Who is afraid of brominated flame retardants?

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AMI Fire Resistance in Plastics
February 2021

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ICL is a leading global Fertilizers and specialty minerals company

- **$5.3bn** sales in 2019
- Manufacturing sites spread around the world
- **~13,000** Employees
- **20** R&D centers with 500 researchers
- Newly included in the FTSE4 Good index for sustainability efforts

Leading Positions in Our Markets

Market Leadership

Number 1 Market Positions

- #1 in Bromine capacity
- #1 in Bromine Iso-tank fleet
- #1 in Brominated biocides
- #1 in Phosphorus FRs
- #1 in Clear Brine Fluids
- #1 Self-extinguishing Hydraulic fluids

Leading Market Positions

- Flame Retardants
- Specialty Magnesia
- Magnesium Chloride

R&D Leadership

- R&D in Israel, USA
- Developing next-generation polymeric, reactive products
- New FR Product Pipeline: SaFRon®, TexFRon®, VeriQuel®, PolyQuel®
- ZnBr Energy Storage complexing agent for Energy storage Batteries
- Additional attractive bromine applications under R&D

Environmental Leadership

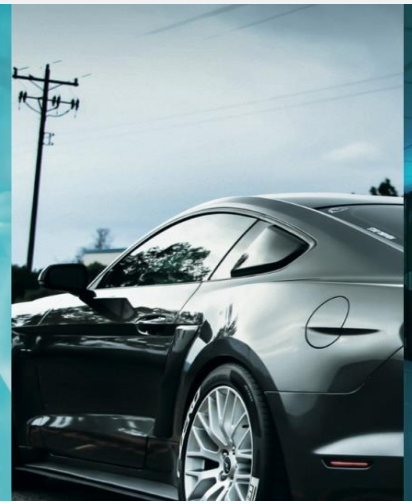
- Responsible Care
- VECAP® (Voluntary Emissions Control Action Program)
- Greenhouse gas reduction
- SAFR® – Scientific Assessment for Flame Retardants

Brominated Flame Retardants & critical fire safe uses

Communication

Electronics

Automotive



Servers

Smart Manufacturing

Internet of Things & Big Data

Electric & Autonomous Vehicles

Medical Devices

Solar Panels

Smart Roads

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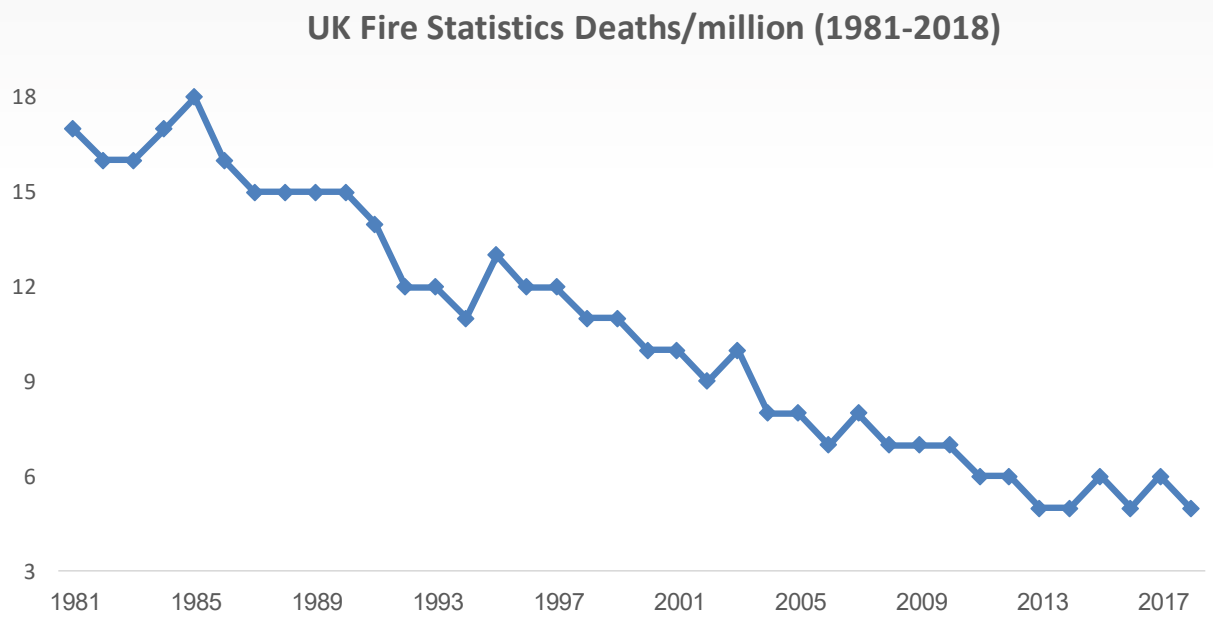
Brominated Flame Retardants & fire safety standards

