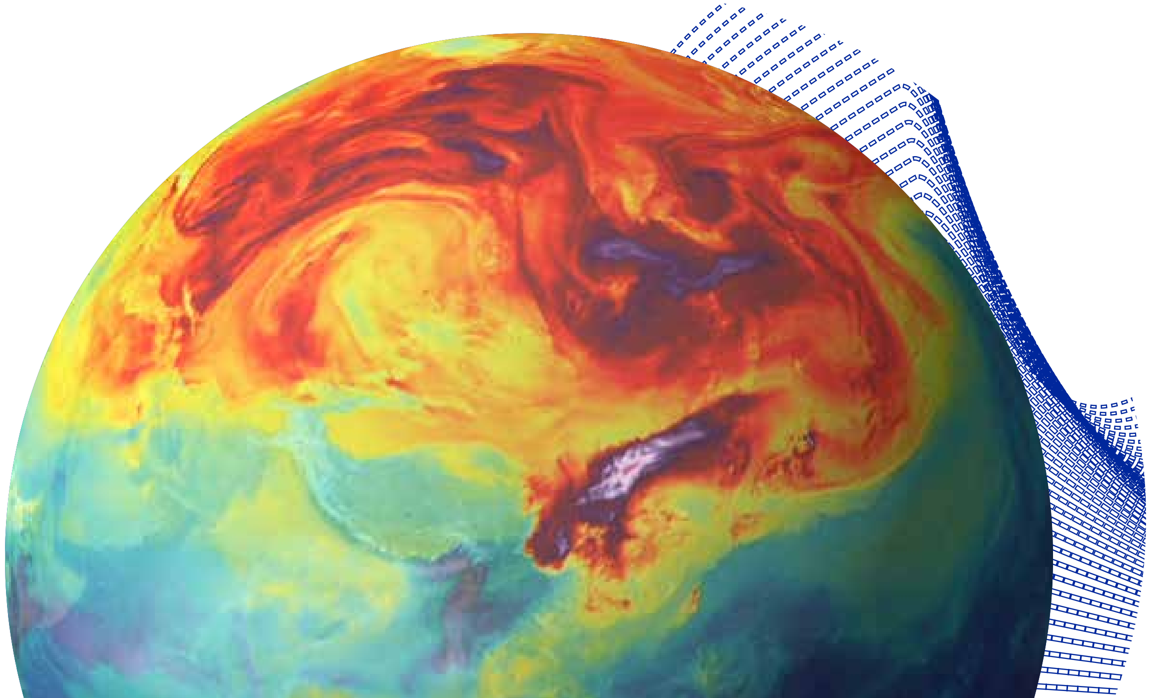
PALL CORPORATION

The path to green energy

The energy transition challenge

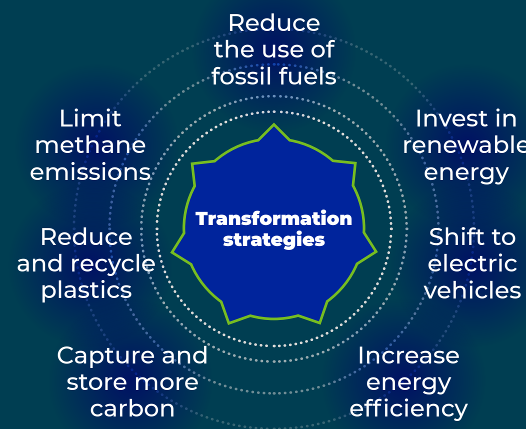
Our world is heating up at a rate that is not sustainable. We are already at 1.2°C/2.2°F above pre-industrial levels and moving closer to the 1.5°C/2.7°F threshold that scientists warn we must not surpass. The slightest rise in temperature can have a drastic impact on the planet and if the earth becomes just 2°C/3.6°F hotter, an increase of just half a degree Celsius will severely damage lives, livelihoods and ecosystems.



