RADTECH UV+EB 2020

# Recyclable Packaging Options with Electron Beam Curing Technology

Im Rangwalla

Energy Sciences Inc.

Wilmington MA

RADTECH UV+EB 2020

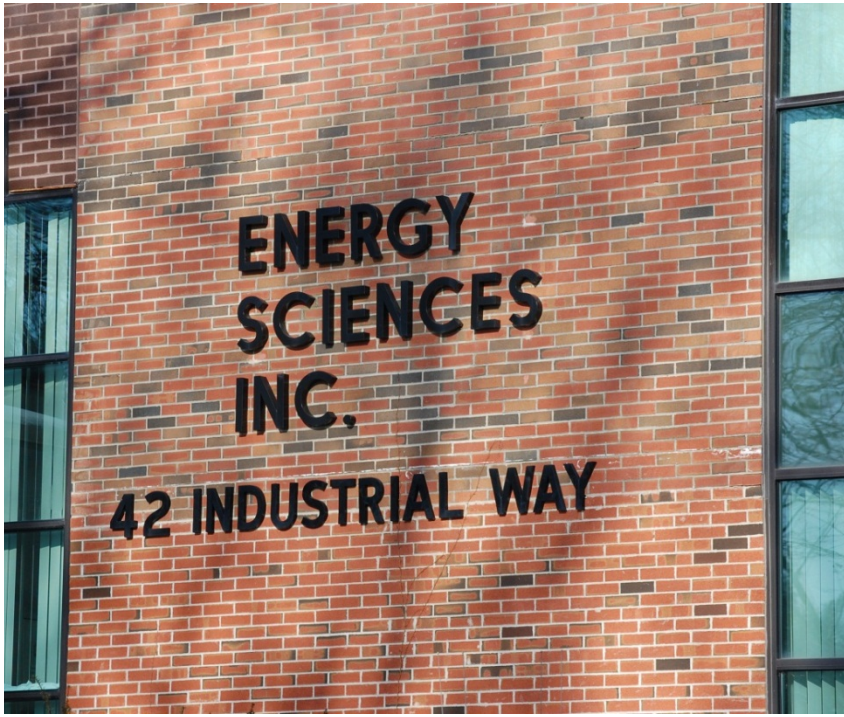
# Agenda

- Flexible Packaging Markets
- Sustainability Mandates from CPG's and States
- Electron Beam Curing Options to Provide Sustainable Packaging
- Re-Cylability Study
- Conclusions & Next Steps

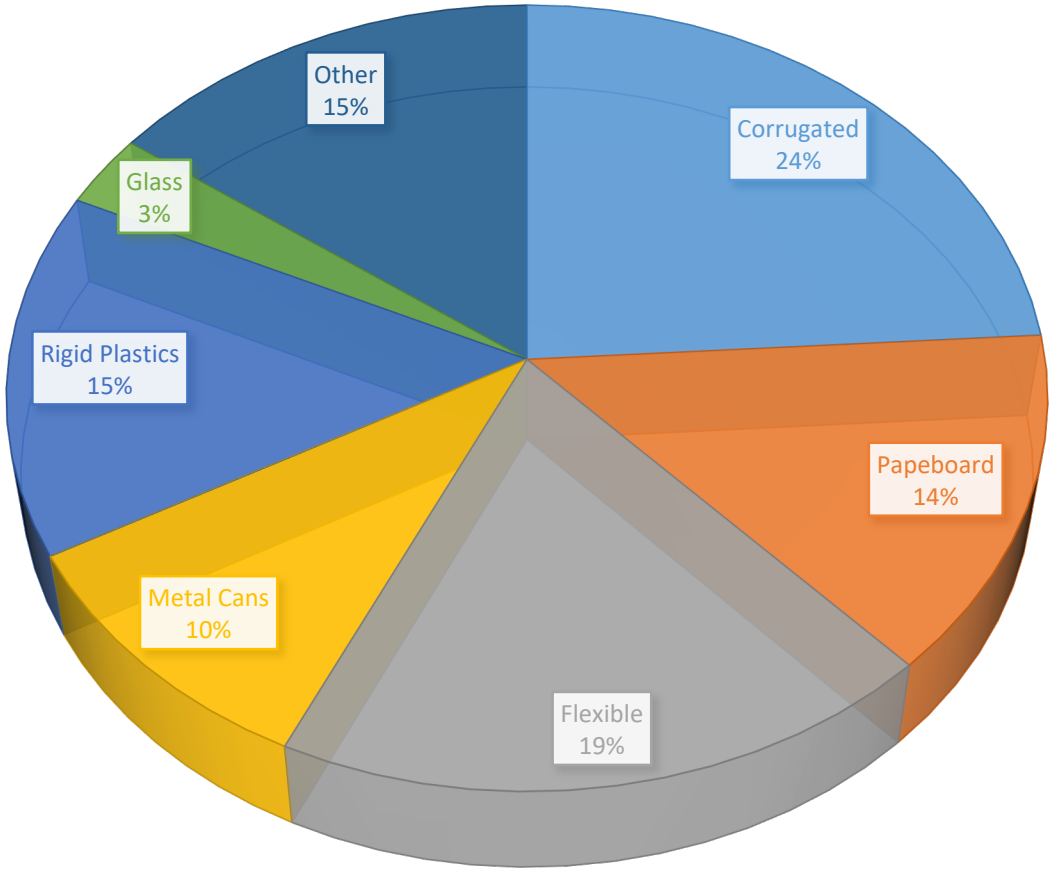
# Who is Energy Sciences Inc. (ESI)

- Founded in 1970
- Headquartered in USA
- Wholly Owned Subsidiary of Iwasaki Electric Japan
- Global Sales and Service

  (U.S.A., Japan, Europe)
- ISO 9001-2008 Registered
- World's Largest EBeam Co.