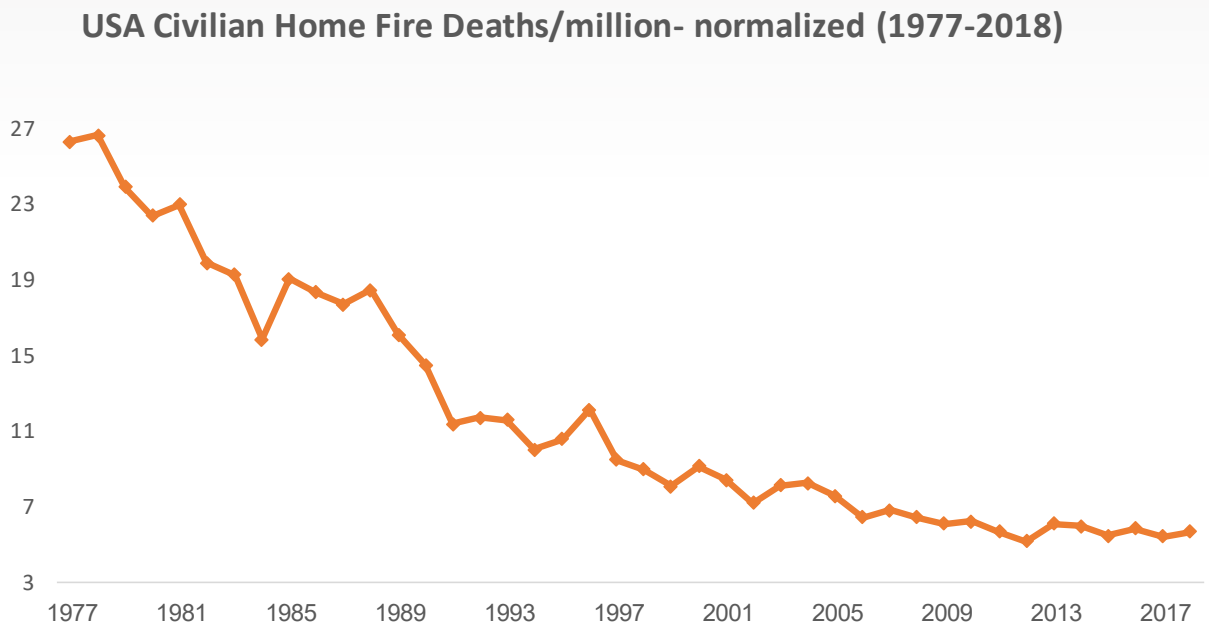
E & E

Categories	Fire safety standard
Consumer equipment and household appliances	IEC 60335 (International); EN 60065 (Europe)
Wire & cables	ISO 6722 (International); ASTM D2863 (US); EN 50265; EN 50266 (Europe)
Fire Hazard Tests for Electrotechnical Products	IEC 60695-2-10; IEC 60695-2-12; IEC 60695-2-13 (International)
Evaluation of Materials for Electrical End Products	UL 746A (US); ASTM D 3638-85 (US); IEC 112 (International)
Heat and Smoke release	UL 2043 (US)
Corrosion Damages	IEC 60695-5 (International)
General for E&E equipment	UL 94

