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THE WORLD NUCLEAR INDUSTRY

STATUS REPORT 2017

The World Nuclear Industry Status Report 2017

Foreword by

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The cover page was designed by Agnès Stienne. The picture below the solar panel is based on a photography of the Juragua site in Cuba, where building of two Russian-designed 413 MW reactors started in 1983 and was abandoned in 1992. Photography by © Darmon Richter – August 2014.

TABLE OF CONTENTS

FOREWORD	10
KEY INSIGHTS IN BRIEF	12
EXECUTIVE SUMMARY AND CONCLUSIONS	13
INTRODUCTION	21
GENERAL OVERVIEW WORLDWIDE	23
THE ROLE OF NUCLEAR POWER	23
OPERATION, POWER GENERATION, AGE DISTRIBUTION	26
OVERVIEW OF CURRENT NEW BUILD	30
CONSTRUCTION TIMES	32
CONSTRUCTION TIMES OF REACTORS CURRENTLY UNDER CONSTRUCTION	32
CONSTRUCTION TIMES OF PAST AND CURRENTLY OPERATING REACTORS	32
CONSTRUCTION STARTS AND CANCELLATIONS	34
OPERATING AGE	37
LIFETIME PROJECTIONS	40
FOCUS COUNTRIES	43
FRANCE FOCUS	43
Introduction	43
French Nuclear Power and Electricity Mix	44
The Troubled Flamanville-3 EPR and the Creusot Forge Affair	47
Rising Costs and a Lurking Investment Wall	50
GERMANY FOCUS	52
JAPAN FOCUS	56
Restart Prospects	57
Energy Policy	59
Restarts	60
Critical Aging and Life Extensions	62
Monju Shutdown	65
New Build Projects	67
SOUTH KOREA FOCUS	69
Future of Nuclear Power	69
UNITED KINGDOM FOCUS	72

UNITED STATES FOCUS	78
Securing Financing, Shutdowns and Reversing Shutdowns	80
New Reactor Construction	91
Vogtle and V.C. Summer AP1000 Projects	91
Construction	93
Vogtle	94
V.C. Summer	96
Quality-Control Failures, Disputes and Acquisitions	96
Uncertainty Over V.C. Summer and Plant Vogtle	97
Factors Determining the Future of Vogtle and V.C. Summer	98
Westinghouse / Toshiba Guarantees	98
Federal Loan Guarantees	99
Tax Credits	100
Costs to Customers and the Position of the Public Services Commissions	101
President Trump on Nuclear Power	102
Termination of V.C. Summer project	103
POTENTIAL NEWCOMER COUNTRIES	104
UNDER CONSTRUCTION	105
CONTRACTS SIGNED	108
“COMMITTED PLANS”	113
“WELL DEVELOPED PLANS”	118
“DEVELOPING PLANS”	120
CONCLUSION ON POTENTIAL NEWCOMER COUNTRIES	122
NUCLEAR FINANCES A TOUGH MARKET ENVIRONMENT	123
INTRODUCTION	123
The Trend Towards a Decentralized Model	123
About Spot Power-Price Exposure	123
Contracting Profits	125
THE GERMAN NUCLEAR SINGULARITY	126
The Spin-off Idea	126
Creation of the KfW and Provision Analysis	127
Proposal of a Sovereign Fund for Nuclear Waste	128
EFFECTS OF THE LOW-RATE ENVIRONMENT	129
Lower Interest Cost and Higher Debt Levels	129

Lower Allowed Returns on Regulated Assets	130
Higher Provision Requirements	131
Higher Pension Deficits	133
COMPANY STRATEGY, SHARE PRICE BEHAVIOR, AND RESULTS	134
RWE (Germany)	134
E.ON (Germany)	135
AREVA (France)	136
EDF (France)	137
ENGIE (France)	140
ENEL (Italy)	141
TEPCO (Japan)	142
Toshiba (Japan)	143
KEPCO (South Korea)	145
CGN (China)	146
Exelon (U.S.)	147
OUTLOOK ON ENERGY SECTOR DEVELOPMENTS	148
Emission Trading System (ETS)	148
Power prices	149
CONCLUSION ON NUCLEAR FINANCES	150
SMALL MODULAR REACTORS	151
United States	151
Russia	154
South Korea	155
China	156
India	158
Argentina	159
Conclusion on Small Modular Reactors	159
FUKUSHIMA STATUS REPORT	161
INTRODUCTION	161
ON-SITE CHALLENGES	161
Current Status of the Reactors	161
Contaminated Water Management	163
Worker Exposure	164

