

Nam, Ilchong (Ed.); Rothwell, Geoffrey (Ed.)

Research Report

New Nuclear Power Industry Procurement Markets: International Experiences

KDI Research Monograph, No. 2014-01

Provided in Cooperation with:

Korea Development Institute (KDI), Sejong

Suggested Citation: Nam, Ilchong (Ed.); Rothwell, Geoffrey (Ed.) (2014) : New Nuclear Power Industry Procurement Markets: International Experiences, KDI Research Monograph, No. 2014-01, ISBN 978-89-8063-902-1, Korea Development Institute (KDI), Sejong,
<https://doi.org/10.22740/kdi.rm.e.2014.01>

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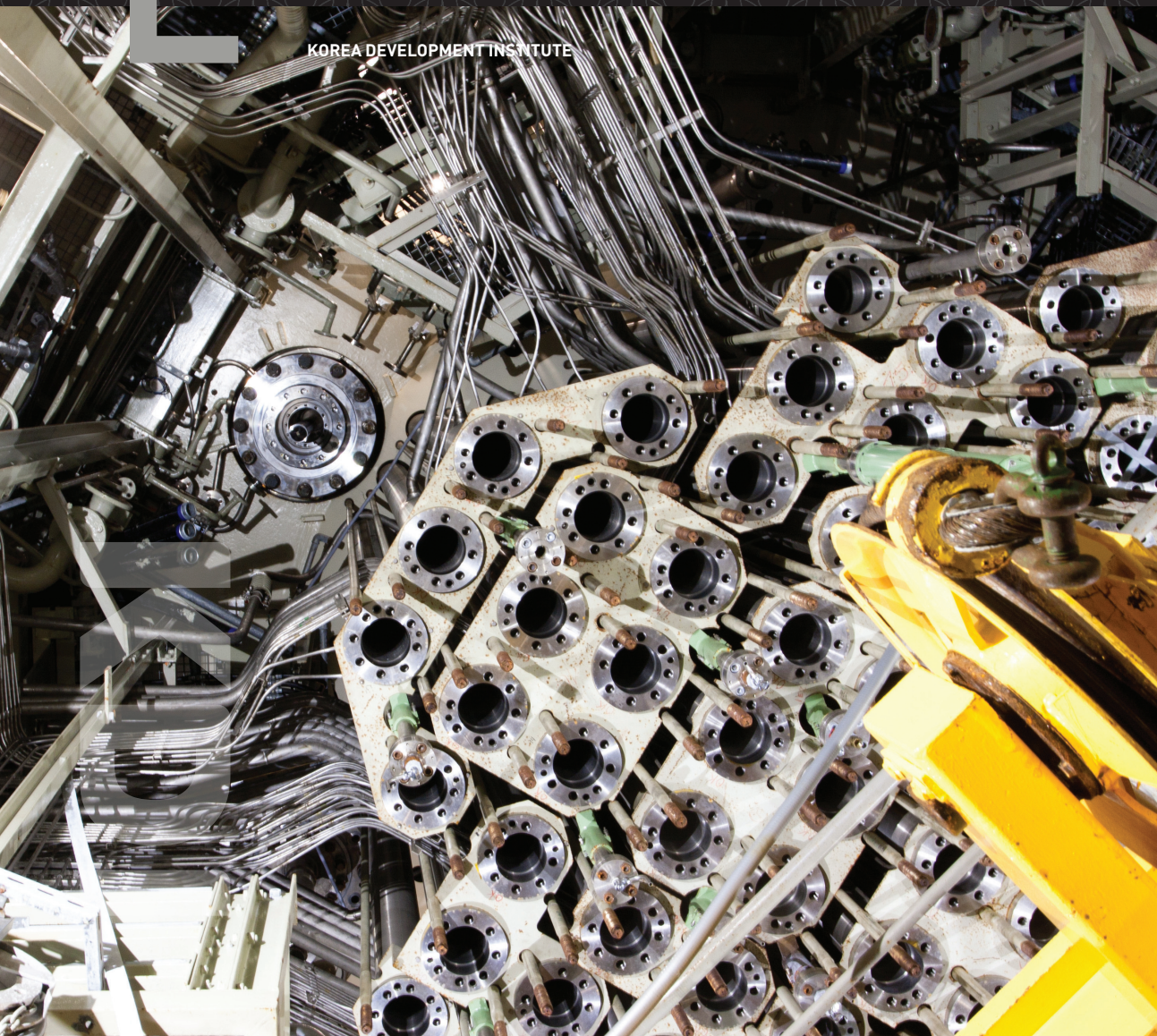
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New Nuclear Power Industry Procurement Markets: International Experiences

Edited by
Ilchong Nam and
Geoffrey Rothwell

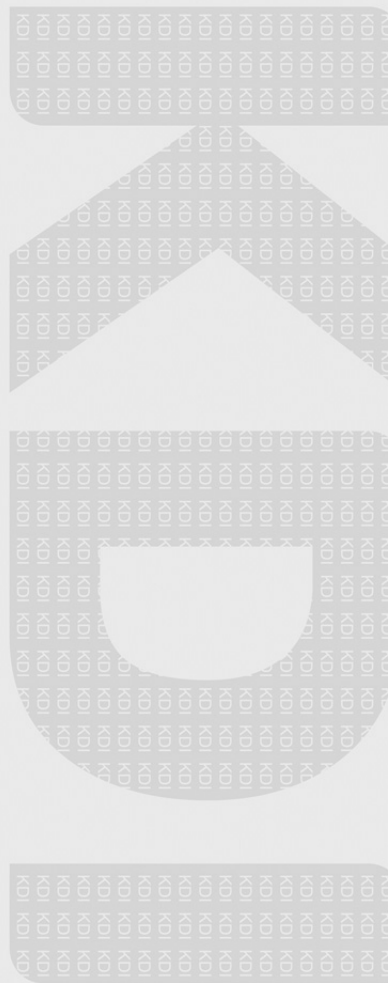
KOREA DEVELOPMENT INSTITUTE



New Nuclear Power Industry Procurement Markets: International Experiences

Edited by

Ilchong Nam and Geoffrey Rothwell



© December 2014

Korea Development Institute

15, Giljae-gil, Sejong-si

339-007, Korea

ISBN 978-89-8063-902-1 (93320)

Price: ₩8,600



| Preface |

Despite the uncertainties about the cost and nuclear reactor melt-downs, nuclear power remains one of the major energy sources in many industrialized countries. Nuclear power is one of the major low carbon energy sources that many developing countries hope to depend on in the future. Ensuring the safety and efficiency of nuclear power generation is vital to the economic performance of many countries and their citizens. Efficiency and safety of this technology depends on many factors. One of the crucial safety and efficiency factors of nuclear power generation is the performance of the procurement market in which parts, components, and services to build and operate nuclear power plants are traded. In particular, performance of the market in which safety related parts and components are traded is crucial to the efficiency and safety of nuclear power generation. Despite the importance of the procurement market for nuclear power generation, there have been few economic studies on this issue.

This book is the first of its kind published by professional economists on the procurement market in the nuclear power industry. It offers a rare opportunity to understand the operations and problems of the procurement markets in the nuclear power industry that lead to sub-optimal management of these activities in Korea, France, and the UK. The editors for this work are Ilchong Nam of the KDI School of Public Policy and Management and Geoffrey Rothwell of OECD-NEA. Ilchong Nam and Geoffrey Rothwell authored the introductory chapter. Chapters 2 and 3 on Korea were written by Ilchong Nam. Claire Mays, Henri Boyé, and Marc Poumadère wrote the chapter on France, and William Nuttall

and John Earp wrote the chapter on the UK.

Ilchong Nam analyzes the structure of the procurement market in the nuclear power industry in Korea and the behavior of major players and the effects of relevant laws, policies, and regulations. He also identifies the shortcomings of the current system, explains why they lead to sub-optimal performance of the market, and proposes a set of policy recommendations that can potentially alleviate the problems that have plagued the market. Claire Mays, Henri Boyé, Marc Poumadère present a clear picture of the nuclear procurement market in France, focusing on the laws and institutions that work to prevent corruption in the procurement systems of the major players including EDF, Areva, and GDF Suez. William Nuttall and John Earp focus on the decentralized British system in which individuals and organizations in the nuclear power industry are given discretionary power that comes with responsibility, which is crucial for market reliability.

The chapters included in this book shed light on the complex nature of the business of efficiently procuring more than two million parts and components used by nuclear power plants while at the same time securing the required level of safety standards. The complexity of the procurement market has increased significantly in most countries that restructured electricity markets because decisions for the nuclear power market are affected by profit incentives and competition now. The task of achieving efficiency and safety in the procurement market has become more challenging for governments because this market operates in a decentralized way. The work in this book clearly demonstrates that the nuclear power industry has evolved differently in each of the three countries and as a result, the structure of the industry and the main challenges faced by the government are substantially different. However, they all agree that the legal infrastructure on the authorities and incentives of individuals and firms, corruption, and transparency are significant for the performance of the nuclear power industry in terms of safety and economic efficiency.

I believe that the findings and policy implications discussed in this volume will contribute to a better understanding of the factors that adversely affect the performance of the nuclear power procurement market and to the development of alternative policies that can improve its performance. I would like to thank Ilchong Nam who played the crucial role in the project that led to the publication of this book, authored two chapters on the Korean market, co-authored the introductory chapter, and co-edited the book. I also thank Geoffrey Rothwell of OECD-NEA, Marc Poumadère, Claire Mays, and Henri Boyé, for their contributions.

The views expressed in this book are solely those of the authors and not necessarily those of the Korea Development Institute.

Joon Kyung Kim
President of KDI

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Summary

Safety and efficiency of nuclear power generation is an important policy objective in countries that rely, or plan to rely, substantially on this source of energy. Safety and efficiency of nuclear power generation depends in large part on the performance of the procurement market in which parts, components, and services used by nuclear power plants are traded. The structure of the nuclear power procurement market has changed substantially over the last three decades in many countries because of electrical industry restructuring and three large accidents that led to a substantial reduction in construction of new nuclear power plants and increased levels of safety requirements. This book contains the analyses of the nuclear power procurement markets of Korea and two EU countries, France and the UK, that have restructured their electricity. Although the three countries all restructured their electricity industry, they differ substantially on the history of nuclear power industry, ownership and governance of firms in the industry for both the service and vendor sides, safety regulations, and on a higher plateau the overall legal infrastructure and the way the governments and markets operate.

Korea began commercial nuclear power generation in the 1970s based on technologies imported from the US, France, and Canada. It subsequently developed its own technology and actively pursued a strategy of building a large fleet of nuclear power plants to realize economies of scale by standardization. It successfully built a large fleet of plants that supplied more than 1/3 of electricity needs for its industrial and consumer demands at a substantially lower cost than most other countries. Along the way, it successfully built a large do-

mestic vendor industry that supplies much of the parts, components, and services in use by nuclear power plants. However, investigations following the discoveries of a large number of irregularities in the procurement by Korea Nuclear and Hydro Power (KHNP), the monopolistic state-owned enterprise in nuclear power generation, revealed that the procurement market suffered from a lack of transparency, ineffective competition, frauds, violation of nuclear safety regulations, and corruption. The most striking finding was the extensive involvement of a large number of executives and managers of KHNP in frauds, corruption, and violations of safety regulation in the procurement of parts and components.

Combining facts about the behavior of individuals, firms, and the relevant government agencies with a game-theoretic analysis, the chapters on the Korean procurement market identified the major problems that led to the failure of the market. The sub-optimal performance of the procurement market was due mostly to the governance structure of SOEs in the nuclear power industry that was against transparency and accountability as well as ineffective safety regulation. Governance of SOEs in the nuclear power industry is based primarily on the command and control approach that allows the line ministry to run the nuclear power and electricity industries in ways that are incompatible with accountability and transparency of the relevant SOEs. The peculiar governance structure of the SOEs allowed KHNP a dominant role in all parts of the nuclear power industry, which allowed some executives and managers of KHNP to take advantage of the power they have in pursuing interests of some groups of individuals they had ties with. Nuclear safety regulation for the procurement of parts and components had been weak at best before the establishment of the independent regulator Nuclear Safety and Security Commission (NSSC) and was not sufficient even after its establishment.

The chapters on Korea end with a set of recommendations aimed at improving the safety and efficiency of the procurement market in the nuclear power industry of Korea. These recommendations include a fundamental change in the governance structure of relevant SOEs in a way that is consistent with shareholder value maximization of each SOE, transparency, accountability, and effective separa-

tion of the units of KHNP that operate nuclear power plants from those that construct new plants. Additional recommendations include changing the process of information exchange on procurement activities, strengthening of the role of NSSC, and the penalties for violations of the laws on safety regulation relating to procurement systems for nuclear power parts.

The chapter on France focuses on laws on corruption and procurement of SOEs in France and in European Union. The laws on corruption apply to all parts of France and are not limited to the nuclear power industry. But they affect the behavior of firms and individuals in the nuclear power industry effectively when it comes to frauds and bribes. While no case of fraud has been identified in the French nuclear supply chain, the fight against corruption is a transversal concern in the Europe Union, France, and other nuclear operator member states. Similarly, the ongoing reform of public procurement rules in the Europe Union and its member states is not specific or limited to the nuclear sector. However, reinforcing these rules to diminish conflict of interest, to exclude fraudulent suppliers, and to enhance enforcement, provides strong operational tools to support the achievement of a high level of safety and economic efficiency in nuclear procurement. Properly implemented competitive bidding minimizes “out-of-sight” agreements. In the nuclear sector, both the 2014 European Nuclear Safety Directive and the 2006 French Law on Nuclear Safety and Transparency have specific provisions for transparency that indirectly influence procurement. The chapter also reviews procurement policies of AREVA, EDF, and GDF SUEZ.

The chapter on the UK explores the relationship between professionalism and nuclear safety in that country. This chapter considers the history of civil nuclear energy in Britain and the near complete shift in emphasis from state owned enterprises to the private sector. This chapter presents illustrative examples, real and fictional, that gives insight into the UK nuclear safety culture and discusses the wider nature of the British society with respect to corruption. The chapter points out that the unique basis of safety regulation in the UK, essentially permissive rather than prescriptive, has a key role to play in promoting and maintaining nuclear professionalism.

CHAPTER 1

Introduction

Ilchong Nam
Geoffrey Rothwell

Nuclear power capacity has been an important component of generation portfolios in many countries, see Table 1. Nuclear can be regarded as a secure long-term economic source of generation in terms of lower average long-term costs, also known as “levelized” cost compared to thermal power generation and renewables in many countries. Table 2 provides worldwide median levelized costs of generating electricity circa 2010.¹ The cost of renewables has significantly declined since 2010. However, because of their capacity factors, levelized costs are still generally higher than nuclear power capacity.

Costs of nuclear power generation have recently been rising for various reasons. These include increased safety standards, increases in waste management costs, and increases in the expected costs of decontamination and dismantling. With increased safety standards has come increased systems complexity. With over two million components in a nuclear power unit, managing the procurement of these components, their operation, and their replacement has increased the managerial and regulatory tasks of building, operating and decommissioning nuclear power plants. However, one factor that affects the ultimate costs of nuclear power generation that has not received serious attention is procurement.

¹ These data are being updated and will be published in 2015 by Nuclear Energy Agency and International Energy Agency.

Procurement affects the social costs of nuclear power generation in the following four ways:

First, costs of purchasing goods and services that are used in building and operating nuclear power plants directly affect the costs of construction, operating, and maintenance.

Second, documenting and tracking these hundreds of thousands of components is a resource cost to the owner-operator and corresponding safety regulator.

Third, a small error in procurement documentation can lead to large financial impact in trying to trace the cause of minor, as well as serious, failures. If any such system failure should happen, the resource costs of tracing the root cause are enormously higher without proper documentation.

Fourth, efficiency in procurement affects the probability and duration of unplanned outages, which affect revenues and operating profits.

|| Table 1-1 || Distribution of Nuclear Power Plants in the World, Order by MWe

Country	Units	MWe
USA	100	99,081
France	58	63,130
Japan	48	42,388
Russia	33	23,643
Korea, Republic	23	20,721
China	23	19,056
Canada	19	13,500
Ukraine	15	13,107
Germany	9	12,068
Sweden	10	9,474
United Kingdom	16	9,243
Spain	7	7,121
Belgium	7	5,927
India	21	5,308
Chinese Taipei	6	5,032
Czech Republic	6	3,884
Switzerland	5	3,308

Table 1-1 Continued.

Country	Units	MWe
Finland	4	2,752
Bulgaria	2	1,906
Hungary	4	1,889
Brazil	2	1,884
South Africa	2	1,860
Slovakia	4	1,815
Argentina	3	1,627
Mexico	2	1,330
Romania	2	1,300
Iran	1	915
Pakistan	3	690
Slovenia	1	688
Netherlands	1	482
Armenia	1	375
Total	438	375,504

Source : International Atomic Energy Agency, *Power Reactor Information System*, accessed Nov. 2014.

Table 1-2 Projected Costs of Generating Electricity (2010, to be updated in 2015)

Median case specifications coal	Nuclear	CCGT	SC/USC	Coal w/90%CC (\$)	Onshore wind	Solar PV
Capacity (MW)	1 400.00	480.00	750.00	474.40	45.00	1.00
Owner's and construction	3 681.07	1 018.07	1 915.65	3 336.96	2 236.80	5 759.35
Overnight cost (\$/kW) ¹⁾	4 101.51	1 068.97	2 133.49	3 837.51	2 348.64	6 005.79
O&M (\$/MWh)	14.74	4.48	6.02	13.61	21.92	29.95
Fuel cost (\$/MWh)	9.33	61.12	18.21	13.04	0.00	0.00
CO2 cost (\$/MWh)	0.00	10.54	23.96	3.22	0.00	0.00
Efficiency (net, LHV)	33%	57%	41.1%	34.8%	-	-
Load factor (%)	85%	85%	85%	85%	26%	13%
Lead time (years)	7	2	4	4	1	1
Expected lifetime (years)	60	30	40	40	25	25
LCOE (\$/MWh)	5%	58.53	85.77	65.18	62.07	96.74
	10%	98.75	92.11	80.05	89.95	137.16
						616.55

Note : 1) Overnight costs include owners, construction and contingency costs but exclude IDC.
Source : Nuclear Energy Agency/International Energy Agency, *Projected Costs of Generating Electricity*, 2010 (now in the process of updating, to be published mid-2015).

These costs of constructing, operating, and deconstructing a nuclear power plant, including the costs of certifying qualities on safety and necessary documentation, translate into an increase the social cost of electricity provision: An increase in the operating cost of a nuclear power plant due to inefficient procurement, including the lack of complete documentation will, in general, lead to increases in the wholesale market prices of electricity, which in turn can lead to increases in retail tariffs. An increase in the frequency and duration of unplanned outage can lead to higher wholesale electricity prices, and at times forced outages of the supply of electricity.

Thus, efficiency in the procurement market of the nuclear power industry is crucial to the cost minimization of nuclear power generation. There are several ways a country can simultaneously achieve cost minimization *and* safety in the nuclear power procurement market. Among the countries that have large fleets of nuclear power plants, Russia and China rely on a centralized economic system of the nuclear power industry through which the state produces and supplies goods and services monopsonistically to nuclear power plants it, directly or indirectly, monopolistically owns and operates. In some parts of the US and countries with restructured electricity markets, a small number of privately-held firms owning and operating nuclear power plants purchase goods and services from the world market based on profit incentives and competition. In some countries, most notably Korea and France, state owned enterprises dominate nuclear power generation and the vendor industry.

Ensuring the cost efficiency and safety of the procurement in the nuclear power industry has become a national agenda in Korea since the discovery in 2012~2013 that Korea Nuclear and Hydro Power (KHNP henceforth), the state-owned nuclear power generation company with more than 30% electricity market share, purchased and used a large number of safety grade parts and equipment that were accompanied by fraudulent certifying documents. The discovery raised the question of why the system failed in preventing the purchase of improperly documented items on such a large scale despite the fact that Korea has fairly detailed laws on procurement by state owned enterprises, nuclear safety regulators, and the governance of state-owned enterprises (SOE). Subsequent investigations of KHNP and its vendors also discovered many

irregular activities in the procurement of KHNP, leading many to wonder about the transparency of the procurement market in the nuclear power industry.

The incidents that occurred in Korea remind us that the procurement market in the nuclear power industry is vulnerable to incentives of firms, as well as incentives for individuals working for these firms to pocket “shaved costs.” These pocketed “saved costs” can distort competition and bypass regulation. There is no guarantee that Korea is unique. In fact, most countries are fighting to screen out fraudulent items or items that, while *not* fraudulent, have non-complying documentation. It is also true that most firms that construct nuclear power plants are struggling to cut costs to stay competitive and could have an incentive to sacrifice safety or proper documentation for reduction in costs. SOEs in many countries are under a governance structure that allows managers of SOEs who make decisions on procurement, and the bureaucrats who control the SOEs, to use their control to promote their interests at the expense of the SOEs

This monograph is an outcome of a research project KDI organized to analyze the procurement markets in different countries and to compare them. It contains two papers on the procurement market in the nuclear power industry in Korea, and two papers on two countries of the European Union: France and the UK. The first chapter on Korea, written by Ilchong Nam, provides a detailed explanation on the structure of the industry, major players, and roles that the relevant regulators and the government agencies play. His second chapter looks into the incentives of firms and managers of SOEs who play key roles in allocating resources in the procurement market in the nuclear power industry and explains the outcomes that occurred in the market as an incentive-compatible equilibrium of a non-cooperative game. It points to the governance structure that has dominated the Korean nuclear power industry for more than four decades as a source of these inefficient outcomes in the procurement market and suggests a set of policy alternatives that could potentially improve the performance of the procurement market.

Safety and efficiency of nuclear power generation is an important policy objective in countries that rely or plan to rely on nuclear power for energy. Safety and efficiency of nuclear power generation depend in

large part on the performance of the procurement market in which parts, components, and services used by nuclear power plants are traded. This book contains analyses of the nuclear power procurement markets of three countries that have restructured (to various degrees) their electricity industry: Korea, France, and the UK. However, they differ substantially on the history of the nuclear power industry, ownership, and governance of firms in the nuclear power industry.

Korea began commercial nuclear power generation in the 1970s based upon technologies imported from the U.S., France, and Canada. But it subsequently developed its own technology and actively pursued a strategy of building a large fleet of nuclear power plants that realized economies of scale by standardization. It successfully built a large fleet of plants with an average cost that is substantially lower than most other countries. Along the way, it also successfully built a large domestic vendor industry that supplies much of the parts, components, and services used by nuclear power plants. However, investigations following the discoveries of a large number of irregularities in the procurement of KHNP revealed that the procurement market suffered from a lack of transparency, ineffective competition, fraudulent documentation, violation of nuclear safety regulation, and kickbacks. The most striking finding was the extensive involvements of large numbers of executives and managers of KHNP in violations in procuring parts and components.

Combining facts about the behavior of individuals, firms, and the relevant government agencies with a game-theoretic analysis, the next chapter on the Korean procurement market identifies the major problems that led to the failure of this market. The sub-optimal performance of the procurement market was due mostly to the governance structure of SOEs in the nuclear power industry. Governance of SOEs in the nuclear power industry is based primarily upon the “command and control” approach that allowed a ministry to run the nuclear power and electricity industries in ways that are incompatible with the accountability and transparency of the relevant SOEs. The peculiar governance structure of the SOEs has allowed KHNP to create dominant roles in all parts of the nuclear power industry. This gave some executives and managers of KHNP incentives to pursue personal advantages of their power, rather than in pursuing national interests. Nuclear safety regulation on the pro-

curement of parts and components had been weak at best. This was particularly true before the establishment of the independent regulator NSSC, and has not been sufficient after its establishment.

