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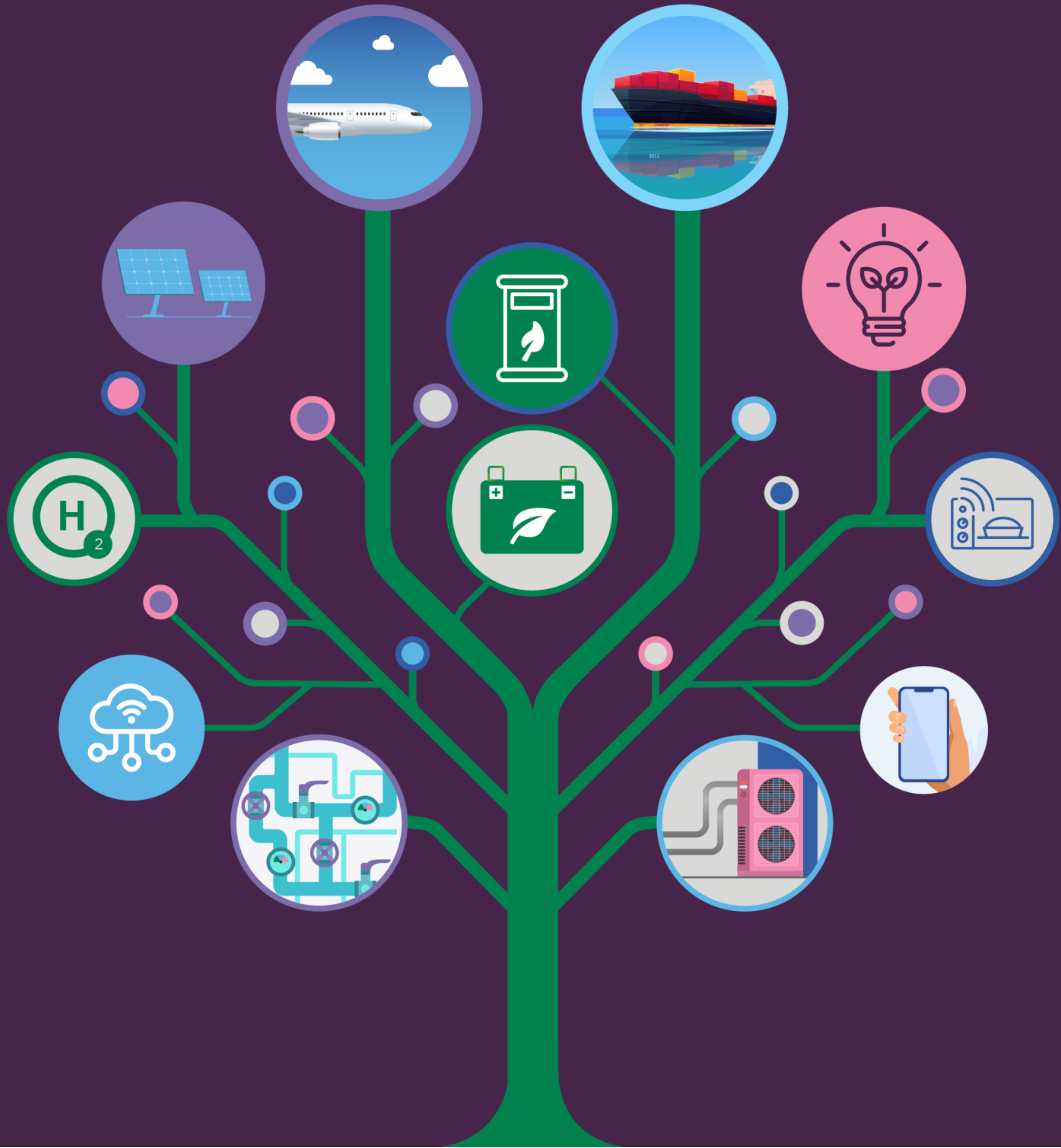
Decarbonisation solutions transforming the energy space



