TECHNOLOGY AND BUSINESS CHALLENGES IN CREATING VALUE OUT OF POST CONSUMER PLASTIC WASTE

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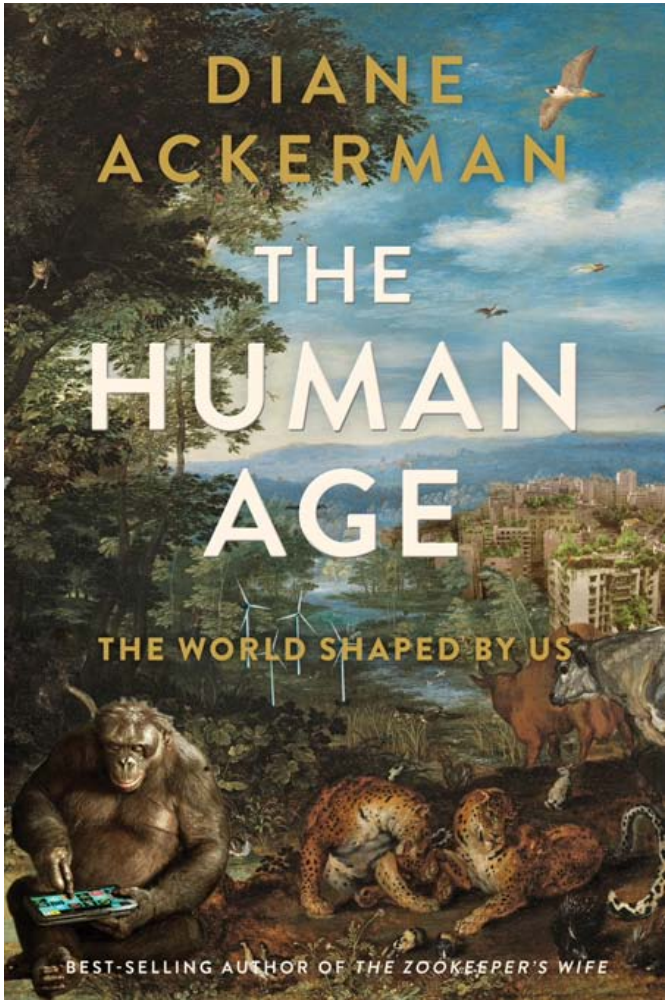
THE HUMAN ANTHROPOCENE AGE

- Humans are leaving an indelible imprint on Planet Earth
  - Carbon cycle
  - Nitrogen cycle
  - Ocean pH
  - Extinction rate of species and habitats
- Human ingenuity and innovation capacity is also at an all time high
- However, emergence of technology alone is no guarantee that its benefit will tickle down to humanity at large.

