

# Defining recycling in the context of plastics

THROUGH THE LOOKING GLASS  
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STANDARDS RESEARCH

## Defining Recycling in the Context of Plastics

A Principled and Practical Approach

August 2021

# Why define recycling?

- Clearly defining recycling is critical to enabling the effective implementation of recycling targets under EPR in Canada.
  - A clear definition is of importance to both public policy makers that are seeking to achieve specific environmental outcomes and to the regulated community that must deliver them.
  - A clear definition of recycling is also of importance to the plastics recycling sector as it will determine what choices producers make in packaging design and manufacture, supply chain design and infrastructure investments toward driving a circular economy for plastics in Canada.

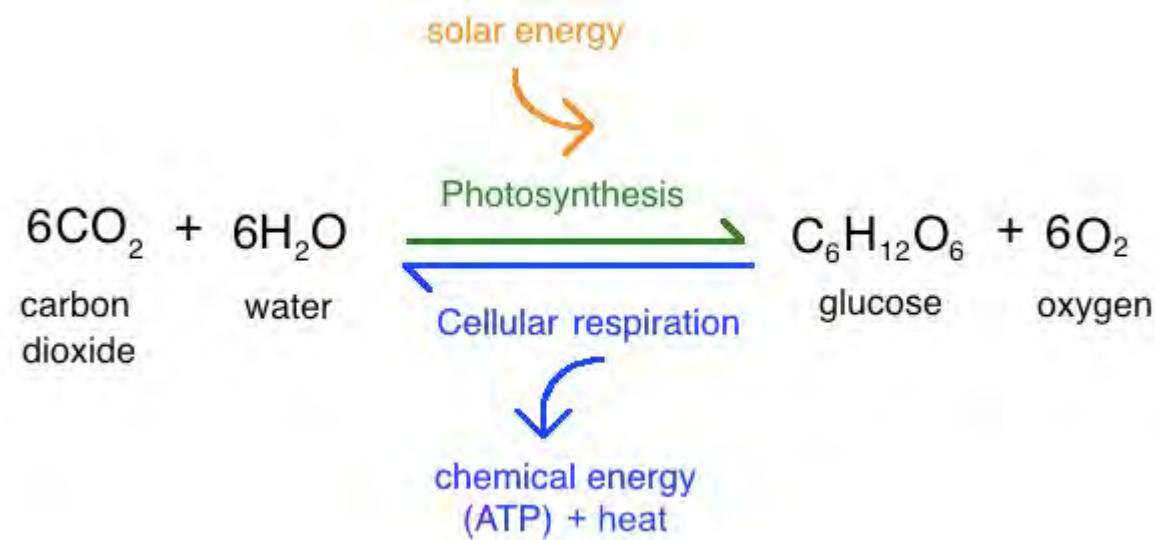
# Methodology

- Scan of the scientific and technical literature to summarize the physical and chemical processes to make and recycle plastics
- Scan conceptions of recycling
  - Sustainable Materials Management
  - McDonough- Braungart Cradle to Cradle
  - Circular Economy principles
- Review of existing definitions of recycling and a jurisdictional scan of various definitions of recycling adopted by the European Union, 10 US States and all Canadian provinces
- A questionnaire-based survey of the plastic packaging production, use and recycling value chain to understand its views on the definition of recycling