INDUSTRY INSIGHT – Low Carbon Products

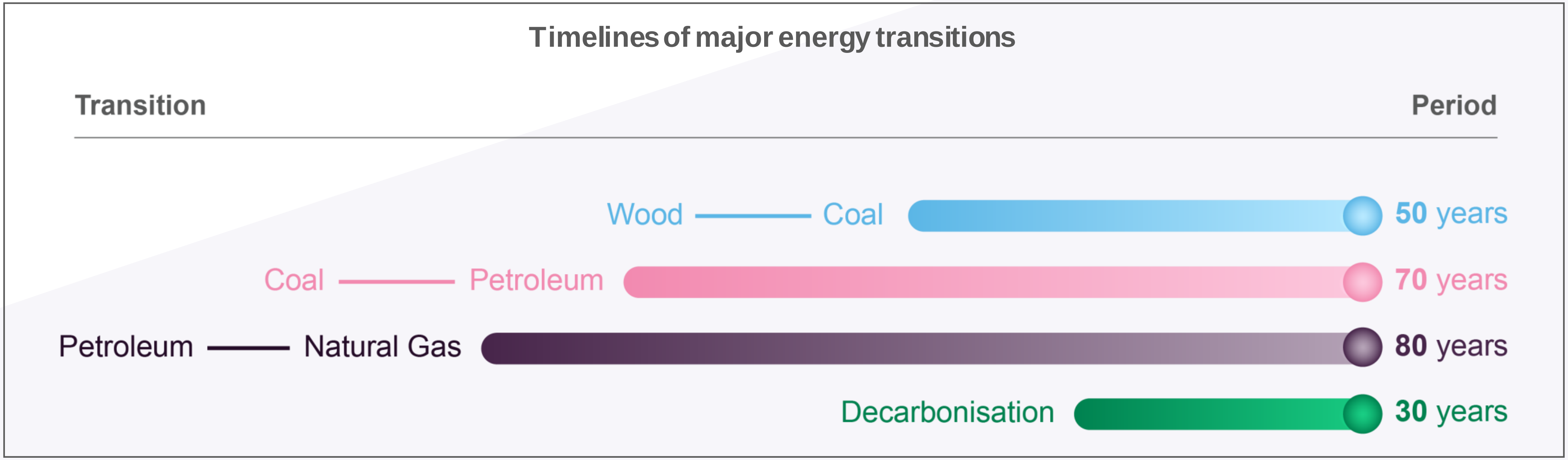
July 22

Energy transition is the core component of the global target to achieve net-zero carbon emissions by 2050 across geographies and industries. Although, as we dive deeper into the scale and pace of the efforts needed to limit global temperatures from rising by 1.5 degrees C, the word “energy transition” loses some of its relevance. The more apt term seems to be **energy transformation**. And this accelerated move to a sustainable energy future is now being seen in a contrary light to the ‘economic blackhole’ that it had previously been touted as. With the scope of **transformation** opportunities in mind, we look at some of the top innovations across energy spheres to enumerate their impact towards decarbonisation.

Why a transformation?

It is, for the first time, that the impact of the energy transition hinges on eliminating a key constituent of all current energy sources – carbon. The absolute need to pivot away from and substitute the prevalence of carbon, as well as move from introducing newer solutions as smaller additive components into the existing energy mix, and instead towards implementing new energy sources is a challenge for the ages.

Previously, the world has transited from wood to coal, then to oil (petroleum), and subsequently to natural gas as energy sources. Each of these transitions usually took place over a few generations rather than the relatively slim 3-decade time window we are looking at for decarbonisation.



Source: Evalueserve Insights; U.S. EIA

Accelerate opportunities

This slim window of time requires that the transition towards decarbonisation be accelerated through transformation. To facilitate a speedy uptake, industry players will need to focus on innovations within decarbonisation. While there are methodologies for adopting decarbonisation en masse using the Evalueserve GREEN framework, as illustrated in our recent case study, there are also sector-specific opportunities within value chains that can be explored.

