2023

July

The Role of Natural Gas – Transition Fuel or Part of the Long-Term Global Energy Mix?

Sustainability Research Paper

The Al-Attiyah Foundation

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Natural gas has seen a rapid expansion since the 1970s as it has many attractive characteristics, including a low direct greenhouse gas emissions intensity. Many analysts have therefore seen it as a key "bridge fuel" to cushion the energy transition from coal and oil to renewables over the next decades. However, an increasing understanding that methane emissions in gas production and transportation are generally high, as well as the sudden realisation of the vulnerability of natural gas importers, as highlighted by the Russian invasion in Ukraine, has recently dimmed the prospect of natural gas. How has the natural gas market developed over the last decades? Can natural gas be considered a sustainable fuel? Which role does blue hydrogen play in this context?

SUSTAINABILITY RESEARCH PAPER

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03 EXECUTIVE SUMMARY

- Natural gas has seen a rapid expansion since the 1970s as it has many attractive characteristics, including a low direct greenhouse gas emissions intensity.
- Many analysts have seen it as a key "bridge fuel" to cushion the energy transition from coal and oil to renewables over the next decades.
- However, an increasing understanding that methane emissions in gas production and transportation are generally high, as well as the sudden realisation of the vulnerability of natural gas importers, as highlighted by the Russian invasion in Ukraine, has recently dimmed the prospect of natural gas.
- Forecasts by key energy-related entities (IEA 2022a, BP 2023) generally see an opposing trend regarding natural gas consumption in emerging economies where it is foreseen to rise and in industrialised nations, where it is expected to fall rapidly. Especially in Net Zero Scenarios global natural gas demand is already estimated to fall until 2030.
- Key parameters for the fate of natural gas are the perceived urgency of climate change mitigation policies, and the speed of transition away from coal.
- Under a high urgency scenario where willingness to pay is paramount, high-cost solutions such as electricity storage or integrated hydrogen systems will be preferred to a system where natural gas peak load power plants serve to stabilise a grid powered by intermittent renewable energies.
- A low urgency scenario would see the continued exploitation of coal as the cheapest fuel.
- Thus, the prospects of natural gas would be highest in a scenario where coal phaseout is embarked upon in a serious manner by emerging economies, but policymakers eschew high-cost investments in electricity storage or hydrogen-based solutions. In such a scenario demand for blue hydrogen would probably be high, if carbon capture and storage is available at low costs.
- The perspective of natural gas is best in a world which addresses climate change in a steady manner and where the key role of natural gas as an enabler of high penetration of intermittent renewables persists.
- This would however require that methane emissions from natural gas production and transport are reduced significantly compared to past and current operations.

As the world continues to grapple with the urgent need to address climate change and to transition to sustainable energy systems, the role of natural gas in the global energy mix has become subject of intense debate. Natural gas, a fossil fuel with lower direct carbon emissions compared to coal and oil, has often been hailed as a potential "transition fuel" that could help bridge the gap between "dirty" energy sources and clean alternatives. However, doubts remain regarding its long-term viability and compatibility with carbon-neutral future objectives (IEA, 2022a). The latest Synthesis Report from the IPCC has conveyed a sobering message: our ability to achieve a 1.5°C pathway is highly uncertain. The next ten years will be crucial for effectively reducing greenhouse gas emissions and containing the global temperature increase within the limits of 1.5°C or possibly 2°C (IPCC 2023).

The use of natural gas in the past decades has provided numerous benefits, such as relatively lower greenhouse gas emissions, enhanced energy market stability, and economic returns. Its abundance, affordability, low level of local air pollutants linked to its use and widespread infrastructure has made it an attractive option for power generation, industrial processes, and heating. The flexibility of natural gas-fired power plants has also allowed them to complement intermittent renewable energy sources, providing stability to the grid (BP 2023).

