The Need for a Framework to Assess Sustainability, Circularity & Recycling Approaches

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Messages

- Circularity & Sustainability may not always go hand in hand
- We need Scalable Solutions
- There is no “No Magic Bullet”
- Policy, Technology, Investment & Collaboration Needed

A Systems Level Framework to Make Decisions Needed

What is Sustainability?

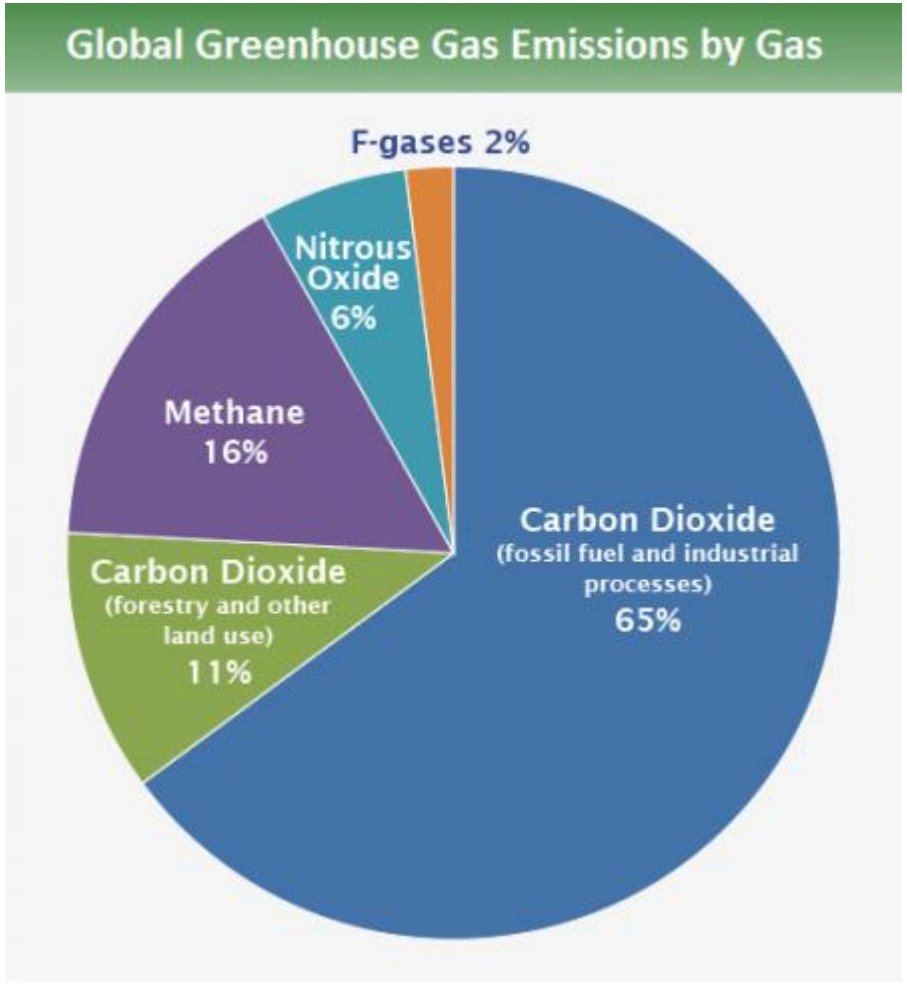
- The ability to continue a defined behavior indefinitely
- Meeting the needs of the present without compromising the ability of future generations to meet their own needs
- Making every decision with the future in mind
- 9 billion people living well within the limits of the planet
- The possibility that humans and other life will flourish on the earth forever
- *In everything we do, we strive for positive impact on society and the planet*

Positive impact includes:

- ✓ Clean Air
- ✓ Clean Water
- ✓ Healthy Soil
- ✓ Safe, inclusive and resilient infrastructure
- ✓ Good personal and community well-being
- ✓ Affordable and clean energy
- ✓ Stable climate
- ✓ No waste