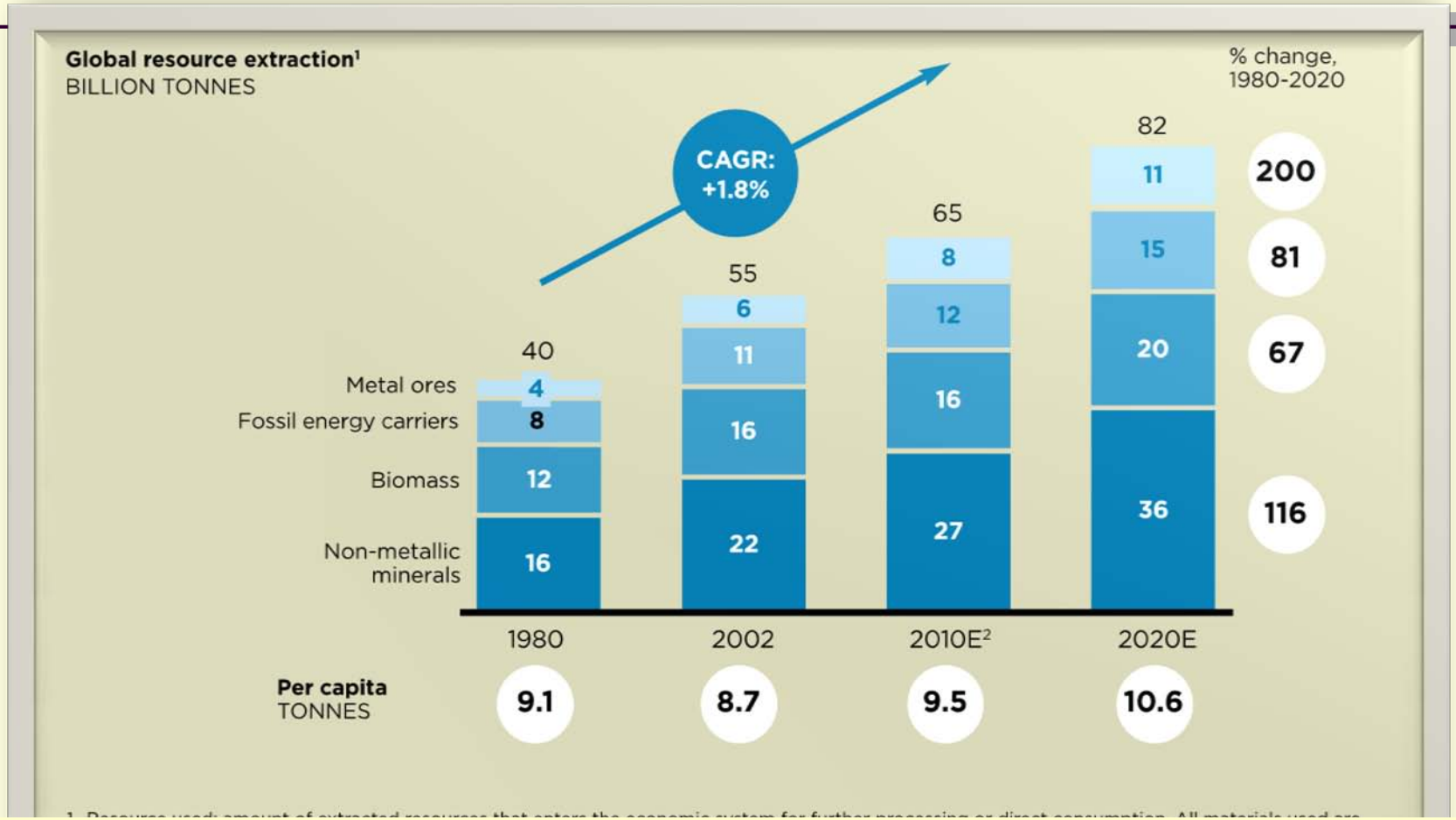


2014

CHALLENGES TO SUSTAINABILITY

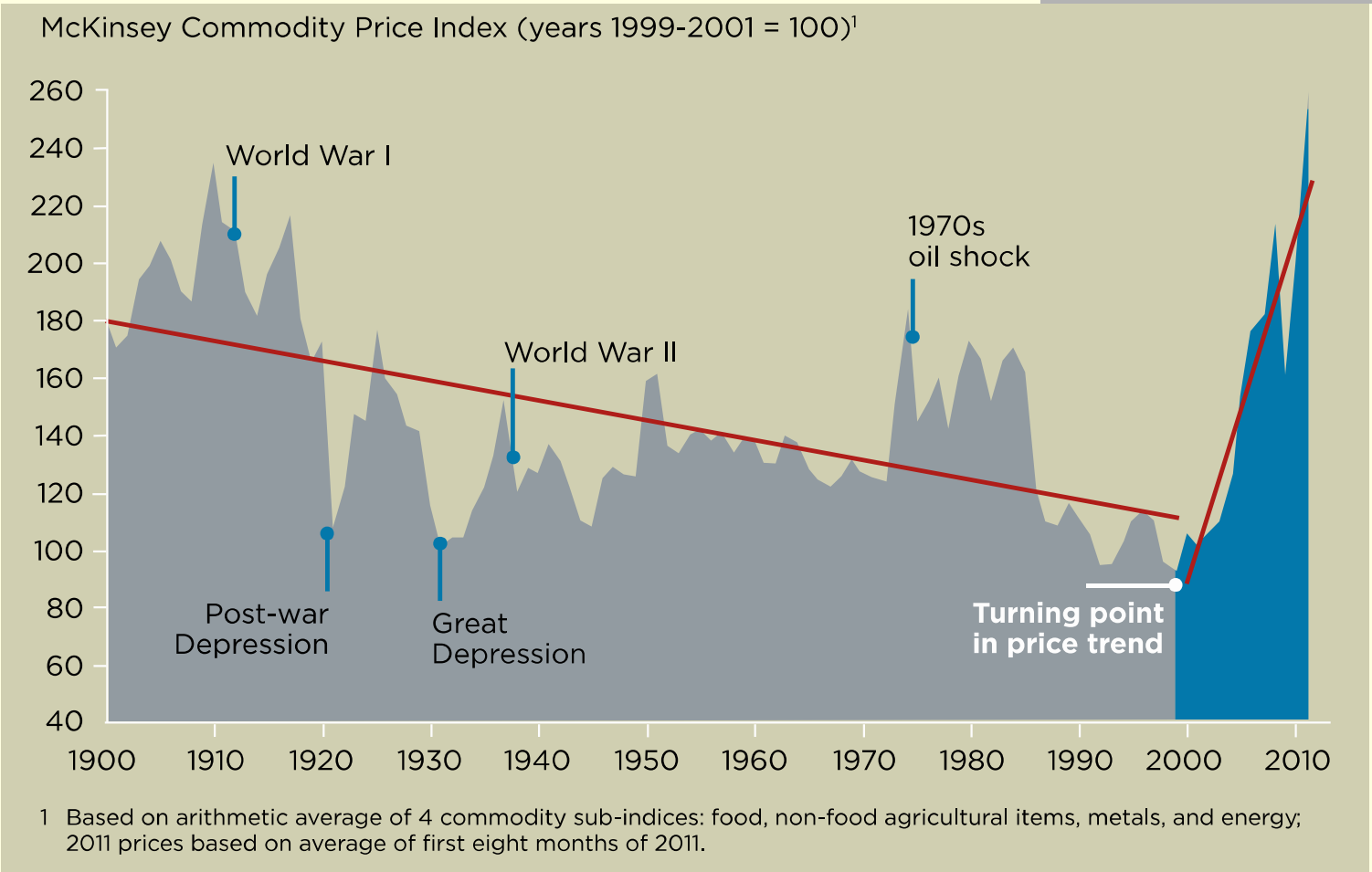
- Population and earth's carrying capacity (> 9 billion by 2030)
- Irreversible changes in global climate (+3°C ⇧)
- Providing enough food for the people (land use pattern)
- **Depletion of earth resources (excessive consumption and rapid urbanization)**
- Access to affordable clean energy (societal and quality of life inequities)
- ***Increasing burden on environment by "end-of-use" objects and materials in a "throw-away" society***

GLOBAL RESOURCE EXTRACTION EXPECTED BY 2020



Using resources at the current rate we will need " the equivalent of more than two planets to sustain us " by 2100 !

GLOBAL COMMODITY PRICES ARE ON AN INCREASE

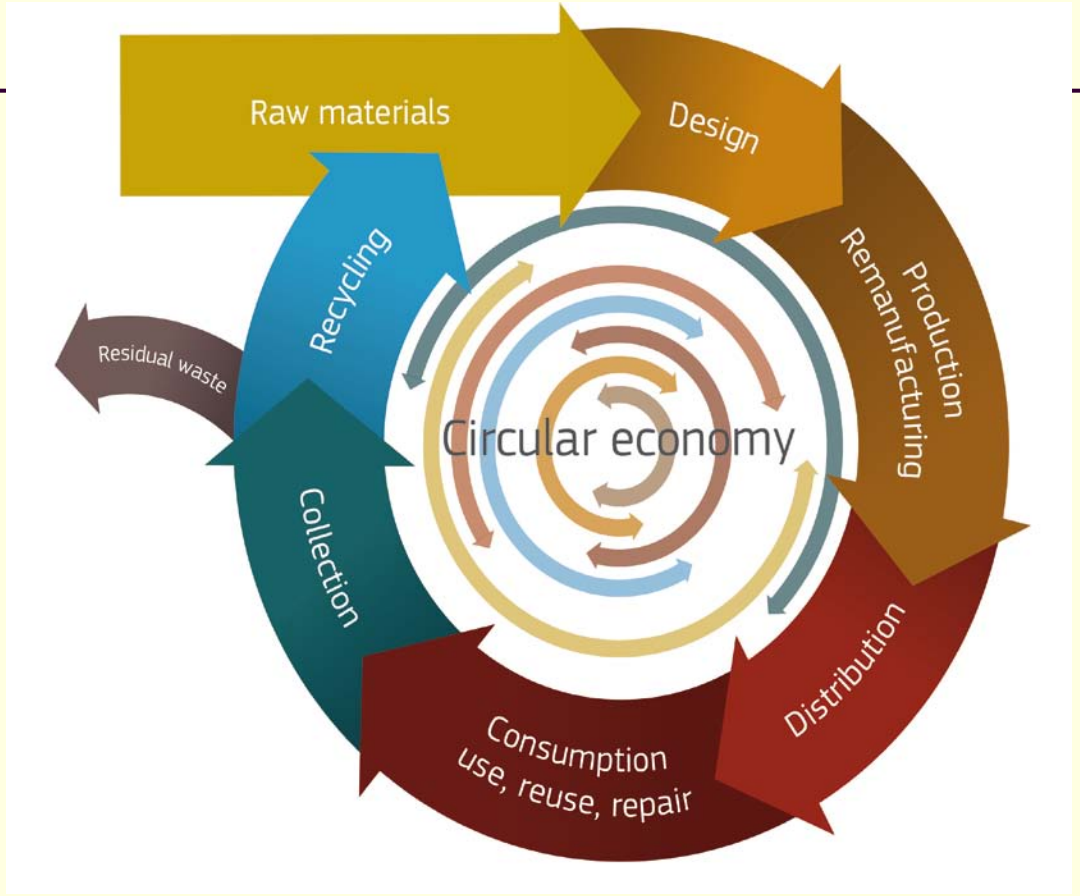


RESOURCES AND SUSTAINABILITY

- Abundance of “Cheap” resources will lead to its wasteful use (r-selection)
- Scarcity of resources will lead to more sustainable use (k-selection)
- Post industrial communities represent r-selection; but it is necessary for our survival to move to k-selection
- The easiest way to drive this process is to make resources artificially scarce, before they disappear
- This, however, flies in the face of all that we ‘know’ about how economics works : ‘Cheap’ resources are better’; in practice, the rational choices that individuals and companies make in their own self interest end up depleting the overall resource available

