KAPSARC

مركز الملك عبدالله للدراسات والبحوث البترولية

King Abdullah Petroleum Studies and Research Center

Hydrogen in the circular carbon economy

Linear economy

Linear economy: once-through system with “limitless” resources and “limitless” capacity to absorb waste

But resources are finite and so is the Earth’s capacity to take on waste

Linear economy has resulted in environmental problems like climate change, poor air and water quality, hazardous waste, and plastics contamination

Finding a solution to environmental problems within the linear model means making do with less and a declining quality of life for everyone, especially the world’s poor

Toward a circular economy

Circular economy recognizes that resources are finite, and so is the Earth's capacity to take on waste

Circular economy aims to 1) **reduce** resource use intelligently by providing the same goods and services with fewer resources, 2) **reuse** as much as possible, and 3) **recycle** the component materials of what cannot be reused

Through the circularity of reducing, reusing and recycling, economic activity and quality of life can be sustained while keeping raw resource use and waste to a minimum

Circular carbon economy

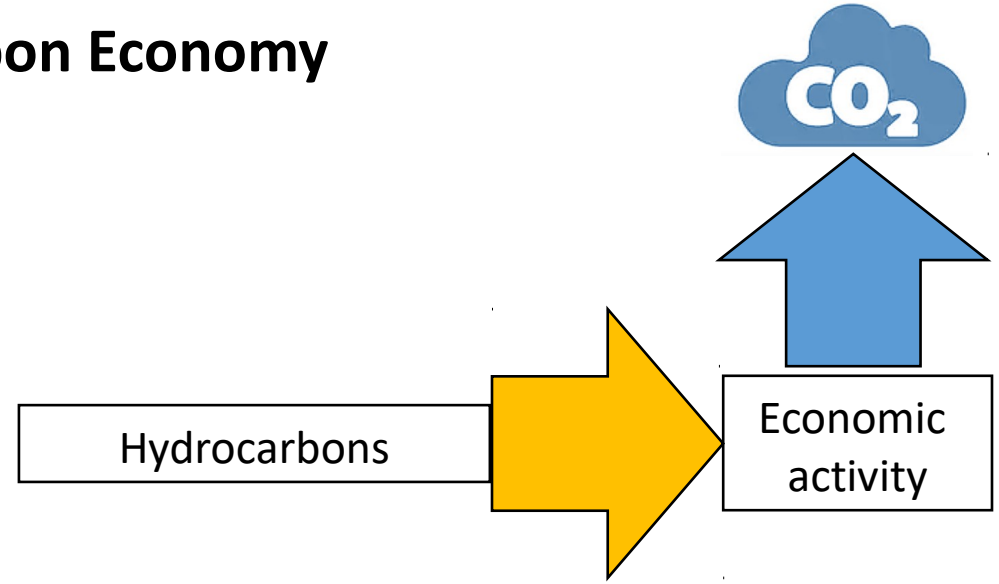
Circular economy focuses on material flows rather than energy and emissions

Circular carbon economy (CCE) builds on the principles of the circular economy but the priority is managing **energy and climate flows** to reach a carbon balance or net zero in order to achieve the climate goals of the Paris Agreement

In addition to **reduce**, **reuse** and **recycle** of circular economy, CCE adds **remove**