The Overall CO_2 Picture

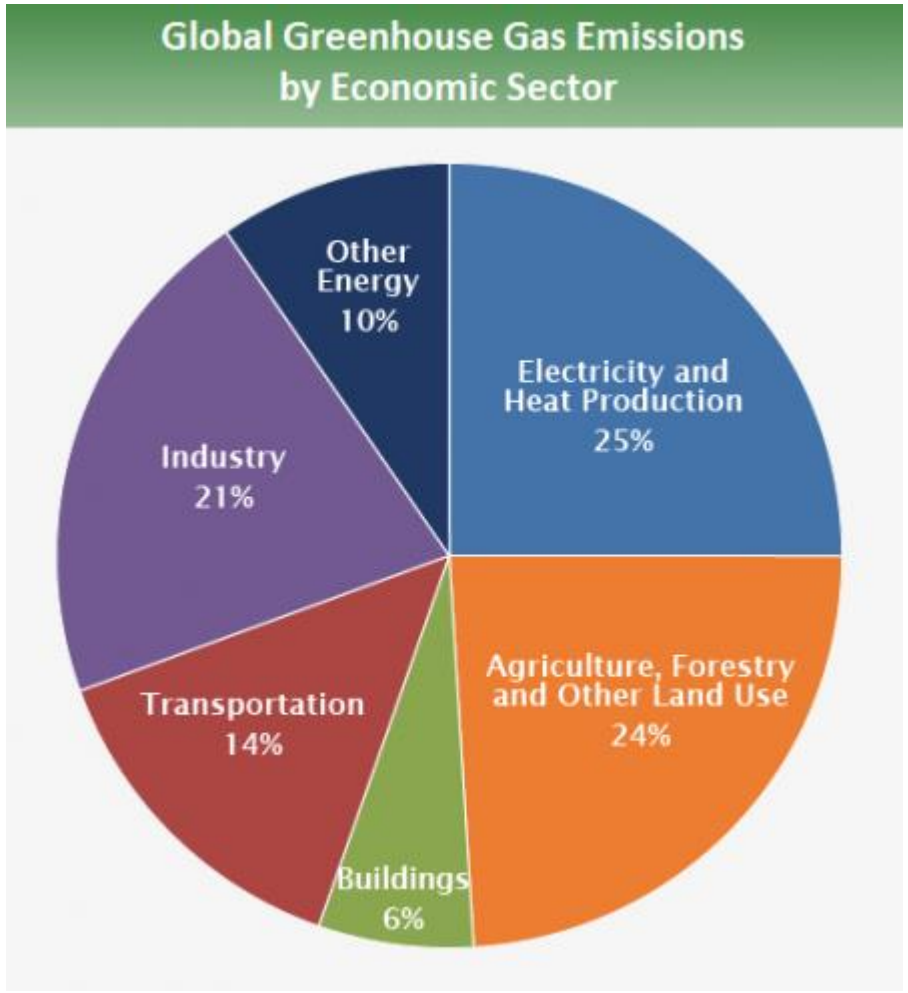
Global Green House Gas (GHG) from 2010



- CO_2 accounts for 76 % of all GHG emissions
- Not all GHG's have the same impact

Source: IPCC (2014) EXIT based on global emissions from 2010. Details about the sources included in these estimates can be found in the *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*

Global GHG Emissions by Sector

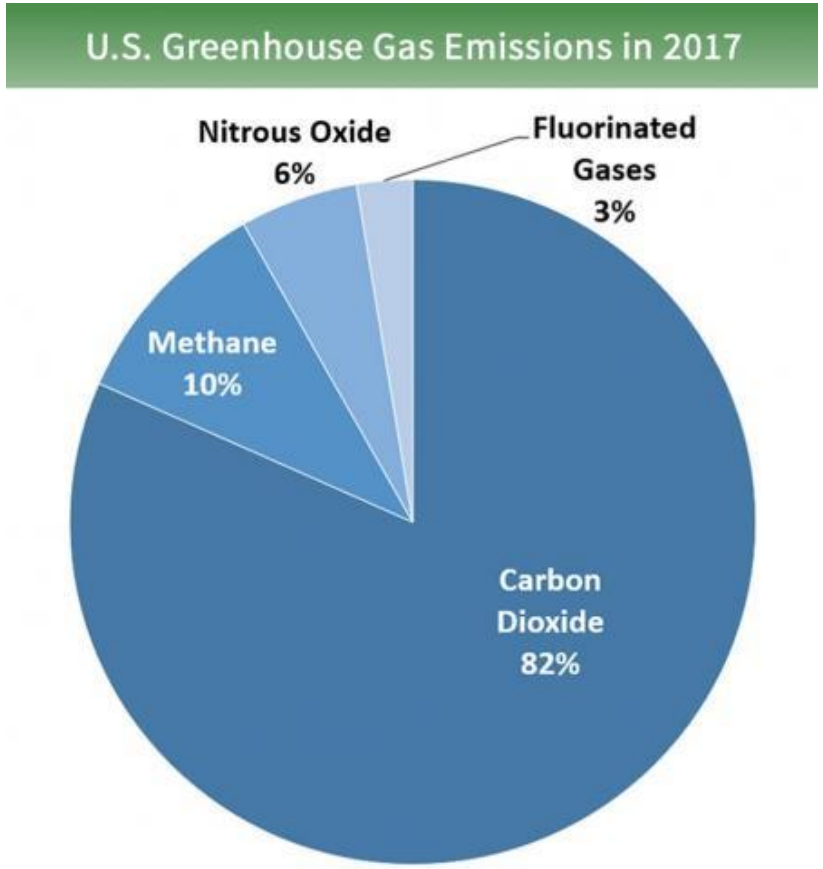


- Energy, Transportation, Electricity & heat Generation → 50% of GHG emissions
- Industry & Agriculture account for a bulk of the remaining GHG generation

- Industry accounts for about 1/5th of the total GHG emission

Source: IPCC (2014); EXIT based on global emissions from 2010. Details about the sources included in these estimates can be found in the *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*.