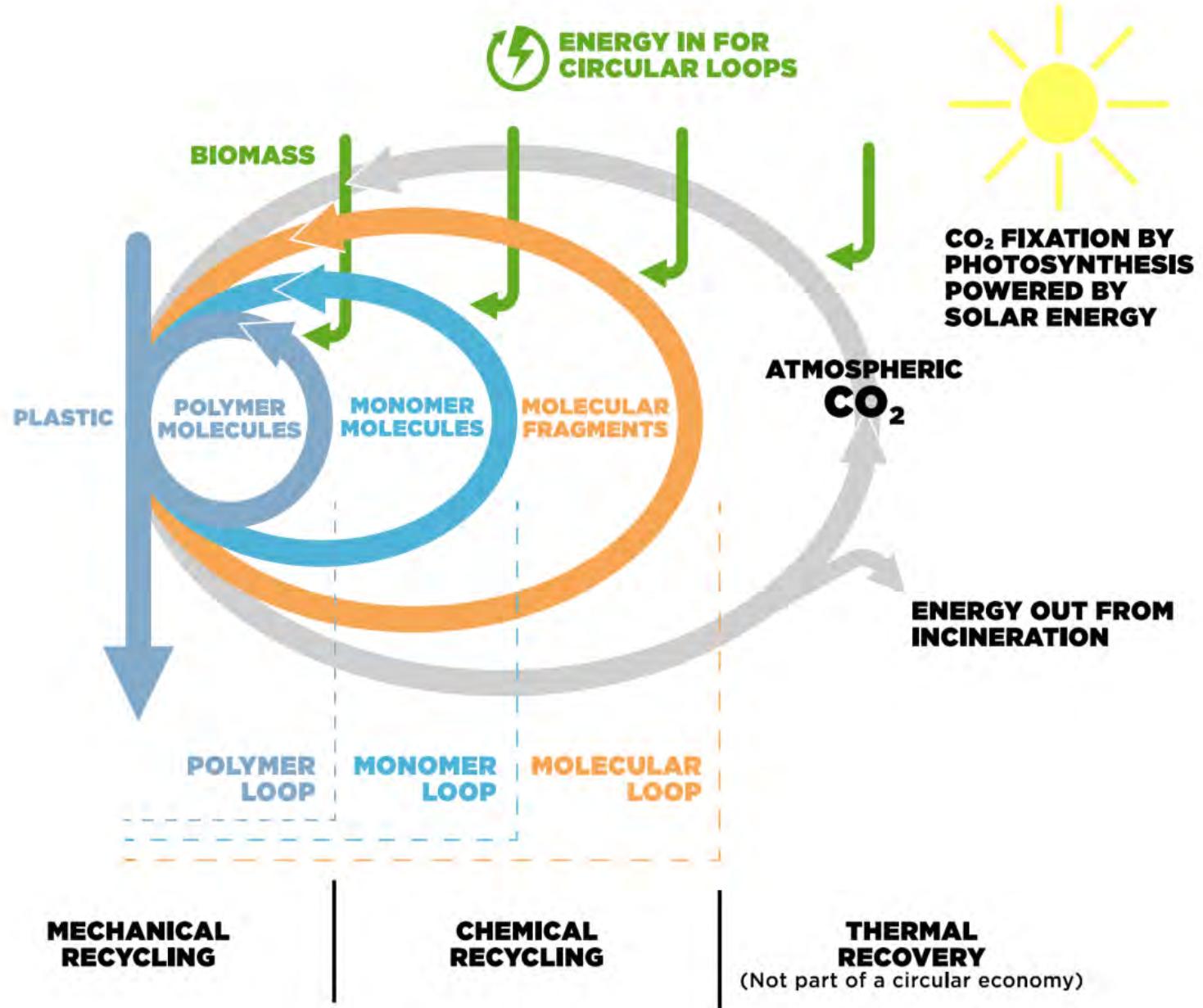
# Why reuse and recycle?

- Fossil-based plastics – PE, PP, PS etc. – highly ordered molecules not found in nature
  - Energy to reform base hydrocarbons found in oil and natural gas as well as other elements into monomers (single unit molecular building blocks) and polymers (chain-like structures made of monomers)
- To reclaim the fossil resources in plastics (as reusable components or packages, polymers, monomers or constituent chemical building blocks) in order to displace the use of fossil resources and avoid waste (e.g. GHG, other air pollutants, effluents etc.) associated with its production
- Various recycling methods and technologies are not the same:
  - In terms of what they produce (i.e. polymer, monomer or constituent chemical building blocks);
  - How effective they are (how much of what is processed is returned as recycled material);
  - How much energy they use

# Recycling and nature



**From a thermodynamic perspective recycling is the reconstitution of materials into a more ordered state (negentropy) using inputs of energy derived from sunlight**