# Total NA Packaging Market US $170 Billion
# Flexible Packaging Largest Growth (US $32.3 Billion)
# FPA 2018

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# US Flexible Packaging Industry Overview
# FPA 2018

| GROWTH | 2000 | 2008 | 2009 | 2018 |
|---|---|---|---|---|
| Total Flexible Packaging Industry | $ 19.7B | $26.6B | $23.2B | $31.8B |
| % Growth | 3.7% | 0.6% | -12.9% | 2.7% |
| Benchmark GDP | 4.1% | -0.3% | -2.8% | 2.9% |

# Flexible Packaging Purchases in NA 2018

**Value About $17.5 B**

| | |
|---|---|
| • Film & Resins | 70 % |
| • Paper | 6 % |
| • Aluminum Foil | 4 % |
| • Other | 10 % |
| • Inks | 6 % |
| • Coatings & Adhesives | 4 % |

# Brand Owners Push For Sustainability

- PepsiCo said its "sustainable plastics vision is rooted in three pillars" — reduction of plastic use, increasing recycling rates and reinventing packaging
- Unilever committed to ensuring that all of its plastic packaging is fully reusable, recyclable or compostable by 2025.
- Nestle, “We are committed to finding improved solutions to reduce, re-use and recycle. Our ambition is to achieve 100% recyclable or reusable packaging by 2025”.
- P&G, 100% recyclable or reusable packaging by 2030.Reduce global use of virgin petroleum plastic in our packaging by 50% by 2030

# States Re-Cycle Mandates

## California Packaging Legislation CA SB54

"CalRecycle to come up with a plan and regulations to implement an aggressive rate/date scheme for recovery and recycling/composting of all packaging in the state".

Producers will have to prove that:

Amount of Packaging Re-Cyled or Composted:

30% by 2026

40% by 2028

75% by 2030

**Maine, Vermont, Washington, Oregon, Connecticut, New York to Follow**

# Commonly Available Structures Using Disimilar Plastics Food and Non-Food Packaging

Top layer PET OR OPP.

(Provides Heat Resistance, Clarity, COF and other Properties)

Reverse Print

Adhesive

PE Sealant (Could Be Barrier Like EVOH)

**Result:  NOT RECYLABLE**

To Make it RECYLABLE Need to make packages from similar materials. 2 OPTIONS

# Commonly Available Structures Using Disimilar Plastics Food and Non-Food Packaging

- OPTION 1:

Top Layer MDOPE or BOPE

Reverse Print

Adhesive

PE Sealant (Could Be Barrier Like EVOH)

- OPTION 2:

Top Layer EB OPV

Surface Print

Adhesive

PE Sealant (Could Be Barrier Like EVOH)

# Further Evaluation of Option 1

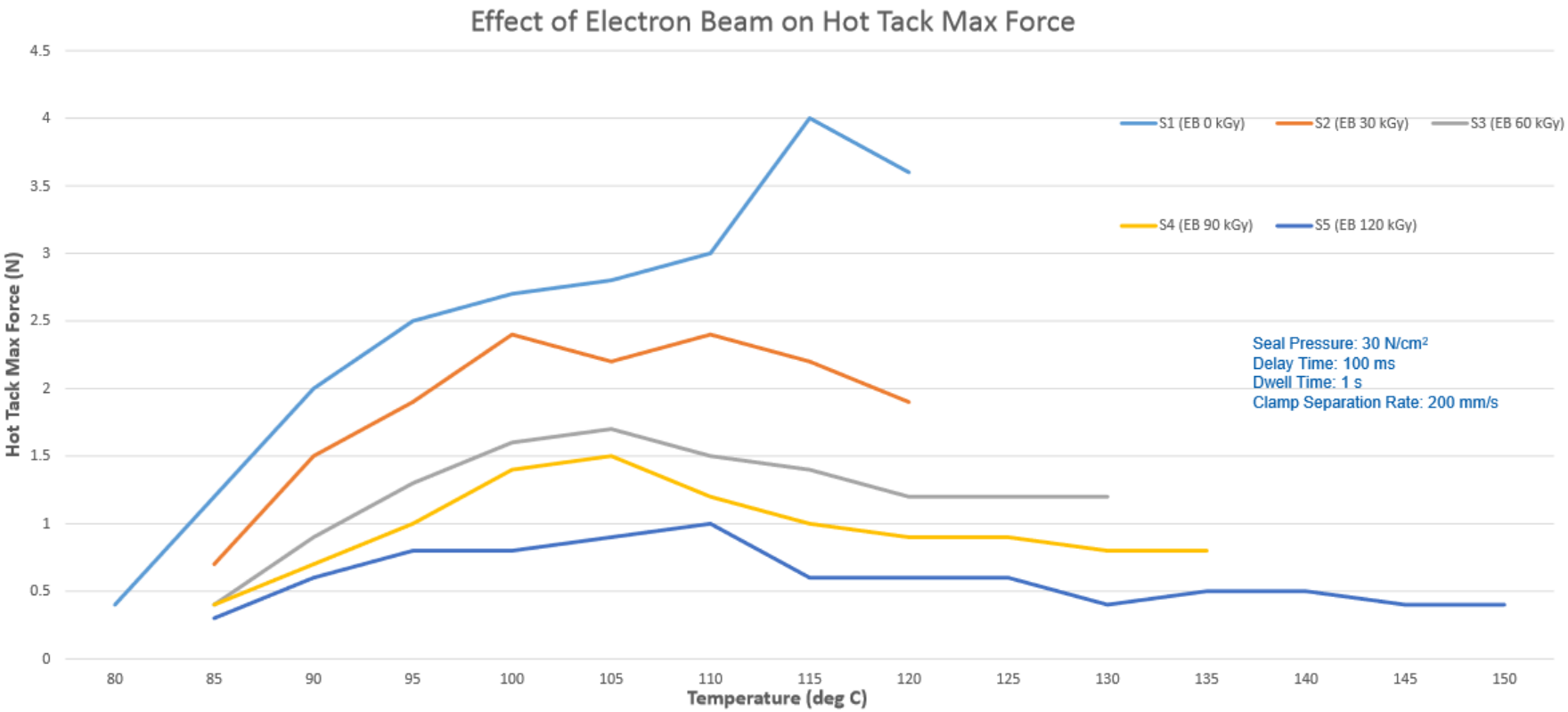
- To facilitate re-cyling of flexible packaging similar material laminates like PE\PE are being developed to replace PET\PE or OPP\PE.
- Haze and other mechanical properties of top layer PE can be similar to PET or OPP by use of stretching technologies like MDO or BOPE
- Barrier can be provided by using co-extruded EVOH or SiOx or ALOx technology to the sealant PE film.
- Major challenge of mono materials is its heat resistance compared to PET or PA or OPP leading to pre-mature melting or sticking of the top layer PE to the sealing bars restricting high speed automatic sealing.
- Through the use of electron beam to increase the heat resistance of the top ply PE film, a sufficient temperature gradient could be created between the top ply printed film and the bottom ply sealant film to permit high speed automatic sealing compared to the current dissimilar structures.