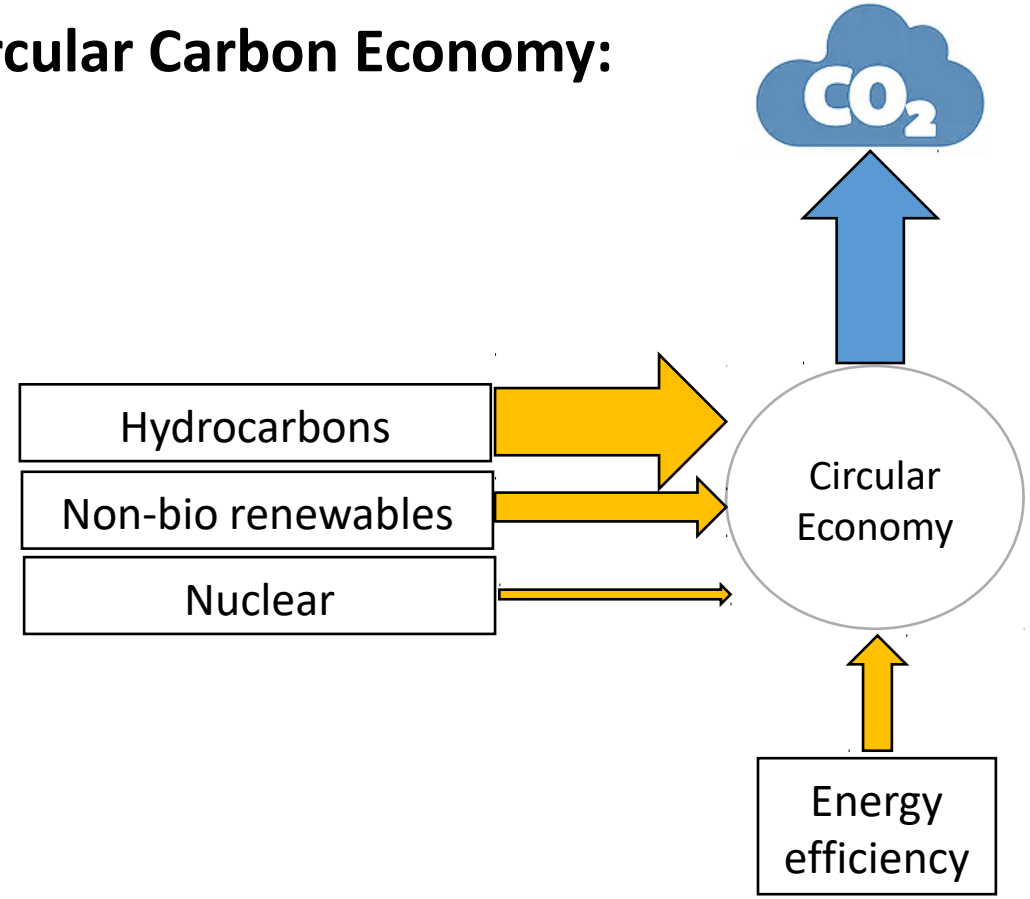
CCE 4Rs are not hierarchical but instead guide how elements of the energy and carbon management system are interrelated -- more from one R means less is needed from another

