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Nuclear Renaissance: Myth or Reality?

Moscow, 10 June 2014

THE BOSTON CONSULTING GROUP

Today's discussion topics

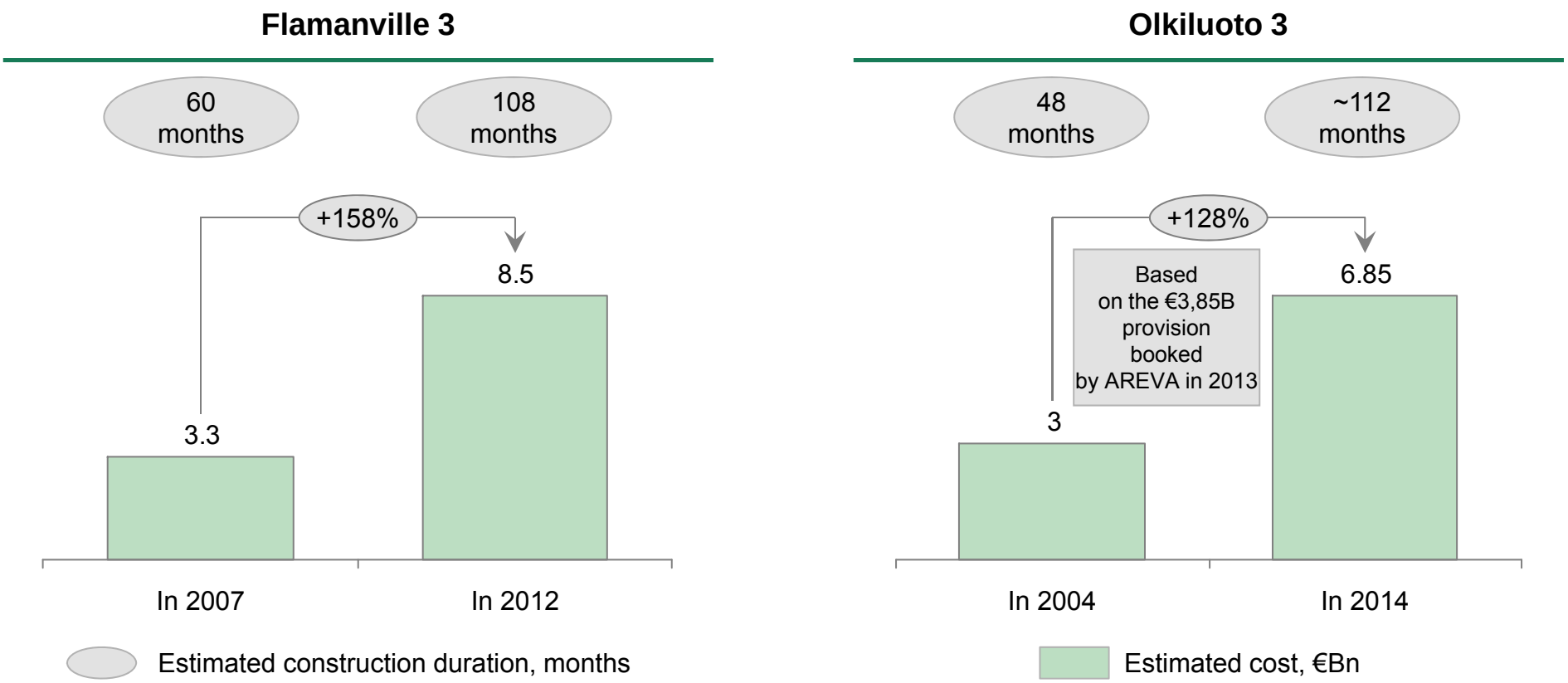
Nuclear Renaissance: Myth or Reality?

£92.5/MWh[1]

£66/MWh[2]

1. Negotiated strike price for Hinkley Point C 2. Current FiT for >250kW installations offered by Ofgem in UK
Source: Fraunhofer institute, Press searches

Poor track record of new builds indicates that initial investment assessments tend to underestimate the costs



Other examples of overruns exists: Kudankulam Nuclear Project (India), Vogtle (U.S.), V.C. Summer (U.S.)