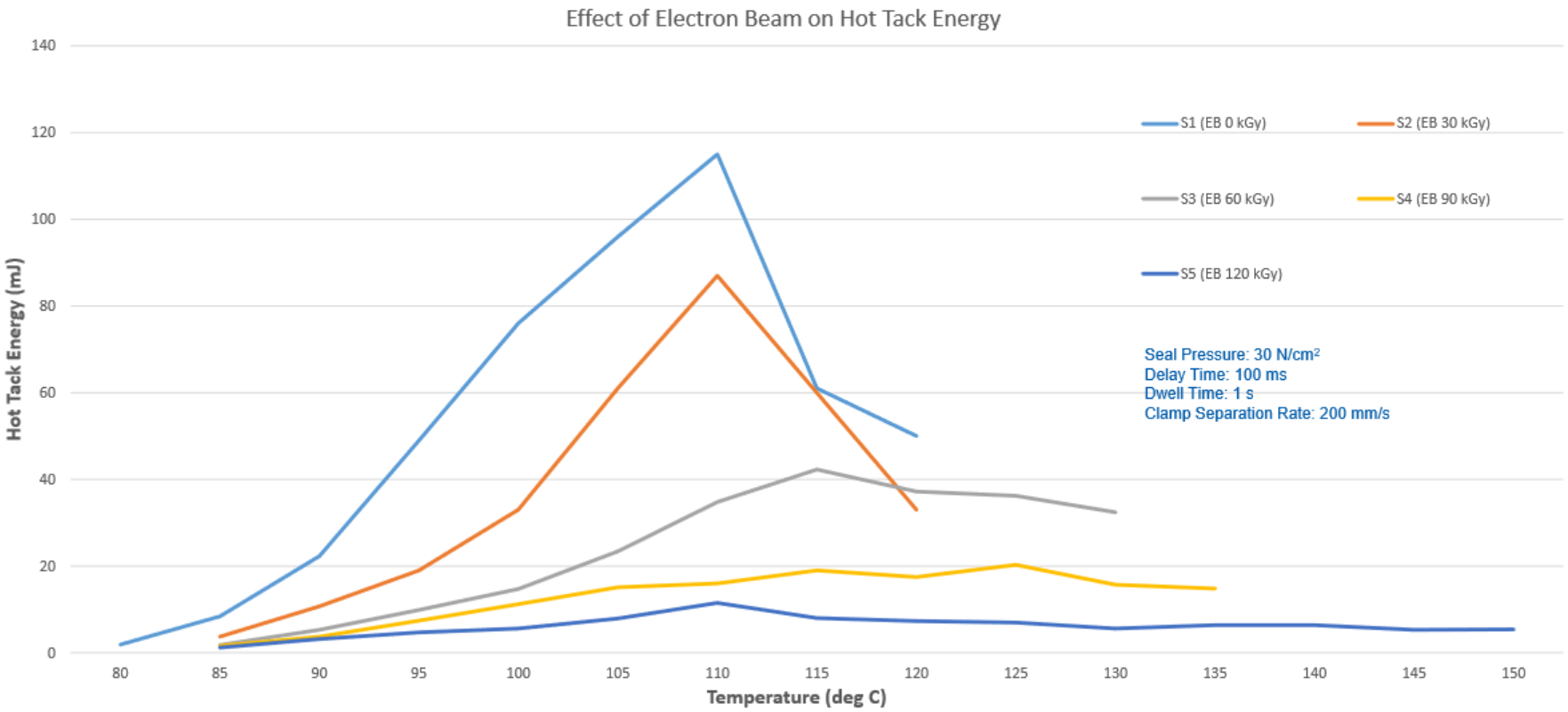
# EB Treatment of the Top layer PE Film

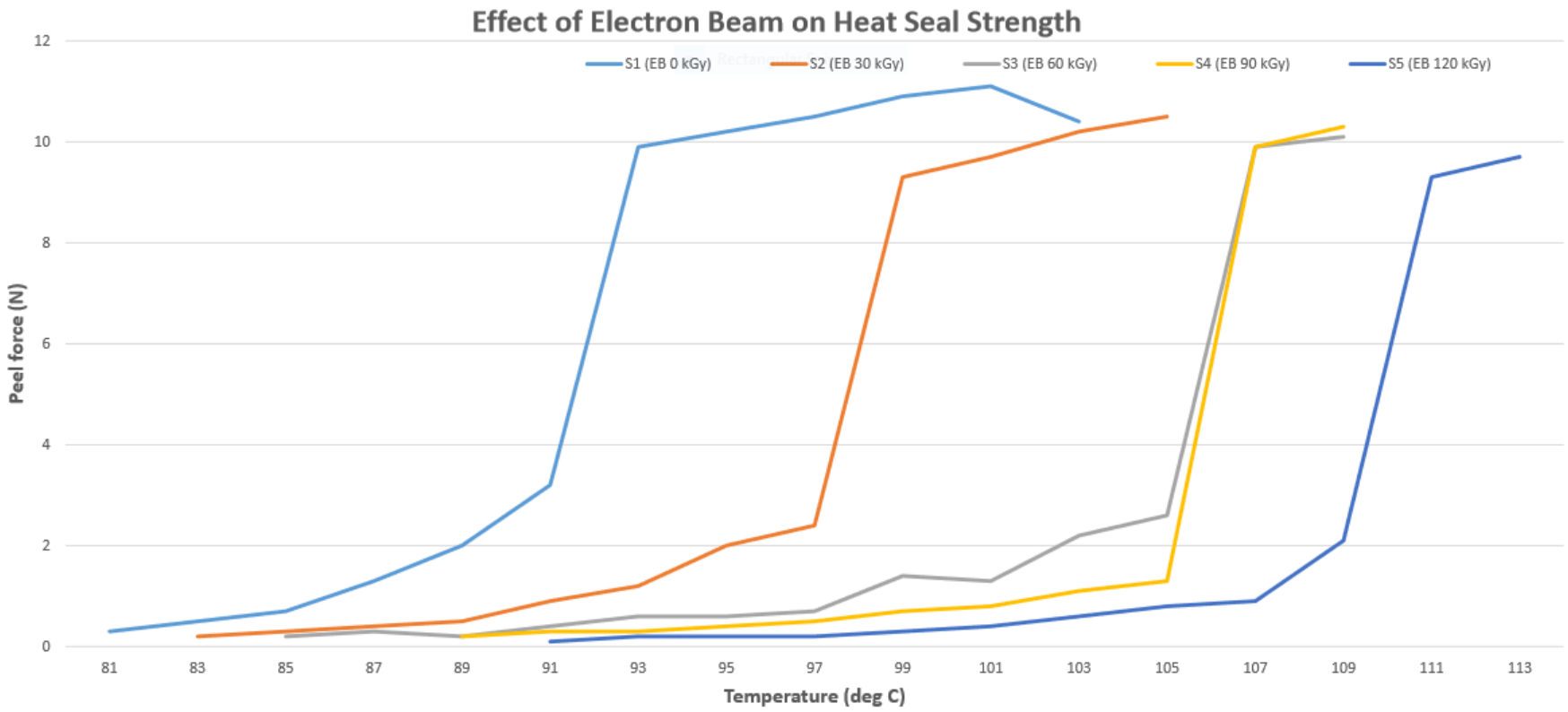
- Top Layer MDO PE Film Thickness 25 microns

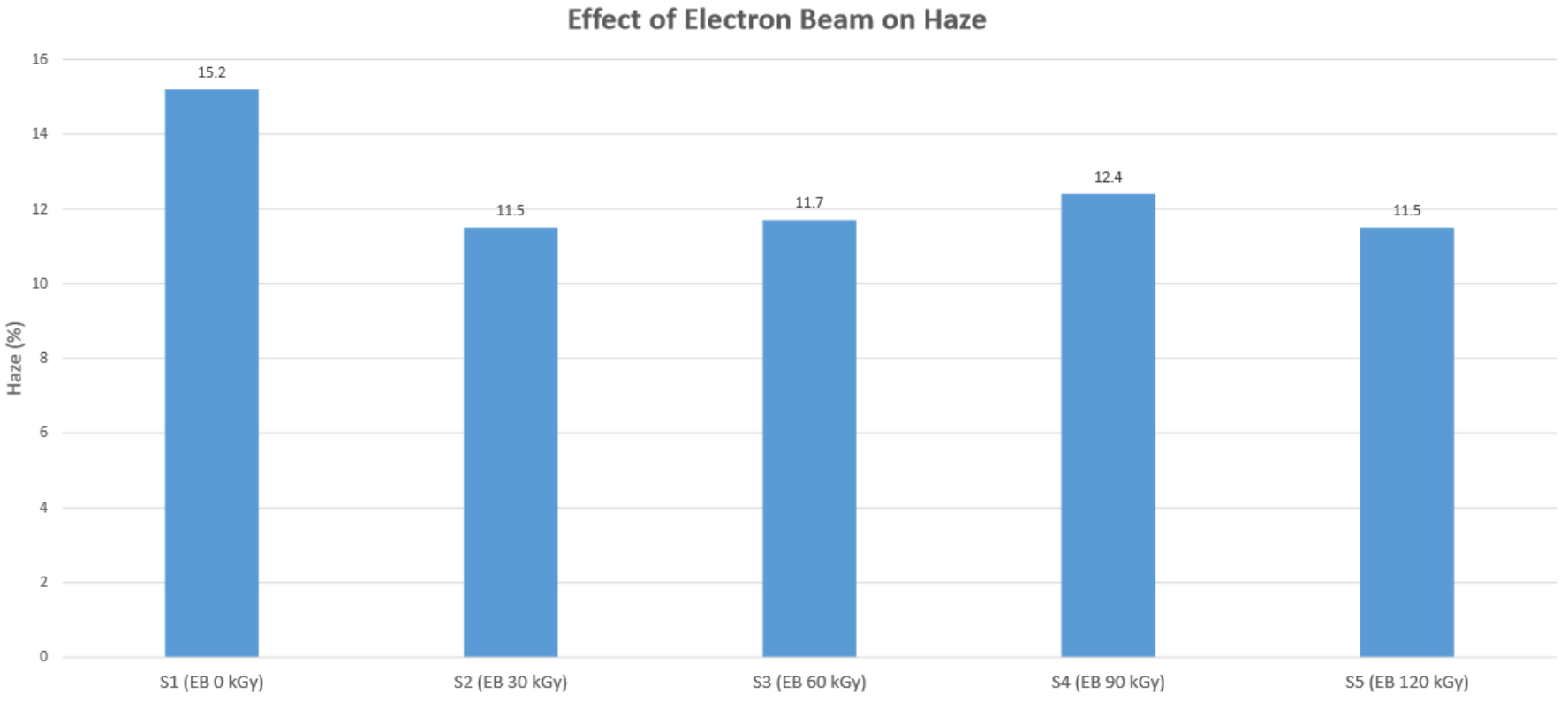
- EB Conditions: 125 kV providing complete penetration
  - Sample S1  0 kGy Control
  - Sample S2 30 kGy
  - Sample S3 60 kGy
  - Sample S4 90 kGy
  - Sample S5 120 kGy