US Green House Gas (GHG) in 2017

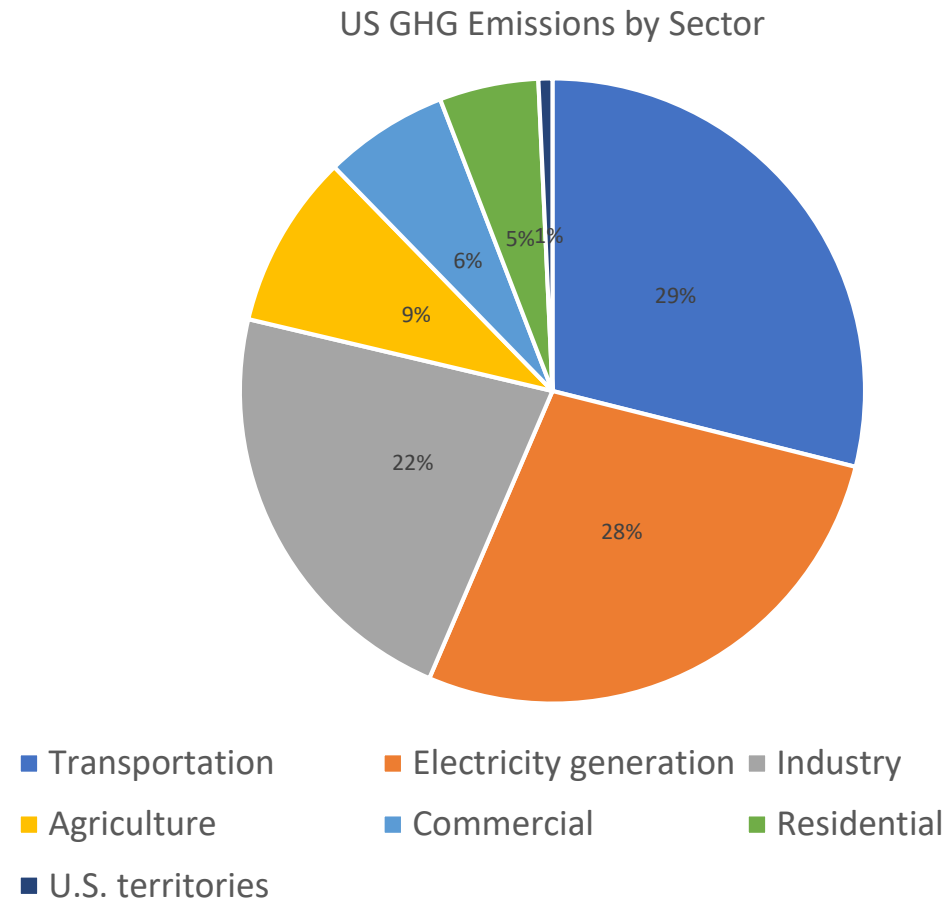


- GHG dominated by CO_2
- Not all GHG's have the same impact
- Total Emissions in 2017 = 6,457 Million Metric Tons of CO_2 equivalent or 6.4 B Tons

- US accounts for approx. 15% of the total GHG emission

Percentages may not add up to 100% due to independent rounding
Source US EPA website

US Green House Gas (GHG) by Sector in 2017



- Transportation, Electricity & heat Generation → 68% of GHG emissions
- Industry & Agriculture account for a bulk of the remaining GHG generation
- US → Industry 22% and Agriculture → 9%
- US and Global Industry accounts for ~ 22-28%
- Agriculture GHG substantially lower in US vs. Global

The Plastics Industry

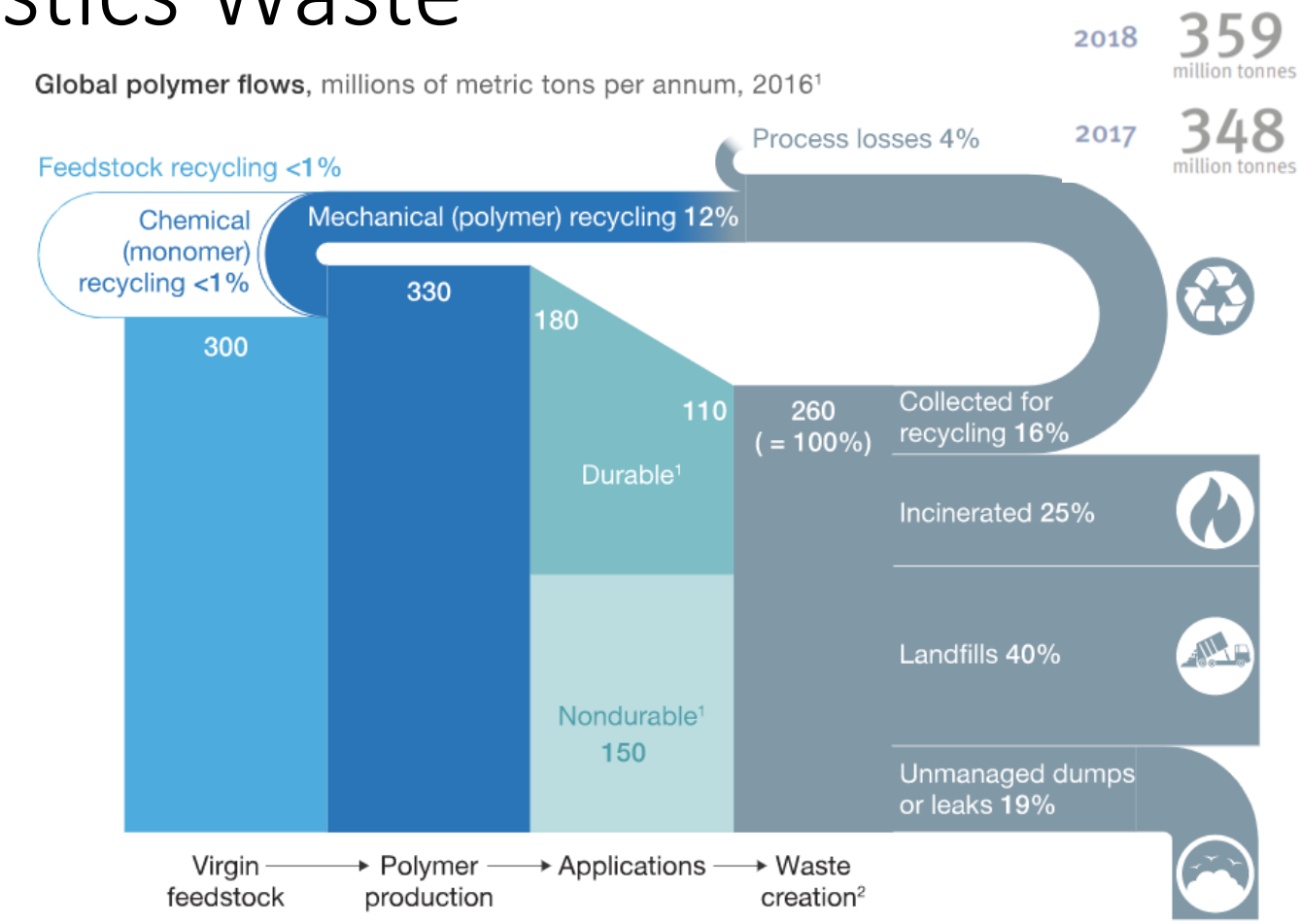
Emission by Industry

Industry Type	Amount (%)
Other Sources	35
Bulk Chemicals	20
Refining	18
Iron & Steel	8
Food Products	6
Paper Products	4
Transportation Equipment	2
Fabricated Metal Products	2
Plastics	***2***
Cement & Lime	2
Aluminum	1

US Energy Information Administration (2019a), US Energy Information Administration (2019c) & US EPA (2019c)

- Plastics only a small portion of the US Emissions
- Plastics bring benefits

Plastics Waste



[1]Durable applications with an average lifetime >1 year will end up as waste only in later years; nondurable applications go straight to waste.
[2]150 million metric tons of mixed plastic waste from nondurable applications that end up as waste in same year, plus 110 million metric tons of mixed plastic waste from production in previous years.