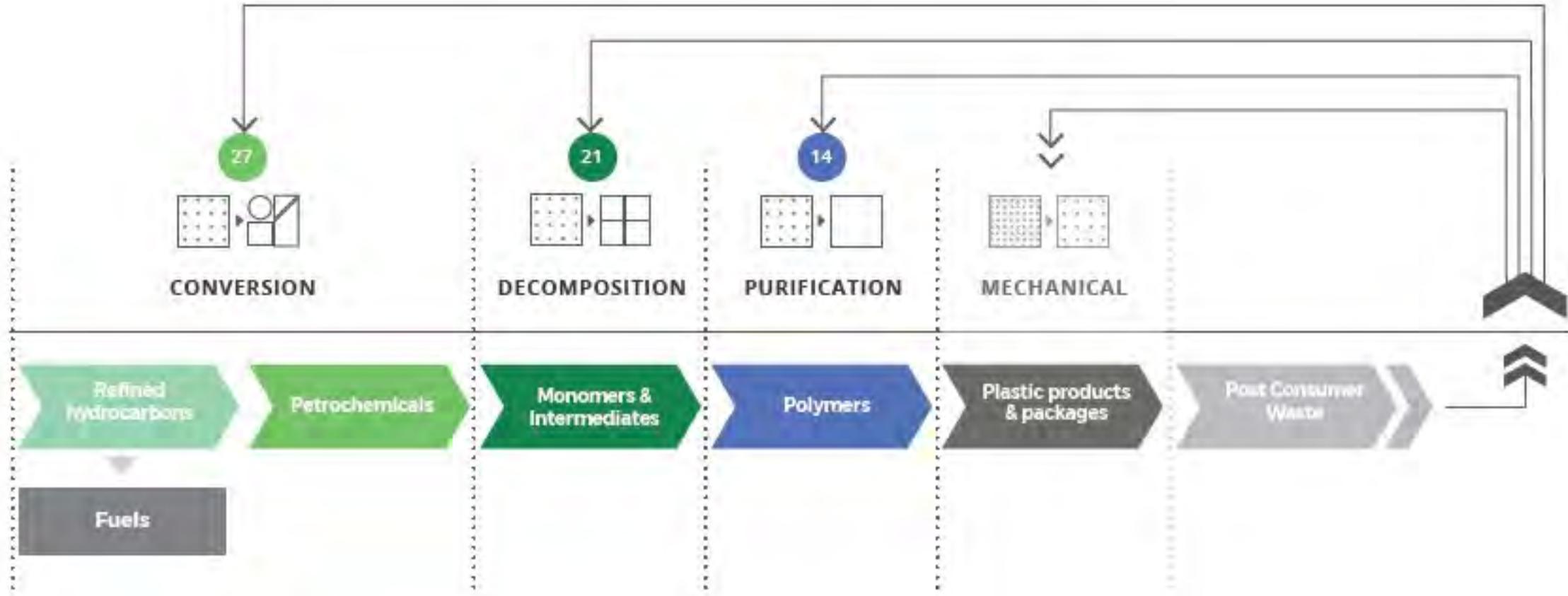


Source: Ellen MacArthur Foundation

- Washed and refilled: no need to reconstitute the plastic in the bottle mechanically or chemically; or,
- Recycled
  - Mechanically to recirculate the plastic itself as feedstock
  - Chemically to recycle the constituent molecules in the plastic (polymers, monomers or constituent chemical building blocks such as hydrogen and carbon monoxide reformed to chemical carriers)
- More effort (energy) is required to return plastics to market as the complexity increases in terms of the admixture of resins in closures, labels and the bottle body increases
  - Further exacerbated by the complexity of other plastic packaging and products that may be processed in the same recycling stream as the bottle - more energy to overcome entropy of waste



# Plastics recycling pathways



Source: Closed Loop Partners

# Characterizing “recycling”

- **Closed-loop recycling:** Where plastic, polymer, monomer or chemical building blocks are reutilized for the original purpose they were created (LDPE plastic bag to LDPE container to LDPE tub etc.)
- **Open-loop recycling:** Where plastic, polymer, monomer or chemical building blocks are reutilized for a purpose for other than what they were created with the potential that they may not be subsequently reintroduced into the system for recycling them (LDPE to park bench)
  - Can the bench be recycled to recirculate plastic, polymer, monomer or chemical building blocks? If not...
- **Down-cycling:** open-loop recycling of a material such that it is practically unrecoverable for the original purpose it was created
  - Puts plastic into a high entropy (more disordered) state that is difficult to recover
  - Primarily a problem where the plastic is made with fossil resources
- **Upcycling:** Pulling materials that are locked in down-cycled applications back into closed-loop systems
  - Gasify the park bench to recover plastic chemical building blocks
  - Requires inputs of energy to overcome entropy to recover chemical constituents

# Synthesizing a definition of recycling

- From a conceptualization to working definition of recycling
  - Synthesize the literature and regulatory best practices to offer a working definition
  - Test against criteria
  - Identify practical issues arising from the application of the proposed definition in regulation
  - Anticipate how the recycling definition may play out in the market

## **Organic recycling**

### **Bio-based**

Biological nutrients

Polymer, monomer or constituent chemical building blocks to displace primary or raw materials in the production of plastics

Not recycling (fossil plastics converted into a net loading of greenhouse gases to the environment)

Polymer, monomer or constituent chemical building blocks to displace primary or raw materials in the production of plastics

### **Mechanical and chemical recycling**

### **Fossil-based**

# Future work to develop a standard

- A recycling standard built upon the proposed definition will require the following elements:
  - Rules for reporting the amount of plastic supplied into the market,
  - Rules establishing a measurement point where plastics are deemed recycled,
  - Rules for calculating the recycling rate,
  - Rules for performing mass balance calculations in chemical recycling pathways where recycled chemicals carriers are produced and blended into virgin production supply-chains.
    - Such rules are not only critical for verifying the recycling of plastics but also for establishing plastics recycled content claims by producers of resins and plastic products.