Wiri Waste Advisory Service

Plastics 101

WILKINSON ENVIRONMENTAL LIMITED

Auckland Council
Te Kaunihera o Tāmaki Makaurau

WIRI Means Business

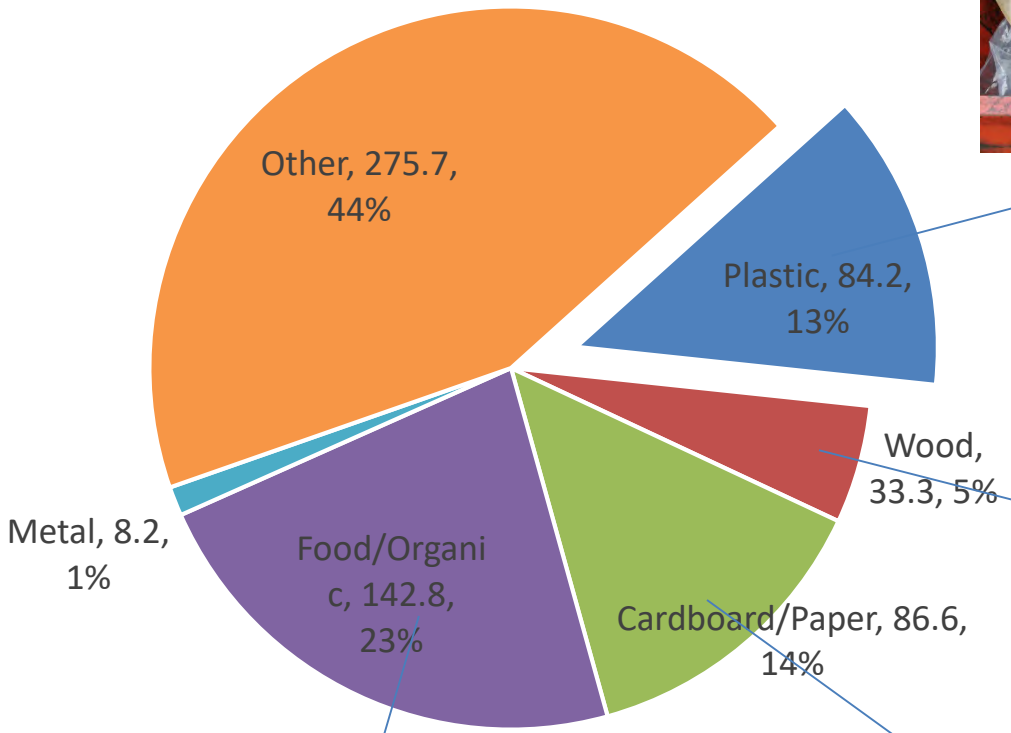
Wiri Waste Assessments

“Door knocks”	126	
Assessments	39	
Current waste to landfill	1,548	tonnes
Current recycling	996	tonnes
Diversion potential identified	**631**	**tonnes**
Implemented	**4.54**	**tonnes**

WILKINSON ENVIRONMENTAL LIMITED

WIRI Means Business

Recycling opportunities



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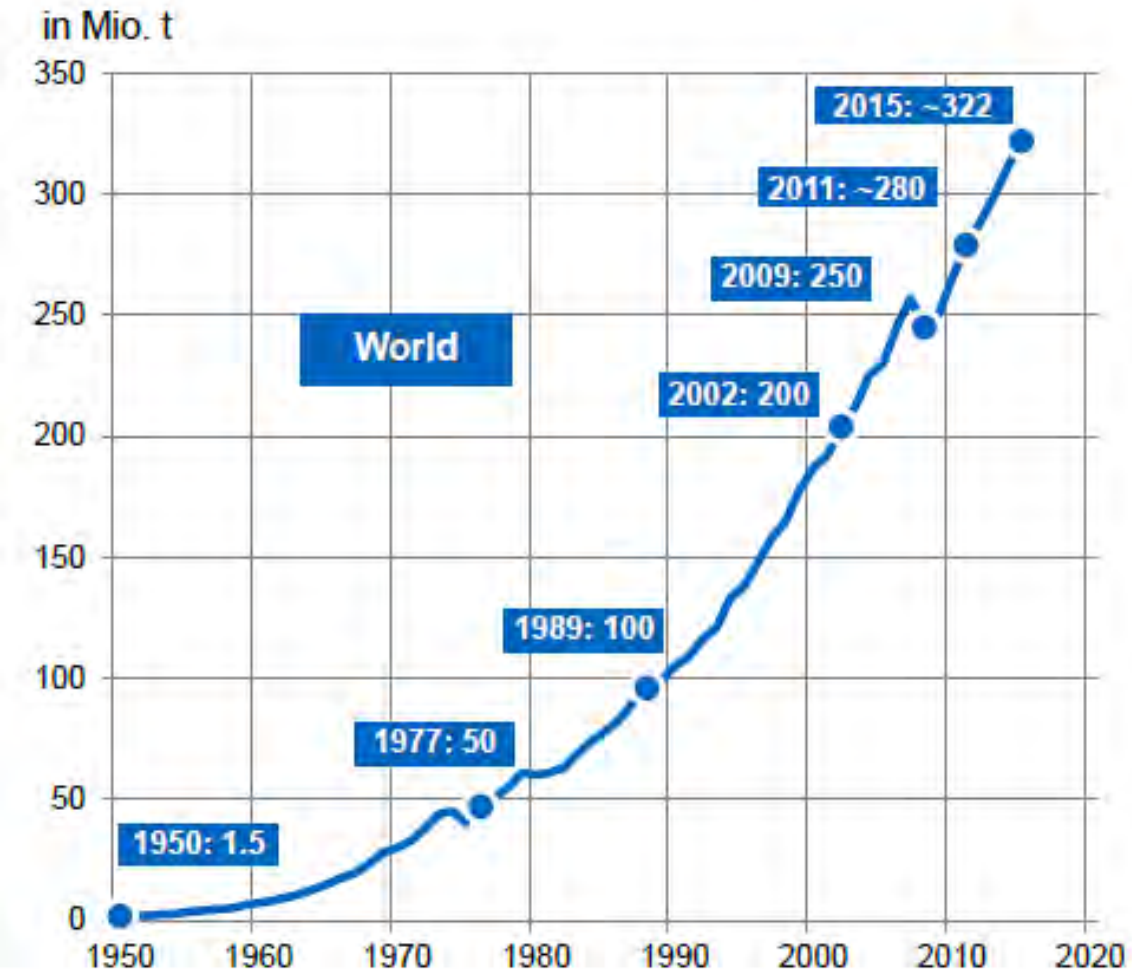
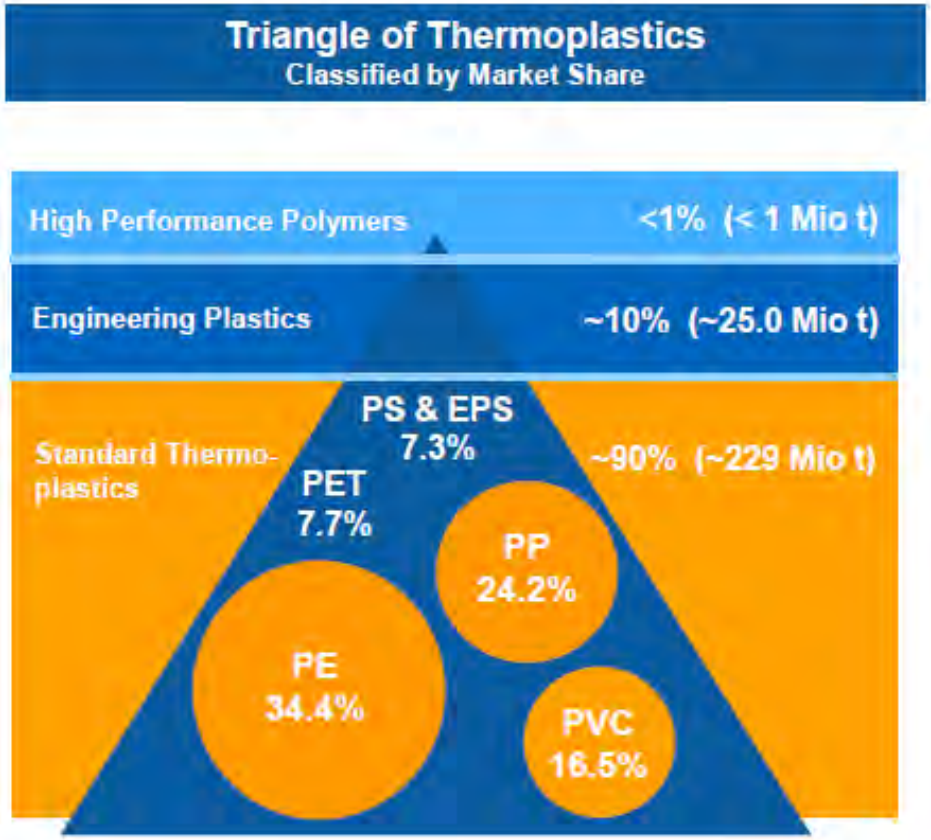
Polymers (without any chemistry)