The chapters on Korea end with a set of recommendations aimed at improving the safety and efficiency of the procurement market in the Korean nuclear power industry. These include (1) a fundamental change in the governance structure of relevant SOEs in a way that is consistent with the shareholder value maximization, (2) transparency, accountability, and effective separation of the units of KHNP that operate nuclear power plants from those that construct new plants, (3) information revelation on procurement activities, and (4) strengthening of the role of NSSC and the penalties for violation in the nuclear power procurement.

The chapter on France focuses on laws on corruption and on laws on procurement of SOEs in France and in European Union. The laws on corruption apply to all parts of France and not just to the nuclear power industry. But they affect the behavior of firms and individuals in the nuclear power industry in a profound way when it comes to frauds and bribes. While no case of fraud has been identified in the French nuclear supply chain, the fight against corruption is a transversal concern in the Europe Union, France, and other nuclear operator member states. Similarly, the ongoing reform of public procurement rules in the Europe Union and its member states is not specific or limited to the nuclear sector. However, reinforcing these rules to diminish conflict of interest, to exclude fraudulent suppliers, and to enhance enforcement, provides strong operational tools to support the achievement of a high level of safety in nuclear procurement. Properly implemented competitive bidding minimizes “out-of-sight” agreements. In the nuclear sector, both the 2014 European Nuclear Safety Directive and the 2006 French Law on Nuclear Safety and Transparency have specific provisions for transparency that indirectly influence procurement. The chapter also reviews procurement policies, as announced by France’s three nuclear industry operators: AREVA, EDF, and GDF SUEZ. Examples of how guidelines are implemented in the nuclear industry, including the role of the Nuclear Safety Authority (ASN), are provided.

The last chapter on the UK explores the relationship between professionalism and nuclear safety in the UK. It considers the history of civil

nuclear energy in Britain and the near complete shift in emphasis from SOEs to the private sector. It shows how in recent years the government has acknowledged that a truly liberalized electricity industry is unable to deliver the construction of new nuclear power stations as part of a future low-carbon electricity system. Throughout, however, the intention has been for UK policy merely to incentivize the private sector rather than to steer industry strategy directly. This said, the line between strong incentives and weak control can be hard to see. This chapter (1) presents illustrative examples that give insight into the UK nuclear safety culture and (2) discusses the wider nature of UK society with respect to corruption. It concludes that the unique basis of safety regulation in the UK, essentially permissive rather than prescriptive, has a key role to play in promoting and maintaining nuclear professionalism.

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CHAPTER 2

Procurement Market for the Nuclear Power Industry of Korea

Ilchong Nam

1. Introduction

Despite uncertainties, many countries maintain and operate nuclear power plants. Further, a growing number of countries that had not operated commercial nuclear power plants in the past have started building or plan to build new plants. This means that there still are many countries that believe that nuclear power is more economical than other sources of generation available to them or should be included in an optimal portfolio of generators in the long run. Countries that depend substantially on nuclear power or that are planning to build new nuclear power plants must make decisions on technologies, the capacity of nuclear plants, locations, entities that would build and operate nuclear power plants, pricing of electricity generated from nuclear power plants, and so forth.

In countries that have restructured their electricity markets, these decisions are generally delegated to profit-seeking generation companies and potential investors in the market. In countries that still employ a central planning approach to the electricity market, decisions on these and other issues are made directly by the government. In the case of the latter, decisions are ultimately made by politicians, bureaucrats, and employees of government businesses. Some countries adopt mechanisms that lie between the two approaches. These countries depend on a mix-

ture of market forces and public governance in running their electricity markets and nuclear power industries.

While countries differ in the mechanism they employ in running the electricity and nuclear power industries, the ultimate goals are the same for most countries, economic efficiency and safety. Finding an optimal mechanism in terms of economic efficiency and safety is a complex task that requires analyses of many factors. One crucial part of this optimization problem is procurement of goods and services that are used to build and operate nuclear power plants. Ensuring efficiency and safety in the procurement is a challenging task for any country, considering that more than 2 million parts and components are used in building and operating a large commercial nuclear power plant, in addition to various construction and other services. Among them, parts and components that are safety related are of particular interest because it can lead to reactor failures. Efficient production and use of safety-related parts and components that meet the safety standards have become an important goal of all countries that operate nuclear power plants.

There are many possibilities for a failure in the procurement market. Privately owned nuclear power generation companies may have an incentive to sacrifice safety standards for higher profits. Privately owned manufacturers of parts and equipment also have an incentive to cut the corners to lower production costs and increase profits. Profit incentives for generation companies and vendors are likely to lead to an efficient outcome when there is sufficient competition in the market and if regulation on the safety of parts and components works properly. However, competition is far from perfect for many safety-related parts and components due to concentrated market structure. The number of manufacturers is usually small due to various factors that have affected the nuclear power industry, and their cost structure is not efficient.²

2 A firm that wants to enter the market for safety-related parts or components usually pays substantial costs in R&D and in obtaining quality certifications that work as a high-entry barrier. High costs of R&D and quality certification tend to work as a high-entry barrier as they are sunk costs to incumbent firms, leading to a small number of firms in the market. The procurement market in many countries suffered from low demand after the three reactor accidents, leading to a significant reduction in the number of firms. Low demand that fluctuated widely deprived many firms of the economies of scale. All these factors conspired to raise costs of

Korea is one of the few countries with a large nuclear power generation industry as well as a large vendor industry, as a result of the industrial policies of the successive administrations in the last four decades. It completed its first commercial nuclear power plant in 1978 through a turn-key contract with a foreign vendor. However, it adopted a strategy of building a strong domestic vendor industry, standardization, and mass construction to lower the costs of construction. Overall, the strategy of the Korean government has worked well. Korean SOEs acquired the technologies from foreign vendors to design and build nuclear power plants and developed the ability to design new models of their own. In addition, a strong domestic vendor industry emerged to supply parts and components needed to build and operate nuclear power plants. Korea now has twenty-three commercial nuclear power plants that are in operation, with five more under construction. The average levelized cost of generation for a nuclear power plant is significantly lower than that of most other generator types.³

A string of incidents that surfaced in 2012 and 2013, however, involving the purchase and use of parts and components, raised a serious concern about the performance of the procurement market in the nuclear power industry in Korea. The Nuclear Safety and Securities Commission (NSSC), the nuclear safety regulator created in 2012 as an entity independent of any ministry, found a large number of fraudulent quality certification documents that accompanied thousands of safety-related parts and components, many of which had been installed and used in nuclear power plants. Prosecutors also uncovered a string of bribery cases involving executives and managers of KHNP, the monopolistic nuclear power operating SOE. NSSC, a special team of prosecutors, and the Ministry of Trade, Industry, and Energy (MOTIE) have conducted a series of audits and investigations into the procurement system of KHNP and came up with more discoveries of violations of laws on pro-

parts and components that nuclear power plant operators pay.

- 3** The levelized cost of generation of a nuclear power plant in operation is around 2/3 and 1/3 of the levelized cost of a coal-fired power plant and a gas-fired power plant, respectively, in Korea. Table 2-3 in Section 2 contains the levelized costs of various generator types.

curement, nuclear safety regulation, and bribery.

It is true that it would be difficult if not impossible for any country to prevent the purchase and use of sub-standard parts and components completely, considering that there are more than 1.5 million parts and components that affect the safety of a nuclear power plant. In many cases, purchases of faulty or fraudulent items are due to lack of expertise or human resources in QA units of nuclear power plant operators and vendors. However, some of the cases of KHNP involved managers who knowingly purchased fraudulent items, and raised the possibility that the procurement market was performing inefficiently. In particular, the case of JS Cable is alarming as well as informative. In this case, managers working for a procurement unit in KHNP, engineers of Kepco E&C who were in charge of authenticating testing reports, executives of a testing firm, and a supplier of a safety-grade control cable colluded and fabricated testing reports and induced KHNP to purchase faulty cables that failed to meet required safety standards.

The objective of this chapter is to explain the industrial organization of the procurement market in the nuclear power industry and present the evidence of sub-optimal performance of the market using the data published by the government and KHNP in the last two years. This chapter also explains the measures that the Korean government and KHNP have taken since the discovery of a large number of irregularities since 2012. Organization of this chapter is as follows.

Section 2 provides an overview of the nuclear procurement market, including market structure, major players in the market, and their ownership and governance structures. This section also summarizes basic facts and data about the nuclear power industry and the procurement market. Section 3 summarizes the contents of the relevant laws that affect the performance of the nuclear procurement market. Section 4 presents some of the evidence on sub-optimal performance of the procurement market in the nuclear power industry in Korea. Section 5 summarizes the measures that have been taken by the government and KHNP to improve the efficiency and safety of the nuclear power procurement market. Section 6 summarizes the chapter.

2. An Overview of the Procurement Market for Nuclear Power Plants in Korea

2-1. Evolution of the Nuclear Power Industry of Korea

Korea adopted nuclear power generation at an early stage. It started building its first nuclear power plant in the early 1970s and completed it and began operation in 1978. Since then, Korea has kept building and operating a large number of nuclear power plants, not being affected seriously by the Chernobyl, Three Mile Island, and, more recently, Fukushima accidents. As of the end of 2013, Korea had twenty-three nuclear power plants in operation, with a combined capacity of 20,716 MW, accounting for 23.8% of the generation capacity, with five more under construction. The following tables, Table 2-1 and Table 2-2, summarize the share of nuclear power in generation from 2004 to 2013. The proportion of nuclear power has gradually declined in both capacity and volume of energy generated. The proportion of nuclear power in terms of the volume of energy generated is substantially larger than the proportion in terms of capacity, as nuclear power has been used as base-load.⁴ The drop in the proportion of nuclear power in terms of the volume of energy in 2012 and 2013 is due partly to the shut-down of some nuclear power plants ordered by NSSC after the discovery of fraudulent parts and components.

Table 2-1 Capacity of Generating Plant and Nuclear Share for the Last 10 Years (2004~2013)
(Unit: Capacity = MW; Share = %)

Category	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total capacity	59,961	62,258	65,514	68,268	72,491	73,470	76,078	79,342	81,806	86,969
Nuclear capacity	16,716	17,716	17,716	17,716	17,716	17,716	17,716	18,716	20,716	20,716
Share	27.9	28.5	27.0	26.0	24.4	24.1	23.3	23.6	25.3	23.8

Source: Korea Electric Power Corporation, *Monthly Report on Major Electric Power Statistics*, Vol. 422, 2013.

⁴ For detailed information and discussions on the electricity market, effects of the market rules on competition, and investment incentives for nuclear power plants, see Nam (2012), Nam (2013b), and Nam (2014).

Table 2-2 Generation and Nuclear Share for the Last 10 Years (2004~2013)

(Unit: Generation = GWh; Share = %)

Category	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total generation	342,148	364,438	381,181	403,124	422,355	433,604	474,660	496,893	505,653	513,464
Nuclear generation	130,715	146,779	148,749	142,937	150,958	147,771	148,596	154,723	150,327	138,784
Share	38.2	40.3	39.0	35.5	35.7	34.1	31.3	31.1	29.7	26.9

Source : Korea Electric Power Corporation, *Monthly Report on Major Electric Power Statistics*, Vol. 422, 2013.

Since the mid-1980s, Korea has actively pursued a strategy aimed at realizing economies of scale in nuclear power generation and the supply chain. The ultimate goal was to produce large volume of electricity at low cost and to develop the capability to design, build, and manufacture nuclear power plants and the necessary parts and components. Korea achieved this goal quite successfully from the mid-1980s to the first decade of the twenty-first century by using a system that is essentially a central planning approach. Successive administrations during this period used the Old Kepco group as a vehicle to achieve the goal.⁵ Old Kepco was a vertically integrated monopolistic SOE in the electricity market, which also owned the majority shares of Kepco E&C (the only engineering firm in Korea designing nuclear power plants) and Korea Heavy Industry (the only manufacturer of turbines/generators).⁶ Old Kepco and its two subsidiaries acquired the technologies to design and construct nuclear power plants and to manufacture reactors and turbines/generators from American firms, developed standardized Korean

5 Kepco before 2001 was the vertically integrated monopoly in all stages of the electricity market. After the restructuring in 2001, Kepco was forced to divest all of its generators to six generation companies, established as its subsidiaries. Since then, Kepco has been reduced to the monopolist in transmission, distribution, and retail. Kepco has been prohibited from intervening in the management of the six generation companies even though it owns them. To distinguish Kepco before 2001 from Kepco after 2001, we call Kepco before 2001 Old Kepco.

6 The Korean government forced Kepco to sell Korea Heavy Industry to private investors in 2002. It changed its name to Doosan Heavy Industry after its controlling interest was sold to the Doosan group. Kepco E&C is better known by its old name of KOPEC. It originally started as a joint venture between an American engineering firm and the Old Kepco but became a subsidiary of Old Kepco later.

models based on them, and constructed a series of nuclear power plants using the models.

As a result of this strategy, Kepco E&C grew into a major engineering firm specializing in designing nuclear power plants while Korea Heavy Industry became a competitive manufacturer of reactors and turbines/generators. During this period, successive administrations actively sought to build a domestic supply chain by encouraging the entry of Korean firms into the manufacturing of parts and components used to build and operate nuclear power plants. The policy of promoting the domestic vendor industry has been generally successful in that the proportion of domestically supplied goods and services in the procurement market has increased substantially, replacing imported parts, components, and services. This policy has also been viewed as successful in that nuclear power plants supplied electricity at low costs. The levelized cost of generation is significantly lower for nuclear power compared to coal, natural gas, and oil in Korea, allowing the government to maintain a low level of retail tariffs for electricity for a prolonged period of time.⁷ The following table, Table 2-3, compares the estimated levelized costs of generation of various fuel sources in Korea, estimated by the Korea Power Exchange (KPX). Nuclear power is the cheapest, followed by coal, which is substantially cheaper than natural gas and oil. Korea is endowed with poor hydro and renewable potential.

All nuclear power plants are owned and operated by KHNP, the largest generation company in Korea. KHNP is 100% owned by Kepco, which also owns 100% of each of the other five next largest generation companies. Thus, KHNP is the only generation company in the procurement market for the Korean nuclear power industry. KHNP's monopoly over nuclear power generation is a result of Korean government

⁷ It is generally believed that the estimated costs of generation using nuclear power plants, published by the government or government-run institutes, do not reflect the true costs of decommissioning and decontamination and are probably lower than true costs by a substantial margin. Some claim that nuclear power generation will not be more economical when all relevant costs are taken into account. It is fair to say that nobody knows the true costs of nuclear power generation in Korea with reasonable accuracy. The expected costs of decommissioning and decontamination, and the risks of serious accidents are beyond the scope of this paper.

Table 2-3 Levelized Cost of Generation of Different Fuel Sources

(Unit: KRW/kwh)

Generator type	PWR 1000	ARP 1400	COAL 500	COAL 800	COAL 1000	LNG 500	LNG 700	OIL 40	OIL 100
Total cost	41.4	34.1	62.8	61.3	60.3	114.3	113.2	145.5	144.5

Note : The levelized costs are estimated based on the assumptions that operation rate is 90%, annual discount rate is 6%, life span of non-nuclear power plants is thirty years, and life span of nuclear power plants is sixty years.

Source : KPX.

policies and not a market driven outcome. The reason that the Korean government decided to maintain an SOE monopoly in nuclear power generation is not clear. It is probably a by-product of the incomplete restructuring of the electricity market that the Korean government started in 2001 but could not complete.

In the downstream, there is a single supplier in the market for designing nuclear power plants, Kepco E&C. No other Korean firm has the capability to design nuclear power plants. There is only one firm in the market for reactors and in the market for turbines/generators, Doosan Heavy Industry (DHI). DHI manufactures most of the large components used to produce reactors and turbines/generators but purchases some of the smaller parts and components from other firms.

BOP (balance of plant) uses many parts and components. Some parts and components are not produced domestically and must be imported. KHNP purchases these items from the world market. However, for many parts and components used to build BOP, there are domestic manufacturers. The market for each such item usually consists of a small number of firms, due to the idiosyncratic nature of the nuclear power industry. These firms face only one buyer, KHNP, and find it difficult to sell products they develop to nuclear power plants in other countries. Demands depend heavily on the policy of the Korean government as well as uncertain exogenous variables such as Fukushima failures.

The following table, Table 2-4, summarizes the size of the procurement market we are analyzing in this paper. Revenues of vendors steadily increased in both design/engineering services and manufacturing, re-

flecting the construction of new power plants in domestic markets as well as exports to the U.A.E. Within manufacturing, NSSS, turbines/generators, and BOP account for 60%, 11%, and 29%, respectively, during the ten-year period. Most of the figures covered in NSSC and turbines/generators likely went to DHI. Table 2-5 below Table 2-4 contains the revenues of Kepco E&C from sales of designing services for nuclear power plants during the same period. Its revenues in the nuclear power procurement market have grown by 267% in the ten-year period as a result of export to the U.A.E. and continued construction of new nuclear power plants in the domestic market.

Table 2-4 Breakdown of Revenues of the Nuclear Procurement Market

(Unit: 100 million Won)

Years:	Design and engineering	Equipment manufacture				Total
		NSSS system	T/G system	BOP	Sub-total	
2003	1,963	3,641	554	786	4,981	6,944
2004	2,048	3,476	583	1,007	5,066	7,114
2005	1,986	2,369	600	961	3,930	5,916
2006	2,499	3,402	655	1,659	5,716	8,215
2007	2,292	2,931	937	2,547	6,415	8,707
2008	2,929	11,718	1,574	3,137	16,429	19,358
2009	3,528	5,815	2,045	3,992	11,852	15,380
2010	5,132	9,449	396	5,751	15,596	20,728
2011	5,277	10,325	3,130	5,163	18,618	23,895
2012	5,096	10,464	3,051	4,131	17,646	22,742
Average	3,275	6,359	1,353	2,913	10,625	13,900

Source : Ministry of Science, ICT, and Future Planning, *The 18th Survey on the Status of Nuclear Industry in 2014*, prepared by Korea Atomic Industrial Forum (KAIF).

KHNP procures goods and services from foreign suppliers as well. The exact proportion of goods and services purchased by KHNP from domestic suppliers is not known. However, some survey results have estimated the proportion of domestically supplied parts and components at an average of 67%. According to the survey conducted by NEISC, the proportion of the parts and components supplied by domestic suppliers in building Hanbit #5 and #6 plants was 91% for pipes, 64% for electric

items, 20% for instruments and control, and 71% for machinery.⁸ DHI manufactures most of the key components it uses in producing NSSS and turbines/generators, as mentioned above. The number of firms manufacturing various components that constitute BOP are given in Table 2-6 below. It should be noted that the number of firms in each of the cells corresponding to a component in BOP in the table is not the number of firms competing with one another. Most of the firms operating in the market for a component produce parts or smaller components used in producing the component. For instance, most of the firms operating in heat exchangers do not produce the heat exchangers that are purchased by KHNP but produce parts and smaller components that are used by other firms that produce heat exchangers.

Table 2-5 Revenue of Kepco E&C from the Sales to KHNP
 (Unit: 100 million Won)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Revenue	1,775	1,324	1,577	2,156	2,090	2,416	3,039	4,542	4,658	4,740

Source : Ministry of Science, ICT, and Future Planning, *The 18th Survey on the Status of Nuclear Industry in 2014*, prepared by Korea Atomic Industrial Forum (KAIF).

Table 2-6 Number of Domestic Manufacturers in the Nuclear Power Procurement Market

Systems	Components	Number of
Nuclear system	Steam Generator (Vaporizer), Nuclear Reactor, Pressurizer, Reactor Coolant Pump, Volume Control Tank, Safety Injection Tank, RCS Piping	1
	Sub-total	1
Turbine/Generator	Generator	2
	Turbine	1
	Exciter	1
	T/G Piping	1
	Sub-total	5

8 NEISC (2013). A plant here means one unit of generation facility consisting of a reactor, a generator/turbine, and a BOP.

Table 2-6 Continued

Systems	Components	Number of
BOP	Piping/Valve	49
	Heat Exchanger	30
	Instrumentation/Measurement Equipment	23
	Other Pipings/Filter	21
	Air Handling Facility/Duct	20
	Main Control Switchboard	19
	Main Transformer	16
	Electricity Cable	13
	Containment/Turbine Crane	10
	Water Circulation Pump	4
	Feed Water Heater	4
	Steam Condenser	4
	Diesel Generator	2
	Condensate/Feed Pump	1
	Sub-total	216

Source: Reproduced part of the Table 11 of Analysis of Nuclear Equipment Technology Trend, Korea Nuclear Equipment Industry Support Center (NEISC), 2013.

Table 2-7 Revenues of the Nuclear Procurement Market in Korea

(Unit: 100 million Won, %)

	KHNP	Others	Total
Design and engineering	2,203	2,893	5,096
	43.23	56.77	100
Manufacturers of parts and components	10,514	9,823	20,337
	51.7	48.3	100

Source: Ministry of Science, ICT, and Future Planning, *The 18th Survey on the Status of Nuclear Industry in 2014*, prepared by Korea Atomic Industrial Forum (KAIF).

The sizes of the revenues of firms in the vendor industry are generally small. The following table, Table 2-7, summarizes information on the amount of revenue for each group of suppliers from sales to KHNP as well as to other consumers, which are mostly the government or indus-

trial consumers, in 2012. Thus, the market in the table consists of sales to government agencies, research institutes, and private firms in addition to KHNP and is much larger than the market for procurement of KHNP. Sizes of domestic firms are also generally small. Except for Kepco E&C, there are only two other firms in the market for design/engineering services, one small and one medium-sized firm. In manufacturing, thirteen firms are large firms while forty-nine firms are small or medium sized. The proportion of the revenues for small and medium-sized firms to total revenues for all firms was 14.7% in 2011 and 7.3% in 2012.⁹

Table 2-8 Distribution of Revenues of Manufacturers in the Nuclear Procurement Market
 (Unit: Number of firms)

Revenue brackets	Above 100 billion Won	Between 50 and 100 billion Won	Between 10 and 50 billion Won	Between 5 and 10 billion Won	Between 1 and 5 billion Won	Below 1 billion Won	Total
Manufacturing sector	2	1	7	10	23	19	62

Source : Ministry of Science, ICT, and Future Planning, *The 18th Survey on the Status of Nuclear Industry in 2014*, prepared by Korea Atomic Industrial Forum (KAIF).

Among the vendors, firms that make sizable revenues from the nuclear power procurement market are few. Only DHI, Kepco E&C, Kepco Nuclear Fuel, and KPS earned revenues exceeding USD 100 million from the nuclear procurement market. The rest of the vendors earn revenues that are relatively small. Only one firm earned a revenue exceeding USD 10 million from the sales of design/engineering services in 2012. The distribution of revenues for manufacturers other than DHI and Kepco Nuclear Fuel is given by Table 2-8 below, which confirms that almost all domestic manufacturers are small in terms of their revenues from the nuclear power procurement market.