Brominated Flame Retardants contribution to fire safety

A steady reduction in lethal fires and fire deaths





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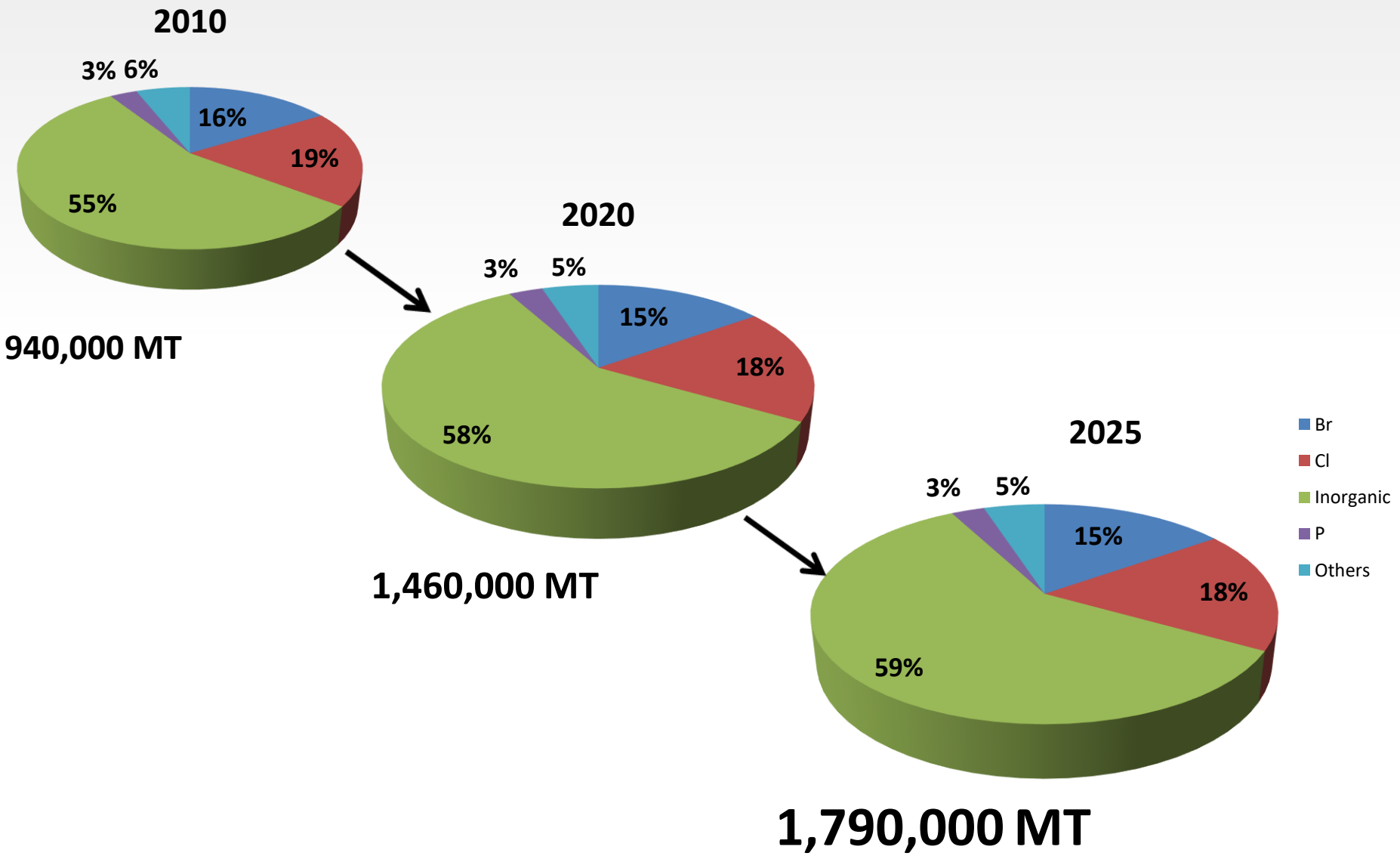
Source: NFPA Survey of fire Department 1977-2018; UK National statistics

