Management of HFR Wastes in the U.S.:

THE NEED FOR A CIRCULAR ECONOMY APPROACH

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National Science Foundation
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National Institute of Environmental Health Sciences
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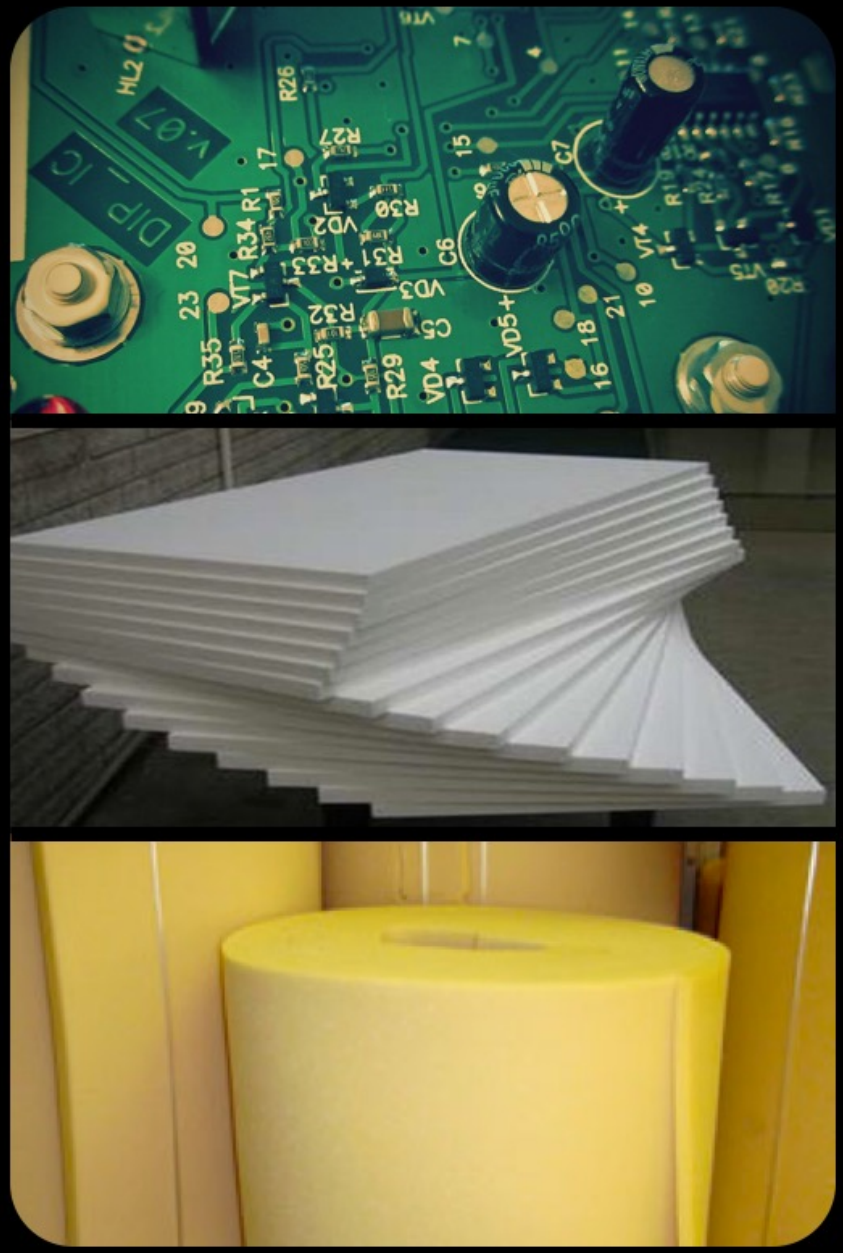
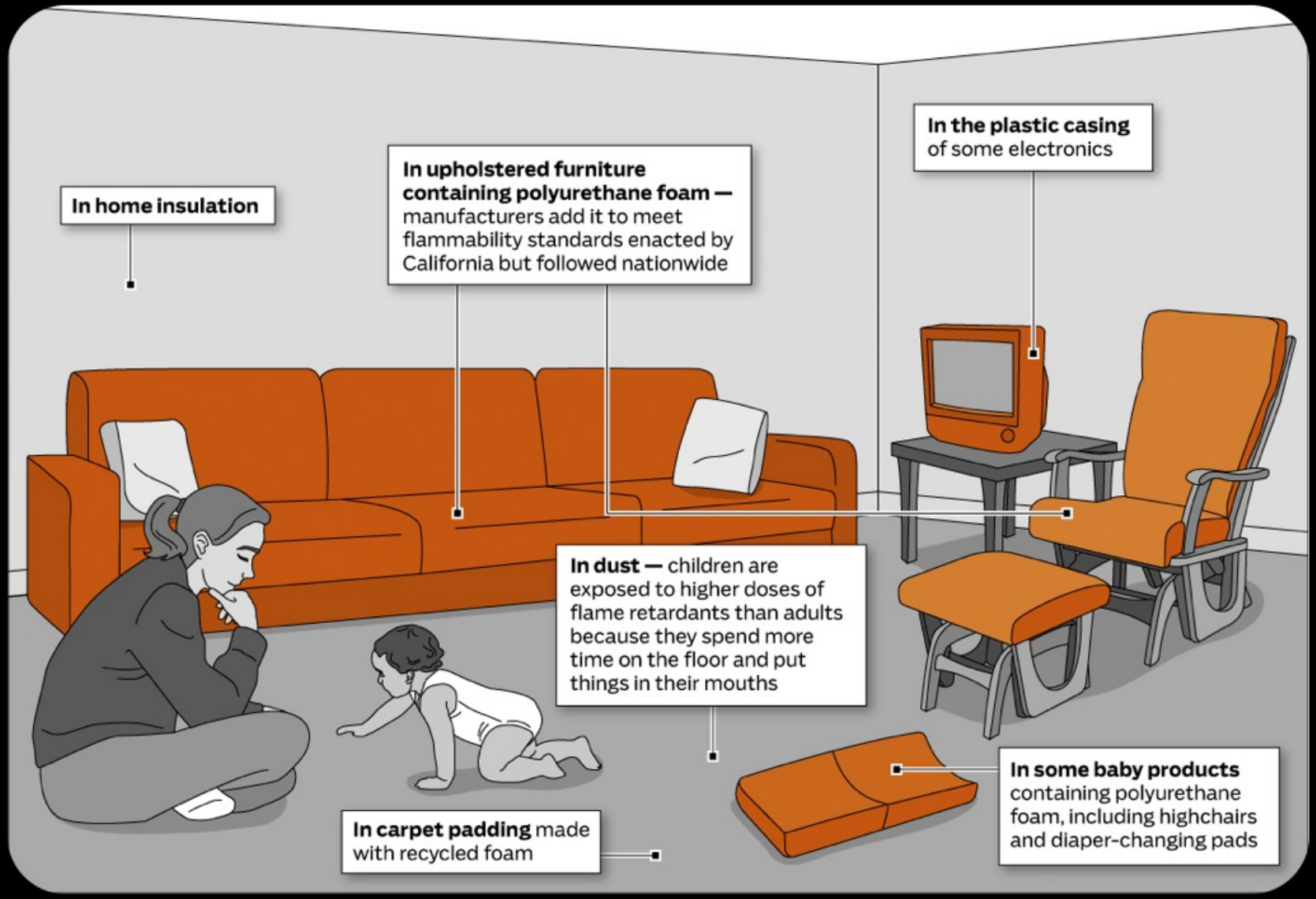
FLAME RETARDANTS USED TO MEET STANDARDS