The Tragedy of Commons,
Garret Hardins, Science, 162(3859), 1243, 1968

THE CIRCULAR ECONOMY



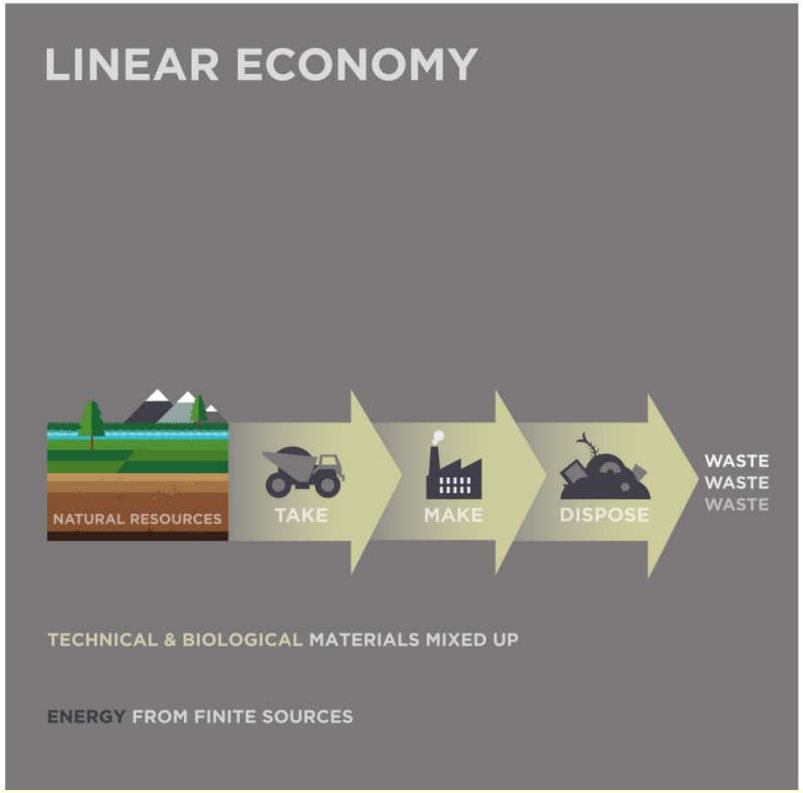
2013

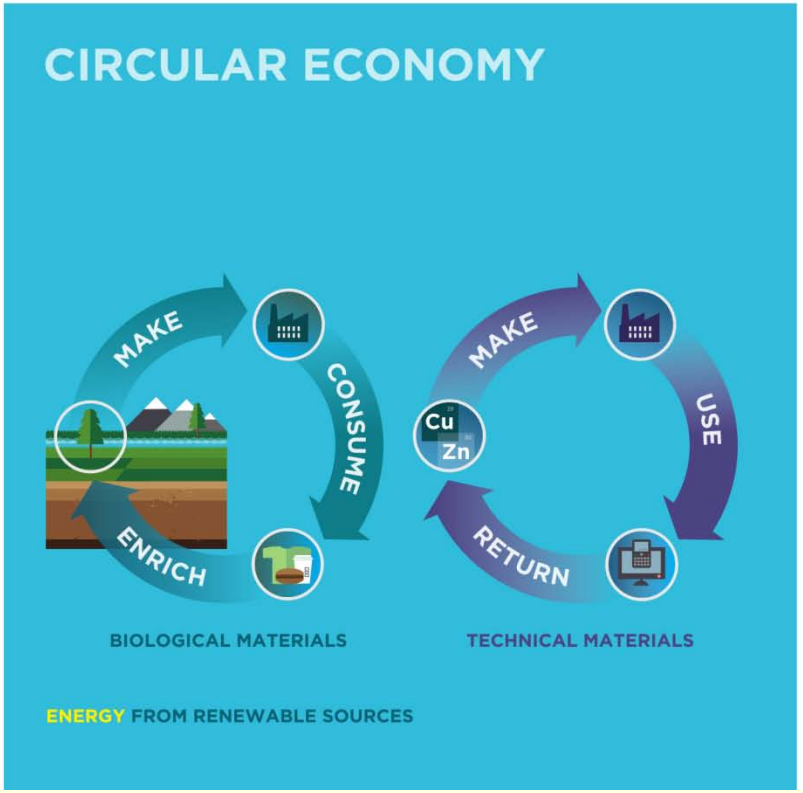
The circular economy offers the opportunity to move away from our "take - make - dispose" model, by ensuring, through careful design and innovative business models, that technical and biological materials continuously flow, safeguarding valuable resources and restoring natural capital.

CIRCULAR ECONOMY: RETHINKING THE SYSTEM

- The circular economy model is a different way to think about production and consumption that changes the linear “take, make, dispose” model to one that is restorative and regenerative by design.
- Designing and implementing circular economy processes into production and design of products and services offers significant long-term advantages.
- Circular economy models can help reduce the need for virgin materials, help find new markets for by-products, and offer better connections to consumers.

FROM A LINEAR TO A CIRCULAR ECONOMY

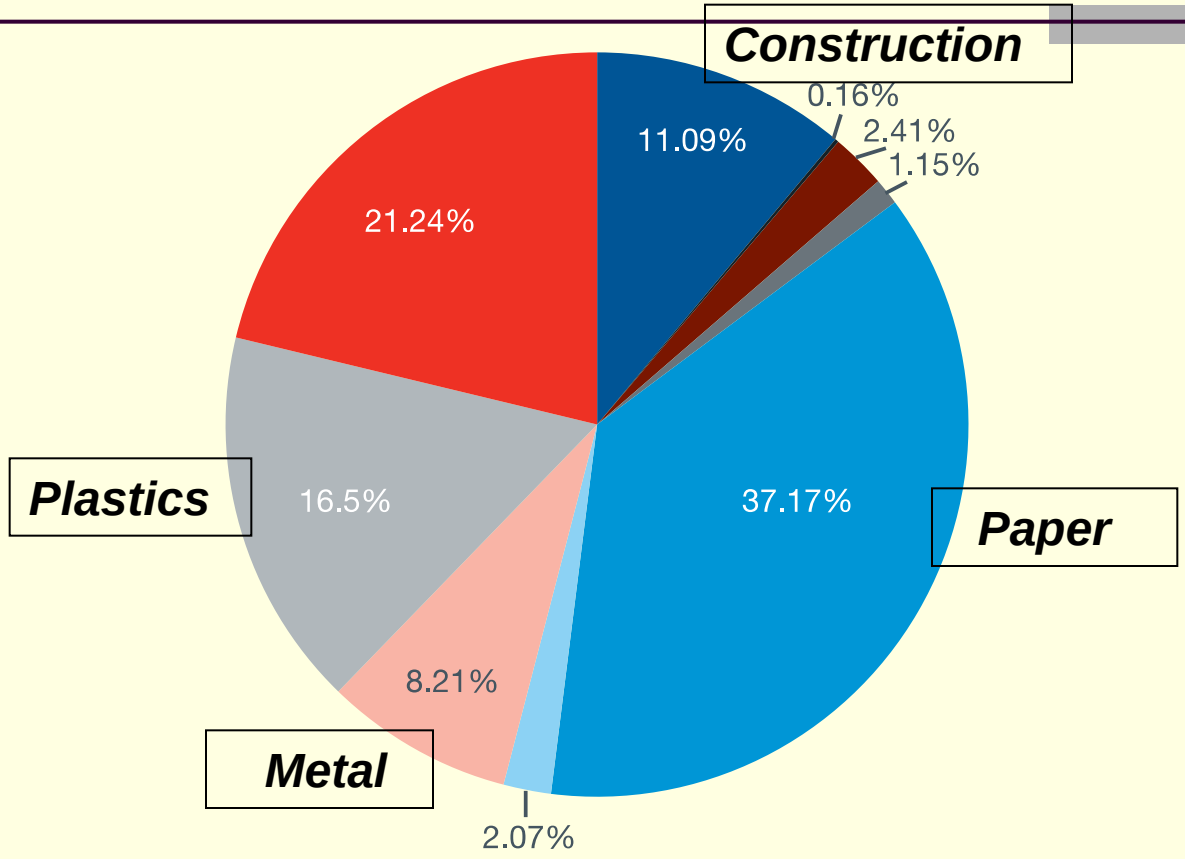




"*The goods of today are the resources of tomorrow at yesterday's resource prices*"