OFF-SITE CHALLENGES	165
Current Status of Evacuation	165
Radiation Exposure and Health Effects	168
Food Contamination	169
Decontamination	170
COSTS INVOLVED	173
CONCLUSION ON FUKUSHIMA STATUS REPORT	175
NUCLEAR POWER VS. RENEWABLE ENERGY DEPLOYMENT	176
INTRODUCTION	176
INVESTMENT	178
RECORD-LOW PRICE LEVELS ACROSS THE WORLD	180
INSTALLED CAPACITY AND ELECTRICITY GENERATION	181
STATUS AND TRENDS IN CHINA, THE EU, INDIA, AND THE U.S.	183
CONCLUSION ON NUCLEAR POWER VS. RENEWABLE ENERGIES	188
ANNEX 1 OVERVIEW BY REGION AND COUNTRY	190
AFRICA	190
THE AMERICAS	192
ASIA AND MIDDLE EAST	198
EUROPEAN UNION (EU28) AND SWITZERLAND	210
Western Europe	212
Central and Eastern Europe	224
FORMER SOVIET UNION	232
ANNEX 2 REACTOR RESTART PROSPECTS IN JAPAN	239
NUCLEAR REGULATION AUTHORITY REVIEW AND REACTOR RESTART PROSPECTS	239
FUTURE NUCLEAR OPERATIONS OF TEPCO	245
ANNEX 3 DEFINITION OF CREDIT RATING BY THE MAIN AGENCIES	249
ANNEX 4 ABOUT THE AUTHORS	250
ANNEX 5 ABBREVIATIONS	253
ANNEX 6 STATUS OF NUCLEAR POWER IN THE WORLD	262
ANNEX 7 NUCLEAR REACTORS IN THE WORLD “UNDER CONSTRUCTION”	263

TABLE OF FIGURES

Figure 1 Nuclear Electricity Generation in the World	24
Figure 2 Nuclear Electricity Generation and Share in Global Power Generation	25
Figure 3 Nuclear Power Reactor Grid Connections and Shutdowns	27
Figure 4 Nuclear Power Reactor Grid Connections and Shutdowns - The China Effect	27
Figure 5 World Nuclear Reactor Fleet, 1954-2017	29
Figure 6 Nuclear Reactors Under Construction	30
Figure 7 Average Annual Construction Times in the World	33
Figure 8 Construction Starts in the World	34
Figure 9 Construction Starts in the World - China	35
Figure 10 Cancelled or Suspended Reactor Constructions	35
Figure 11 Age Distribution of Operating Reactors in the World	37
Figure 12 Age Distribution of Shut Down Nuclear Power Reactors	39
Figure 13 The 40-Year Lifetime Projection	40
Figure 14 The PLEX Projection	41
Figure 15 Forty-Year Lifetime Projection versus PLEX Projection	42
Figure 16 Age Distribution of French Nuclear Fleet	46
Figure 17 Main Developments of the German Power System Between 2010 and 2016	53
Figure 18 Japanese Reactor Status	56
Figure 19 Japanese Nuclear Activity Program History	58
Figure 20 Age Distribution of Japanese Nuclear Fleet	64
Figure 21 U.K. Reactor Startups and Shutdowns	73
Figure 22 Age Distribution of U.K. Nuclear Fleet	74
Figure 23 Age Distribution of U.S. Nuclear Fleet	79
Figure 24 IAEA Forecasts of Installed Nuclear Capacity	104
Figure 25 RWE Forward Contracting	124
Figure 26 Average Profitability of Six European Nuclear Operators	125
Figure 27 Average European Nuclear Operator Credit Ratios	129
Figure 28 RWE Share Price Development Since 2006	134
Figure 29 E.ON Share Price Development Since 2006	135
Figure 30 AREVA Share Price Development Since 2006	137
Figure 31 EDF Share Price Development Since 2006	138
Figure 32 ENGIE Share Price Development Since 2006	140
Figure 33 TEPCO Share Price Development Since 2006	143
Figure 34 Toshiba Share Price Development Since 2006	144
Figure 35 Kepco Share Price Development Since 2006	146

Figure 36 CGN Share Price Development Since its Launch in 2014	146
Figure 37 European Emission Trading System Performance	148
Figure 38 Distribution of Radiation Doses According to Airborne Monitoring	172
Figure 39 Estimated Cost of Fukushima Accident Countermeasures	173
Figure 40 Global Investment Decisions in Renewables and Nuclear Power 2004-2016	178
Figure 41 Top 10 Countries for Renewable Energy Investment 2014-2016	179
Figure 42 Wind, Solar and Nuclear Capacity and Production in the World	182
Figure 43 Wind, Solar and Nuclear Capacity and Production in China 2000-2016	183
Figure 44 Startup and Shutdown of Electricity Generating Capacity in the EU in 2016	185
Figure 45 Variations in Installed Capacity and Electricity Generation in the EU	186
Figure 46 Wind, Solar and Nuclear Capacity and Production in India 2000-2016	187
Figure 47 Suspended Angra-3 Construction Site in November 2015	195
Figure 48 Age Distribution of Chinese Nuclear Fleet	199
Figure 49 Nuclear Reactors Startups and Shutdowns in the EU28, 1956–2017	210
Figure 50 Nuclear Reactors and Net Operating Capacity in the EU28	211
Figure 51 Age Distribution of the EU28 Reactor Fleet	211
Figure 52 Age Distribution of Swiss Nuclear Fleet	223