Some major product categories with flame retardants (in the US):

- Electronics (EEE)
  - circuit boards and other internal elements
  - plastic enclosures
- Building materials & insulation
- Transportation sector
- Furnishings

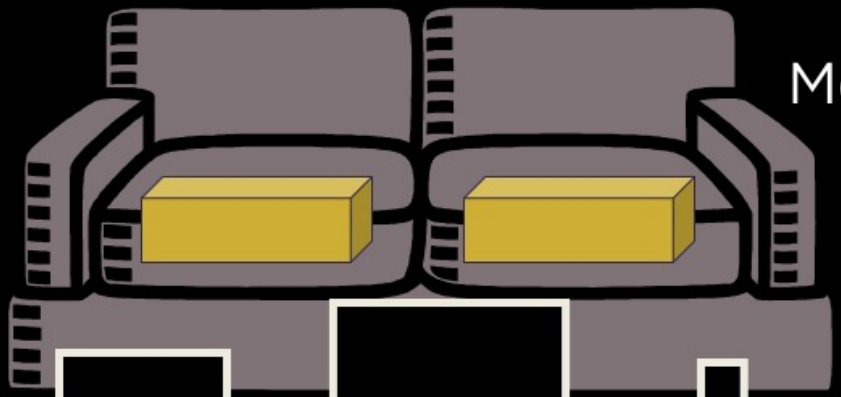


FLAME RETARDANTS IN PRODUCTS → EXPOSURES



- Image by Katie Nieland/Tribune. Sources: EPA, Tribune Reporting

WHAT WILL HAPPEN TO TODAY'S FURNITURE (FOAM)?