19% unmanaged flow ~ 50 - 55 MM tons!

Incineration has CO_2 implications

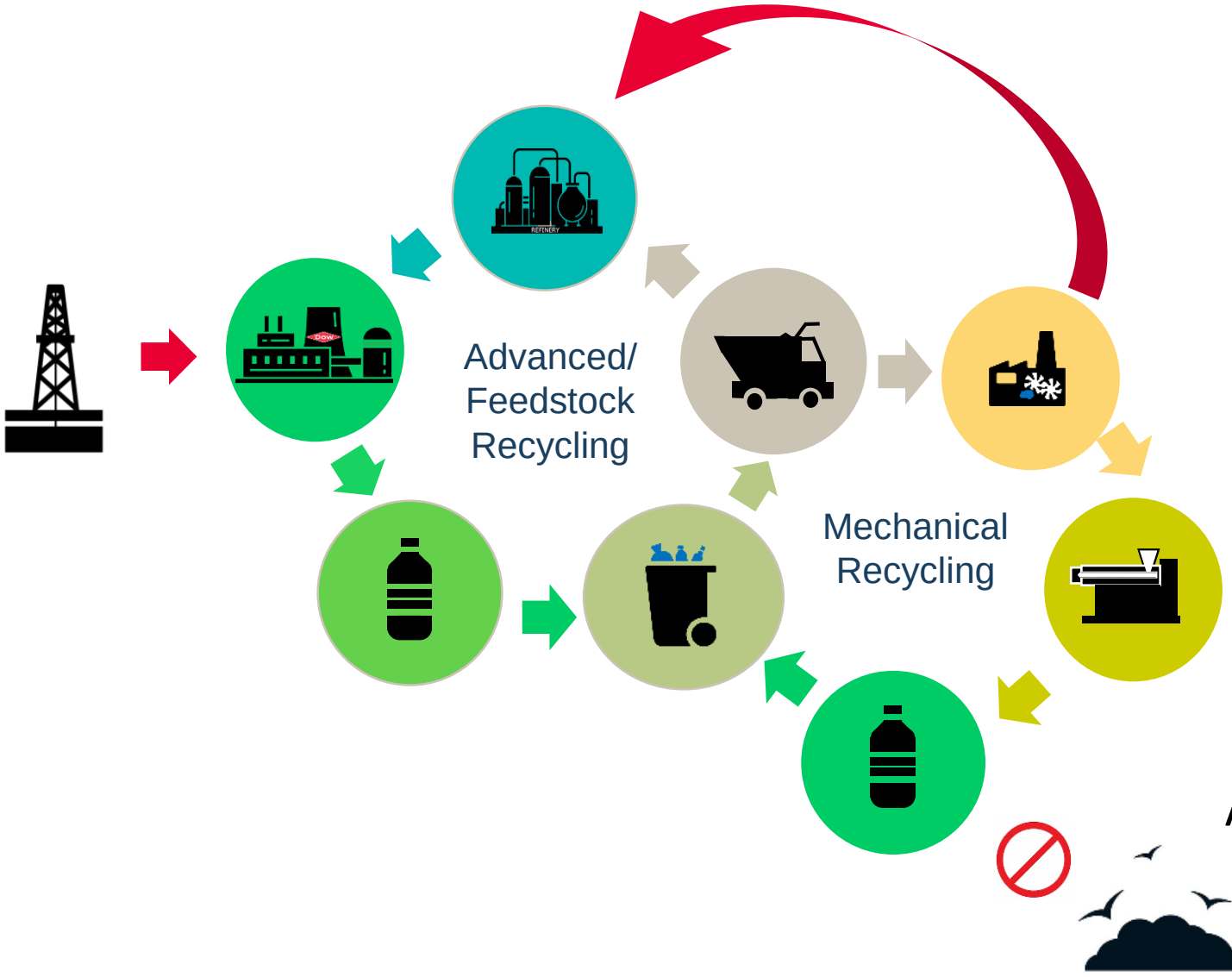
Landfills have limited viability

Need to Stop the Waste
&
Close the Loop

https://www.plasticseurope.org/application/files/9715/7129/9584/FINAL_web_version_Plastics_the_facts2019_14102019.pdf

https://www.mckinsey.com/industries/chemicals/our-insights/how-plastics-waste-recycling-could-transform-the-chemical-industry

Plastics Circular Solutions



Polyethylene:

- Ethane → Ethylene → Polyethylene (PE)
- Reaction exothermic,
  - C-H bond → ~101 Kcal/mol
  - C=C bond → ~150 Kcal/mol
- Energy to melt PE pellets → ~286 J/g

- Evaluate competing factors – CO_2, Waste Reduction, Cost, Energy, Scalability, Selectivity?
- Value chain Partnerships
- Will Consumers Value these Solutions
- What Scale is Necessary to Demonstrate Meaningful Impact - Near Term and Long Term
- Distributed vs Integrated Solutions

A System Level Framework is Needed

Plastics Production & Top 5 Plastics

322 MM Tons produced in 2015

Plastic Type	Volume %
PE	32
PP	23
PVC	16
PS/EPS	7
PET	7

We need Scalable Solutions – this is not very scalable!