This time around, we are looking at some of the top transformation opportunities within the energy space, as this space reportedly accounts for 3/4th of all present-day greenhouse gas (GHG) emissions, as per the World Resources Institute (WRI). Some of the broad categories within energy consumption are power generation and applications within industrial sectors, transportation, and buildings (residential and commercial). The following is an overview to showcase the range of opportunities within these sectors of the energy space, and is by no means an exhaustive collection of solutions:

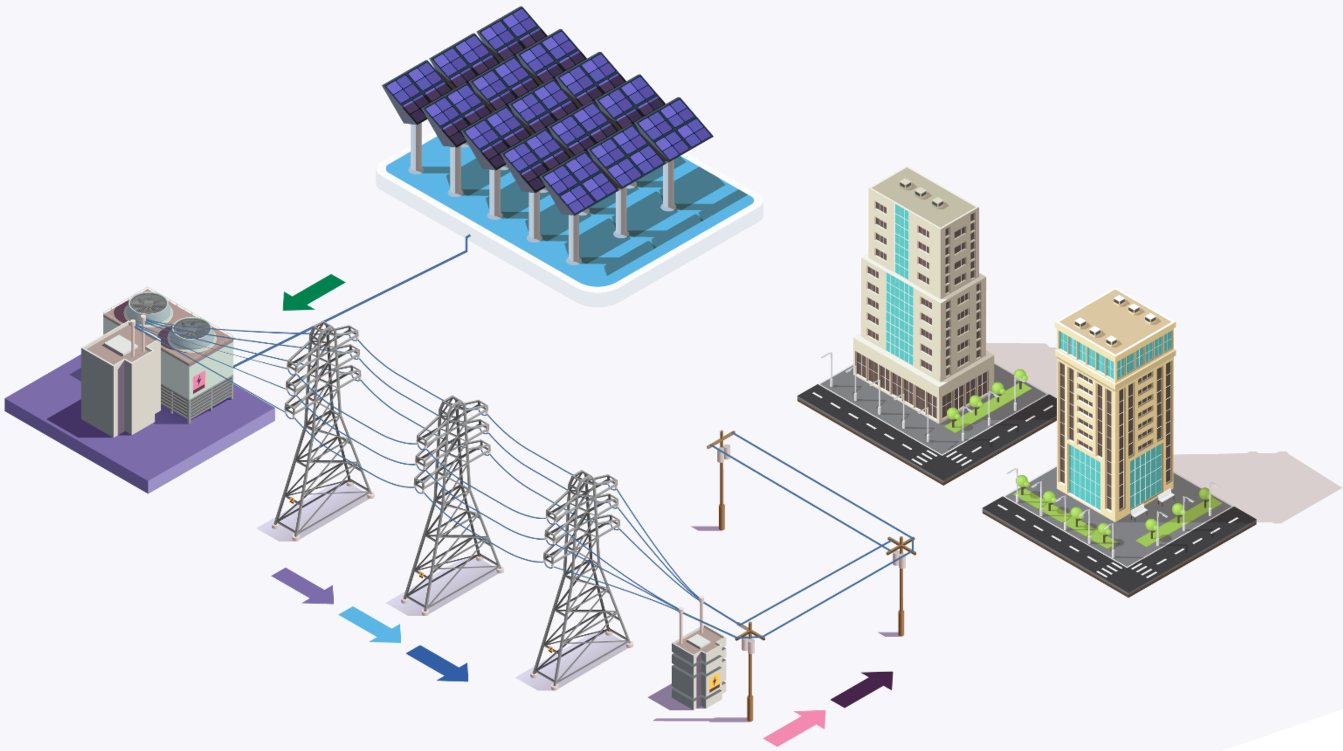
Solar

Solar power generation is gaining popularity and we see it as the most likely renewable source to replace the primary non-renewables as more players embrace decarbonisation. For example, while solar accounted for 11% of U.S. renewable electricity generation in 2018, it is pegged to account for 48% of the renewable power generation by 2050. Reports state its CAGR stands at 20.5%. The growth potential and the fact that solar energy is the most abundantly available sustainable energy source is driving the rapid innovation development towards it.

The power generation efficiency of current photovoltaics (PVs) stands around 20%. Most of the development focuses on semiconductor materials and technology that take it closer to its theoretically optimal efficiency of 68.7% (86.8% in case of concentrated solar radiation). Among these are **high-efficiency crystalline PVs** such as III-V multijunction solar cells which have been tested to deliver 47.1% efficiency. Then there is also bifacial technology, which can harvest energy from both sides of the solar panel, boosting a standard crystalline silicone-based solar panel's efficiency by 11%. In addition, development is also being made in **second generation thin film solar cells** and **perovskite solar cells** (PSCs), which has recently witnessed efficiency breakthroughs of 27.3%.