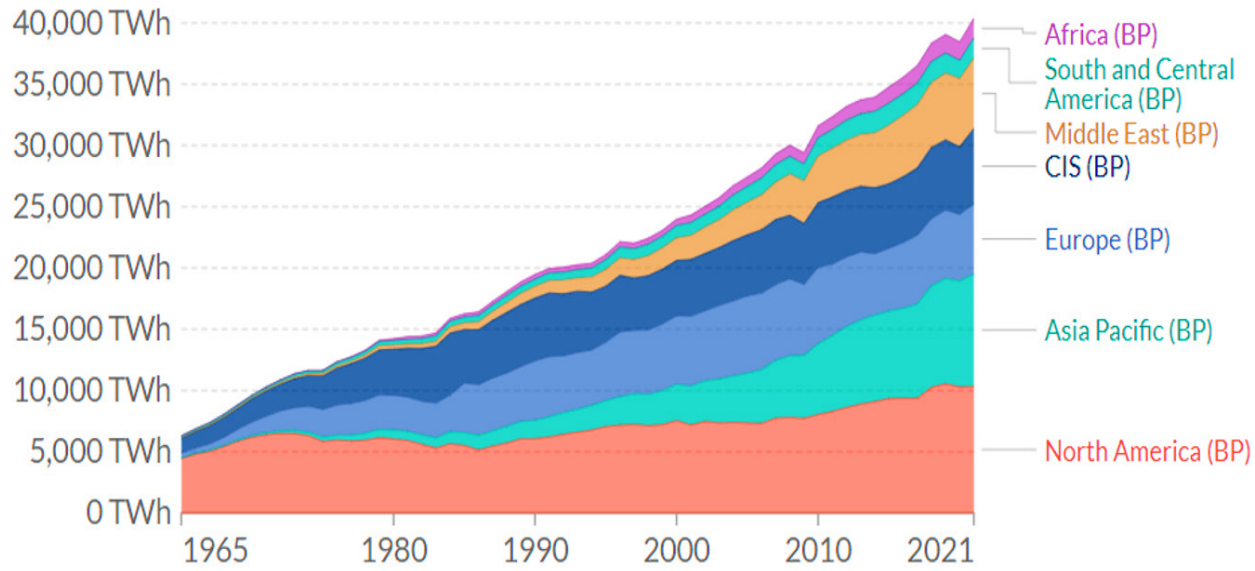
However, natural gas still leads to significant direct greenhouse gas emissions and the environmental impacts of natural gas extraction must be carefully examined. Methane, the primary component of natural gas, is a potent greenhouse gas with a much higher warming potential than carbon dioxide. Methane leakage during extraction, transportation, and distribution can significantly offset the emission benefits of natural gas.

An array of scientific studies in the last years has stressed the past massive underreporting of methane emissions related to gas production (IEA 2022b). Further, the recent war in Ukraine has shown the strong dependency of European countries on only very few energy suppliers which has created a recent energy "crisis", both regarding energy security as well as economic affordability. This led to a strong call within Europe to diversify energy sources as well as suppliers and has given a big push to install various liquid gas terminals, which have long technical lifetimes and can thus prolong the EU`s dependency on natural gas (IRENA 2023).

The global energy transition requires a comprehensive assessment of the role of natural gas in the long run. While some argue that natural gas can serve as a bridge fuel to support the transition to a low-carbon future, others emphasise the need to prioritise renewable energy sources and energy efficiency measures instead (BP 2023). The availability and affordability of renewable technologies have improved significantly in recent years, potentially reducing the future demand for natural gas. The prospects for blue hydrogen, produced from natural gas with carbon capture and storage technology, have gained increasing attention. Blue hydrogen could potentially offer a cleaner alternative to natural gas by capturing and storing parts of the greenhouse gas emissions associated with natural gas. But whether blue hydrogen will see commercial-scale implementation depends on its cost-effectiveness, the level of remaining CO2-emissions as well as upstream emissions from natural gas (IEA 2022a).

This paper will explore the contrasting perspectives surrounding natural gas, and summaries its merits as a transition fuel, as well as the challenges and considerations associated with its continued use in the global energy mix.

