Overview of e-beam technology and technical cooperation applications for containment management and disposal

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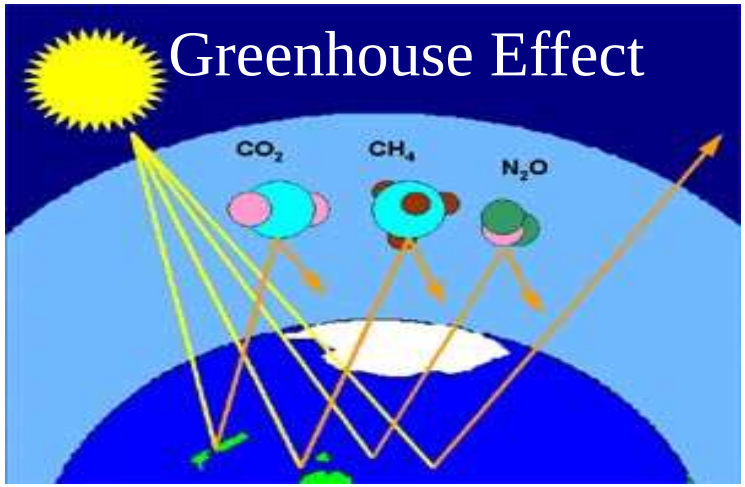
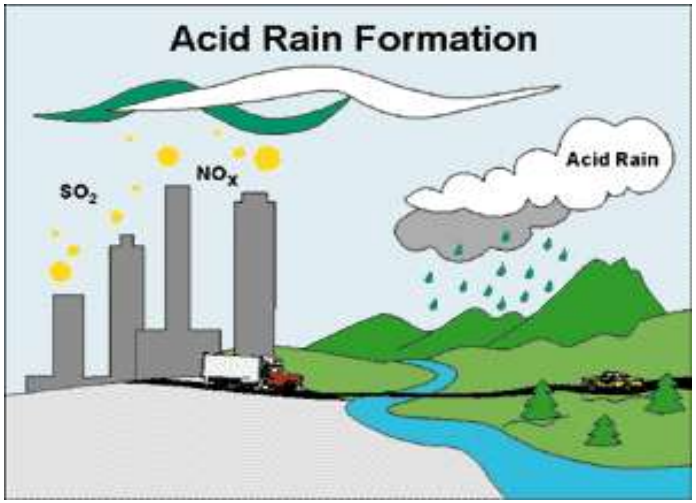
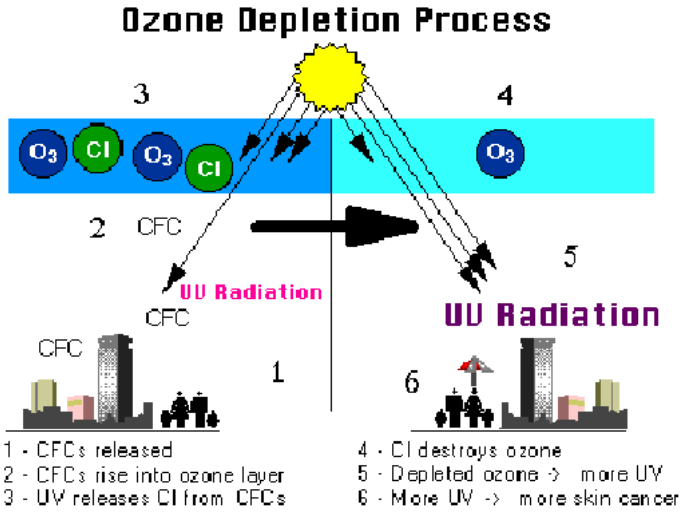
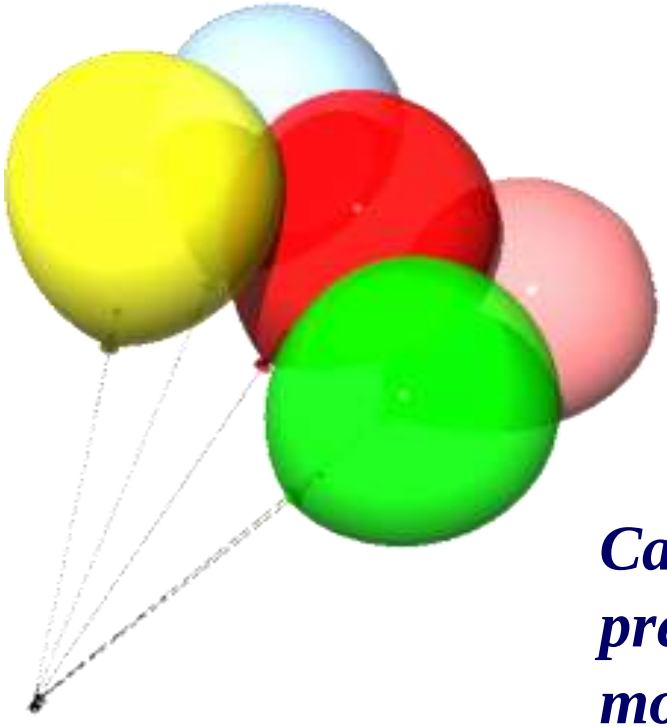
International Atomic Energy Agency


Greenhouse Effect
CO_2
CH_4
N_2O


Acid Rain Formation
SO_2
NO_x
Acid Rain


Ozone Depletion Process
3
4
O_3
Cl
O_3
Cl
O_3
2
CFC
5
UV Radiation
CFC
UV Radiation
CFC
1
6
1 - CFCs released
2 - CFCs rise into ozone layer
3 - UV releases Cl from CFCs
4 - Cl destroys ozone
5 - Depleted ozone -> more UV
6 - More UV -> more skin cancer

Conventional curing leaves toxic residues!!