The Road To Net Zero

The Paris Agreement and the Glasgow Climate Pact set out the global framework for countries to reduce greenhouse gas emissions and reach net zero by mid-century, pursuing a 50% reduction by 2030.

To achieve these goals, we need to decarbonize across every sector.



The race to stop climate change

How can society evolve to move away from fossil fuels and embrace a greener future? We need a complete change in the way we think, plan and act.

Solving the unsolvable

Progress comes from a willingness to push the boundaries of what is possible, and Pall has been part of many pivotal breakthroughs from space travel to the electric car revolution. As challenges become more complex technology must be utilized to advance production, connect industries and future-proof supply chains so our planet can thrive.

Creating a sustainable future

The race to stop climate change is a global challenge that impacts everyone and it's something organizations around the world are taking very seriously. Industries should be empowered to leverage innovations that will help the transition to green energy, and investments from governments and businesses must be made to make this possible.

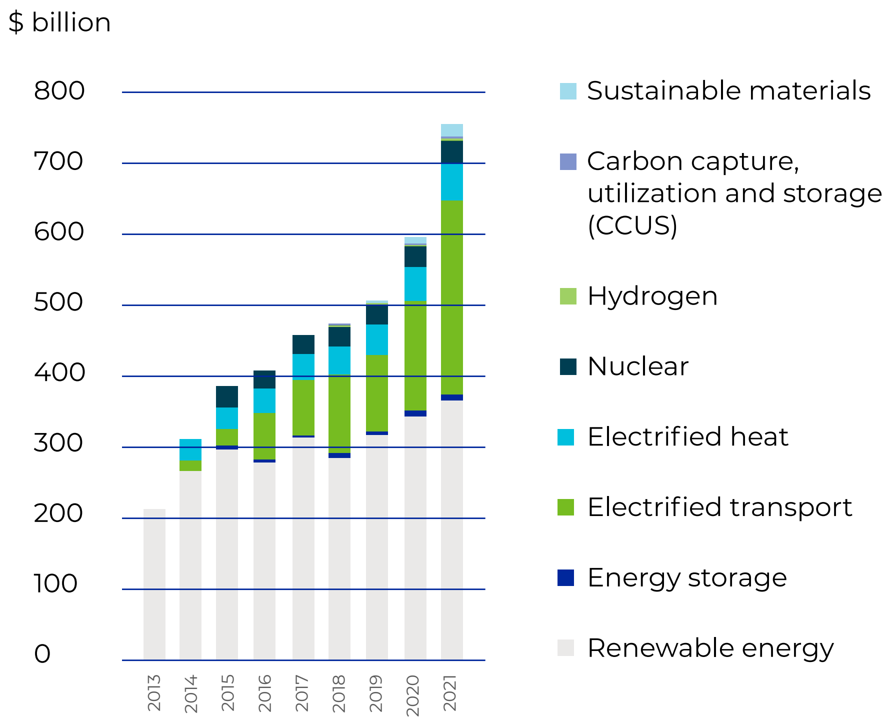
More action has to be taken so that alternative fuels, lithium-ion batteries and sustainable practices can improve our environment.