RW 260219

World
Plastics Production 1950 – 2015



Thermoplastics
Market Share 2015



Source: PlasticsEurope Market Research Group (PEMRG) / Consultic Marketing & Industrieberatung GmbH

SYMBOL	TYPE OF PLASTIC
 PET	**PET** Polyethylene Terephthalate
 HDPE	**HDPE** High Density Polyethylene
 PVC	**PVC** Unplasticised Polyvinyl Chloride PVC-U Plasticised Polyvinyl Chloride PVC-P
 LDPE	**LDPE** Low density Polyethylene **LLDPE** Linear low density Polyethylene
 PP	**PP** Polypropylene
 PS	**PS** Polystyrene
 EPS	**EPS** Expanded Polystyrene
 OTHER	**OTHER** Letters below indicate ISO code for plastic type including SAN (styrene, acrylonitrile), ABS (Acrylonitrile butadiene styrene), PC (polycarbonate), Nylon, degradable plastic e.g. PLA

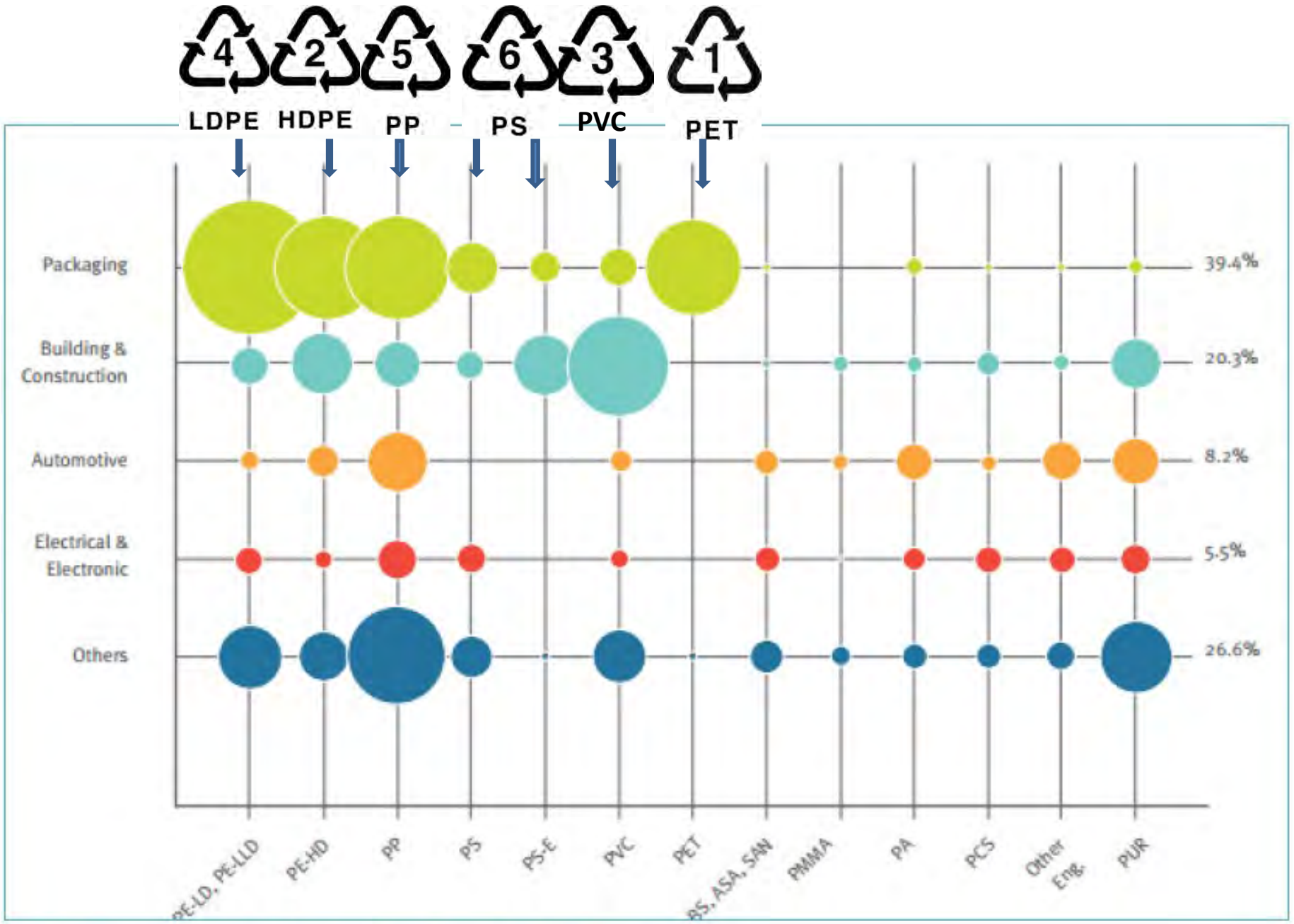


Figure 4 European plastics demand by segment and resin type 2012[5]

Jargon Alert!!!!

Our journey today