Carcinogenic nitrosoamines are present in high concentrations in most of the rubber products

Serious Matters of Concern

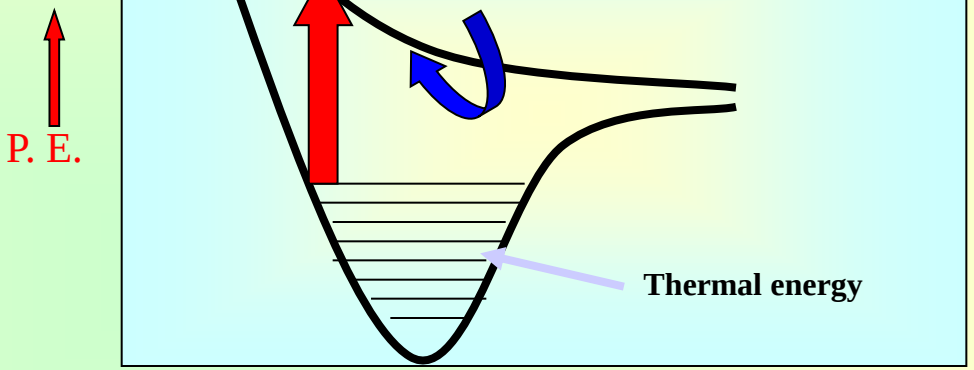
- **Increasing CO2 levels in atmosphere**
- **Increasing NO_x and SO_2 levels in atmosphere**
- **Increasing VOCs in air**
- **Toxic chemical additives in products**
- **Sewage sludge**
- **Industrial waste disposal**

Expectations from new technologies

- **Energy Saving**
- **Must provide superior products**
- **Environment friendly**
- **Cost effective**
- **Public acceptance**

How is Radiation Different from Thermal energy ?

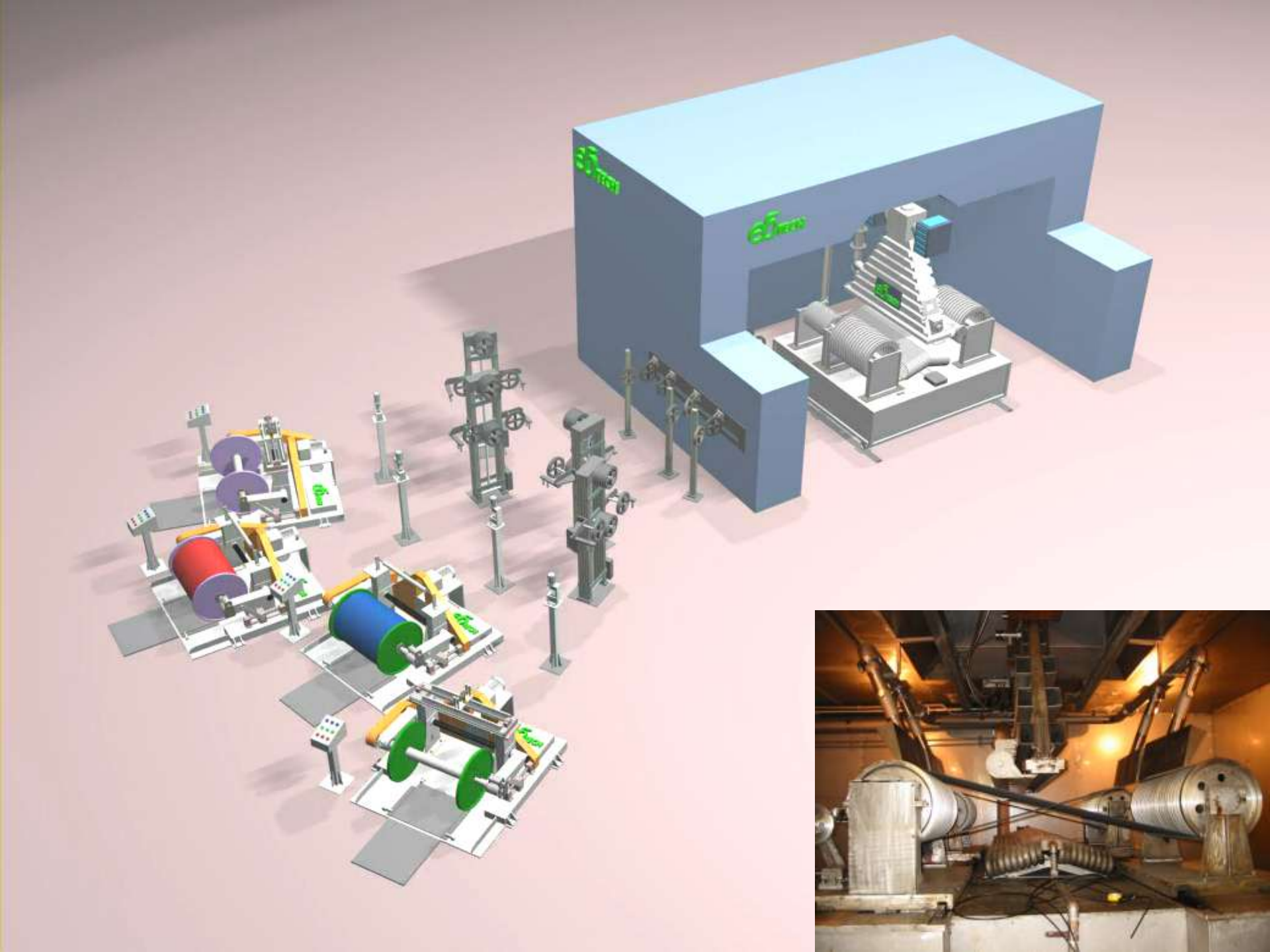
Thermal energy **is very strongly coupled to Translational, Rotational and Vibrational modes of the energy absorber. Ionization, bond rupture and other processes leading to chemical reactions occur only in the high energy region of the Maxwellian tail.**