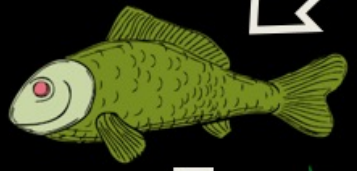
Mechanical Recycling

Low income communities

Student housing

Resale

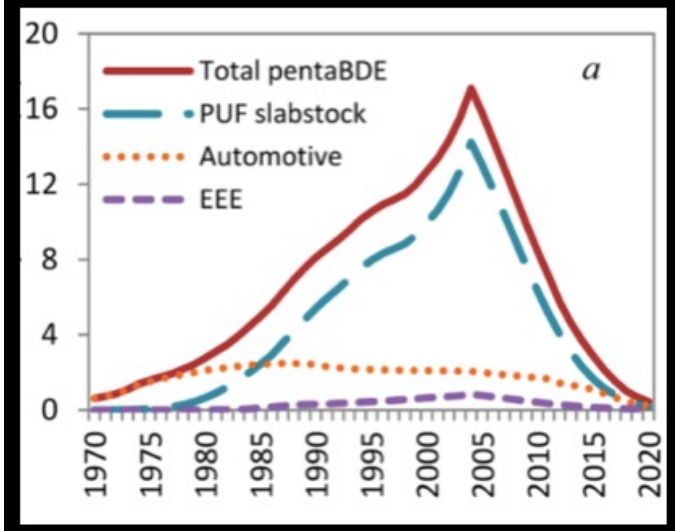
Landfill



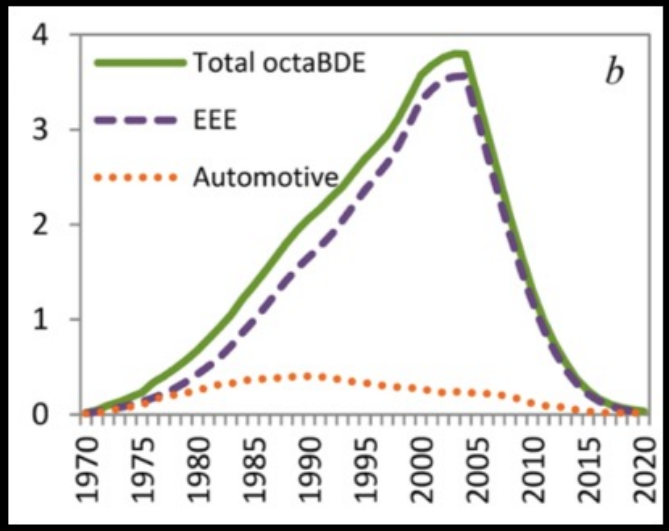
Bonded carpet cushion

PBDE USE IN PRODUCTS IN NORTH AMERICA

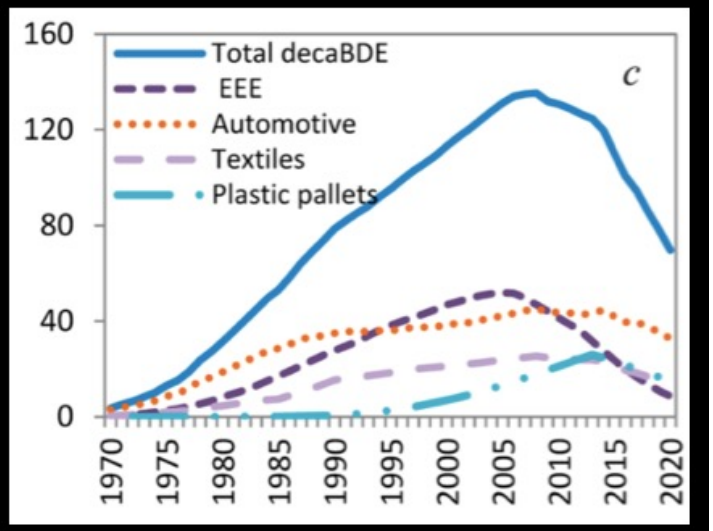
Stock of PBDE commercial mixtures in in-use products in N. America (in kT)



