

**Global energy investment in 2015 amounted to United States dollar (USD) 1.8 trillion, down 8% (in real terms) from 2014 mainly due to a sharp fall in upstream oil and gas investment.** After three years during which the United States was the largest destination for investment in energy supply, the People's Republic of China (hereafter, "China") retook the top position in 2015, largely due to the record level of electricity sector investment in China and the decline of US oil and gas investment. The rebalancing and slowdown of the Chinese economy, which are curbing the country's energy needs, are having a major impact on energy investment globally, largely as a result of lower demand growth for oil, gas and coal. In mature economies such as Europe, Japan and the United States the dominance of the services sector is weakening the link between energy demand and growth in gross domestic product (GDP). These structural changes are reinforced by investment in energy efficiency, which reached USD 220 billion globally in 2015. Given that the majority of upstream oil and gas and almost 40% of electricity sector investment is aimed at replacing ageing assets, substantial investment is essential to maintaining supply security even as macroeconomic and energy policy developments slow demand growth globally. Oil and gas still represent the largest single category of global energy investment, accounting for over 45% of the total. Investment in the electricity sector rose to a record USD 690 billion, or over 37% of the total, despite a marked slowdown in demand growth, driven primarily by the expansion of renewables and networks.

**Fossil fuels continue to dominate energy supply, but the composition of investment flows points towards a reorientation of the energy system.** Oil, the largest primary energy source, slightly increased its share of the global energy mix, but its share of global energy investment declined as the industry reacted to a sharp fall in prices since late 2014 with cuts in capital expenditure, most notably in North America. Unlike oil, gas demand growth remained subdued due to the slowdown of electricity demand and the expansion of renewables that contributed to a fall in gas-fired power generation investment. In addition, low oil and gas prices have also led to cuts in investment in upstream and transportation infrastructure, with most major gas infrastructure projects in East Africa and the Eurasian region facing delays. Coal demand has declined, largely because of China and the United States, but coal has retained its position as the world's second-largest primary fuel. China continued the restructuring of its mining industry, which represents half of global supply, in order to reduce excess capacity. Investment in coal globally is increasingly affected by climate policy, which is expected to drive down demand especially in Europe and the United States. On the other hand, Indian coal production continues to be supported by strong investment. Renewables are expanding rapidly but asymmetrically: wind, solar and hydropower and are reshaping the electricity system. In USD terms

renewable investment has remained relatively stable since 2011, but investment supports an accelerated production expansion due to declining technology costs. On the other hand, with the exception of solar heat in China, the investment in biofuels and renewable heat remains minor.

**Upstream oil investment remained robust in the Russian Federation (hereafter, “Russia”) and the Middle East, helping to push up the share of national oil companies (which dominate production in those regions) in oil and gas upstream investment to an all-time high of 44%.** The relatively low cost of developing reserves in these regions and currency movements that mitigated the fall in the dollar oil price helped to support investment there. While the Middle East produces over one-third of the world’s oil, it accounted for only 12% of global upstream investment due to exceptionally low drilling costs. In Russia, capital spending even increased in ruble terms, helping to stabilise Russian production at a post-Soviet high.

**The impact of low oil prices on cash flow tested the debt-financed investment model of the US shale oil industry, leading to a particularly sharp fall in investment of 52% in that sector** in the past two years. The shorter investment cycle of shale projects and the widespread use of futures hedging has enabled independent shale producers to rely on a highly leveraged business model, in contrast to major oil and gas companies that rely predominantly on internal cash flow for investment. Access to bond markets for US shale companies and the cost of capital are directly influenced by oil prices. While financial pressures in the shale industry remain widespread, despite a recent partial recovery in oil prices, the operators that have filed for bankruptcy represent only a minor proportion of total US non-conventional production.

**Unit capital costs of supply declined across the energy spectrum, with average cost reductions in 2015 ranging from 3% in the case of onshore wind to 30% for US shale oil and gas.** These cost changes are reshaping competition between fuels and technologies. Projects representing over half of total energy investment experienced significant cost declines, notably solar photovoltaic (PV), upstream oil and gas, and electricity storage. While technology improvements and learning-by-doing effects were the dominant drivers, excess capacity in the supply chain also played a major role in pushing down costs, especially for upstream oil and gas. Upstream costs may rebound if investment experiences a cyclical upturn. Some other technologies, such as nuclear power, carbon capture and storage (CCS) and energy-efficient building renovations – whose costs are benefiting less from modularity and learning by doing, risk falling behind in the future, especially if project management risks affect financing.