Aside from innovations in materials, better energy harvesting methods are also emerging. This includes using **lenses as optical boosters** to concentrate solar light beams by up to 200 times. Then, there are prototypes being developed for thermoradiative PVs or **reverse solar panels**, which generate electricity at night using the heat irradiated from panels, as well as **integrated hybrid devices** that capture solar energy right at the source and can store it to prevent energy losses before transmission.

A novel idea for hybrid solar use is 'Floatovoltaics', or **floating solar farms**. These can be created on reservoirs, dams, canals and other water bodies. Such floating farms can offer up to 10% better efficiency due to the cooling effect of water, are cost-saving and reduce land use, and act as a cover for the water below to decrease water losses from evaporation. There is great interest in **building-integrated photovoltaics** (BIPVs) such as solar windows, solar paint and solar roofs as well.



Wind

After solar, wind energy is next big sustainable energy source, with a CAGR of around 18.6% in global offshore, compared to a CAGR projection of 0.3% for onshore. The wind industry reached a critical landmark last year after the reduction in its Levelised Cost of Energy (LCoE), as per the International Renewable Energy Association (IRENA). Even with this breakthrough, all the world's new offshore installs in 2020 totaling 6.6GW took place in Europe's North Sea. Patterns of complacency within the industry are being discussed and it is time for an innovation push for wind to meet the estimated building of 12 times more power generation capacity per year in the coming decades than it does today.

Floating wind farms present a fresh avenue for offshore wind development in new regions, and the first commercial floating capacity auctions are expected to take place later this year across parts of Europe, Japan, Taiwan and the U.S. To aid this, **semi-submersible** platforms, **tension leg** platforms as well as **spar buoys** are being developed for large-scale use. For wind turbine blades, there are innovations in both directions, **bigger blades** as well as **bladeless turbine designs**, currently under development. Bladeless turbines use less space and can be installed at lower heights. They cause less noise and installed closer to urban areas. The bladeless design may also reduce the effect on the biodiversity, particularly birds, in biodiversity rich areas.

The classic debate for increased profitability by either **rotor extension** potentially up to 300 meters or **MW uprating** to increase performance at low-wind sites continues and looks to be divided regionally. While most traditional wind farms rely on horizontal axis wind turbines (HAWTs), newer studies into installing **vertical axis wind turbines** (VAWTs) in pairs suggest they can increase each other's performance by up to 15%. Another key factor affecting efficiencies is their grid formations. Aligned correctly, **grid formations** place turbines to make optimum use of the wind flow and for an available land area.

Rare earth permanent magnets are also being considered as replacements for ferrite magnets in generators owing to their superior properties and declining prices. As for the potential logistical challenges that the growing sizes of rotors and blades present, wind OEMs are looking at **integrated product modules** that are customised to meet permissible transport limits. Offshore wind is also quickly seeming to be a favourable transformation opportunity for oil and gas industry players.