Finance underpins progress

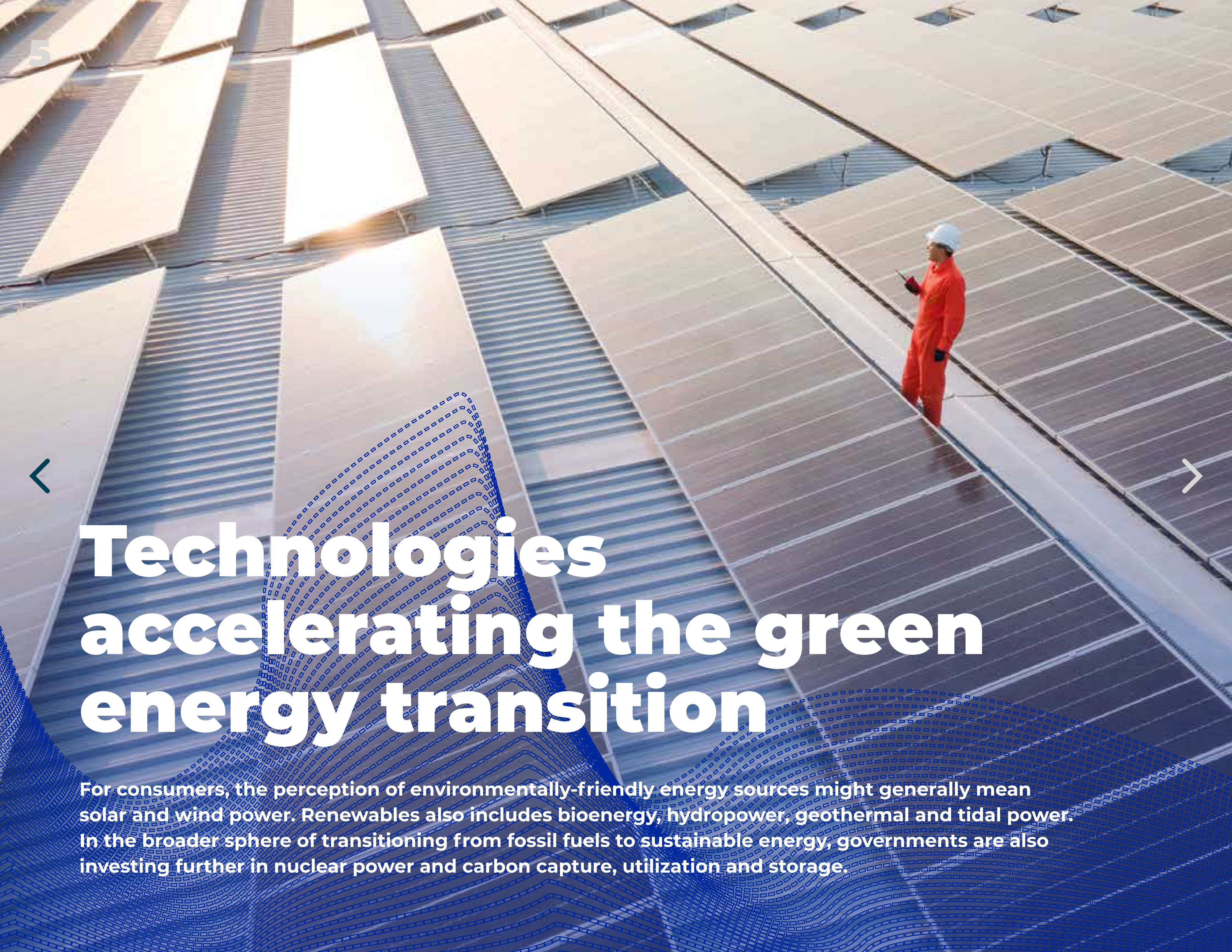
Increasing investment in energy transitions

Global investment in energy transition is increasing year-on-year. Over the past decade, electric transport has seen the greatest rise in financial backing, with upturns also in renewables, electrified heat, hydrogen production, energy storage and other sustainable practices.

Progress in technology and infrastructure are key, with analysts at BloombergNEF forecasting that investment levels need to triple to around $2.1 trillion per year between 2022-2025 and then to double again, to approximately $4.2 trillion between 2026 and 2030 if net zero goals for 2050 are to be achieved.



Source: BloombergNEF. Note: start-years differ by sector but all sectors are present from 2019 onwards.



Technologies accelerating the green energy transition

For consumers, the perception of environmentally-friendly energy sources might generally mean solar and wind power. Renewables also includes bioenergy, hydropower, geothermal and tidal power. In the broader sphere of transitioning from fossil fuels to sustainable energy, governments are also investing further in nuclear power and carbon capture, utilization and storage.

