EMERGING TECHNOLOGIES:
BEYOND MECHANICAL RECYCLING

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September 16, 2019

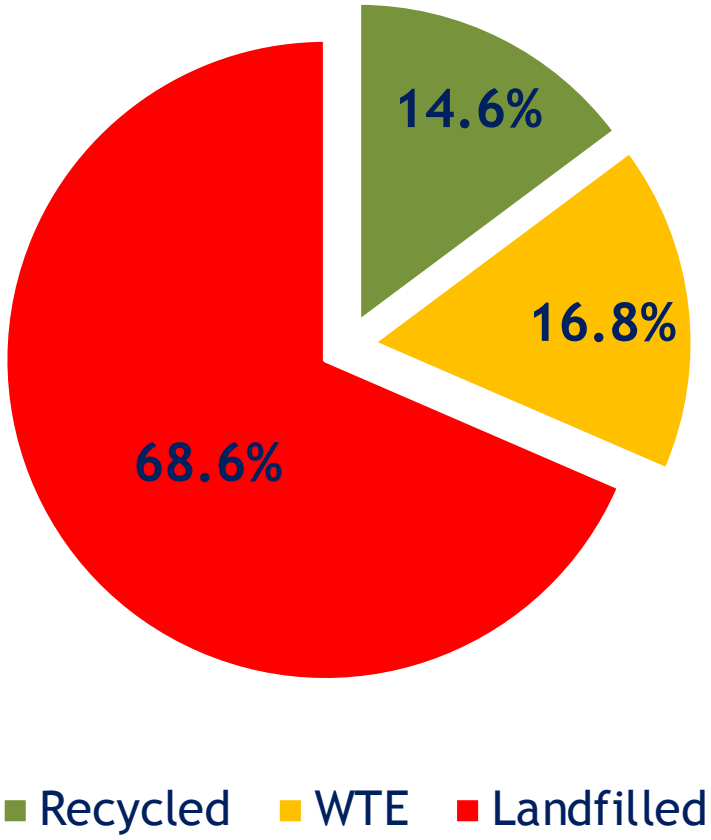
American Chemistry Council

Why do we use plastics?

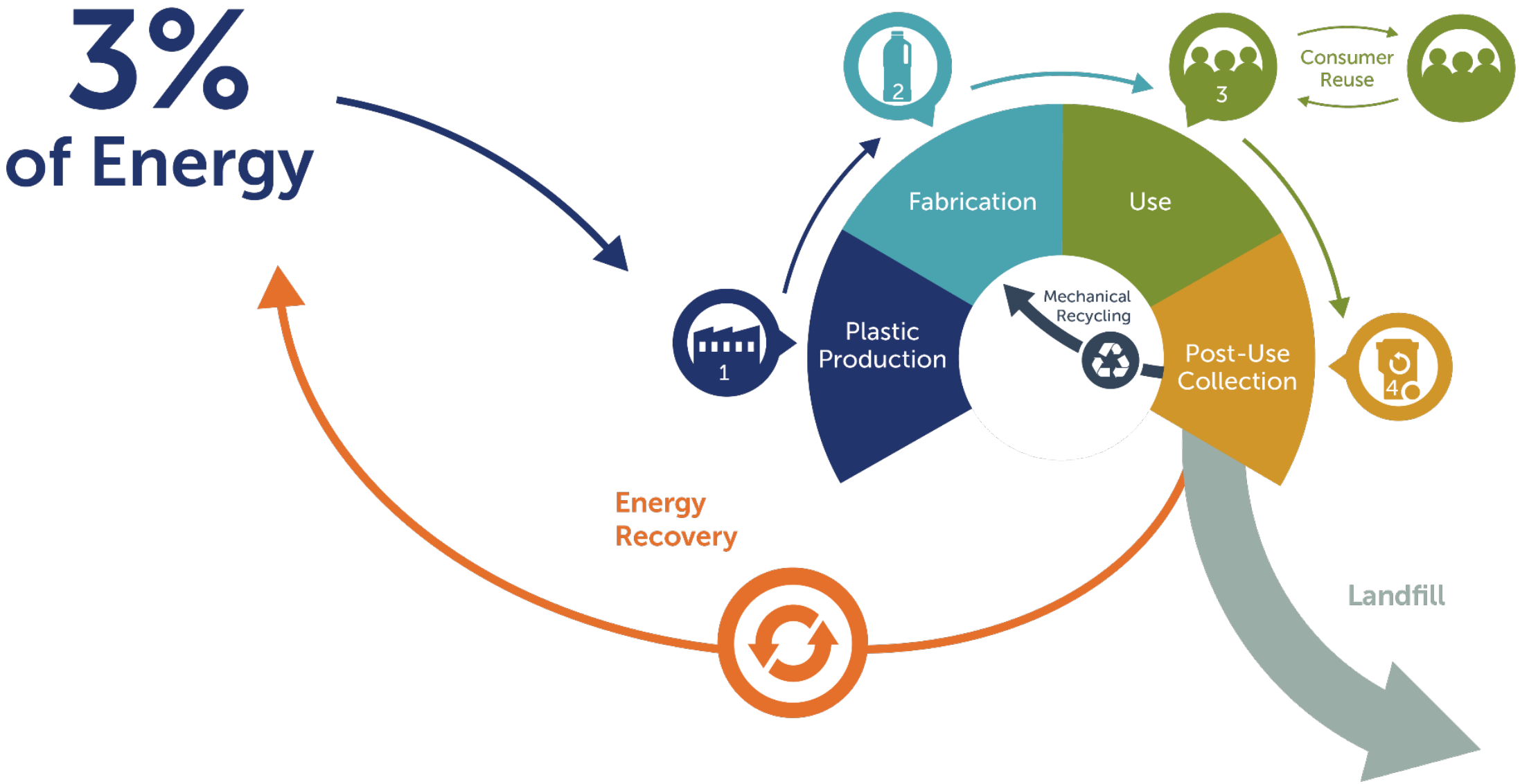
- Lightweight, versatile, durable
- Prevents food waste, reduces food spoilage
- Low cost
- Wide range of applications