Linear Carbon Economy

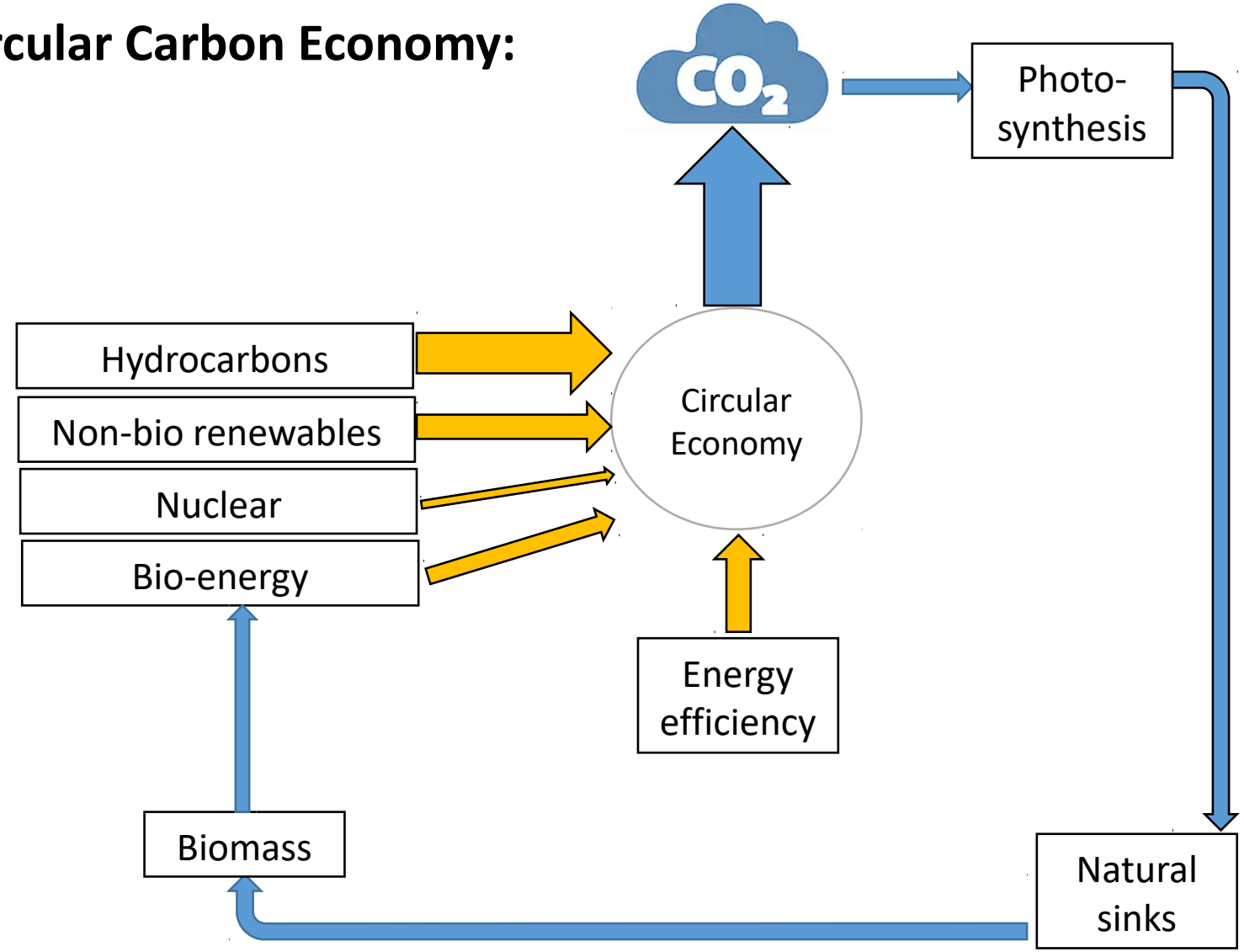


Toward Circular Carbon Economy:

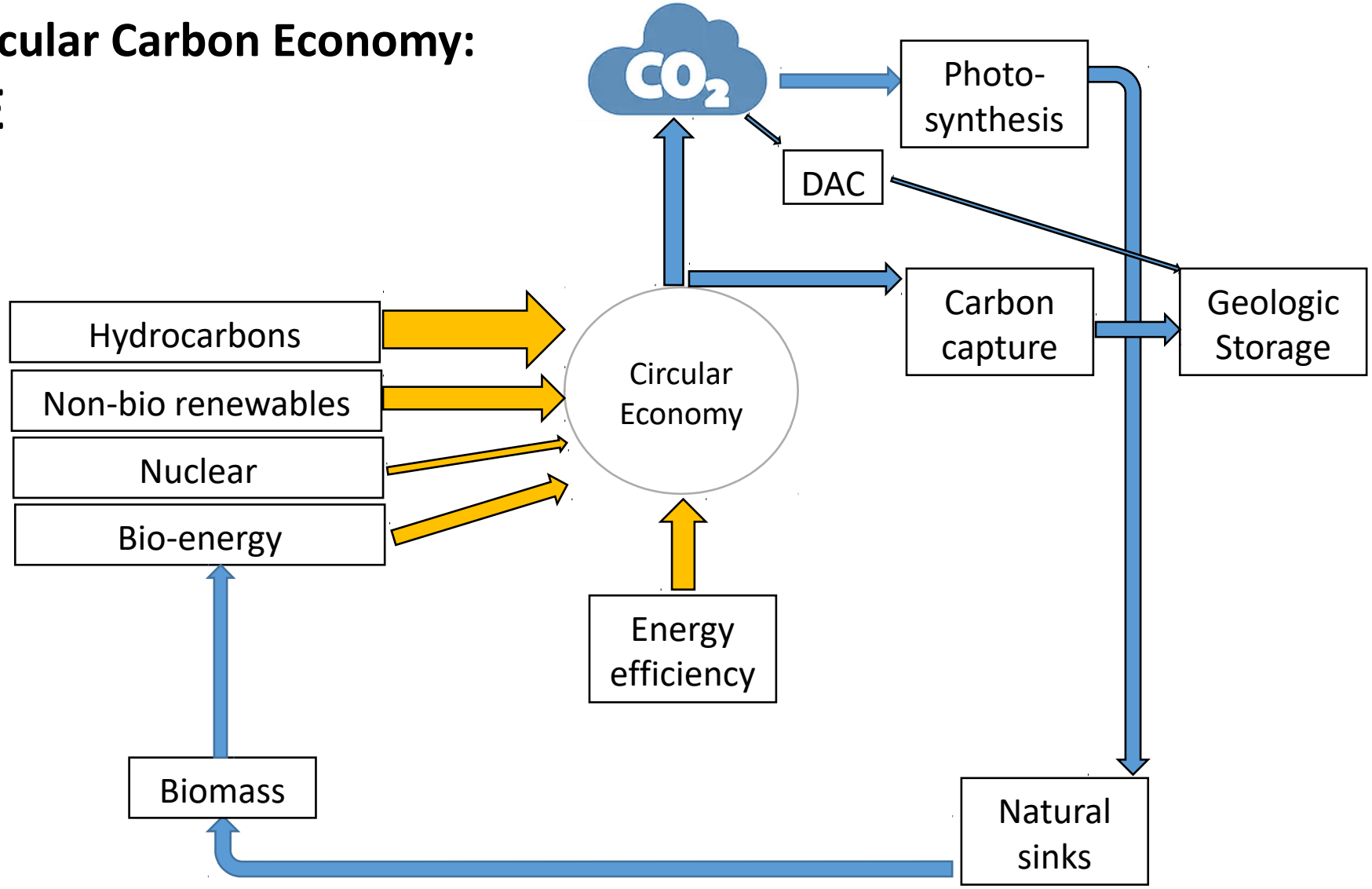
REDUCE



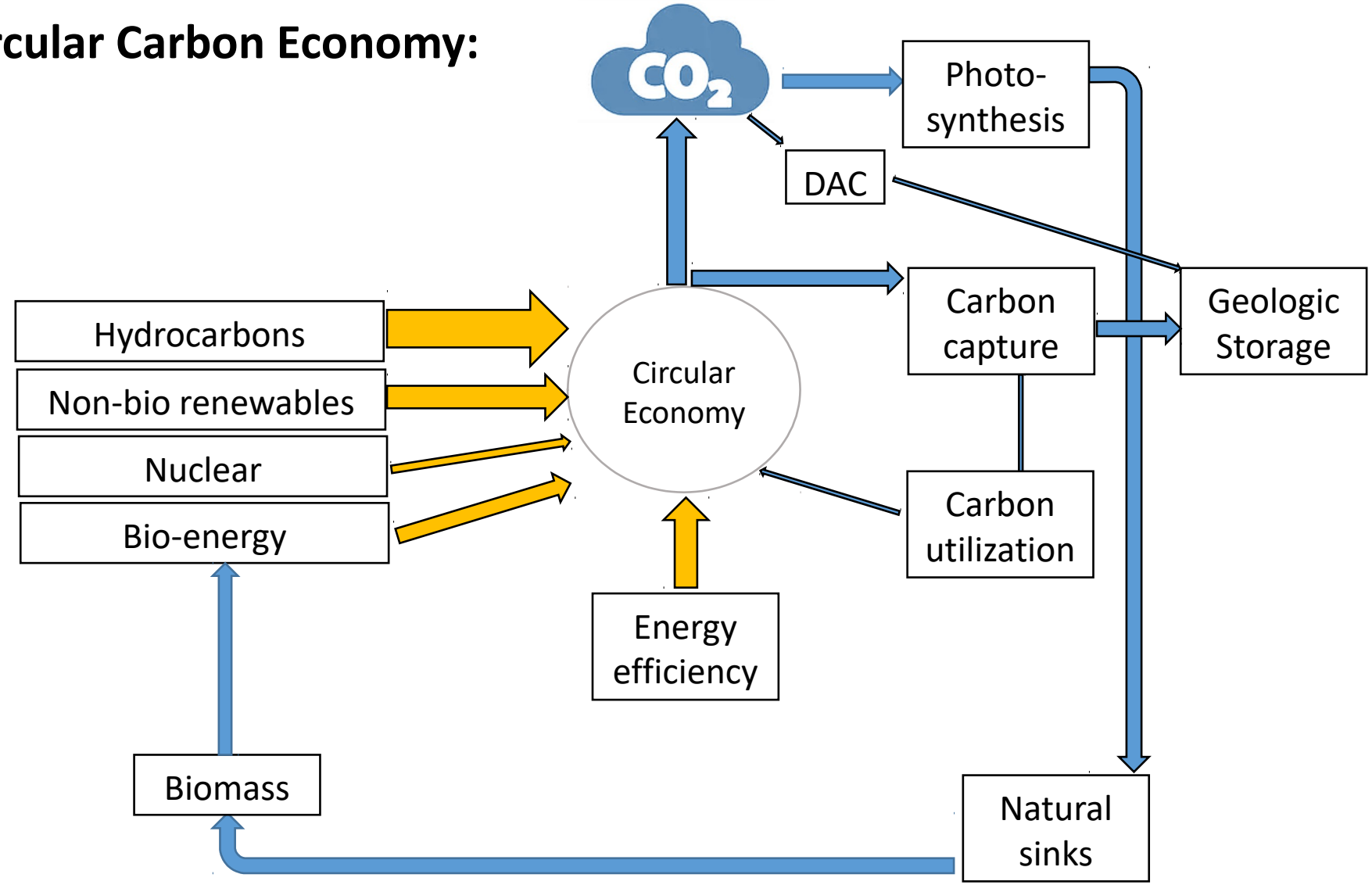
Toward Circular Carbon Economy:
RECYCLE



Toward Circular Carbon Economy:
REMOVE



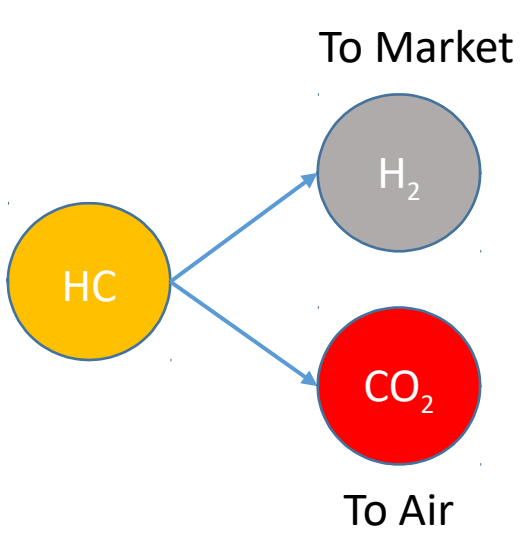
Toward Circular Carbon Economy:
REUSE



Hydrogen production is versatile

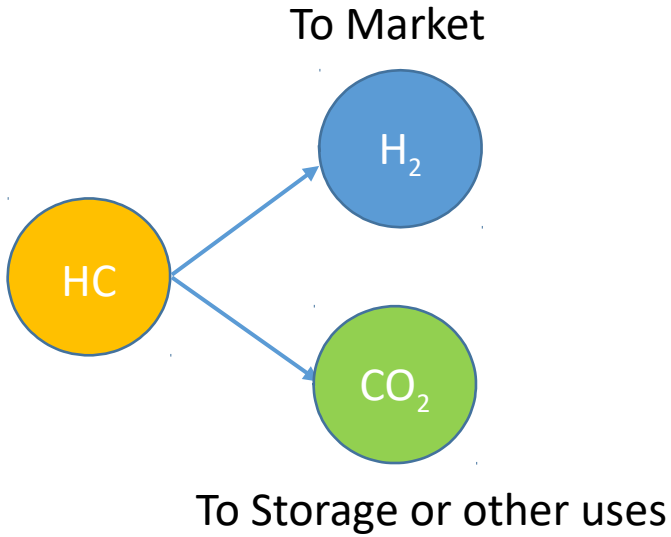
Gray/Brown

Gray hydrogen is produced from natural gas via steam reforming that emits CO_2 to atmosphere; Brown hydrogen is derived from coal through gasification, also without capturing the CO_2



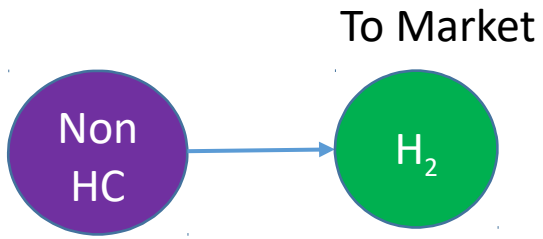
Blue

Blue hydrogen is produced from natural gas or coal, but uses CCUS to reduce the CO_2 emissions