Ionizing radiation **is almost entirely absorbed by the electronic structure of absorber which increases the energy level of its orbital electrons.**

Effective, Efficient generator of reactive Species.

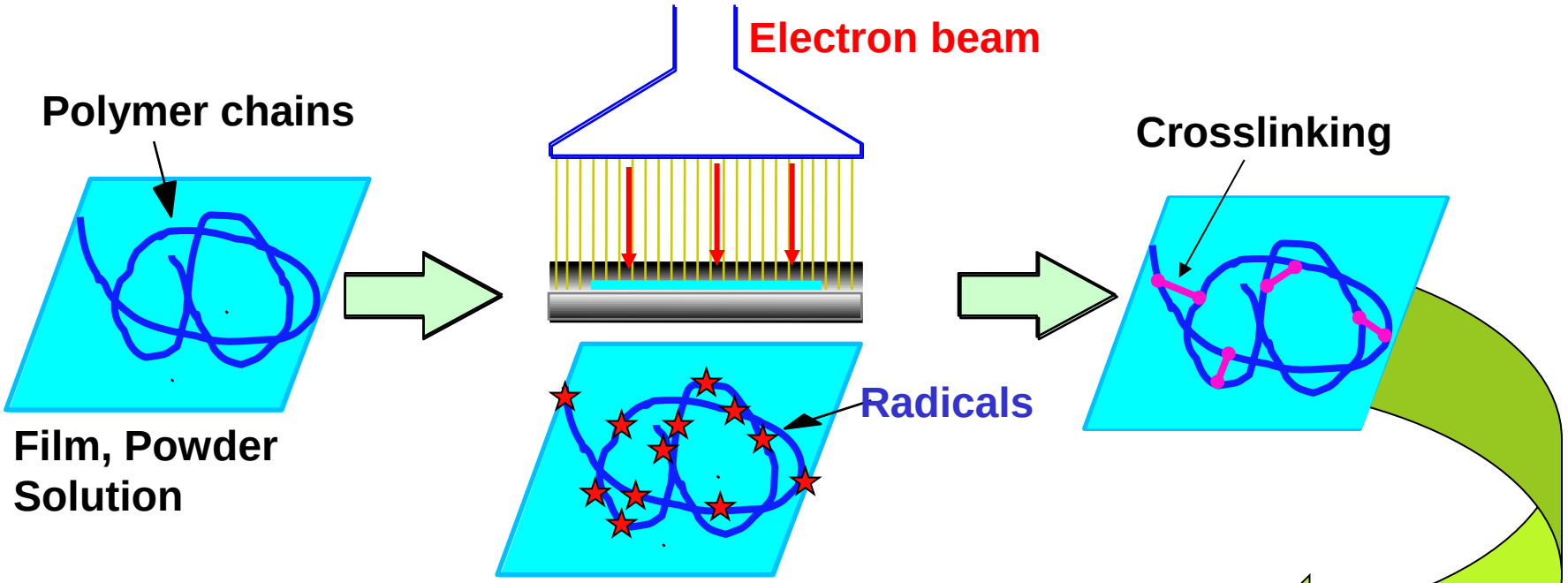
Energy in the form of large quanta can have more pronounced chemical effects than energy in the form of small quanta



Applications of Electron Beam Technology

- *Crosslinking of polymers*
- *Degradation of high molecular weight materials*
- *Curing of polymer coatings*
- *Graft polymerization*
- *Sterilization of medical products*
- *Food irradiation*
- *Sewage Sludge Hygienization*

Radiation Crosslinking



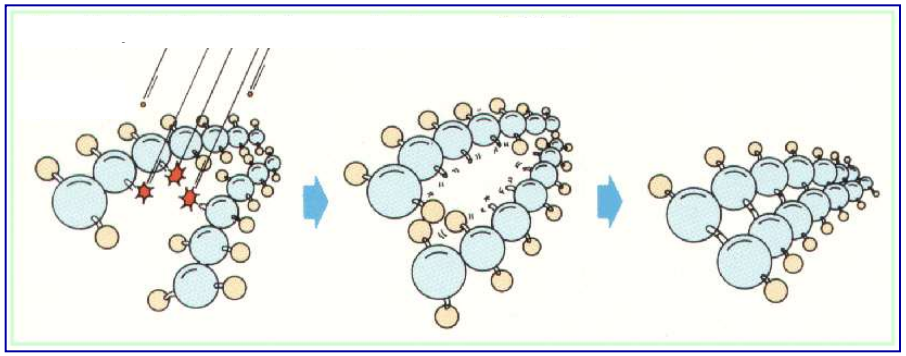
Advantages

- Clean
- Without heat
- Keep shape
- High speed

Improvement by crosslinking

1. Heat stability
2. High strength
3. Processability
4. insoluble

How we use these radiation sources?