Figure 1: Historical development of natural gas consumption



Natural gas is a low-density, explosive commodity that requires sophisticated transport infrastructure. Traditionally, natural gas was primarily transported through pipelines before technologies during the 1960s were developed to produce liquefied natural gas (LNG) which was then transported in specially designed ships (Jensen 2004). In the 1960s, massive natural gas discoveries in Europe and Russia led to a conversion of the domestic energy system from coal to gas (Jegourel 2016). This initiated the start of LNG trading in significant volumes in the 1970s, first in the Atlantic, and subsequently in the Pacific. Supply initially came mostly from Southeast Asia and Algeria; Qatar entered the market only in the late 1990s (Jensen 2004, p. 9). Since the 1990s, and fully since the mid-2000s a competitive natural gas market reacting on supply and demand in a region, a so-called "hub", has emerged (Hafner and Luciani 2022, p. 380), mainly driven by the rapid increase of shale gas production in the US. This development is reflected in Figure1, showing the development of natural gas consumption broken down by regions. While the gas consumption in 1965 was mainly driven by North America and the Commonwealth amounting to a total of 6300 TWh (644 bcm), the global gas consumption has constantly risen over recent years and today is equal to approximately 40,000 TWh (4094 bcm). In 2019, natural gas provided approximately 23% of the global primary energy demand, showing the high relevance of this energy carrier (IEA 2021). The five biggest gas producing countries today are, in descending order, the United States, Russia, Iran, China and Qatar (statista 2023).

During the first year of the COVID-19 pandemic, natural gas demand proved more resilient than other fossil fuels. It grew by 5% in 2021, double the average growth rate of the past decade. Factors such as fewer new projects, weather-related demand spikes, LNG outages, and reduced Russian exports tightened global gas supply from mid-2021, leading to a price spike, particularly in Europe. Russia's invasion of Ukraine exacerbated an already fragile global gas balance, causing potential shortages and skyrocketing prices. Prices at Europe's TTF[1] rose from less than

USD 10/MBTU (Million British Thermal Units) in 2021 to USD 90/MBTU in 2022, a full order of magnitude. Caused by that, shortages occurred in countries like Pakistan and Bangladesh, while major markets like India and China reduced their LNG imports. Even though prices have fallen significantly in recent months, the crisis has prompted discussions on gas market reforms, better supply management, and protecting customers from volatile prices, all while considering the future role of natural gas in energy transitions (IEA 2022a).Today, there are no concrete national plans for a complete phaseout of natural gas. The Netherlands has committed itself, following the Dutch Climate Agreement from 2019, to completely phase out natural gas in the heating sector by 2050 (CE Delft 2022).

Stipulated by the Danish Climate Act, Denmark has stated to completely phase out natural gas extractions by 2050, while it is not specifying a phase out of natural gas utilisation (The Guardian 2020). Following the Russian invasion of Ukraine, Western Europe has set itself the target to eliminate natural gas imports from Russia by 2027. Simultaneously Western European countries are expanding import infrastructure such as LNG terminals.