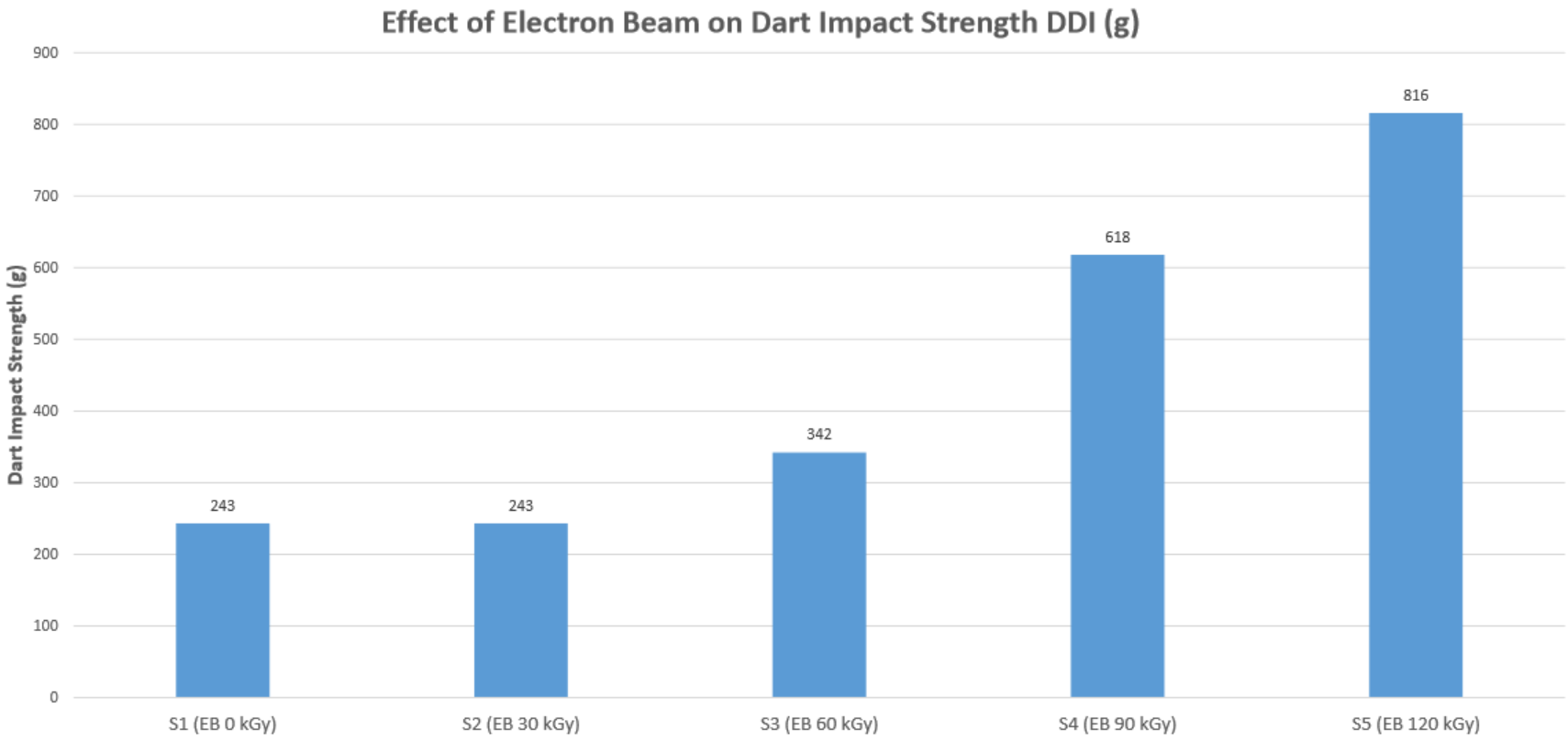
Films tested for sealing \ hot tack


Effect of Electron Beam on Hot Tack Max Force
Hot Tack Max Force (N)
Temperature (deg C)
S1 (EB 0 kGy)
S2 (EB 30 kGy)
S3 (EB 60 kGy)
S4 (EB 90 kGy)
S5 (EB 120 kGy)
Seal Pressure: 30 N/cm²
Delay Time: 100 ms
Dwell Time: 1 s
Clamp Separation Rate: 200 mm/s
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150