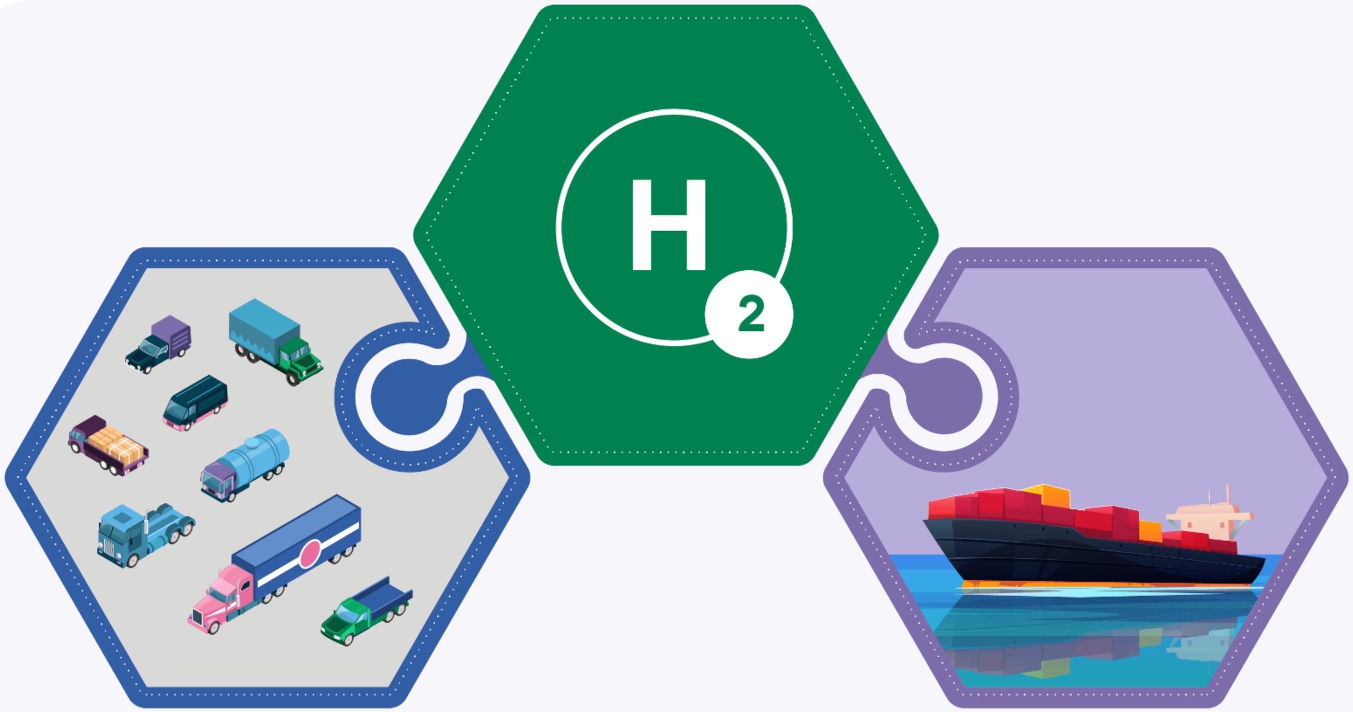
Hydrogen

Hydrogen is being touted as the next big energy source to fuel transportation across land, sea and air in a net-zero economy as hydrogen fuel cell electric vehicles (FCEVs) can deliver on the range required for the long haul for which battery electric vehicles (BEVs) currently cannot. Evalueserve has carried out a detailed look at the role hydrogen can play in the energy transformation. Its demand has grown three-fold since 1975 and the global hydrogen powered transport market is expected to grow at a CAGR of 56.3% in 2021.

The biggest challenge for its wide use remains in **clean hydrogen production**. Currently, the majority of hydrogen is produced using non-renewable natural gas and coal, while the future of hydrogen production lies in **electrolysis** using cleaner sources of electricity as they become increasingly cost-efficient. There is also a lot of interest driven towards **X-to-Hydrogen-to-X** processes, including the developing **waste-to-hydrogen** conversion systems using **gasification, pyrolysis, fermentation** and others to maximise the use of resources towards aligning with other streams of decarbonisation and outputting other carbon-neutral byproducts.

There is hence a major push for developing **advanced electrolysers** based on **proton exchange membranes** (PEM), **anion-exchange membranes** (AEM) and **solid oxide electrolysers** (SOE). For the purposes of transportation, developing high efficiency **hydrogen fuel cells** will be key. As fuel cells gain popularity, **diagnostics tools** for the maintenance of fuel cell stacks should become lucrative markets as well. Meanwhile, **hybrid fuel cell e-aircrafts** under development could be a way forward for the aviation industry.

Another important part of hydrogen adoption is a **conducive policy framework**. For example, major players including Shell, Volvo Group, Daimler Truck AG, IVECO, and OMV have collaborated on a program named H2Accelerate to work with policy makers and regulators towards a policy environment that supports scaling up of **hydrogen truck manufacturing** as well as the creation of a **hydrogen refueling network** and **hydrogen distribution systems** across Europe.