Plastics Packaging Recovery (U.S.)

Low recovery rate driving concerns about plastics packaging and waste



The Plastics Economy Today



Plastics Division Members

AmericasStyrenics LLC

BASF
We create chemistry

BAYPOL

Braskem

Celanese

Chevron Phillips Chemical Company LP

covestro

DOW

DUPONT

ExxonMobil

LANXESS
Energizing Chemistry

lyondellbasell

NOVA Chemicals

سابك
sabic

SASOL

Shell Chemicals

SOLVAY
asking more from chemistry®

TOTAL

TRINSEO

The Vinyl Institute

Plastics Division Sustainability Goals

- ✓ **2040 Goal**
  - 100% of plastics packaging is reused, recycled or recovered
- ✓ **2030 Interim Goal**
  - 100% of plastics packaging is recyclable/recoverable
- ✓ **Best Practice Goal**
  - 100% of Division's U.S. manufacturing sites participate in Operation Clean Sweep Blue by 2020, with all North American sites by 2022

Seven Initiatives to Achieve Commitments

1) Define, Inventory, and Target

2) Design Packaging to Enable Recovery

3) Create Circular Business Models

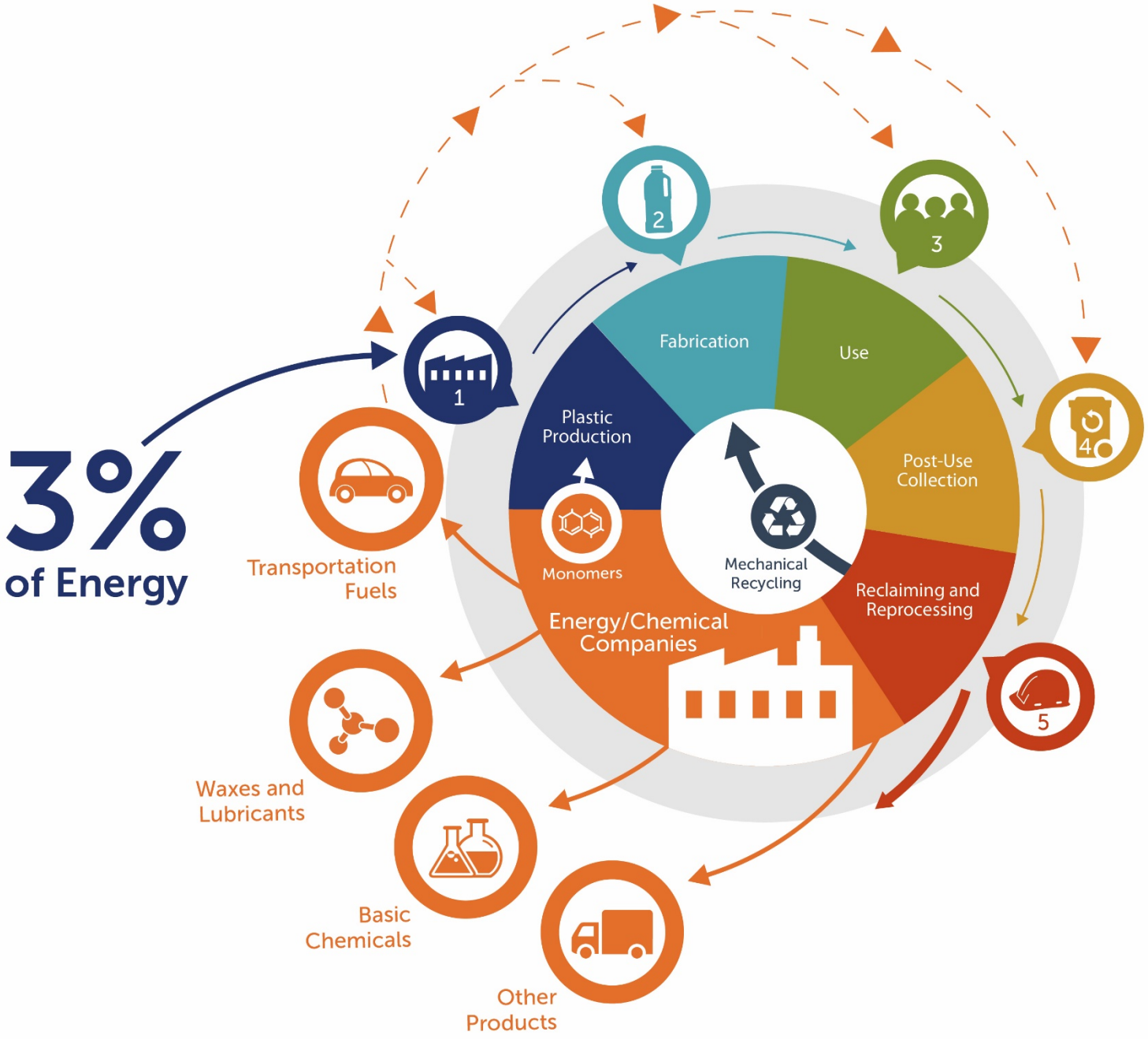
4) Invest in Access and Infrastructure

5) Invest in New Disruptive Technology

6) Educate Consumers and Change Behavior

7) Expand Stakeholder Partnerships

Plastics in a Circular Economy



The Buzz Around Chemical Recycling

GreenBiz

The 5 things you need to know about chemical recycling

CBS THIS MORNING

Chemical recycling could be the answer to our single-use plastic problem

Solving the recycled plastics puzzle

Rob Kaplan
Thursday, September 21, 2017 - 1:35am

Raw plastic pellets for use in manufacturing.

What is Chemical Recycling?

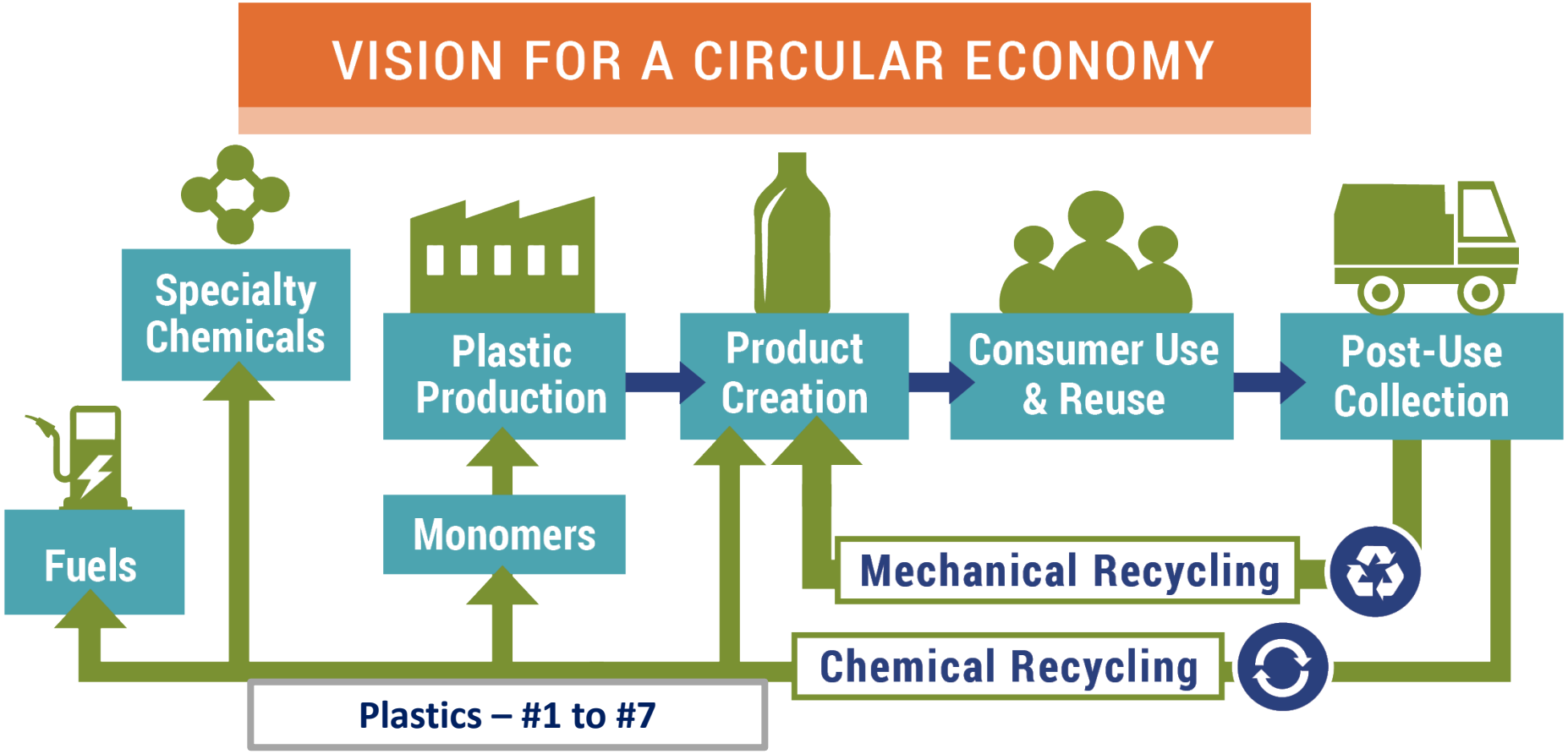
Leveraging chemistry to convert post-use plastics into valuable products which extend the life of the plastic