1) Thermoplastic and thermoset polymers

2) Thermoplastic Polymer types

3) Thermoplastic Polymer Families

4) Thermoplastics Polymer Sub families

5) Grade range (This is what someone buys and processes!)

Thermoplastics and thermoset polymers

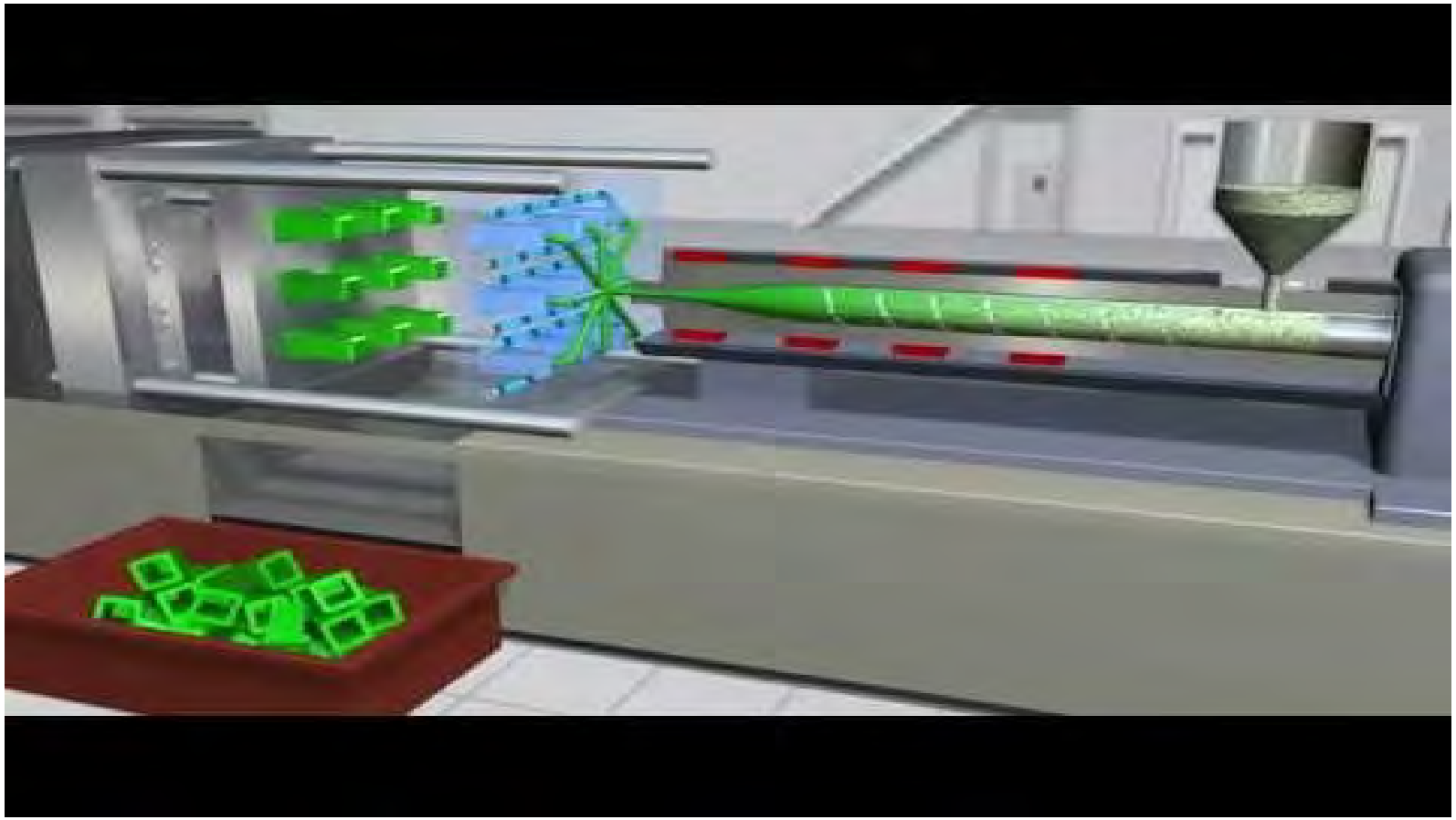
Thermoplastics are processed by heat and can generally be reprocessed more than once.

EG

Thermosets are processed by heat. During processing a chemical reaction occurs as the final article is created. Once cured the material cannot be reprocessed.

EG

Plastics Processing Methods



Thermoplastic Polymer types

What is a polymer?

From the monomer to the polymer

Compose a train out of waggons

Thermoplastic Polymer types

From the monomer to the polymer

Waggon = Monomer

Long train = Polymer

Polymer has repeating chemical units - it may be symmetrical or it may not be based on how it was (deliberately) produced.

