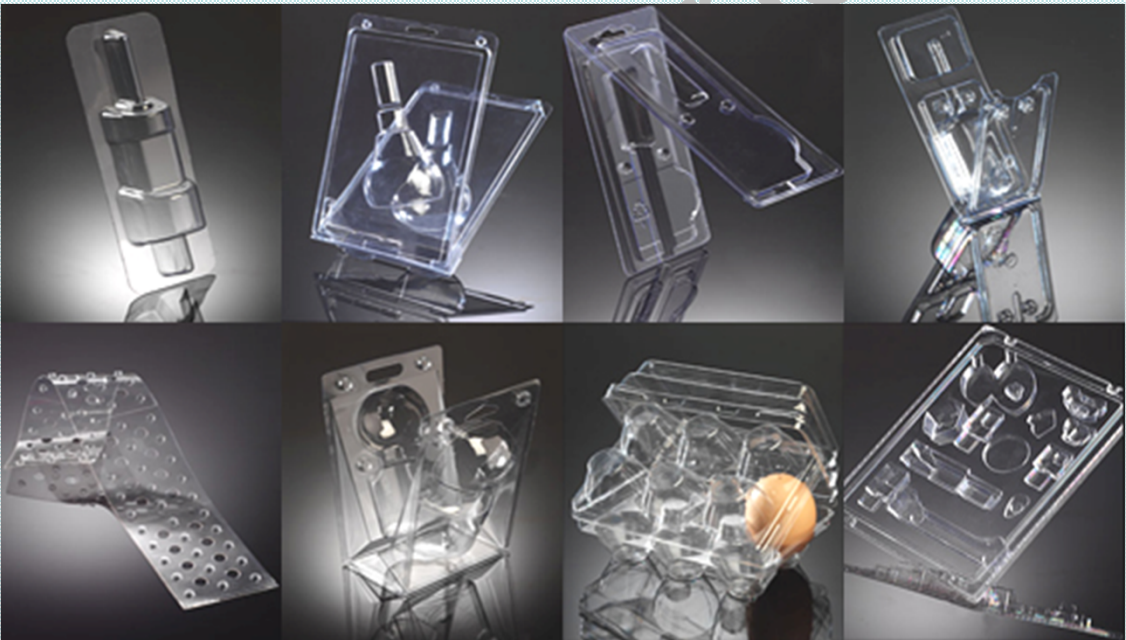
**Recycled PET
Granules (Pellets)**



PET Bottles



**HOT WASHED
PET FLAKES**



**RECYCLED PET SHEET
THERMOFORMED END
PRODUCTS**



Upcycling of Plastics – KPS Consultants



**Partially Oriented
Yarn (POY)**



**Polyester Staple
Fiber (PSF)**



Containers for non-food applications



PET Strapping Tape





Non-woven PET Fabric



PET (Polyester) Film

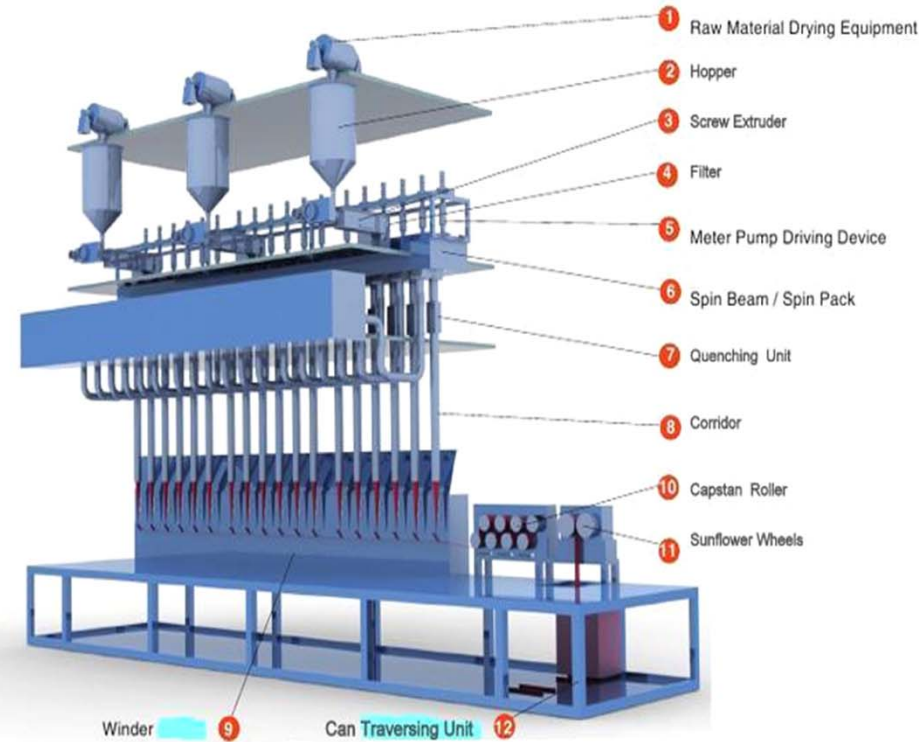


Clean PET Flakes