PentaBDE



OctaBDE



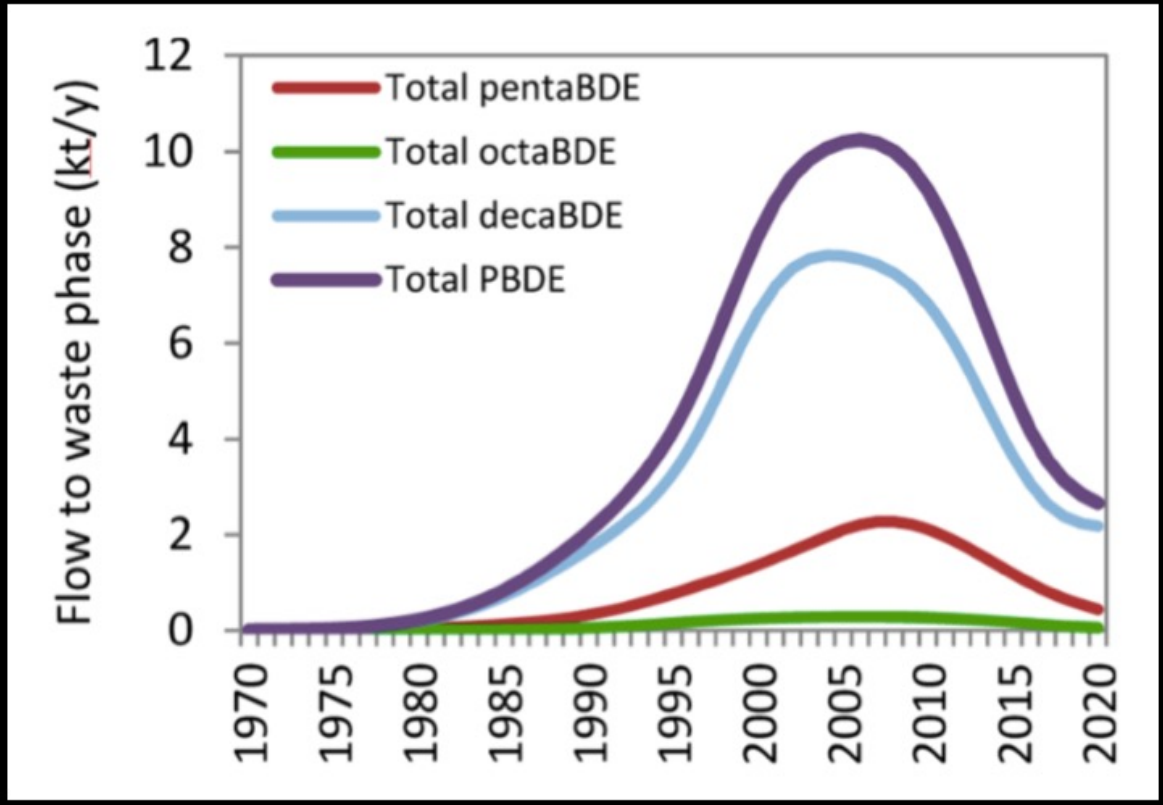
DecaBDE

- Assumes no re-use of products (and excludes large transportation vehicles)
- DecaBDE used most extensively and will remain in in-use products on the longest timescale.

Abbasi G *et al*, ES&T 2015

PBDE USE IN PRODUCTS IN NORTH AMERICA

Flows of PBDEs to the waste stream in N. America (in kT/year)