In fact, most of the privately owned firms selling design/engineering services or parts and components in the nuclear industry are small and medium-sized firms that employ fewer than 300 employees. The num-

9 Ministry of Science, ICT, and Future Planning (2014).

ber of privately owned small and medium-sized firms was forty-three in the design/engineering services and forty-nine in manufacturing in 2012, while the number of large firms operating in design/engineering was two, with thirteen in manufacturing.¹⁰

2-2. Ownership and Governance of Firms

All major players, except DHI, in the market are SOEs that are subsidiaries of Kepco. Kepco owns 100% of KHNP, around 70% of Kepco E&C, around 97% of Kepco Nuclear Fuel, and 63% of KPS. Kepco also owns 100% of the other largest non-nuclear generation companies in Korea. Kepco E&C is 17% owned by private investors and is listed in the stock market. Doosan, Inc., a holding company of the Doosan group, owns 41% of DHI. Kepco itself is 51.1% owned by the government and other SOEs.

While Kepco owns 100% or controlling interests of KHNP, Kepco E&C, Kepco KPS, and Kepco Nuclear Fuel, it does not exercise control over these subsidiaries in the same way that private firms in Korea do. Even when Kepco exercises some control over them, it does not use its control to maximize the economic value of its shareholders. Kepco and its subsidiaries are subject to a stringent set of regulations imposed by the Act on the Management of Public Institutions (AMPP) and the Kepco Act, which limit its profit incentives severely and allow politicians and bureaucrats to use Kepco and its subsidiaries as instruments to achieve the goals they believe to be appropriate. As a consequence, Kepco is limited in its ability to control its subsidiaries. It should also be noted that the executives of Kepco, who are in a position to exert influence on Kepco's subsidiaries, generally do not use their power to maximize the shareholder value of Kepco. Their incentives are not aligned strongly with the financial performance of Kepco. Further, they are required by AMPP and the Kepco Act to pursue objectives that are against the maximization of the value of their firm. The governance structure of the Kepco group affects the incentives of the individuals who make key decisions in the nuclear power procurement market and merits detailed discussions.

¹⁰ Ministry of Science, ITC, and Future Planning (2014), p.59.

3. Relevant Laws and Regulations

Procurement of parts, components, equipment, and design services that are purchased by KHNP to be used in construction and operation of nuclear power plants are subject to several laws in Korea. The most important ones are the laws that govern procurement of SOEs in Korea, the laws that govern nuclear safety regulation, and the laws on the governance of SOEs operating in the nuclear power and electricity industries. In addition, the Criminal Law defines penalties for violations of the above laws and for illegal actions taken by firms and individuals in the procurement market.

The most important laws that govern the procurement of KHNP, Kepco E&C, and Kepco are the Act on Contract in Which the State is a Party (ACSP) and AMPP. In addition, procurement of the SOEs is subject to the WTO agreement on procurement. ACSP requires conditions that government agencies must satisfy in procuring goods and services, based on competition and transparency. Article 44 of AMPP allows the procurement activities of SOEs to follow the procedures specified in ACSP. Article 44 also allows SOEs to give preferential treatment to small and medium-sized firms in procuring goods and services. Article 39 – (3) of AMPP allows the Ministry of Strategy and Finance to determine the principles and rules that SOEs must follow in procurement and a detailed set of principles and rules, called “The Rules on the Contracting of SOEs and Quasi Government Institutions,” that have been drafted by the ministry and authorized by the government. The Rules on the Contracting of SOEs and Quasi Government Institutions specify the procedures that SOEs must follow on a wide range of issues.

The Act on Nuclear Safety and Security (ANSS) specifies various responsibilities of KHNP aimed at ensuring safety in operating nuclear power plants. As a part of the requirements, the act and a set of rules and guidelines based on the act require KHNP to ensure that parts and components it purchases and uses in building and operating nuclear power plants meet the technical standards required by safety regulation. Contrary to the belief of many, the act did not deal with the question of whether safety-related parts and components meet required safety standards per se, until its amendment in May 2014. Thus, it was not against

this law to sell safety-related parts and components that failed to meet the safety standards or to fabricate testing reports of safety-related items or conspire to fabricate certifying documents or to knowingly buy or sell faulty items. In short, the act depended on KHNP for using parts and components that were safety related.

The act and the rules and guidelines based on it led to a set of technical standards that each safety-related part, component, and system must meet for KHNP to use it in building and operating nuclear power plants. The technical standards take the form of codes designed by professional organizations such as ASME of the U.S. or KEPIC of Korea. KHNP is then required by the act to use only parts and components that meet the industrial technical standards designed by one of a handful of professional organizations.

In addition to the laws listed above, AMPP and the Kepco Act affect the performance of the nuclear power procurement market profoundly by determining the environment in which the executives and employees of the SOEs work. AMPP stipulates a detailed set of rules on the governance of most of the SOEs and public institutions in Korea, including rules on the composition and operation of the board, appointment and firing of the CEO, authority and responsibility of top management, decision-making processes, constraints on organization and spending, performance evaluations, and remuneration, among others. KHNP, Kepco E&C, Kepco Nuclear Fuel, KPS, and Kepco are all subject to AMPP. The Kepco Act puts additional constraints on the governance of Kepco and its subsidiaries, including four SOEs in the nuclear power industry. Although AMPP and the Kepco Act do not concern procurement or nuclear safety specifically, they determine the incentives of executives and employees of the SOEs in the procurement market, as well as authority they actually exercise in allocating resources. The incentives and authorities of executives and employees of the SOEs determine their behavior in the procurement market

3-1. Laws Concerning the Procurement of SOEs

Article 39 of AMPP allows the Minister of Strategy and Finance to determine rules on the accounting and procurement of SOEs and public

institutions. Based on this, the Ministry of Strategy and Finance imposes a detailed set of rules (“Rules on the Contracting of SOEs and Quasi Government Institutions, Ministry of Strategy and Finance Order 431”) that govern the procurement of SOEs, including KHNP, Kepco E&C, Kepco Nuclear Fuel, KPS, and Kepco. Article 44 of AMPP allows the application of the Act on the Contracts in Which the State is a Party to SOEs. We summarize some of the principles and rules that are important to the procurement market of the nuclear power industry below.

- Principle of equality: SOEs should not unfairly restrain the interests of the other party.
- Types of bidding: SOEs can use several different types of bidding in procuring goods and services. Open bidding is encouraged in general. However, SOEs are allowed to use other types of bidding, provided that there are justifiable reasons. The types of biddings SOEs can use include restrictive bidding, in which an SOE can restrict participants in bidding by requiring that they meet specific conditions; selective bidding, in which an SOE selects those who can participate in bidding; and single-source of bidding.
- Reservation price: SOEs use a reservation price in procurement. A reservation price is used as a ceiling for the bid prices. It is not clear exactly how SOEs determine reservation prices although it is known that they are determined based in part on the prices that have been submitted in similar procurement contracts in the past and on the prices of the same or similar items to be procured in open markets. For some reason, SOEs are not allowed to disclose the reservation price until the selection of the winner is made. SOEs frequently use a random device to generate the exact amount of the reservation price to be used in an auction to make it more difficult for the bidders to predict it.
- Method of selecting the winners and the terms of the contracts: An SOE can choose various methods in selecting winners and the terms of the contracts. The most frequently used methods are selection by the price only; selection by a bid price that is closest to the reservation price among the prices that do not exceed the reservation price; selection based on both the price and other charac-

teristics such as quality, functions, and options; and selection by negotiations with a bidder selected as the preferred bidder to negotiate with. In most of the cases, an additional criterion, that the winner must possess the ability to successfully carry out the terms of the contract, applies. Officially, SOEs cannot freely choose methods to be used to determine whether a bidder satisfies this criterion and must follow the guidelines given by the Ministry of Strategy and Finance. However in practice, SOEs often enjoy a large degree of discretion in choosing methods they will use to determine whether this criterion is satisfied.

- SOEs can use single-source procurement if there is only one supplier or if there is no effective competition or if competition is expected to lead to higher prices or if the goods to be purchased are produced by a small or medium-sized firm that meets specific conditions or if the goods meet the conditions for promotion of domestic production.
- SOEs can require qualifications that each bidder must satisfy to participate in bidding.

In summary, SOEs are subject to a large and complex set of restrictions in procurement, the goal of which is to force SOEs to purchase goods and services in the most efficient way, taking into account both the price and other characteristics that affect their ultimate value to the SOEs. The reason that Korea and some other countries have extensive restrictions on the procurement activities of SOEs is that executives and employees of SOEs work in an environment that allows them to shirk more easily compared to private firms due to the fact that SOEs do not operate under a governance structure that is well aligned with the economic efficiency.

However, it is clear that despite the restrictions, executives and employees of SOEs who are in charge of procurement still have much room for using their own discretion when they procure goods and services for which quality and other characteristics are important. The executives and employees of SOEs ultimately make decisions on qualifications for bidders; technical standards and other conditions that goods or services must satisfy; bidding methods; and methods for selection,

inspection, and payment. Outsiders do not have access to information about their activities. While the Board of Audit and Inspection audits procurements of all SOEs and government agencies, their resources are limited considering the size of the procurement contracts in the public sector. It generally does not possess expertise and information specific to each contract that would be necessary to analyze a contract involving a complex set of qualifications, qualities, characteristics, and technical standards.

The discretion that the executives and employees of SOEs have in procurement is probably larger in SOEs operating in the nuclear power industry than in those in any other industry, for various reasons.

3-2. Act on Nuclear Safety and Security

ANSS affects the procurement market in the nuclear power industry primarily by requiring KHNP to purchase goods and services that meet the safety standards based upon it when they are safety related. KHNP takes a series of actions given below, aimed at ensuring that each safety-related part or component meets the technical standards that are based on ANSS and a set of rules and guidelines attached to it.

First, KHNP maintains and manages the list of qualified vendors that are eligible to supply goods and services. A vendor must be registered in the list to sell its products to KHNP. Thus, a firm that wants to sell a safety-related part or component needs to apply to become a qualified vendor first. KHNP evaluates relevant factors and determines whether a firm that applied to become its vendor is qualified, makes decisions on approval, registers approved vendors, and manages the list.

Second, once KHNP decides to purchase a safety-related part or component, it hires Kepco E&C to prepare a set of technical standards that the item must satisfy to meet the safety standards required by nuclear safety regulations and includes it as a necessary condition that each bidder must satisfy in the procurement notice.

Third, when all bids are submitted, KHNP hires Kepco E&C in the selection process to evaluate the parts on technical specifications included in each bid. KHNP evaluates the price and other parts of the bids. KHNP selects the winner based on the evaluations.

Fourth, once it selects the winner, KHNP hires Kepco E&C to prepare the parts on technical specifications in the contracts, which are essentially the same as the specifications Kepco E&C prepared for the procurement notice. KHNP prepares the other parts of the contract.

Fifth, KHNP requires the selected vendor to hire a testing or certifying firm, which will test samples of the product to be delivered or verify its quality. The vendor must submit a testing report or other forms of quality certification to KHNP before delivering the products.

Sixth, when the vendor obtains quality certification documents from a firm it hires, it submits them to Kepco E&C for authentication. Kepco E&C compares the contents of the certification documents with the technical specifications included in the contracts and determines whether they are compatible. Based on the comparison, Kepco E&C issues an authentication report.

Seventh, KHNP must reject the delivery of the product if the authentication report of Kepco E&C states that the quality verification document shows that the product failed to meet the technical standards specified in the contract.

Eighth, if the authentication report of Kepco E&C states that the quality verification document shows that the product meets the technical standards specified in the contract, KHNP proceeds to confirm that the product actually meets the technical standards, usually by checking samples when such additional checking of the samples is deemed necessary. KHNP does this itself or hires a firm to do it on its behalf.

In addition to the above, KHNP often sends its employees, or technicians from a firm it hires, to production facilities of vendors for quality audits. KHNP also often sends its employees, or technicians from a firm it hires, to testing firms retained by the vendors to observe the testing of samples to ensure that testing is conducted according to the specifications required by safety regulations.

ANSS does not make it illegal to sell safety-related parts or components that fail to meet required standards to nuclear power plant operators. Nor does it make it illegal to issue a certification document that does not reflect the true quality of a product or of the samples submitted for testing. Also, before its amendment in May 204, ANSS did not require designers or manufacturers of safety-related components or certi-

fyng institutions to report to it if they found that a part or component did not meet the safety standards it requires. As a result, the individuals who participated in the fabrication of testing reports of safety-related components did not violate ANSS and were punishable only for violation of the Criminal Law on forgery of documents or bribery. The amendment requires KHNP to report to NSSC on contracts it signs with firms that design or manufacture safety-related components and equipment or certify or test them. The maximum penalty for violation of this clause is a criminal fine of KRW 10 million or slightly above USD 9,000. The amendment also requires KHNP, firms that design or manufacture safety-related components or equipment, and firms that test or certify them to report to NSSC if they find that components or equipment do not meet the standards required by the act. The maximum penalty for violation of this responsibility is an administrative fine of KRW 30 million or around USD 28,000.

3-3. AMPP and the Kepco Act

AMPP specifies a set of rules on the governance of SOEs, including KHNP, Kepco E&C, and Kepco, as well as public institutions. AMPP basically perceives the SOEs as policy instruments and aims to reduce costs of SOEs while they conduct the businesses that the government requires.¹¹ AMPP specifies detailed rules on a wide range of issues concerning the governance and operation of SOEs and public institutions, including the following:

- Composition of the board
- Appointment and firing of board members and the auditor

11 In 2007 AMPP replaced the Framework Act on the Management of the Government-Owned Corporations, which had been in effect since the early 1980s. The Framework Act on the Management of the Government-Owned Corporations basically took a command-and-control approach that perceived the SOEs subject to it as being instruments of their line ministries instead of commercial enterprises. AMPP has some new elements. In its implementation, however, AMPP works very similarly to the old law it replaced. For a detailed discussion on AMPP and its implementation, see Nam (2013a).

- Appointment and firing of CEO
- Authority and responsibilities of the board
- Management contract between the board and CEO
- Authority and responsibilities of executives
- Salaries and bonuses of executives and employees
- Accounting and financial plans
- Investment
- Budget
- Hiring of employees, and ceiling on employment
- Audits
- Management goals
- Performance evaluation and remuneration of CEO, executives, and employees

AMPP also gives the Minister of Strategy and Finance and the minister of the line ministry of each SOE and public institution the power to supervise the management of them. In addition to AMPP, the Kepco Act allows Ministry of Trade, Industry, and Energy (MOTIE) to intervene in the management of Kepco and its subsidiaries quite freely on a wide range of issues, including investment in the electricity industry and the governance of subsidiaries.¹² AMPP and the Kepco Act allow MOTIE to run Kepco and its subsidiaries, including KHNP and Kepco E&C, as its instrument. These two laws have led to the emergence of an environment in the SOEs operating in the nuclear power industry that determines the rules of the game according to which the executives and employees must behave and an incentive mechanism according to which they are compensated. Most executives and employees of the SOEs in the nuclear power industry seek survival, promotions, better jobs within their firms, and financial achievements. They make choices that suit their interests best according to the rules of the game that they perceive prevail in their firms.

Thus, it is important to ask whether the rules of the game and the in-

12 The law allows MOTIE to supervise Kepco on issues related to the benefit of the public, which is interpreted very broadly, thereby allowing MOTIE to intervene in the management of Kepco and its subsidiaries quite freely.

centive mechanisms that executives and employees face induce them to take actions that are consistent with those that the laws intended. Since the MOTIE is not much interested in profitability or internal efficiency of SOEs and is interested primarily in achieving its various objectives using the SOEs in the energy sector as instruments, its strong control over the SOEs generally leads to inefficiency of the SOE. The environments in which the executives and the employees of SOEs operate and the rules of the game according to which they make choices generally induce the executives and employees to follow what MOTIE orders rather than to try to increase the efficiency and competitiveness of their firms. Failure in the nuclear power procurement market suggests that the laws ended up leading to the emergence of the rules of the game and the incentive mechanisms that gave executives and employees of the SOEs wrong incentives and induced them to take actions not consistent with the efficiency and safety of the procurement market.

4. Evidence of Sub-optimal Performance of the Nuclear Power Procurement Market

In 2012, KHNP reported to NSSC its findings about fraudulent equipment qualification (EQ) documents in 60 procurement contracts that covered 7,682 items.¹³ This is the first report of fraudulent documents that NSSC ever received.¹⁴ All of the documents were commercial-grade dedication items (CGDI). NSSC started the investigation of the equipment qualification EQ documents of all CGDI items. During the investigation, NSSC discovered that quality certification documents of some safety-related items were fabricated. A separate investigation conducted by NSSC on control cables, prompted by anonymous tips, led to the discovery of fabrication of testing reports in the procurement of

13 The facts on fabrication of documents quoted in this section are based on NSSC (2012), NSSC (2013), Prime Minister's Office (2013), MOTIE (2013a), and MOTIE (2013b).

14 NSSC was created in 2012. We are not aware of any such report made by KHNP to the government before the establishment of NSSC.

control cables classified as safety related.

In 2013, NSSC conducted the investigation of all testing reports and EQ documents of all safety-related items that had been purchased by KHNP and used in twenty-three nuclear power plants in the preceding ten years. The investigation turned up a large number of fraudulent documents. Out of 21,681 testing reports that accompanied the safety-related items purchased by KHNP, 247 reports or 1.27% of the total number turned out to be fraudulent. The number of items accompanied by fraudulent reports was 1,511, out of which 1,017 had been actually installed in nuclear power plants. In addition, 406 testing reports, or 1.9% of the total number of testing reports, were impossible to verify for authenticity. The number of items that were supplied with such reports was 6,716.

On EQ documents, NSSC investigated all of them that accompanied the items sold to KHNP and used by nuclear power plants since 1996, and discovered that out of the total number of 2,699 documents, 62 or 2.3% of the total were fraudulent and that 53 or 2.0% were impossible to verify. The investigation revealed that one of the seven testing firms in Korea, Saehan TEP, repeatedly fabricated testing reports, accounting for forty-eight of the sixty-two cases of fraudulent reports. The rest of the fraudulent cases consisted of five cases of fabrication by the manufacturers themselves who conducted EQ activities on the items they produced, and eight cases of fabrication by suppliers of the original EQ documents prepared by third parties, and one case of selling items without EQ documents.

A special team of prosecutors was created to investigate fraud and other crimes in the procurement market of the nuclear power industry. Its investigation turned up a string of frauds, bribery, and other crimes, leading to the indictment of a large number of employees of KHNP, suppliers, and testing firms. Internal audits of KHNP revealed more cases of purchasing and installing fraudulent items and other illegal activities in its procurement of parts and components used by nuclear power plants. KHNP requested the prosecutors to investigate 101 firms and their employees suspected of fabricating EQ or testing documents in 2013.¹⁵ The special team of prosecutors indicted 107, including 70 from

¹⁵ Annual, quarterly, and special audit reports published by the auditor's office of

the 101 firms that KHNP requested to be investigated. The types of illegal activities listed in audit reports prepared by the Auditor's Office at KHNP include the following:

- Bribery involving some executives, including a former CEO, and managers
- Overpaying for goods and services purchased by KHNP and other preferential treatment to suppliers
- Limiting competition in bidding
- Favoritism toward one of the bidders in procurement by managers involved in procurement
- Purchase of imported items disguised as components developed and produced by domestic firms
- Accepting parts and components that were not accompanied by EQ documents and paying for them
- Accepting parts and components accompanied by fraudulent testing reports or EQ documents
- Accepting parts and components accompanied by fraudulent testing reports or EQ documents by KHNP managers who knew that they were fraudulent
- Fabrication of testing reports in which KHNP managers, engineers of Kepco E&C, a testing firm, and the vendor participated.

Although not directly related to procurement, it was also discovered by the prosecutors that some executives and managers of KHNP took bribes from other employees of KHNP and that some managers who took bribes from vendors shared the bribes with their superiors.

It is true that purchase of fraudulent items does occur in other countries too because some manufacturers and distributors try to make quick profits by selling fraudulent items to nuclear power plant operators. Nuclear power plant operators and the regulators in all countries exert substantial efforts to screen out fraudulent items. However, it is impossible to screen out fraudulent items completely because there are more than 1.5 million parts and components that are safety related, which makes

KHNP in 2012 and 2013.

the job of successfully screening out all fraudulent items difficult. However, there are reasons to suspect that the incidents that took place in KHNP are unusual.

First, the number and the proportion of cases of fraudulent items seem to be extraordinarily large, although it is impossible to compare the frequency in Korea with the frequency in other countries, because comparable data does not exist for those other countries.¹⁶

Second, it seems unusual for employees of nuclear power plants to knowingly accept fraudulent items that are safety related, the use of which can cause damages the costs of which can be hundreds of millions of dollars or even billions of dollars to their firm. It is puzzling, too, in that the employees who knowingly accepted parts and components accompanied by fraudulent certifying documents exposed themselves to the risks of criminal and civil penalties that could be very severe.

Third, it seems uncommon that a testing firm repeatedly fabricated testing reports for an extended period of time.

Fourth, it seems that managers in charge of procurement had a large degree of discretionary power in designing the bidding mechanism and selecting the winners, which often allowed some of them to openly favor some bidders over others.

The JS Cable case sheds more light on the problems that have existed in the nuclear procurement market in Korea. It is the most widely known case of failures in the nuclear procurement market and has many elements that merit a detailed analysis. Analysis of this case leads to the causal roots of the failures in the procurement system that have surfaced in this and other cases.

Reports published by KHNP, NSSC, and the Auditor General's Office also confirm that the procurement system of KHNP did not function properly in many ways. Managers in charge of procurement frequently purchased parts and components from firms not registered in the list of qualified vendors. KHNP's inventory system was also deemed inadequate in that it did not maintain sufficient quantities of spare parts and

16 The measures Korea took in response to procurement scandals is extraordinary in that it investigated all contracts in the preceding ten years and publicly announced the results of the investigation.

components that are difficult to purchase on short notice. This gave the KHNP managers and vendors a strong incentive to buy and sell sub-standard parts and components when they found out that legitimate parts and components KHNP needed urgently could not be purchased through acceptable channels in time.¹⁷

We did not include collusion on the part of suppliers in our analysis in this paper, but there are reasons to believe that collusion among suppliers in bids to sell goods or services to KHNP may be more prevalent than previously thought.¹⁸ There are three cases of collusion that have been confirmed by the Korea Fair Trade Commission (KFTC) since the establishment of KHNP in 2001. One of the three cases involved cable companies.¹⁹ It is reasonable to suspect that there were more collusion cases involving cable companies in the procurement of KHNP, considering that cable companies have been found to have colluded frequently in other markets and that KHNP purchases large quantities of various cables every year. It is also reasonable to suspect that large construction companies may have colluded in bids to win contracts on various construction and engineering projects procured by KHNP, considering that it has been repeatedly found by KFTC that large construction companies routinely colluded in bids for construction and engineering contracts procured by the government, local governments, and SOEs.²⁰

17 It usually takes a considerable length of time to obtain quality certification documents, especially when the documents are issued by institutions in foreign countries. Most commercial-grade dedication items need quality certification by foreign institutions.

18 Song (2013) contains detailed information on collusion in auctions and the regulation of KFTC on them. It includes some of the data on collusion involving SOEs.

19 KFRC Decision 2013-011 states that there was collusion by cable manufacturers in a bid for cables procured by KHNP. Interestingly, JS Cable participated in the collusion. The other two cases involved manufacturers of some equipment used for maintenance and a coolant system. See KFTC Decision 2009-125 and 2013-107 for details of the two cases.

