

FUNDAMENTALS

The nuclear option

Does a decarbonising world need atomic energy?



Nick is the Head of Commodity Research at Legal & General Investment Management (LGIM). He joined in 2013 as a Fund Manager in LGIM's Global Equity team, focused on energy and natural resources.

- Does expensive, complex and potentially dangerous nuclear power have a role to play in the energy mix of the future?
- In the US and Europe, probably not. It's too expensive
- However, we think investors who write off nuclear altogether are missing a renaissance taking place in Asia, enabled by the structural market differences

On 27 June 1954, the 'peaceful atom' – the world's first commercial nuclear reactor – began generating electricity for the Russian grid. Nuclear reactors were soon adopted in a number of countries, initially in the UK, France and the US. Energy experts declared that a new age of clean, sustainable energy had arrived.

The nuclear industry has disappointed investors, commentators and utilities ever since.

THE PERPETUAL DISAPPOINTMENT

The promise of a nuclear future: a proliferation of nuclear power, where cheap and abundant energy would end both pollution and energy poverty, has not arrived.

In much of the Western world the reactor fleet is ageing. In the US, ultra-cheap gas, combined with the ever-falling cost of renewables, is even putting existing reactors at risk of closure. In Europe, they are likely to remain economically viable for some time, but there are very few new reactors being built, as high construction costs have rendered them uncompetitive. For example, Hitachi's decision to abandon Wylfa and write off nearly \$3 billion of sunk costs has left the UK with only one reactor under construction. The vast majority of the existing fleet is likely to shut by 2030.

Public perception has not been improving either. Following a series

of disasters; Germany, Taiwan and South Korea have all either expressed significant reservations about the role of nuclear power in their economies, or actively rejected it. Even in Europe's nuclear powerhouse – France – policy and public perception appears to be hardening.

The contrast between renewables and nuclear power is stark. Most forecasters studying renewables have been positively surprised, year after year, as installation rates and cost reductions have exceeded expectations. In many electricity grids, renewable power can now compete with fossil fuels, unsubsidised. Where renewables do not yet compete, we think they are likely to do so within a few years.

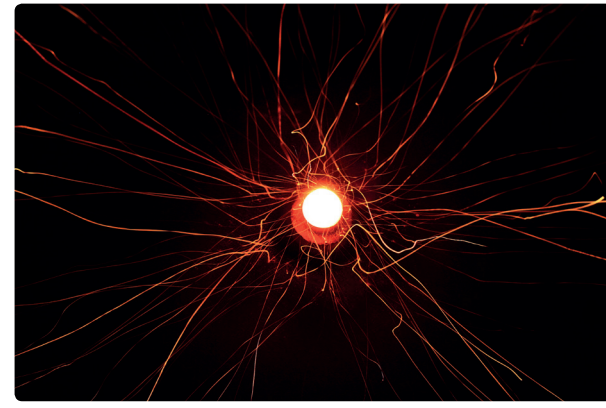
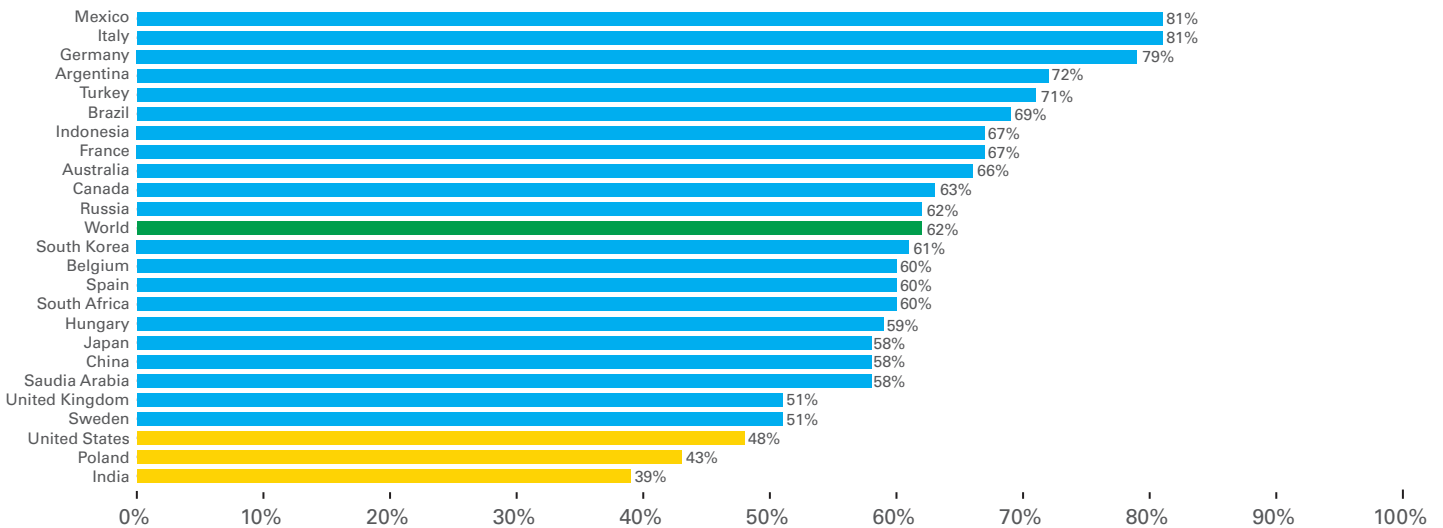