TABLE OF TABLES

Table 1 Nuclear Reactors “Under Construction” (as of 1 July 2017)	31
Table 2 Reactor Construction Times 2007–2017	33
Table 3 Legal Closure Dates for German Nuclear Reactors 2011-2022.	55
Table 4 Japanese Reactors Officially Shut Down Post-3/11.	62
Table 5 Early Shutdowns of U.S. Reactors 2009–2025	90
Table 6 Summary of Nuclear Newcomer Countries (Actual and Potential)	121
Table 7 Credit Rating History of Major European Utilities.	130
Table 8 Nuclear Operators’ Provisions	132
Table 9 Results of Thyroid Cancer Examinations 2011-2016.	168
Table 10 Total Cesium Measured in Food Products in Fukushima Prefecture	170
Table 12 Government and Independent Assessments of Cleanup and Remediation Costs of the Fukushima Daiichi Nuclear Disaster (in billion US\$).	175
Table 11 Closure Dates for Belgian Nuclear Reactors 2022–2025	213
Table 13 Status of Japanese Nuclear Reactor Fleet (as of 1 July 2017).	240
Table 14 Status of Nuclear Power in the World (as of 1 July 2017)	262
Table 15 Nuclear Reactors in the World “Under Construction” (as of 1 July 2017).	263

FOREWORD

by **S. David Freeman**¹

Nuclear power was born in a sea of euphoria out of a collective American guilt over dropping the atomic bomb. And for at least two decades it was the “clean” alternative to coal that was going to meet all of our energy needs forever.

*Perhaps the most decisive document
in the history of nuclear power...*

The Three Mile Island meltdown, in 1979, ended the euphoria but the dream continued and it still goes on without much regard to contrary facts.

The opponents of nuclear power have shown a similar disregard for changing facts. They largely ignored the fact that many well-meaning people viewed local air pollution and climate change more of a danger than nuclear. In those years shutting down a nuclear plant did mean increased emissions of local pollutants and green house gases.

The debate about nuclear power was similar to talking about a religion. It was seldom grounded in all the relevant facts- each side had a religious belief in their point of view boosted by whatever ad hoc facts supported their view.

Because of that history, this 2017 *World Nuclear Industry Status Report* is perhaps the most decisive document in the history of nuclear power. The report makes clear, in telling detail, that the debate is over. Nuclear power has been eclipsed by the sun and the wind. These renewable, free-fuel sources are no longer a dream or a projection-they are a reality that are replacing nuclear as the preferred choice for new power plants worldwide.

It no longer matters whether your greatest concern is nuclear power or climate change the answer is the same. The modern-day “Edisons” have learned to harness economically the everlasting sources of energy delivered to earth by Mother Nature free of charge.

The value of this report is that this conclusion no longer relies on hope or opinion but is what is actually happening. In country after country the facts are the same. Nuclear power is far from dead but it is in decline and renewable energy is growing by leaps and bounds.

The entire Report is must reading so that the facts of nuclear decline in the U.S., Germany, Japan, and France –indeed just about every country- really sinks in. It is more than symbolic that the Japanese Government has formally accepted the death of its breeder reactor, which was the original holy-grail of nuclear power.

Most revealing is the fact that nowhere in the world, where there is a competitive market for electricity, has even one single nuclear power plant been initiated. Only where the government or the consumer takes the risks of cost overruns and delays is nuclear power even being considered.

1 - S. David Freeman was appointed Chairman of the Tennessee Valley Authority (TVA) by President Jimmy Carter in 1977. Subsequently, he served for two decades as general manager of several large public power agencies including the Los Angeles Department of Water and Power, the New York Power Authority, and the Sacramento Municipal Utility District.

*The report makes clear, in telling detail,
that the debate is over*

The most decisive part of this report is the final section- Nuclear Power vs Renewable Energy Development. It reveals that since 1997, worldwide, renewable energy has produced four times as many new kilowatt-hours of electricity than nuclear power.

Maybe the Revolution has not been televised, but it is well underway. Renewable energy is a lower cost and cleaner, safer alternative to fossil fuels than nuclear power.