Radiation can initiate chemical reactions

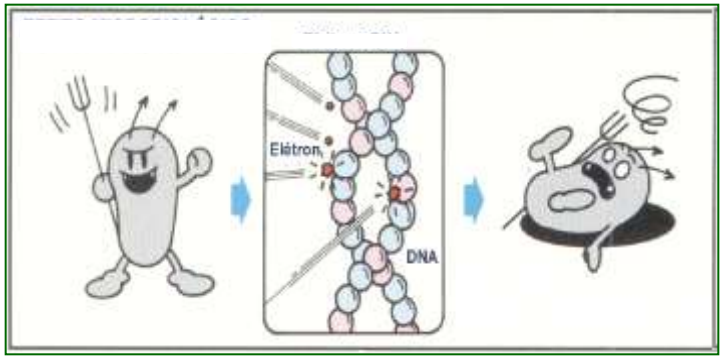

Filament Wound/Tape Wound Composite Parts
High Temperature Wiring
Tire Components
Seals Gaskets And Hoses
Formed Polymer Components
Composite RTM Components
Composite Body Panels
Adhesive-bonded Composite Components

1. Radiation Crosslinking of Polymer Materials

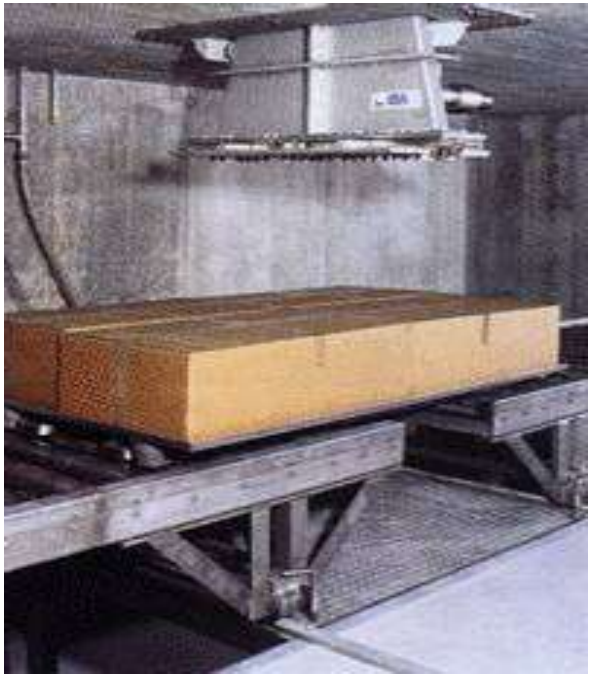
2. Car Parts Produced by Crosslinking technology

- Wire and Cable
- Foam
- Shrinkable Tube
- Tire
- Polyswitch

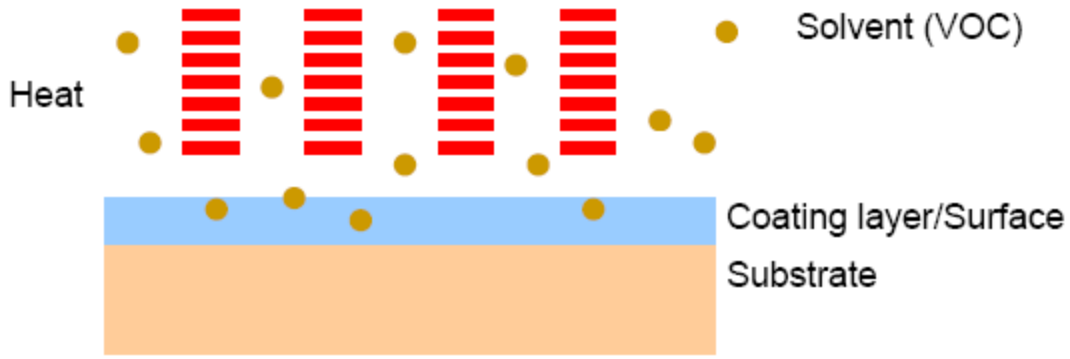
How we use electron beams?



Radiation can destroy microbes

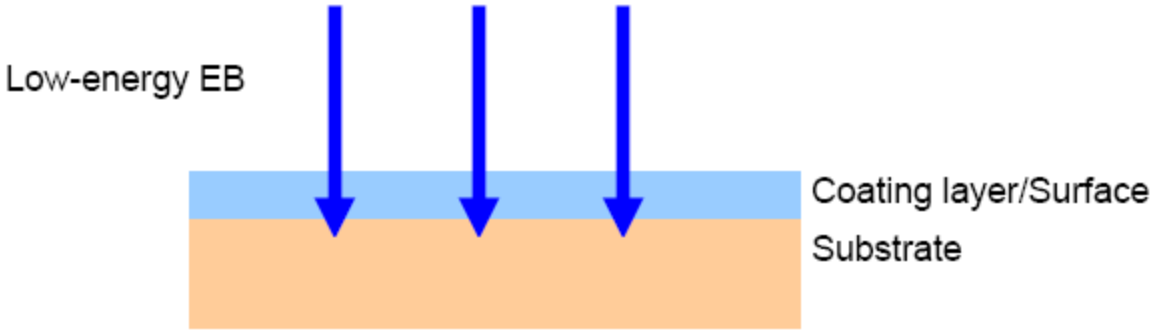


Thermal drying for Curing



- Well-established process. Solvents required.
- VOC (Volatile Organic Compound) + CO_2
- Larger energy (heat sauce) required