Figure 1: Public opposition to nuclear energy production after the Fukushima disaster



Share of public who oppose nuclear as a means of electricity production in 2011. This constitutes the sum of respondents who stated they were either "somewhat opposed" or "strongly opposed" to nuclear energy. Source: Ipsos MORI

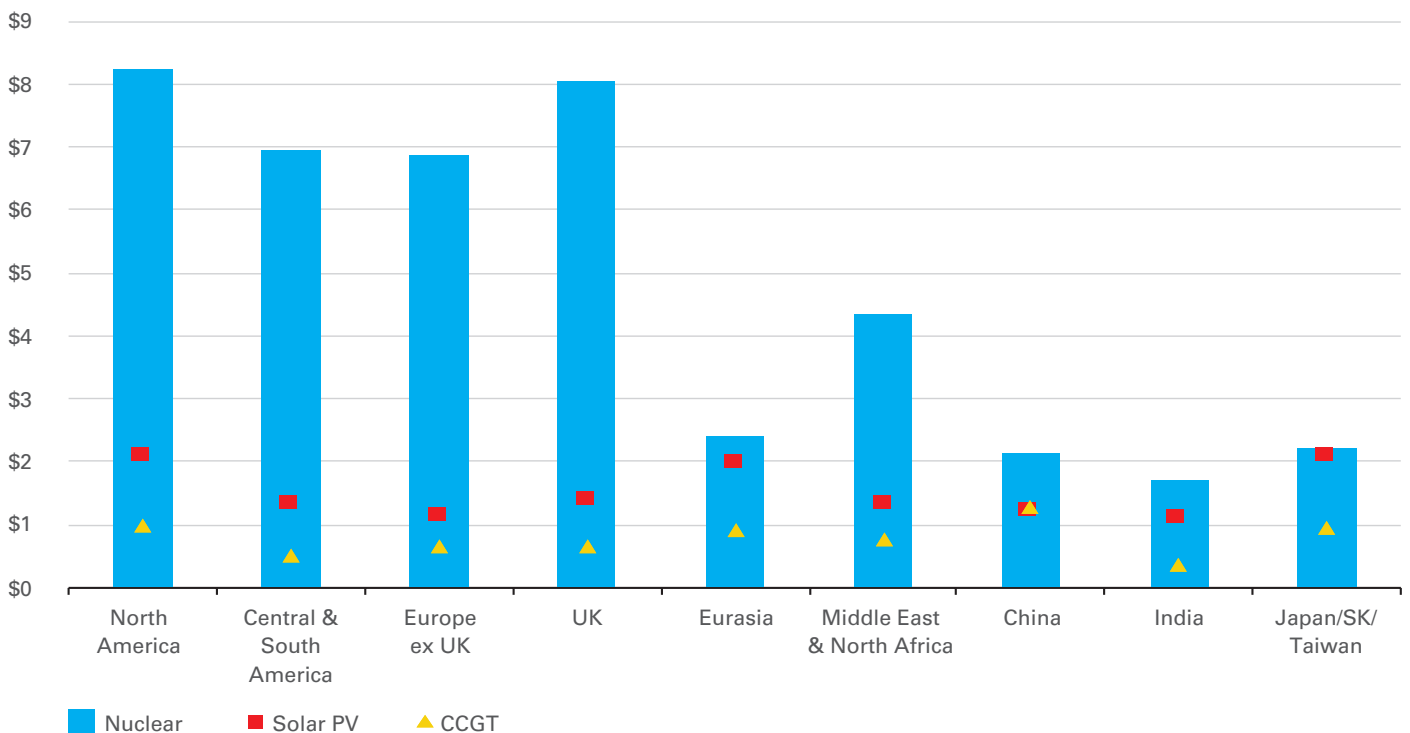
While some new reactors will be built to maintain a diversity of supply, the future of Western nuclear power looks dim. As a consequence, many investors have concluded that nuclear power will play only a marginal role, if any, in the energy mix of the future.