Thermoplastic Polymer types

Take a seat and order spaghetti

Thermoplastic Polymer types

Imagine a polymer chain as a spaghetti

Length (and shape) of the spaghetti relates to the Molecular Weight of the polymer

Thermoplastic Polymer types

– when hot enough to be processed

hot spaghetti: soft, movable, take random shape

hot amorphous polymer

Thermoplastic Polymer types

PET

PVC

PS

cold spaghetti: hard, rigid, in random shape

frozen amorphous polymer

Amorphous = “glassy”

Thermoplastic Polymer types

2

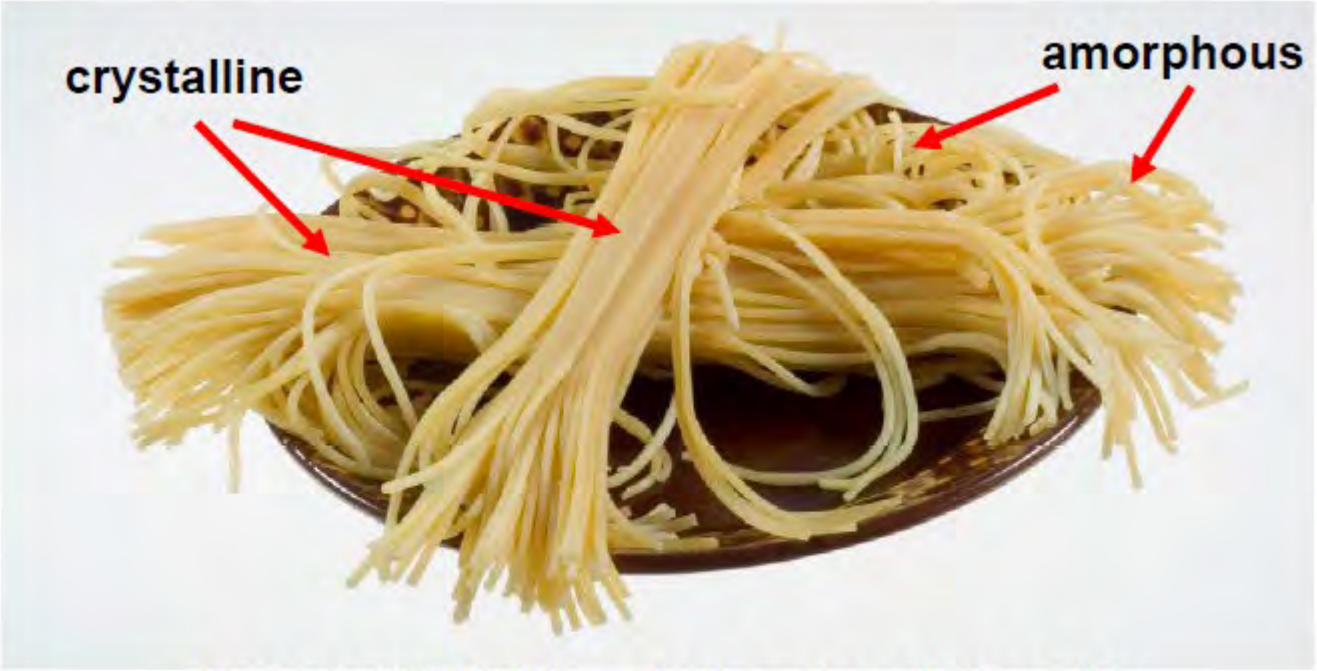
PE-HD

4

PE-LD

5

PP



Spaghetti with bonded, ordered domains

partially crystalline polymer

Partially crystalline = Semi crystalline

Thermoplastic Properties Comparison

Property	Amorphous	Semi-Crystalline
Chemical Resistance	Poor	High
Usage Temperature	Lower	Higher
Solvent Sensitivity	Often sensitive	Not sensitive
Optical clarity	Transparent	Opaque
Strength	Lower	Higher
Toughness	Higher	Lower
Density	Lower	Higher
Fatigue & Wear	Poor	Excellent
Molecular Cuddling	None	High

Thermoplastic Properties Comparison

- Processing Related:

Property	Amorphous	Semi-Crystalline
Structure	Random	Orderly
Thermal Response	Broad softening range	Sharp melting point
Mould Shrinkage	Lower	Higher (& differential)
Tolerances	Tighter	Loose
Dimensional Stability	More forgiving	Can be problematic

Thermoplastic Polymer types

Polymer	Strength	% stretch	Stiffness	Density	Clarity?	V$*
LDPE	E	B	E	E	No	105
HDPE	D	**A**	D	D	No	115
PP	C	B	C	E	Some	110
PS	C	E	**A**	C	Yes (not HIPS)	150
uPVC	B	D	**A**	**A**	Some (only f-PVC)	-
PET	**A**	C	**A**	**A**	Yes	150

A= Highest relatively
E= Lowest relatively

* V$ = Global US$/cm3 indexed to LLDPE)