Outputs:

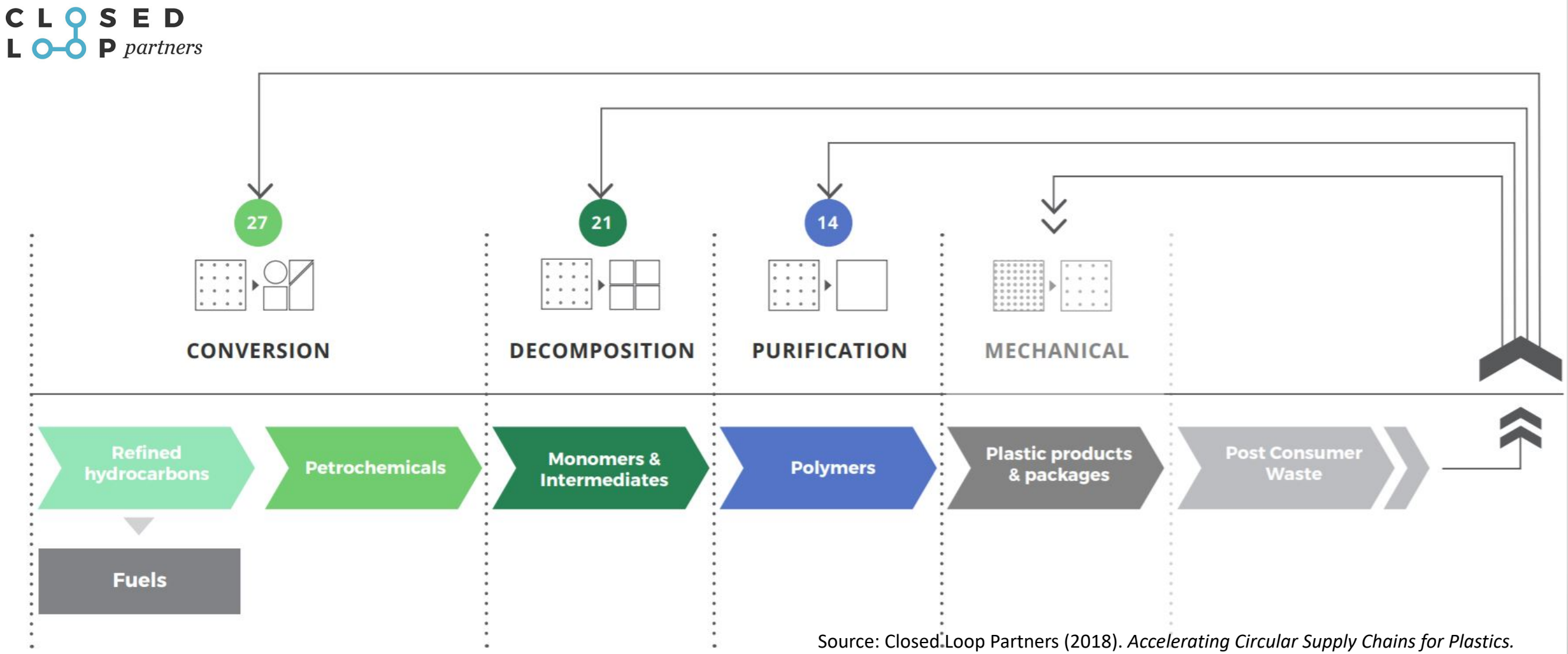
- Virgin Like Plastics
- Specialty Chemicals
- Basic building blocks (monomers)
- Chemical feedstocks (naphtha)
- Fuels

These products are then used as alternative to fossil based products.