AN ASIAN NUCLEAR RENAISSANCE

We think differently – that the world is actually at the cusp of a nuclear renaissance – but one that is almost exclusively going to take place in Asia and emerging markets.

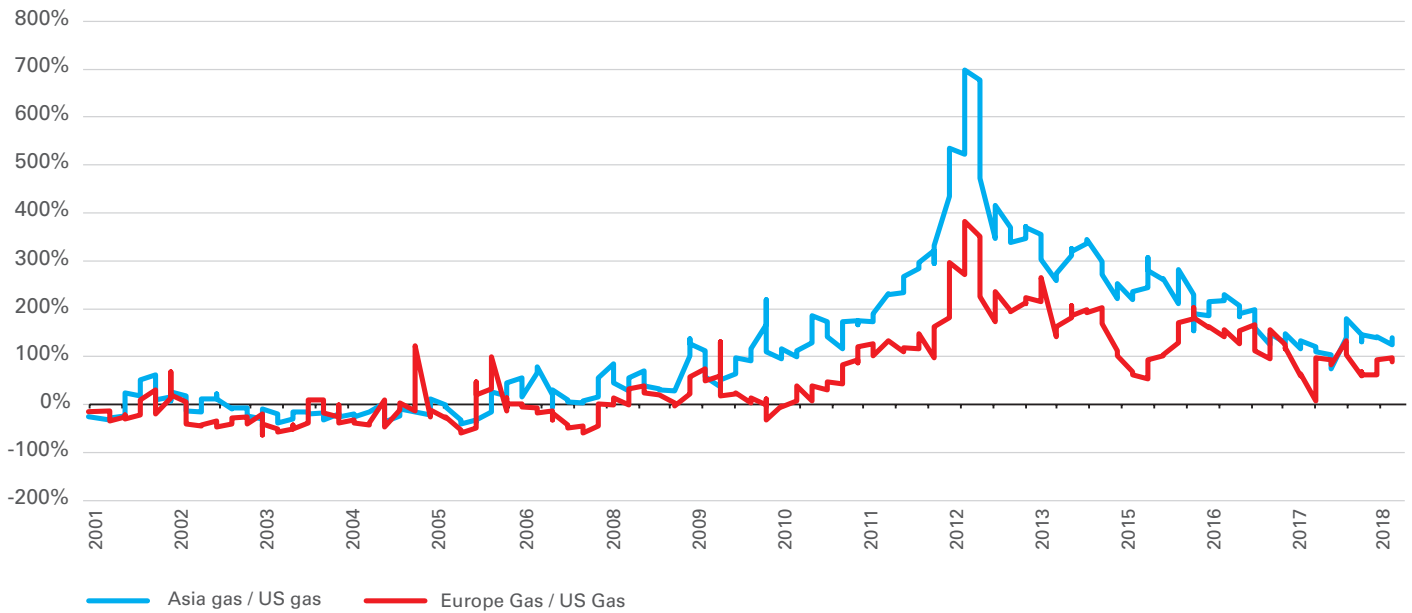
There are a number of reasons for this, but the biggest is the relative cost. In many emerging markets, especially in Asia, nuclear is at the bottom of power generation cost curves (graphs showing the cost of production as a result of the quantity produced), rather than being at the top, as it is in the US and Europe.