As an example:

- Assume we can incorporate 1% CO2 into the largest volume Plastic

- PE ~ 100 MM Tons
- 1% of 100 MM Tons is ~ 1 MM Tons
- Scale of the CO2 problem ~ 18,000 MM Tons
- If we can incorporate 10% ~ 10 MM Tons

- Back of the envelope calculation do not take into account feasibility of the Chemistry
- The Scale mismatch is too large for CO2 incorporation into plastics/chemicals to be a viable solution to the CO2 problem

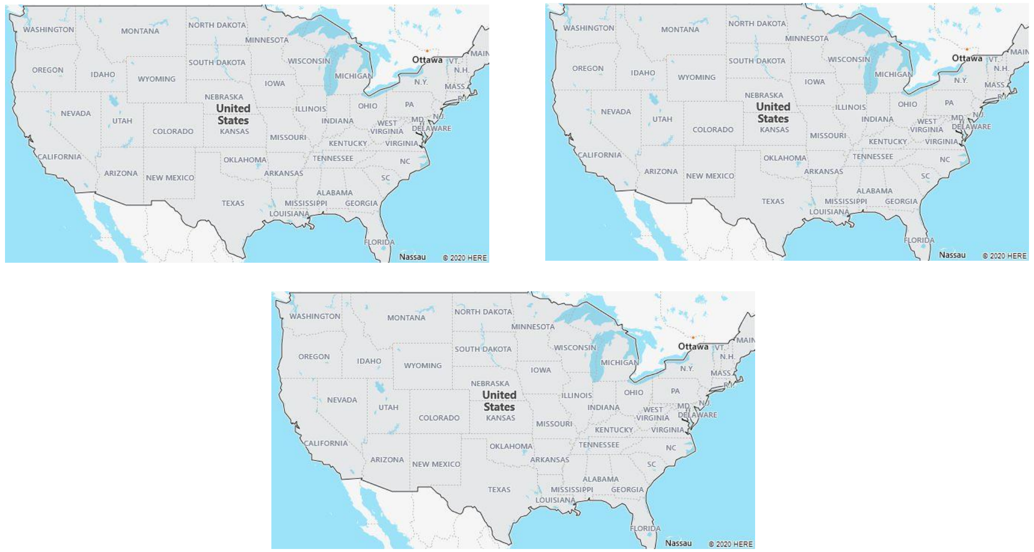
Increased Efficiency - Energy Generation & Transportation

- % CO2 emissions from Heating, Electricity & Transportation ~ 50%
- Total Global CO2 emissions ~ 36,000 MM Tons
- CO2 emissions from Heating, Electricity & Transportation ~ 18,000 MM Tons
- Impact of 1% reduction in CO2 emissions from Heating, Electricity & Transportation ~ 180 MM Tons

Magnitude much larger than incorporating into a molecule, but still smaller than the overall problem – Better but leaves more to be done!

Is Re-forestation an Option – Not really!

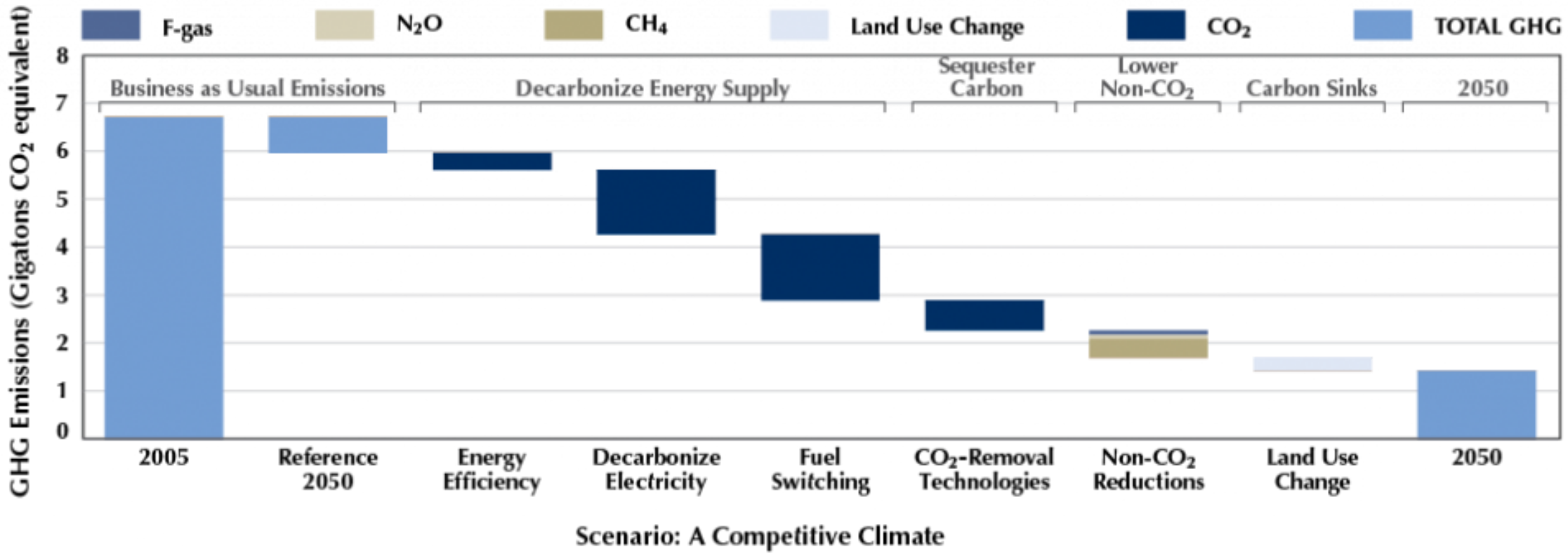
- Trees play a role
  - Young trees → 13 lb/yr/tree
  - Mature trees → 48 lb/yr/tree
- One acre can sequester 2.5 T CO2/yr/acre
- Scale of the problem → 18,000 MM Tons
- Reforestation Acreage
  - 7200 MM Acres or 7.2 Billion Acres
  - 3X land area of the US would need to be forested to tackle the CO2 emissions!



Area of the united states → 2.4 B Acres

Again not very scalable – but plays a role!