Source: EDF and AREVA annual reports; Press research

In many countries nuclear plans are on hold or phase out decided

Germany

Nuclear shut-down
- Strong reaction from public opinion/ government
- Shut down of all installed nuclear capacity by 2025

Massive shift to renewable energy
- Strong investments in renewables
- Buildup of renewables "on top" of conventional system

Japan

Strong Fukushima impact
- Initial decision to shut down and decommission all working reactors by 2040
- Now all reactors are still stopped until significant revision/ safety tests
- No new builds planned

Belgium

Announced a nuclear exit next to Germany
- Plans to decommission 3 reactors by 2015
- Gradual phase out for the remaining nuclear capacities

Italy

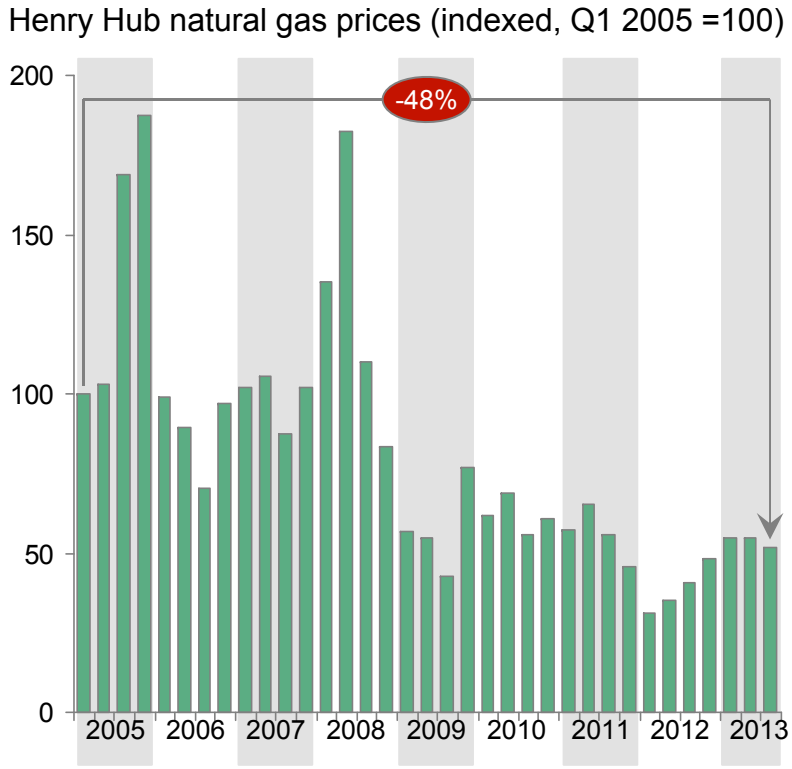
Full public rejection of nuclear energy
- All nuclear plants shut down after first Italian nuclear power referendum held in 1987
- Public referendum in June 2011 banned any new construction in nuclear sphere again

Switzerland

Gradual phase out of nuclear power plants
- No new builds planned
- Run existing units until it's economically reasonable

Shale gas revolution has already undermined future development of nuclear in the U.S.

Shale gas development has led to quickly declining natural gas prices in U.S. …



… which further questioned development of largely unprofitable nuclear energy sector

"We see no room for nuclear to expand in the U.S. at this time. So we are being realistic. U.S. nuclear is no longer a priority for us"

Henri Proglio, Chairman and CEO at France's Electricite de France (EDF)

"It's just hard to justify nuclear, really hard. Gas is so cheap and at some point, really, economics rule"