**Cost deflation, efficiency improvements and reduced activity levels are the key contributors to the steep fall of upstream oil and gas costs, but this trend may not be sustainable in the case that demand for services and equipment picks up rapidly.** Globally, cost reductions explain almost two-thirds of the fall in investment spending, with reduced activity accounting for the rest. At its current level, investment may be insufficient to maintain oil and gas production, indicating tighter markets ahead with different time

horizons. Given that the impact of wind and solar investment on gas-fired generation is far stronger than the competition to oil in transport from alternative technologies, oil markets are likely to rebalance before gas markets, with low-carbon investment putting a lid on gas demand. Nevertheless, the looming collapse in investment in liquefied natural gas (LNG) from 2017, which will result from a lack of final investment decisions on new projects, points to a tightening of LNG markets and potential supply security concerns in the coming years.

**Energy efficiency investment increased by 6% in 2015 despite falling energy prices. Nevertheless, low oil prices risk derailing fuel efficiency improvements in the transport sector, especially in countries with low taxes.** Lower oil prices have had a visible impact on vehicle markets in some regions. The rate of fuel economy improvements in new light-duty vehicle sales slowed by two-thirds in the United States and stagnated in India although it continued to accelerate in China. Reaching fuel economy targets will require robust efficiency standards, which can be reinforced by price incentives such as excise taxes and reduced fossil fuel subsidies. Despite lower oil prices, sales of electric cars (and investment in recharging infrastructure) continue to increase rapidly, driven by government policies in a growing number of countries. They are helping to offset the slowdown in fuel economy in the United States. Investment in other types of energy efficiency is proving resilient to declining fossil fuel prices. Investment in more energy-efficient appliances and equipment is driven mainly by standards and mandates as well as dedicated sources of financing. For energy services such as residential lighting standards have improved the efficiency of lightbulbs so much that the cost of lighting has generally fallen since 2005, despite increases in electricity prices of up to 50% in some countries.

**A major shift in investment towards low-carbon sources of power generation is underway. New low-carbon generation – renewables and nuclear – from capacity coming online in 2015 exceeds the entire growth of global power demand in that year.** Renewables investment, primarily in wind, solar PV and hydropower was almost USD 290 billion. Technological progress and economies of scale are driving down the cost of renewables. The average carbon intensity of power generation from new capacity worldwide continued to fall, reaching 420 kilogrammes of carbon dioxide (CO<sub>2</sub>) per megawatt-hour in 2015. While this decline has been a factor in the stagnation of global CO<sub>2</sub> emissions over the past two years, the current pace of decarbonisation of power generation remains insufficient to meet the climate goal of keeping average temperature increases below 2°C, necessitating stronger policy support. This can draw on recent experience with ramping up investment in and mobilising cheap financing sources for low-carbon energy sources such as long-term contract auctions for renewable energy capacity. Nuclear power investment reached its highest level for two decades in 2015, largely due to the expansion in China, where new nuclear capacity is reducing the need for coal-fired generation. But low wholesale prices, weak carbon price signals and project management problems continue to hinder nuclear investment in Europe and North America, sometimes making even lifetime extension investment uneconomical.

**Higher fuel transportation costs and infrastructure bottlenecks are limiting the competitiveness of gas-fired power generation compared to that of coal in Asia.** In most importing countries, LNG infrastructure to a gas-fired power plant requires twice as much investment as the plant itself. Coal-to-power supply chains are considerably less capital-intensive. Coal mining and transportation infrastructure absorbs only 4% of global energy investment, yet coal meets 28% of global primary energy demand. Given Asia's reliance on long-distance imports, high transportation costs put gas at a competitive disadvantage to coal across the region. Rapid growth in electricity demand, as well as energy security and cost considerations, are continuing to drive large investments in coal-fired capacity in India and the region of the Association of Southeast Asian Nations (ASEAN). On the other hand, gas is the preferred generating option in areas with abundant low-cost resources, such as North America, the Middle East and Russia. In the United States, its cost advantage is reinforced by environmental and climate regulations.

**With recent investment in renewables-based and nuclear power capacity now largely covering electricity demand growth, signs of overinvestment in coal-fired generation have emerged in China.** Macroeconomic restructuring and large-scale energy efficiency investments have put Chinese electricity demand on a structurally slower growth trajectory. Despite a decline in the average utilisation of coal-fired plants, over 70 GW of new projects started construction in 2015. With nearly 200 GW of capacity under construction in the first half of 2016, some coal-fired generators may face further reductions in operating hours and increased difficulty in recovering their capital costs. The Chinese government has since introduced measures to prevent further overinvestment.