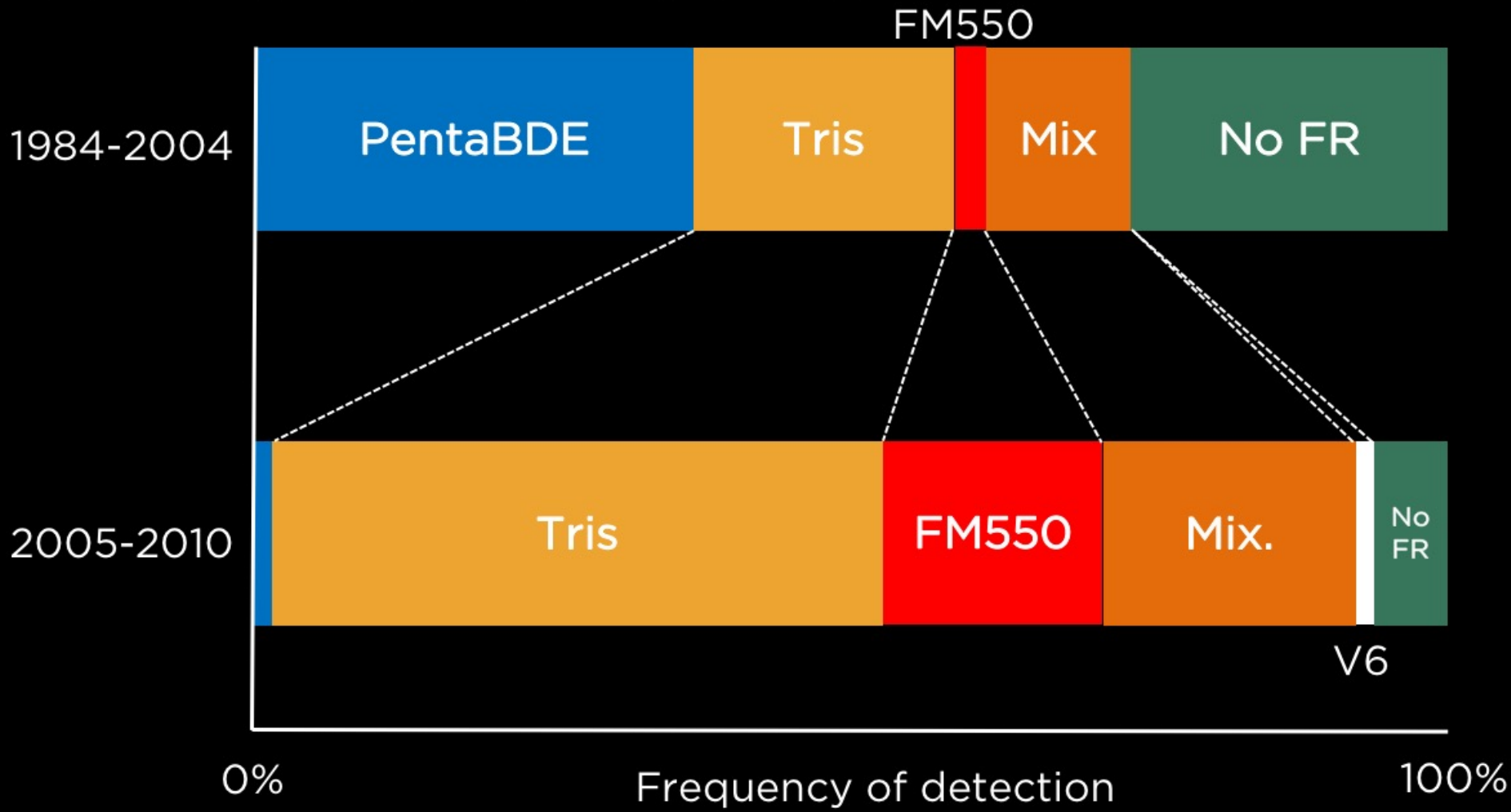


- Excludes transportation sector

Abbasi G *et al*, ES&T 2015

WASTE STREAM IS NOT HOMOGENEOUS
e.g. PBDEs HAVE BEEN REPLACED WITH OTHER FRs

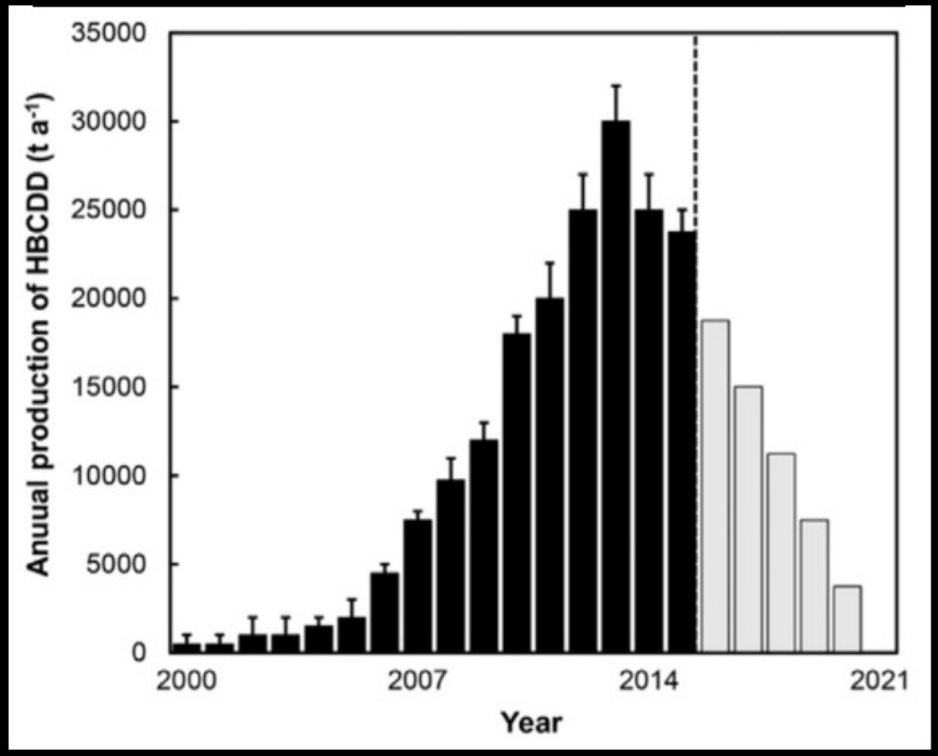
Flame Retardants in 102 U.S. couches –
Before & After 2005 PentaBDE phase-out