Jeff Immelt, the chief executive of General Electric in interview to FT

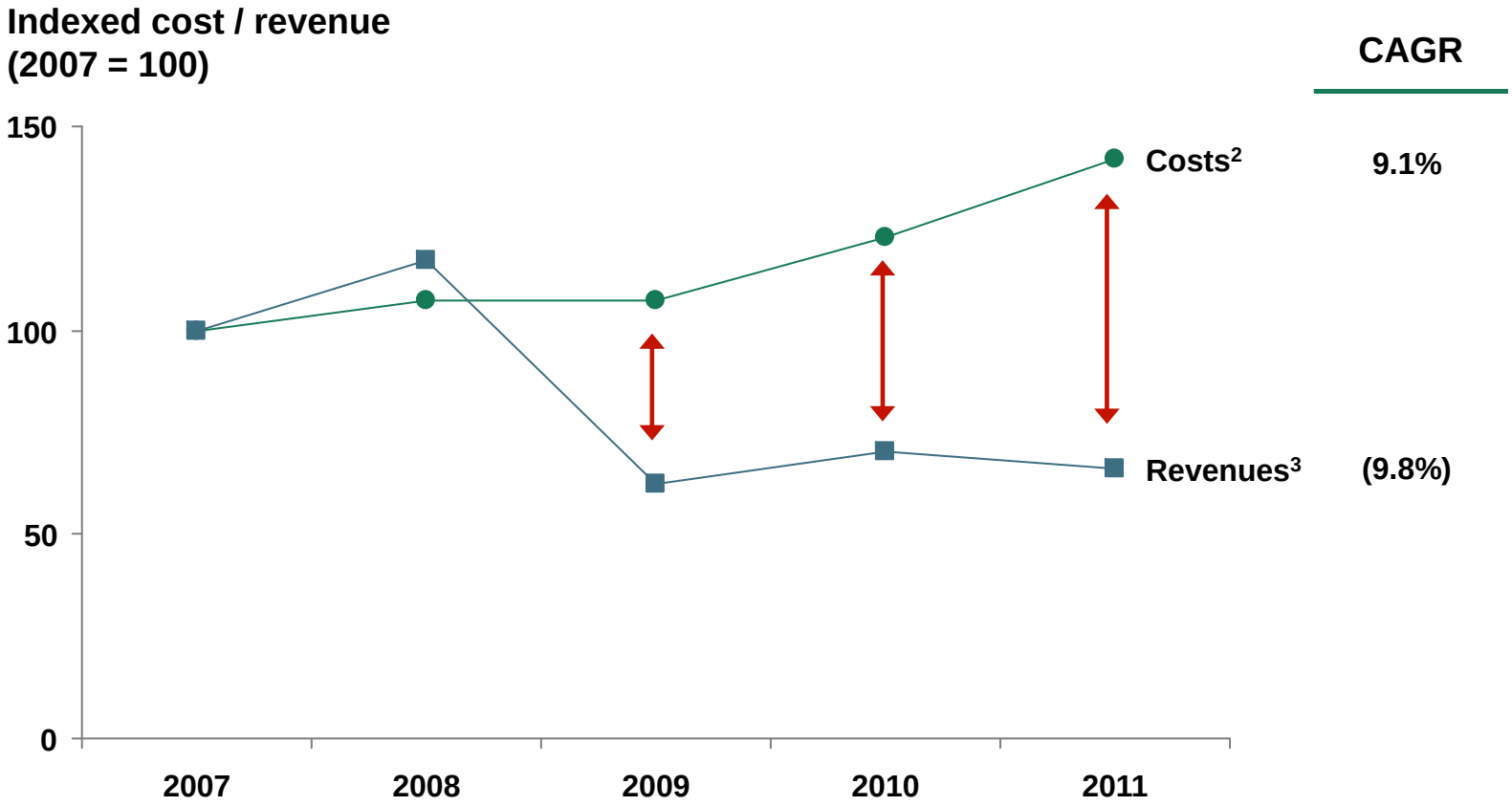
" You don't build a new plant for the sake of monument building. You only do it if it makes economic sense. Right now, it doesn't. If it did, the capital would be readily available"

John Rowe, ex-CEO of Exelon

Source: IEA quarterly energy price and tax statistics; EIA Natural Gas Monthly; Utilitydive.com; Financial times; Businessweek.com

Economics of US nuclear fleet are challenged as a result of low power prices and increasing cash costs

Indexed cost / revenue profile of nuclear plants, 2007-2011
(Example ISO: NewYork[1], unregulated)



1. 5 plants (all unregulated): Indian Points 2, Indian Point 3, James A. FitzPatrick, Nine Mile Point, R.E. Ginna/Ontario Sta. 13 2. Costs: Include Fuel, Total Non-Fuel Operating expenses, Total Maintenance expenses 3. Include capacity payments
Source: SNL financial, FERC (Energy Velocity), BCG analysis

If not renaissance, are there any chances for nuclear at all?