Complementary to Mechanical Recycling

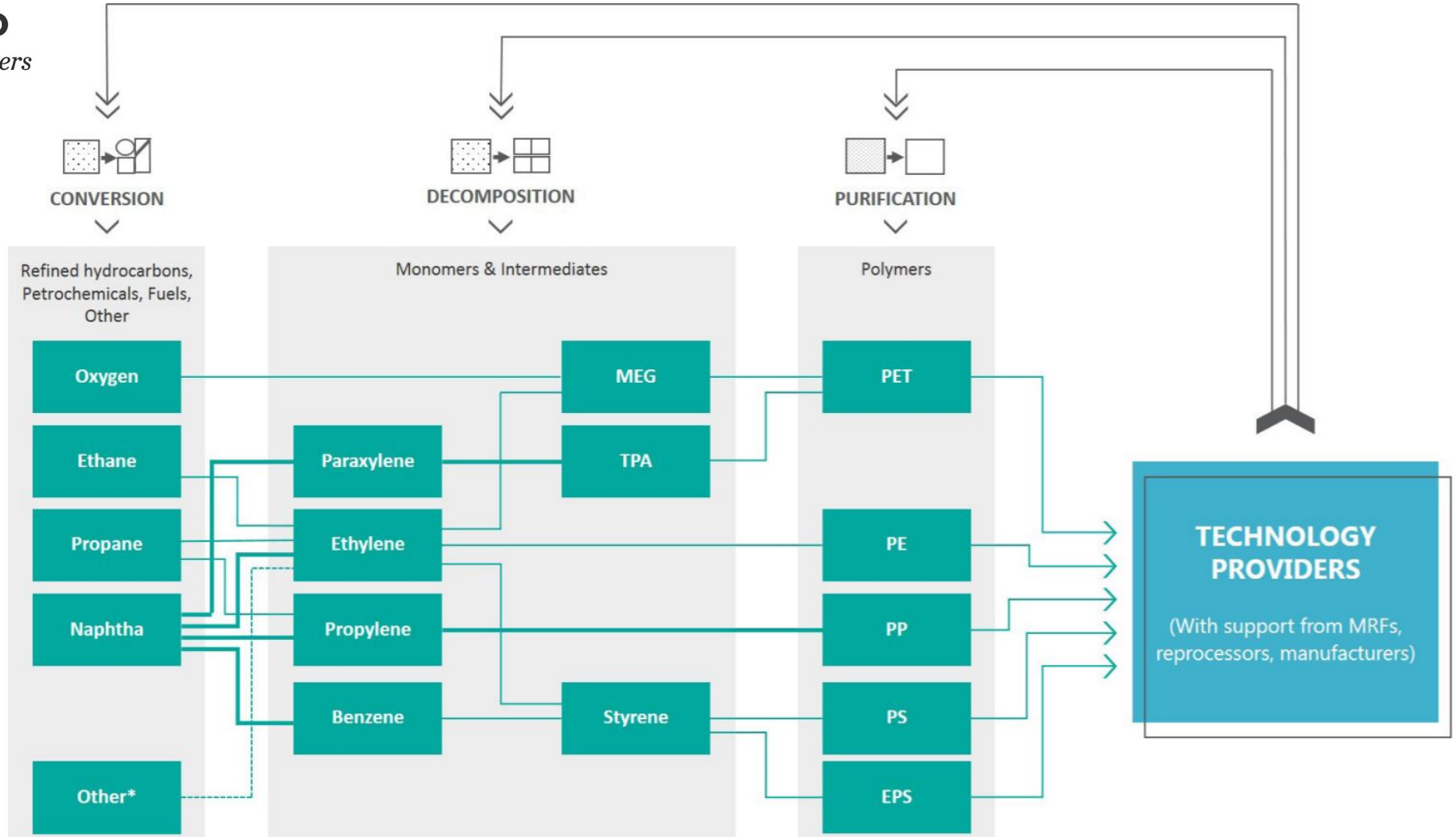


Types of Chemical Recycling



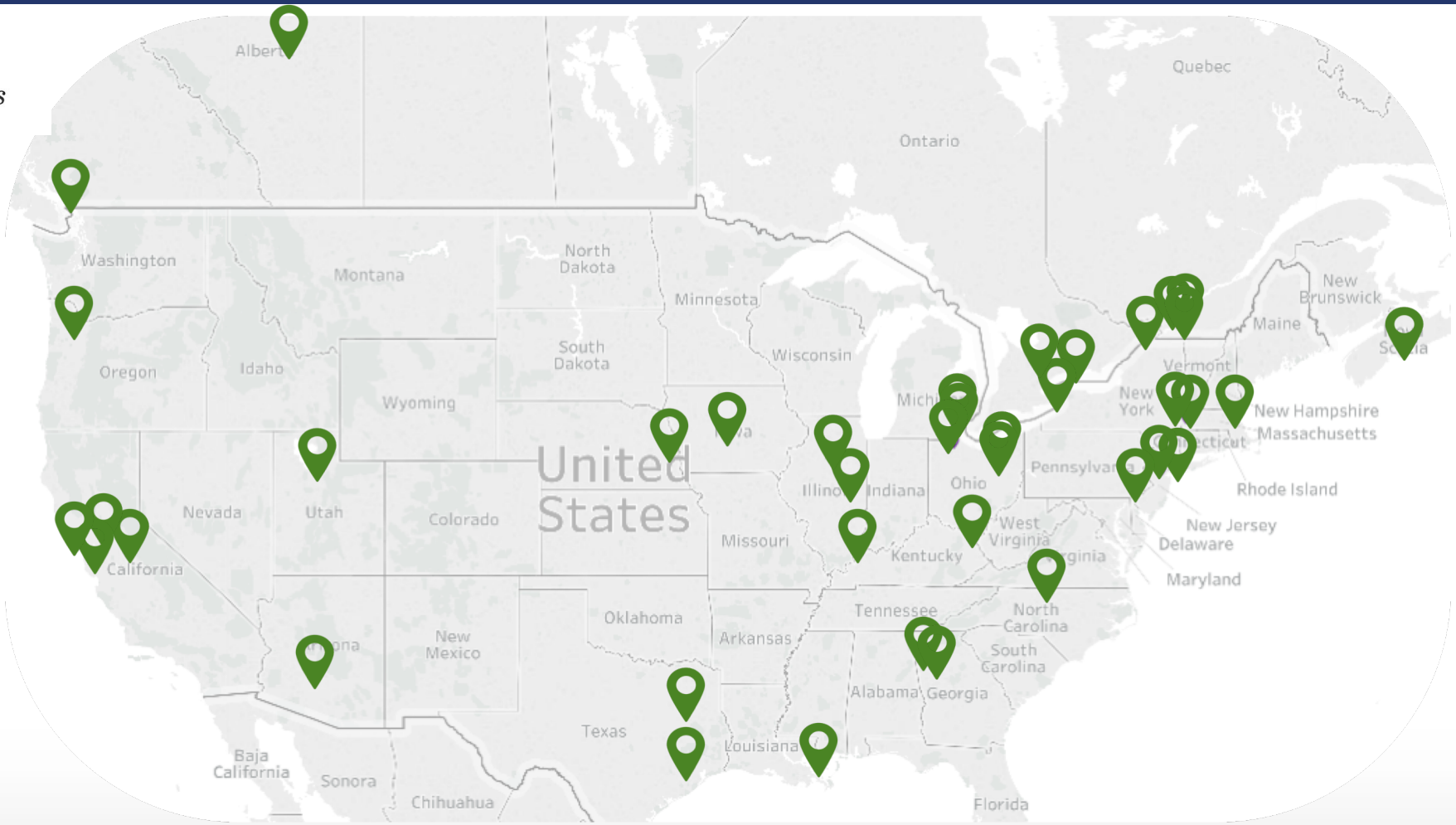
Source: Closed Loop Partners (2018). *Accelerating Circular Supply Chains for Plastics.*

Products of Chemical Recycling



Source: Closed Loop Partners (2018). *Accelerating Circular Supply Chains for Plastics.*

40 Facilities Already in Operation



Source: Closed Loop Partners (2018). *Accelerating Circular Supply Chains for Plastics.*

DEFINING STAGES OF MATURITY

Concept
Public announcement made about intended research

Karlsruhe Institute of Technology
TRASH2CASH
University of Massachusetts-Lowell

Lab
Technology is being researched and tested at a lab

AmberCycle (moral fiber)
Axens
Biocellection
Illinois Sustainable Technology Center
The Pennsylvania State University
Tyton Biosciences
University of Portsmouth
University of Ulsan

Pilot
A small pilot demonstrates the technology

CarBios
Climax Global Energy
Garbo
Geep
Gr3n
Jeplan
Next Generation
Polycycl
Polystyvert
Reclaimed EcoEnergy
Resinate Materials Group
Resynergi
Worn Again Technologies

Early Commercial
Technology is upscaled to an industrial scale

Agilyx
APK
Brightmark Energy
Cadel Deinking
CreaCycle GmbH
EcoFuel Technologies
Ecopek
Enerkem
Enval
Equipolymers
Fulcrum Bioenergy
Galactic
Geo-Tech Polymers
Golden Renewable Energy GreenMantra Technologies
Ioniqa
JBI Plastic2Oil
Jeplan
Loop Industries
Natureworks
New Hope Energy
Nexus Fuels
PureCycle Technologies
Pyrowave
Recycling Technologies
ReNew ELP
Renewlogy
Sierra Energy
Vadxx

Growth
Technology is being implemented in various parts of the world

Agile Process Chemicals LLP
Anhui Oursun Environmental Technologies
Aquafil
Blest
Klean Industries
perPETual
Plastic Energy
SABIC Innovative Plastics