**Around 95% of power generation investments rely on vertical integration, long-term contracts or price regulation to manage risks.** The role of wholesale price signals in driving investment in power generation is declining. Utility-scale renewables benefiting from long-term fixed-price contracts or regulated pricing is the largest and fastest-growing component of power generation investment worldwide, representing over half of the total. Consumer-led spending under new business models – including distributed solar PV for households and businesses and corporate buying of renewable power – accounted for over USD 50 billion of renewable investment, led by the United States, Europe and Japan. In North America, low gas prices and the retirement of coal-fired stations are still supporting market-based investment in new conventional generating capacity. Liberalisation is driving investment in Japan. On the other hand, conventional power generation investment has essentially come to a halt in Europe, where the effect of low wholesale prices is being reinforced by the financial weakness of many utilities. Given the looming decommissioning of a large amount of coal, nuclear and even gas capacity in the European Union, energy security concerns are on the rise. Investment in electricity storage is growing but, at USD 10 billion in 2015, remains nowhere near big enough to allay fears of a shortfall in dispatchable capacity. In non-OECD countries, investment in conventional generation generally remains strong, dominated by state-owned utilities and independent power producers contracting with them. The growth in coal-fired capacity remained strong in developing Asia, with over 75 GW starting operation in 2015 – as much as all renewable

capacity additions in the region combined. In sub-Saharan Africa, however, investment remains wholly inadequate to eliminate energy poverty: with 15% of global population and more than half the people without access to electricity, this region represents only 1.5% of global electricity investment. In all regions, a credible investment framework is critical to ensure enough investment to maintain system adequacy and ramp up low-carbon production.

**The growing role of decentralised renewables production does not eliminate the need for continuing investment in the electricity network, given the limited prospects for large-scale electricity storage in the medium term.** In fact, renewables investment often requires additional network investments in order for it to be integrated effectively into the system. The over USD 260 billion invested in electricity networks globally in 2015 is a crucial component of energy security. Almost all of this is subject to regulation, reinforcing the importance of a stable and transparent regulatory environment to maintain adequate investment.

**Although energy markets around the world are generally well supplied at present, investment trends warn against complacency about energy security.** The cuts in upstream oil and gas investment disproportionately affect regions where geopolitical risk is low. While there have been major improvements in project management that have helped to lower costs, there are concerns about the industry's ability to quickly ramp up investment should market conditions warrant it. Investment in inter-regional LNG chains and major pipelines is falling rapidly, in part a result of geopolitical constraints. Given the long lead times of these projects, this decline raises concerns about the adequacy of supply infrastructure in the years to come. In the electricity sector, wind and solar are now meeting a substantial proportion of the growth in demand in annual production volumes, but integrating them effectively into the power system requires additional investment and changing operational methods across the electricity system. In many countries, there is a policy debate about the ability of the current regulatory institutions to achieve this. Investment in flexible types of electricity generation, such as gas power, is crawling to a halt in Europe and there are emerging uncertainties about its prospects in North America. In emerging markets such as Mexico and India, long-term contracts are helping to mobilise investment in renewables, but difficulties in upgrading the grid in order to integrate them into the system persist. Investment in transmission lines is critically dependent on the regulatory framework and often faces licencing obstacles. For systems where variable renewables account for a large and growing share of the power generation mix, investment in both electricity storage and smart demand-response solutions will need to expand substantially. A consistent, investment-friendly policy and regulatory environment remains crucial for maintaining energy security.

**Globally, energy investment is not yet consistent with the transition to a low-carbon energy system envisaged in the Paris Climate Agreement reached at the end of 2015.** While wind, solar PV and electric-vehicle investments are broadly on a trajectory consistent with limiting the increase in global temperature to 2°C, investment in other low-carbon

technologies is falling behind. In several countries, nuclear capacity is ageing with little investment going to replacement capacity, and renewables are struggling to compensate for reduced nuclear output. Large-scale investment in CCS has yet to take off. On the demand side, economically viable alternatives to oil have yet to emerge in aviation, heavy-duty transport and shipping, which collectively account for the bulk of oil consumption. And large investments are still being made in highly inefficient subcritical coal plants, which risk locking in carbon emissions for decades. A combination of accelerated technological innovation and an investment framework aimed at encouraging rapid, large-scale deployment of low-carbon technologies will be essential to steer the transformation of the energy system in a timely way in order to jointly achieve climate and energy security objectives.