The world no longer needs to build nuclear power plants to avoid climate change and certainly not to save money. If you have any doubt about that fact please read the *World Nuclear Industry Status Report 2017*.

S. David Freeman

KEY INSIGHTS IN BRIEF

Global Overview—The Chinese Exception, Yet

- Global nuclear power generation increased by 1.4% in 2016, due to a 23% increase in China, although the share of nuclear energy in electricity generation stagnated at 10.5% (-0.2%).
- Ten reactors started up in 2016, of which one-half were in China. Two reactors were connected to the grid in the first half of 2017—one in China, one in Pakistan (by a Chinese company)—the first units to start up in the world whose construction started after the Fukushima disaster began.
- Three construction starts in the world in 2016—two in China, one in Pakistan (by a Chinese company)—down from 15 in 2010, of which 10 were in China. One construction start in India in the first half of 2017, none in China or in the rest of the world.
- The number of units under construction is declining for the fourth year in a row, from 68 reactors at the end of 2013 to 53 by mid-2017, of which 20 are in China.

Closures and Construction Delays

- Russia and the U.S. shut down reactors in 2016, while Sweden and South Korea both closed their oldest units in the first half of 2017.
- Election of a new President in South Korea, who closed one plant and suspended the construction of two more, puts hopes of the national nuclear industry to expand and export into jeopardy.
- Thirteen countries are building new reactors, one less than in WNISR2016, as the construction of Angra-3 in Brazil was abandoned following a massive corruption scandal involving senior project management.
- There are 37 reactor constructions behind schedule, of which 19 reported further delays over the past year. China is no exception, at least 11 of 20 units under construction are behind schedule.
- Eight projects have been under construction for a decade or more, of which three for over 30 years.
- WNISR2016 noted 17 reactors scheduled for startup in 2017. As of mid-2017, only two of these units had started up and 11 were delayed until at least 2018.

Bankruptcy/Bailout of Historic Nuclear Giants – Deep Financial Crisis for Nuclear Utilities

- After the discovery of massive losses over its nuclear construction projects, Toshiba filed for bankruptcy of its U.S. subsidiary Westinghouse, the largest nuclear power builder in history.
- AREVA has accumulated US\$12.3 billion in losses over the past six years. French government has provided a US\$5.3 billion bailout and continues break-up strategy.
- The large quality-control scandal at AREVA's Creusot Forge further erodes confidence in the industry.
- Share-value erosion and downgrading by credit-rating agencies of major nuclear utilities.

Fukushima Status Report

- Six years after the Fukushima disaster began, the Japanese Government started lifting evacuation orders in order to limit skyrocketing compensation costs. The total official cost estimate for the catastrophe has doubled from US\$100 billion to US\$200 billion. A new independent assessment has put the cost at US\$444–630 billion (depending on the level of water decontamination). Only five reactors have been restarted.

Renewables Distance Nuclear

- Globally, wind power output grew by 16%, solar by 30%, nuclear by 1.4% in 2016. Wind power increased generation by 132 TWh, solar by 77 TWh, respectively 3.8 times and 2.2 times more than nuclear's 35 TWh. Renewables represented 62% of global power generating capacity additions.
- New renewables beat existing nuclear. Renewable energy auctions achieved record low prices at and below US\$30/MWh in Chile, Mexico, Morocco, United Arab Emirates, and the United States. Average generating costs of amortized nuclear power plants in the U.S. were US\$35.5 in 2015.

EXECUTIVE SUMMARY AND CONCLUSIONS

The *World Nuclear Industry Status Report 2017 (WNISR2017)* provides a comprehensive overview of nuclear power plant data, including information on operation, production and construction. The WNISR assesses the status of new-build programs in current nuclear countries as well as in potential newcomer countries. The WNISR2017 edition includes a new assessment from an equity analyst view of the financial crisis of the nuclear sector and some of its biggest industrial players. The Fukushima Status Report provides not only an update on onsite and offsite issues six years after the beginning of the catastrophe, but also the latest official and new independent cost evaluations of the disaster. Focus chapters provide in-depth analysis of France, Japan, South Korea, the United Kingdom and the United States. The Nuclear Power vs. Renewable Energy chapter provides global comparative data on investment, capacity, and generation from nuclear, wind and solar energy. Finally, Annex 1 presents a country-by-country overview of all other countries operating nuclear power plants.

Reactor Status and Nuclear Programs

Startups and Shutdowns. In 2016, ten reactors started up, five in China, one each was commissioned in India (Kudankulam-2), Pakistan (Chasnupp-3), Russia (Novovoronezh-2-1), South Korea (Shin-Kori-3) and the U.S. (Watts Bar-2, after 43 years of construction). Two reactors were closed in 2016, Novovoronezh-3 in Russia and Fort Calhoun-1 in the U.S.