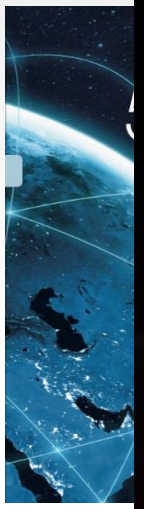
Global flame retardants market split



Source: ICL internal market survey

Can we imagine a world without Brominated Flame Retardants in critical uses ?

Com



Inter
&

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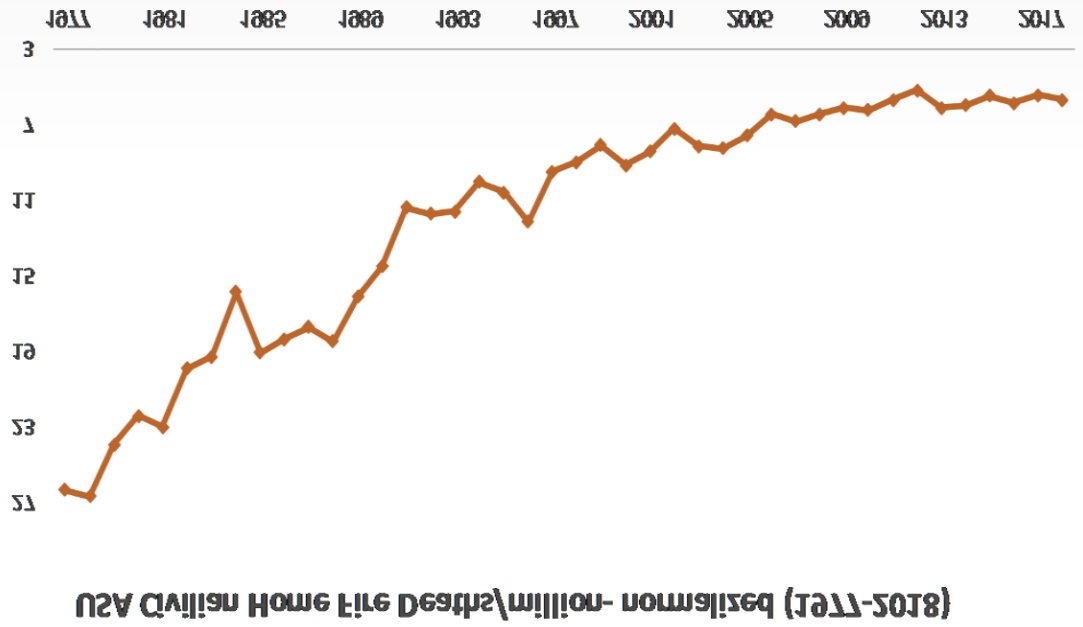
Can we imagine a world without Brominated Flame Retardants in critical uses ?

A steady increase in lethal fires and fire deaths ?



Source: NFPA Survey of fire Department 1977-2018; UK National statistics

Can we imagine a world without Brominated Flame Retardants in critical uses ?

Brominated Flame Retardants are essential for meeting fire safety standards. Let's not make them the scape goat of public chemophobia!