Figure 2: Capital costs for new capacity by region (\$mn / Mw)



Source: LGIM research. As at 2018.

Figure 3: Energy cost ratios in Asia versus the US and Europe



Source: LGIM research, Bloomberg

The nuclear industry in Asia has achieved cost efficiencies that have eluded providers elsewhere. A strong competitive advantage in skilled engineering labour rates has been a significant contributor. Standardisation has been another. The Korea Electric Power Corporation (KEPCO), Korea's domestic nuclear champion, has sponsored the construction of highly standardised reactor designs which are significantly cheaper than the complex projects that have recently been proposed in Europe. Lower financing costs, and an efficient and established supply chain have helped reduce construction costs further.

EXPENSIVE ENERGY ALTERNATIVES

The second factor driving the adoption of nuclear in Asia has been the relative cost of alternatives. The US is endowed with a large and very cheap domestic gas resource, and European gas prices have been moderated by the availability of relatively inexpensive Russian gas. By contrast, Asia is overwhelmingly dependent on relatively costly liquefied natural gas (LNG), the price of which is linked to oil and has expensive embedded transportation costs.

Nuclear is an extremely attractive alternative to burning gas for

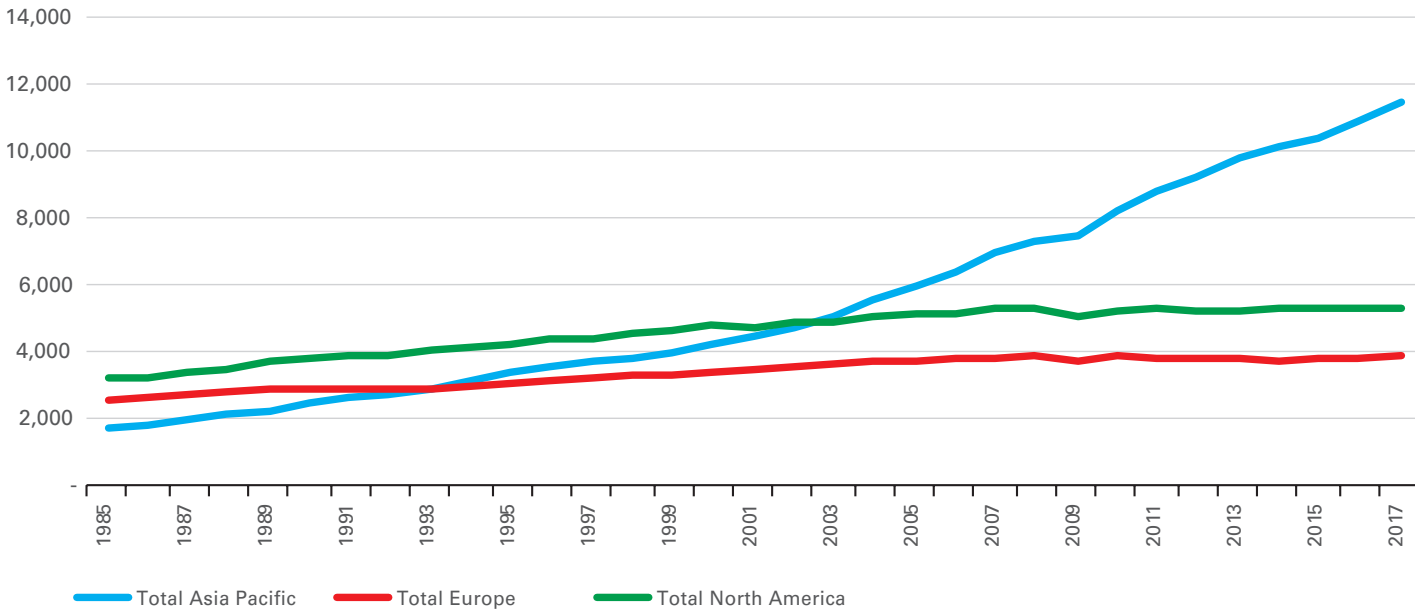
baseload power¹ given not just the cost, but also the desire to limit energy dependence on the outside world, which especially exists in China.