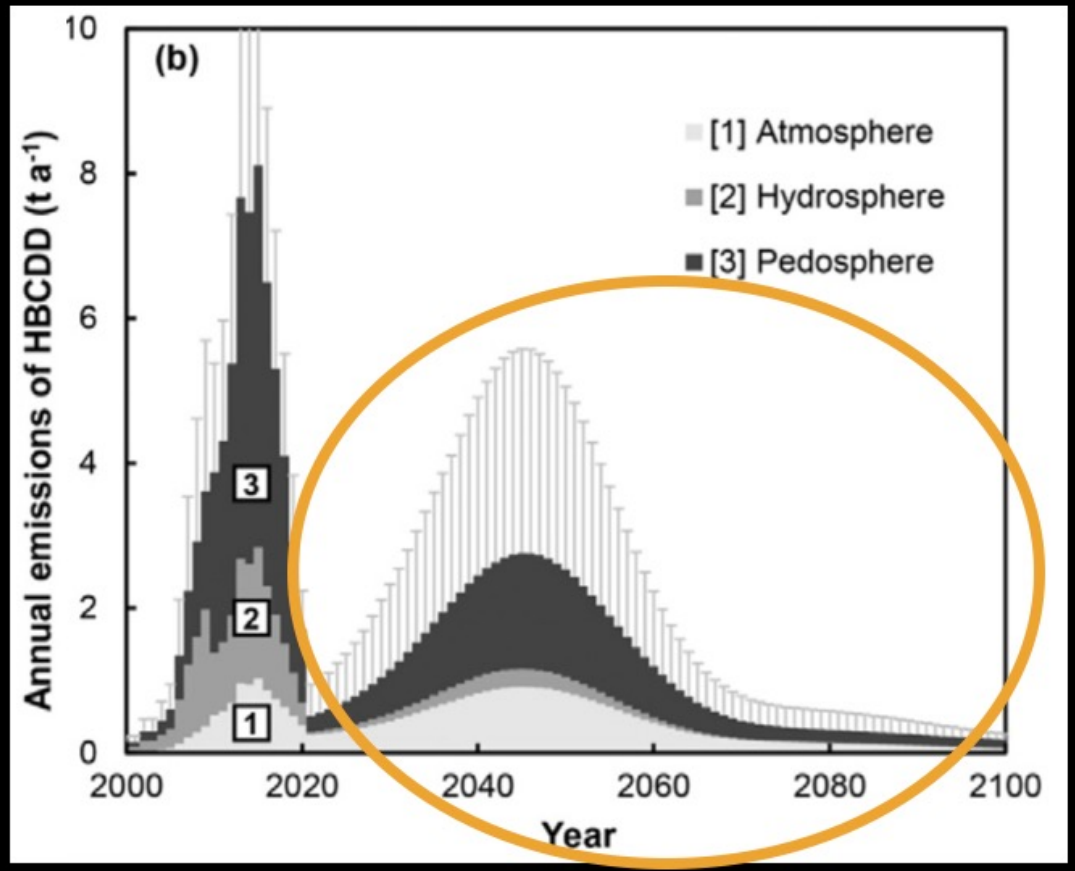
Stapleton et al, ES&T 2012

PRODUCTS WITH FRs ENTER THE WASTE STREAM

Annual use of HBCD in China



Predicted emissions over time

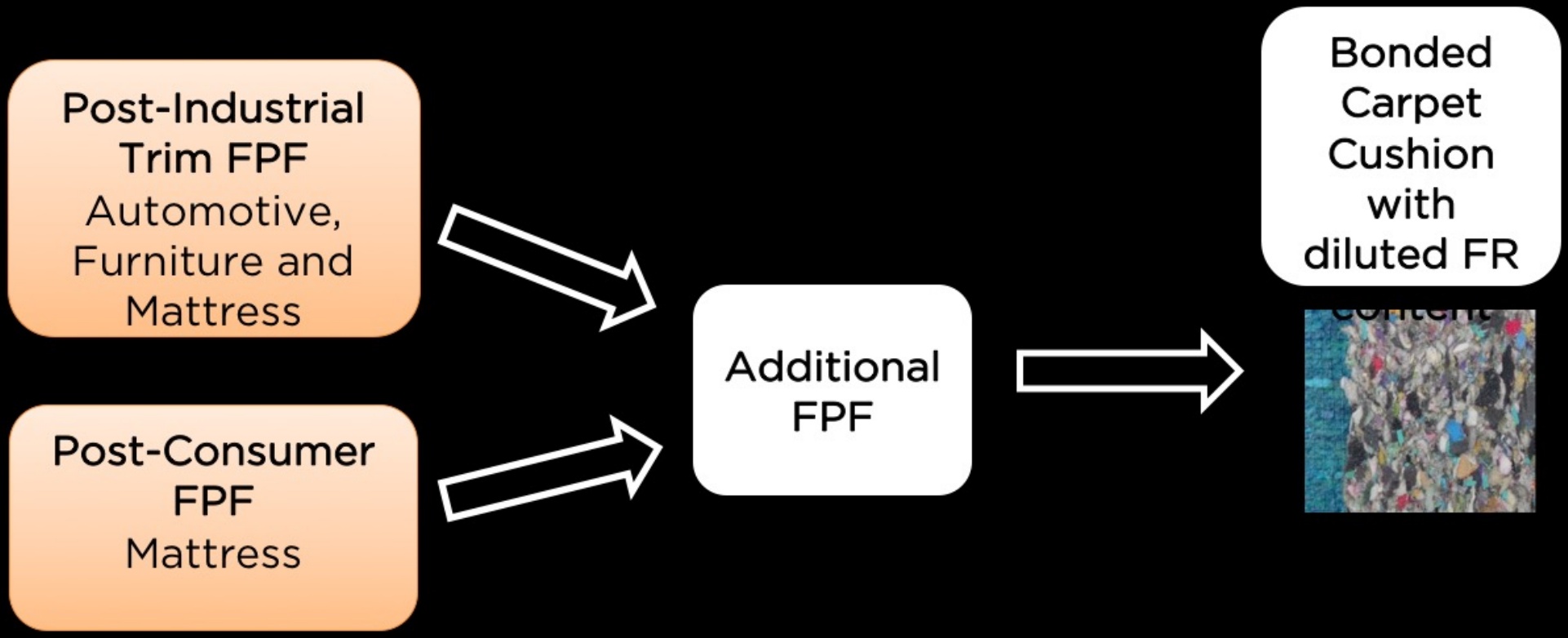


Li L *et al*, Env. Int. 2016

CIRCULAR ECONOMY → REDUCE WASTE (RECYCLE?)

e.g. Recycling of FPUF to carpet cushion:

- FRs cannot be removed completely from FPF
- Dilutes the FPF to 0.1% PentaBDE



Courtesy: Bob Clark, Carpet Cushion Council
Bob Luedeka, PFA