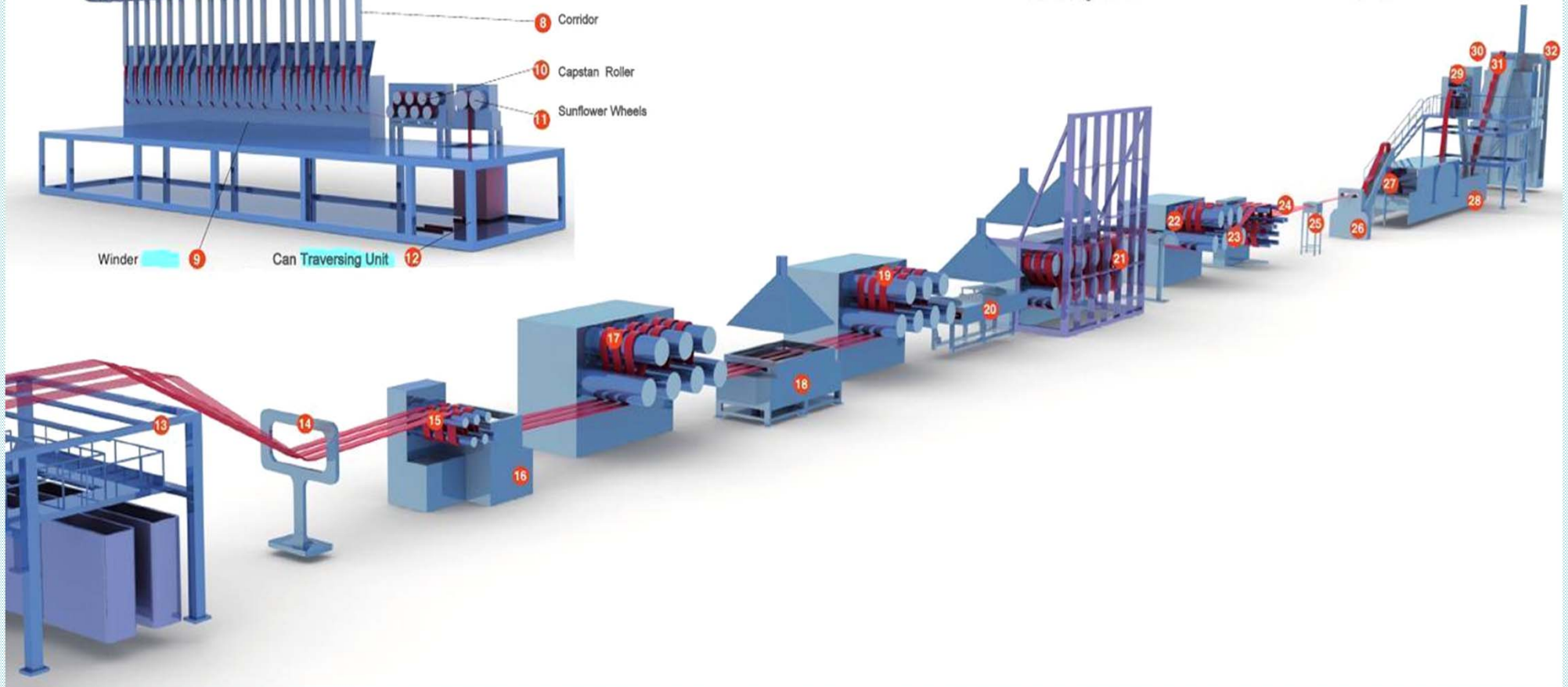
Re-generated
Polyester Staple
Fiber

SPINNING LINE



FINISHING LINE

- 13. Creel Stand
- 14. Furl Stand
- 15. Guiding Frame
- 16. Dip Oil Bath
- 17. First Drafter
- 18. Draw Bath
- 19. Second Drafter
- 20. Steam Heated Beam
- 21. Annealer
- 22. Cooling Device
- 23. Third Drafter
- 24. Stacking Machine
- 25. Steam Preheating Box
- 26. Crimper
- 27. Belt Conveyor
- 28. Relaxing Oven
- 29. Tension Device
- 30. Cutter
- 31. Fiber Conveyor
- 32. Baler