AN URGENT NEED TO MITIGATE POLLUTION AND CARBON

Many Asian end markets – especially China and India – are facing a very different end-demand pattern to that which exists in Europe and the US. In the Western energy markets of recent years, efficiency and ongoing deindustrialisation have offset the effects of economic growth, leading to broadly flat electricity demand. By contrast, Asian demand is rapidly growing, and we think that is likely to continue.

1. The supply of electricity that can be predictably generated to meet the average level of demand during the course of a day.

Figure 4: Asian, European and North American electricity demand in terawatt hours (TWh)



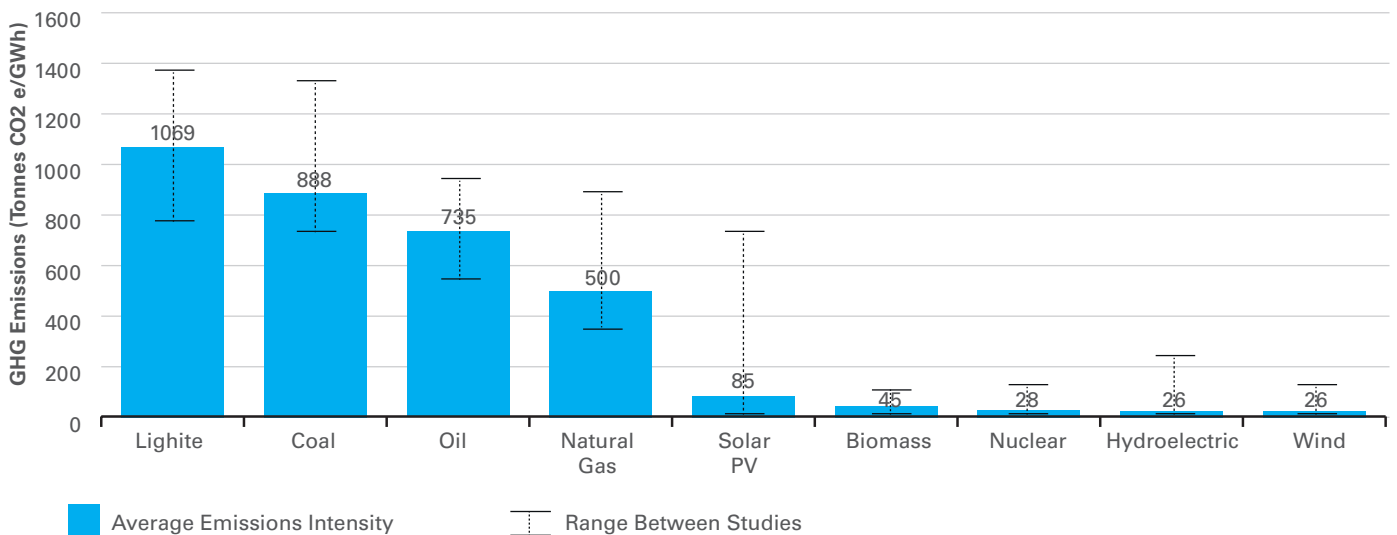
Source: LGIM Analysis, BP statistical review

The challenge to clean up and decarbonise Asian energy systems is even more extreme than it is in the US and Europe. Nuclear power represents an extremely attractive option to provide clean, decarbonised electricity. While

estimates vary, and calculations are imprecise, most studies agree that nuclear power produces at least as few carbon emissions, if not fewer, than renewables. Importantly, nuclear power is also fundamentally 'dispatchable' – it

can be used on demand as the power grid operators require. This is as opposed to wind and solar energy, which produce electricity only intermittently.