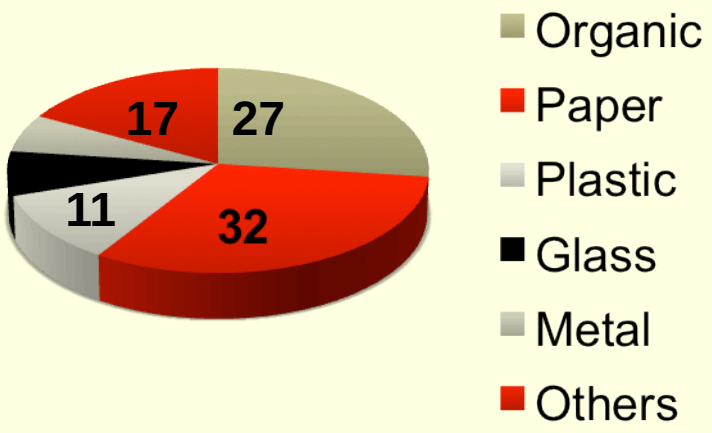
*Professor Walter R. Sta**hel***

WASTE BY TYPE : ALL INDUSTRIES

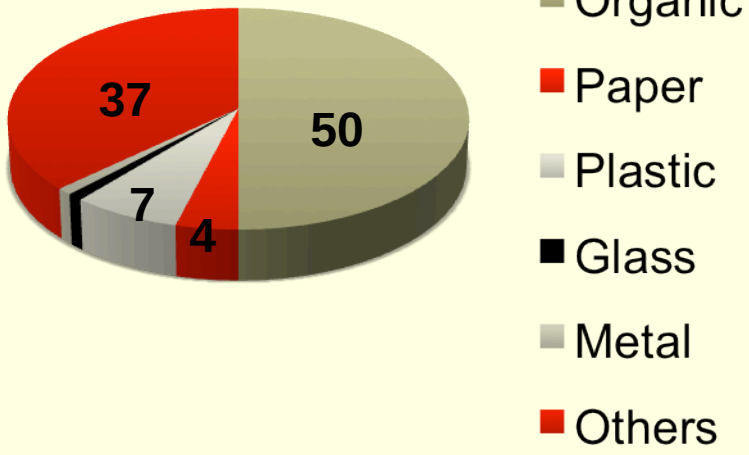


WASTE COMPOSITION IS DIFFERENT IN DIFFERENT REGIONS OF THE WORLD

OECD, %



S.ASIA, %



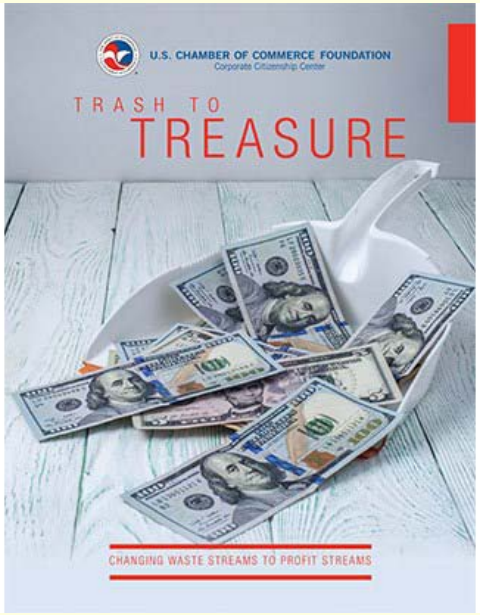
More than 50% of the world's population have no access to regular trash collection; Unregulated dump sites serve about 4 billion people and hold over 40 % of the world's waste

Source: What a Waste, The World Bank, 2012

RECYCLE POTENTIAL FOR MATERIAL WASTES

HIGH POTENTIAL	***Transformational potential*** • **Wood** • **Plastics** • **Textile**	***Apply best practice*** • **Cardboard** • **Steel** • **Aluminum**
LOW POTENTIAL	• **Ceramics**	• **Glass** • **Paper**
	LOW RECYCLE RATE IN SOCIETY	**HIGH RECYCLE RATE IN SOCIETY**

January 2016

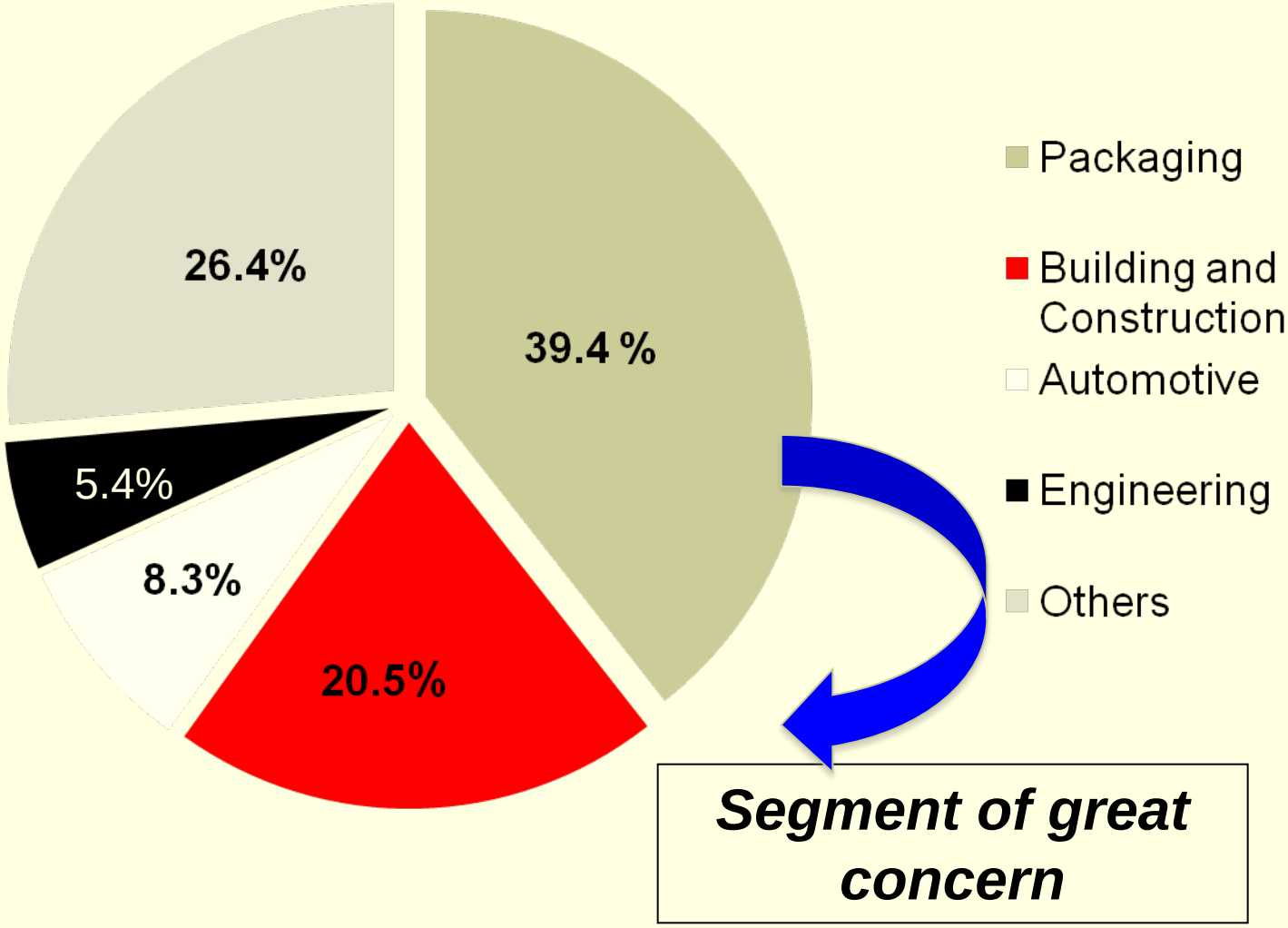


February 2016

POLYMER MATERIALS

- Global production of polymers exceeds 300 mtpa today; to double by 2035
- W. Europe consumes an average of 16 tons of materials per person per year, of which 6 tons ends up as waste, including 3 tons of landfill
- We consume 30 kg of packaging material per person per year, all of which ends up as waste
- We discard about one trillion single use plastic bags each year; generate 2 billion tons per annum of municipal waste; 13 billion plastic bottles thrown away annually
- 8 million tons of plastics leak into ocean every year; 200 million tons of plastics are already in our oceans