Effect of Electron Beam on Hot Tack Energy
Hot Tack Energy (mJ)
Temperature (deg C)
S1 (EB 0 kGy)
S2 (EB 30 kGy)
S3 (EB 60 kGy)
S4 (EB 90 kGy)
S5 (EB 120 kGy)
Seal Pressure: 30 N/cm²
Delay Time: 100 ms
Dwell Time: 1 s
Clamp Separation Rate: 200 mm/s


Effect of Electron Beam on Heat Seal Strength
S1 (EB 0 kGy)
S2 (EB 30 kGy)
S3 (EB 60 kGy)
S4 (EB 90 kGy)
S5 (EB 120 kGy)
Peel force (N)
0
2
4
6
8
10
12
81
83
85
87
89
91
93
95
97
99
101
103
105
107
109
111
113
Temperature (deg C)


Effect of Electron Beam on Haze
Haze (%)
16
14
12
10
8
6
4
2
0
15.2
11.5
11.7
12.4
11.5
S1 (EB 0 kGy)
S2 (EB 30 kGy)
S3 (EB 60 kGy)
S4 (EB 90 kGy)
S5 (EB 120 kGy)

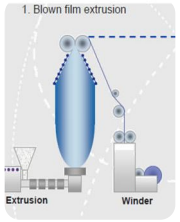

Effect of Electron Beam on Dart Impact Strength DDI (g)
Dart Impact Strength (g)
900
800
700
600
500
400
300
200
100
0
243
243
342
618
816
S1 (EB 0 kGy)
S2 (EB 30 kGy)
S3 (EB 60 kGy)
S4 (EB 90 kGy)
S5 (EB 120 kGy)

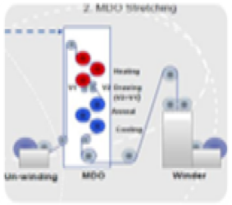
# Findings and Observations

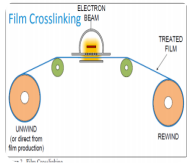
- Heat resistance of PE films is increasing with higher dose of EB irradiation.
- At 60 kGy the hot tack is dropped to quite a low level.
- At 90 + kGy the films do not hot tack anymore indicating heat resistance is quite high.
- Between 0 and 120 kGy difference in seal initiation temperatures is about 18 C.
- Films turn more transparent haze drops and some mechanical property improvement with EB dose
- MD film shrinkage reduces with EB dose, better for printing.
- PE films after EB treatment increases in temperature resistance, better mechanical properties. **BUT**

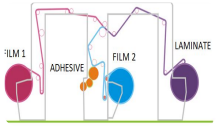
  - **Will it be functional in package forming and filling?**
  - **Is it RECYLABLE?**

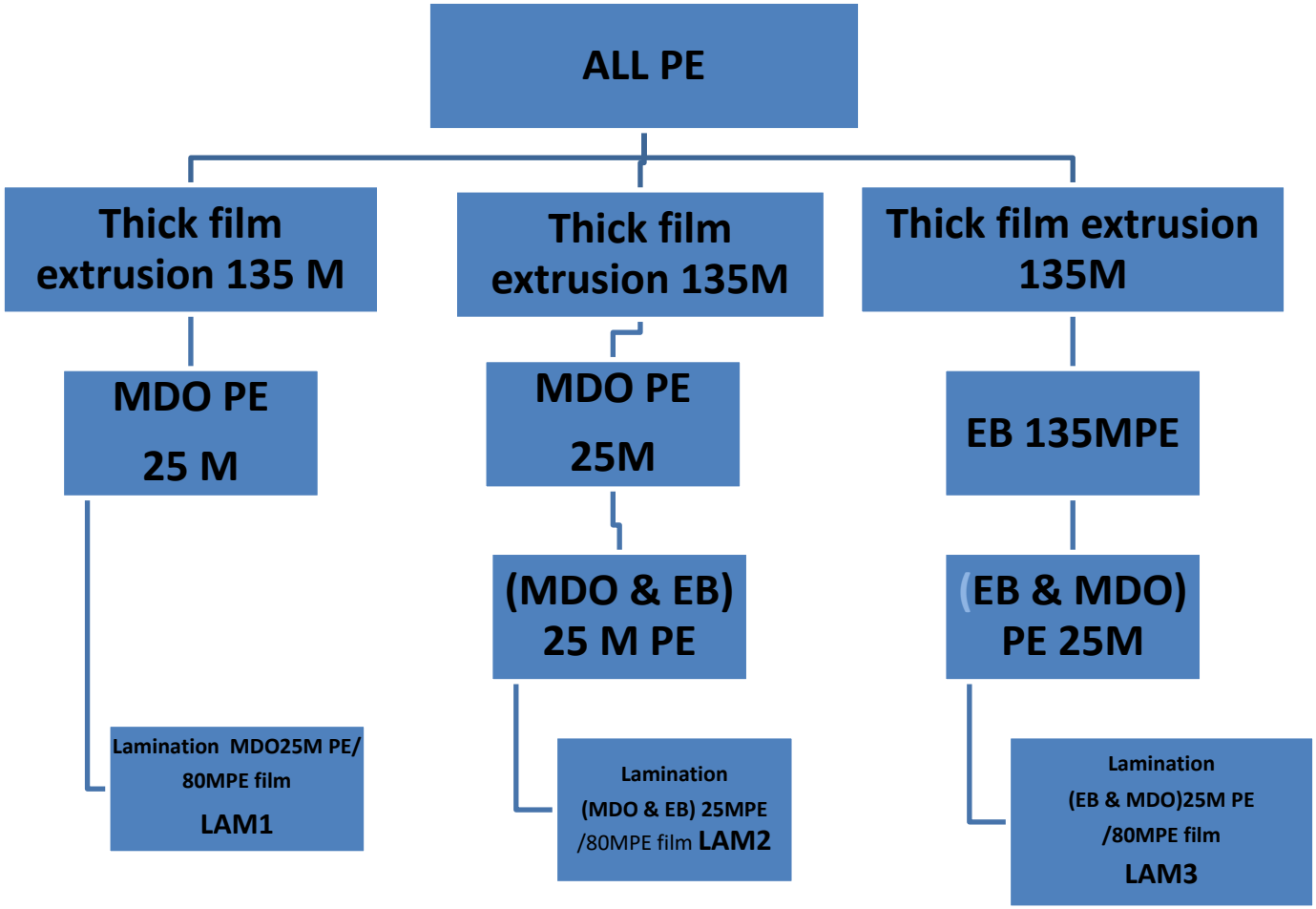
# MDO: EB/MDO/Lamination Combinations. ReCylability Studies