Poor track record of new build	+	Nuclear context	+	Challenging power economics
EPR • Olkilouto 3 • Flamanville **AP1000** • Vogtle 3&4 • Summer		**Fukushima requirements**		**Low gas price**
		Increasing operating costs		**Intermittent must run units *aka renewable***
		Increased public concern		**Lack of sustained CO2 price signal**

Since renewable energy fluctuates there is a need for storage and/or back up solutions

Renewables wind and PV are a powerful source of energy …

… but not always

PV

Wind

Conventional energy generation capacities should anyway remain operable OR enough storage created

Source: BCG

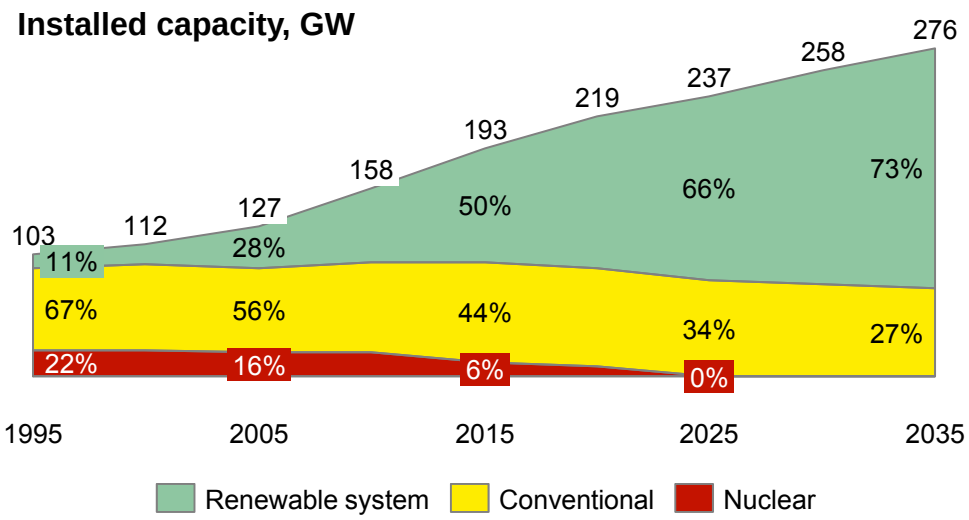
Taking into account all required "add-ons" renewables turn to a costly competitor to nuclear

Additional cost buckets should be considered for renewable

- Costs for back up and/or storage solutions
- Grid connection and grid extension
- Building new conventional capacities to replaces aging ones while renewable solutions are not yet mature to offer enough scale

German dedication to renewable sources of energy have a high price

- Two parallel systems to be run: renewable built "on top" of the conventional system
- Total installed capacity is to be nearly twice bigger

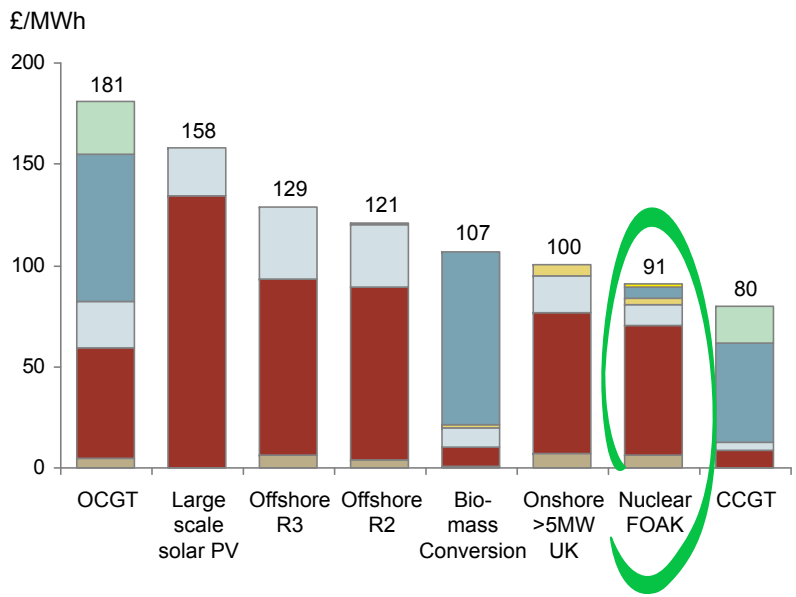


System costs of generation and grid in Germany will be at least 50%[1] higher than that of conventional system by 2033