PLASTIC DEMAND BY APPLICATION SEGMENT



1
PETE

Poly(ethylene terephthalate)

Every second we throw away about 1500 bottles

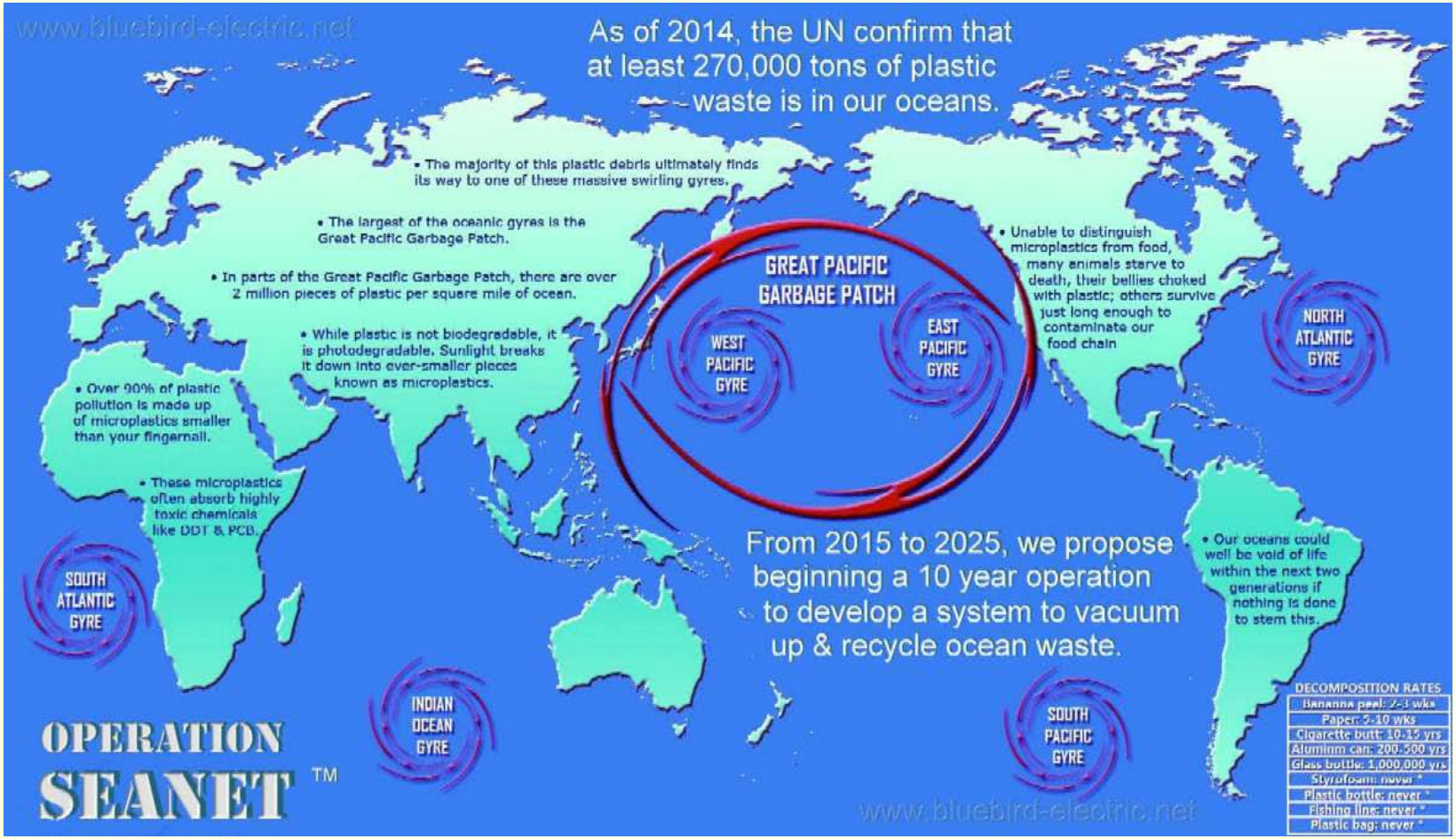
Over 30 billion liters of bottled water is consumed annually

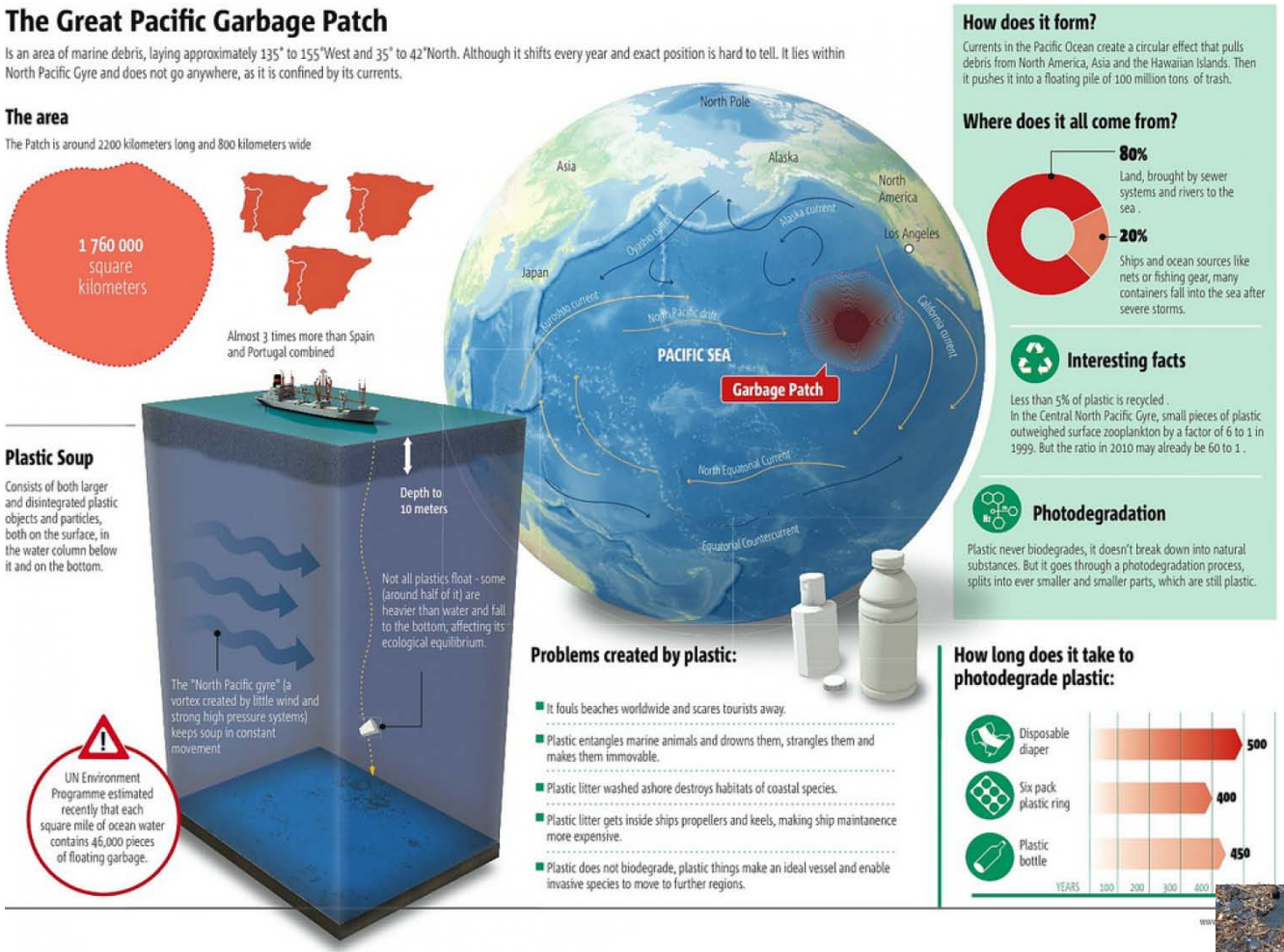
What is the solution ?