20 Another possibility is collusion between managers of KHNP in charge of procurement and some suppliers they prefer. There is no data available on the proportion of the prices of the winning bids to reservation prices in the procurement of KHNP. Some data, however, on the proportion of winning bid prices to reservation prices in Kepco's procurement were revealed during the congressional audits, which showed that in the cases of some items Kepco purchased, the winning bid prices were re-

5. Measures Taken by the Government

MOTIE and NSSC studied the procurement system of KHNP in response to the incidents that surfaced in 2012 and 2013. They each identified the problems they found and took measures they believed would improve the performance of the procurement market significantly. NSSC focused on the safety of parts and components in its approach to the procurement market while MOTIE addressed a wider set of issues although priority was given to the issues of corruption and safety.

5-1. NSSC and the Act on Nuclear Safety and Security

NSSC found that the procurement system of KHNP was grossly inadequate. It found that basically no system existed that effectively controlled the procurement processes within KHNP. As a consequence, employees working for procurement units routinely violated laws or internal regulations, unchecked and unpunished. Communications and coordination among units performing different procurement functions were extremely poor. In short, KHNP management completely failed in running the units on procurement and quality assurance reliably and efficiently.²¹ NSSC also found that the behavior of KHNP managers in routinely demanding vendors to supply parts and components on short notice contributed to the purchase of fraudulent items. Finally, NSSC found that KHNP lacked the human resources and legal power necessary to effectively run its quality assurance systems.

The Act on Nuclear Safety and Security was amended in May 2014 to enable NSSC to regulate the safety of parts and components used in nuclear power plants. The main contents of the amendment are as follows:

peatedly close to 99.99% of the reservation prices, raising suspicion that not only did bidders collude, but they received information on the reservation prices beforehand.

- 21** NSSC (2012) discusses incidents in which parts and components were installed before they were inspected and in which used components were removed from operating nuclear power plants by KHNP managers, who gave them to a vendor who sold them back to KHNP disguised as freshly produced components.

- KHNP is required to notify NSSC on the contracts with firms that design or build facilities and test or certify the quality of the facilities that are safety related.
- KHNP is required to notify NSSC when it discovers violations of the standards in safety-related facilities.
- NSSC can appoint a testing institution to test or certify quality or performance of facilities used in nuclear power plants.
- Heavy penalties are provided for violation of relevant laws by testing or certifying institutions or their employees.
- Incentives are provided for reporting violations of the act.
- Fines can be imposed on KHNP in case it fails to report to NSSC on contracts or violations of the act.
- The maximum amounts for fines were increased.

5-2. MOTIE and KHNP

MOTIE found widespread connections between executives and managers of KHNP and vendors and inefficient bidding and contracting methods that KHNP used as the main problems, in addition to a loose and inadequate system of quality assurance and inspection and a lack of expertise, independence, and human resources in the procurement unit of KHNP, which NSSC also identified.²² In particular, MOTIE blamed the connection between ex-employees of KHNP working for vendors and incumbent employees for much of the corruption and lack of competition and transparency existing in the procurement market. Other problems it identified included difficulty in detecting fraudulent items; absence of penalties, in the contracts between vendors and testing firms, for testing firms producing inappropriate testing reports; excessive discretionary power that KHNP procurement managers had over the selection of methods for bidding and contracting; and heavy reliance on single-source procurement.

A special committee, the Committee on Improving the Procurement System in the Nuclear Power Industry, organized by MOTIE to study the problems in the procurement market, also identified similar prob-

22 MOTIE (2013a).

lems found by NSSC and MOTIE. This committee focused on the details of the procurement system of KHNP and made additional observations on the problems in the nuclear power procurement market and solutions to them. Some of its claims include the following: (1) inefficient cost structures of vendors due to diseconomies of scale, (2) lack of attention to quality, and excessive emphasis on cutting costs and construction periods on the part of KHNP management, (3) excessive competition in markets for safety or quality-grade parts and components used in BOP, (4) excessive discretion of managers in procurement in selecting bidding and contracting methods, and (5) difficulty in determining reservation prices that reflect the true costs of production.

MOTIE ordered KHNP to change its procurement system. The measures KHNP has taken can be summarized as follows:

- Submission of testing reports to KHNP by testing firms. KHNP began forcing its vendors to require testing firms they contracted to submit testing reports directly to KHNP as well as to the vendors.
- Payment of testing fees by KHNP. KHNP began paying fees directly to testing firms for testing samples produced by its vendors.
- Discouraging ex-employees of KHNP from accepting employment with vendors. KHNP ordered the prohibition of retired level 1 and level 2 executives from accepting employment with its vendors and announced penalties on vendors that hired these retired executives in the bidding process.
- Requiring prequalification in the procurement of all Q-grade parts and components.
- Disclosure of procurement plans in advance.

MOTIE and KHNP also announced plans aimed at increasing competition, increasing the prices of parts and components, and increasing the use of best value, instead of lowest price, as the criterion to select winners among qualified bids.

6. Chapter Summary

The incidents that occurred in the procurement market for the Korean nuclear power industry in 2012 and 2013 were extraordinary in many respects. It was clear that the procurement market did not function properly and failed to ensure safety. Thousands of parts and components that did not have legitimate documents certifying their safety were purchased, installed, and used. In some cases, purchases of fraudulent items were not due to a lack of expertise or negligence. Instead, they were accepted by some managers of KHNP who knew that they were not accompanied by legitimate documents.

The procurement market also failed to induce an efficient allocation of resources. Large amounts of money were wasted to purchase the parts and components that nuclear power plants should not use. Huge costs were incurred to replace faulty parts and components identified by audits and investigations as faulty. Several nuclear power plants have been shut down for a substantial period to replace faulty components and assess safety. KHNP experienced hundreds of millions of dollars in lost revenues. In addition, the shutdown of nuclear power plants led to a jump in the prices of electricity in the wholesale market, forcing Kepco to pay substantially higher prices for the electricity it purchased. The higher wholesale electricity prices resulted in higher consumer tariffs.

The lessons are clear. Distortion in the procurement market in the nuclear power industry proved to be very costly in terms of economic efficiency and safety. The Korean government initiated a wide range of measures aimed at improving the performance of the procurement market on nuclear safety regulation and procurement of SOEs in the market. Whether the measures will be sufficient to induce a significant improvement in the performance of the procurement market is not yet clear. This subject will be examined further in Chapter 3.

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CHAPTER 3

Factors That Caused the Inefficiency in the Procurement Market for the Nuclear Power Industry of Korea

Ilchong Nam

1. Introduction

Chapter 2 presented evidence of the problems that existed in the procurement market in the nuclear power industry. It summarized the measures that NSSC and MOTIE took to improve the efficiency and safety of the procurement market. This chapter identifies the factors ultimately responsible for the failure in the procurement market by analyzing the incentives of the firms and individuals in the procurement market. This chapter also presents a set of policy recommendations that could improve the performance of the procurement market. The analysis shows that the inefficient governance structure of the SOEs in the nuclear power industry was the single most important factor that was responsible for the procurement market failures. Consequently, simple changes in the procurement methods used by the SOEs will have limited effects.

To identify the fundamental factors behind the distortion in the nuclear power procurement market, we model the JS Cable case mentioned in Chapter 2 as a sequential move game in which executives, managers, and engineers of KHNP, Kepco E&C, JS Cable, and Saehan TEP are the players. This case involved employees of two major SOEs

in the nuclear power industry whose motives in participating in the collusion were not directly related to bribes. Our analysis of the case, which focused on the incentives of the firms and individuals involved, led to our primary conclusion that the peculiar governance structures that have dominated SOEs in the Korean nuclear power industry over the last four decades were ultimately responsible for the inefficiency of the procurement market.

This chapter proceeds as follows. Section 2 describes important facts about the JS Cable case and raise crucial questions about the incentives of the players. We then model the JS Cable case as a simple, extensive form game and analyze the equilibrium of the model. The equilibrium involved collusion by managers of KHNP, engineers of Kepco E&C, executives of the manufacturer of the faulty cables, and executives of the testing firm to fabricate testing reports to enable KHNP managers to purchase faulty cables. This collusion was incentive compatible. What are the incentives of each player to participate in the collusion? Why would the manager of KHNP want to order fabrication of testing reports and to purchase faulty cables that can only lower the profitability of his firm? Why would engineers of Kepco E&C want to fabricate testing reports that can only harm their firm? The current evidence strongly suggests that simple bribery theory cannot explain their behavior. We focus on the particular governance structures that have dominated the SOEs in the nuclear power industry for more than four decades to identify the factors that are ultimately responsible for the problems that have surfaced in recent years.

We then assess the expected effects of the measures taken by the Korean government, summarized in Chapter 2, and explain the fundamental problems that plague the procurement market in the Korean nuclear power industry. The final section concludes with a set of policy recommendations we hope can improve the efficiency and safety of the procurement market.

2. Case of the JS Cable

2-1. Importance of the Case and the Need for a Case Study

The case of JS Cable involved (1) managers in charge of procurement at KHNP, (2) engineers in charge of authenticating certifying documents at Kepco E&C, (3) executives and employees of a testing firm, and (4) executives and employees of a manufacturer of safety-grade control cables, who colluded and fabricated the testing reports. It is an interesting case in many respects that merits an extensive analysis. It is particularly interesting in that executives and managers of four different firms. Understanding the collusion of such a large number of individuals from different firms performing different functions could help us understand the fundamental problems existing in the nuclear procurement market. The case study will also shed light on the incentive structures of the individuals who make key decisions in the nuclear procurement market in KHNP, Kepco E&C, suppliers, and testing firms. The case study will provide a basis for a game-theoretic analysis of the JS Cable case presented in the next section.

2-2. Key Facts about the Case²³

JS Cable Inc. is a manufacturer of various cables used in the electricity industry.²⁴ In 2004, it participated in a bid to win the contract for safety-grade control cables from KHNP. Safety-grade control cables are a component in the BOP that perform functions that include transmitting signals in case of some emergent situations, including LOCA (loss of coolant) accidents which can lead to the meltdown of the reactor if measures to restore cooling are not taken in time. Naturally, there is a

23 The facts about the case included in this sub-section are based on court records and interviews we conducted with experts in the nuclear power industry. See Busan District Court, Dongbu Branch Judgment 2013-107, for more details of the JS Cable case and other cases involving executives and managers of the four firms. KHNP (2013), NSSC (2013), and MOTIE (2013b) also include discussions on the case.

24 JS Cable was originally established as Yeonhap Cable in 1968, and changed its name twice before changing it again to its current name in 2007.

stringent set of standards, based on the Act on the Nuclear Safety and Security, imposed on cables to be used in a nuclear power plant. The requirements include proof of the ability to sustain exposure to large doses of radiation under high temperature in a steam-filled atmosphere for a specific period of time.

KHNP used to purchase the control cables from foreign manufacturers for all nuclear power plants it built before Shin Gori #1 and #2. In July 2004, KHNP selected JS Cable, a domestic manufacturer, as the supplier of the control cable for four units of reactors in Shin Gori #1 and #2 and Shin Wolsung #1 and #2, which it planned to build, and signed purchase contracts with JS Cable. The contracts included specification of the technical standards that the cables had to meet and the procedures for testing the cables. The contracts also included the criteria for determining whether testing results are consistent with the requirements in the contracts.

In particular, the contracts included the criteria that samples of the cables used in testing had to meet under LOCA conditions. The LOCA tests, required by the procedure and the criteria included in the contract, specify what kind of samples should be used in the tests, testing methods, and the criterion to determine whether the samples pass the tests. KHNP was to accept the cable only if it passed the tests.

When JS Cable bid for the contracts to supply the control cables for the four nuclear power plants to be built, it did not have the confirmed capability to manufacture control cables that would meet the standards originally given by Kepco E&C and specified in the procurement notice. Still, JS Cable participated in the bid, was selected as the winner, and signed contracts for the cables that were scheduled to be delivered in several tranches over the next several years. The contract amount for the first shipment of the cables, scheduled for July 2007, was KRW 5,545,454,400.

According to the procurement contract, testing and authenticating of the testing reports were required to proceed as follows:

- JS Cable was to retain a testing firm, which would test the samples of the cable that it wanted to deliver to KHNP.
- The testing firm would conduct testing of the samples submitted

by JS Cable and would produce a report on the result of testing those samples.

- JS Cable and the testing firm would send the testing report to Kepco E&C, which specified the technical standards that the cables must meet when it designed the power plants and was also contracted by KHNP to authenticate testing reports. Kepco E&C was to review the testing report and determine if the result of testing included in the testing report was consistent with the conditions specified in the purchase contract.
- Managers in charge of inspecting the cables at KHNP were required to determine whether the cables met the technical standards based on the authenticating report prepared and signed by the engineers at Kepco E&C.
- They were required to accept the cables only if the cables were accompanied by testing reports that were consistent with the specifications in the contract and an authenticating report from Kepco E&C which confirmed that the contents of the testing report were consistent with the specifications.

JS Cable was required by the contract to (1) manufacture the cable, (2) have it tested, (3) have it pass the tests, (4) obtain a testing report that certified that all six samples passed the testing, (5) have Kepco E&C authenticate the testing reports, and (6) have the authenticating report from Kepco E&C sent to KHNP before July 2, 2007, the date for the delivery of the first shipment of the cable. In July 2005, JS Cable hired Saehan to conduct the testing and sent samples to Saehan for LOCA testing in May 2006. Saehan subsequently sent the samples to TCMT, a testing firm in Canada, for LOCA testing as it did not have the facility necessary to conduct LOCA testing. In June 2006, TCMT conducted the testing of the samples under the conditions specified in the technical standards in which representatives of JS Cable and Saehan were present as observers. It turned out that only one of the six samples passed the tests, and the other five failed. Thus, the samples failed to meet the technical standards and should not have been used in nuclear power plants in Korea as the standards required that all six samples had to pass the tests.

In September 2006, JS Cable and Saehan requested RCMT to con-

duct a new round of testing.²⁵ This time, the six samples Saehan sent RCMT included two illegitimate samples. The two samples were supposed to have been exposed to large doses of radiation according to the specifications, but Saehan sent RCMT samples of the cables that had never been exposed to radiation. The two illegitimate samples passed tests, but the other four samples failed again. The final result was another failure.²⁶ In January 2008, RCMT sent Saehan a report on the two rounds of testing, which stated that only three out of the twelve samples passed the tests. Saehan subsequently submitted RCMT's testing report to Kepco E&C. The engineer who reviewed the report saw without difficulty that the result of the testing clearly meant a failure to meet the required standards and notified the finding to his superiors in Kepco E&C, who in turn immediately notified the relevant managers in KHNP.

Managers of KHNP then sent an order to the engineers at Kepco E&C to the effect that they should come up with a way to make the testing result a success so that they would be able to accept and purchase the cables. Relevant engineers at Kepco E&C and executives and managers of Saehan and JS Cable agreed to alter the testing reports from RCMT to make the testing results look satisfactory. An engineer of Kepco E&C subsequently altered the testing reports from RCMT, using a computer belonging to Kepco E&C in an office of Saehan, and produced a fabricated testing report that stated that all the samples passed the tests.

A Kepco E&C engineer sent KHNP the fabricated testing result from RCMT along with an authenticating document that stated that the results of the test given in the report from RCMT were consistent with the standards specified in the contracts. KHNP managers subsequently accepted the delivery of the cables and allowed JS Cable to be paid for the cables. In February 2008, JS Cable delivered the first shipment of its cables which it knew failed to meet the standards, along with the fraudu-

25 The second round of testing itself was apparently against the terms of the contract which specified that the outcome of a single testing of six samples was to be used to determine whether the cables met the technical standards.

26 Of course, passing of the two samples was an outcome of their being fraudulent. RCMT would have declared the outcome of testing the two samples as a failure too, had it known that the samples had not been exposed to radiation.

lent testing reports. It went on to sell more of the same cables over the next several years and earned around USD 18 million in revenue.

2-3. Questions about the Incentives for Individuals Who Played Key Roles in the Collusion

The JS Cable case raises questions about the incentives of the firms and individuals involved. The first question that comes to mind is why the managers of KHNP in charge of the procurement of the cables chose to order the engineers at Kepco E&C and executives and employees of Saehan and JS Cable to fabricate the testing reports when they had an option to simply decline to accept the cables. The prosecutors did not present evidence that they received money from JS Cable in return for ordering fabrication of the testing reports and subsequent acceptance of the sub-standard cables.²⁷ Thus, it appears that they did not order fabrication of testing reports because Saehan paid them bribes in return for ordering fabrication. The question arises as to what incentives they had for ordering fabrication of the testing reports, which was likely to lead to the purchase and use of faulty cables that could lead to serious failures. They also knew fully well that they were violating the internal rules of KHNP concerning procurement.

The behavior of the engineers at Kepco E&C is equally puzzling. Although they accepted small gifts, there was no evidence that they received substantial amounts of money that would be sufficient to induce them to follow the order from the KHNP managers. Thus, the question arises as to what incentives they had to follow the order from the managers of KHNP to fabricate the testing reports and to prepare and sign a fraudulent authenticating report, which was a serious crime that could destroy their careers and cause serious damage to their firm. The behavior of Kepco E&C engineers is also puzzling in that they followed the order from a manager in another firm.

27 However, the prosecutors found evidence that the same managers received bribes from suppliers in other procurement contracts and presented it to the court, which was accepted by the court. The court subsequently found them guilty of taking bribes.

The behavior of the executives and employees of Saehan needs explanation, too. They committed crimes that would not only tarnish their reputation and the reputation of the firm, but would also mean the end of their careers and heavy penalties if detected. The amount Saehan was to receive from JS Cable as fees for testing was not large enough to justify the risks they were taking in fabricating samples and participating in the conspiracy to fabricate testing reports. Thus, the question arises as to what incentives executives and employees of Saehan had to actively participate in the fabrication.

The incentive for the executives and employees of JS Cable is easier to explain than those in the cases of Saehan and the two SOEs. The primary motive must have been the gain to JS Cable. But what profit? It is possible that the amount of money involved in the sales of the control cables was large enough for JS Cable to take the risks and sell faulty cables with fabricated documents. But it is also possible that the amount of money involved in the sales of the control cables was not sufficient to justify the risks. In the latter case, there must have been other factors affecting the profitability of JS Cable that were linked to the successful supply of the control cables as specified in the contracts.

To find satisfactory answers to these questions, one must understand the factors that determine the incentives the firms and their executives and employees had. In the next section attempts to give answers to the above questions by modelling the JS Cable case as a simple sequential move game and analyze its equilibrium.

3. A Game-theoretic Analysis of the Control Cable Case

The most interesting question about the JS Cable case is why the managers of KHNP in charge of procuring the control cables and the engineer of Kepco E&C responsible for authenticating the testing reports chose to fabricate the certifying documents. Their actions not only violated relevant laws, but were against their own interests, not to mention the profitability and reputation of their firms. As we observed above, financial gain from the bribes from JS Cable in return for fabricating cables or accepting and purchasing the faulty cables was unlikely to be

the reason for their actions. Understanding the motives behind the two managers of the SOEs is key to the understanding of the failure in the procurement market.

The motives behind the executives and managers of Saehan and JS Cable were profits. But the question is, how was it possible for them to increase their profits by fabricating testing reports. This question is more relevant to Saehan as its business is testing components, in which reputation is crucial. In the case of JS Cable, too, it is not clear how the sale of faulty cables through fabrication of testing reports could increase its long-term profits.

Understanding their motives is crucial in identifying the factors that determined the incentives of the players who colluded in fabricating certifying documents and inducing KHNP to purchase and use sub-standard cable. To understand the motives of the key stakeholders who participated in the collusion, we model the JS Cable case as a non-cooperative sequential game in which executives and managers of the four firms are players, and interpret their behavior as an incentive-compatible collusion. We then attempt to identify the factors that determine the payoffs of each of the players in such a way that participating in collusion to fabricate testing reports is optimal for each player, given the actions chosen by the other players in equilibrium. We argue that a broad set of institutional infrastructure imposed on the SOEs affiliated with the Kepco group is primarily responsible for the behavior of the managers of KHNP and Kepco E&C.

3-1. The Model and Equilibrium Concept

We model the situation surrounding the testing, authenticating, and accepting/rejecting of the control cables that JS Cable was producing, by the following sequential game, depicted by Figure 3-1 below.

Players

There are four players; the manager of KHNP in charge of procurement for the control cables denoted by K; the engineer of Kepco E&C denoted by E; the owner/manager of Saehan denoted by S; and the own-

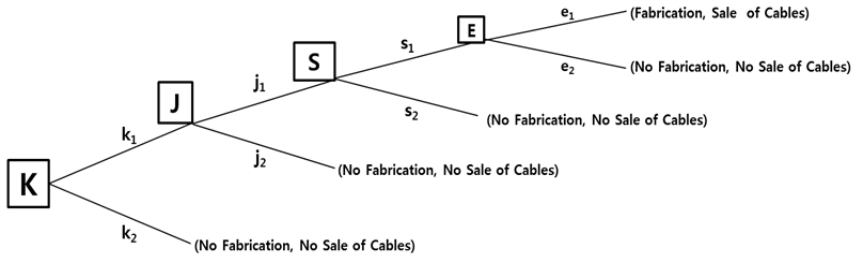
er/manager of JS Cable denoted by J. Each of the four players represents the group of individuals who were involved in producing, testing, authenticating, and accepting the cables.

Sequence of Actions and Action Sets

We assume that before the game starts, all the decisions on selection of JS Cable and terms of procurement have already been determined. We also assume that JS Cable already retained Saehan as the testing institution for the cables it developed, that Saehan had RCMT of Canada conduct the testing, that it received testing reports showing failure, and that it notified the other three players of the testing results.

At the starting node of the game, K moves. Its action set consists of $\{k_1, k_2\} = \{\text{order the other three players to fabricate the testing reports, tell the other three to follow the laws and the contract}\}$. If K chooses k_2 , it will not accept the faulty cables even if J attempts to deliver them to KHNP. If K chooses k_1 , it orders S and E to fabricate the testing reports and to sign a fraudulent authentication document and J to ship faulty cables with fraudulent documents. If K chooses k_2 , the game ends. There will be no fabrication of reports, and there will be no sale of the cables produced by J. If K chooses k_1 , J makes a move after observing K's choice of k_1 . J's action set consists of $\{j_1, j_2\} = \{\text{participate in fabrication and commit to shipping faulty cables along with fabricated documents, reject K's order and give up selling the faulty cables}\}$. If J chooses j_2 , the game ends. Again, there will be no fabrication and no sale of the cables. If J chooses j_1 , S observes it as well as k_1 chosen by K and makes a choice from its action set $\{s_1, s_2\} = \{\text{participate in fabrication, reject the order of K}\}$. If S chooses s_2 , the game ends with an outcome of no fabrication and no sale of cables. If S chooses s_1 , E observes the moves made by the three players and makes the last move in the game. If E chooses e_2 , the game ends with the outcome of no fabrication and no sale. But if E chooses e_1 , the game ends with an outcome of fabrication of the reports and sale of the cables produced by J.

Figure 3-1 Game Tree Describing the Model



Equilibrium

As the equilibrium concept of the game, we will use subgame perfect Nash equilibrium (SPNE) as the game described in the above is a complete information, sequential move game. A subgame perfect Nash equilibrium of the above procurement game is a strategy combination of the four players with the following properties:

- (1) Given the strategies of the other three players in equilibrium, it must be optimal for a player to choose the action that is a part of the equilibrium.
- (2) The strategy of a player in equilibrium is optimal in the forward-looking sense

The first condition requires incentive compatibility of each player. The second condition, generally called subgame perfection, requires that a player should not believe an empty threat by another player who will move after its choice of an action. Note that if one of the four players makes a decision not to participate in fabrication and sales of faulty cables, the attempt to fabricate testing reports will fail and the sale of faulty cables will become impossible even if the other three players all decide to participate in the fabrication.