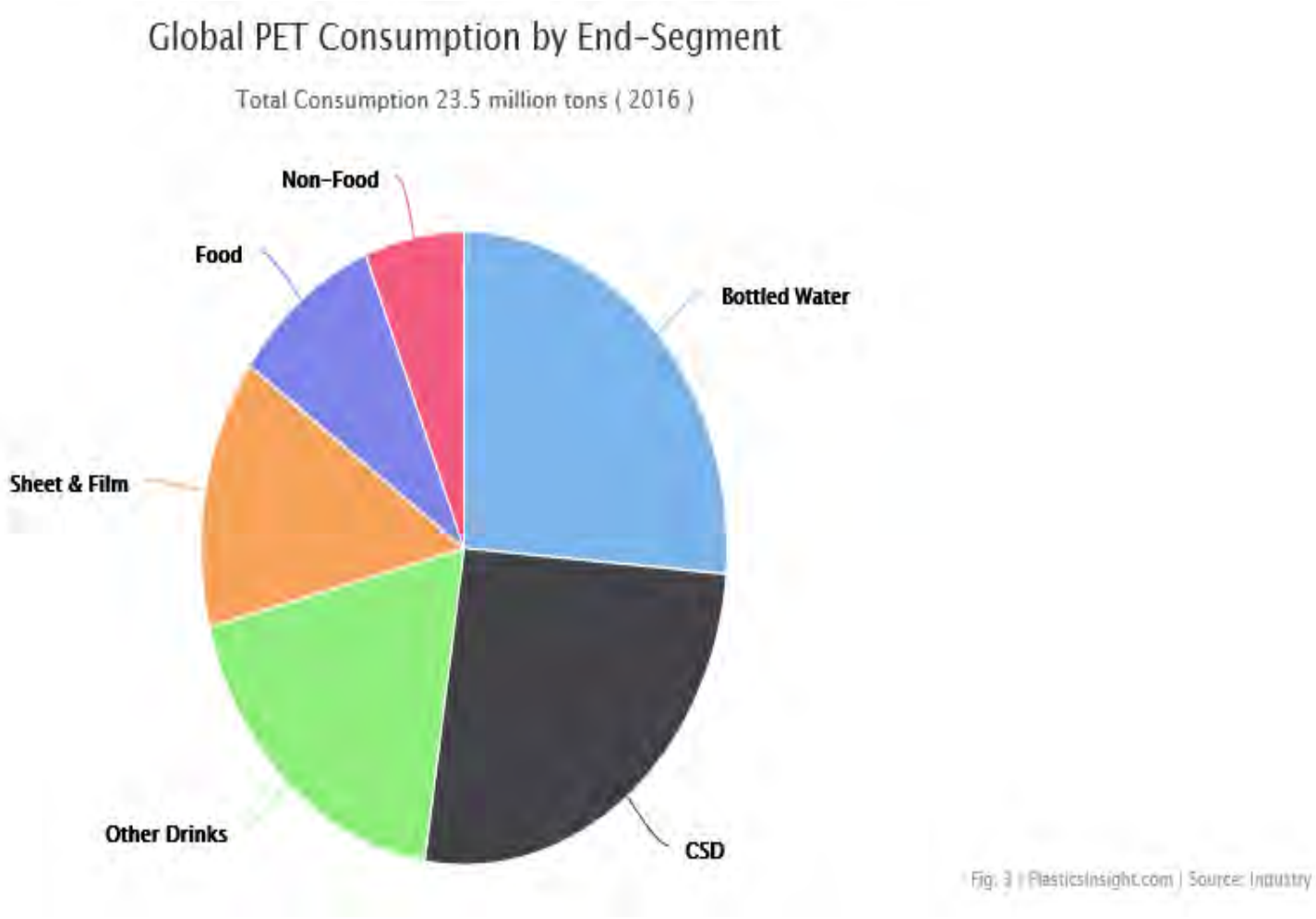
Polymer families and sub families

PET - one sub family

Nice and simple!!

Recycled in NZ

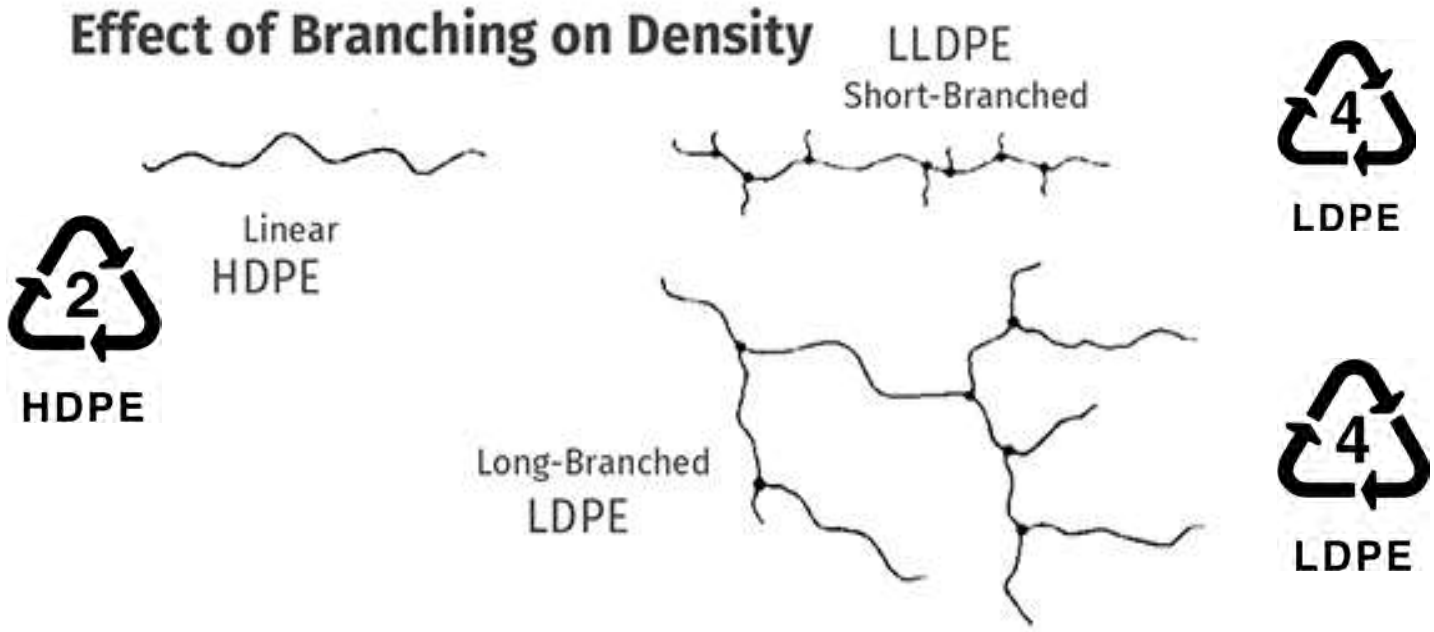
(NB: PETG isnt PET!)



CSD = carbonated soft drinks

Polymer families and sub families

Polyethylene (PE) - three sub families



Recycled in NZ

LDPE application examples

HDPE application examples

Polymer families and sub families

PVC - two sub families

POLYVINYL CHLORIDE (PVC)

FORMULATIONS

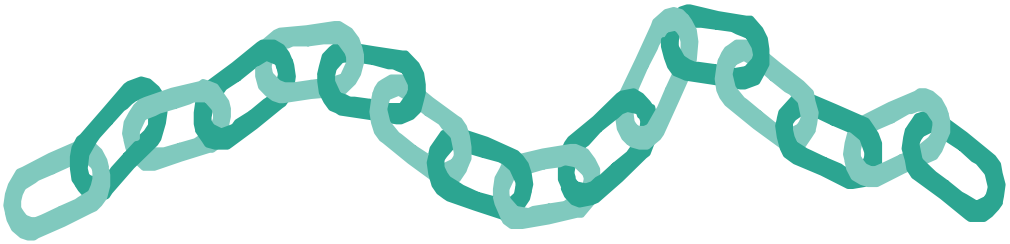
	Rigid PVC (phr)	Flexible PVC (phr)
Ingredient		
PVC	100	100
Heat Stabilizer	2	2
Lubricant		
Internal	3	0.5
External	1	-
Processing Aid	3	5
Impact Modifier	15	-
Filler	5	-
Pigment	3	3
Plasticizer	-	>30