PLASTICS IN PACKAGING: BANE OR A BOON ?

Plastic packaging is taking over the supermarket, enveloping almost every food product we buy. Environmental activists say the material is causing the planet huge environmental damage and that the chemical industry should do more to make packaging easier to recycle. Industry acknowledges a need to improve but says it is combating an even bigger environmental challenge, food waste.

THE GREAT PACIFIC GARBAGE PATCH



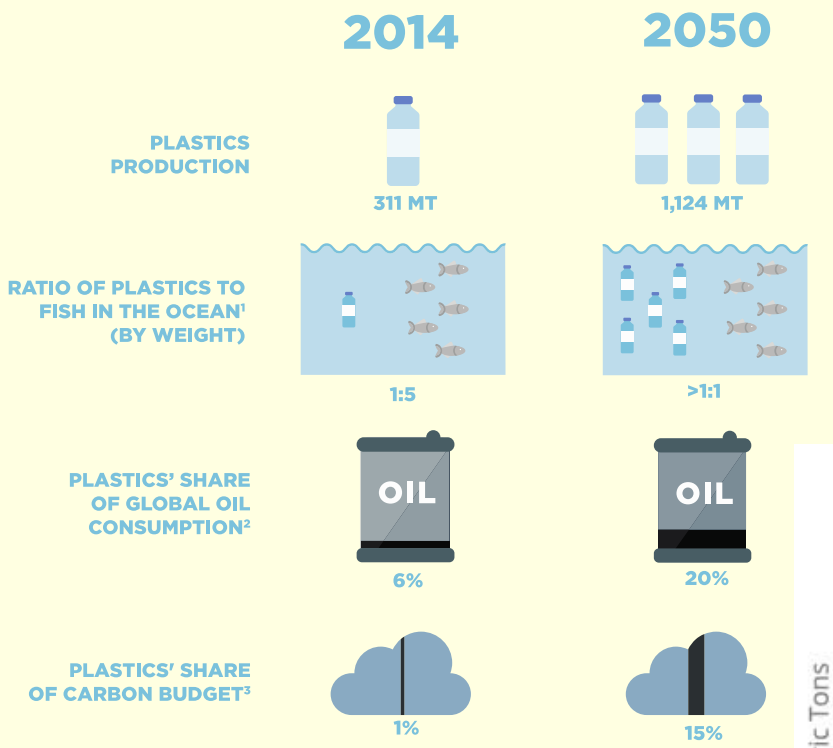


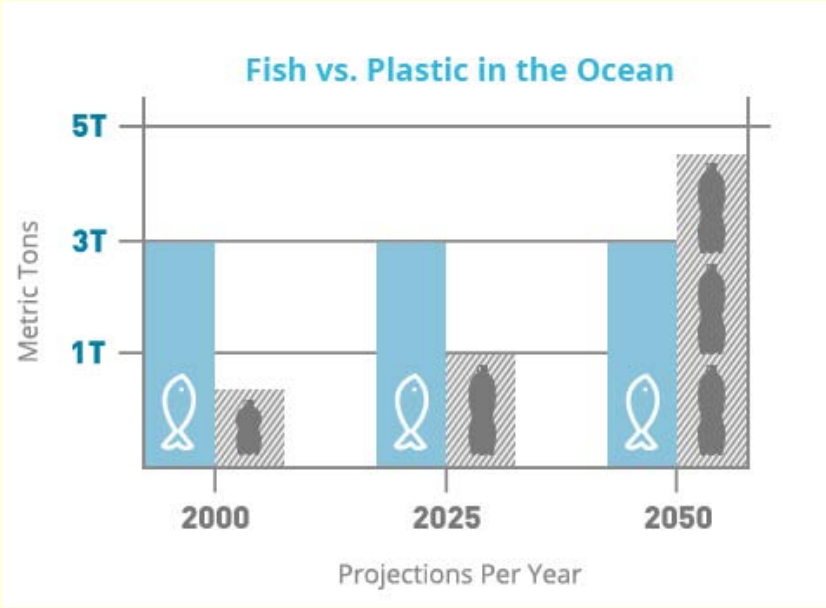
http://visual.ly/great-pacific-garbage-patch

The patch contains 270,000 tons of plastic waste
Microplastics upto <5 mm dia
Leachates detected : nonylphenol, Triclosan, PBDE 47 etc

There is an estimated 200 million tons of plastics litter in our oceans
Our oceans can be devoid of life in the not too distant future if nothing is done to stem this

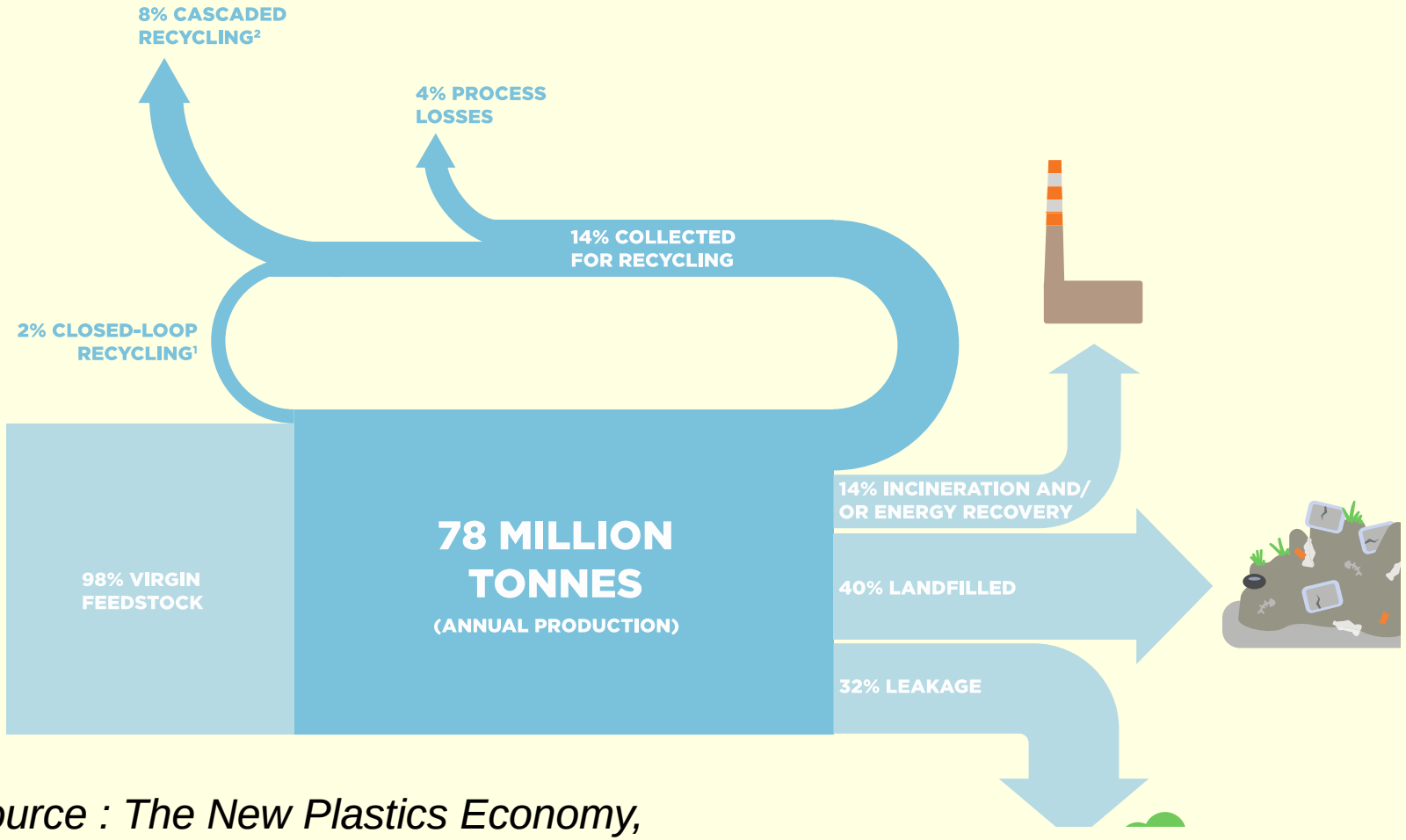
WILL THERE WILL BE MORE PLASTICS THAN FISH IN THE OCEAN ?