Options to mitigate – No Magic Bullet



- **Decarbonization of Energy key**
- **Energy efficiency & Land-use change play a role**

Life cycle thinking & assessment

- Life Cycle Thinking (LCT) takes a holistic view of the production and consumption of a product or service and its impacts on the environment through the entire life cycle.

- Life Cycle Assessment (LCA) is the quantification of life cycle thinking

Salsa: Glass jar, rigid plastic, flexible plastic

Pace Chunky

Stated package contents: 16 oz

Package Components:

Glass:	287.9g
Aluminum Cap	8.0g
Total package weight:	295.9g

HEB Fresher Lasting

Stated package contents: 16 oz

Package Components:

LLDPE:	7.2g
BO Nylon:	2.4g
PU Adhesive:	0.4g
EVOH:	0.9g
Total package weight:	10.0g

Source: James Nuttall & Tony Kingsbury, November, 2007, Updated January 2011

Pace Squeeze

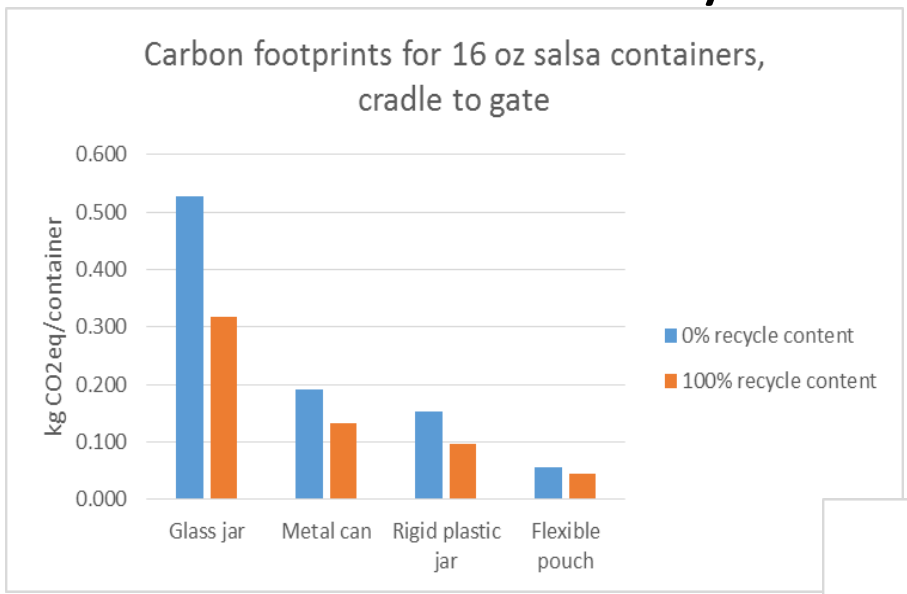
Stated package contents: 20 oz

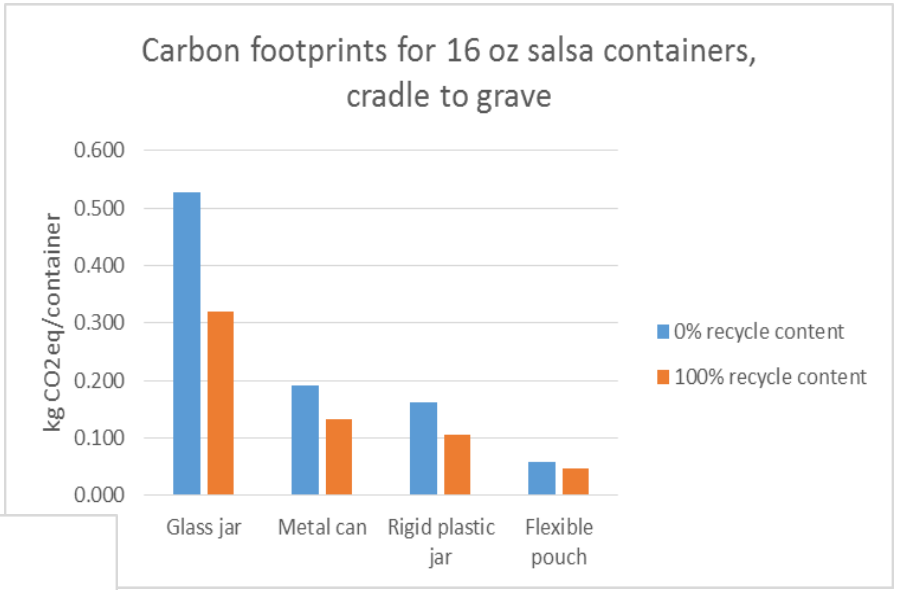
Package Components:

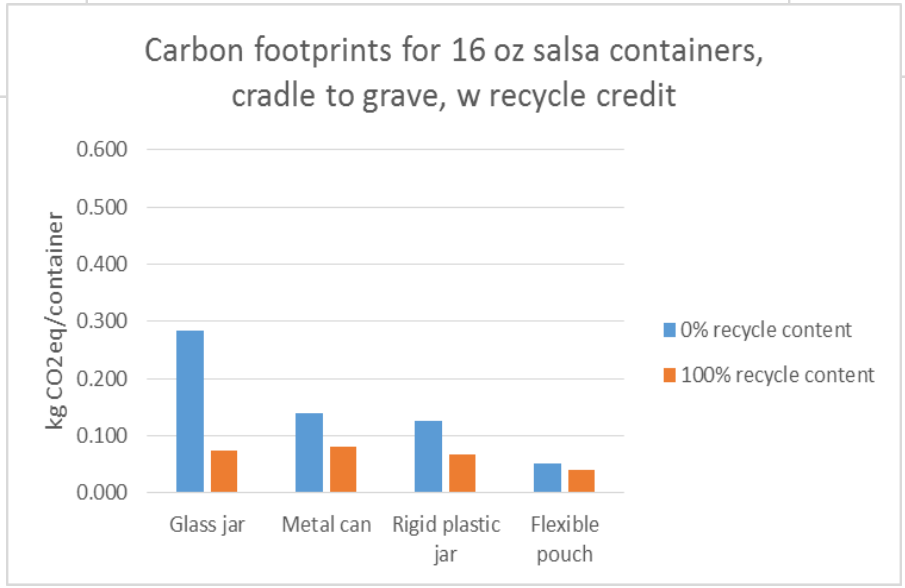
PP:	47.7g
EVOH:	1.3g
MA-modified LDPE:	0.5g
Total package weight:	49.6g