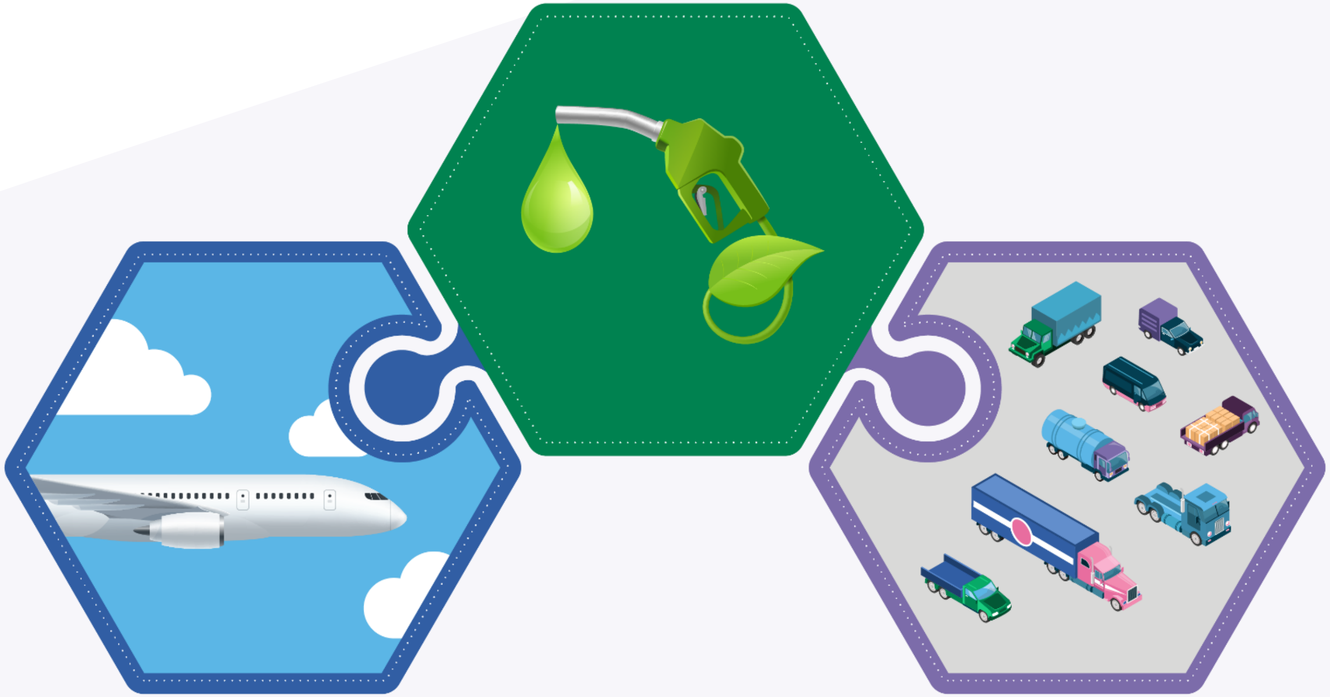


Biofuels

Biofuels in and of themselves are not a new concept. Government blending mandates in countries such as the U.S. surrounding surplus crop-based biomass fuels like ethanol and biodiesel have so far ensured a steady supply and increased consumption in line with overall fossil fuel growth numbers. Now, however, in the context of a future with decreasing reliance on gasoline, biofuels could well serve as an intermediary solution for sectors wherein the traditional fuels ruled. One such big space is passenger vehicles. However, with the projected pace of development and adoption of BEVs and FCEVs, the scope within passenger vehicles might be limited.

At the same time, the scope for decarbonisation which biofuels can offer within transportation, a sector heavily dependent on fossil fuels, is huge. For, they can be used to power existing internal combustion engines with small updates to make them **flexible-fuel vehicles** (FFVs), capable of using higher blends or even pure biofuels as the energy source. The first opportunity arises in second generation biofuels that use **cellulosic waste as feedstock**. There is much scope for **organic waste recycling** through this process.

Subsequently the development of future **third and fourth generation biofuels**, which do not compete with food crops and require only non-arable land use for their feedstock, is on the rise. They instead rely on microorganisms like **algae and genetically engineered cyanobacteria** as feedstock and are also more energy dense compared to the previous generation biofuels. Some processes within these advanced biofuels have even been tested to be carbon-negative, owing to **inherent carbon capture** and are hence attracting a lot of attention despite being in early stages development. The CO2 thus captured can be used in processes such as a **reverse microbial fuel cell** (R-MFC) to produce liquid biofuels. Research is currently also looking into other **CO2-to-fuel conversion** technologies which result in **electrofuels**.