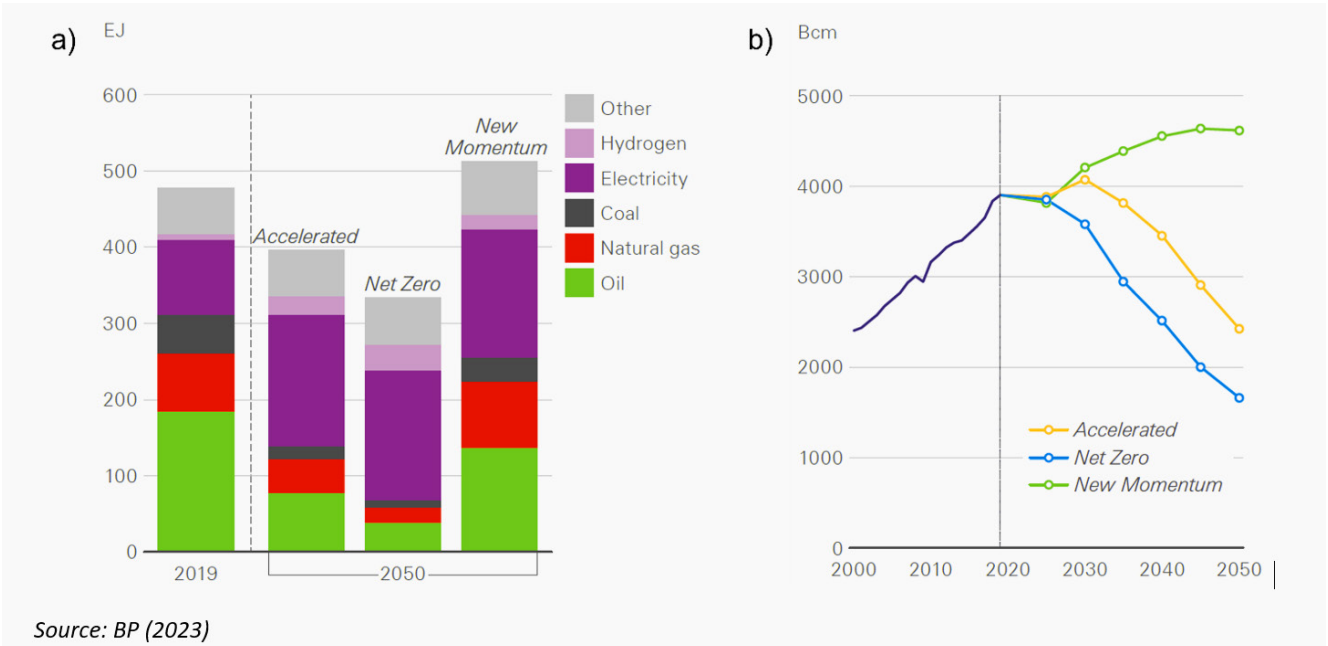
1- Europe's Title Transfer Facility (TTF) is a facility that is widely recognized as the benchmark for natural gas trading in Europe. The TTF provides a transparent and standardized platform for gas buyers and sellers to trade gas contracts, primarily through over-the-counter (OTC) transactions.

The BP Energy Outlook (BP 2023) defines three different scenarios for future energy demand. The NetZero Scenario describes the future global energy system achieving a global emissions reduction scenario by 95% in 2050, the Accelerated Scenario considers a reduction by 75% and the New Momentum Scenario a reduction by 30% compared to 2019 levels.

As shown in Figure 2a), final energy consumption will see a significant decrease of fossil fuels and an increase in global electrification, with a significant decarbonisation of the power sector. In terms of total final consumption (TFC), the share of fossil fuels used decreases from ca. 65% in 2019 to 20-50% in 2050 over all three scenarios. Among hydrocarbons, coal is expected to experience the most significant decline as the world increasingly adopts green electricity and low-carbon hydrogen in various industries. The share of oil also decreases, primarily due to reduced consumption in road transportation.

In contrast to this, the relevance of electricity increases in all three scenarios, with electricity consumption projected to increase by ca. 75% by 2050. This increase occurs uniformly across all scenarios. The future of natural gas depends on two opposing trends: increasing demand in emerging economies due to economic growth and industrialisation, and a shift towards lower-carbon energy in industrialised nations. In the New Momentum and Accelerated scenarios, global gas demand increases over the next decade, driven by China and other emerging Asian countries from industrialisation and switch from coal to gas. However, in the Net Zero scenario, natural gas consumption peaks in the mid-2020s and then starts to decline. While gas use continues to grow in the emerging world until 2030, it is outweighed by decreasing consumption in industrialised countries. From the early 2030s, natural gas demand declines further in the Accelerated and Net Zero scenarios, driven by reduced application in the industrialised world, China, and the Middle East.

Figure 2: BP`s scenarios for a) total energy consumption by fuel b) global natural gas demand



Source: BP (2023)