The strategies of the players and the SPNE can be explained as follows. If one of K, S, or J chooses “non-fabrication”, E will not get a chance to make a decision. Thus, E’s strategy is a contingency plan as to what it will choose in case it is called upon to play. It has two possible

contingency plans, which are “follow the order to fabricate” or “reject the order”. Similarly, J will get a chance to make a decision only if K and S choose “fabrication”. J’s strategies are also contingency plans as to what to do in case it is called upon to play. J also has two possible contingency plans, which are “follow the order to fabricate” or “reject the order”. Similarly, S has two possible strategies, which are “follow the order to fabricate” or “reject the order” in case it is called upon to play. K’s strategies are not contingency plans as it moves first. Its possible strategies are the same as the actions it can choose.

A SPNE is a strategy combination of the players with the following properties:

- E’s strategy leads to the choice of an action from {fabrication, rejection} that gives it a higher payoff given that K, S, and J all chose fabrication so that it is called upon to make a choice. --- (E)
- J will choose a contingency plan that leads to the choice of an action from {fabrication, rejection} that gives it a higher payoff given that K and S all chose “fabrication” and that E will make the choice described by the condition (E) in the above if J chooses “fabrication” as well. --- (J)
- S will choose a contingency plan that leads to the choice of an action from {fabrication, rejection} that gives it a higher payoff given that K chose “fabrication” and that J and E will make the choices described by the condition (E) and (J) in the above if S chooses “fabrication” as well. --- (S)
- K will choose an action that gives it a higher payoff given that S, J, and E will make the choices described by (E), (J), and (S) if it chooses “fabrication”. --- (K)

Thus, SPNE requires each player to choose an action that is optimal for it based upon the expectation that each of the other players, who will make a choice after it, will make a choice that is optimal for that player from a forward-looking perspective given that the player is called upon to play.

Payoffs

There are five end nodes in the game. The node that follows the sequence of actions $k_1 - j_1 - s_1 - e_1$ leads to an outcome in which fabrication of reports occurs based on which faulty cables are sold to KHNP. All the other end nodes lead to the same outcome of no fabrication of testing reports and no sale of cables. However, they generally lead to different payoffs to players. For instance, E's payoff given by the path k_2 can be different from its payoff given by the path $k_1 - j_1 - s_1 - e_2$. In the former case, K chose not to order fabrication. As a consequence, E has no need to commit the crime of fabricating testing reports. Thus, E does not need to be concerned about the possible threat of retaliation from K for refusing to follow the order to fabricate reports. However, in the latter case, K chose to order E to fabricate testing reports and issue fraudulent documents, and J and S chose to participate in fabrication. By choosing e_2 , E makes the effort of K to have fraudulent documents submitted futile. As a result, E exposes himself to possible retaliation from K. In this case, its payoff will be lower than its payoff given by the path k_2 chosen by K. Thus E's payoff given by the path $k_1 - j_1 - s_1 - e_1$ can be different from its payoff given by the path k_2 even though both paths lead to no fabrication – no sale of cables.

Payoffs of the other three players can also be different in outcomes that involve no fabrication – no sale of cables in general. The payoff of K, for instance, depends on whether it commits illegal activities in addition to outcomes in terms of the success or failure of fabrication. In the path given by k_2 , K is not involved in an illegal activity because he chose not to order fabrication. But, in the path given by $k_1 - j_1 - s_1 - e_2$, K is involved in an illegal activity of ordering fabrication although its attempt turns out to be futile by E's choice of e_2 . There is some probability that K's failed attempt to have E issue fraudulent documents will be detected ultimately by law enforcement authorities who can punish him for his action. Thus, even though the two paths lead to the same outcome of no fabrication – no sale of cables, K's payoff can be lower following the path of $k_1 - j_1 - s_1 - e_2$ than its payoff that follows the path k_2 . Payoffs of J and S can also be different in different outcomes that entail failure to fabricate for similar reasons.

We denote the payoffs of the players in the following way. Let $\pi_i(k, j, s, e)$ denote the payoff of player i when the players choose k, j, s , and e as their actions, $i = K, S, J$, and E . The set of possible values for k is $\{k_1, k_2\}$, the set of possible values for $s = \{s_1, s_2, 0\}$, the set of possible values for $j = \{j_1, j_2, 0\}$, and the set of possible values for $e = \{e_1, e_2, 0\}$. Here, we use the convention that the value 0 for a player means that one of the players that move before him chooses not to participate in the collusion to fabricate so that he does not get a chance to make a decision. In this case, fabrication does not occur naturally. For instance, $\pi_S(k_2, 0, 0, 0)$ is the payoff of S when K decides not to order fabrication, ending the game so that S, J , and E do not get a chance to play. Similarly, $\pi_S(k_1, s_2, 0, 0)$ is the payoff of S when K orders fabrication but J declines thereby ending the game so that S and E do not get a chance to play.

As we will see shortly, players chose the path $k_1 - j_1 - s_1 - e_1$. This implies the following.²⁸

- For E , $\pi_E(k_1, j_1, s_1, e_1) > \pi_E(k_1, j_1, s_1, e_2)$
- For S , $\pi_S(k_1, j_1, s_1, e_1) > \pi_S(k_1, j_2, s_2, 0)$,
- For J , $\pi_J(k_1, j_1, s_1, e_1) > \pi_J(k_1, j_2, 0, 0)$, and
- For K , $\pi_K(k_1, j_1, s_1, e_1) > \pi_K(k_2, 0, 0, 0)$

3-2. Equilibrium Path

It is more convenient to focus on equilibrium paths than equilibrium itself in analyzing sequential move games. We do not have information about the payoffs of the players in different outcomes needed to calculate the equilibrium. But we already know that the four players chose $k_1 - j_1 - s_1 - e_1$, in that order, which led to the outcome of fabrication and supply of sub-standard cables. Thus, $k_1 - j_1 - s_1 - e_1$ is the unique sub-

28 We make the inequalities strict here to make the SPNE unique. The probability that all or parts of the payoffs in the inequalities will be the same are practically zero in reality.

game perfect Nash equilibrium path.²⁹ This information can be used to estimate the relative magnitudes of the payoffs of a player when he chooses different choices as follows.

For E, it must hold that his payoff is larger when he chooses e_1 than when he chooses e_2 , given that other players chose (j_1, k_1, s_1) . In other words, given that other players all chose to participate in the collusion to fabricate the certifying documents, E found it in his interest to choose “following the order from K” rather than “rejecting the order.” This information is useful because we can then ask what factors made his payoff when he follows the order from K larger than when rejecting it. Similar inequalities must hold for the other three players as well. The equilibrium can be viewed as collusion by the four players organized by K. This collusion is credible in two senses. First, it is incentive compatible in the sense that none of the players has an incentive to defect from this collusion, given that the other three players participate. Second, this collusion does not depend on threats that are not credible by a player who moves at a later stage of the game.

Lastly, it should be noted that the model incorporates the fact that if K’s order to fabricate testing documents is rejected by one of the other players, the probability that its attempt at fabrication will be detected is positive and it can suffer a substantial loss if its attempt is detected. This raises the interesting possibility that other players, in particular E, could use it as leverage in trying to persuade K not to order fabrication. It is conceivable that E may even try to threaten K that it would notify the law enforcement authorities of K’s attempt at fabrication if K orders it to fabricate in the hope that the threat would discourage K from making the order. However, such a threat is not credible in the sense that E finds it in its interest not to carry out the threat once K orders fabrication.

29 It can be easily shown that there is no other equilibrium in this game unless the payoff to K in one of the non-collusive outcomes is exactly the same as its payoff in this equilibrium. The probability of such an event is practically zero in the real world.

3-3. Analysis of the Incentives of the Players

3-3-1. Incentives of the Engineer at Kepco E&C

When E has to make a decision, the other three players have already committed themselves to collusion to fabricate; E cannot change the decisions of the others. However, E can still reject the order from K and destroy the collusion if he wants. In that case, attempts by the other three players will fail. On the other hand, if E follows the order, there will be fabrication and supply of the sub-standard cables. In the latter case, E will receive a modest gift from J, which will increase his utility. But at the same time, his utility will diminish, too, from his participation in the crime. He will face a stiff prison term, fines, loss of his job and career, and stigma if he gets caught and prosecuted for the crime. The probability of such an event jumps from 0 to a positive number p .

It seems quite clear that the increase in his utility as a result of the modest gift is likely to be significantly smaller than the decrease in his utility from facing various penalties with a probability $p > 0$. The fact that K ordered fabrication to E supports this claim. If the gift from J is sufficient to induce E to fabricate the testing reports and sign a fraudulent authentication report, there was no need for K to get involved, and K would not order E to fabricate.

Thus, there must be factors other than the gift that affected E's utilities that led him to choose to follow the order from K. The only plausible explanation one can think of is that E would be punished by the management of his firm for refusing to follow the order from K. If the management finds it in their interest to ensure that the engineer of their firm follows the order from K, they have an incentive to punish E if he refuses to follow the order from K. Thus, E faced the threat of a big career loss with certainty if he refused the order and uncertain risks of losses in terms of his career, wealth, and criminal penalties if he followed the order. He found that the threat of a big loss in his career was worse than the uncertain risks of losses in terms of his career, wealth, and criminal penalties, and consequently chose to follow the order.

E probably believed that the probability of detection was small. He also probably believed that even if fabrication was detected, he would

not face serious penalties because he thought quite a few people at KHNP and Kepco E&C wanted fabrication and they would somehow protect themselves and him. Such beliefs had the effect of making the negative impact of participating in the crime small. He must have formed such beliefs based on his observations of how his firm and the whole system in the nuclear power industry worked and his understanding of what the management of his firm wanted. Actually, there was no engineer ever accused of following similar orders from managers of KHNP previously.

The question is why the management of Kepco E&C would want its engineers to fabricate testing reports on safety-grade control cables, which was clearly illegal and detrimental to their firm. The only plausible answer to this question is that they faced a threat of big losses in their career if the engineers did not follow the order from K, which was worse to them than the uncertain risk of various losses they might face later if they followed the order. In short, they were in a situation similar to that of the engineers who chose to participate in the crime. The crucial question is what led them to believe that their career would be destroyed if they did not follow the order from the manager at KHNP to fabricate testing reports and that the probability that the crime would be detected was small and that the expected loss to them would be small.

Somehow, the governance structure that dominated the SOEs in the nuclear power industry gave a strong incentive to the executives of Kepco E&C to ensure that their engineers followed the order from managers of KHNP to fabricate testing reports of safety-grade components so that faulty components could be purchased and used by KHNP in its nuclear power plants. This implies that Kepco E&C was under a governance structure that forced its management to take actions that were seriously harmful to firm value and to allow managers of KHNP to intervene in the decision-making process of their firm on issues crucial to survival and profitability of their firm. In short, the governance structure that dominated Kepco E&C was extremely abnormal and incompatible with the laws on the corporate governance of listed firms. The governance structure that dominated Kepco E&C somehow allowed KHNP managers to control it as an instrument to achieve their personal objectives. AMPP and the Kepco Act did not explicitly specify such govern-

ance structures for Kepco E&C and KHNP. But in reality, the two laws and other government policies led to the emergence of such a governance structure, intended or unintended.

3-3-2. Incentives of the Manager of KHNP

The payoff to K depends primarily on wealth, career, and criminal penalties, as in the case of E. Let us assume that he did not receive bribes from J in return for helping it obtain fraudulent documents and accepting faulty cables. K would be better off in the short run by choosing to reject the faulty cables than by ordering E to fabricate the testing reports. This is obvious from the fact that by choosing to order fabrication of the documents, K's chance of incurring criminal penalties increases without any benefit he could expect in return. Thus, the fact that he chose to order E to fabricate the reports implies that his choices must have had long-term effects on his welfare that dominated the short-term effects. There are several possibilities.

One possibility is that K took illegal actions in the selection and contracting stage to help J win the contracts or to make the terms of the contracts favorable to J.³⁰ In this case, K has an incentive to order E to fabricate the reports. Failure to purchase the cables could lead to a substantial delay in the construction schedule, which was likely to trigger audits and investigations into the whole procurement processes involving the contracts, which in turn would likely lead to the discovery of his illegal actions. K has an incentive to stop this sequence from occurring.

Another possibility is that K was pressured to fabricate the documents and accept faulty cables by someone who was in a position to affect his career significantly. In other words, someone or a group of people in the management KHNP who were powerful enough to control K's career had a strong interest in making sure that KHNP would purchase the cables from JS Cable as scheduled to prevent audits and investigations that were expected if the purchase of the cables was delayed

30 He did choose illegal actions in return for bribes or possibly at the orders of someone else in KHNP in other cases, although the prosecutors failed to present evidence that he received bribes from JS Cable.

substantially. This person or group of people must have expected to suffer a loss in terms of career, wealth, or criminal penalties if JS Cable failed to sell the control cables as scheduled. That is why they pressured K to make sure that KHNP would purchase the cables from JS Cable.

The question is why they would expect to suffer a loss if JS Cable failed to sell the cables according to the contract. There are two possible answers to this question. One possibility is that some executives may have expected to suffer a serious setback in their careers if the construction schedule was to be delayed under the governance structure imposed on KHNP regardless of whether the selection of JS Cable was done improperly or not. The other possibility is that some executives may have exerted influence improperly in the selection of JS Cable earlier and feared that the failure of JS Cable to deliver cables in time would lead to audits and investigations, which would reveal their improper involvements in the selection process. In short, some executives must have faced the threat of a serious setback in their careers if a delay was caused by the failure of JS Cable to deliver the cables as scheduled. It is reasonable to expect them to take advantage of their control K to organize collusion to fabricate the certifying documents and to ensure that JS Cable delivered the cables as scheduled to avoid audits and investigations.

In short, the governance structure that dominated KHNP and Kepco E&C allowed some executives of KHNP power to force managers of KHNP in charge of procurement purchase and install faulty components instead of rejecting them. The governance structure also allowed them power to force managers in charge of procurement to force Kepco E&C and its engineers to fabricate testing reports.

3-3-3. Incentives of the Owner/manager of Saehan

The payoff of S depends primarily on wealth and criminal penalties. The action S chose in the equilibrium is difficult to explain as a rational behavior if we restrict attention to the testing of the cables to be delivered in 2008. The amount of revenue from one testing contract would not be sufficient to risk the reputation of the firm and possible criminal penalties. Also, S already received 60% to 70% of the testing fees before the discussions on fabrication began and had even lower incentives

to participate in fabrication. Again, we need to consider the long-term effect of participating in fabrication of the testing reports in this case to understand the incentives of S correctly.

One plausible explanation about the incentive of S to participate in fabricating testing reports is that fabricating testing reports and other certifying documents was actually an important business of S. S established a reputation of being able to provide suppliers of components that failed to meet required safety standards with certifying documents they needed to sell their products to KHNP. In short, Saehan was a firm an important part of whose business was criminal in nature.

It is also likely that K knew about S' criminal business practices well before ordering it to fabricate the testing results along with E. Otherwise, it is difficult to explain K's order to S to fabricate. The success of S' business of fabricating certifying documents also likely depended on meeting the expectations of KHNP managers in charge of procurement, who participated in or acquiesced to the production of fraudulent documents. By rejecting the order from K to fabricate, S could expect to lose future revenue from the fabrication business. Following the order from K and participating in fabrication in the JS Cable case were just a routine business for S, who had no reason to give up one more opportunity to follow regular practices and make money.

3-3-4. Incentives of the Owner/manager of JS Cable

The incentives of the owner/executive of JS Cable are simpler to explain than those of the other three players. It is possible that the short-term gain in profit from the sale of the faulty cables was more important to J than the expected value of long-term losses from detection of the crime. But even if J's short-term gain was not large enough to justify its participation in the frauds, its loss in long-term profit from failing to deliver the cables in time would be large enough to justify the risks involved in committing the frauds. The substantial delay in schedule that was inevitable with failed cables was likely to force KHNP management to punish JS Cable by disqualifying it in bids for future contracts. JS Cable could be prohibited from participating in the procurement market of other SOEs too.

3-4. Analysis of the Equilibrium and the Roles of the Policy Variables

In the SPNE of the game, E chooses “fabrication” if all the other players choose “fabrication” even though by doing so it commits a serious crime and exposes himself to the risk of severe penalties that will be realized if the crime gets detected by law enforcement authorities. The reason that “fabrication” is an optimal choice for E is that the other choice of “rejection” leads to an even larger loss of welfare because K is likely to retaliate by making the management of KHNP order the management of Kepco E&C to punish E for not following the order. The management of Kepco E&C is likely to follow the order from KHNP management even though Kepco E&C is not owned or controlled by KHNP officially, due to the peculiar governance structure that dominates the SOEs in the nuclear power industry.

J’s optimal strategy is to choose “fabrication” in case K and S choose “fabrication” because it expects E to choose “fabrication” if it chooses “fabrication” and also because participating in the successful collusion to fabricate testing reports will give it larger long term payoffs, despite the risk of penalties for the crime, than rejection, which will lead to the loss of all future revenues from KHNP. Optimality of S’ strategy can be similarly explained. Their fear of losing future contracts with KHNP in case they reject the order from K is based upon their belief that K and other executives and employees who are close to K will retaliate by cutting them off from the procurement market for KHNP. Such retaliations by K and his colleagues are possible due to the peculiar governance structure of the SOEs in the nuclear power industry that allow them to wield the power to intervene in the management of Kepco E&C.

K understands the incentives of each of the other three players and knows that it is in a position to force the other players to accept its decision on fabrication a *fait accompli* and make a choice that is optimal for them given its order to fabricate.

The important properties of the model and the equilibrium are as follows:

- The manager of KHNP has the power to force the manufacturer, testing firm, and the authenticating firm which is a different SOE

- to fabricate testing and authenticating documents if he wants.
- The manager of KHNP prefers fabrication of certifying documents that is against the interest of his firm.
- The engineer of Kepco E&G expects to suffer a serious set-back in his career if he rejects the order to fabricate from the manager of KHNP even it is against the interest of his firm.

More generally, the above model and its equilibrium imply that the executives and managers of KHNP have the power to force the management of Kepco E&C and at least some vendors and testing firms to take actions that are against the safety and efficiency of the procurement. Some of the executives and managers of KHNP actually exercised the power to exert influence in the procurement process in such a way that was beneficial to them but detrimental to KHNP and Kepco E&C. The factors that we considered in modelling the procurement market as the above game are the governance structure of the SOEs in the nuclear power industry, industrial policy of MOTIE and the mechanism by which it implements its industrial policy, nuclear safety regulation, and general law enforcement on corruption in Korea.

The governance of SOEs in the nuclear power industry, industrial policy of MOTIE, and the mechanism by which MOTIE implements its industrial policy in the last three to four decades led to the emergence of a structure that allocates authorities among firms and individuals as well as determines rewards to them in such a way that executives and managers of KHNP enjoy a predominant role in nearly all parts of the industry. This structure allowed executives and managers of KHNP large room to make decisions on the allocation of the resources of KHNP as well as of other firms to promote their personal interests even if their decisions cause damage to KHNP and other firms.

Nuclear safety regulation plays an important role in determining the structure of the game by affecting the probability of detection of activities that are against the safety in procurement and the size of the punishment if such activities are detected. Weak safety regulation in the last four decades led to the payoffs of the players in the game and led to the emergence of the SPNE that we observed in the above. Law enforcement on corruption involving large firms has been generally weak in

Korea compared to other industrial countries and also contributed to the emergence of the inferior SPNE in the above game by making the probability of detection and the size of the punishment for corruption small.

Section 4 provides a detailed explanation on the effects of the policy environment on the equilibrium of the procurement market for the nuclear power industry.

3-5. Link between Contracting Stage and the above Game

The extensive form game we considered in this chapter can be seen as a part of a much bigger game as is true of any game that is modelled to describe a real life situation. In particular, it is a part of a larger game in which executives and managers of KHNP make decisions on selecting the vendor and the terms of the supply contract before the above game is played. In this larger game, executives and managers of KHNP who participated in the selection of JS Cable do not have to further decisions if JS Cable delivered the cables that meet the safety standards in time as specified in the contract. However, if JS Cable failed to develop cables that meet the required standards, they must play an extensive form game along with JS Cable, Saehan TEP, and Kepco E&C that we analyzed in the above. Thus, they make two decisions sequentially in this larger game. The decisions they make first at the selection and contracting stage must be consistent with the decision that they will make at a later stage when it turns out that JS Cable has failed to develop cables that meet safety standards.

At the selection stage, K knows that if it selects J as the vendor, there is some positive probability that J will fail to develop legitimate products. It also knows that if that happens, it will end up fabricating testing reports and accept and use faulty cables rather than order legitimate cables from a third manufacturer. Thus, K must know that it will choose to organize the fabrication of testing reports and will accept faulty cables based on the fabricated reports if JS Cable fails to develop cables that meet the safety standards when it makes decisions on whether to award the contract to JS Cable. The question is why would K select JS Cable at the selection and contracting stage knowing that it must participate in a serious crime if JS Cable fails to develop cables that meet the safety

standard?

There must be some benefits to K when it chooses JS Cable as the winner of the contract despite the risks his choice entails. The benefit must outweigh the cost K incurs by selecting JS Cable. It is plausible to hypothesize that K expected to receive benefits in terms of higher chance of promotion, assigned to positions that would give him a chance to take large amounts of bribes from suppliers that significantly outweighed the costs he incurred by taking the risks of having to fabricate testing reports in case JS Cable fails to develop cables that meet the requirements. It is also possible that K believed that the probability of detection of fabrication was small and that even if the fabrication is detected, the penalty would be relatively small because the group of people for whom he worked might be able to protect him.

Thus, K's decision to award the contract for the control cables to JS Cable, which had never proven its capability to manufacture the control cables KHNP was going to purchase, is not inconsistent with what it would do later when JS Cable fails to develop the cables of the required qualities.

A possible defense for the decision to award the contract to JS Cable is the industrial policy of promoting domestic vendors. It is true that few domestic firms will get a chance to manufacture a component and sell it to KHNP if KHNP allows only the manufacturers that have proven track records. If the government wants domestic firms to produce a component to be used by nuclear power plants in Korea, it must have KHNP give a chance to domestic firms to develop the component and sell it to KHNP even though they have never produced it in the past. However, it is difficult to justify the decision to award the contract for control cables to JS Cable considering that a failure to develop, produce, and deliver the cables in time was likely to cause a significant delay in the construction schedule of the power plants, which would cost several hundred times the budget for procuring the cables in lost revenues and increased construction costs.

If KHNP awarded the contract to JS Cable to give it a chance to develop the cables and supply them to many nuclear power plants in the future, it should have signed an option contract with a reliable foreign manufacturer with a proven track record according to which the foreign

firm will deliver the cables if JS Cable fails to develop them. The fact that KHNP did not sign such an option contract suggests that KHNP was run by an incompetent management.

4. Fundamental Problems and Alternative Solutions

4-1. Assessment of the Measures Taken by NSSC and MOTIE³¹

As observed in the previous section, the governance structure of the SOEs in the nuclear power industry, and the laws and their enforcement regarding nuclear safety regulation, generally determine the environment in which SOEs and the vendors dealing with them operate. In addition, laws concerning procedures and contracts of SOEs and their enforcement affect (1) the structure of this game and (2) the payoffs of the players involved. The government can try to change the outcome in the procurement market by changing the relevant laws and their enforcement. The Korean government made a set of changes aimed at improving safety and efficiency of the procurement market for the nuclear power industry. The question is whether the measures taken by the government summarized in Chapter 2 solve the problems in the nuclear power procurement market and, more importantly, improve performance of the market.