Applications towards **sustainable aviation fuel** (SAF) in the form of **aviation biofuels** like HEFA-SPK blended with fossil jet fuel have been on the rise in recent years but stood at 0.01% of aviation fuel demand in 2018. This demand is pegged to grow to 10% by 2030 and about 40% by 2040. **Aviation biofuel distribution** presents a great opportunity as less than 5% of global airports account for 90% of international flights. This means that making SAF availabile at a small number of airports could fuel higher consumption. To meet cost reduction and parity, there is great scope in advanced **aviation biofuel refineries, subsidised SAF consumption policies**, and higher **SAF blend mandates**.

Much of the industry's decarbonisation targets depend on the Carbon Offsetting and Reduction Scheme for International Aviation (**CORSIA**), which looks to stabilise net CO2 emissions from international aviation starting this year.

District heating and cooling

District heating and cooling (DHC) is the single largest end-user of energy, accounting for over 30% of global final energy consumption, according to the International Energy Agency (IEA). The majority of its present demand is powered by fossil fuels, and hence its contribution to GHG emissions is significant. To mitigate this, biofuels have been a traditional alternative. Now, though, with an eye on the future, buildings with **advanced insulation and digitalization** are opening the sector up to various other renewables including **low-temperature geothermal, solar thermal**, and **waste heat** products.

Using these renewables efficiently will require the integration of **combined heat and power** (CHP) cogeneration and **trigeneration** (electricity, heating and cooling) plants.

With over at least 25% of EU's population residing in areas suitable for geothermal district heating, the scope for adding this compatibility to structures finds reason. Greater data availability and **connected building renovation strategies** at the municipal level can bring awareness and increased integration of low-temperature renewables to the game. According to IRENA, renewables can account for up 77% of the energy supplied to DHC systems by 2050, a significant rise from 8% in 2017.

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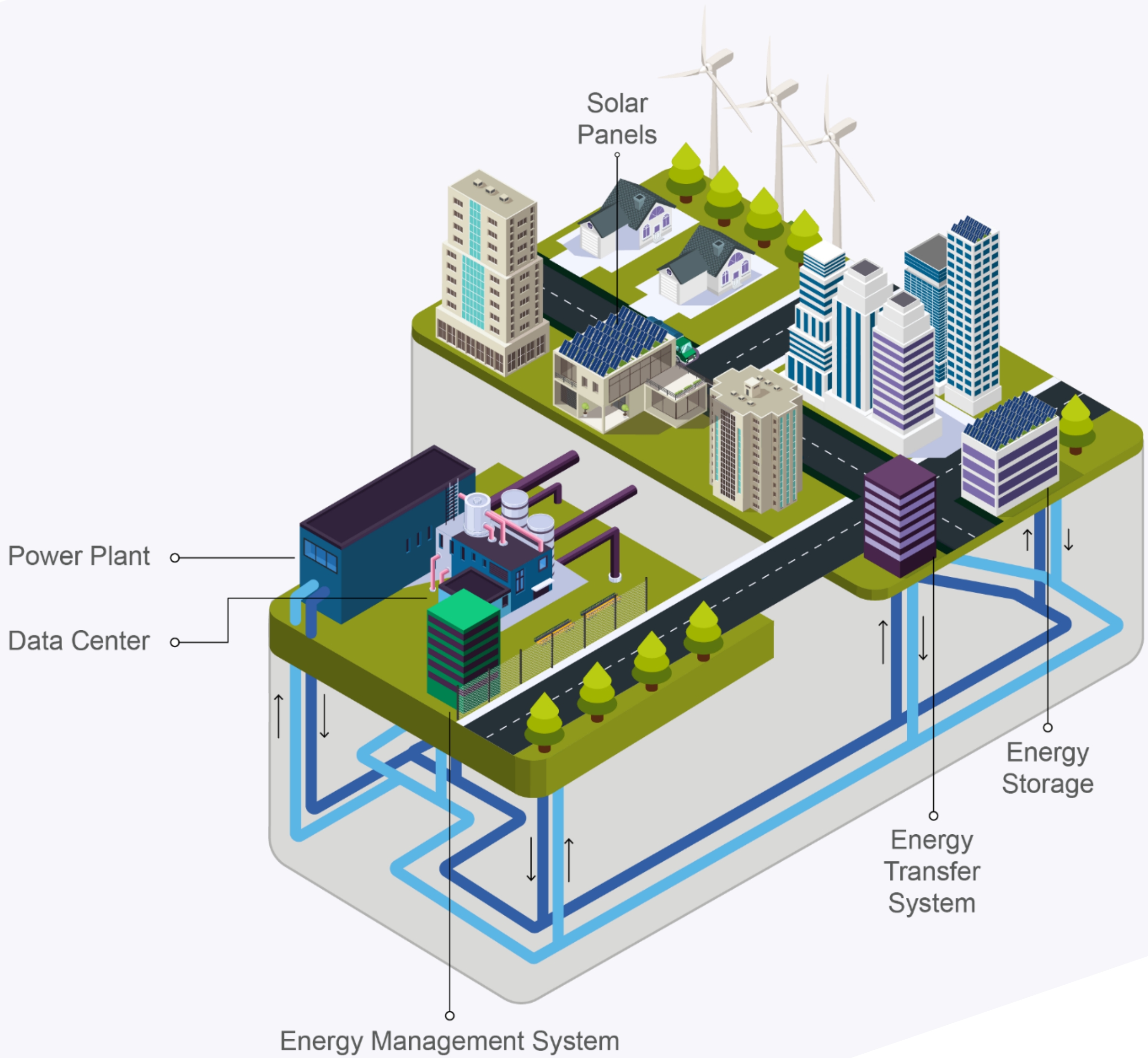
Buildings