In the first half of 2017, two reactors started up in the world, one each in China (Yangjiang) and Pakistan (Chasnupp-4, built by a Chinese company), while two were shut down, the oldest units respectively in South Korea (Kori-1, after 40 years of operation) and in Sweden (Oskarshamn-1, after close to 46 years of operation).

Operation and Construction Data

Reactor Operation. There are 31 countries operating nuclear power plants.¹ These countries operate a total of 403 reactors—excluding Long-Term Outages (LTOs)—just one unit more compared to the situation mid-2016, 35 fewer than the 2002 peak of 438. The total installed capacity increased over the past year by less than one percent to reach 351 GW,² which is comparable to levels in 2000. Installed capacity peaked in 2006 at 368 GW. Annual nuclear electricity generation reached 2,476 TWh in 2016—a 1.4 percent increase over the previous year, but about 7 percent below the historic peak of 2006. As in 2015, the 2016 global increase of 35 TWh is due to the production hike in China, where nuclear generation increased by 23 percent or 36.6 TWh.

¹ - Unless otherwise noted, the figures indicated are as of 1 July 2017.

² - All figures are given for reference net electricity generating capacity. GW stands for gigawatt or thousand megawatt.

WNISR2017 classifies 33 Japanese reactors as being in LTO,³ three less than in WNISR2016, as two were restarted (Ikata-3 et Takahama-4) and Monju was closed permanently.

Besides the Japanese reactors, two French units (Bugey-5, Paluel-2), as well as one unit each in Argentina (Embalse), India (Kakrapar-2), Switzerland (Beznau-1) and Taiwan (Chinshan-1) meet the LTO criteria.

All ten reactors at Fukushima Daiichi and Daini are considered permanently closed and are therefore also excluded in the count of operating nuclear power plants.

Share in Electricity/Energy Mix. The nuclear share of the world's power generation remained stable⁴ over the past five years, with 10.5 percent in 2016 after declining steadily from a historic peak of 17.5 percent in 1996. Nuclear power's share of global commercial primary energy consumption also remained stable at 4.5 percent—prior to 2014 the lowest level since 1984.⁵

The “big five” nuclear generating countries—by rank, the U.S., France, China, Russia, and South Korea—generated 70 percent of the world's nuclear electricity in 2016. China moved up one rank. The U.S. and France accounted for 48 percent of global nuclear generation.

Reactor Age. In the absence of major new-build programs apart from China, the unit-weighted average age of the world operating nuclear reactor fleet continues to rise, and by mid-2017 stood at 29.3 years. Over half of the total, or 234 units, have operated for 31 years and more, including 64 that have run for 41 years and more.

Lifetime Extension. The extension of operating periods beyond the original design is regulated differently from country to country. While in the U.S., 84 of the 99 operating reactors have already received license extensions for up to a total lifetime of 60 years, in France, only 10-year extensions are granted and the safety authorities have made it clear that there is no guarantee that all units will pass the 40-year in-depth safety assessment. Furthermore, the proposals for lifetime extensions are in conflict with the French legal target to reduce the nuclear share from the current three-quarters to half by 2025.

Lifetime Projections. If all currently operating reactors were shut down at the end of a 40-year lifetime—with the exception of the 72 that have passed the 40-year mark—by 2020 the number of operating units would be 11 below the total at the end of 2016, even if all reactors currently under active construction were completed. The installed capacity, however, will increase by 4 GW, because many of the older units have lower power outputs when compared to most of the reactors currently under construction. In the following decade, between 2020 and 2030, 194 units (179 GW) would have to be replaced—almost four times the number of startups achieved over the past decade. If all licensed lifetime extensions were actually implemented and achieved, the number of operating reactors would still increase by only five, and adding 16.5 GW in 2020. By 2030, 163 reactors would have to be shut down and the loss of 144.5 GW would have to be compensated for.

³ - WNISR considers that a unit is in Long-Term Outage (LTO) if it produced zero power in the previous calendar year and in the first half of the current calendar year. This classification is applied retroactively starting on the day the unit is disconnected from the grid. WNISR counts the startup of a reactor from its day of grid connection, and its shutdown from the day of grid disconnection.

⁴ - Less than 0.2 percentage points difference with 2015 and the five years on average, a level that is certainly within statistical uncertainties.

⁵ - According to BP, “Statistical Review of World Energy”, June 2017.

Construction. Thirteen countries are currently building nuclear power plants, one less than in previous years. Construction at the only new-build project in Brazil, Angra-3, was halted after corruption charges were brought against senior management.

As of 1 July 2017, 53 reactors were under construction⁶—five less than one year earlier and 15 fewer than in 2013. Twenty of the 53 reactors are being constructed in China.⁷ Total capacity under construction is 53.2 GW (–8%).