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The truth on Brominated Flame Retardants

- All commercial BFRs are *approved* for unrestricted use regulatory wise; Polymeric FRs are registration *exempted*
- BFRs exhibit *high cost/efficiency ratio* in the vast majority of thermoplastic applications; in most applications, the required BFRs loading is *lower* compared to alternatives, for reaching same fire safety standards
- BFRs are solid, free-flow, *easy to handle* materials and exhibit *excellent processing performances*

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The truth on Brominated Flame Retardants

- BFRs show excellent *hydrolytic stability* in thermal processes and end-uses, even under harsh conditions. BFRs are *thermally stable* in all thermoplastic transformation processes
- BFRs *maintain* mechanical and rheological properties and have *little impact* on the initial polymer performances
- Flame retarded polymers with BFRs are *fully recyclable*, keep properties resilience and meet *circular economy* requirements

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WEEE/ELV plastics part of a circular Economy

Limitations mechanical recycling due to legacy contaminants

Challenges for all recycling activities and all plastics:

- Collection and sorting system
- Substances of concern and change of POP limits
- Scale of Economy
- Constant changing of legislation/ notification
- Demand of recyclate
- Low oil price compared to virgin polymers

Recycling technologies

Today material/mechanical recycling:
- Sorting and Mechanical processing

Physical recycling:
- Dissolution/purification: (separating additives & recycling polymer)

Chemical recycling:
- Depolymerisation into monomer
- Gasification/pyrolysis
- Solvolysis

Pre-sorting is nearly always needed! Improving sorting technologies – more efficient recycling!

Sorting technologies development

For all recycling technologies a certain sorting step plus purification is needed:

- Plastics with BFRs separation using density separation
- XRF-NIR technologies are used to separate bromine/halogens containing plastics
- Near and Mid Infra Red Sorting even becoming possible for black plastics
- Tomra technology, Steinert and others to be used to separate different polymer type
- Challenge for WEEE/ELV (automotive) plastics sorting efficiency >98% → quality issue

Innovative recycling technologies for Styrenics, ABS and HIPS containing BFRs

- Focus is on physical/chemical recycling methods that allow separation of BFRs and recycling in dedicated streams including destruction of POPs and bromine recovery.
- Certain projects of relevance
  - ✓ PolyStyreneLoop handling EPS with HBCD (insulation foam) waste
  - ✓ NONTOX handling WEEE, ELV, and CDW plastics with BFRs
  - ✓ PLAST2bCLEANED: using super heated solvent with Br and ATO recovery and focus on E&E and automotive plastics with BFRs
  - ✓ PWB precious metal recycling
  - ✓ SMX project, tracing BFRs for recycling(BSEF/NAFRA study)

NONTOX project : Successor of CLoseWEEE

A H2020 funded project:

Removal of BFRs and contaminants from WEEE/ELV/C&D plastics

Using CreaSolv® Technology and Extruclean

A potential process for scaling up to a Demoplant similar to PSLoop

Aim:

- ✓Optimise and demonstrate the efficacy of different technologies to extract functional additives like ATO and bromine from the polymer
- ✓Develop and improve techniques for efficient characterisation and pre-treatment of contaminated plastic waste
- ✓Boost the market uptake of plastic recycling technologies and recycled products by a systematic evaluation of potential techniques to upgrade recyclates towards potential wider applications range

PLAST2bCLEANED

A H2020 funded project

WEEE/ELV recycling: recovery of ABS , HIPS, BFR and ATO

Started June 2018. Main partners: Elix Polymers, TNO, Coolrec, ICL, Campine

Using superheated solvent with physical removal of ATO and BFRs

Aim:

- Improved sorting of HIPS and ABS containing BFRs and ATO from other polystyrene and ABS fractions
- Dissolution of WEEE plastics in heated solvents
- Separation of additives to concentrate bromine flame retardants and antimony trioxide fractions for recycling
- Using technologies like active carbon, ultra-filtration with ceramic filters
- Energy efficient recovery of solvent and of polymer.