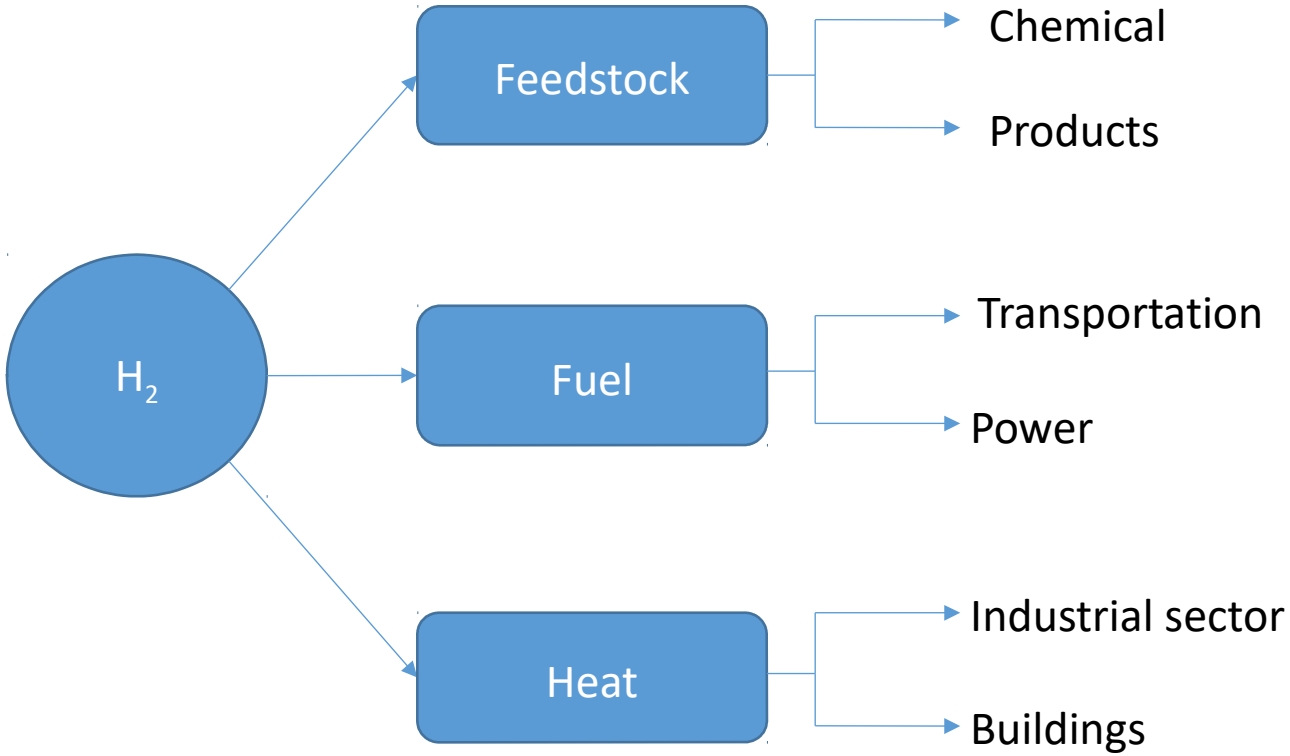


Green

Green hydrogen is produced from non-carbon sources entirely. This is primarily associated with electrolysis, but can include other methods such as biological processes