Realizing the potential of green hydrogen

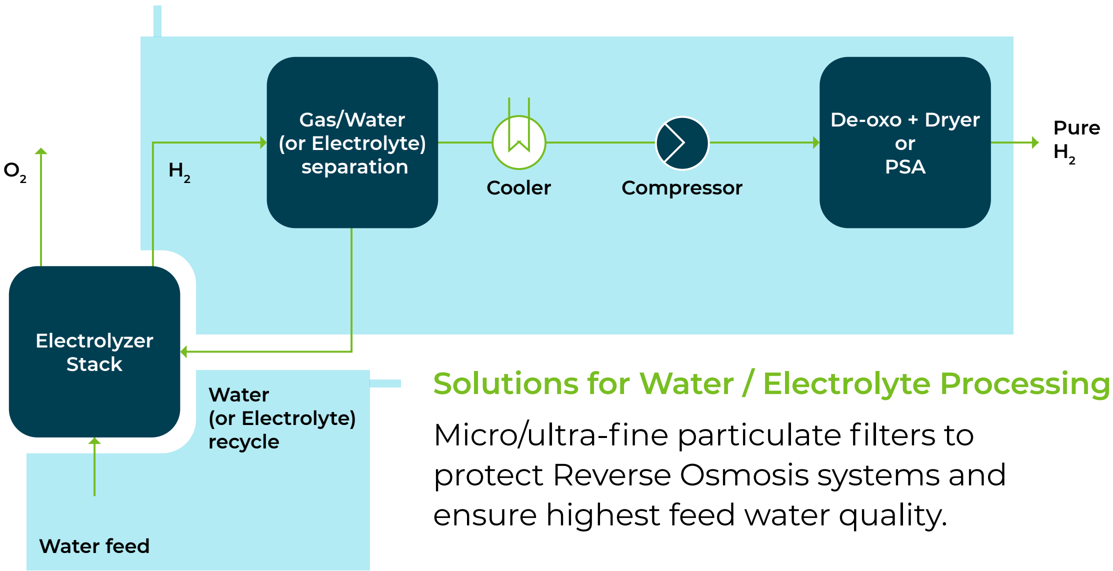
Hydrogen is a beacon of hope in the race to net zero, but the blue, gray and brown varieties are produced from fossil fuels and release emissions.

Green hydrogen, produced from the electrolysis of water, is generated by electricity from renewable sources. It is an energy intensive process but it does not emit CO_2 and is considered the 'cleanest' hydrogen option.

Targeting purity for green hydrogen

Solutions for Hydrogen Processing

High efficiency coalescers and fine particulate filters protect compressors and catalyst beds and ensure final product purity.



Solutions for Water / Electrolyte Processing

Micro/ultra-fine particulate filters to protect Reverse Osmosis systems and ensure highest feed water quality.

Overcoming technological hurdles

Electrolysis involves the dissociation of the water molecule in an electric field. Hydrogen is produced at the cathode and oxygen at the anode with an electrolyte present in between the electrodes. Hydrogen stream has to be processed to remove solid liquid and gaseous contaminants. Typically, concentrations of between 2,000-6,000 parts per million of oxygen and more than 2,000 ppm of water are seen in hydrogen using commercial alkaline electrolysis. Stringent regulations mean that the maximum concentration allowed for fuel cell vehicles is 5 ppm of each, so the gas has to be decontaminated.

The need for purification

Solid contaminants, originating from oxidation in process piping and equipment such as pumps and compressors, must be eliminated. If adsorbent fines are used in the final drying equipment, they may get released, contaminating the gas. To remove the solid contaminants, regenerable and disposable gas filters in different micron ratings are deployed throughout the process.