Low-energy EB for Curing



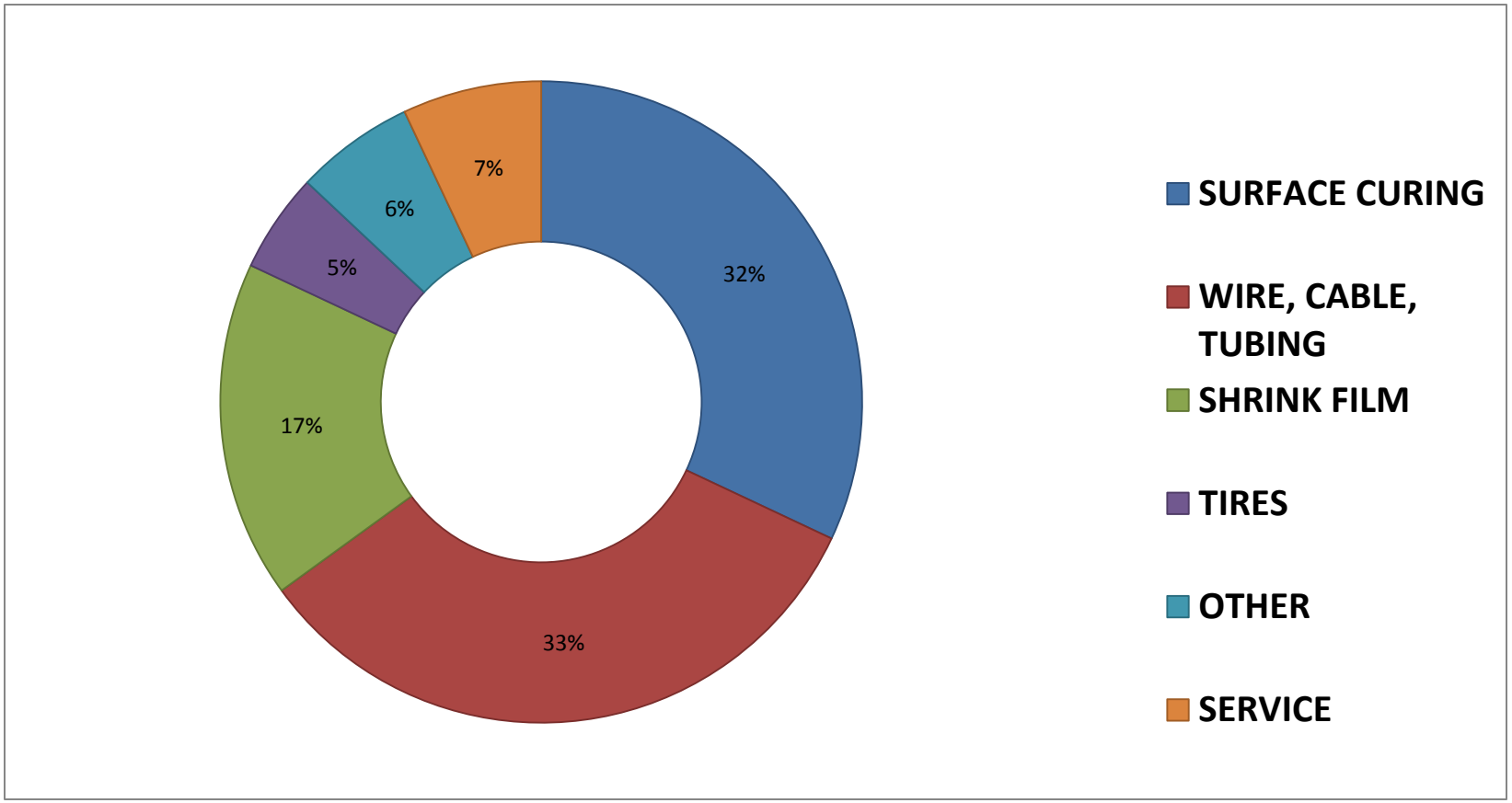
- Just gives energy to surface area. No VOCs.
- Smaller size for inline, continuous process.
- High dose rate: high speed process

Energy Demand to Dry/Cure Coatings

System	Solvent	Solvent	Water	EB cure
Solids	30%	40%	40%	100%
Diluent	heptane	toluene	water	none
Boiling Point,	98 ^{0}C	111 ^{0}C	100 ^{0}C	-
Vapour pressure at 20 ^{0}C	35 mm Hg	22 mm Hg	17 mm Hg	-
Heat of vapourization (cal/gm diluent)	76	88	540	-
Energy to dry 1g dried coating	740	555	3390	30 at 30 kGy

Ref: A.J.Berejka, IAEA-TECDOC-1386, 2004, 6 65-72

Scale of utilization of radiation in various industries



Over US$ 85 Billion industry!