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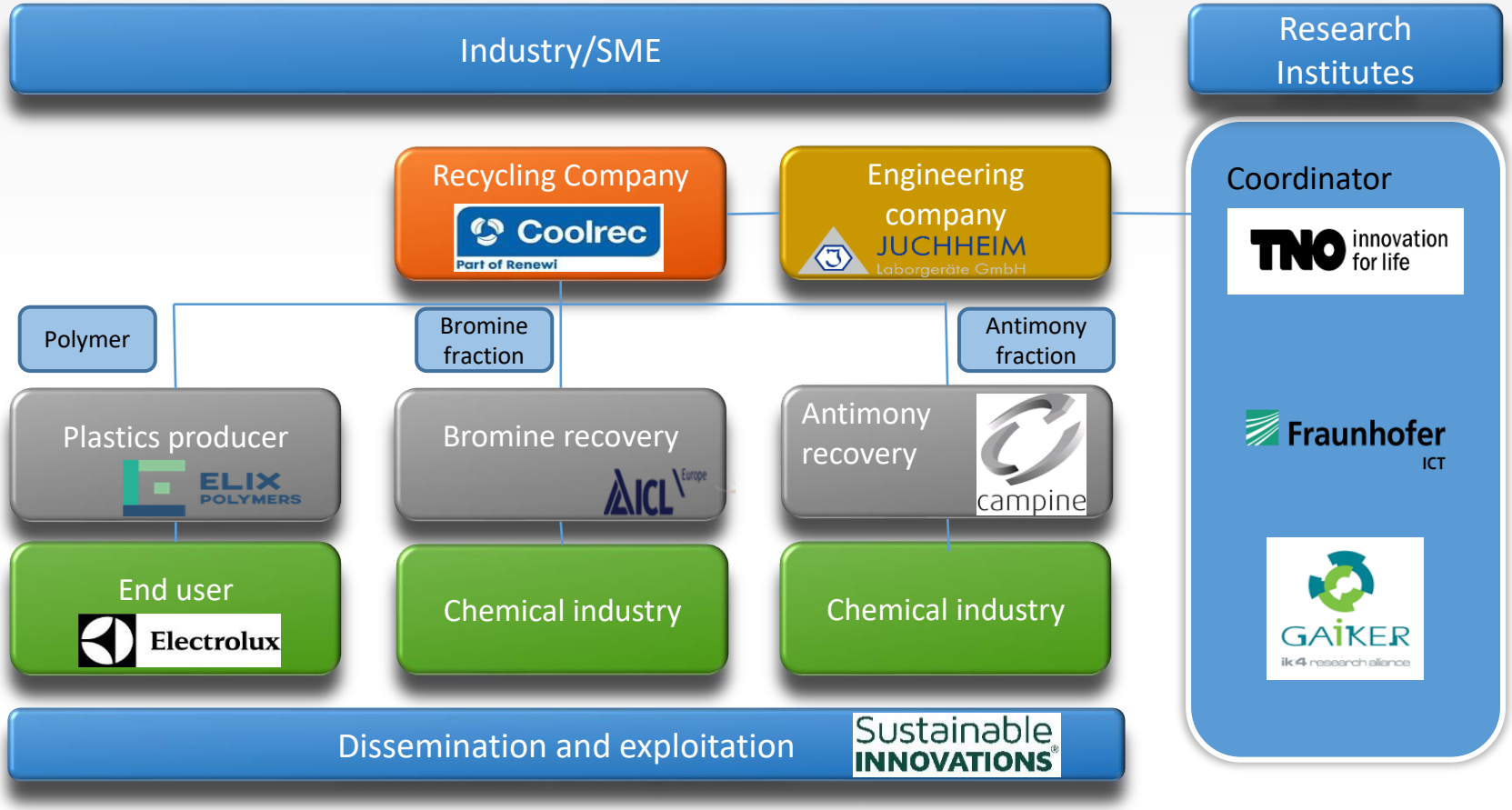
PLAST2bCLEANED

CONSORTIUM



PolyStyreneLoop Demoplant 3000 mt/y with Bromine recycling under construction next to ICL Terneuzen, start up Q2 2021