Learn more

The increasing demand for lithium-ion batteries

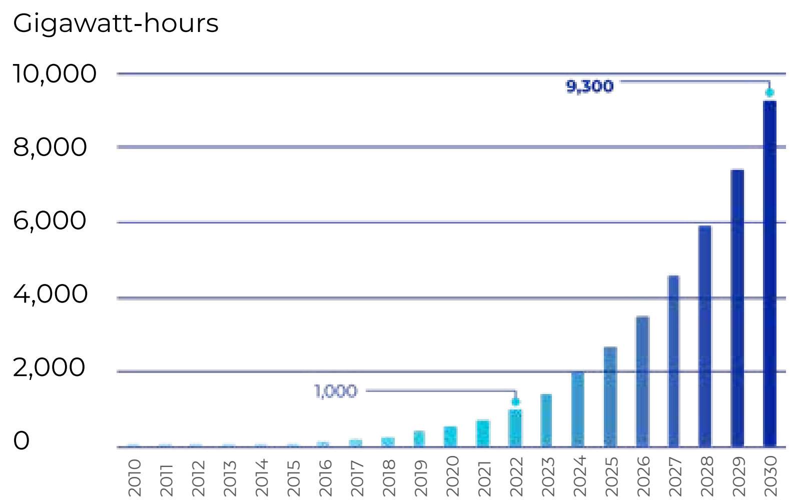
Electric vehicles are predicted to account for more than 40% of new car sales by 2040. But there remain some limiting factors to the EV revolution – the biggest of which is the performance of lithium-ion batteries. The materials used in battery manufacture directly affect the ultimate performance of the electric vehicle.

Cleanliness impacts performance

The three components of lithium-ion batteries that are most at risk of contamination during manufacture are separators, cathode active materials, and liquid electrolyte. The 'cleanliness' of each individual component – often at a microscopic level – has a significant impact on the final product.

As components get exponentially smaller and more sensitive to contamination robust quality control becomes increasingly difficult.

Demand for lithium-ion batteries is rising year-on-year



Source: Bloomberg

Accelerating the EV revolution with battery purity

Meeting standards

Advanced filtration solutions are required to meet the exacting standards of EV battery manufacturers.

During the separation manufacturing process each aspect, including process water, paraffin liquid, plasticizer, polymers and protection liquid, has different requirements. In cathode manufacture there are dozens of processing lines that need an array of cleanliness and quality controls, from oxygen and nitrogen to solvents and pure/mixed solutions. With liquid electrolyte, the high degree of acidity of the electrolyte, which requires EFTE-coated stainless-steel vessels, and the high cleanliness levels require very fine particulate removal ratings (from 0.45µm to 2µm).

Learn more

Powering the future with advanced biofuels

Biofuels are a growing part of the energy mix, with demand expected to increase 28% from 2021 to 2026. 'Advanced' biofuels are produced from wood chippings, non-edible plant material, residential waste such as cooking oil, industrial and commercial waste including beef tallow, and algae.

Their differing molecular composition leads to varying levels of solid particulates, water content, gels and waxes, as well as variable particle size, density and viscosity.

They are pre-treated to turn them into a consistent form prior to refining, which may include physical processing (chipping or milling), chemical (addition of acid or alkali) or biological (use of microbes or enzymes) techniques.

Challenges in biofuels production

Co-processing

Conversion of biomass into biofuels can be done in existing refineries, with ‘co-processing’ helping optimize capacity. Most co-processing happens in hydrotreaters, hydrocrackers or fluid catalytic crackers. These catalytic processes remove sulfur, oxygen, nitrogen and metals.

Protecting downstream equipment

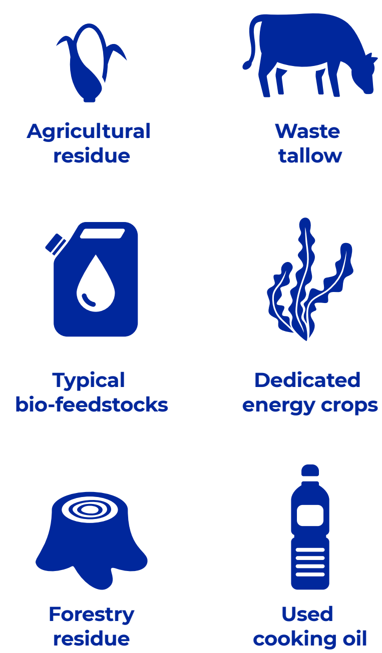
Despite pre-treatment, biomass tends to degrade during transportation and storage. Additionally, biomass typically contains an abundance of oxygen that gets converted to carbon monoxide, carbon dioxide and water during hydroprocessing.