Source : The New Plastics Economy, The Ellen MacArthur Foundation

ONLY 2 % OF PACKAGING PLASTICS ARE SUBJECTED TO CLOSED LOOP RECYCLING



Source : The New Plastics Economy, The Ellen MacArthur Foundation

URBAN WASTE: THE INDIAN PROBLEM

- Urban India produces 70 mtpa of Municipal Solid Waste; of this 27 mtpa is sent to landfill and close to 15 mtpa is left to rot in the open
- MSW is likely to be about 165 mtpa by 2030 and 500 mtpa by 2050
- Delhi alone will need 28 sq km of land for landfill by 2020, an area of the size of Lutyen's Delhi !
- Plastic wastes in many urban area constitute about 10-15 % of the total MSW

City	MSW, tpd
Delhi	9000
Mumbai	6500
Bangalore	5000
Kolkata	4500
Chennai	4500
Ahmedabad	4200
Pune	2000

Land filling un-segregated waste is an environmental disaster; toxic leachates, ground water contamination, bacterial growth, methane generation and fire hazard

URBANIZATION OF INDIA

- India's urban population is growing at 6 % per annum against a population growth of 1.7 % per annum
- India is currently 30% urbanized; About 380 million people living in 8000 cities
- 53 Indian cities have a population of over 1 million
- Land to population ratio has decreased four fold since 1950; India's cities are land starved
- Governance of Indian cities are challenged by multiple bodies overseeing the city governance, namely, municipality, state government and quasi state bodies with many overlapping functions and all not necessarily working in concert

Source :The Economic Survey, 2017, Chapter 14, Government of India

ARE MORE SUCH DISATERS WAITING TO HAPPEN ?

URBAN MINING : RESOURCES FROM WASTE

- E waste: Mobile phone , one phone per person, average use per phone ~ 2-3 years
- Other E wastes (TV,s PC’s laptop’s)
- Metal and construction wastes
- Used automobiles and vehicles
- Tyres: India produces 650,000 tyres per day and disposes of 275,000 tyres per day; 100 million tyrs are discarded per annum. In theory, 1 ton of tyre can yield 450 L of fuel, 150 L of gas, 250 kg of carbon and 75 kg of steel
- Flourescent and CFL lamps
- Lead acid and lithium ion batteries

CURRENT RECYCLING OPTIONS

- Waste to energy : 35- 40 MW per ton of waste plastic
- Waste to fuel : Catalytic pyrolysis, most suitable for polyolefins; recently alkane metathesis has been claimed to be a better process
- Waste to syngas: Plasma or microwave incineration
- Waste to monomers and chemicals: Possible only for a few polymers , e.g., PMMA or PET
- Post consumer waste to more valuable virgin polymers: PET to PBT, waste CD's to polysulfones
- Photo- and oxidative degradation : Plagued by safety issues since this introduces microplastics in the environment
- Anerobic degradation by composting: suitable only for a small group of polymers / applications

Most of these solutions require efficient waste segregation ; comingled wastes are not viable feed-stocks

WASTE TO FUELS : TECHNOLOGIES

- Rochem Separation Systems Pvt Ltd : Pyrolysis (Plant installed in Pune, not working)
- Concord Blue (www.concordblueenergy.com**)** :Gasification to hydrogen rich gas for power generation (700 tpd plant in Pune)
- A Thailand company will commission another waste to energy plant in Pune in 2019; processing contracted at Rs 380 per ton of waste delivered at the doorstep
- Ventana (www.ventanatech.com) claims that they have a continuous process which can handle dirty waste producing 900 L of liquid fuels/ per ton of waste at Rs 20 per L; Demo plant in operation In Chandigarh at Company's premises. Start up raising Ser A funding
- Anjali Exim, Surat (www.anjaliexim.com)
- Rudra Environmental Solutions, Pune (700 kg per day waste, at Jejuri and Hadaspar)
- BVG Enterprises, Pune at Pimpri, now shut down
- Sustainable Technology and Environmental Products Pvt Ltd, Mumbai (Polycrack Process)

WASTE TO FUEL PLANTS : ISSUES

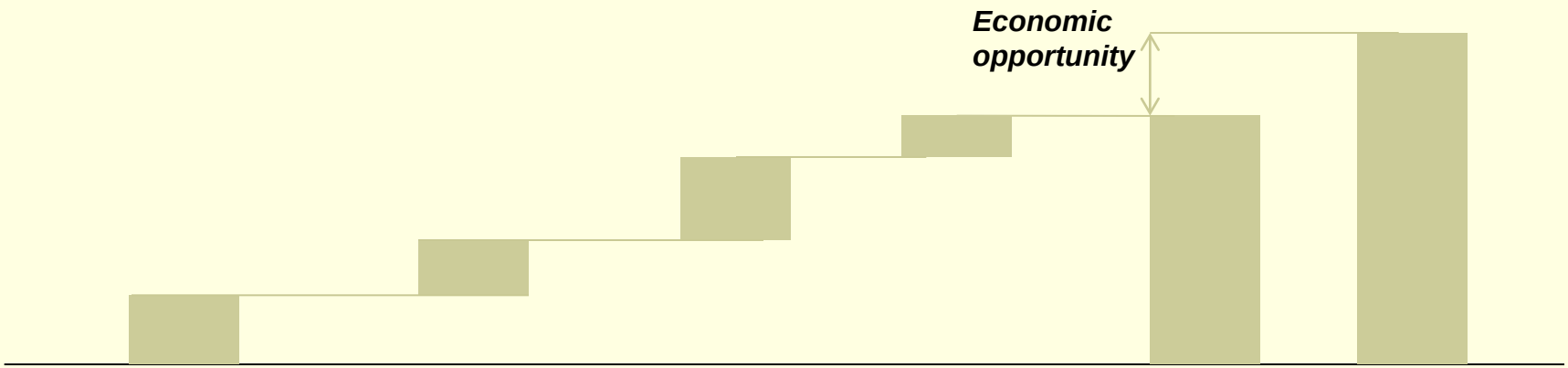
- Only few plants in operation; many non functional due to inability of municipal governments to provide waste of “right” quality
- Mostly home grown technologies with low capacities, batch operations and poor emission handling; resistance from neighborhoods because of emissions causing foul smell
- Most power generation capacities not grid connected; draining power is a problem
- Fuels will have to be internally consumed, mostly as substitute for furnace oils for boilers; not approved for transportation by OMC
- Economic viability not established; most companies work as a contractor on a fixed fee for conversion
- Heavily subsidized; waste is delivered at the door step of companies, free land, subsidized water etc.