BFRs FOUND IN RECYCLED PLASTICS

PBDEs detected in recycled plastic products, including in sensitive uses with exposure (Chen et al. 2009; Ionas 2016)

PBDE in childrens' toys China
(Chen *et al*, ES&T 43, 4200, 2009)

PBDE in food contact material
(Miriam Diamond)

PBDEs in thermo-cup

(Samsonek & Puype, Food Add. & Contam. 2013)

⇒ Need a better life cycle management for more circular economy

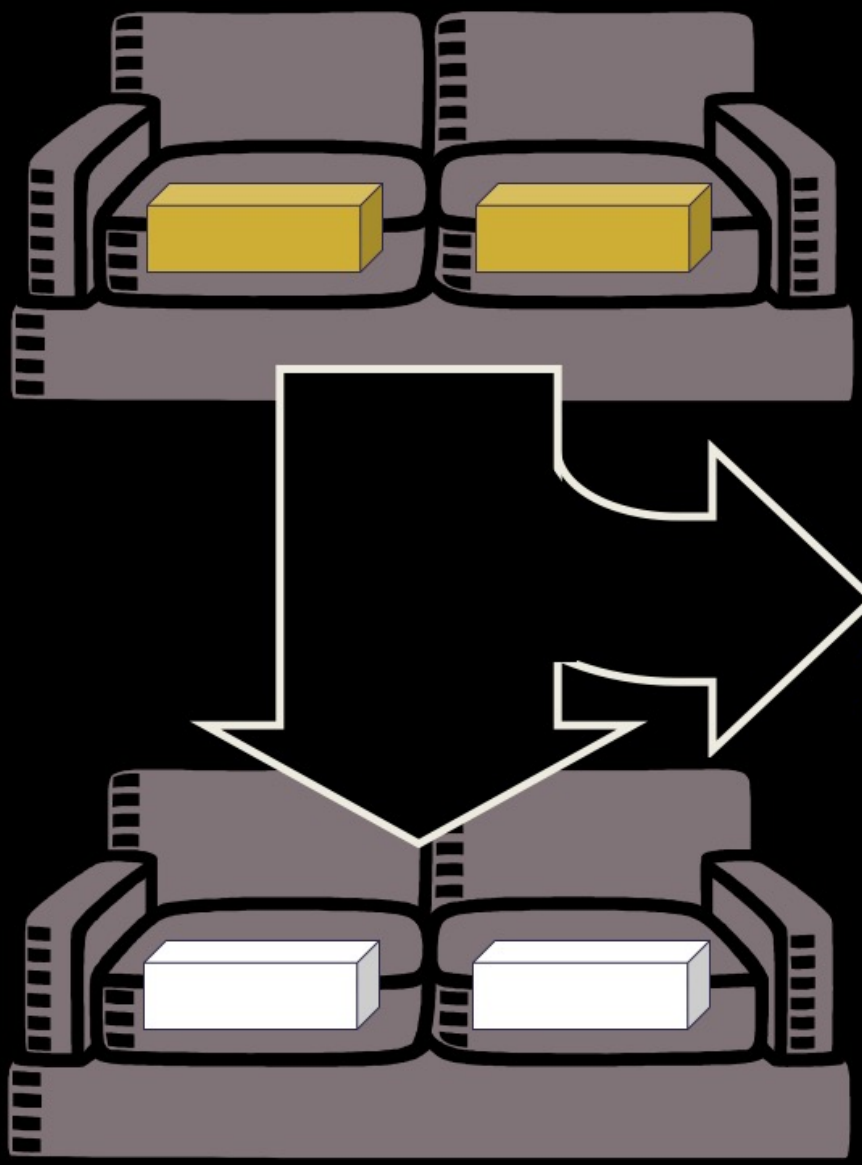
Adapted from Roland Weber, POPs Environmental Consulting