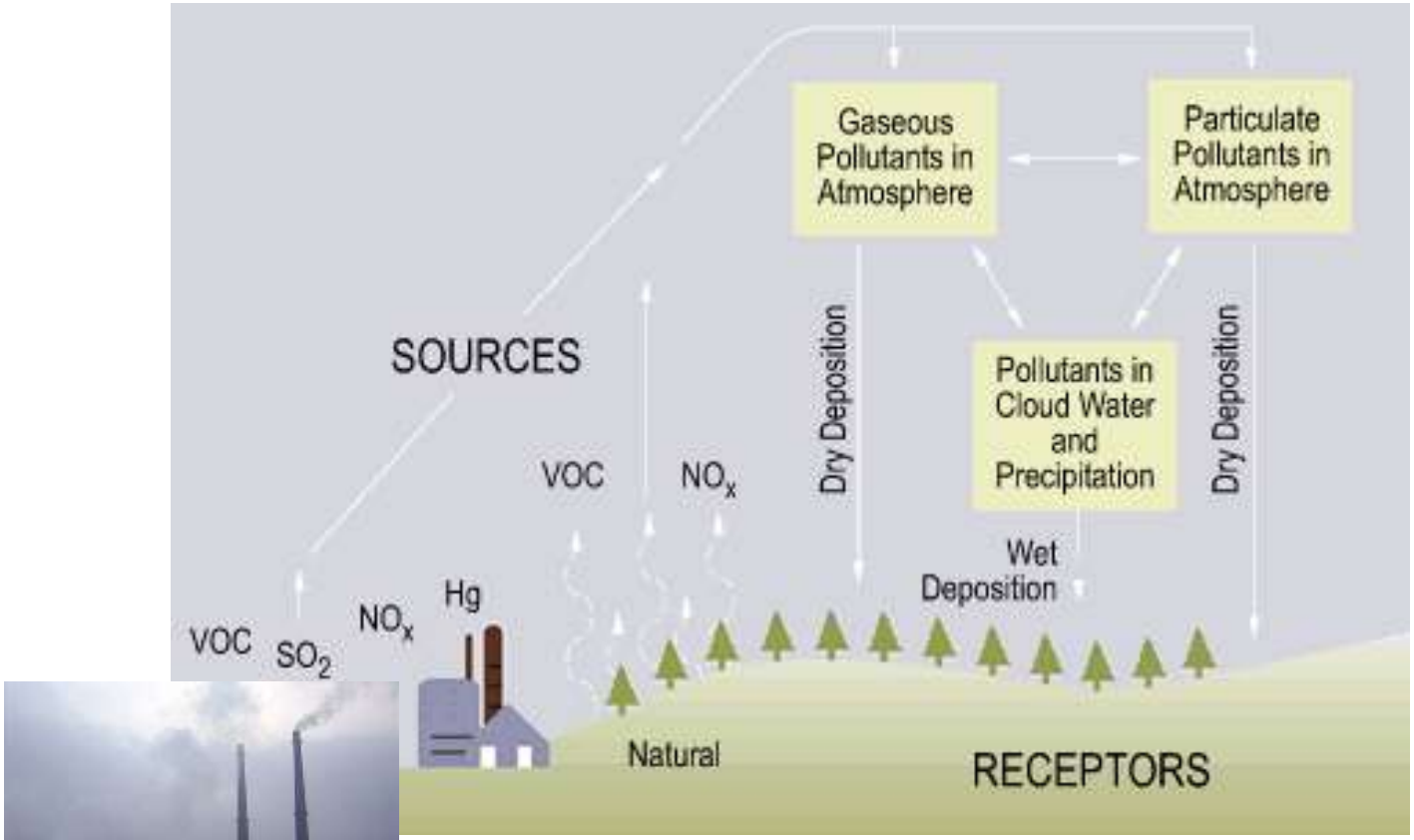
Electrons Beam Applications for Protection of the Environment

