# Net Zero by 2050: The future of the heat exchanger market in the energy transition

**The global energy market is preparing for an energy transition in the decades ahead. Satisfying the growing energy demand while reducing the risks of global warming and social costs from climate change is a big challenge in the energy economy. An energy transition to reach net zero carbon dioxide emission by 2050 is needed to address this challenge, according to the roadmap provided by International Energy Agency (IEA) issued in May 2021 and global discussions at COP 26, November 2021.**

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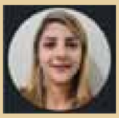

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To explain the rapid change in the energy market based on working towards Net Zero by 2050, data shows renewable energy supply and consumption will continue to increase through 2050. Despite the benefits of renewable energy, the transition to its large-scale use will not be an easy process due to large land use, high labor cost, dependency on weather conditions, issues with storage systems and batteries due to requirements for rare minerals, new infrastructures, and distribution systems. To protect global energy security and orderly transition, fossil fuels with carbon capture technology will remain in the energy market for reliable and sustainable energy supply.

## Why is an energy transition required?

The main reason is "global warming". In 1824, Joseph Fourier discovered the greenhouse gas effect. We know $CO_2$ and other greenhouse gases trap heat in the earth atmosphere. Human activities produce more $CO_2$ than the atmosphere and oceans have historically been able to absorb. In 1988, the UN's Intergovernmental Panel on Climate Change (IPCC) was formed to study human activity in climate change. Global temperature has been increased since 1970 as industrial activities increased fossil fuel combustion for energy supply. Increasing temperature and carbon dioxide emissions will continue with population and economic growth and current policy and technology trends.

In 2014, IPCC introduced the Representative Concentration Pathway (RCP) describing different levels of greenhouse gases that might happen in the future to predict global temperature increase by the end of 21 century. The Paris Agreement saw countries agreeing for the first-time to work together to limit global warming to well below 2 degrees, and Sustainable Development Scenarios were developed to reach the goals from 2015. With COP 26 in November 2021, energy transition and climate change discussions continued about limiting global warming to 1.5 degrees based on a Net Zero Emission pathway by 2050.

## NZE key pillars for decarbonization

Increasing energy efficiency by improving process and equipment design, trusting new technologies, behavioral

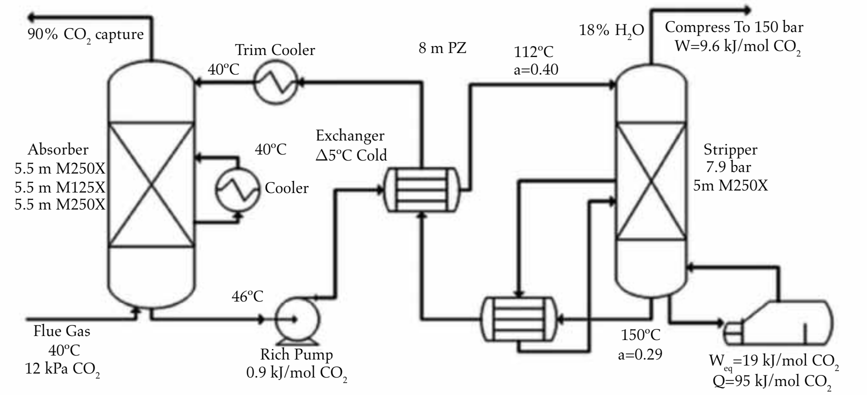
changes with rapid transition to a circular economy, and reducing waste in consumption and sustainable energy production are all important to reach NZE goals.
Electrification and renewables are the important key pillars for the NZE scenario. Renewable energy is going to be the main resource for electricity. We will see more smart homes and electric cars with renewable electricity resources such as solar energy. This provides opportunities for projects related to advanced batteries, hydrogen electrolysers, and E-fuels. Low emission fuels such as hydrogen and hydrogen-based fuels and bioenergy will be used in the areas where electrification is not possible.
Carbon capture utilization and sequestration (CCUS) will have a significant role in the energy economy in the NZE scenario; keeping fossil fuels in the energy market to help with an orderly transition and ensure energy security.
NZE scenario is based on using all the available technologies and emissions reduction options, and international co-operation and contribution to net-zero is needed if 2050's goals are to be reached.

## What does the net-zero energy future look like?

By decarbonizing electricity, main resources for electricity will be wind and solar, hydropower with back up from bio-fuels, and nuclear energy. For total and heavy industries energy demand up to 2050, oil will keep its place in the industry and natural gas with CCUS will play a significant part. However, there will be huge demand for electricity and hydrogen, and the demand for bioenergy and waste will also increase significantly. For global transportation, the main recourses will be electricity, hydrogen-based fuels, and biofuels (70% with electricity and hydrogen). Electricity from renewable resources will be used for buildings.
Due to an increase in renewable energy supply and demand, coal demand will decline by 90%, oil by 75%, natural gas by 55%, and fossil fuels will be used for non-energy products where the carbon remains in the product (like plastics) and also in the plants with CCUS.
Investment in carbon capture and utilization will increase to help existing power plants and industry with fossil fuels, new biofuel plants, blue hydrogen and ammonia from natural gas and help to produce E-fuel in the future.
Low emission fuels such as bioenergy and hydrogen are 1% of global final energy demand today, this will increase to 20% in 2050.