This target towards net-zero carbon emissions is a key goal of the fourth generation DHC (4GDHC) systems, which utilises **smart energy systems. Artificial intelligence** (AI) tools which monitor uncertainties in weather and accordingly forecast energy demand against energy storage capacity could offer solutions to peaks and drops in heating and cooling requirements. **High-efficiency heat pumps** might play a big role in this change, as more stringent building energy codes are announced across geographies. Another change we will see is a relatively higher **increase in district cooling** needs as global average temperatures rise and more demand increases in developing economies.



Internet of Things (IoT)

Decarbonisation of energy will also mean maximising energy efficiencies. A effective way to achieve this is through process automation and operational efficiency. Internet of Things (IoT) applications can drive this change with the plethora of energy management systems-based savings, security and efficiency they offer for each aspect of the **energy supply chain network** from electric utilities all the way to consumers.

Monitoring systems are not new within the energy space but IoT provides the distinct advantage of decentralising these systems based on critical and non-critical usage areas as well as offering real-time data on all aspects of a **smart energy distribution system**, while also applying changes to match this data. This can be in the form of employing smart grids to locally redistribute surplus energy production towards sectors with higher demand and anticipating high demand by storing excess energy and reducing energy losses.

Particularly, **IoT-based HVAC management** systems can serve a big role towards preventing energy losses in buildings. They can also lower energy consumption based on need and usage patterns, while also accounting for energy storage when the systems have a surplus. Similarly, **IoT-based smart lighting** systems can be switched off when left on in unoccupied zones or when there is ample natural light present in a zone. IoT systems can also offer real-time updates on energy consumption and send out alerts when consumption has exceeded set limits.

IoT can also significantly impact **modern transportation** systems to minimise energy losses as well as automate both driving as well as the recharging of BEVs, maintain a fleet of connected vehicles, or find and suggest locations based on usage patterns. **Traffic monitoring** can be done from a systems perspective to maintain a steady stream of connected vehicles evenly distributed across various parts of a smart city to help reduce the chances of congestion.

IoT relies on these four basic components – sensors, communication protocols, computation and data storage – to function. Development of **better AI, big data analytics**, and **sensor technology** for specific data gathering as well as **advanced communication** technologies can all benefit the growth and scope of IoT applications.

Conclusion

The signs of the energy transformation are clearly visible everywhere, and each moment that industry players delay stepping onto this bus, is equivalent to an opportunity missed. The biggest detractor to the inevitable adoption of transformative and actionable decisions here has been cost. To subdue this rhetoric of the energy transition costing stakeholders dearly, a new analysis by IRENA suggests otherwise. It shows that accelerating the energy transformation towards renewables can grow the world's economy by 2.4% over the expected growth of current plans within the next decade. **The pivot towards decarbonisation is as much a responsibility as it is a business decision, and offsetting initial costs as well as facilitating smooth transformation through identifying and implementing the right solutions and frameworks will be key to maximising the burgeoning opportunities of the energy transformation.**

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