Some Application of Regenerated PSF

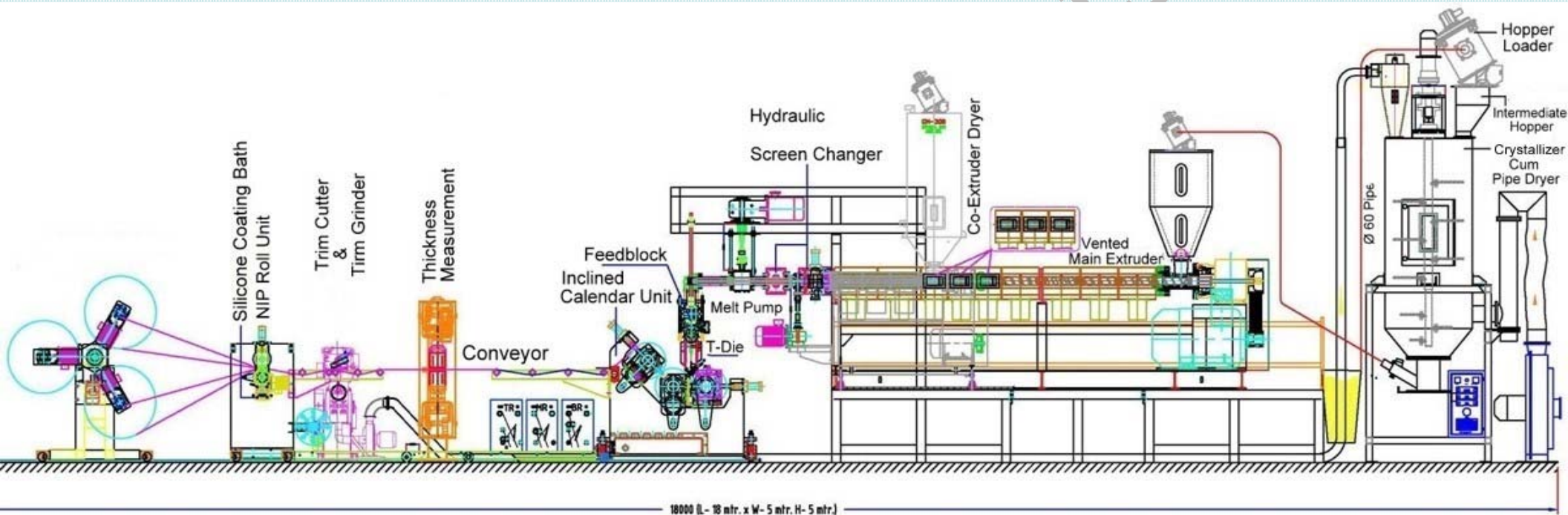


Extruded Sheet for Thermoformed Packaging Material

- Single layer or Three-layer co-extruded (A-B- A) sheet
- 15% Virgin PET + 70% R-PET + 15% Virgin PET (A-B-A structure)
- 0.2 to 1.5 mm thickness
- A-PET / PET-G / C-PET Sheet for Thermoformed Packaging