DOW

Three graphs – by material & recycled content for different life-cycle boundaries







Sustainability is Complex

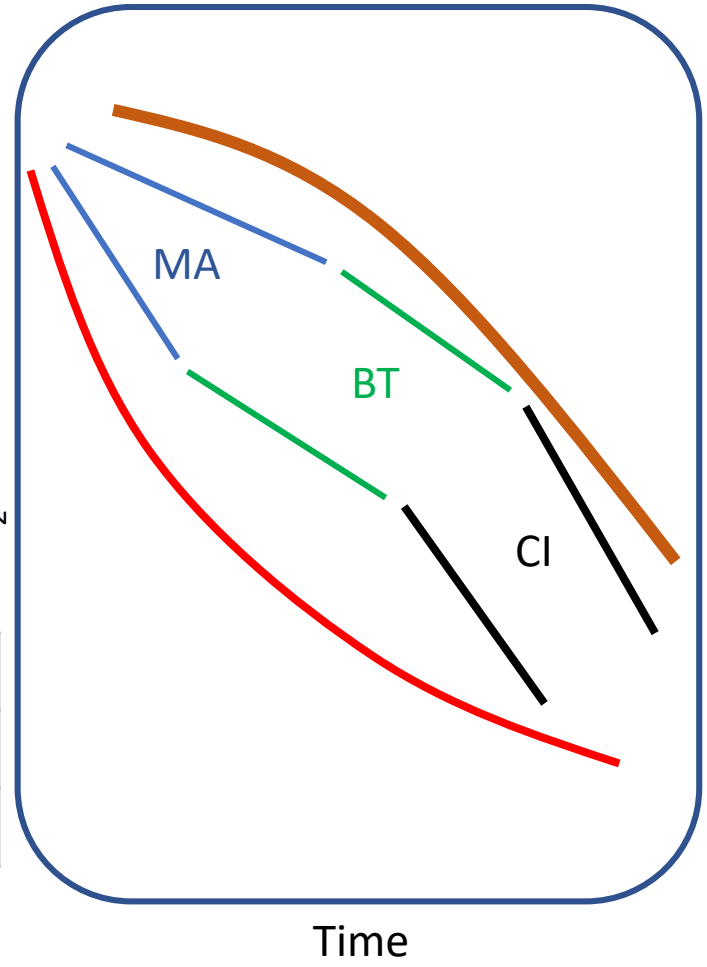
Continuous Improvement (CI) → Breakthrough Technologies (BT) → Mitigation Approaches (MA)

Cradle to Gate | **Gate to Grave**

Cost	Medium
Scalability/Impact	Medium
Implementation Time	Medium

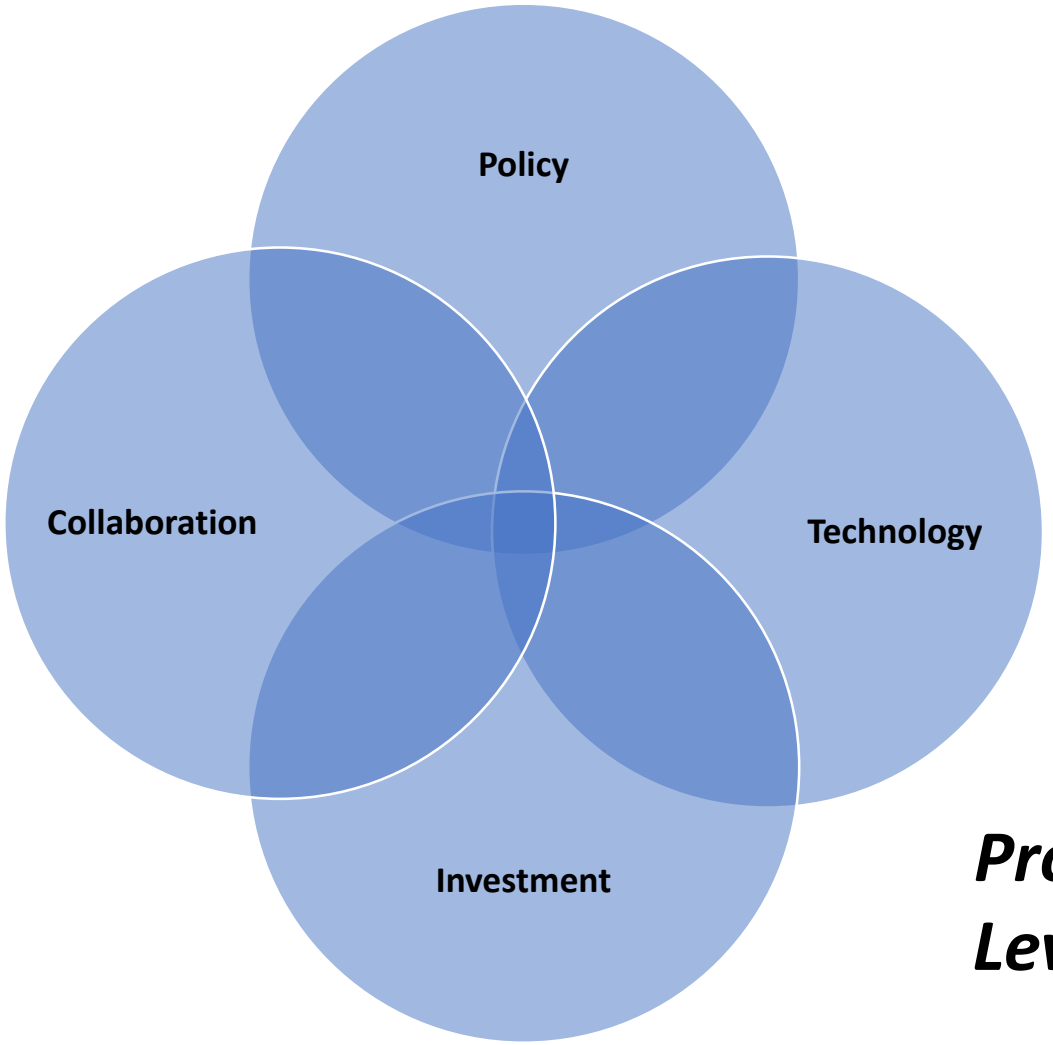
Cost	High
Scalability/Impact	High
Implementation Time	High/Medium