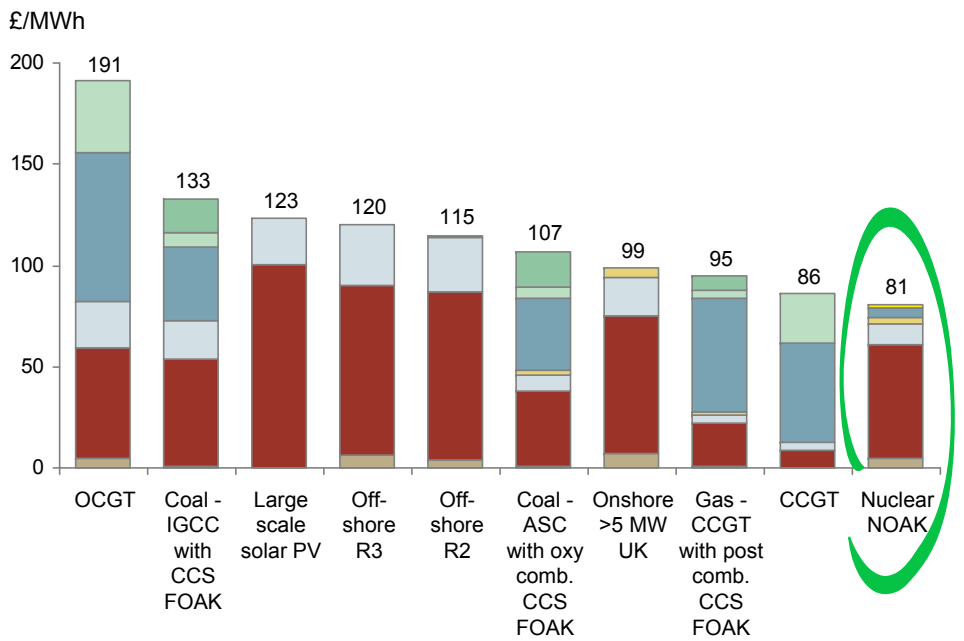
1. w/o CO2 certificates taken into account
Source: BCG

Levelized costs of nuclear energy are competitive now and are going to stay so in the nearest future

LCOE for Projects start in 2013



LCOE for Projects start in 2019



Cost for most technologies may vary greatly depending on country specifics

Note: 1. FOAK – First of a Kind 2. NOAK – Nth of a Kind 3. 10% discount rate applied 4. OCGT levelised costs have been calculated at a low load factor to reflect the fact that it tends to operate as a peaking plant. This low load factor results in a higher levelised cost for OCGT
Source: Electricity Generation Costs (December 2013); Department of Energy and Climate Change UK

The three factors why Nuclear will continue to expand long term

Environmental concerns

Ambitious CO_2 emission reduction targets in EU and US

Fossil fuel fired power generation is a key source of GHG emissions

Security of supply

Diversified and stable sources

- 40% of production stems from Canada and Australia
- Supplies available on all continents
- Fuel represents less than 10% of the total cost

Resources shortage unlikely

- At least 200 years reserves at 2009 consumption rate
- Stock levels account for a period 20 times longer than for gas and oil

Higher resources price predictability

Cost competitiveness

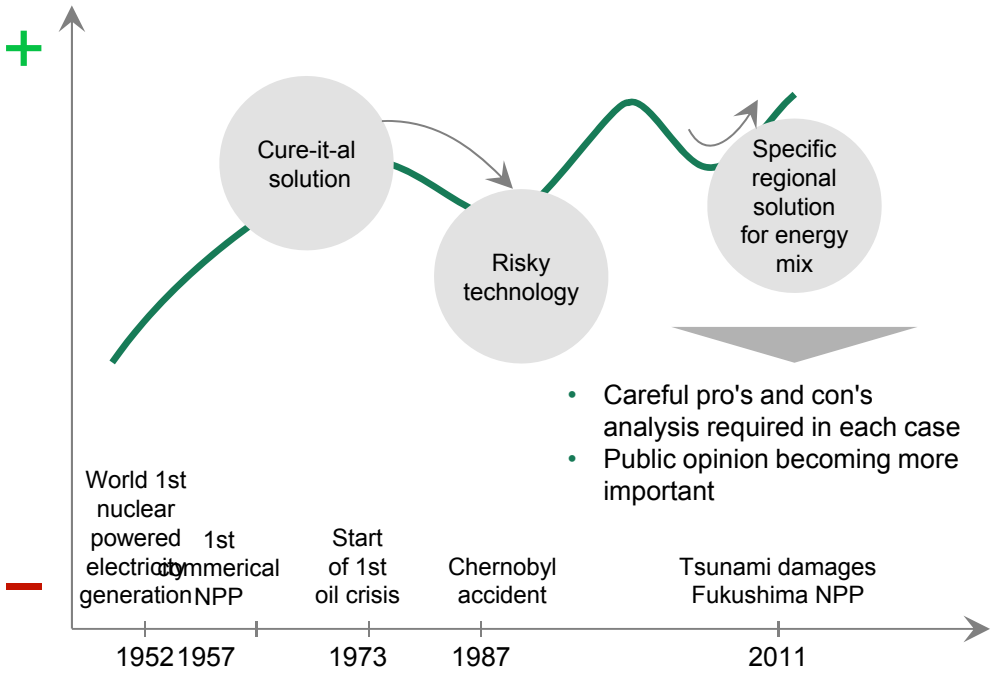
Nuclear energy is cost-competitive compared to other available power generation technologies if full costs are taken into account