Typical Production Line and Equipment Layout





Upcycling of Plastics – KPS Consultants

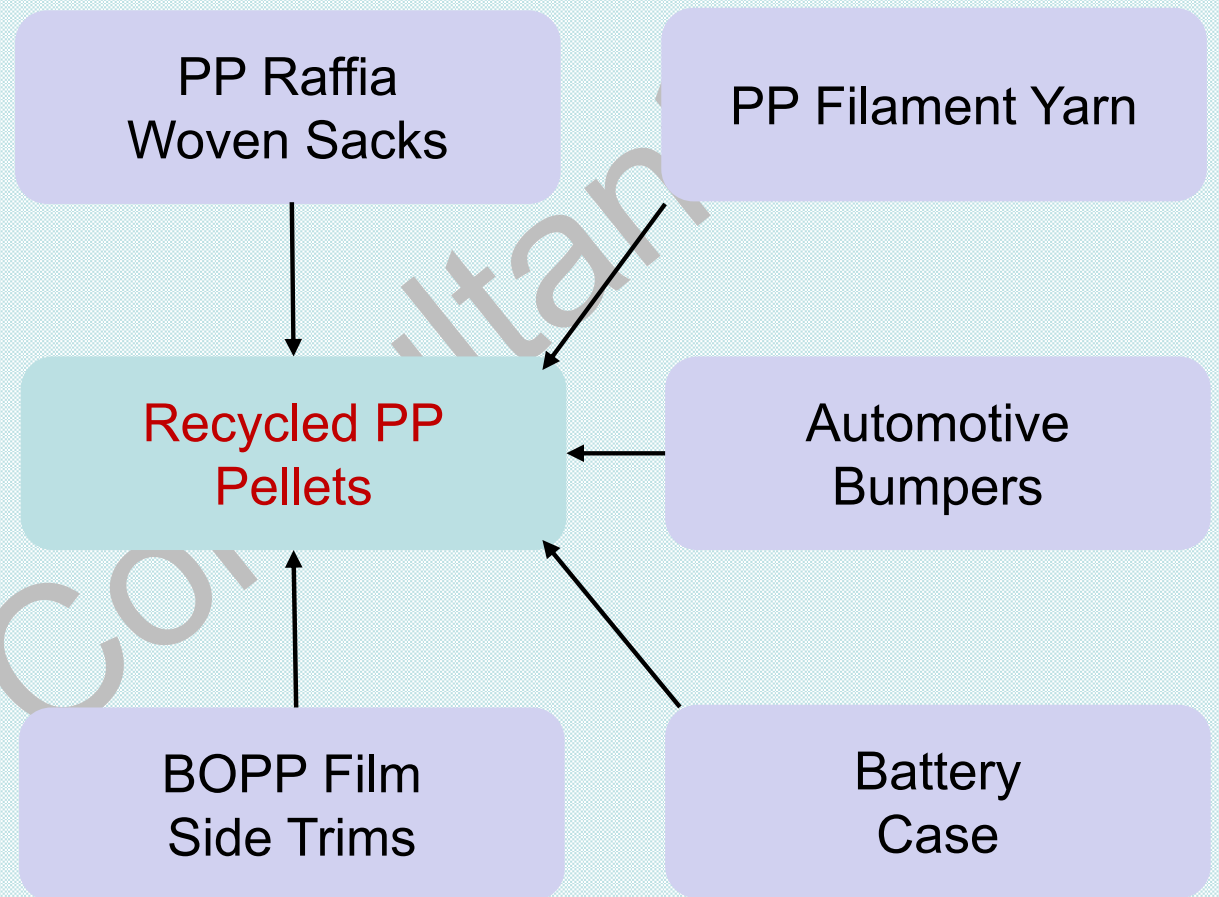