PVC application examples

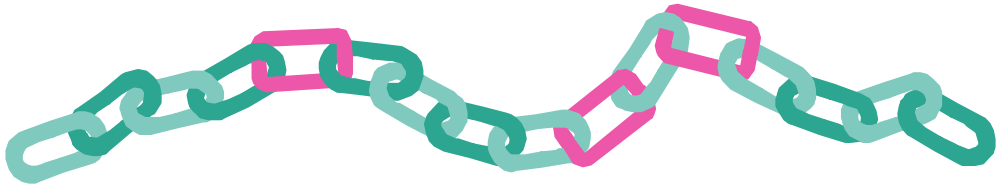
Polymer families and sub families

<u>Polypropylene - three sub families</u>
(based on the wagons)

Polypropylene homopolymer



Polypropylene random copolymer



Polypropylene Block Copolymer (Polypropylene Impact copolymer)

- PP Application Examples

PP Thin Walled Moulding Examples

5

PP

Polymer families and sub families

Polystyrene - three sub families

Polystyrene (PS or GPPS)

HIPS (High impact polystyrene) = polystyrene reacted with 3- 5 % rubber

Expanded polystyrene (EPS) = polystyrene plus added pentane blowing agent to make it foam during processing

PS (GPPS) and EPS Application Examples:

HIPS application examples

Grade Range

Each sub family has a range of standard grades.

Polymer grades are tailored to application and to process requirements.

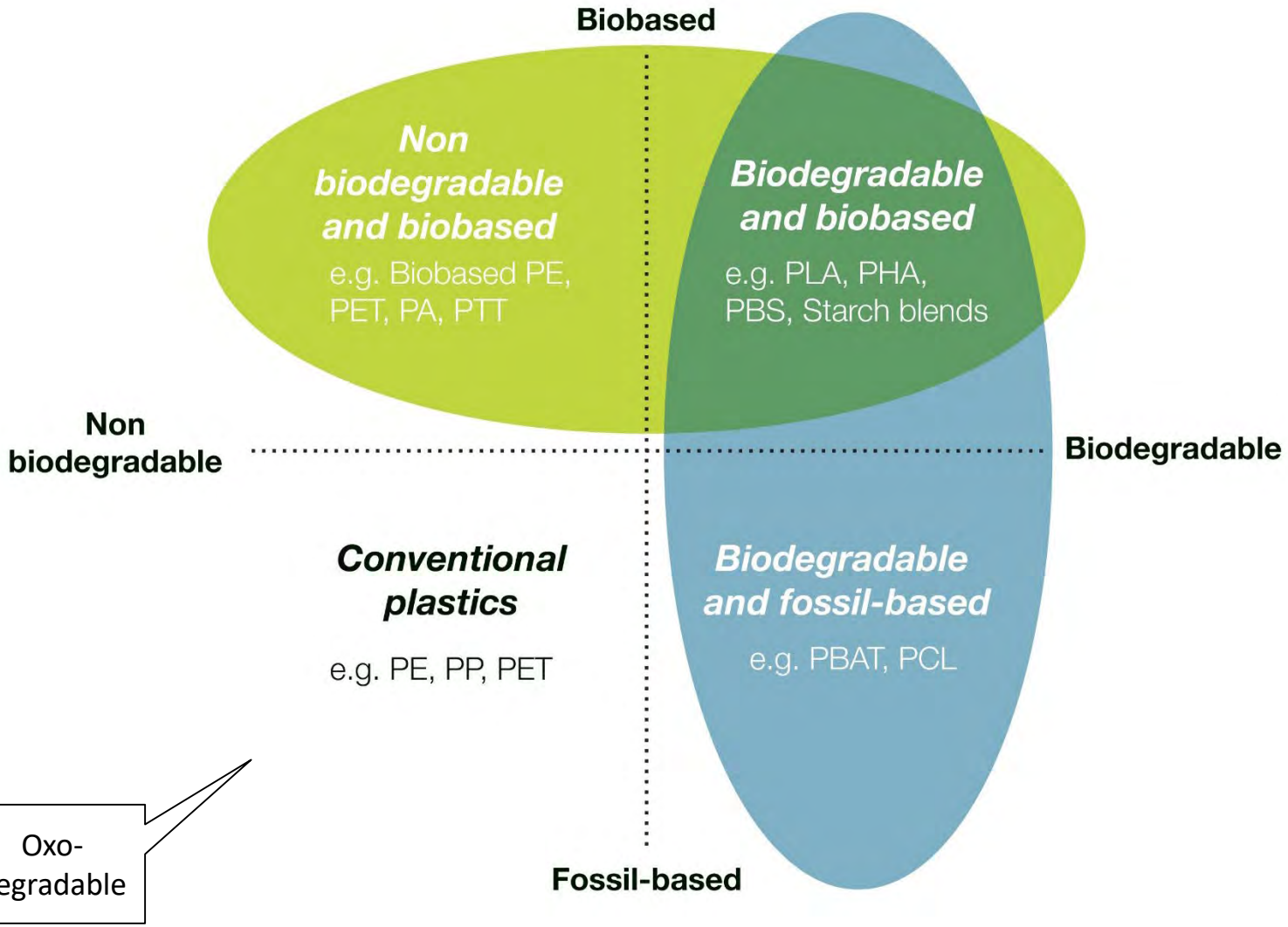
Generally within a sub family the range of grades is defined by various additives and/or different molecular weight.

High molecular weight gives a product better heat and physical properties.
Lower molecular weight gives more forgiving processing.
This is a choice about trade offs.

Some additives included in polymers

- Heat Stabilized
- Plasticized
- Impact Modified
- Pigmented
- Optically brightened
- Flame Retardant
- Lubricated
- Mold Release added
- Nucleated
- Light Stabilized
- Magnetic Media
- Glass / Carbon Fiber Reinforced
- Mineral Filled
- Antiblock / Slip
- Conductive / Antistat ...

"Bioplastics" – what are they??



Some polymer truths - Materials

You cannot look at a polymer and tell what it is (family, sub family or grade).

Both material price and processing costs are significant to the total product cost.

‘Same grades’ from different suppliers very often are not the same – for either performance or processing.

The ‘same’ end product can sometimes be made from different polymer families quite adequately eg plastic drink ware. It all depends on the specification requirements.