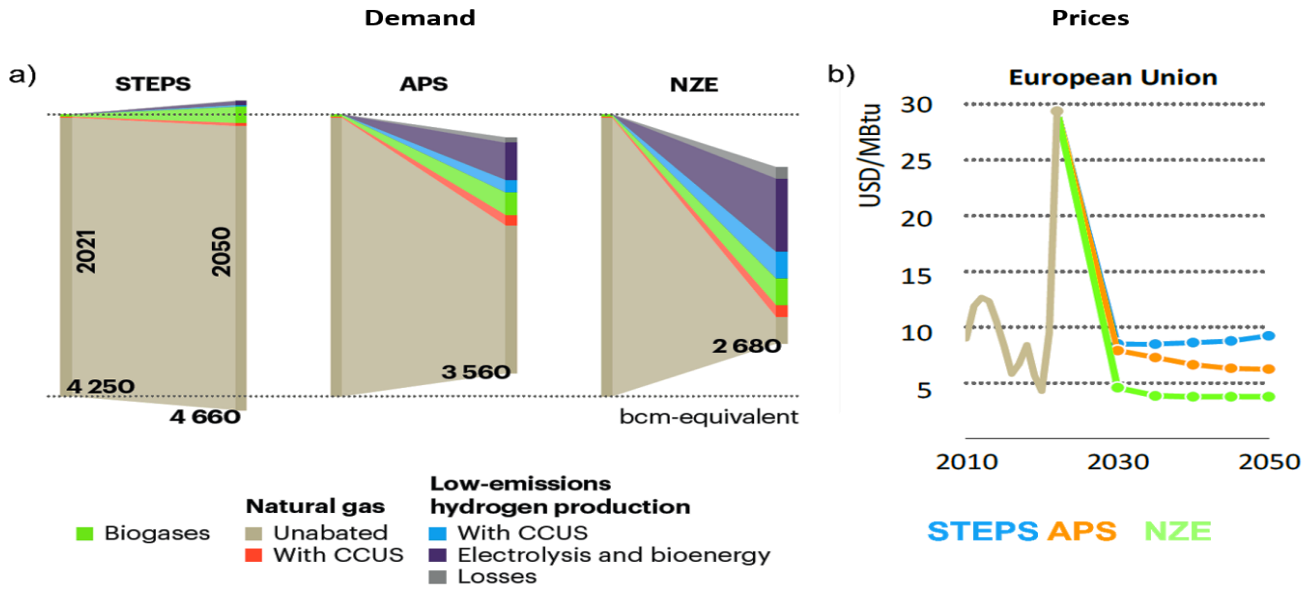
The decline in natural gas demand is partially offset by blue hydrogen production. By 2050, in the Accelerated scenario, natural gas demand is around 40% lower than 2019 levels, and in the Net Zero scenario, it is 55% lower. In contrast, in the New Momentum scenario, global natural gas demand continues to grow throughout the period, reaching around 20% above 2019 levels by 2050 (BP 2022).

The IEA's World Energy Outlook (IEA 2022a) also defines three major scenarios based on the Global Energy and Climate (GEC) Model:

- STEPS is designed to reflect the impact of existing and stated policy frameworks.
- APS assumes that all climate commitments made by governments around the world will be met in full and on time.
- NZE defines a pathway for the global energy sector to achieve net-zero emissions by 2050.

As demonstrated in Figure 3, in the STEP scenario natural gas demand grows at 0.4% per year until 2030, which is much lower than between 2010 and 2021. Demand reaches 4400 bcm in 2030 and remains steady until 2050 due to factors like a global supply squeeze resulting in high gas prices, dampened demand growth prospects in emerging gas markets in Asia, and accelerated European efforts to reduce gas consumption. The deployment of renewables, increased flexibility options in the power sector, and improved efficiency, driven by policies like the Inflation Reduction Act in the United States, contribute to this reduced demand outlook. Coupled with a downward adjustment in GDP growth, global gas demand is projected to be 750 bcm lower by 2050 than previously projected in WEO-2021.

Figure 3: IEA`s scenarios for gaseous fuels



Source: IEA (2022a)

In the APS, global natural gas demand soon reaches its peak and by 2030, it is nearly 10% lower than in 2021. While there is a modest increase in demand in emerging markets and developing economies from 2021 to 2030, it is outweighed by reductions in advanced economies. In these advanced economies, gas is gradually replaced by renewables and offset by efficiency gains, particularly in the buildings sector. The European Union aims to reduce its natural gas demand by almost 45% by 2030. By 2050, global natural gas demand declines by 40% compared to 2021 levels. Low-emission gases, such as hydrogen, biogases, and synthetic methane, will play a significant role, accounting for nearly 30% of total gaseous fuel demand, exceeding 1000 bcm equivalent.