Upcycling of Plastics – KPS Consultants

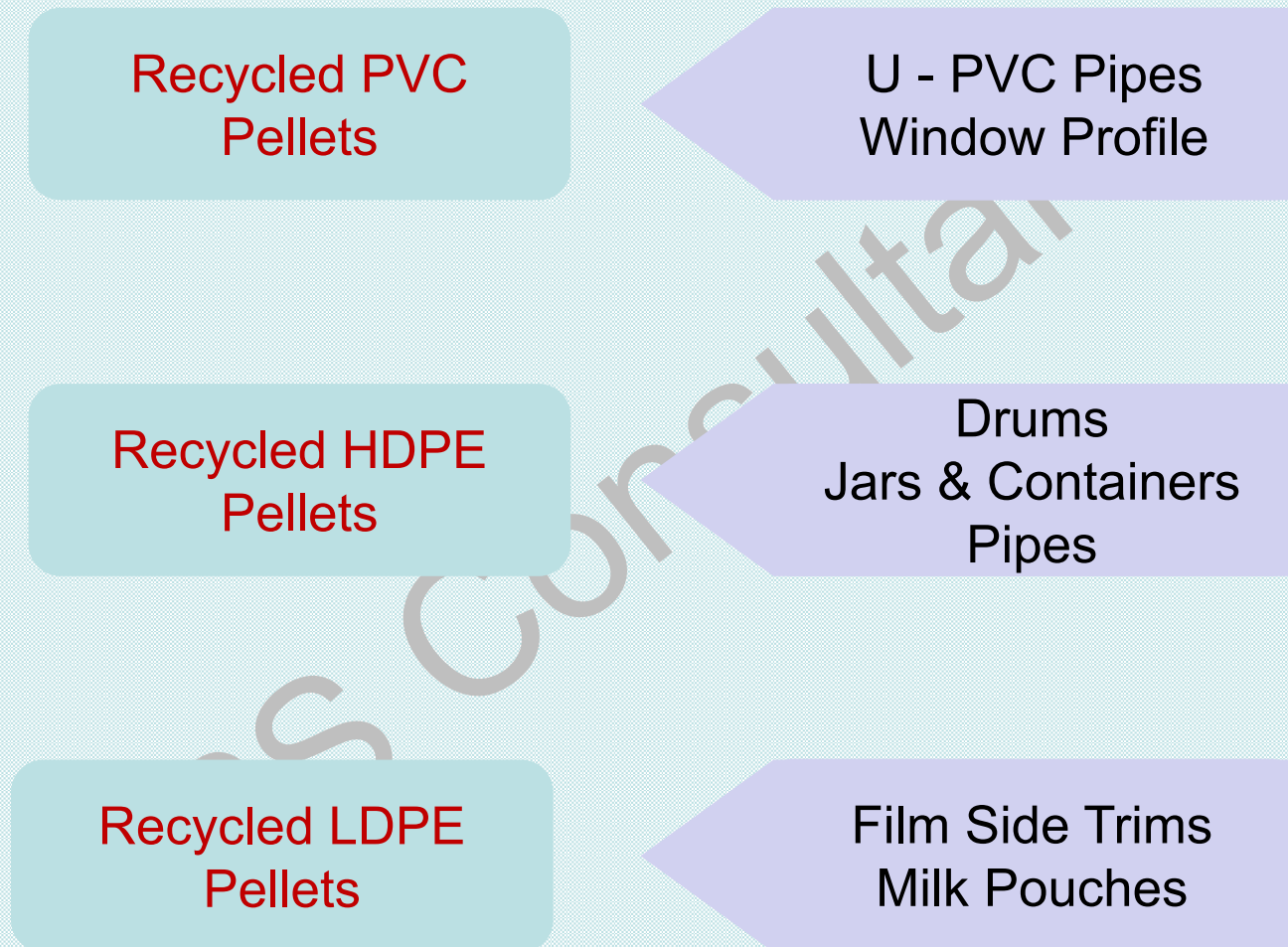
Myths and Realities of Plastic Recycling