Flue gas Purification

Wastewater Treatment

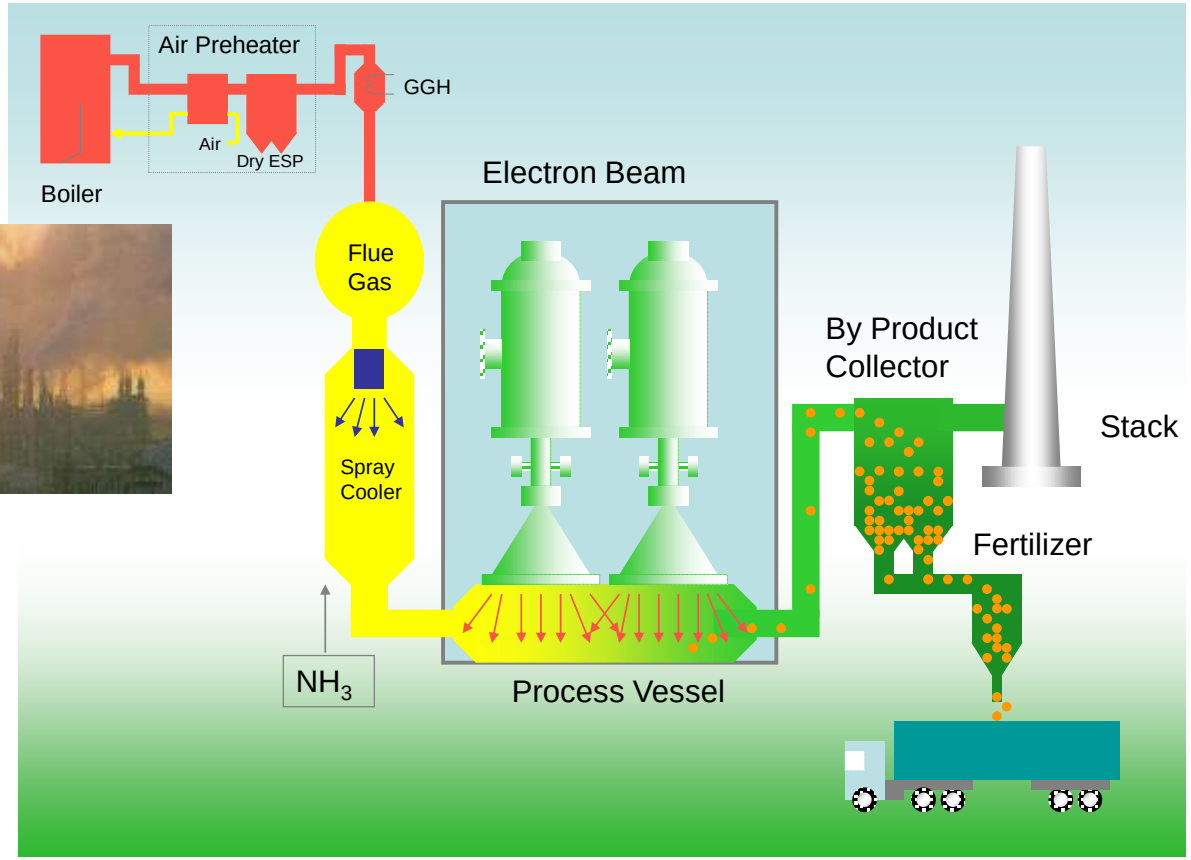
Sludge Hygienization

Tackling environmental challenges



Acid rain

Electron Beam Flue Gas Treatment (EBFGT)



Plant set up with the assistance of IAEA

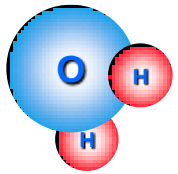
Polluted industrial and municipal wastewater

Water pollutants

Persistent organic compounds (POP's : Pesticides, dyes, etc.

Not persistent compounds present in lower concentrations but heavily toxic E.g. pharmaceutical compound

Principles of Wastewater treatment with e- beam



Water Molecule

e_{aq}

OH

~~H~~

H_2O

2

Active Radicals

Harmful Organic in Waste water

Complete Decomposition → H_2O, CO_2

Partial Decomposition

Suspended solid

Monomer to Polymerization

Coagulation

Removal of Toxic group → Bio-Treat

Removal of Color, Odor

CRP on Treatment of Waste waters by radiation technology for reuse (2011- continuing)