Figure 5: Carbon emissions per type of energy source



Source: LGIM Analysis, World Nuclear Association, International Energy Agency, International Atomic Energy Agency, World Energy Council, Australian Government, OEC Nuclear Energy Agency, European Commission. As at July 2013.

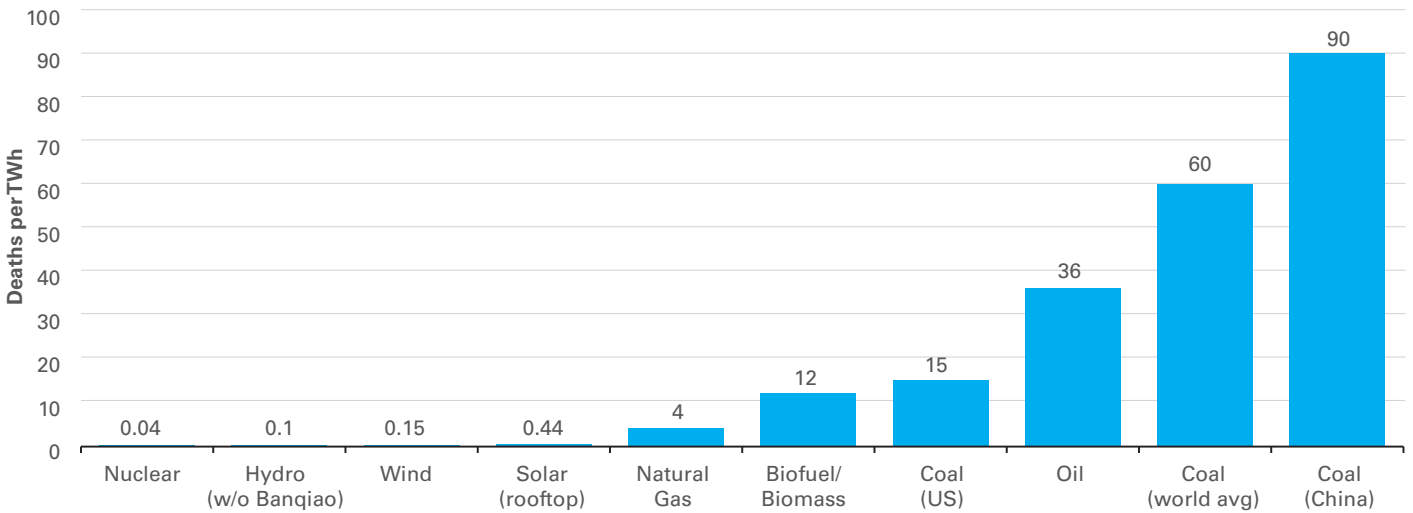
PUTTING SAFETY CONCERNS IN CONTEXT

Despite the promise of clean and cheap energy, most polls suggest that the public has been sceptical of nuclear power from the start. However, public opposition has significantly increased following each of the

three major catastrophes in the history of nuclear power – Three Mile Island, Chernobyl and Fukushima. Public opposition to nuclear power has not just limited the growth of new nuclear power, but has even led to countries with existing nuclear fleets committing to either prematurely close, or not

to renew working reactors. The underlying concerns about nuclear safety are based on the very real, and unique, safety and environmental challenges posed by nuclear power. That public concerns about nuclear power are elevated after these tragedies, is unsurprising.

Figure 6: The human life toll of different energy sources



Source: LGIM analysis, International Energy Agency. Range from 2002 - 2011.