- 80% of total plastic consumption used in packaging
- Majority of plastic packaging – single use & throw away
- Multi-layered flexible plastic packaging
- Mixed plastic waste from municipal waste
- Both multi-layer & mixed plastic waste difficult to recycle
- Segregation of mixed plastic waste is the main issue
- Economic incentive – e.g. waste PET bottles
- Segregation of waste plastics at source
- Waste plastics should not mix with other waste streams

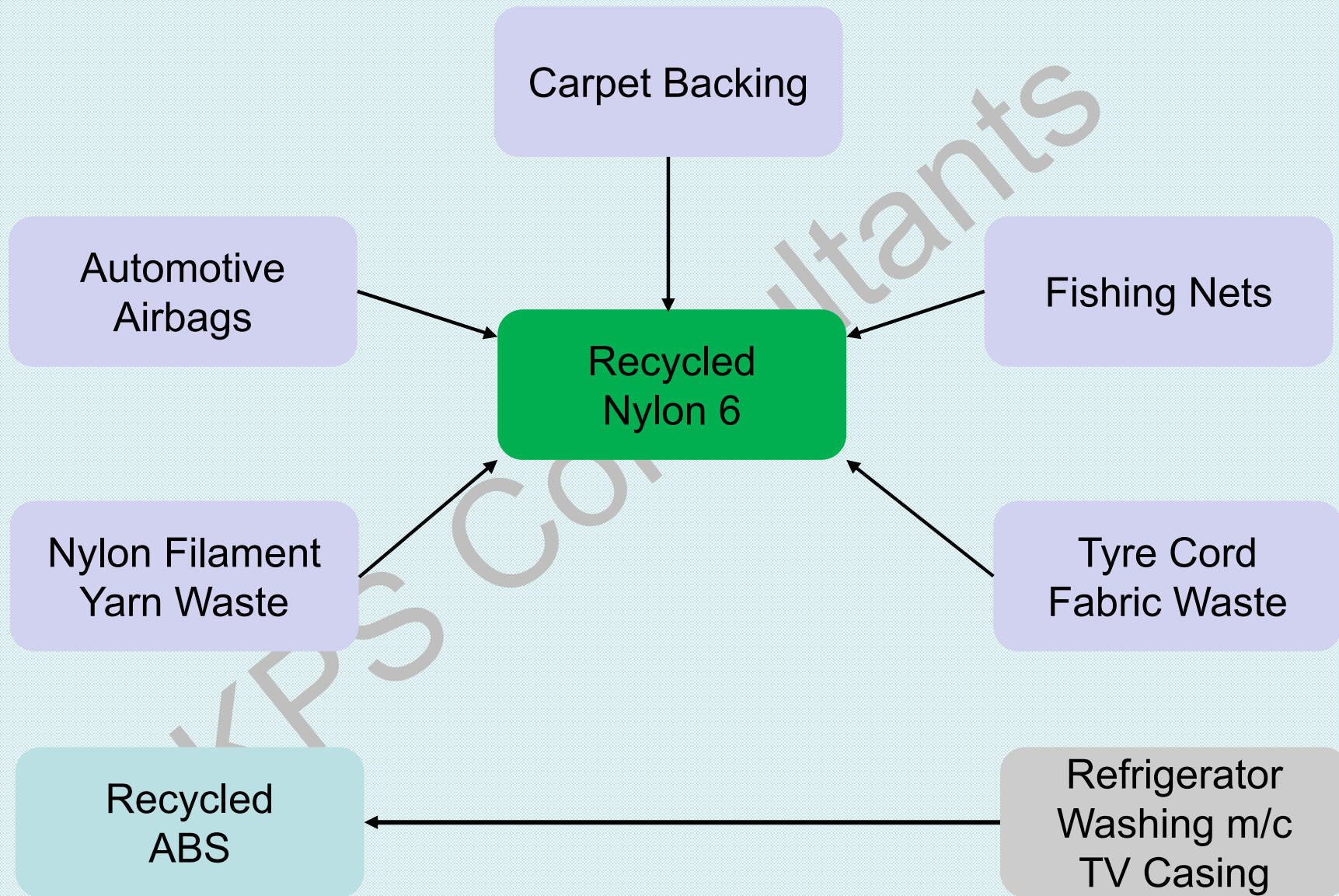
Recycling of Commodity Plastics



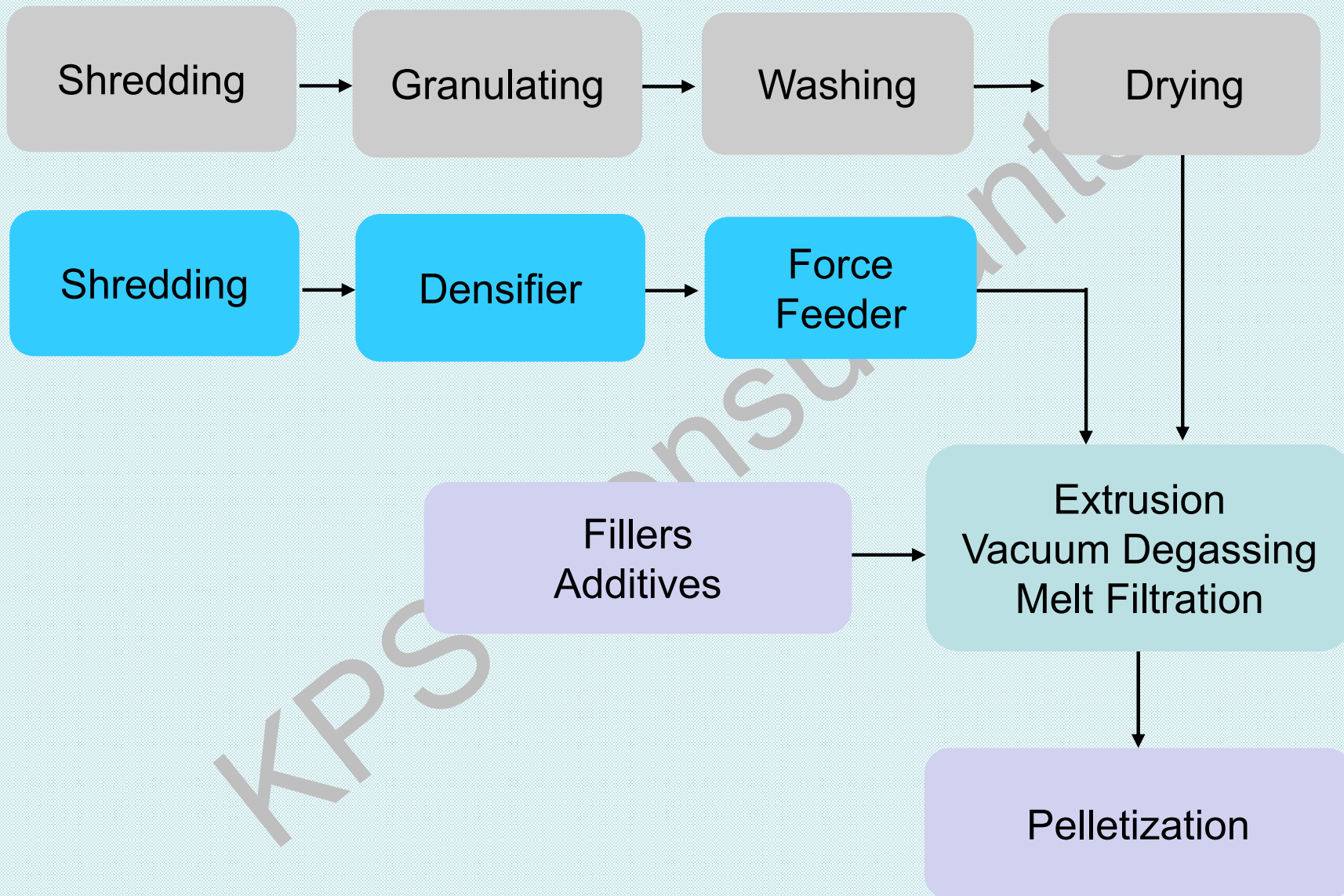
Recycling of Commodity Plastics



Recycling of Engineering Plastics



Basic Recycling Scheme



Re-cycling of Post-Consumer PET Bottles

PET is one of the few thermoplastics that can be Up-Cycled

PET resin is highly hydrophilic i.e. readily absorbs moisture from surrounding air

When PET bottles flakes are recycled (extruded) the polymer undergoes

Thermal, Oxidative & Hydrolytic Degradation leading to undesirable drop in mechanical & chemical properties

- The Intrinsic Viscosity (IV) of the PET polymer decreases leading to a drop in physical - mechanical properties
- Generates impurities like Aldehydes and other VOCs due to which it cannot be used further for food contact applications
- Leads to Dis-colouration or yellowing of the resin
- Formation of agglomerates & lumps
- The post consumer PET bottle flakes contain foreign matter & impurities that needs to be filtered out.

What is the way out? There are various methods & technologies available. Some of them are used together in conjunction to do the job

- 1) Pre-drying of PET bottle flakes to reduce moisture content
- 2) Vacuum De-gassing to remove moisture and VOCs during extrusion
- 3) Melt Filtration through Screens to remove agglomerates and solid contaminants
- 4) Adding chemicals called Chain Extenders to increase polymer IV
- 5) Liquid State Polycondensation (LSP) process utilizes the inherent capability of the PET polymer to condensate in the molten phase under vacuum that leads to an increase of IV. The high performance vacuum effectively decontaminates the material from harmful chemicals enabling it to be used for food contact applications.