WASTEWATER TREATMENT

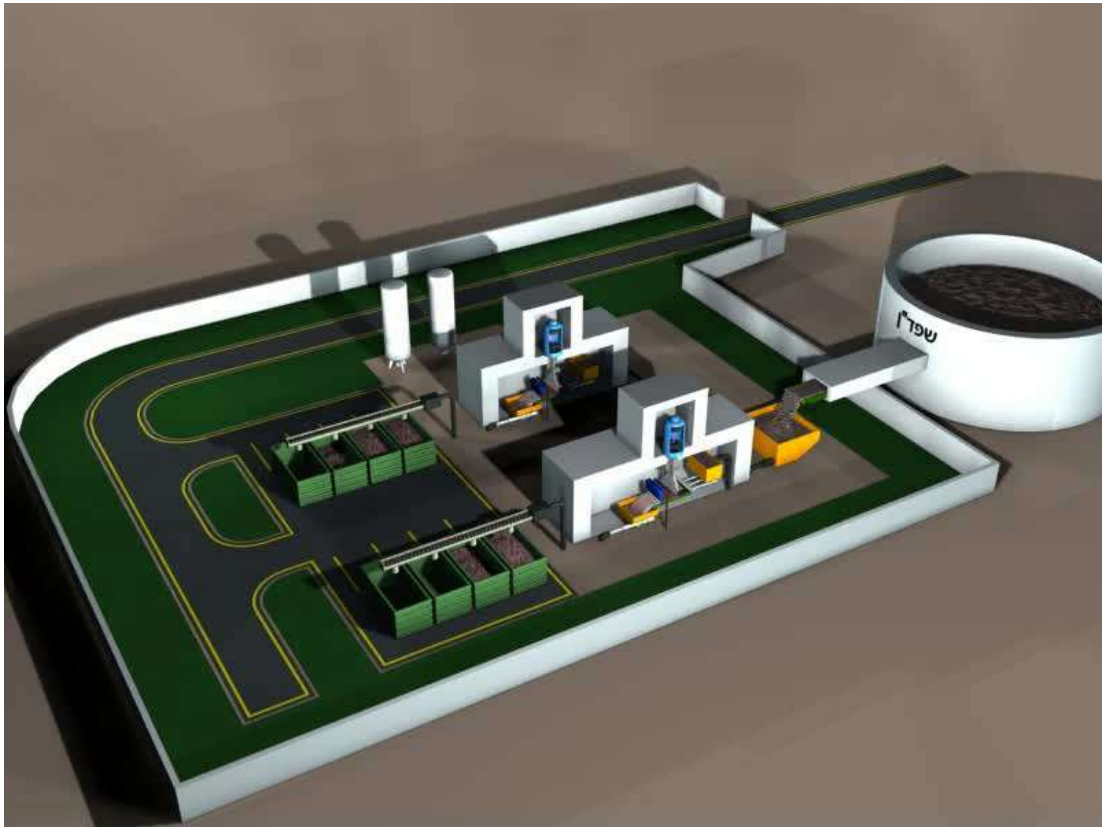
Daegu, Korea

First pilot plant set up with assistance of IAEA

Animation and Photograph: Courtsey Dr Bumsoo Han

Bio solidsTreatment

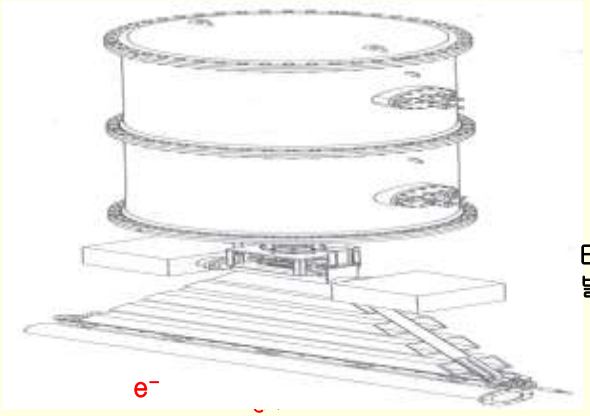
Treatment of domestic sewage sludge



Animation and Photograph: Courtsey Dr Bumsoo Han

Utilization of enriched hygienized sewage sludge and water for growing grapes in Gujarat in the area where most of the land has very low fertility

Treatment of PCBs using Electron Beam Accelerator

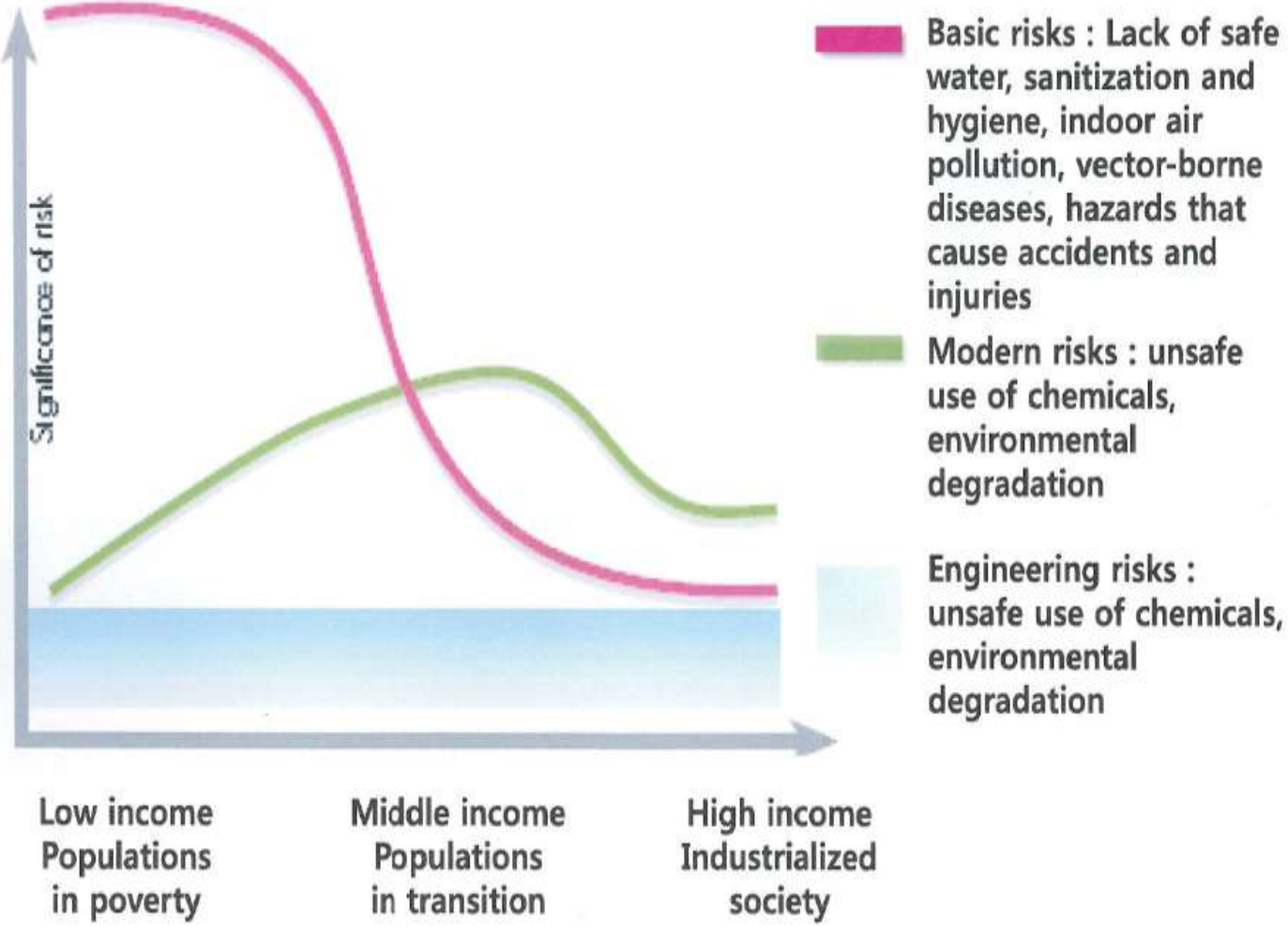


E-beam
발생기

가속된 전자

PCB의
탈염소화

Biphenyl



Environmental health risk transitions

Slide Courtsey: Dr Bumsoo Han

Thank you!