Mandatory reporting of violations will increase the costs of fraud by vendors. Simultaneously, firms selling testing, authenticating, and inspection services should have some effect in reducing fraud. However, the effect will be limited unless the SOEs and private firms protect and reward those who report violations. There has been no reporting of violations by the employees of KHNP or Kepco E&C, to our knowledge.

Mandatory submission of testing reports to KHNP by testing firms is expected to reduce the incidents of colluding to fabricate reports originally issued by foreign testing firms. However, this measure will have limited influence on eliminating fraudulent documents unless employees

31 Measures summarized in this section are based on the policy changes included in MOTIE (2013a), MOTIE (2013b) and NSSC (2013).

of KHNP act properly. Similarly, the effects of KHNP's paying testing fees will also be limited, if the managers of KHNP in charge of procurement do not act properly.

The effects of the other measures that KHNP has introduced to improve transparency in the procurement market are limited or unclear. The objective behind forcing KHNP to disclose its procurement plans in advance is to give all potential vendors an equal opportunity to prepare for bidding. The measure is desirable. But the effect of this measure on its costs is likely to be limited because competition is limited due to the small number of competitors. There is only one firm, for example, supplying reactors and turbine/generators in Korea. For each component belonging to the BOP, there are usually only one to three firms competing.³²

The effect of discouraging retired executives of KHNP from working for a vendor is not clear because the prohibition applies to executive positions in a vendor. An ex-executive of KHNP can work for a vendor without officially taking the position as an executive of the firm.

MOTIE's announcement about promoting more competition and strengthening the independence and expertise of the procurement units of KHNP are goals rather than plans. It is not clear how MOTIE can achieve these goals. MOTIE's announced plan to minimize single-source procurement is also closer to a goal than a plan. Further, it is not clear whether this is a desirable goal, considering that many components have only one supplier. A more meaningful goal would be to prohibit single-source procurement when there are two or more qualified suppliers.

Raising the prices of safety-related parts and components is also a goal rather than a plan. Further, it is not clear that this is a desirable goal. The rationale behind the MOTIE's plan as follows: In markets for many parts and components, the price of the winning bid is substantially lower than the level that would allow the supplier to recover the costs and earn a fair return on its investment.

There are two main reasons for this phenomenon. One is an excessively low reservation price, which is a result of underestimating the

32 MOTIE (2013a), p.11.

costs by KHNP managers at the stage of determining reservation prices. The other is excessive competition among the suppliers who try to undercut competitors to win the contract. As a result of excessive competition, the winning bid for the price is substantially lower than the reservation price, *which was already set below the cost-recovery level*.

The reason that this phenomenon is seen by MOTIE and KHNP as a problem is that suppliers will lower the quality to cut costs once they win the contract and are likely to end up producing products that fail to meet required safety standards. Therefore, the argument goes, it is necessary to raise the price of the winning bid to enable the supplier to produce products that meet safety standards while at the same time recovering costs.

There are several problems with the above arguments. First, it is not clear whether reservation prices are set below cost recovery level. Second, even if the reservation prices are set at non-sustainably low levels, raising the reservation price will not lead to a higher winning price unless bidders collude. In other words, there is no clear way to raise the price of the winning bid by raising the reservation price if there is a firm that is willing to bid a price that is lower than the existing reservation price. Thus, it is not clear that an increase in the reservation price will lead to an increase in the price of the winning bid.

Also, there is no reason to believe that suppliers will increase quality just because KHNP pays higher prices. The cause of supplying sub-standard components is sub-standard inspection that allows sub-standard products to pass, and not low bid prices. Besides, KHNP cannot control the price of the lowest bid unless it colludes with bidders, as we have observed.

If the government wants to ensure that vendors of safety-related parts and components supply products that meet safety standards, it should strengthen inspection practices. One method is by increasing the costs that vendors must pay when they fail to meet required standards and by consistently punishing those who fail to meet required standards. This will allow vendors to form an expectation that supplying poor quality products is against their best interest. When vendors have such expectations, few will bid a price that is below a long-run cost-recovery level because they can only expect to lose money by winning the contract at

that price. The effect of the announced plan to rely more on “best-value-bidding” and less on “competitive bidding” is not clear. The best-value method uses a formula that assigns points to various characteristics of the good or service to be purchased, as well as the bid price to select the winner whose total score is the highest among the bidders.

On the other hand, selection by the price among the bids that meet the minimum required qualification lets the bidder win who submits the lowest price among the bids that meet the minimum qualification, including safety standards required by nuclear safety regulation. The best-value method leads to a more efficient outcome if the scoring system correctly reflects the value of various characteristics. But the best-value method requires expertise and impartiality of the managers who design the scoring system and evaluate the characteristics of the products of bidders. It is riskier to use in the sense that it allows the procurement managers to exert greater influence on the selection of the bidders and to abuse their power to award contracts to bidders whom they prefer for personal reasons. Additional information is required on (1) the details of the items for which best-value methods will be used, (2) expertise and independence in the managers, and (3) the costs of designing scoring systems that accurately reflect the value of various characteristics to judge the efficacy of the best-value method.

4-2. Fundamental Problems in the Nuclear Power Procurement Market

The problems revealed by the incidents that surfaced in 2012 and 2013 can be summarized as follows:

Nuclear safety regulation did not adequately cover production and testing of parts and supply. Laws on nuclear safety did not make it illegal to sell sub-standard parts and components to nuclear power plant operators. Nor did they make fabrication of quality certification documents illegal. Nor did they make reporting of sale, attempted sale, fabrication, or presenting fraudulent certifying documents a responsibility of the participants in the industry. *Safety regulation depended exclusively on KHNP, which turned out to be incapable of screening out sub-standard parts and components.*

The procurement system of KHNP had been inadequate in many re-

spects for a long time. Managers working for procurement units were long protected from the scrutiny of outsiders. This was done by their taking advantage of the lack of expertise among outsiders and their inability to obtain information due to the many restrictions that shrouded the nuclear power business. They had a large degree of discretionary power in determining qualifications, methods of bidding and selection, terms of contracts, enforcing and changing the terms of contracts, authentication, inspection, accepting products, and payment. They failed to detect fraudulent certifying documents in thousands of contracts. They abused their discretionary power in many procurement cases. They accepted components that were not accompanied by authenticating reports and used them in power plants. Some of the executives and managers (1) ordered the fabrication of testing reports by testing firms and authenticating firms, (2) knowingly accepted faulty components, and (3) knowingly accepted bribes from vendors. (Some of them took bribes from other employees.)

Investigations and audits have presented the evidence that suggests that the problems that existed in the procurement system of KHNP often involved executives and managers who officially worked for other units that are not directly involved in procurement. This suggests that the executives and managers outside of the procurement unit exert influence on the decisions made by the managers in the procurement unit. Was the top management of KHNP not aware of criminal activities that had gone on for many years in the procurement unit? The bribery involving a former CEO who headed the firm for five years addresses this question. It is possible that some executives used power they had over the promotion and job assignment of employees of KHNP to induce the employees working in procurement unit to take actions that that would favor suppliers they had ties with.

The audits and investigations thus far focus on the inspection stage of KHNP's procurement system, and provide only limited information on qualification, methods of bidding and selection, contracting, and revising the terms of contracts. However, there is no reason to believe that the collusion among the executives and managers within KHNP was limited to the inspection stage. On the contrary, the evidence about the irregularities in the inspection stage and the information on the other

stages of procurement suggests that it is likely that the executives and managers wrongly used their influence in other stages, which led to increased costs.

The behavior of engineers at Kepco E&C in the JS Cable case suggests that it was probably not their first involvement in issuing fraudulent authentication reports. It is likely that the top management knew about the demands from KHNP to issue fraudulent documents (and implicitly ordered the engineers to meet the demands of KHNP, or at least acquiesced in the frauds). The analysis of the JS Cable case suggests that the management of Kepco E&C had a strong incentive to ensure that their firm issued fraudulent documents *if KHNP demanded it*, under the governance structure that dominated their firm. The fact that its CEOs had frequently been selected from the pool of politicians and former executives of Kepco who spent decades in nuclear power generation probably contributed to the abnormal behavior of engineers in Kepco E&C.

More generally, the governance structure of the SOEs in the nuclear power industry is ultimately responsible for most of the problems in the procurement market in the industry. The governance structures are based on an outdated command and control system that was installed in many SOEs and public institutions more than three decades ago. This system allows MOTIE to run the nuclear power industry using Kepco, KHNP, Kepco E&C, and other SOEs as direct policy instruments. The Ministry of Strategy and Finance plays a minor role compared to MOTIE, which focuses on budgets, ceiling on employees, salaries, and performance evaluation and remuneration.

Politicians make decisions on the appointment of CEOs and other top executives, as well as board members. The Board does not generally have the power to make key decisions because they are mostly made by the government or more specifically, politicians and bureaucrats. However, the body that evaluates the performance of SOEs does not possess the expertise and resources needed to evaluate the performance properly. Remunerations of executives and managers generally are not based on the performance of SOEs as commercial firms.

Politicians and bureaucrats who make decisions for SOEs are interested mainly in using the resources of SOEs in projects they favor and

do not pay a serious attention to the success of SOEs as commercial enterprises. Executives and employees of commercial SOEs have little incentive to try to improve the efficiency or minimize the costs because there is little reward for the efforts or contribution to efficiency. For top executives of SOEs, meeting the orders from the decision makers in the government is the most important activity that affects their career crucially. Although the politicians and the bureaucrats in the government have the power to intervene in the affairs of SOEs extensively, they lack the expertise, the resources, or the information necessary to manage the SOEs efficiently.

Under such a governance structure during the three decades, there emerged an environment in SOEs that induced executives and managers to actively seek personal objectives while trying to manage the risks of meeting laws and regulations as best as they can. Procurement and investment are the two areas in which executives and managers are tempted to pursue personal objectives more fruitfully than in other areas. These are also the areas in which executives and managers can exchange favors with the stake-holders who can affect their career.

It is fair to say that MOTIE probably perceives KHNP as its business unit in building and operating nuclear power plants and Kepco E&C as its business unit in the designing of nuclear power plants. It is this system of running the nuclear power industry, headed by MOTIE, that is ultimately responsible for the strengths and weaknesses of the nuclear power industry of Korea. This system, along with the governance of SOEs, led to the emergence of the incentive mechanism in KHNP and Kepco E&C that in turn led to the case that we analyzed in the previous section. The governance of SOEs and the system of running the nuclear power industry allowed large room for some executives and managers to exert influence on procurement to promote their personal interests without taking a serious risk of getting caught and punished.

Weak nuclear safety regulation also played a part in inducing executives and managers of KHNP to make wrong decisions in procurement by making the probability of detection of purchasing and using fraudulent items small. Weak safety regulation also encouraged market participants, including executives and employees of KHNP and Kepco E&C as well as testing firms and vendors, to buy and sell fraudulent items and

even fabricate certifying documents.

Lastly, weak law enforcement on corruption involving SOEs, and more generally, weak law enforcement on diverting money from large firms, contributed to the problems in the procurement market for the nuclear power industry in Korea by making the expected cost of corruption low.

5. Measures for a More Fundamental Reform

It is clear from the analyses and arguments in the previous sections and from scattered evidence that measures that leave the current governance structure intact will have little effect on the efficiency of the nuclear procurement market. To improve the efficiency and the safety of the nuclear power procurement market in a fundamental way, the following measures should be considered.

1. The governance of SOEs in the nuclear power industry should be changed in a fundamental way, while allowing them to operate based on strong profit incentives and management autonomy. This requires a fundamental change in the role of the line ministry and the Ministry of Finance and Strategy in the affairs of SOEs in the industry. Each SOE in the nuclear power and electricity industries should be run as profit-seeking commercial enterprises free from government policy concerns. The management of KHNP and Kepco E&C should be allowed to reform their procurement units based on long-term maximization of firm value, subject primarily to safety concerns rather than industrial policy concerns. MOTIE can pursue its industrial policy objectives more efficiently by resorting to more neutral methods that do not have serious conflicts with profit-oriented operation of SOEs.

2. These reform of the governance structure of SOEs will lead to arms' lengths relationship between KHNP and Kepco E&C. However, the governance reform depends on the decisions of politicians and may take a substantial time. Therefore, it is important to erect a firewall between KHNP and Kepco E&C as early as possible regardless of the overall governance reform. Kepco E&C should be allowed to seek to

maximize the economic value of its shareholders as an engineering firm. In other words, the government and KHNP should not intervene in the management of Kepco E&C to force it to act in ways that are against the economic interests of its shareholders.³³ This is necessary for Kepco E&C to provide the checks and balances to the procurement of KHNP that are crucial to safety, transparency, and effective competition in the procurement market. Contracts between KHNP and Kepco E&C should also be based on a level playing field.

In addition, various contracts between KHNP and Kepco E&C need to be designed and executed in a way that hits the right balance between the safety and cost minimization. MOTIE (2013b) contains extensive discussions on conflicts between the managers of KHNP and the engineers of Kepco E&C. The conflicts between the two firms are natural in bilateral monopoly – monopsony situations. Further, it is necessary to force the managers and engineers of the two SOEs to discuss their views in a way that is transparent to the public. NSSC and its technical arm, Korea Institute of Nuclear Safety (KINS), should be actively involved in the process of resolving conflicts between the two firms. Finally, the terms in contracts between the two SOEs that can be used to promote the personal interests of executives and managers of them rather than the efficiency of the two firms, should be abolished.

3. It may be necessary to separate the unit of KHNP on construction from the unit on operation, considering that KHNP organization has been operating for many years under an environment that allows quite a few executives and managers room to take advantage of the weaknesses of governance structure of their firm to promote their personal interests. There are several ways to achieve this. One way is to erect a firewall between the two units. If this measure does not work, structural separation should be considered. Structural separation appears to have advantages considering that most nuclear power plant operators in the US,

33 Recall that Kepco is the dominant shareholder of Kepco E&C and that KHNP does not own a share in Kepco E&C. The control that KHNP managers had over Kepco E&C was possible due to the fact that the government is the dominant shareholder of Kepco, which in turn is the dominant share holder of all its subsidiaries including KHNP and Kepco E&C.

France, and other European Union countries are closer to pure operators who purchase construction services from firms specialized in construction of nuclear power plants. For instance, France has been maintaining such a structural separation between EDF and Areva even though the majority of the shares of the two firms are owned by the French government.

4. KHNP and Kepco E&C should be required to make information on procurement, including information on qualification, rationales for methods of bidding selected, bids, contracts, changes in the terms of contracts after signing, testing methods, testing firms, authentication reports, and acceptance available to the public.

5. NSSC should get involved more aggressively in ensuring that safety-related parts and components meet required standards. The penalties for violations need to be increased substantially. Individuals who participated in the fabrication of testing reports in the JS Cable case received penalties for criminal forgery of private documents (and not for violations of the Act on Nuclear Safety and Security). Frauds involving safety-related parts and components should be punished for violations of a law on nuclear safety and should be subject to heavier (criminal) penalties to deter fraud that could lead to nuclear system failures. NSSC should use a large pool of experts that include nuclear engineers, economists, and lawyers, in its regulation of the procurement market of the nuclear power industry. Thus far, it has depended almost exclusively on engineers at KINS and the employees of KHNP.

6. NSSC should make transparent to the public all information about violations of the act, including information on the failure to report violations.

7. KHNP should focus on designing more efficient contracts for single-source procurements rather than on reducing the number of single-source procurement contracts because it seems difficult to have new entrants into a market for a safety-grade part or component considering the costs of entry that entrants must pay in developing technologies and obtaining necessary certifications. KHNP must be vigilant into the possibility of collusion by vendors. In particular, it should pay attention to prevent collusion by vendors of the goods and services, such as construction services and cables, that are known to have colluded frequently

in other markets.

8. Market rules for the wholesale electricity market should be revised fundamentally to make them compatible with the restructured electricity market.³⁴

These recommendations can be implemented within a reasonably short period if the government decides to adopt them. From a longer-term perspective, completion of the restructuring of the electricity market will improve the efficiency in the nuclear power industry procurement market by making the management of KHNP, Kepco E&C, and other SOEs accountable for the actions they choose and by subjecting them to proper profit incentives and competition. Introducing competition into nuclear power generation can be a solution to problems plaguing the nuclear power industry if other measures fail to induce a more efficient and reliable system within KHNP due to the absence of the pressure of market forces.

This paper did not include a detailed analysis of the industrial policy pursued by the Korean government in the last four decades aimed at building a strong domestic nuclear vendor industry due to the lack of reliable data. Future studies of the extent and effects of the industrial policies pursued by the Korean government will lead to a better understanding of the factors that affect the industry performance and contribute to the development of directions for alternative policies that can improve performance of the nuclear power industry.

34 The market rules governing competition in the wholesale electricity market and the Plan for Supply and Demand of the Electricity that MOTIE publishes periodically affect the performance of KHNP substantially. But these subjects are beyond the scope of this paper. See Nam (2012) and Nam (2013b) for detailed discussions on the problems with the current wholesale market rules and the Plan for Supply and Demand of Electricity and their adverse effects on the efficiency of KHNP.

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CHAPTER 4

Nuclear Procurement in the French Context

Claire Mays
Henri Boyé
Marc Poumadère

1. Introduction

Procurement is an issue to be taken seriously in the nuclear domain worldwide. Materials and services must satisfy technical needs and their supply must fit with economic imperatives. Above all, however, the quality of supply and the irreproachable character of procurement are vital to ensuring a high level of reliability and safety of nuclear installations. In this way, the excellence of nuclear procurement engineering and governance, and the freedom from conflict of interest or corruption, are direct contributors to the protection of health and safety of citizens, in both the national and the cross-border context.

Awareness of this issue is testified by international organizations such as IAEA and OECD. Taking procurement seriously is the central message of the document issued by IAEA (2013): *Procurement Engineering and Supply Chain Guidelines in Support of Operation and Maintenance of Nuclear Facilities; Draft Report* (C-41 May 2013). The draft report conclusions state, inter alia, '*Procurement related activities have a key impact on safety. Graded approaches allow utilities to focus efforts on critical equipment and ensure that supply chain processes do not adversely affect safe operation of an NPP.*' (p.137) The draft report notices that in some contexts, counterfeit or fraudulent items may in-

creasingly be found, and the authors urge that plant operators need to be aware of this and set up processes to detect and report suspected items. After highlighting particular operational areas in which processes (traceability, monitoring, evaluation...) should be established or in which vigilance may be needed (e.g. in software and digital tools), the conclusions point out challenges for sustainable safety over the years. *‘Operating organizations should not take it for granted that a robust supply chain will be available for their plant equipment over extended plant lifetimes. They need to take proactive steps to understand national and global procurement marketplaces, analyse critical plant equipment that is either low purchasing volume or has few known suppliers, and take appropriate actions to ensure required items are available. Collaboration among operating organizations is recommended and has been shown to be useful in other industries’* (IAEA, 2013; p.137)

The OECD Nuclear Energy Agency Committee on the Safety of Nuclear Installations (CSNI) in its 2012 technical opinion also focuses on organizational means to safe procurement. According to the CSNI, the purchaser must establish *‘an “intelligent customer” capability –to ensure that the organisation has, within its own workforce, the capability, underpinned by appropriate processes, to maintain oversight of the supply chain including among other aspects a sound procurement strategy and an effective spare parts policy. Licensees need to be “intelligent customers” when dealing with contractors. This implies that the licensee has the in-house competencies to manage, review, verify the contractor work, and to assess the right competence as well as conduct appropriate training. The licensees should also assess the balance of outsourcing versus the use of in-house personnel. The “proper” balance of work done by contractors versus that done by in-house staff will depend on such factors as the nature of the work, the nuclear safety significance and the availability and competencies of the in-house staff. This balance may vary over time.’* (NEA/CSNI, 2012; p.10)

The general guidelines provided by IAEA (2013) and NEA/CSNI (2012) are useful. However, each national and cultural setting shows strengths and weaknesses which are worth investigation as a source of mutual learning. In this prospect, the context and the practical dimensions of nuclear procurement as organized in France will be presented.

Indeed we would argue that for nuclear procurement in France to be fully understood, the national contextual and practical dimensions have to be kept in mind. These dimensions go far beyond the nuclear procurement example to touch the entire European and French legislative bases for ensuring nuclear safety, and moreover, probity and transparency in public life (for this reason we will present the relevant laws in our report). Strong options are taken that may potentially differ from those seen in other contexts: for instance, nuclear procurement in France is resolutely focused on selecting the “Best Overall Value” or “Most Advantageous Offer” which incorporates not only the optimization of economic criteria, but also takes into account a number of other values seen to be important for safety assurance in the long term. If such contextual dimensions are absent or cannot be taken into account, it is not certain that the French procurement organization will prove efficient when transposed to another country. A striking example that immediately clarifies this point is: while France has a single State-controlled operator (EDF) for all its reactors, there are several private operators in the U.S., thus requiring an overarching organization (such as NUPIC: the Nuclear Procurement Issues Committee).

To gain a living picture of actual performance – including weaknesses – in France’s prime nuclear operator, readers of the present report will find particularly noteworthy the EDF Inspector General’s report (EDF, 2013). It furnishes a sort of roadmap on internal control and continuous improvement. A large number of observations pertain to nuclear procurement and moreover, relationships with suppliers. The Inspector General’s detailed and forthright guidance³⁵ on the management of these relationships communicates the importance of supplier relationships in assuring the nuclear safety of procurement. Items highlighted by EDF’s Inspector General in the French context might be worthwhile assessing in other contexts (although precise situations and best solutions may not be comparable across nations).

The report goes on to consider some historic and current aspects that make France’s nuclear context unique, including the network of actors in section 2. The European and French legal bases for transparency (in-

35 Of particular interest are the passages on pp.8, 11, 42, 44, 46, 47 (EDF, 2013).

cluding in the nuclear domain) and for preventing corruption are then presented, alongside examples of how these are implemented in the nuclear industry in section 3. Procurement policy for France's three nuclear operators, AREVA, EDF and GDF SUEZ, is reviewed in section 4. Incentives and Best Overall Value approach are selected for detailing in section 5. The influence of principles of conformity and continuous improvement is highlighted in section 6. Conclusions review lessons learned and point to areas for new research in section 7.

2. The Nuclear Landscape in France: History, Evolution and Actors

In parallel with development in the military sector in the aftermath of World War II, the exploitation of France's uranium reserves in a France-designed electronuclear program served a definite goal of national prestige and autonomy. The civil application of the atom gained in industrial scale in France at the beginning of the 1970's with the governmental decision to retain the Westinghouse PWR technology. Two international events soon would focus French attention on the instability of fossil fuel supply: the Israeli-Arab war in 1973 and the oil crisis (the price per barrel doubled twice in 1973). France was in full economic development and the rapid response to this shocking realization of energy dependency was a State-decided acceleration of the French electronuclear program.

This shows, and we should always be reminded, that in France the nuclear program from the outset has been intrinsically linked to political dimensions and direct interventions and control by the State, in particular on the level of strategy on energy independence and security, and the development of appropriate structures (industrial organizations across the whole fuel cycle as well as regulatory institutions).