- 6) Solid State Polycondensation (SSP) at elevated temperature and under vacuum of the recycled PET pellets to increase IV followed by thermal crystallization.

Collection strategies

- Local & regional scrap dealers
- Tie-up with local NGOs (organize ragpickers with incentives)
- Thermoformed packaging (skeletons), PET sheet side trims and off-spec PET bottle preforms
- Tie-up with local interstate bus terminals and railway stations
- Reverse vending machines in shopping malls, railway stations and bus terminals where consumers put used bottles in vending machines and get coupons as incentives
- Tie-up with local movie theaters, amusement parks, shopping malls
- It is possible to import hot washed PET flakes by actual users
- Tie-up with mineral water and carbonated soft drink companies - under the extended producer responsibility (EPR)

Bottle Grade PET Resin (B to B Process)

Different technologies are available for the purpose, notably **Liquid State Polycondensation (LSP)** process that enables rapid increase in polymer IV and high level of decontamination for producing US FDA compliant food contact bottle grade PET resin pellets – either clear (APET) or crystalline (CPET). **Solid State Polycondensation (SSP)** and Thermal **Crystallization**. The extruded recycled PET resin pellets undergo SSP that involves application of heat under vacuum which increases the polymer IV and effectively decontaminates the material making it suitable for food contact applications with US FDA approval



Solid State Polycondensation



Courtesy: EREMA™

Solid State Polycondensation

1 PET flake pretreatment
Highly efficient decontamination
The patented pretreatment at elevated temperature and under vacuum before the extrusion process removes moisture and migration materials from the feedstock very effectively and in a stable process environment. This prevents any hydrolytic and oxidative decomposition of the melt in the extruder.