- The current average time since work started at the 53 units under construction is 6.8 years, an increase of 0.6 years from the status one year ago. The main reasons are the low number of construction starts and new delays. At mid-2017, 11 of 17 scheduled startups for the year had already been pushed into 2018 or beyond.⁸
- All of the reactors under construction in 8 out of the 13 countries have experienced delays, mostly by a year or more. Over two thirds (37) of all construction projects are behind schedule. Most of the 16 remaining units under construction, of which 9 are in China, were begun within the past three years or have not yet reached projected start-up dates, making it difficult to assess whether or not they are on schedule.
- Of the 37 reactors behind schedule, 19 have reported increased delays over the past year since WNISR2016.
- Construction of three reactors has started more than 30 years ago: Mochovce-3 and -4 in Slovakia and Rostov-4 in Russia.
- Two units, the Prototype Fast Breeder Reactor (PFBR) in India and Olkiluoto-3 in Finland, have been listed as “under construction” for a decade or more, while Shimane-3 in Japan and Flamanville-3 in France will reach 10 years of construction before the end of 2017.
- The average construction time of the latest 51 units in ten countries that started up in the past decade, since 2007, was 10.1 years with a very large range from 4 to over 43 years.

Construction Starts & New Build Issues

Construction Starts. In 2016, construction began on 3 reactors, 2 of which were in China and one in Pakistan (by a Chinese company). This compares to 15 construction starts—of which 10 were in China alone—in 2010. In the first half of 2017, only India started building a reactor. Historically, construction starts in the world peaked in 1976 at 44.

Construction Cancellations. Between 1977 and 1 July 2017, a total of at least 91 (one in eight) of all construction sites were abandoned or suspended in 17 countries in various stages of advancement.

Newcomer Program Delays/Cancellation. Only two newcomer countries are actually building reactors—Belarus and UAE. Progress was halted at Belarus’ Ostrovets project, when the reactor pressure vessel was dropped during installation and had to be replaced. The UAE an-

⁶ - In late July 2017, construction of two units at the V.C. Summer site in the U.S. was suspended and one additional reactor started up in China. This leads to 50 units under construction as of 1 September 2017.

⁷ - One unit started up in China in July 2017 was on schedule. As of 1 September, that leaves 11 of 19 units under construction in China behind schedule.

⁸ - A third unit started up in China in July 2017. As of 1 September, that leaves three units scheduled for startup in 2017.

nounced that it had to delay startup of the first of four units to 2018, due to a lack of locally trained and licensed domestic personnel.

Further delays have occurred over the year in the development of nuclear programs for most of the more or less advanced potential newcomer countries, including Bangladesh, Egypt, Jordan, Poland, Saudi Arabia, and Turkey. Vietnam abandoned its new-build project due to slowing electricity demand increases, concerns over safety and rising construction costs.

Nuclear Finances: A Tough Market Environment

Bankruptcy of Historic Builder Toshiba-Westinghouse. Following technical problems, delays and massive cost overruns at its U.S. construction projects V.C. Summer and Vogtle, the Japanese group Toshiba in March 2017 filed for bankruptcy protection of its US. subsidiary Westinghouse. As a consequence, construction at the two V.C. Summer reactors in the U.S. was halted.

AREVA Debacle (another new episode). The French state-controlled integrated nuclear company AREVA went technically bankrupt after a cumulative six-year loss of US\$12.3 billion. The French government has provided a bailout for US\$5.3 billion and continued a break-up strategy that has state utility EDF take over the nuclear building and services subsidiary AREVA-NP. The rescue scheme has been approved by the European Commission. AREVA has been delisted from the Paris stock market since August 2017. The embattled company is struggling also with a vast quality-control scandal that led to the provisional shutdown of a dozen reactors in France. Thousands of fabrication dossiers have to be examined for irregularities or falsifications. The safety implications remain to be assessed.

Nuclear Utilities in Difficulty. Many of the traditional nuclear and fossil fuel based utilities continue to struggle with low wholesale power prices, a shrinking client base, declining power consumption, high debt loads, increasing production costs at aging facilities, and stiff competition, especially from renewables.

- In **Europe**, energy utilities Centrica (U.K.), EDF, Engie (France), E.ON, and RWE (Germany) have all been downgraded by credit-rating agencies over the past year. As of early July 2017, compared to their peak values during the past decade, the utilities' shares had lost most of their value: RWE -82%, E.ON -87%, EDF -89%, Engie -75%.
- In **Asia**, the share value of Japanese utility TEPCO, de facto nationalized after the Fukushima disaster, as of early July 2017, was still 89% below its February 2007 peak value. Toshiba, hit by the bankruptcy of its U.S. subsidiary Westinghouse, saw its share value shrink again to a quarter of its 2007 peak level. Chinese utility CGN, listed on the Hong Kong stock exchange since December 2014, over the past year and a half never recovered from the 60 percent loss of its share value compared to the peak in June 2015. The Korean utility KEPCO, the only major nuclear utility to reach its peak share value in 2016, has lost 37% of its value over the past year following tariff cuts, increased operating expenses and the temporary shutdown of four reactors. The election of a new president exacerbates the situation.