Cost	Low
Scalability/Impact	Low/Medium
Implementation Time	Low



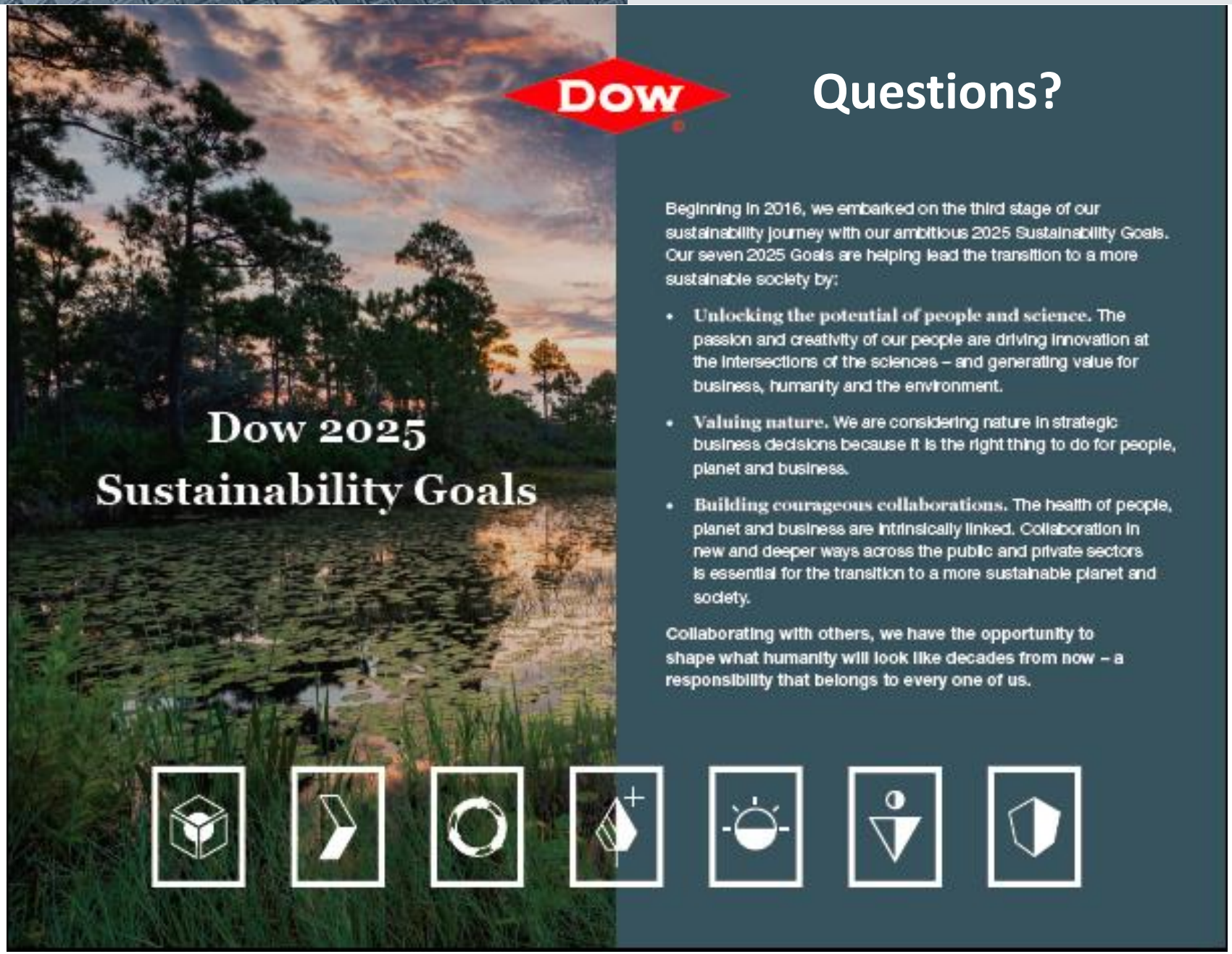
Challenging to pick the trajectory that will allow foot print reduction, meet financial targets, manage risk & timeline

How do we get there?



- New & Innovative Technology,
- Consistent Policy Framework
- Directed & Sustainable Investment
- Smart Partnerships & Collaboration

Problem is Large & Complex → Needs System Level Framework & Consistency of Purpose to Solve



Questions?

Beginning in 2016, we embarked on the third stage of our sustainability journey with our ambitious 2025 Sustainability Goals. Our seven 2025 Goals are helping lead the transition to a more sustainable society by:

- **Unlocking the potential of people and science.** The passion and creativity of our people are driving innovation at the intersections of the sciences – and generating value for business, humanity and the environment.
- **Valuing nature.** We are considering nature in strategic business decisions because it is the right thing to do for people, planet and business.
- **Building courageous collaborations.** The health of people, planet and business are intrinsically linked. Collaboration in new and deeper ways across the public and private sectors is essential for the transition to a more sustainable planet and society.

Collaborating with others, we have the opportunity to shape what humanity will look like decades from now – a responsibility that belongs to every one of us.