In the Net Zero Scenario, natural gas demand experiences a substantial drop. In 2030 it will be more than 900 bcm lower compared to 2021, representing a decrease of around 20%. By 2050, unabated natural gas meets less than 15% of total gaseous fuel demand, while low-emission gases account for over 70% of the total. Natural gas is either used for non-combustion purposes or equipped with carbon capture, utilisation, and storage. Around 500 bcm of natural gas is utilised with CCUS to produce low-emission hydrogen in 2050, meeting approximately 25% of total hydrogen demand, while the majority will be produced by electrolysis.

Depending on the scenario considered, gas prices in 2050 will range from approximately USD 4 – USD 9/MBTU. The strong price drop in the NZE scenario is caused by the rapid decline in natural gas demand leading to a floor price equal to the marginal cost of gas production and delivery (IEA 2022a).

The conventional justifications for natural gas have primarily revolved around its role as a reliable partner in the shift towards cleaner energy and its capacity to fill the void left by diminishing coal and oil resources. However, these arguments are currently being challenged due to the global repercussions of Russia's actions in Europe. Amidst a worldwide energy crisis, fundamental questions are arising regarding natural gas: how can its supply be guaranteed both today and, in the future, and at what price? The situation in late 2022, with its profound and far-reaching implications, has sparked concerns about the future affordability and availability of natural gas. These concerns have eroded confidence in its reliability and dealt a significant blow to the notion of natural gas as a transitional fuel. As a result, the era of rapid global growth in natural gas demand was seen as coming to an end (IEA 2022a). However, the rapid fall of the natural gas price in Western Europe back to USD 10/MBTU indicates that this fear may have been overblown.

To conclude, both reports generally see an opposing trend regarding natural gas consumption in emerging economies and industrialised nations. In the least ambitious scenarios both reports foresee an increase in natural gas consumption until 2050. The second scenarios (Accelerated & APS), predict a peak of global natural gas consumption around 2030 which will be followed by a massive decrease of demand until 2050. In both Net Zero Scenarios, natural gas demand will experience a significant drop, approximately 20% by 2030. According to the IEA, natural gas consumption will reach approximately 1000 bcm in 2050 of which large amounts will be used for blue hydrogen production or will be combined with CCS-technologies. According to the BP report, natural gas demand in the net-zero scenario will reach approximately 1700 bcm, but even higher percentages will be used for hydrogen production.

Over the last 15 months, interest rates in the key industrialised economies have risen from around zero to more than 4%. This hike is due to the attempt of central banks to fight inflation peaking at levels not seen since the oil crisis of the 1970s, and which has remained persistently high. Economic theory finds that a rise of interest rates leads to a price reduction for fossil fuels including natural gas. Natural gas would thus become more competitive compared to renewable energy. However, the magnitude of this effect is probably small (Schmidt et al. 2019).

Construction of capital-intensive supply infrastructure such as pipelines and LNG terminals and freighters will become more expensive and thus the expansion rate of such infrastructure is likely to slow down.

With rising interest rates and costs around three times lower than those of coal and wind power plants (OECD 2020), natural gas fired power plants have become more competitive. Furthermore, the downward pressure on gas prices will reduce their operating costs, so their competitiveness will increase substantially.

The combined impact of price pressure on natural gas as well as the more competitive position of natural gas power plants thus leads to short-term improvements in natural gas competitiveness, especially if no new transport infrastructure is needed.

According to IEA (2023), despite this positive short-term perspective investors do not want to engage in large gas supply and power generation projects as the increasingly stringent climate policy targets goals darken the perspectives both for producers as well as for users of natural gas. Many importers have been reluctant to commit to long-term contracts for gas supply. A preference for floating regasification terminals which potentially can be transformed from LNG to other energy carriers like hydrogen derivatives has been a way to avoid locking in future emissions.

13 CONCLUSION

Natural gas has seen a significant upswing in the last decades due to several attractive characteristics such as being widely available; easy to use; having a low greenhouse gas intensity; and not being linked to significant local air pollution. It has also benefitted from a symbiotic link to renewable energies where natural gas power plants enable high penetration of renewable electricity sources due to the flexibility of gas power plant operation.