The German Singularity. Lower electricity and commodity prices, added to increased competition and the implementation of the country's Energiewende have led private utilities RWE

and E.ON to make the strategic choice to split themselves in two. They separated their generation and trading activities from network operations and renewables in an attempt to reduce their exposure to commodity price movements, while providing new growth opportunities and value creation. Following this, the German government set up an independent commission (KFK) to review the process. As a result, the German government created a sovereign nuclear waste fund to cover future storage costs, transferring the risk from operators to the government.

A Low-Rate Environment. The positive effect from a lower cost of debt following the financial crisis had additional effects on nuclear operators. As in many cases nuclear generators are also operators on electricity networks, allowed returns have been revised downwards by regulators to avoid excessive gains. Moreover, lower interest rates imply that nuclear operators have to set aside more money today for future expected costs, increasing the total amount of provisions required.

Sector Developments.

- Emission Trading System (ETS) prices are near historical low levels, while new measures have been taken by the European Union to boost prices in the mid-term by reducing allowance supply. New trading systems are being implanted in the world similar to the European model to comply with COP21 agreements.
- Power prices touched historical low levels in the first half of 2016, with a rebound on the second half, which continued in 2017. The increase has been driven by a rebound on coal prices added to capacity shortages in France due to a lower nuclear generation from reactor inspections concerning the AREVA manufacturing irregularities. The rebound should positively impact earnings from 2018 onwards, but profits in 2017 are expected to tighten further as most of the generation has already been contracted at a lower price level.

Fukushima Status Report

Six and a half years have passed since the Fukushima Daiichi nuclear power plant accidents (Fukushima accident) were triggered by the East Japan Great Earthquake on 11 March 2011 (also referred to as 3/11 throughout the report). A number of onsite and offsite challenges have arisen since and remain significant today.

Onsite Challenges. The latest revision (June 2016) of the government's mid-and-long-term roadmap fixed new target dates, some of which, one year later, are already outdated.

- **Spent Fuel Removal.** Spent fuel was to be removed from unit 3 in Financial Year (FY) 2017, but is now envisaged for the middle of 2018. Spent fuel removal from unit 1 was to be carried out by FY 2020 and is now scheduled for in 2021 at the earliest. No new timescale is available for unit 2.
- **Molten Fuel Removal.** Radiation levels remain very high inside the reactor buildings and make human intervention impossible. Fuel debris removal at unit 1 has been delayed to start in 2021. A robot was introduced into unit 2, but it got stuck in debris. No conclusive video footage is available and it remains unknown where the molten fuel is actually located. A radiation dose level of 210 Sv/h has been measured close to the pressure vessel.

- **Contaminated Water Management.** Every day, still over 200 m³ of water are injected into the three reactor cores to cool the molten fuel. The highly contaminated water runs out of the cracked containments into the basement where it mixes with water that has penetrated the basements from an underground river. A frozen soil wall that was designed to reduce the influx of water was commissioned at end of March 2016. Its effectiveness is limited and has reduced the influx of water only from 760 m³ to 580 m³ per day. The cumulated amount has increased by 100,000 m³ to 750,000 m³ over the past year. The commissioning of a dedicated bypass system and the pumping of groundwater has reduced the influx of water into the basements to about 130 m³/day. An equivalent amount of water is decontaminated to some degree, but still contains very high levels of tritium (over 500,000 Bq/l) and is stored in large tanks.
- **Workers.** About 8,000 workers per month are involved in decommissioning work. Several fatal accidents have occurred at the site. In December 2016, the Ministry of Health recognized, for the first time, recognized the thyroid cancer developed by a TEPCO employee in his forties as occupational disease.

Offsite Challenges. The future of tens of thousands of evacuees, the assessment of health consequences of the disaster, the management of decontamination wastes and the costs involved range amongst the main offsite challenges.

Evacuees and Compensation. According to government figures, the number of evacuees from Fukushima Prefecture as of March 2017 was about 79,000 or less than half of almost 165,000 in May 2012. On 31 March/1 April 2017, the government lifted restriction orders for 32,000 people. According to a survey of residents' intentions conducted by the Reconstruction Agency, at the maximum only 18 percent of the households desired to return in each of three of the five municipalities located in the evacuation zones. The government has decided to terminate the monthly compensation of about US\$900 per person by March 2018 for all evacuees, except for those from so-called difficult-to-return areas for which there is no plan to lift the evacuation order. Compensation for some 12,400 Fukushima-Prefecture households that evacuated voluntarily was terminated in March 2017. The social effects of this termination are severe.