# Packaging Trials Results

- EB Conditions of PE1 Film after MDO and Before MDO.
  125 kV and 90 kGy
- PE1 25 Microns Film laminated to PE2 80 Microns Sealant Film using time cured PU based adhesives from Dow. **LAM 2**
- PE1 Film EB treated before MDO was successfully stretched from 135 microns to 25 microns.
- This was then laminated to PE2 80 microns Sealant Film using time cured PU adhesives from Dow. **LAM 3**
- **LAM 2** and **LAM 3** performs much better in VFFS and bag making machines than **LAM 1**.
- Broader heat seal range and increase in SIT by EB treatment helps packaging.

# Re-cylability Results

- **LAM 1** and **LAM 2** has been shredded chopped and re-pelletized to be used in combination with virgin materials for production of blown films in the Buss compounder.
- Process ability during film extrusion as well as effects on film properties have been evaluated.
- The pellets from **LAM 2** show an increase in viscosity as well as a slight yellowish color.

| | Color of Pellets | MI |
|---|---|---|
| LAM1 | White | 0.7 |
| LAM2 | Yellow | 0.1 |

# Recylability Results CONTD

- The re-grinded material from treated films has been re-cyled in the production of blown films when blended with virgin materials using Collins lines.

  - **With 30 % LDPE (310E)**
  - **With 50 % LLDPE(DOWLEX2645)**

- Better Draw-ability in blends with LLDPE than LDPE

- Films made with **LAM 1** and **LAM 2** had gel spots attributed to the adhesive.

- Mechanical properties slight decrease in tensile elongation at break

- A significant increase in haze is the main difference when we compare films made with **LAM 1** and **LAM 2**.

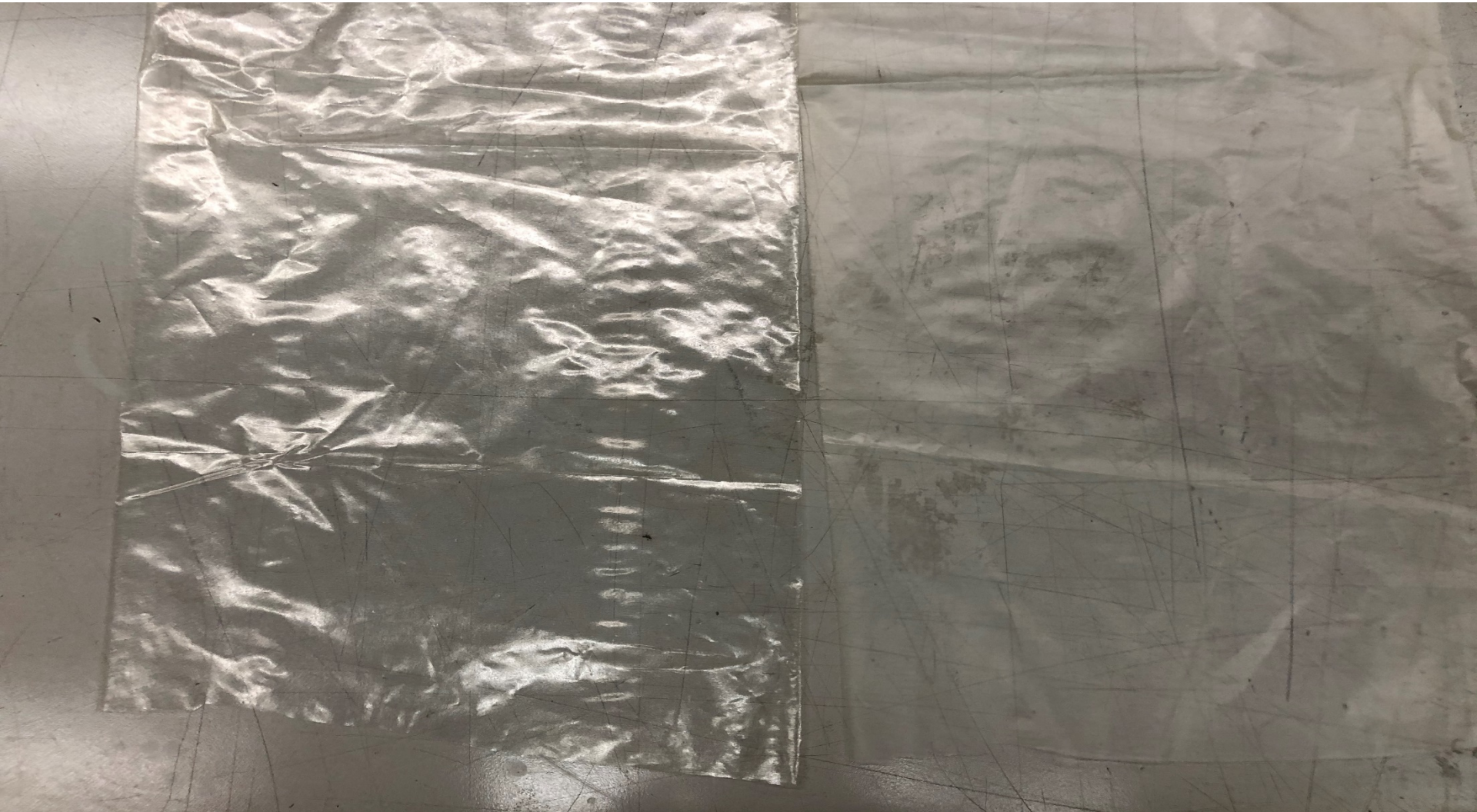
# With 30 % LDPE (310E)