LANDFILLS: NO SUCH THING AS "AWAY"

- FRs (PBDEs, organophosphates) escape through leachate, can off-gas, etc.
  - ASR sometimes used as "daily cover"
- Water treatment facilities may not be equipped to deal with FRs in leachate
- Landfill fires a source of dioxins and furans
- Not a secure repository for persistent chemicals

Gullett *et al.* (2010) ES&T
Liu, R., *et al.* (2016) ES&T
U.S. Fire Administration (2001)
Ramin Yazdani, Yolo County, UC Davis

ARE THERE BETTER STRATEGIES?



Alternative Destruction Technologies?

Energy Recovery? Thermal Destruction?

More Secure Landfills?

DESTRUCTION TECHNOLOGIES:

- Strengths:
  - Long-term, permanent reduced exposures
  - Potential economic benefit from energy recovery
- Challenges:
  - Knowledge gaps for existing and emerging technologies, esp. regarding real-world waste streams and scale-up
  - Infrastructure & funding

    e.g. collection, separation, pre-treatment, monitoring
  - Environmental justice considerations & social perceptions

CHALLENGES TO A CIRCULAR ECONOMY APPROACH:

- Technology & scale of the problem
  - Collection
  - Separation and treatment of articles
- Costs & determining responsible parties
- Regulations not uniform
- Environmental Justice - disproportionate health & environmental impacts for fenceline communities

CONCLUSIONS

- The U.S. has a long way to go
- Reduce use of flame retardants where they are not needed:
  - Improved codes or flammability regulations
  - Selection of inherently safer materials
- Prevent ”regrettable subsitutions”
  - Consider classes, or groups, of chemicals of concern (e.g. SixClasses.org)

SIXCLASSES.ORG

1. Highly Fluorinated (PFASs) stain and water repellants
2. Chlorinated Antimicrobials triclosan and triclocarban
3. Flame Retardants brominated, chlorinated, phosphate
4. Bisphenols And Phthalates phthalates, BPA, BPS, BPF, etc.
5. Organic Solvents benzene, methylene chloride, xylene, etc.
6. Certain Metals lead, mercury, chromium, cadmium, arsenic, etc.

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- Prevent ”regrettable subsitutions”
  - Consider classes, or groups, of chemicals of concern (e.g. SixClasses.org)
- Increase awareness and educate stakeholders
  - Many waste management professionals are not aware of these issues
  - Practitioners, regulators, researchers, and affected parties need to work together
  - More practical to reduce chemicals of concern **upstream**

ADDITIONAL RESOURCES

http://ehp.niehs.nih.gov/1509934/

Basel Convention: www.basel.int

Rotterdam Convention: www.pic.int

Stockholm Convention: http://chm.pops.int/

Montreal Protocol/Vienna Convention: http://ozone.unep.org

SAICM: http://www.saicm.org/

POPs phase out & alternatives http://poppub.bcrc.cn/

OECD/IOMC: http://www.oecd.org/chemicalsafety/

Science: www.ipcp.ch; http://greensciencepolicy.org/

NGO: www.ban.org; www.ipen.org; www.ihpa.info; www.chemsec.org

Better-world-links: http://www.betterworldlinks.org/

Courtesy: Roland Weber, POPs Environmental Consulting

YOU ARE INVITED

Responsible Disposal of Flame Retarded Foam and Plastic: Developing the Basic Science

JOIN US! FEBRUARY 8, 2017
Workshop in Berkeley, CA

GREEN SCIENCE POLICY INSTITUTE

February 8, 2017 workshop in Berkeley, CA:

- Discuss FRs & implications for recycling/waste management.
- Explore opportunities for scientific research to advance end-of-life management of these products.
- **Develop collaborative research projects** with other leading experts.

For more information: sara@GreenSciencePolicy.org

http://GreenSciencePolicy.org/responsible-disposal-february-2017/

MANY THANKS TO:

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The Green Science Policy Institute Team

University of California at Berkeley
National Science Foundation – Bill Cooper
National Institute of Environmental Health Sciences

April workshop attendees & collaborators


With a more circular economy
we can have a healthier world
For More Information:
Google: Green Science Policy
www.GreenSciencePolicy.org