The issues with cost and time overruns with new builds will be overcome as the industry goes through the learning curve

1. Statement by President Obama (2009) 2. EU energetic policy "20-20-20" (2008) 3. Philip Lowe, Director General for Energy European Commission
Source : BCG analysis

Nuclear will still play an important role in energy mix of many countries

Ups and downs in the confidence in nuclear energy



- Careful pro's and con's analysis required in each case
- Public opinion becoming more important

In many cases, nuclear pay a big role in building a balanced energy portfolio

Need for a reliable long term solution

- Aging power plants need to shut down
- Serious commitment to CO2 emission reduction prevents from using traditional fossil

Security of supply

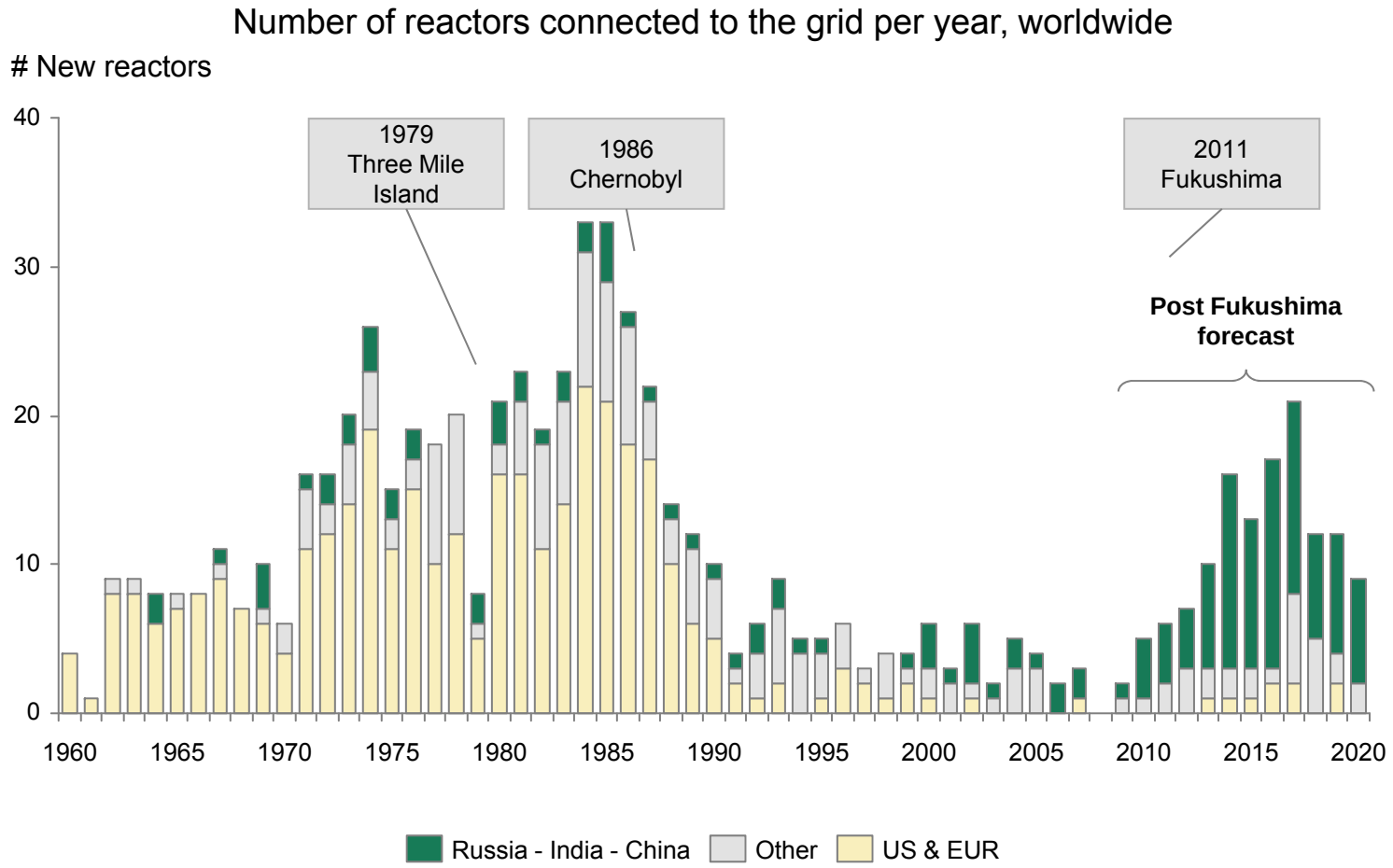
- Hedge against fluctuation in fossil fuel prices
- Support of diversified energy portfolio