Health Issues. The controversy around health effects, especially thyroid cancer, continues. At present, the number of cancer cases found in children is about 30 times that of the national average. The official survey consistently stated that "it cannot be concluded whether or not the incidences of thyroid cancer found in the examination are due to exposure from the Fukushima accident." This implies that a causal effect cannot be excluded.

Decontamination. By the end of March 2017, 22,000 residential areas, 8,500 hectares (ha) of farmland, 5,800 ha of forest and 1,400 ha of roads had been "decontaminated". While the Environment Ministry claims dose rate reductions at 1 m above ground between 61% on roads and 71% on residential land, the effectiveness of these measures remains questionable, especially in the case of wooded areas that have only been decontaminated up to a radius of roughly 20 m around homes.

Cost of the Accidents. Official cost estimates have doubled over the years and increased by one third over the past year to reach about US\$200 billion, of which 36% each for decommissioning and compensation, 18% for decontamination and the remaining 10% for interim sto-

rage of waste. A new independent assessment has put the cost at US\$444–630 billion (depending on the level of water decontamination).

Small Modular Reactors (SMR)

WNISR2017 provides an update of the 2015 assessment of the status of Small Modular Reactor (SMR) programs around the world. While some design went to the construction phase with one reactor in China scheduled for startup in 2018, global interest in the technologies has faded. Some of the most promising designs (SMART in South Korea and mPower in the U.S.) have not found any buyers. While SMRs were meant to solve the size issues (capacity and investment) of large nuclear plants, they are affected by the general decline in interest in nuclear new-build.

Nuclear Power vs. Renewable Energy Deployment

Investment and Installed Capacity. After an all-time high of over US\$310 billion in 2015, global investment in new renewable energy based electricity generating capacity dropped to about US\$240 billion. However, the 23-percent fall in investment volume mainly reflects the rapid reduction in costs per GW as total renewable capacities installed in 2016 (excluding large hydro) added up to 138.5 GW, more than 127.5 GW the year before. Renewables accounted for 62% of additions to global power generating capacity.

China remains the largest investor with US\$78 billion, doubled its solar capacity to a cumulative 78 GW and added 20 GW of wind power capacity to reach just under 150 GW in total, more than all of Europe combined. This compares with China's addition of 4.6 GW of nuclear capacity in 2016 to reach a total of 32 GW.

Net global increase of nuclear capacity in 2016 was 9 GW—vs. a record 75 GW for solar and 55 GW for wind—and was limited to 3 GW over the year since July 2016.

Since 2000, countries have added 451 GW of wind energy and 301 GW of solar energy to power grids around the world, which dwarfs the increase of only 36 GW, including all reactors in LTO status, in nuclear power capacity over the same period. Taking into account the fact that 36 GW of nuclear power were in LTO as of the end of 2016, and thus not operating, the current nuclear capacity is just the same as in 2000.

Electricity Generation. Brazil, China, Germany, India, Japan, Mexico, the Netherlands, Spain and the U.K.—a list that includes three of the world's four largest economies—all generate more electricity from non-hydro renewables than from nuclear power.

In 2016, annual growth rates for global generation from solar was 30 percent, for wind power almost 16 percent, and for nuclear power 1.4 percent, exclusively due to China.

Compared to 1997, when the Kyoto Protocol on climate change was signed, in 2016 an additional 948 TWh of wind power was produced globally and 332 TWh of solar photovoltaics electricity, compared to nuclear's additional 212 TWh.

In China, as in every year since 2012, electricity production from wind alone (241 TWh), exceeded that from nuclear (198 TWh) in 2016. The same phenomenon is seen in India, where wind

power (45 TWh) outpaced nuclear (35 TWh) again. In fact, while annual Indian nuclear power generation increased by 5 TWh since 2014, solar power alone added 7.5 TWh over those two years.

The figures for the European Union illustrate the rapid decline of the role of nuclear: during 1997–2014, wind produced an additional 293 TWh and solar 111 TWh, while nuclear power generation *declined* by 82 TWh.

Record Low-Price Levels. New renewables come in cheaper than operating and maintenance costs of existing nuclear power plants. Renewable energy auctions achieved record low prices at and below US\$30/MWh in Chile, Mexico, Morocco, United Arab Emirates, and the United States. In comparison, average generating costs of amortized nuclear power plants in the U.S., about one quarter of the world’s nuclear fleet, stood at US\$35.5 in 2015.