## How will NZE change the heat exchanger market?

Because of the fossil fuels production drop and increasing demand for clean energy, the heat exchanger market will have new opportunities in CCUS and low emission fuels projects.
Carbon capture is separation of $CO_2$ from flue gas or direct air capture. 90% of high-pressure $CO_2$ in the US is injected to oil wells for enhanced oil recovery, however 2050 goals for $CO_2$ utilization are based on providing more chemicals from $CO_2$. Carbon capture can be done for any stationary $CO_2$ resources or direct air capture. The process includes "Feed Dehydration, $CO_2$ capture and then $CO_2$ Compression", and all processes need mass and heat transfer. Carbon capture is a complex gas separation process using chemical absorption or adsorption, or membrane separation. The following diagram is an example for $CO_2$ absorption process:
Gas absorption to remove $CO_2$ from flue gas will happen in an absorption column and liquid stripping (desorption) to remove $CO_2$ from amine solvent will be done in a stripper column. This process is based on gas-to-liquid mass transfer and design of heat exchangers is important to optimize heat integration and minimize utility and investment costs.
The growing recognition that CCUS is necessary to meet net zero goals along with a growing interest in producing




*Intercooled Absorber/Interheated stripper with 8 m PZ.*

**References**

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low-carbon hydrogen are main reasons for increasing CCUS projects in the US and Europe. Diversity of the stationary $CO_2$ resources with different feed compositions, different $CO_2$ purity and $CO_2$ recovery dictate different $CO_2$ capture process for each project. High temperature of the flue gas from combustion of fossil fuels can challenge material selection and fabrication requirements of heat exchangers.

## Low emissions fuels: Hydrogen

Hydrogen is one piece of the Net Zero by 2050 puzzle. Blue hydrogen refers to any hydrogen with fossil fuel resource with carbon capture technology. Approximately 98% of the current global hydrogen production is from the reformation of methane or gasification of coal or similar fossil-fuel origin, and only about 1% of hydrogen production from fossil fuels includes carbon capture and storage. For green hydrogen production and electrolysis, renewable electricity is used to split hydrogen from water. The IEA estimates that less than 0.4% of hydrogen is produced by the electrolysis of water powered by renewable electricity. Blue and green hydrogen production plants require heat transfer equipment for steam methane reforming or electrolyzing and liquification of hydrogen. Liquid hydrogen needs very high pressure or cryogenic service (-473 F boiling point) and slurry hydrogen requires vacuum pressure for transport. Gaseous hydrogen can be very easily ignited. Engineering and fabrication of mechanical equipment, especially heat exchangers for hydrogen projects, is complicated. Material selection is the main issue in the engineering stage. Fabrication cost will be high due to additional fabrication requirements for hydrogen services. Considering engineering and supply chain problems for pure hydrogen, hydrogen-based fuels (such as ammonia), and e-fuels/synfuel will have a large role in the hydrogen economy. The combined share of low-carbon hydrogen and hydrogen-based fuels in total final energy use will reach to 13% in 2050. Hydrogen in the forms of gas, liquid, and solid (as chemical component) will be used directly in the chemical and heavy industries. Ammonia (NH3) will have the most important role in the hydrogen economy as a hydrogen carrier in the industry and fuel for shipping.



## What is Net Zero by 2050?

In recent years, the energy sector was responsible for around three quarters of global GHG emissions. The IEA (International Energy Agency) released its first comprehensive energy roadmap to reach net-zero emissions by 2050 in May 2021. Net zero emissions by 2050 (NZE) scenario provides only 50% chance of limiting global warming to below 1.5°C.

## What are the NZE assumptions?

In NZE, it is assumed that the global economy will more than double through 2050 and the global population will increase by 2 billion. Total energy supply will fall by 7% between 2020 and 2030 and remain at this level to 2050. $CO_2$ emissions will fall by nearly 40% between 2020 and 2030, and then to net zero in 2050.


## Low emissions fuels: Biofuels

Biofuel is not new in the US market. Congress established regulations under the Energy Policy Act of 2005 to encourage the mixing of renewable fuels into US fuel supply. Renewable Fuel Standard (RFS) subsidies in the US caused increasing ethanol demand and price in the global market. In 2020, the biofuel market was based on biogas, ethanol and, in a smaller share, bio diesel. Liquid biofuels will meet 14% of global transport energy demand in 2050, up from 4% in 2020. Low carbon gases (biomethane, synthetic methane, and hydrogen) will meet 35% of global demand for gas supplied through networks in 2050, from almost zero today. Nearly all the gasoline now sold in the United States is about 10% ethanol by volume. To meet NZE goals, new infrastructure/refineries and modification to existing distribution infrastructures and end-users' technologies are required. CCUS will be required to capture $CO_2$ from biofuel plants. Different biomass resources require its unique conversion process, therefore each biofuel project is unique based on the feed and process and will require specific heat transfer equipment to meet project requirements and specifications. High fouling feeds and more corrosive products, hydrogen service and hydrogen attack for most of the processes are the challenges for heat exchanger design.

## Conclusion

Net Zero by 2050 is a feasible solution for the global warming problem, and the goal is reducing the greenhouse gas emissions (especially $CO_2$) from the energy sector with minimum social costs – however, it provides only 50% chance of limiting global warming to below 1.5°C. The heat exchanger's traditional market for fossil fuels with CCUS will continue to grow to support increasing global energy and non-energy demand. New markets for heat exchangers are developing to support a renewable and low emission energy market especially biofuels, ammonia, and hydrogen, and carbon capture projects. Design, material selection, and fabrication of mechanical equipment will change due to challenges for higher fouling flows and more corrosive processes for biofuels, high pressure and cryogenic hydrogen projects, and high temperature carbon capture processes in new projects.