2 IV increase
IV value is increased to the required level.

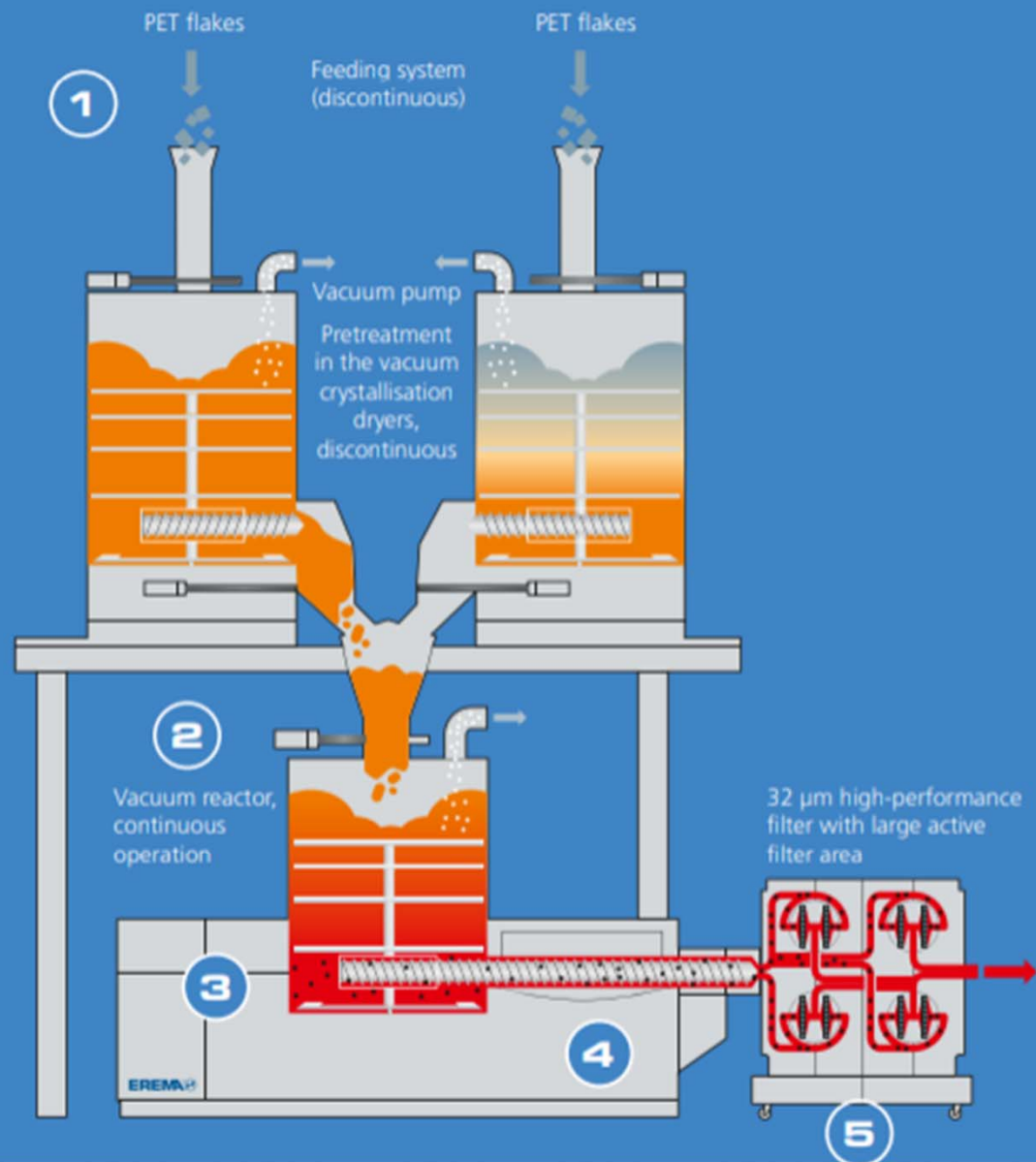
3 Melting under vacuum

4 Low thermal stress
The very short extruder screw without additional extruder degassing reduces the thermal stress on the material through minimised residence time.

5 Large area ultrafine filtration
The robust, fully automatic filter removes even the smallest of aluminium, steel and other particles from the melt. The very large active filter areas enable filtration with up to 32 µm fineness with a low pressure level. The result is highly clean pellets.

Easy operation

The intelligent Smart Start operating concept combines production efficiency with remarkably straightforward operation. The accent is on usability. Featuring a high degree of automation, ergonomic touchscreen and practical recipe management.



Liquid state polycondensation process (LSP)

The process utilizes inherent capability of PET to condensate in the molten phase under vacuum. This condensation leads to an increase of IV. The high performance vacuum effectively decontaminates the material from harmful chemicals, – securing further use of the material for 100% food contact.



Courtesy: NGR P-REACT™

THANK YOU

**THE FUTURE BELONGS TO THOSE WHO SEE
POSSIBILITIES BEFORE THEY BECOME OBVIOUS**

Dr. Anomitra Chakravarty

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