Some of the challenges include:

- Pressure build-up over the catalyst bed and heat exchanger
- Additional hydrogen demand
- Higher gas treatment and removal capacity required
- Removal of additional co-produced water

The increased risk of moisture and contamination in catalysts and critical components may lead to frequent downtime to repair or replace these expensive pieces of downstream equipment.

Bio-feedstock sources



Learn more

Propelling the circular economy

From waste to energy

The world is now producing twice as much plastic as it was two decades ago, with the majority ending up in landfill, being incinerated or simply discarded. Only 9% is successfully recycled. As recycling targets become more aggressive, capabilities and capacities for converting waste into useable products must be increased.

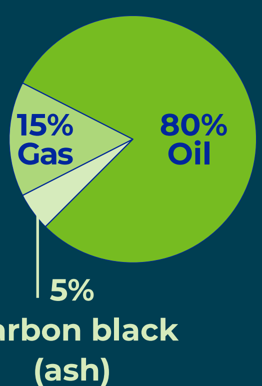
Turning tires into fuel

We put plastic bottles, metal cans and newspapers into recycling bins, expecting them to be made into new containers and products. Yet waste, along with items such as old vehicle tires, can be turned into fuel. The key to this is pyrolysis.

Recycling plastics for new uses

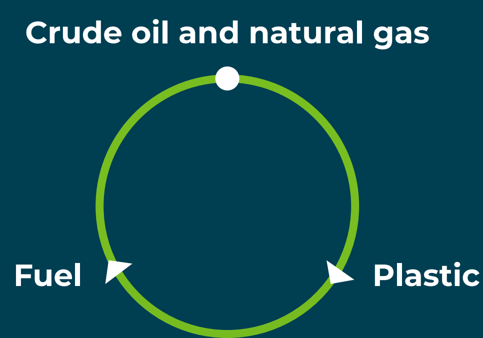
Closing the loop

Pyrolysis is the thermal decomposition of materials at temperatures of 400-600°C/752-1112°F in an oxygen-free environment. The breakdown of polymers to monomers uses a chemical catalyst and leads to a composition of:



High performance filtration solutions and liquid/liquid coalescers are required. The results can be used for the same applications as fossil fuels – heat, transportation and the production of electricity.

Plastic waste in landfill sites could take up to 450 years to biodegrade. Through pyrolysis a circulatory loop is closed: from crude oil and natural gas to plastic and then back to fuel again.



Reducing emissions with carbon capture

Although the transition to green energy is making progress, we still need to deal with the emissions produced by an ongoing use of fossil fuels. Carbon capture, utilization and storage (CCUS) is key. CCUS technologies remove carbon dioxide from fuel combustion and industrial processes and transport the gas either to be used to create products – such as plastics, concrete or biofuel – or stored deep underground in saline aquifers or depleted oil and gas reservoirs.