Some polymer truths - processing

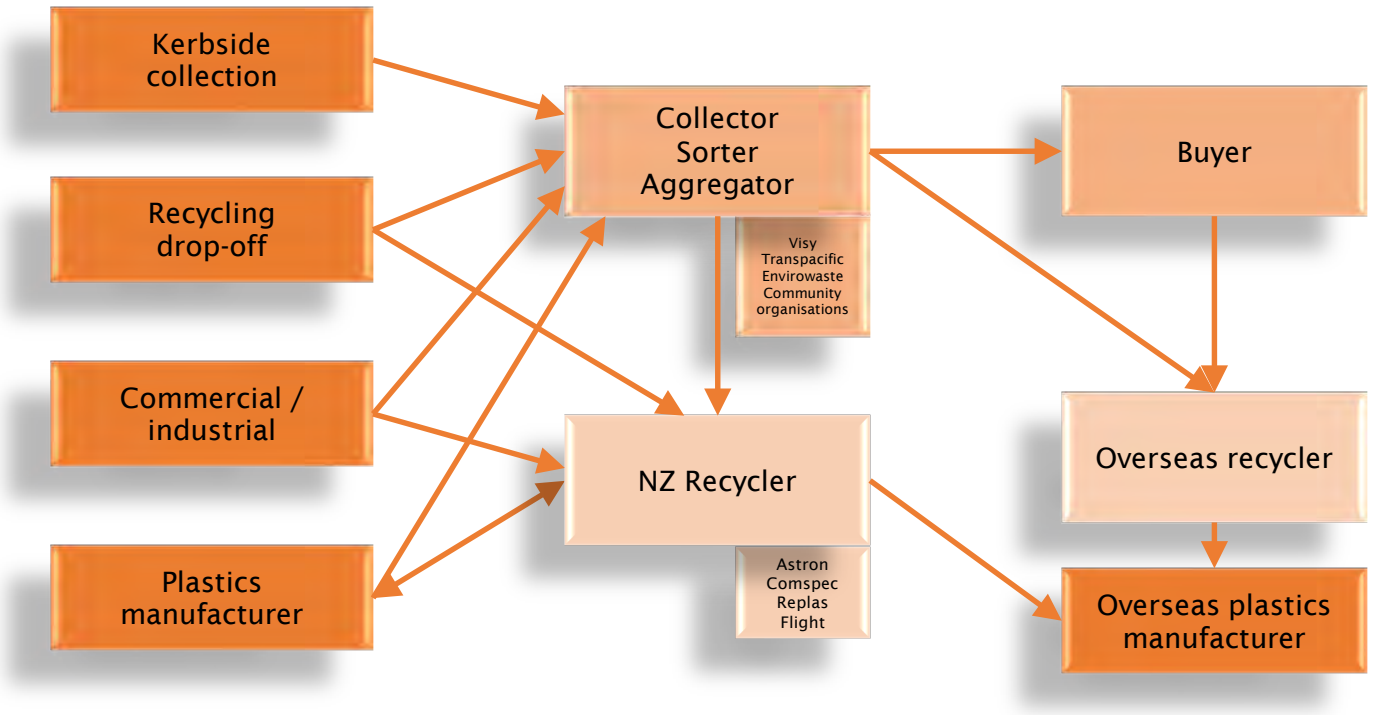
Processing requires constant consistent feeding of the machine under controlled conditions to produce product on specification at an economically viable rate.

Certain processes only operate with certain molecular weight for a given polymer

Eg	blowing film	very high,
	extrusion	high,
	injection moulding	generally medium downwards

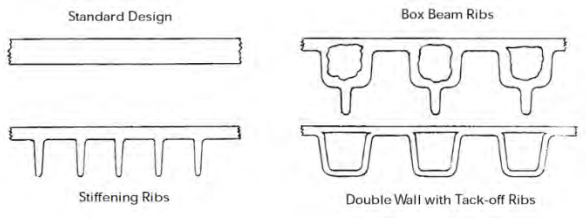
On average each time a polymer grade is reprocessed it loses 10% of its molecular weight. It is usually reprocessed (up to 25% repro) in a blend with virgin material. Repro material must be well separated, have uniform particle size and be uncontaminated. Processing variability generally increases when repro is used.

Plastic Recycling in NZ



Strategies for Reducing Plastic Waste

- Use less material



- Simplify – use easy to recycle polymers, avoid multiple materials

- Avoid labels, fasteners, clips, seals made of different material

- Use recycled polymer

- Consider bio-based polymers

This document is printed on polypropylene, code number 5. It can be recycled.

PLASTICS NEW ZEALAND

SYMBOL	TYPE OF PLASTIC	PROPERTIES	COMMON USES	RECYCLED IN	PACKAGING	NON PACKAGING
1 PET	**PET** Polyethylene Terephthalate	Clear, tough, solvent resistant, barrier to gas and moisture, softens at 70°C	**Soft drink and water bottles**, salad domes, biscuit trays, salad dressing and peanut butter containers, **fleece clothing** and geo-textiles	Pillow and sleeping bag filling, clothing, soft drink bottles, carpet		
2 HDPE	**HDPE** High Density Polyethylene	Hard to semi-flexible, resistant to chemicals and moisture, waxy surface, opaque, softens at 135°C, easily coloured, processed and formed	Crinkly shopping bags, freezer bags, **milk bottles**, ice cream containers, juice bottles, shampoo, chemical and detergent bottles, buckets, rigid agricultural pipe, **milk crates**	Recycling bins, compost bins, buckets, detergent containers, posts, fencing, pipes		
3 PVC	**PVC** Unplasticised Polyvinyl Chloride PVC-U Plasticised Polyvinyl Chloride PVC-P	Strong, tough, can be clear, can be solvent welded, softens at 75°C Flexible, clear, elastic, can be solvent welded	**Cosmetic containers**, electrical conduit, **plumbing pipes** and fittings, blister packs, wall cladding, roof sheeting, bottles Garden hose, shoe soles, cable sheathing, blood bags and tubing, watch straps, commercial cling wrap	Flooring, film and sheets, cables, speed bumps, packaging, binders, mud flaps and mats		
4 LDPE	**LDPE** Low density Polyethylene **LLDPE** Linear low density Polyethylene	Soft, flexible, waxy surface, translucent, softens at 80°C, scratches easily	**Cling wrap**, rubbish bags, squeeze bottles, black irrigation tube, black mulch film, rubbish bins, **shrink wrap**	Rubbish bin liners, pallet sheets, slip sheets		
5 PP	**PP** Polypropylene	Hard but still flexible, waxy surface, softens at 145°C, translucent, withstands solvents, versatile	**Dip pottles** and ice cream tubs, potato chip bags, straws, microwave dishes, kettles, garden furniture, lunch boxes, blue packing tape, **automotive parts**	Pegs, bins, pipes, pallet sheets, oil funnels, car battery cases, trays		
6 PS	**PS** Polystyrene	Clear, glassy, rigid, brittle, opaque, semi-tough, softens at 95°C. Affected by fats and solvents	CD cases, plastic cutlery, imitation 'crystal glassware', low cost brittle toys, video cases, **water station cup, safety helmets**	Coat hangers, coasters, white ware components, stationery trays and accessories		
6 EPS	**EPS** Expanded Polystyrene	Foamed, light weight, energy absorbing, heat insulating	Foamed polystyrene hot drink cups, hamburger take-away clamshells, **foamed meat trays**, protective packaging for fragile items, insulation, **insulation panels**	Car parts, concrete aggregate, plastic timber		
7 OTHER	**OTHER** Letters below indicate ISO code for plastic type including SAN (styrene, acrylonitrile), ABS (Acrylonitrile butadiene styrene), PC (polycarbonate), Nylon, degradable plastic e.g. PLA	Includes all other resins, multi materials (e.g. laminates) and degradable plastics. Properties dependent on plastic or combination of plastics	**Packaging,** car parts, appliance parts, **computers**, electronics, water cooler bottles, medical devices,	Car parts, concrete aggregate, plastic timber		