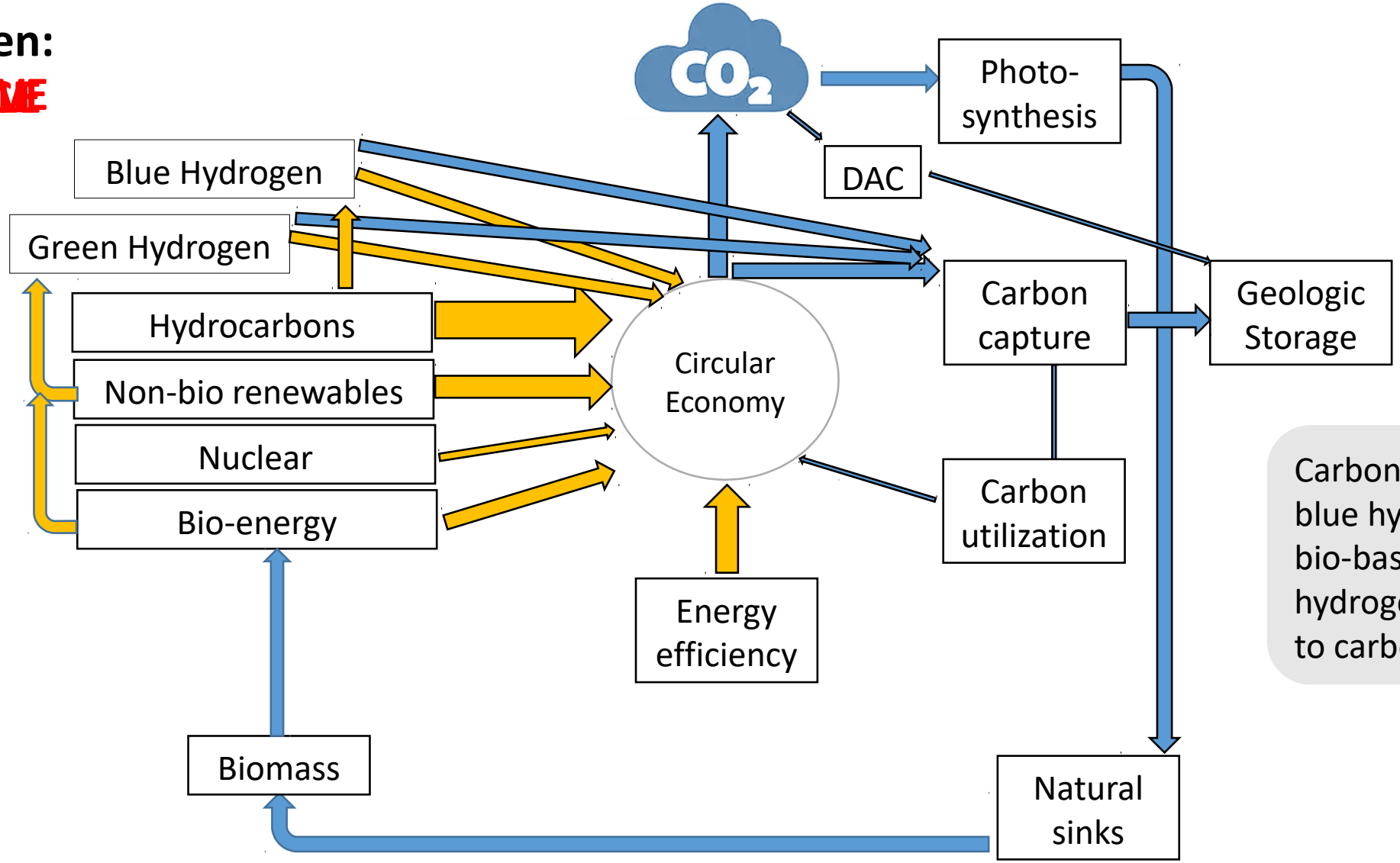


Hydrogen applications are also versatile



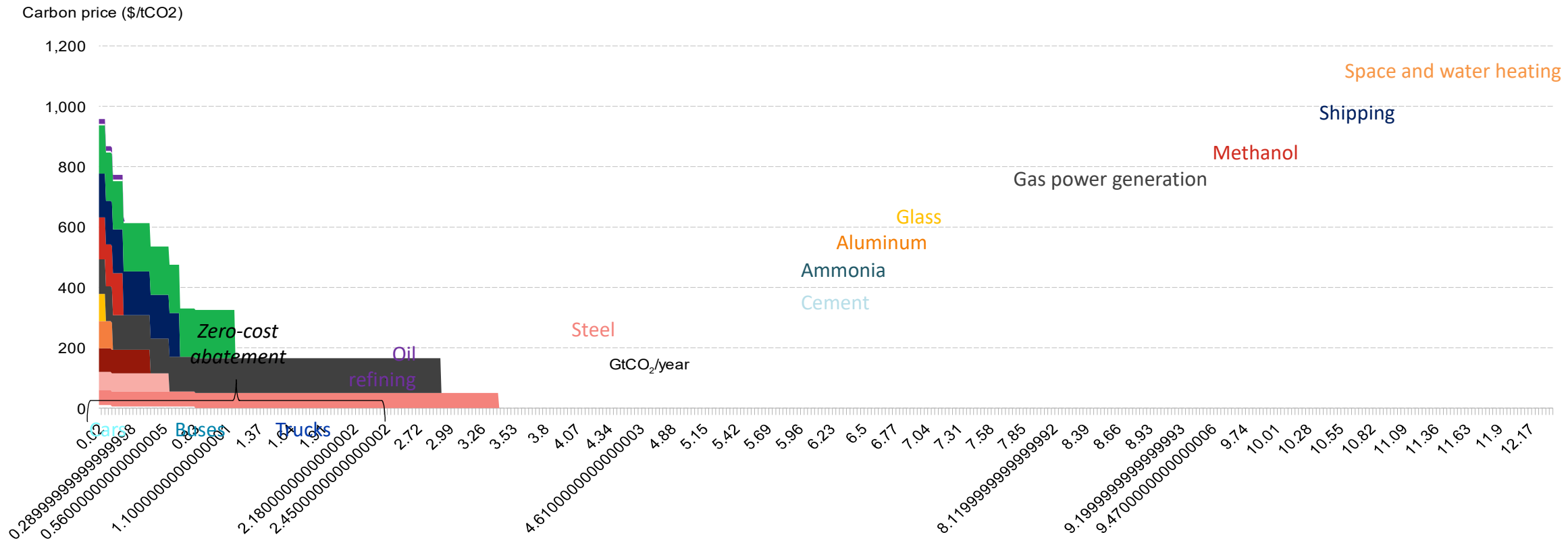
Hydrogen:

REDUCE



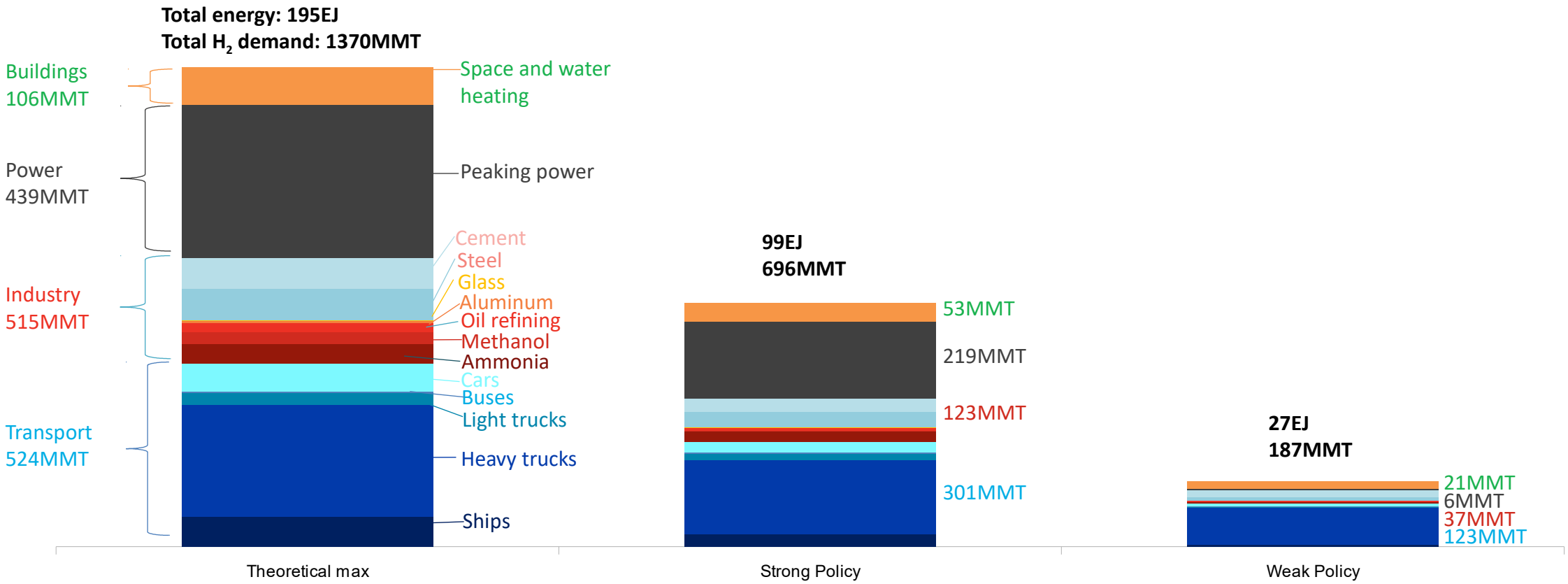
Carbon captured from blue hydrogen and bio-based green hydrogen can also go to carbon utilization

Marginal abatement cost curve from using $1/kg hydrogen for emission reductions, by sector in 2050



Source: BloombergNEF.

How much hydrogen is deployed in 2050 depends on policy



Source: BloombergNEF. Note: Aluminum demand is for alumina production and aluminum recycling only. Cement demand is for process heat only. Oil refining demand is for hydrogen use only. Road transport and heating demand that is unlikely to be met by electrification only: assumed to be 50% of space and water heating, 25% of light-duty vehicles, 50% of medium-duty trucks, 30% of buses and 75% of heavy-duty trucks.

Conclusion

Hydrogen is ideally suited to the circular carbon economy and spans all 4Rs

Hydrogen is very attractive given its diverse applications and its potential to abate carbon emissions

It can be produced via hydrocarbons or renewables, allowing hydrogen production to be tailored to local resources and needs

But a widescale deployment of hydrogen needs policy intervention; the business case for hydrogen is limited without a value associated with carbon

Thank you!