Restarting nuclear energy generation

- Need to minimize dependence on import of fossil fuels
- Need to lower current electricity prices
- Little potential with renewables

Source: BCG

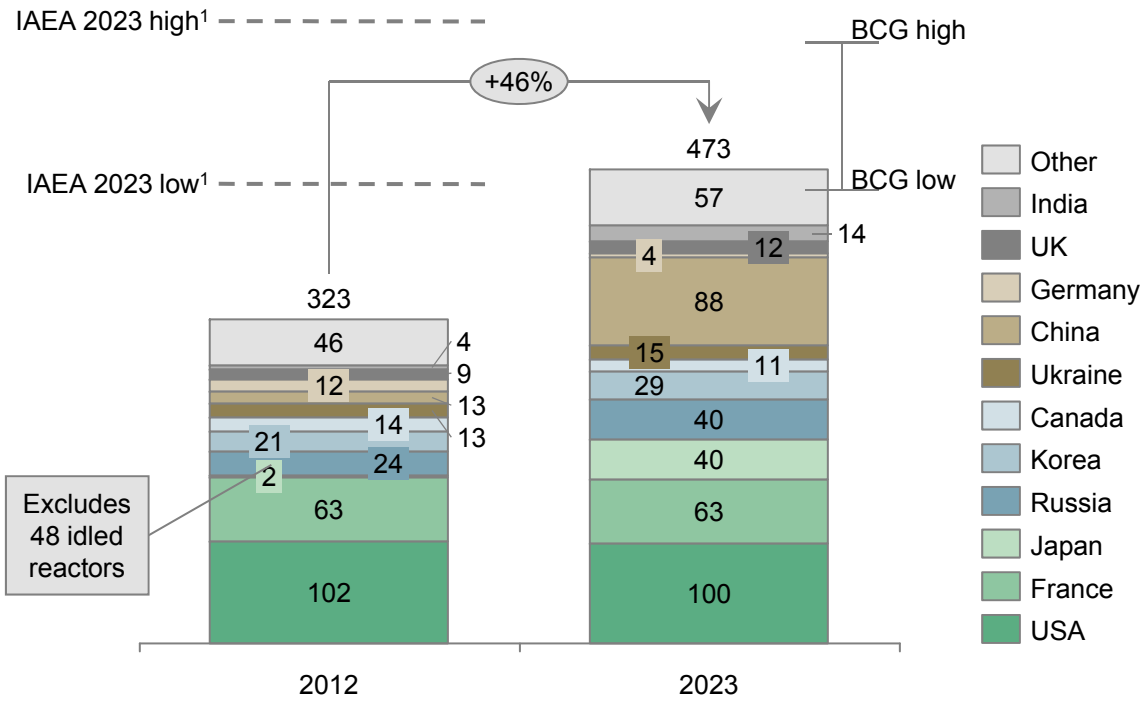
Moderate uplift and geographical shift after Fukushima will be seen in nuclear new builds



Note: Taiwan is included in "Other"
Source: PRIS; WNA

Renaissance is likely to be regional rather than global

Expected installed capacity by country (GW)



1. Uses IAEA 2030 predictions and assumes linear growth.
Source: 2013 IAEA Nuclear Technology Review; World Energy Council; World Energy Perspective; Appendix A; BCG analysis

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Thank you

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