- ✓PolyStyreneLoop handling EPS containing HBCD
- ✓It includes XPS containing CFCs and falls under the Montreal Protocol plus for HBCD under the Basel Convention
- ✓Planned in 2021 to handle 500 mtons of EPS/10 mtons XPS
- ✓The HBCD sludge is treated in the BRU of IPT where the bromine is recovered and re used back into polymeric FR for X-EPS/XPS
- ✓Official opening scheduled June 2021

3300 mtons of EPS/XPS waste /y
Budget 14 million euro

European Community LIFE 16 ENV/NL/000271

PS-foam and Bromine recycling; closing the loop

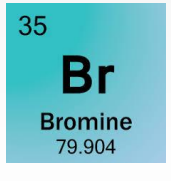
FROM DEMOLITION SITE TO RECOVERING BROMINE AND POLYSTYRENE

Compaction

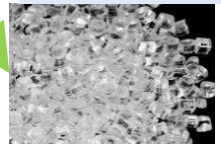
Demolition

PS-foam is treated in the PolyStyreneLoop demonstration plant in Terneuzen, Netherlands

HBCD-sludge is being treated in the Bromine Recovery Unit, safely destructing HBCD



Bromine is reovered and can be used in new flame retardants (Poly-FR)



From PS-foam new GPPS is made

GPPS can be used for new XPS or X-EPS

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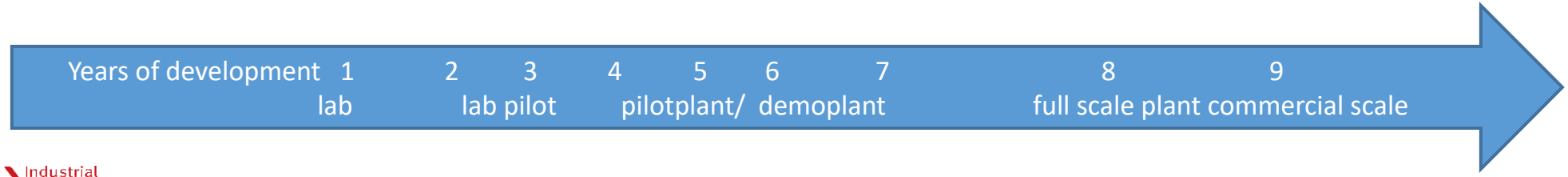
PSLoop Demoplant next to ICL

Progress construction 2021 Start up June2021

Technical readiness and CO_2/LCA

- Mechanical recycling has the lowest carbon footprint (CFP) and highest Technical Readiness (>TR8*)
- Dissolution processes are from TR 1 to TR 4 and <50% CFP of virgin plastics
- CreaSolv© Technology TR 4-6 a demoplant built by Unilever Indonesia at TR6-7
- PSLoop 3300 mtons/y demoplant and start up June2021 TR 6-8
- PLAST2bCLEANED: TR 2-4: very good carbon footprint close to mechanical recycling
- Chemical recycling depolymerisation TR 3-6 pre-sorting/process/polimerisation → LCA CO2
- Feedstock recycling TR3-TR6 Carbon footprint versus R1 incineration

- *TR1 = idea; TR2 – 3 = Lab scale; TR 4 = pilot scale; TR 5-7 = demoplant industrial environment; >TR8 = full proven technology



Conclusions

- Certain plastics need a fire safety function AND be part of a circular Economy
- For E&E/automotive plastics, means often polymers with FRs and other additives
- BFR's are often the best *technical* solution
- E&E plastic waste – very diverse, relatively small volumes
- Complete sorting of waste - technically/economically not possible yet
- Substances of High Concern hinder mechanical recycling
- Emerging technologies are the option: dissolution processes and solvolysis
  - ✓ The SoC is isolated and converted into new resources being bromine
  - ✓ Real material efficiency, recovery of ALL materials at virgin quality
  - ✓ Good progress on the technical developments for new technologies
  - ✓ Scale-up possible and ongoing into direction of demo plants→ full scale plants
  - ✓ This year first PSLoop Demoplant to be started up and could lead to next ones

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THANK YOU

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