**LAM 1** **LAM 2**

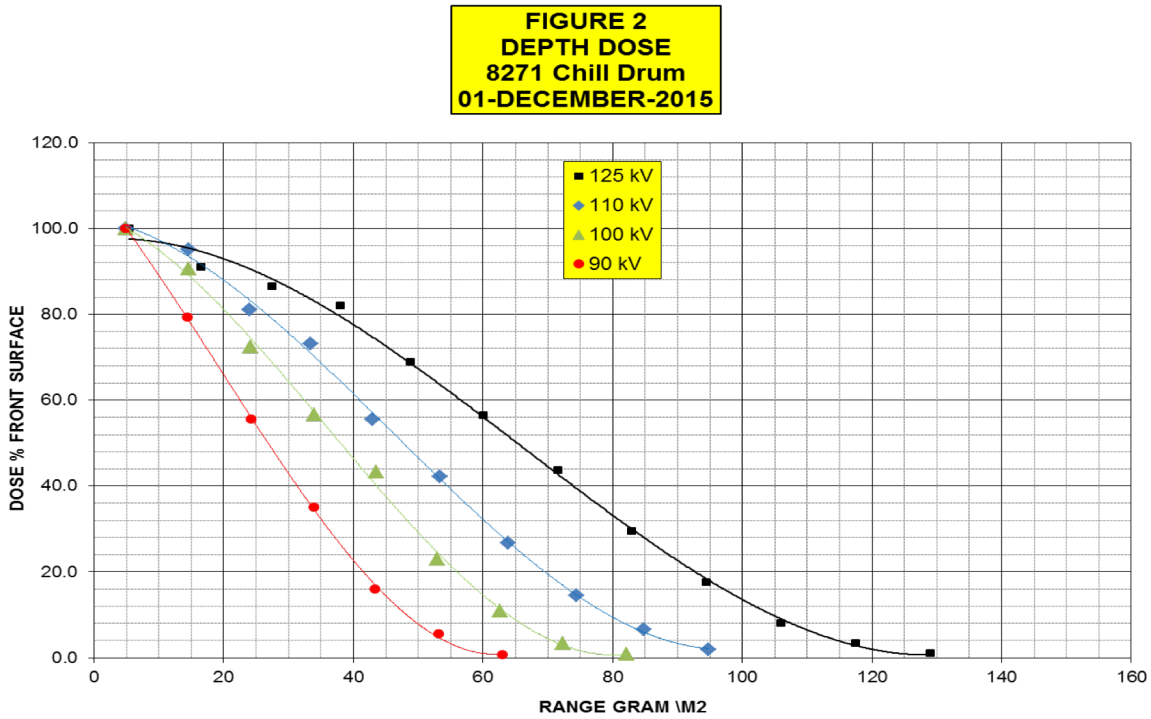
# With 50 % LLDPE(DOWLEX 2645)

LAM 1

LAM 2



# Difference in EB treatment Between LAM 2 and LAM3




**LAM 2: EB treatment PE 1 25 M**

**LAM 3: EB treatment PE 1 6-8 M**

# Conclusions and next steps

- EB treated laminates can be re-cycled.
- Recyled films from LAM2 was very hazy, so cannot be used in clear film applications, but possibly garbage bags.
- LAM 2: The top film PE1 was EB treated after MDO at 125 kV and 90 kGy. At 125 kV we get full penetration of the electrons.
- LAM 3: The top film 135 M thick was EB treated before MDO at 125 kV and 90 kGy. EB treatment up to about 40 gsm. After MDO film is about 25 microns, EB treatment estimated to be about 6-8 microns. MUCH LESS THAN LAM 2.
- Packaging evaluations indicated LAM 3 also functional.
- Re-cylability of LAM 3 plan in Q1, 2020 expectation is will be better than LAM2 since EB treated layer is about 1\4 of LAM 2.
- An option could be to EB cure inks (Flexo or Gravure) and EB crosslink the film to make PE\PE re-cylable similar laminates

# Acknowledgements

Thanks to Dow Europe Performance Plastics based in Horgen Switzerland and Tarragona Spain for all the packaging trials and re-cylability studies

# Thank You
# Any