Undefined

BASF ChemCycling
Battery Resourcers
Biopasatech
BioXycle
ByFusion
Cogent Energy Systems
Connora Technologies
Cynar Recycling
Envion
Esun
Evrnu
FWD Energy
Generated Materials Recovery
Genomatica
Green EnviroTech Holdings
IBM VolCat
Jet Plastics
Kyoto Institute of Technology
MBA Polymers
Modular Genetics, Inc
Omnifusion
Opus12
Origin Materials
P4SB
Quality Circular Polymers
Re:NewCell
Recenso GmbH
Rensselaer Polytechnic Institute
RESYNTEX
saperatec
Sep-All
Sustane Technologies, Inc
Teijin
The Ininited Fiber Company
Total Corbion
Valoren
VinyLoop

Source: Closed Loop Partners (2019). *Accelerating Circular Supply Chains for Plastics.*

More Engagement Needed

250 partners and investors are already engaged with technology providers

- Brands
- Private Capital Providers
- Petro-chemical & Plastics Industry
- Gov't & NGOs

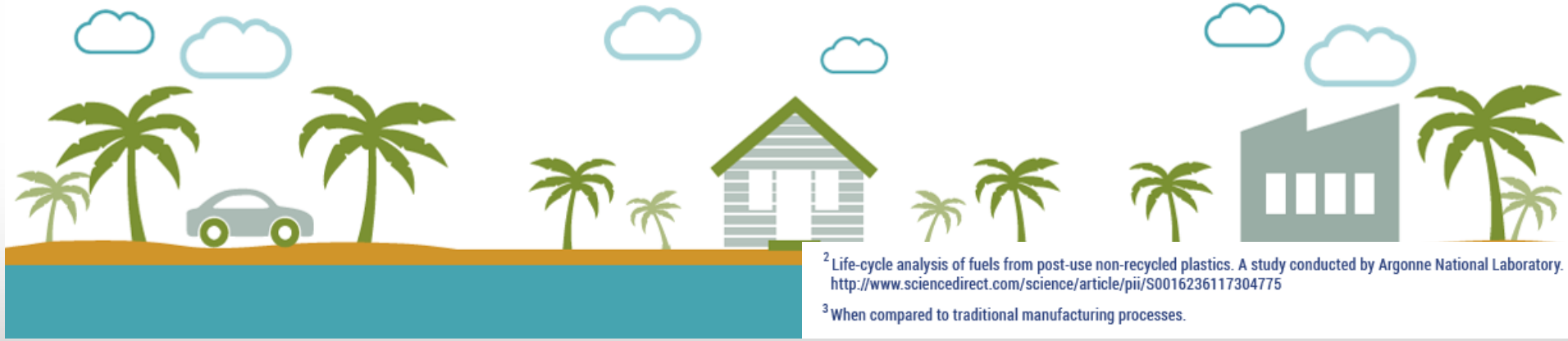
CLOSED LOOP partners

The Environmental Benefits Are Significant

By converting post-use plastics into ultra-low-sulfur diesel, we reduce:[2,3]

WATER CONSUMPTION
-58%

TRADITIONAL ENERGY USE
-96%



[2] Life-cycle analysis of fuels from post-use non-recycled plastics. A study conducted by Argonne National Laboratory. http://www.sciencedirect.com/science/article/pii/S0016236117304775

[3] When compared to traditional manufacturing processes.

Debunking Emissions Myths

How chemical recycling prevents dioxin formation

- Material is heated in a closed, oxygen-deprived environment
  - i.e. Not combustion
- No atmospheric oxygen or halogens
- Products spend virtually no time at the dioxin formation temperature

Economic Benefits

- $120B addressable market in North America
  - Technology owners can profitably transform post-use plastics

CLOSED LOOP partners

- Moderately developed markets in the U.S.
  - Alabama, Florida, Georgia, Louisiana, Texas
    => high-potential market for pyrolysis

BCG BOSTON CONSULTING GROUP

Recent Announcements (N.A.)

Agilyx, Delta Refinery Subsidiary Sign Deal to Convert Waste Plastics into Jet Fuel

Brightmark Energy Closes $260M in Financing for Plastics-to-fuel Plant

Regenyx Process Recycles 'Throw Away' Polystyrene

BP deal will help RES Polyflow open first commercial plastics-to-fuel plant

Renewlogy Converting Landfill-Bound Plastics to Fuel

ReVital Polymers, Pyrowave and INEOS Styrolution partner to launch polystyrene recycling consortium

GreenMantra and INEOS collaborate on chemical recycling

Eastman announces second chemical recycling technology

Recent Announcements (Global)

SABIC And Customers Launch Certified Circular Polymers From Mixed Plastic Waste

Polystyvert, Total partner to recycle post-consumer polystyrene

Shell to Invest in Rotterdam Green Methanol Plant

BASF hits milestone with 'chemically-recycled' prototypes

Plastics company LyondellBasell has announced plans to drive chemical recycling of plastic materials forward.

Unilever Joins Partnership to Turn PET Waste into Virgin Grade Materia

Tupperware to debut products made from Sabic's certified circular polymers

Dow, Fuenix Ecogy Group partner on plastics recycling project

The Chemical Recycling Alliance

Advocating on behalf of technologies that leverage chemistry to convert post-use plastics into new plastics, chemicals, fuels and other products.