However, these concerns should be viewed in the context of the safety implications of the alternatives. Academic studies that have attempted to measure the relative safety of different methods have generally concluded that nuclear power is amongst the safest ways of generating electricity. One way of measuring this is to look at the number of human lives lost per unit of electricity generated. These studies are controversial – and academics have reached different conclusions, depending on assumptions. But when compared

with the enormous harm to human health posed by pollution from coal, nuclear could be considered at least as safe, if not safer, than both wind and solar.²

THE CONSEQUENCES FOR LONG-TERM INVESTORS

There are some directly investable ways for long-term investors to gain exposure to the nuclear industry. The key commodity which goes into nuclear power generation – uranium – currently trades at prices significantly below the incentive price needed to help

stimulate the demand for nuclear energy that will exist if we are correct in our view. This reflects what we perceive to be widespread negativity in many investors’ minds towards this industry. A select number of companies in this industry may turn out to be very profitable investments, throughout the nuclear and nuclear fuel industries. However, this is always going to be an area of niche interest to investors given the size of these companies and markets. We think there are other, more significant implications.

2. Studies include:
<https://www.newscientist.com/article/mg20928053.600-fossil-fuels-are-far-deadlier-than-nuclear-power/>
<https://www.energycentral.com/c/ec/deaths-nuclear-energy-compared-other-causes>
<https://www.nextbigfuture.com/2011/03/deaths-per-twh-by-energy-source.html>
<https://nuclear-economics.com/>, http://www.externe.info/externe_d7?q=node/8
<http://www.nuceng.ca/refer/risk/risk.html>, <https://www.nextbigfuture.com/2011/03/iea-comparison-of-sources-of.html>
<https://www.businessinsider.com/dam-safety-statistics-risk-of-death-2017-2?r=US&IR=T>

TRANSFORMING THE ASIAN ENERGY MIX

We believe the nuclear renaissance that is occurring in Asia should reinforce investor confidence that Asian markets can drive coal out of their energy mix faster than the market expects. There is a high cost associated with burning fossil fuels.

We believe that coal is likely to be displaced much faster than many investors anticipate, by gas in heating and industrial applications; and with an important role to play by nuclear in displacing it from the electricity generation mix. There may also be important implications for the future of LNG demand – if nuclear can meet much of the needs of replacing coal in the generation mix, this may also limit some of the more extreme projections of LNG demand as the need for baseload gas generation in Asia is limited. It may also depress the rate at which Asian markets adopt grid scale battery storage.³ Renewables will

clearly have a large and important role to play in Asian markets, just as they are going to here in Europe. A substantial increase in grid scale battery storage will likely be required – but a lot less than would otherwise be the case.

There may be consequences for renewable investors too. Nuclear power does not ‘throttle’ up and down as well as some other sources of electricity – it works best when it is generating energy at a constant rate. In markets where there is a large nuclear baseload – as we envisage Asian markets to have in 10 to 20 years’ time – it may end up being the case that intermittent renewables rather than baseload nuclear are curtailed at times of oversupply. Whilst there is no evidence of this yet, it is possible that Asian and Western electricity grids end up significantly diverging in areas as foundational as this sort of basic operating principle.

A NEW LEASE OF NUCLEAR LIFE

The prospects for nuclear in Europe and Asia could not be more different. In Europe, nuclear looks like an old-world technology struggling to keep up with an energy market which is changing at an incredibly rapid pace. In Asia, costs and market structures give nuclear a competitive edge that is likely to support continued rapid adoption of the technology in their energy mix. Nuclear can enable many Asian countries, China and India especially, to have control of their own energy destinies – providing cheap, reliable and independent electricity, supplemented by large-scale renewables. After disappointing for fifty years, we think nuclear power is about to start living up to its original promise.

3. A collection of methods used to store electrical energy on a large scale within an electrical power grid.

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Legal & General Investment Management Ltd, One Coleman Street, London, EC2R 5AA www.lgim.com

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