www.plastics.org.nz (search PLASTICS ID CODES)

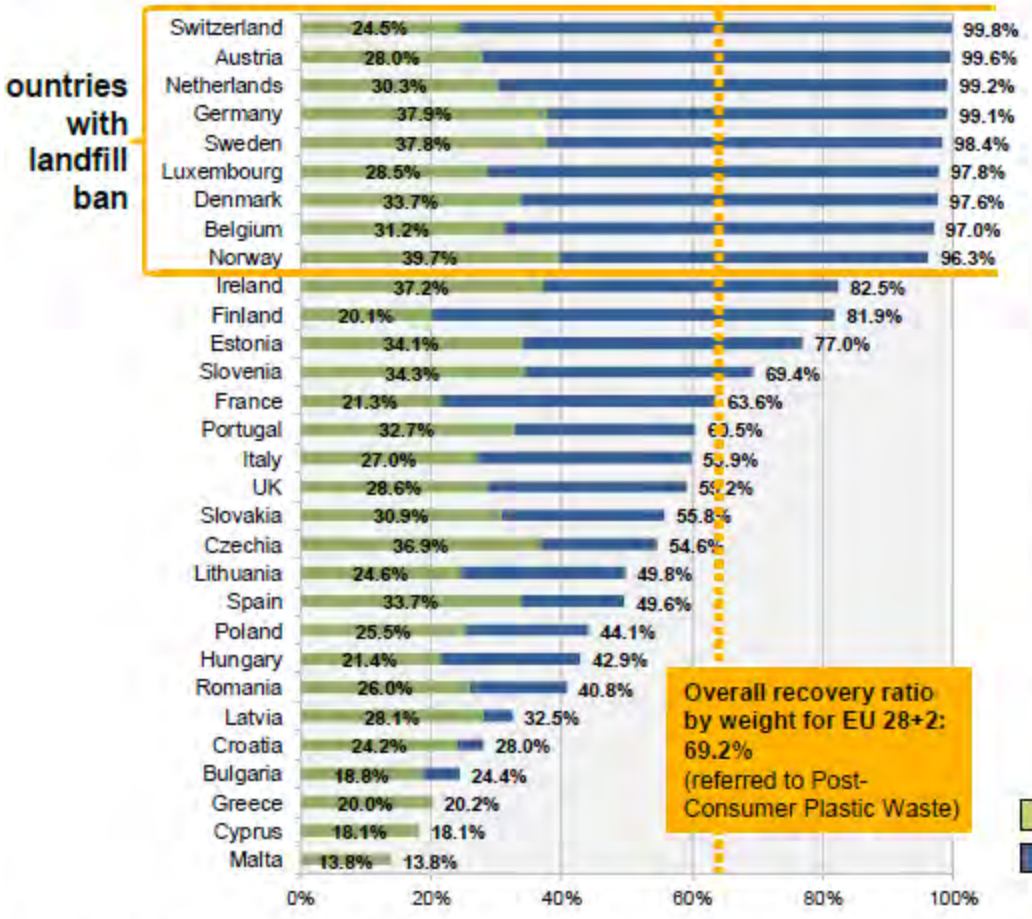
For those of you who are still awake

Any (Easy) Questions??

Extra Slides

Europe (EU 28 + 2)
Recovery of Plastics Waste 2014

PlasticsEurope
Association of Plastics Manufacturers



9 countries in Europe reached a recovery ratio of more than 95% of the Post-consumer Plastic Waste.

These countries have a landfill ban.

Also 6 of these countries are amongst the 11 countries with the highest recycling rates (>30%).

Therefore **„divert from landfill“** boosts higher **recovery** and **recycling** quantities, also of waste streams, which have not been recovered so far.

Source: Consultic Marketing & Industrieberatung GmbH

Leading Bioplastics

- **Polysaccharides**
  - Starches
  - Cellulosics

- **Polyesters**
  - Polylactic acid (PLA)
  - Polyhydroxyalkanoates (PHAs)
  - Polysuccinate esters (PBS,..)
  - Others

Starch

- Main energy storage in cereals, legumes and tubers
- Low cost base material
- Annually renewable / naturally abundant
- Most common starches:
  - Wheat, Potato, Maize,
  - Rice, Cassava, Pea.
- Extracted

Summary - TPS

- Cheap, bio-based, renewable
- Usually readily compostable
- Commercially available (several suppliers)
- Some performance limitations
  - usually overcome (to a degree) by blending

Cellulose Plastics

- Abundant, renewable resourced

- **Regenerated Cellulose Process**
  - Rayon, viscose (fibres)
  - Cellophane™ (Innovia Films)
  - Natureflex™

- **Cellulose Esters/Ethers**
  - Eastman Tenite
  - Acetate, Butyrate, Propionate…..

Renewable &
Biodegradable

PLA – Limitations

- **Permeability**

Property	WVTR	O_2	CO_2	HDT, °C
NatureWorks PLA	21	40	183	54-60
PET	1 - 2	3 - 6	15-25	75

units: g-mil/100 in2 day for WVTR and
cc-mil/100 in2 day atm @ 20°C and 0% RH for O2 and CO2

- **Heat sensitivity**
- **Brittleness - impact strength**
- **Melt strength – during processing**
- **Sensitivity to moisture – during processing**

Higher Performance Bioplastics
Polyamides

PA radiator from DuPont/Denso

Mazda car panels

Tennis racket & fuel line
- Arkema