Chemical Recycling Alliance

SUSTAINABLE SOLUTIONS FOR PLASTICS

agilyx

3ME BRIGHTMARK ENERGY

Golden Renewable Energy

GREENMANTRA TECHNOLOGIES

NEW HOPE ENERGY

RENEWLOGY

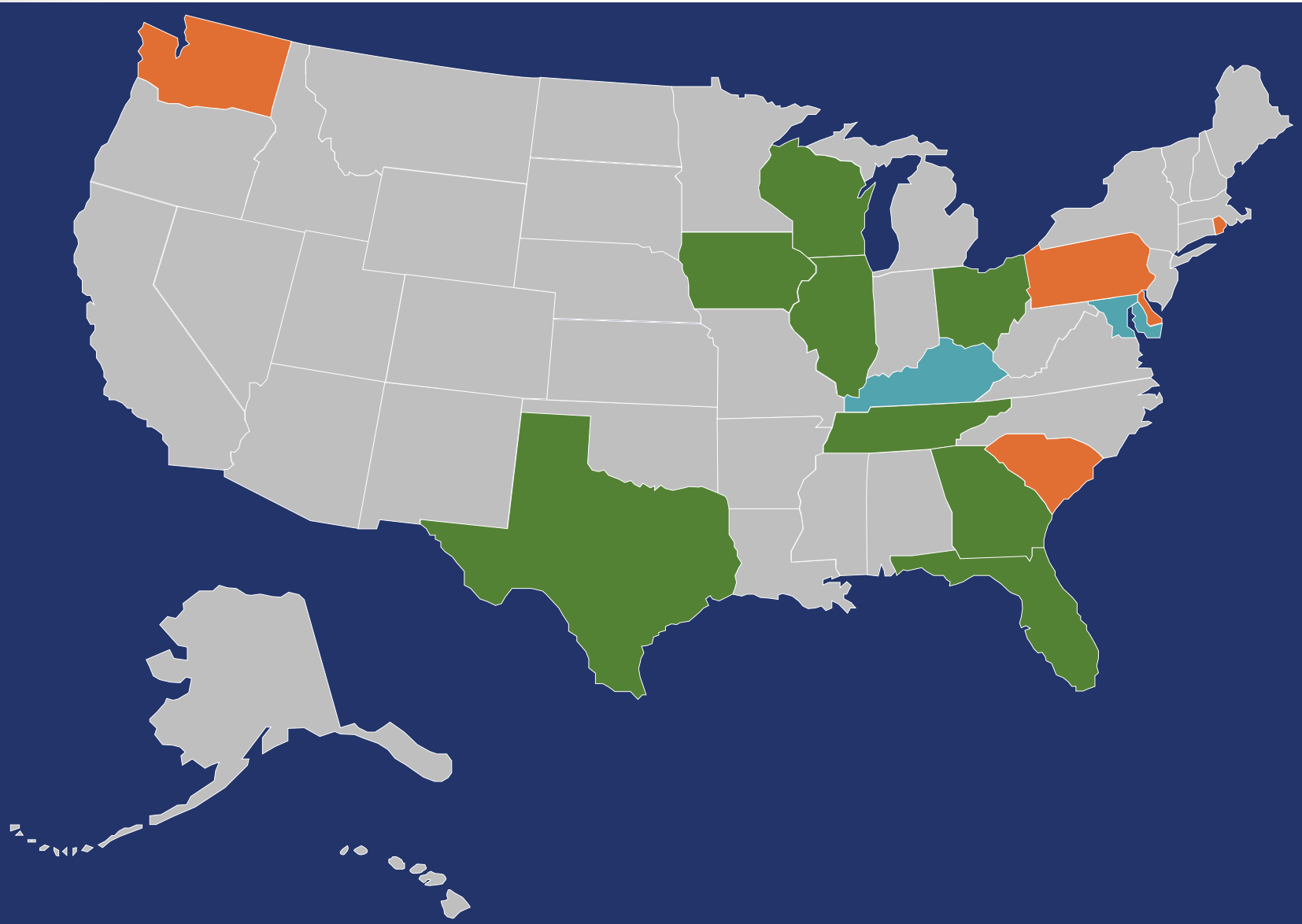
AmSty

Sealed Air

Ravago

TETRA TECH

Removing Barriers to Chemical Recycling



Legislation enacted (8)

Legislative activity (4)

Regulation in progress (2)

Legislative Momentum

HOUSTON CHRONICLE

Texas part of national push for laws promoting fledgling chemical recycling industry

Plastics News

ACC pushes chemical recycling legislation

PLASTICS RECYCLING UPDATE

A Resource Recycling, Inc. publication

State lawmakers give chemical recycling a boost

Stay Connected

@ChemRecycling

Chemical Recycling Alliance

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