Chemical absorption leads the way in CCUS

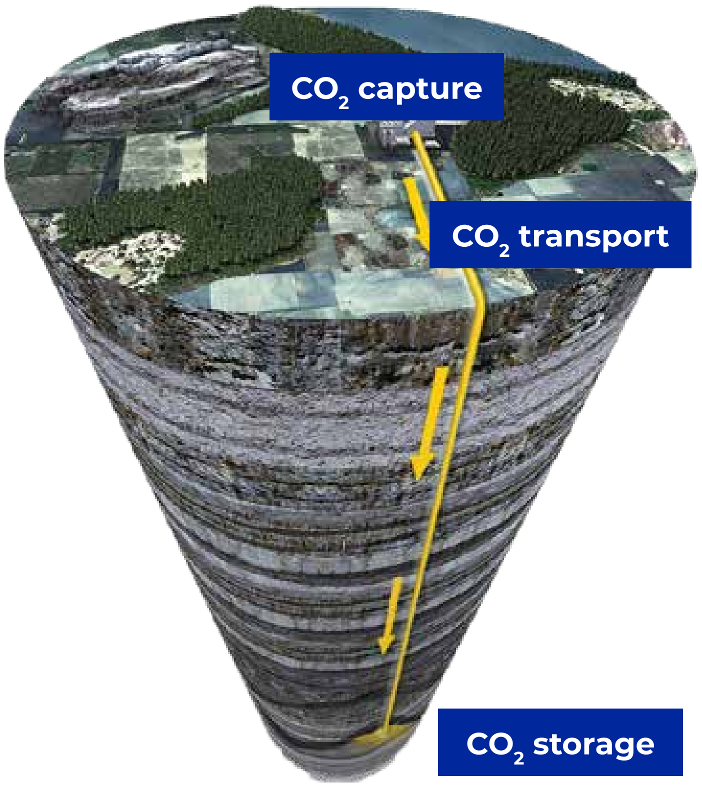
Amine absorption

There are several methods for capturing the CO_2 but the most widely used is chemical absorption. Flue gas containing carbon dioxide and nitrogen is passed through an amine solution which binds with the CO_2. The solution is heated to regenerate the amine and release the CO_2. Challenges include the need for large absorber vessels which can be costly and impact ROI.

Other options

1. Carbon capture can also be done via membrane separation, cryogenic separation and chemical looping.
2. Molecular sieves can be used for direct capture of carbon from the air.
3. Membranes are used in the gas industry, often on offshore rigs where there is a smaller operational footprint.

The carbon capture and storage process



Source: Global CCS institute

Learn more

Investing in the future

Through each aspect of the transition to green energy there are a myriad of factors to consider from regulatory directives and capex/opex costs to technological challenges. Consumers increasingly favor sustainable products and champion organizations that invest in a more sustainable future.

Integrating solutions for an international challenge

Legislative stimuli

Governments are moving forward with legislation and financial stimulus measures to speed up change. The EU's European Green Deal aims for Europe to be the first carbon neutral continent by 2050, with a 55% reduction in emissions by 2030. Key focus areas include: biodiversity, sustainable food systems, sustainable agriculture, clean energy, sustainable industry, building and renovating, sustainable mobility, eliminating pollution and climate action. In the US, a range of tax incentives are encouraging innovation and allowing companies to invest and move forward.

Turning innovation into reality

The complex nature of industry and manufacturing means every part of the value chain must consider how they can improve to operate more sustainably. If companies and their suppliers seize this opportunity and collaborate to develop solutions, those ideas and innovations can be turned into reality.

The role of the filtration technology

The transition away from a reliance on fossil fuels is complex. Technical and financial challenges need to be tackled, but practical options can be leveraged to make a greener future possible. Filtration technology and separation science are key to this transition.

Protecting critical assets

From materials processing and polymer decomposition to product creation and use, there are many procedures for which filtration is not only beneficial but vital. In protecting critical operating assets, improving product quality, safeguarding health, and minimizing emissions and waste, there are solutions that can be tailored to customer requirements.

Collaboration drives progress

As industry and society move to decarbonize, there is an opportunity to take advantage of existing systems and explore emerging technologies. If we innovate, collaborate and expand our view of what we think is possible, we can make real progress on the path to using our planet's resources more sustainably and driving the transition to a greener energy future.

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Towards a greener future

The choices we make today will mean the difference between living in harmony with the environment tomorrow or suffering further from climate change.

For more information, please visit www.pall.com