Jasper (1990) spotted these state-centered characteristics of France when comparing its nuclear energy policies with those of Sweden and the United States. Moreover, he described the support rooted in such cultural institutions as the French system of higher education, and noted that the term 'technocrat' was born in France. *Ecole Polytechnique* or 'X', *Ecole des Mines*, and other *grandes écoles* are elite institutions

training high level engineers who end up ruling not only industry and high commerce, but ministries and political positions as well. Therefore, a certain community of basic views is shared, even and paradoxically when 'X-Mines' graduates meet as representatives of independent institutions with different roles to play (e.g. the nuclear operator EDF and the nuclear safety authority ASN).

The French population was skeptical about nuclear power in the 70's and the French anti-nuclear movement was among the strongest in Europe (Topçu, 2013). The strong top-down government option in favor of nuclear power helps understand how after the oil crisis in 1973 France finally built more reactors than it needed. The political and technological control of Nuclear France by an elite corps of engineers may help to explain general public attitudes: perception of risk from nuclear power remains high, but French citizens, while recognizing that they have little control over risks to their health and safety, have a comparatively high degree of trust in their government and in the experts who design and operate nuclear power plants (Slovic *et al.*, 2000).

Critics have said that in France, nuclear is a 'State within the State', and the president of EDF is sometimes referred to as the 'Minister of electricity'. However, the pride and mastery characterizing the nuclear establishment and the tightly networked elite structures of decision in both politics and industry, are doubled by French pride in rigorous method and governance and also, in democracy. A political history of nuclear France must also trace the gradual mastery of the technocracy by Parliament, and the gradual opening of independent vigilance and control to include actors of civil society. France's technological park is a great achievement. So is the Law n° 2006-686 of 13 June 2006 on Nuclear Transparency and Safety (known as 'TSN' or the Transparency Law). This creates an independent safety authority, guarantees active public information and involvement, and sets a high standard for risk management by each worker in each basic nuclear installation.³⁶ Stepping one level higher, France recently equipped itself with Law n° 2013-907 of 11 October 2013 on Transparency in Public Life, creating scruti-

36 INB or Installation nucléaire de base, the administrative term for fixed (non-mobile) nuclear installations in France.

ny, defining personal responsibilities including for the heads of state-owned enterprises, and notifying negative incentives (sanctions) for corruption. The state-wide ethos of transparency is another vital part of the nuclear procurement context in France. These laws will be presented in part III of the present report.

2-1. France's Nuclear Park

Today, France is a country of 66 million inhabitants which derives over 75% of its electricity from nuclear energy. About 17% of France's electricity is from recycled nuclear fuel. France is the world's largest net exporter of electricity, and gains over € 3bn per year from this activity. Reactors and fuel products and services are a major export, and waste management expertise is another growing product.

France counts 19 nuclear power plants (NPP) for a total of 58 reactors, all operated by the predominantly state-owned enterprise Electricity of France (EDF). Each plant site counts 2 or 4 reactors excepting Gravelines which counts six. The nuclear park is composed of:

- 34 reactors of 900 MWe (of which 6 are class CP0, 18 class CP1 and 10 class CP2; classes CP1 and CP2 are together referred to as CPY);
- 20 reactors of 1300 MWe (8 of class P4 and 12 of class P'4);
- 4 reactors of 1450 MWe (all class N4).

A Generation-III reactor based on a pressurized water reactor design is currently under construction in France next to two existing reactors on the Flamanville site. The design was originally called European Pressurized Reactor, whereas outside Europe it was referred to as Evolutionary Power Reactor, but it is now simply called EPR by principal designer and developer AREVA.

The *de facto* grouping of French reactors in large classes provides clear advantages for procurement management: the members of a same class represent a homogeneous set of technical characteristics and components. Requirements and conformity controls can thus benefit from homogeneous procedures within a given class. From the point of view

of providers, this situation represents potentially an important pool (or market) of components to satisfy. In terms of safety, when a technical issue is spotted in one reactor, the rule is to apply automatically the technical repair or upgrade to all the other reactors of the same class, even if they appear faultless. The drawback is the relatively high economic cost of such an approach.

The cost of safety is of course to be put in relation to the (very high) cost of nuclear accident. The cost estimates based upon accident scenarios involving either controlled or massive releases in France are analyzed by IRSN economists and amount to between € 120bn and € 430bn according to accident severity (Pascucci-Cahen & Momal, 2012).

2-2. France's Nuclear Actors – National and International Organisms

Nuclear actors in France are organized in a relatively tight network within which procurement is inserted and tightly controlled at all levels, with transparency and safety requirements throughout. Not each actor participates directly in the governance of the supply chain, but all are linked indirectly and contribute to its efficiency. Certain international organisms also should be considered part of the influential network and are cited here. Moreover, a complete analysis of influences on safety would include actors like Greenpeace France, which openly opposes the nuclear option while nonetheless contributing actively to joint initiatives in favor of vigilance and safety (e.g. ACN France GT2). This section offers simple guideposts to the complex French nuclear institutional landscape (secondary actors are mentioned only in footnotes); the full role, relative importance of actors and their interaction is beyond the scope of this report.

2-2-1. French Ministries and Central Administration

National administrative oversight of nuclear energy is handled and shared by several governmental entities. In November 2014 the principal ones are:

- Ministry of Ecology, Sustainable Development and Energy, in-

cluding the DGEC (General directorate of energy and climate). The Ministry of Economy, Industry, and Digital also participates in elaborating and implementing policy related to energy and primary materials, notably in order to ensure supply security and economic competitiveness.

- Ministry of Foreign Affairs and International Development;
- Ministry of Higher Education and Research;
- Ministry of Defense.

2-2-2. Independent Administrative Authority

ASN: *Autorité de Sûreté Nucléaire* or Nuclear Safety Authority is an independent administrative authority created by the Transparency Law of 2006. The ASN carries out, on behalf of the State, the control of nuclear safety and radiological protection in the goal of protecting workers, patients, the public and the environment from risks associated with nuclear applications. The ASN contributes to public information.

2-2-3. National Organisms

OPECST: *Office Parlementaire d’Evaluation des Choix Scientifiques et Technologiques* or Parliamentary Office of Evaluation of Scientific and Technological Choices was created in 1983. Its mission is to enlighten Parliamentary decisions with information on the foreseeable consequences of scientific and technological options. It collects information, sets up studies and conducts evaluations.

HCTISN: *le Haut Comité pour la Transparence et l’Information sur la Sécurité Nucléaire* or High Committee for Transparency and Information on Nuclear Safety was created by the Transparency Law in 2006. It ensures information, deliberation and debate on the risks linked to nuclear activities and impacts on human health, the environment and nuclear security.

CNE: *la Commission nationale d’évaluation* or National evaluation

commission audits the research on radioactive waste management conducted under the pertinent laws of 1991 and 2006.

ANCCLI: *l'Association Nationale des Comités et Commissions Locales d'Information* or National Association of Local Information Committees and Commissions is a federation of independent citizen monitoring groups created by law to contribute to control of Basic Nuclear Installations.

2-2-4. Public Establishments or Agencies

IRSN : *l'Institut de radioprotection et de sûreté nucléaire* or Institute for Radiological Protection and Nuclear Safety is the French national public expert in nuclear and radiological risks, created in 2001 and providing independent support to ASN.

CEA : *Commissariat à l'Energie Atomique et aux énergies alternatives* or Atomic Energy and Alternative Energies Commissariat is a public research establishment of scientific, technical and industrial character. It conducts research in the areas of energy, defense, information technologies, material sciences, life and health sciences. The CEA represents the French state to the International Atomic Energy Agency (IAEA) as well as to countries wishing to acquire nuclear power installations.³⁷ It was renamed in 2010 when it enlarged its historic focus on nuclear energy to include renewable energies.

ANDRA: *l'Agence nationale pour la gestion des déchets radioactifs* or National radioactive waste management agency is a public industrial and commercial establishment ruled by the law of 28 June 2006 relative to the sustainable management of radioactive materials and waste. It is

37 AFNI: l'Agence France Nucléaire Internationale or International France Nuclear Agency was created in 2008 as part of the CEA. It helps the countries wishing to acquire civil nuclear power installations to set up the institutional, human and technical environment needed for an electronuclear power sector respectful of strict safety norms, non proliferation and environmental preservation.

placed under the oversight of ministries in charge of energy, research and environment. Andra is tasked with the long term management of radioactive waste produced in France.

2-2-5. Scholarly Societies

Two scholarly societies exist in the French nuclear field:

- **SFEN**, *Société Française d’Energie Nucléaire* or French Nuclear Energy Society (member of the European Nuclear Society)
- **SFR**, *Société Française de Radioprotection* or French Radiation Protection Society.

2-2-6. International Organizations

EURATOM: The Euratom Treaty establishing the European Atomic Energy Community (Euratom) was initially created to coordinate the Member States’ research programs for the peaceful use of nuclear energy. The Euratom Treaty today helps to pool knowledge, infrastructure, and funding of nuclear energy. It ensures the security of atomic energy supply within the framework of a centralised monitoring system.

IAEA: International Atomic Energy Agency based in Vienna is a direct emanation of the United Nations Security Council, seeking to promote the peaceful use of the atom and to limit the risk of weapons proliferation.

NEA: The Nuclear Energy Agency is a specialized agency of the intergovernmental Organisation for Economic Cooperation and Development and is based in Paris. Its mission is to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes; to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

European Nuclear Society (**ENS**) and **FORATOM** are respectively the European-level scholarly society and trade association.

2-3. France's Nuclear Actors - Industry

After succinctly presenting the industry actors, we elaborate on the roles of the two major nuclear state-owned industries EDF and AREVA. We provide historical background to why the two entities co-exist, the strong and weak points of having these two public entities in France, and information on their general governance as public enterprises.

2-3-1. Nuclear Enterprises

EDF: *Electricité de France* or Electricity of France is a predominantly state-owned enterprise operating the 58 reactors in service in France. It has competences in all the electrical trades and also has international operations, making it the largest producer of electricity in Europe and in the world.

AREVA: A predominantly state-owned enterprise, world leader in nuclear energy across the entire fuel cycle from mining to fuel manufacture and enrichment to reactor design and construction to fuel recycling. AREVA is organized into five Business Groups: Mines, Front End, Reactors and Services, Back End, and Renewable Energy. The Reactors and Services group designs and constructs reactors for power generation, naval propulsion and research, and manufactures the associated equipment. It also supplies products and services for operating plants.

GDF SUEZ: Owned a little more than one-third by the state, this Franco-Belgian energy group was created in 2008 by a fusion between *Gaz de France* and Suez. It is the foremost world producer of energy since merging with the UK company International Power at the end of 2010. It is the second largest producer of electricity in Europe and in the world after EDF. Its nuclear activity is essentially limited to the operation of NPPs in Belgium by its subsidiary Electrabel but it is expanding this activity in France and abroad.

Aside from the three major players named above, the French nuclear industry is composed of a tight tissue of hundreds of enterprises³⁸ ranging from Small and Medium Industries of fewer than 50 employees to major industrial groups such as Alstom, Schneider Electric or Synodys. These support industries intervene in numerous marketplaces including NPPs, research reactors, laboratories, medical equipment, fuel cycle and waste management. Furthermore, many Small and Medium Enterprises are regular contractors providing support, safety and maintenance services to nuclear installations on a regional basis.

2-3-2. Industry Associations

AFCEN, *Association française pour les règles de conception, de construction et de surveillance en exploitation des matériels des Chaudières Electro Nucléaires* or French Association for Design, Construction and In-Service Inspection Rules for Nuclear Island Components, has more than 40 French and international industrial members. A primary task is writing design and construction codes. AFCEN is not a standardization body; its publications where possible are based on existing standards, with the provision of additional information or clarifying options. Certain individual codes have been approved by the Nuclear Safety Authority (ASN) in the form of a Basic Safety Rule.

Two trade associations are:

FAIF, *Forum Atomique Industriel Français* or French Atomic Industry Forum (member of FORATOM)

GIIN, *Groupe Intersyndical de l'Industrie Nucléaire* or French Nuclear Industry Trade Association. Of interest for procurement of services, this group set up a Certification Committee for member enterprises who monitor personnel working under conditions of ionizing radiation. The group also manages the individual access records these personnel must have to enter protected zones.

38 CSFN, Conseil stratégique de la filière nucléaire or Strategic Council of the Nuclear Sector provides a meeting place for the sum of industrial actors.

2-3-3. Background on the Complementarity of EDF and AREVA

The respective histories and identities of the two major state-owned enterprises EDF and AREVA are very different.

EDF was created in 1946, soon after World War II. General Charles de Gaulle was in power and his government was allied with the French Communist Party (which had close ties with energy workers). EDF was created through a law which unified and nationalized the numerous pre-existing private utilities found up to then in France. At its creation, EDF was immediately one of the largest enterprises both in France and in Europe.

As a state monopoly, EDF had the triple mission of production, transport and distribution of electricity. The act of nationalization explicitly excluded front-end and back-end fuel cycle operations. Moreover, although EDF gradually acquired significant competences in industrial engineering and design, industrial manufacturing activities (electrical equipment or plant components) were also formally excluded.

In later years EDF was organized under the formal regime of EPIC (*Etablissement Public Industriel et Commercial* or Public Industrial and Commercial Establishment). In 2005, responding to the European requirement to abolish monopolies and open the electricity market to fair competition, EDF entered the stock exchange as a *Société Anonyme* or limited company. The French State remained primary stockholder, with less than 30 % of EDF's capital subject to listing.

AREVA is the present-day company formed in 2001 from components of three French establishments: CEA, Framatome, and COGEMA. It assures the industrial nuclear activities that are excluded from EDF's historic mission of electricity production, transport and distribution.

CEA (*Commissariat à l'Energie Atomique*) was created by General de Gaulle immediately after the end of WWII in 1945 (before the creation of EDF), with the objective of researching the uses of nuclear energy in the domains of science (including medicine), industry (including electricity production) and defense (including military weapons). In order to construct the first nuclear pile Zoé, CEA undertook uranium refinement activities. These would be enlarged in the late 1950s in order to provide military fissile materials. A subsidiary COGEMA was formed

(*Compagnie Générale des Matières Nucléaires* or General Company of Nuclear Materials). COGEMA operated mines, produced and enriched nuclear fuels, performed fuel processing and recycling of spent fuel and clean-up and dismantling of installations.

‘The French nuclear system never developed separate civil and military fuel chains. On the contrary, the design of the system was meant to optimize research, development, design, construction and operation of nuclear facilities so that the civil sector would profit from military advances and vice-versa. Also, organizations were set up to deal with both areas, the CEA in the beginning, later also COGEMA (now AREVA NC) to provide and manage nuclear materials for civil and military uses.’ (Schneider, 2009, p.4)

The CEA collaborated with EDF in the early 1960s to construct the first reactors but later diverged with EDF on design preferences: CEA developed the Uranium Natural Graphite Gas (UNGG) design while EDF pursued construction of Pressurized Water Reactors (PWR) manufactured by Westinghouse (this choice was ratified by the French government in 1969 and confirmed in 1974~75). A company Framatome (*Franco-Américain de Constructions Atomiques*, or Franco-American Company of Atomic Constructions) was formed in 1958 between Schneider, Merlin Gerin and Westinghouse Electric, in order to achieve the construction of PWRs in France.

AREVA was created in 2001 by grouping CEA-Industrie, COGEMA and Framatome NP. In this way AREVA became France’s sole integrated industrial actor covering the full nuclear energy cycle. The French State is the primary stockholder. Today two large nuclear divisions exist within AREVA. AREVA NP (Nuclear Power) is the daughter of Framatome and is specialized in the manufacture of nuclear boilers and reactor services. AREVA NC (Nuclear Cycle) is the daughter of COGEMA and is dedicated to mining, enrichment, processing and recycling activities. AREVA NC is present in more than 30 countries.

For both EDF and AREVA, the governance includes a representative of the French State, designated by APE (*Agence des Participations de l’Etat* or State Participations Agency).

3. Legal Basis for Transparency and Prevention of Corruption

It is desirable to present the overall approach to transparency and prevention of corruption in the French context before moving in this report to the specific practices and governance of nuclear procurement. Indeed, control of a subsystem will be enabled if control is well organized at higher level, including at the national and regional international (European) political levels. In France, the land of Descartes, a high value is assigned to the rational application of objective systems, and the Law is their primary embodiment. It is therefore important to bring forward in this report the framing laws and texts. Moreover, a French proverb says: ‘When sweeping the stairs, start by the top steps’. This proverb is even more pertinent in that the French nuclear sector is so tightly coupled with the State level. Upstream rules, principles and practices will influence downstream cases both by the value of example and by the transposition of practical procedures. Notice that this vision corresponds to the second principle of the WANO GL 2006-2 Principles for a Strong Nuclear Safety Culture: *Leaders demonstrate commitment to safety*.

The fight against corruption is a high-level concern in Europe, France, and among nuclear operators. National laws as well as international frameworks set the scene for transparency and ethical behavior. In this chapter we briefly present the European 2014 Nuclear Safety Directive as well as France’s 2006 Law on Nuclear Transparency and Safety. The French law in particular sets the standard for transparency in the nuclear sector and places it in direct relationship with nuclear safety. We then review France’s 2013 Law on Transparency and Integrity in Public Life, which is the major anti-corruption legislation. Then, we present specific French and European provisions relative to eliminating corruption from public contracts in particular.

On the level of implementation by nuclear operators in France, company policies and practices reveal the belief that measures to fight against corruption must be matched by enforcement and publicity of identified cases of fraud. Temptations exist even where strict procedures and ethical company culture exist, and must be continuously fought. We

present measures applied to prevent corruption in EDF Group, and signal a (non-nuclear) case that demonstrates the ongoing need to combat illegal behavior. The GDF SUEZ Frame of reference for Integrity is similarly presented.

3-1. Council Directive 2014/87/Euratom

The Council Directive 2014/87/Euratom of 8 July 2014 amended Directive 2009/71/Euratom establishing a Community framework for the safety of nuclear installations. This body of law organizes nuclear safety among the 28 Member States of the European Union. While it does not contain any language directly regarding procurement, it provides the high-level framework in which safety will be fostered and, at local level, control of nuclear procurement will take place.

The amended Nuclear Safety Directive reinforces the provisions of the 2009 Directive. Of particular interest, among other important gains, are these advances which could have particular pertinence for the excellence of procurement:

- highlighting the principles of “defense in depth” (different levels of protection aiming to prevent an accident or mitigate its consequences) and “safety culture”;
- highlighting the importance of the human factor by promoting an effective nuclear safety culture through management systems, education and training and arrangements by the operator;
- strengthening the powers and independence of national regulatory authorities that supervise the activities of nuclear operators;
- clarifying responsibilities in the oversight of the safety of nuclear installations;
- increasing transparency on nuclear safety matters through the obligation for licensees and authorities to inform the local populations and the stakeholders both in normal operating conditions of nuclear installations and in case of incidents or accidents.

The French Nuclear Safety Authority ASN negotiated in support of France’s position to significantly consolidate the European community

framework with these and other aspects. Member States will have to transpose the provisions of the Directive in national law within three years.

3-2. France's Law on Nuclear Transparency and Safety

The vital character of transparency for achieving nuclear safety is understood and expressed in the **Law n° 2006-686 of 13 June 2006 on Nuclear Transparency and Safety**. If we think of the “three-legged stool” of nuclear safety, this law contributes strongly to the third leg: addressing and reinforcing the management and organization. The text was carefully prepared according to the best practice of consultation: many concerned actors were heard and were able to contribute their intelligence to the drafting of this law that now governs France's safety organization. It does not have direct provisions to govern nuclear procurement but it does provide the needed tools to ensure, on national level, that a halt could be put to any grave dysfunctions not otherwise handled.

The Nuclear Transparency and Safety Law is a foundational text ensuring information to the public on the risks and safety of all activities using or transporting radioactive materials (NPPs, research, medical and military applications) and on radiological protection. Its provisions achieve the organic separation of control, expertise, and information functions, and organize the deepening of nuclear safety in France.

The law (re)created the Nuclear Safety Authority ASN, placing it under the direction of five commissioners named by the President of the Republic, of the Senate and of the National Assembly. All decisions taken by its commissioners must be made public. The Authority has full powers of inspection, control and injunction. The Authority is intended to be independent of both political decision makers and of industry, and capable of responding within minutes in case of crisis. ASN can shut down without delay any nuclear installation which is judged not to fulfill requirements or follow rules. Nonetheless, the government retains power of decision on some major points such as the creation or the definitive halt of any nuclear installation.

The law also reinforced the independence of the expert research arm

IRSN. The legislative basis for freedom of public information in the nuclear sector was provided. An official status and funding are now guaranteed to the local information and monitoring committees attached to each basic nuclear installation. The law also created the pluralistic High Committee for Transparency and Information on Nuclear Safety, presided by a Parliamentarian, whose task is to verify that all nuclear actors fulfill an enhanced duty of public information. This task has been taken very seriously as a broad remit by the presiding Senator. He has engaged the High Committee in many fact-finding missions that call upon the active participation and input of a broad diversity of stakeholders and which contribute directly to reinforcing safety by strengthening the ‘third leg’.

The Nuclear Transparency and Safety Law contains no specific language on procurement. However, it reflects and reinforces the mindset of transparency and safety culture in France’s nuclear sector, throughout its many levels from government to independent control and expertise, through industry and civil society.

3-3. Law on Transparency in Public Life

France’s **Law n° 2013-907 of 11 October 2013 on Transparency in Public Life** was passed in a context of concern for how actors of public life fulfilled their responsibility for full financial disclosure and moreover, respect for the law in their personal financial arrangements. This organic and ordinary law addresses members of Government, national and local elected representatives, and all those persons tasked with a mission of public service and seeks to ensure that they carry out their functions with dignity, probity and integrity. It seeks to prevent the formation of conflicts of interest and to eliminate them where they exist, to protect public figures from coming under the influence of pressure groups, and to avoid illegal personal gain. It also protects whistleblowers.

The law creates an independent administrative authority tasked in its own name to assure the regulation of sectors considered essential and in which Government (President, Prime Minister and delegated Ministers) does not wish to intervene directly.

The High Authority for Transparency in Public Life scrutinizes the personal patrimony declarations that are submitted by public figures at the start and the end of their mandate, including elected and appointed persons and also the directors of the principal public enterprises. Persons who do not respect this declarative obligation expose themselves to criminal sanctions ranging from three years of imprisonment and € 45k fines to five years and € 75k in the case of members of Government. The High Authority benefits from the support of central fiscal administration and has a power of injunction.

The ordinary law introduces a definition of conflict of interest in the aim of preventing interferences between public and private interests. It requires public actors to declare their interests, and also, to abstain (remove themselves) from any situation that might compromise independent, impartial and objective exercise of public functions.

Control on the financial management of political parties and elections also is reinforced.

The High Authority can choose to act on own initiative and can be seized by the Prime Minister, the presidents of the National Assembly and the Senate, and also by the non-governmental consumer protection organizations.

The dispositions specified by law extend the battery of controls that already existed (see III.5 below).

3-4. European Reform of Public Procurement Rules

Public procurement policies are presently undergoing reform on the European level. Public procurement rules organize the way public authorities and certain public utility operators purchase goods, works and services. They set up specific contract award procedures to ensure that public purchases are made in the most rational, transparent and fair manner. European rules aim at ensuring sound competition and obtaining best value for European taxpayers' money. The rules are set and implemented in the larger environment also of World Trade Organization agreements.