While natural gas had historically been linked to pipelines and supply contracts ran for decades, the expansion of LNG infrastructure has allowed to increase market flexibility and liquidity. Nevertheless, the war in Ukraine and the resulting decoupling of Western Europe from Russian gas delivery has put a spotlight on the remaining dependency on specific supply sources.

Before the emergence of a strong social movement for stringent climate policy in the late 2010s, many climate policy strategies foresaw a strong role for natural gas as a "bridging fuel" between a world built on coal and oil and a future one built on renewable energy. This "bridge" is now thought to be shorter than originally, given that many countries have set net zero emissions targets around 2050. Also, the realisation that upstream emissions of natural gas are higher than previously reported has reduced the appeal of natural gas. Many climate policy advocates now call for a rapid replacement of natural gas by renewables and in a number of industrialised countries, policies supporting a fuel conversion towards natural gas have been scrapped. This is reflected in the massive fall of natural gas use in the main scenarios in IEA (2022a) and BP (2023).

A trend that could lead to larger role of natural gas than in the "bridge scenario" would be a coal to gas conversion in key emerging economies. Just Energy Transition Partnerships that have to date been signed by Indonesia, Senegal, South Africa, and Vietnam focus on retiring existing and preventing new coal power plant capacity and replacing it by renewables. In case of intermittency of the latter, natural gas power plants may become crucial to bolster grid stability (unless other solutions, such as hydrogen-based power storage is used). Given limited resources of natural gas within these countries significant gas imports will be required. As most of the emerging economies have a net zero target date of 2060 or even 2070, it would be attractive to build new natural gas infrastructure.

In a world where climate change is still seen as relevant, but not an extremely pressing concern, leading to a phaseout of coal and (to a lesser extent oil) coupled with carbon dioxide removals, natural gas could see an attractive long-term future. This future would become particularly pertinent if electricity storage faces persistent technological or cost barriers. In such a scenario, natural gas would become the cornerstone of an electrification regime, as gas power would be serving the flexible peak load needed to prevent blackouts. In this scenario, natural gas would remain in use until its reserves are exhausted.

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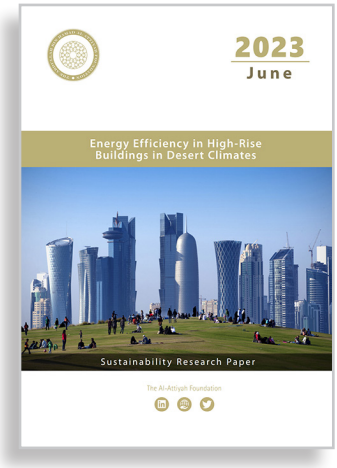

June – 2023

Energy Efficiency in High-Rise Buildings in Desert Climates

The Gulf region has witnessed a significant increase in its number of skyscrapers over the past few decades. This trend of high-rise buildings in the Middle East can be mainly divided into two distinct phases.

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May – 2023

Green Hydrogen Opportunities for the Gulf Region

Green hydrogen can help decarbonise hard-to-abate sectors like refinery, steel and heavy duty transport and the chemical industry. The Gulf region is well positioned to establish itself as a hydrogen hub as it has cheap and abundant renewable energy resources and is located in the vicinity of major hydrogen consumption centres like Europe and Asia.

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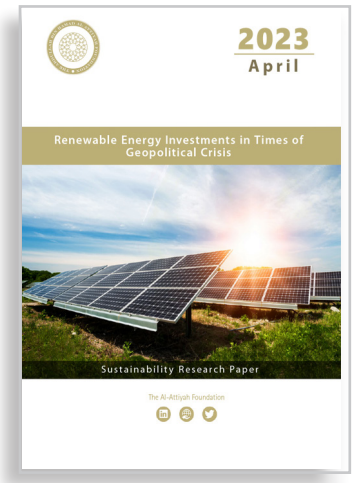

April – 2023

Renewable Energy Investments in Times of Geopolitical Crisis

Since the beginning of the 21st century, renewable energy (RE) for power generation has experienced remarkable global growth and development. By the end of 2022, global RE generation capacity amounted to 3,372 gigawatts (GW), growing the renewable power generation capacity by a record 295 GW or by almost 10% compared to 2021.

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