Need : a focussed approach to place technology on a firm footing based on process efficiency and economics; define barriers to success and seek solutions

WASTE TO ENERGY PLANTS IN INDIA

Location	Company	Megawatt
Narela, Delhi	Ramky	24
Ghazipur, Delhi	ILF&S	10
Jabalpur,MP	Essel	11
Pallavapuram,TN	Essel	5
Surat, Gujarat	Rochem	12
Hyderabad,TN	Ramky	20
Pune, MS	Rochem, BVG, Concorde Blue, A Thailand Owned company, Rudra Env. Solutions, etc.,	? (Both waste to fuel and energy)

A SUSTAINABLE SOLUTION MUST ALSO BE ECONOMICALLY VIABLE



Collection Cost (Including material dumping fee)

Sorting and pre-treatment Cost

Processing and recycling production cost

Additional production costs due to use recycled material

Recycled Material Cost

Virgin Material Cost

NO VIABLE RECYCLING OPTIONS FOR MANY POLYMERS !

- Two phase polymers: ABS, Impact PP, HIPS
- Multilayer coextruded films
- Polystyrene
- PVC, rigid and flexible
- Rubbers
- Polyurethanes
- Low density materials, such as foams, bubble wraps etc
- Polymers that have come in contact with food or beverages

SOME SCIENCE AND TECHNOLOGY GAPS

- Polymers for packaging with single composition and the functionality of multilayer materials
- Polymers that can depolymerize cleanly into monomers (polymers with tailored ceiling temperatures)
- Adhesives that can be easily degraded by application of a trigger; bio-degradable and bio-compatible adhesives
- Design of products using only one type of polymer
- Polymers capable of degrading in marine and aqueous environments
- Food compatible markers for easy identification and sorting of plastics using hand held devices and white LED's (465-700 nm)
- Compostable polymers with a WVTR of < 8g/m^2/day/atm and OTR of < 55 cm^3/m^2/day/atm
- More environmentally benign and efficient waste to fuel technologies

POOR IMPACT IN SPITE OF MANY SOLUTIONS

- Efforts too fragmented and uncoordinated
- Lack of standards
- Poor labeling
- Inadequate infrastructure for organized collection, sorting, grading and reprocessing
- Municipal Governments are not the best agency for execution of what is essentially a chemical process plant
- Poor understanding of material flow and economics of recycling

Need for a global plastic protocol; plastic waste is not a mere municipal problem; it is a matter of perception, which ultimately can damage the industry. The increasingly negative perception regarding plastics can influence both the public and the policy makers

KEY TO SUSTAINABLE PLASTICS INDUSTRY

- Promote responsible manufacturing
- Promote responsible consumption

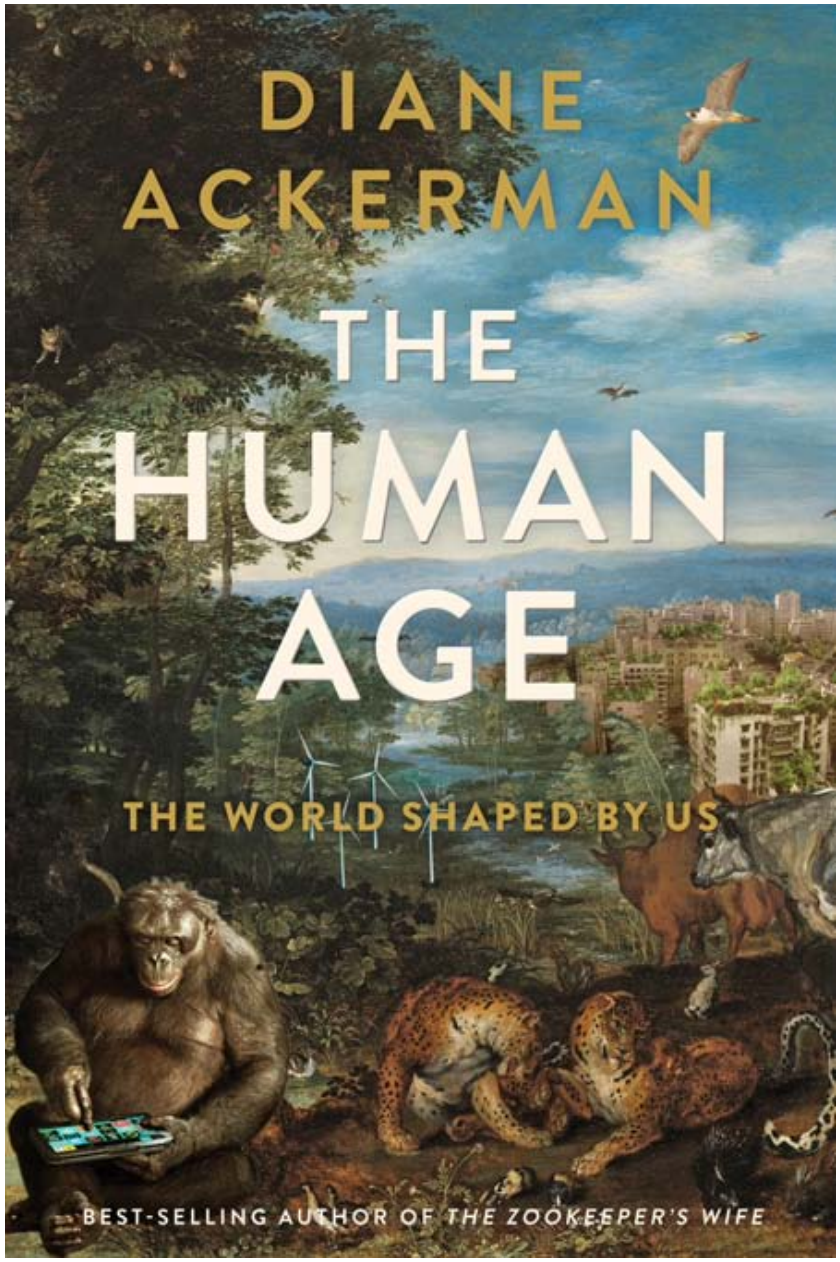
NEW MODELS OF CONSUMPTION

- Extended producers liability
- Voluntary phase out of “short lifetime” and “unfriendly” materials
- Shared ownership (The “ Uber “ model)
- Leased products on pay as per use policy
- Products design for easy disassembly (The LEGO concept)
- ‘Know-your-product” before you buy; transparent labelling

WHAT DOES THE CONSUMER NEED?

- Is the product I am using “safe” for me ?
- Is the product I am using made with the lowest impact on the resources of the planet ?
- What will happen to this product after my “use”? Where will it end up finally ?

Unfortunately, the plethora of sustainability metrics fail to address the above three simple concerns of the consumer clearly and unequivocally



Our relationship with nature has changed radically, irreversibly, but by no means all for the bad. Our new epoch is laced with invention. Our mistakes are legion, but our talent is immeasurable."

Diane Ackerman,
The Human Age

targets
zero-waste
cascade-circles
renewable-materials
eco-design
LCA
multiple-circles
products
inner-circles
ISO
action-plan
research
eco-innovation
renewable-energy
EMAS
knowledge
production-processes

THANK YOU