In December 2011 the Commission proposed the revision of Directives 2004/17/EC (procurement in the water, energy, transport and postal

services sectors) and 2004/18/EC (public works, supply and service contracts), as well as the adoption of a directive on concession contracts. The new directives, respectively 2014/24/EC and 2014/25/EC were voted by the European Parliament on 15 January 2014 and adopted by the Council on 11 February 2014. The Member States have until April 2016 to transpose the new rules into their national law (except with regard to e-procurement, where the deadline is September 2018). In replies to frequently asked questions,³⁹ the Commission points out that the notion of ‘conflict of interests’ is clarified: it shall at least cover *‘any situation where staff members of the contracting authority who are involved in the conduct of the procedure or may influence its outcome have, directly or indirectly, a financial, economic, political or other personal interest which might be perceived to compromise their impartiality and independence in the context of the procurement procedure’*.

In summary, the current reform of public procurement rules in Europe and its Member States is not specific or limited to the nuclear sector. However, reinforcing these rules to diminish conflict of interest, to exclude fraudulent suppliers, and to enhance enforcement, *de facto* provides strong operational tools to support the achievement on local level of a high level of safety in nuclear procurement. According to the legal practice and moreover the culture that are fostered in Europe, France and its nuclear operators, competitive bidding with proper publicity minimizes ‘out of sight’ agreements, the unjust favoring of a particular supplier, etc.: the decision among the received bids must be taken on a comparative basis and using transparent and objective criteria of evaluation. Within the EU, competitive bidding also creates opportunities for suppliers located outside the French national market.

39 Frequently asked questions about the modernization of public procurement rules are answered at the webpage http://europa.eu/rapid/press-release_MEMO-14-20_en.htm?locale=en. A detailed fact sheet on the new pro- transparency and anti-corruption provisions is found at http://ec.europa.eu/internal_market/public-procurement/docs/modernising_rules/reform/fact-sheets/fact-sheet-10-transparency_en.pdf.

3-5. Prevention of Corruption in France

The Law on Transparency in Public Life completes and extends the activities of the **Central Service for Prevention of Corruption (SCPC)**. This inter-ministerial service is overseen by France's Minister of Justice. The SCPC was created by Law n° 93-122 and became operative with the decree of application in February 1993.

Among the missions of the SCPC there are several of direct interest for the case of nuclear procurement by predominantly state-owned enterprises. The SCPC centralizes information related to active or passive corruption, influence peddling, unlawful taking of interest, and offense against the freedom and equality of candidates in the case of public contracts; it provides expert advice and assistance to institutions and justice; it also fosters awareness and provides training, for example in the case of public administrations on the subject of public contracts. Finally, it protects whistle-blowers.

The SCPC publishes an annual report. The 2008 report released in 2009 contains a chapter relative to public contracts. This outlines the steps that must be taken in the case of suspicion of corruption, in order to assemble evidence, and indicates that various forms of evidence that are acceptable: documents, recordings, piecing together of disparate elements. It also indicates measures for internal investigation in any public service, drawing attention to the need to verify contracts, suppliers, and financial vehicle corporations. In subsequent reports (SCPC, 2012; 2013) a total of 13 cases of fraud are described in France and almost all appear to concern contracts attributed by local elected figures. Significantly, no case of fraudulent procurement in the public industrial sector or specifically the nuclear sector is described.

In France, public and industry actors consider that the transparency laws mentioned above, and in particular measures intended to reduce conflict of interest and corruption, must not be purely symbolic. To be effective incentives they must be enforced and when fraudulent behavior is identified and addressed under the law, the outcome must be publicized. Exposing corrupt actors whether in politics or in business is considered to be one side of the coin of 'exemplarity', where the other side is the continuous demonstration of strictly ethical behavior by positive

leaders.

Several examples could be given in 2013-14 of investigations and court proceedings in France targeting the fiscal conduct of high elected officials and even the former President of the Republic in regard to the financing of elections. These send a strong signal that ‘no one is immune to the law’. Investigation and prosecution are organized, resourced and active.

An example of fraud was uncovered in 2014 in the French electricity procurement sector (most likely non-nuclear). This example (described below in III.6) suggests that while perhaps no context is entirely free of misconduct and dysfunctions, what may differentiate the top performers from the rest will be the efficiency of anti-fraud actions and the communication of their outcomes. To support these actions and communications, national law is needed, but also, internal policy and implementation. The following sections present the relevant policy from EDF and GDF Suez.

French practice is ‘pushed’ by exposure to others’ practices. This can be illustrated at least two levels: European law imposes obligations which are reflected downstream in French law; United Kingdom anti-corruption law led to the upgrading of EDF Group’s internal code of conduct.

3-6. OECD Anti-Bribery Convention

To be complete, we must mention the OECD Convention on Combating Bribery of Foreign Public Officials in International Business Transactions (the Anti-Bribery Convention) which entered into force on 15 February 1999, and which was signed by France. An interview with OECD Director General A. Gurria (2014) lends insight into the *‘myriad of (...) factors that may influence the ability of countries to open investigations [into cases of corruption]. Countries must have a robust legislative framework. Countries must be willing and able to provide mutual legal assistance. Measures must be in place to protect whistleblowers, in both the private and public sectors, and companies must see the benefits in order for them to voluntarily disclose acts of bribery. In fact, the co-operation of the private sector is paramount and businesses must be*

fully educated about foreign bribery. Financial managers and accountants can play a key role in detecting possible cases of bribery. Finally, the public, civil society, have a role to play in holding public officials and the private sector accountable. Progress is being made on all of these factors, for example, we are seeing an increasing number of specialised units and resources devoted to investigations. At the same time, technology and the increasingly complex nature of international business transactions means that governments must always try to be one step ahead of the bribers.

A system of peer review monitors country progress in applying the terms of the convention on national level. While no case of nuclear procurement is involved, France did recently receive a low mark on compliance and enforcement. According to a statement released in October 2014, *'The Working Group has requested France to persist in prosecuting the offence of foreign bribery. While acknowledging that 24 new cases have been opened since October 2012, the Working Group remains concerned by the lack of proactivity of the authorities in cases which involve French companies in established facts or allegations of foreign bribery. To this day, no French company has yet been convicted for foreign bribery in France, whereas French companies have been convicted abroad for that offence, and the sanctions for convictions of natural persons have not been dissuasive.'* (OECD, 2014) This may be taken as an indication that national institutions overall remain less operational in addressing and thereby preventing corruption, in comparison to e.g. the French nuclear operators with their agile anti-fraud policy.

3-7. The EDF Anti-corruption Strategy and Code of Conduct

The following describes the EDF anti-fraud policy and its impact in the area of procurement. Since 2010, the anti-corruption policy instated by the President of EDF is enforced in all reaches of the enterprise: zero tolerance for fraud, placed under the leadership of the Chief Financial Officer. Specific guidelines were issued in a letter of instructions. This states: *'EDF Group reinforces the building of awareness, training and control against the risks of fraud and corruption and in favor of respect for the rules of competition'*, with the following points:

1. Managers are responsible. The prevention of fraud is integrated in their action plan and their performance review. A practical guide was distributed to managers.
2. A program to build awareness of the risk of criminal sanction was launched throughout the Group in 2011. It responds to the hardening of anti-corruption laws in the United States and the United Kingdom.
3. A training program concerns all Group operatives.
4. Internal [communications] support and publications are mobilized.
5. Networks disseminate the culture of rule of law and pro-competition in the Group.
6. The Group exercises internal control on risks of fraud and corruption.

According to the Code of conduct, a whistle-blowing mechanism makes it possible to address any reported breaches to EDF Group's Ethics and Professional Conduct Committee.

The Group's Code of conduct was reinforced in response to the 2009 integration of British Energy, and the British anti-corruption law as of 2011.

In 2012, the EDF Generation division set up coordinated actions of fight against fraud. All its divisions mapped their risk of fraud and engaged the controls adequate to each context. Procedures to validate consultant contracts and mandates were reinforced.

The efficiency of these various measures – as well as the demonstration that they are needed – can be illustrated by a recently revealed case of fraud (most likely in the non-nuclear sector). Twenty-four persons including a former EDF executive involved in rigging contracts were brought before court in 2013 and 2014. The principal accused, responsible for negotiating supply contracts for EDF, is suspected of having set up a system of corruption 'soliciting favors in exchange for contracts'. In two years (2008-10) the executive is thought to have pocketed several hundreds of thousands of euro in cash but also in gifts (cars, fancy wine, an aquarium, renovation works in his home, etc.) In July 2011, EDF, alerted by an enterprise whose director refused to pay, filed charges as plaintiff. EDF told journalists that 'The employee left the enterprise immediately. This is an isolated case; numerous anti-fraud mechanisms

are in place' within the group and 'purchases are subjected to strict controls'. The accused's lawyer said that his client admits most of the facts and 'will face his responsibilities'. The 23 other persons identified by the charges are for the most part directors of vendor enterprises. They actively participated in this system by acquiescing to the executive's demands. They could be brought before justice soon for 'corruption' and 'misuse of company assets'.⁴⁰

The case presented above is based on a 2014 newspaper account, demonstrating that publicity was made of the fraud and the charges. No information is available however concerning the division in which the fraud took place or the nature of the contracts. Still, the extensive nature of the fraud combined with the fact that only one EDF operative was involved suggests that this corrupt procurement process was limited to domains in which a single executive was able to exercise a disproportionate decision power. It would appear that this case is exterior to the nuclear supply chain, where the nuclear safety imperative installs a much stronger system of checks and balances.

3-8. GDF SUEZ Integrity Frame of Reference

Another example of upstream principles and standards for the prevention of corruption is provided by nuclear operator GDF SUEZ. The following material⁴¹ summarizes the Integrity Frame of Reference developed as by GDF SUEZ and placed in service in July 2010 as a method for detecting and eliminating (potential) corruption, and monitoring follow-up and progress. This frame is part of the group's Ethics Policy and provides a positive method conceived as a management performance tool. The Integrity Frame of Reference is aimed primarily at managers, who *'will be responsible for ensuring that the conditions in which it should be applied are met by their teams. On a broader level it also concerns every Group employee, whose individual behavior contributes to the overall*

40 Example adapted from an article in regional newspaper Le Parisien, published 21 July 2014.

41 Drawn from www.gdfsuez.com/en/group/ethics-compliance/charters-guidelines/frame-reference-integrity-summary/.

expression of integrity promoted by GDF SUEZ’.

The summary of the Frame instructs managers and employees first to consider that integrity is ‘an excellent tool for enhancing performance as well as a sense of pride in being part of a team, and for promoting cohesion’. Then it urges them to become aware of the current global scope of fraud and corruption, the risks this poses for the general economy and for companies in particular, and the emphasis on sanction that is found in current jurisprudence. Third, it invites personnel to know the definition, type and characteristics of fraud and corruption in order to be able to detect and prevent it. The summary then reviews the regulatory landscape, including OECD and Council of Europe documents providing the international framework for combating corruption and their transposition into French law as well as ‘amendments that are moving towards stronger legal constraints, increased criminal and civil liability for business leaders, and tougher sentencing for fraud in general’.

Then, the Frame has six risk management approaches:

1. Detect areas and particular situations that may be susceptible to fraud and corruption.
2. Refer to the Group’s existing management procedures as a base using the internal monitoring program, the risk management approach and the audit program.
3. Consult the appropriate experts, studies and tools provided by think tanks or initiatives of which the Group is a member.
4. Deal with cases of fraud and corruption. Any instance of fraud uncovered must be dealt with and any proven instance of fraud must be penalized.
5. Implement appropriate awareness and training to enable everyone to have the required skills according to their level of responsibility.
6. Apply widely-used evaluation benchmarks.

4. Procurement Policy in France's Three Nuclear Operators

Publicly available materials, as well as insight gained from interviews, allow us to present the high-level supply chain policy for AREVA, EDF and GDF SUEZ. Then, the external control function by Autorité de Sûreté Nucléaire is described with examples on AREVA and EDF (EPR Flamanville).

4-1. AREVA

AREVA's 2013 General Inspectorate Annual Report noted that: 'The topic of subcontracting continues to be monitored closely at every level of the group. For example, greater consideration for safety, health, occupational safety and environmental requirements were incorporated into the Purchasing process in 2013.

'In July 2013, AREVA submitted its annual report on subcontracting to the minister of the Ecology. In addition to the quantified data it contains, the report gives voice to parties involved in subcontracting - including site directors, project managers, buyers, service providers and university researchers - so that the realities of subcontracting and how it is managed within the group can be grasped in practical terms.

'A group directive was issued in March 2013 that defines the rules for the operational supervision of subcontracted workers at its nuclear facilities; it harmonizes practices and the organization of supervision, and in particular prescribes the related documentation in terms of traceability. A professional training program and a training module were also defined for 500 supervisors identified within the group.' (AREVA, 2014, p.8)

The General Inspectorate goes on to say that: 'The group formalized its nuclear safety priorities for the 2013-2016 period in a nuclear safety policy released in May 2013. Its objectives are divided among three areas: safety of facilities, operational safety and safety management. The objectives are to maintain a high level of safety in the group's facilities, products and services; to share a strong safety culture internally and with our contractors, and to apply nuclear safety into all of our process-

es, beginning with the Purchasing phase.

‘The group’s nuclear safety policy has been widely communicated internally as well as to contractor companies working on AREVA’s sites, products and services...Significant work was carried out to integrate this policy into the performance objectives charges of the [operating] entities and into their 2014 Safety Health occupational Safety Environment (SHSE) performance improvement plans.’ (p.41)

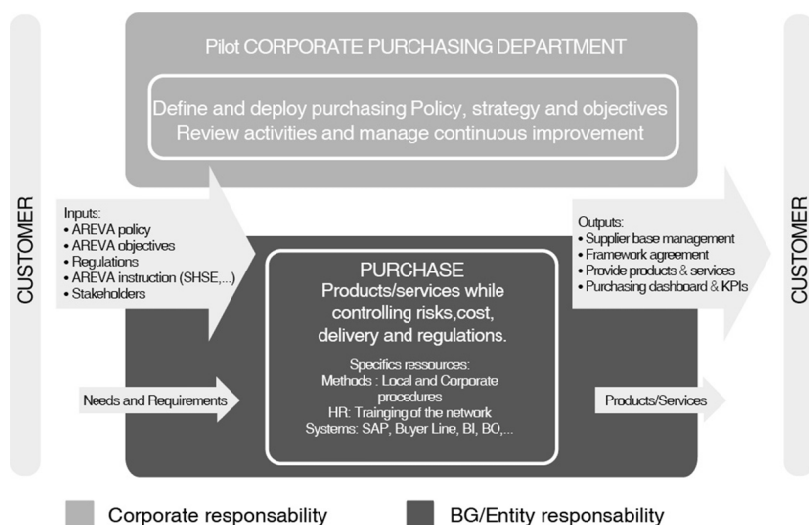
Describing the group’s repository of requirements for nuclear safety and radiation protection, the General Inspectorate reports that SHSE documents issued by the Supply Chain Department (with the Purchasing process) were added to this repository.

4-1-1. AREVA General Inspectorate 2013 Report: Supervision of Subcontracting Services

Important information can be found on pages 46~48 of the 2013 General Inspectorate Annual Report (AREVA, 2014), Part 2 entitled *Crosscutting Processes - Safety management - Supervision of subcontracted services*. These pages describe how ‘*In 2013, on the subject of subcontracting, management and reporting tools were strengthened, a joint initiative was rolled out for greater recognition of Safety Health occupational Safety Environment (SHSE) requirements in the Purchasing process, and actions were taken in the field.*’ (p.46) We reproduce in Figure 1 below a schematic representation of policy, actions and responsibilities, drawn from AREVA (2014) p.46.

The pages report the extension of functionalities of the Supply Chain Department’s information system in the safety and subcontracting field, in particular facilitating the consolidation of sensitive or high-risk type contracts, as well as to give better planning visibility for operational stoppages and worker flows.

■ Figure 4-1 ■ Untitled Figure from p.46 of AREVA (2014) 2013 General Inspectorate Annual Report; the 'Corporate Purchasing Department' was Renamed 'Supply Chain Department' in Late 2013



Further management initiatives reported in AREVA (2014) bear on a 'make or buy' policy for each nuclear site, including a needs-resources gap analysis and in-sourcing where possible; operational roll-out of social specifications to be included in bids to reinforce technical and safety responsibility. Internal prescriptive procedures were revised: AREVA recognizes three classes of sensitivity and performs suitable assessments and monitoring for each class of contract; class 1 contracts identified as having significant SHSE aspects trigger a supplier audit every three years, a graded record of performance, etc. Service providers and contractors are directly involved in a 10-item analysis and sharing of operational feedback from events concerning them. Group practices on contract supervision and traceability were unified, with training for 500 supervisory personnel. A university was engaged in *in-situ* observations of risk management related to subcontracted activities.⁴²

42 It is recommended to consult this important document available online: http://www.aveva.com/mediatheque/liblocal/docs/groupe/Etat-Surete/2014/RIGN2013_A.pdf

4-1-2. AREVA 2013 Annual Report on Subcontracting

Further useful elements are present in the French-language annual report on subcontracting (AREVA, 2013).

Regarding the sensitivity classification described on page 47 of the AREVA (2014) 2013 General Inspectorate Annual Report, the French-language 2013 subcontracting report goes on to state that the majority of enterprises contracted by AREVA are recognized, locally established and enjoy a long-time familiarity with AREVA installations and their particular risks. In this way:

- the Top 10 AREVA suppliers listing is almost unchanged since the year 2010;
- on average 70% of purchases for nuclear sites are procured from local enterprises;
- AREVA gives priority to multi-year contracts in order to foster long-term supplier relationships; almost 800 contracts for 3 years or more were signed in 2013.

The following criteria are used to assess the capacity of external contractors:

- Technical capacity: implementation capacity in terms of human resources, material and organization;
- Economic capacity: financial stability, list of clients and activities;
- Risk prevention and management: safety, radiation and environmental protection;
- Quality control organization relying on ISO 9001 principles;
- Safety culture: degree of managerial engagement, questioning attitude, etc.;
- Social engagement: adherence to AREVA values, diversity, training investment.

Referencing of each supplier is regularly updated according to performance feedback and evaluation (see our section V.1.2 on Incentives

describing the EDF example of Job Assessment Records, similar to AREVA practices, including recovery measures and potential for supplier exclusion, mentioned in AREVA's 2013 subcontracting report).

Supplier audits are carried out every 3 years in the most sensitive activities class. In 2011-13 the top ten suppliers underwent at least one AREVA audit each, with an average of 4 audits per supplier overall, a rate well beyond the rule stipulation. Capacities, qualifications, and training of the external agents is controlled.

Moreover, the preparation and execution of operations by external contractors is accompanied by the supervising AREVA managers.

Technical field audits (visits, technical controls of supply, operational investigations, technical visits...) are also performed by AREVA inspectors to control and monitor subcontracted activities. The priority is given to those most sensitive in terms of safety, radiation and environmental protection. A formal report traces observations and gaps. Contractor recovery plans and their implementation are then followed up by AREVA teams.

4-2. EDF Group

EDF Group Purchasing Division located in France covers EDF SA (the France operator) and a part of ERDF (the France distribution business group), as well as the Supply Chain Director in EDF Energy (United Kingdom). The Production and Engineering (Generation) service pilots procurement in the nuclear park.

The Group Purchasing Division's main priority is to ensure quality and impartiality in EDF's relationships with suppliers. These two goals are clearly expressed and are followed at each step of the process. The four basic principles for meeting these priorities are:

- Competitive bidding
- Equal treatment of suppliers
- Transparency of calls for tender
- Proportionality, which is adaptation of the process to the (more or less sensitive) nature of the purchase.

The Purchasing Division identifies material traceability as a major tool for efficient procurement of quality. This establishes a link (e.g., by marking or tagging, etc.) between the supplied item and the records establishing the acceptability of the item. For assemblies, a production traveler-type system may effectively identify the sub assembly identification and the records for those items. The Division states that it is important to distinguish between commercial/non-acceptance based records and the records used to establish acceptability.

Management services provided by the Purchasing Division include: support the definition of needs and industrial strategies; ensure that needs are met by suppliers; guarantee the respect of rules, ethics and Group values in purchasing processes; to foster Best Overall Value decisions; share and optimize the panel of suppliers on a global level; to conduct client-supplier relations; accompany Small and Medium Enterprises (of less than 50 employees). In 2013, EDF SA employed some 40.000 suppliers, of which almost 50% were Small and Medium Enterprises.

In France, two operational divisions are responsible for nuclear activities: Nuclear Production and Nuclear Engineering. They follow the company policy for procurement which is organized along 6 dimensions: selection of a panel of suppliers; purchasing; training of operatives; safety; radiation protection (aiming at the reduction of individual and collective doses); improvement of working conditions and geographical stay for (displaced) operatives. Both divisions have a delegated national-level committee tasked with industrial relations and the coordination of all contractor activities. This coordination relies on stakeholder diagnostics engaging other EDF divisions, managers of contracting enterprises, unions, and occupational medicine units. An Industrial Relations Mission exists also on each EDF nuclear site and fulfils the same duties for local and regional needs, as the national-level delegation.

Procurement operations are conducted within the rules of the European Directive 2004/17/EC⁴³ governing competitive bidding, publicity, and pre-qualification systems.

Supply chain policy of EDF SA can be inferred from a summary pol-

43 To be gradually replaced by 2014/24/EC; see our section III.4.

icy statement available on the EDF Energy (UK company) website. The statement in EDF Energy (2014) is labeled as consistent with EDF Group policy⁴⁴. It includes ten principles which may be resumed as follows; these indicate that several other elaborated procedures, documents and principles frame procurement: *‘A single procurement policy covers all Supply Chain activities undertaken by anyone across EDF Energy; (...) Nuclear Safety is the overriding priority. All Supply Chain activities shall be conducted safely and ethically in a controlled and sustainable manner to deliver consistent quality outcomes that deliver best ‘through life’ value for EDF Energy. All Supply Chain activities shall be in relation to the fulfillment of Legitimate Business Needs within Financial Authority Levels. All contracts and orders shall be placed with vendors that have been pre-qualified in line with defined criteria and registered on EDF Energy’s Master Data Base. All contracts and orders shall be placed using approved processes and shall be awarded on the basis of Terms and Conditions established by Supply Chain Functions in consultation with EDF Energy’s Legal department. Contract management activities shall be in accordance with approved processes. For all projects, Supply Chain activities should respect and follow the principles of EDF Energy Project Way (EEPW) corresponding to the relative scale and risk. Authorisation shall follow the principles of Requisition Authority and Commitment Authority. The use of Retrospective Orders or Retrospective Vendors is expressly forbidden. Payment terms for all Products must be a minimum of 60 days within all new contracts and contract extensions of any value, save where delegated authority from the Supply Chain Director has been given. All payments shall be in accordance with approved methods. The Supply Chain Director shall be responsible for maintaining and assuring this policy and its associated Framework and Mandatory Practices.’* (EDF Energy, 2014; p.2)

Interestingly, the governance of procurement at EDF Energy includes several special management groups, whose terms of reference are contained within the supply chain framework document:

⁴⁴ This publication, released in February 2014, is available online: http://www.edfenergy.com/sites/default/files/supply_chain_policy.pdf

1. Supply Chain Forum – A meeting chaired by the Supply Chain Director and comprising the Supply Chain Heads.
2. Operational Supply Chain Forum – A meeting chaired by an appointee of the Supply Chain Director and comprising the governance practitioners and other co-opted stakeholders.
3. Pre-qualification Forum – A meeting chaired by an appointee of the Supply Chain Director and comprising the Subject Matter Experts. (EDF Energy, 2014; p.4)

In the French context, specific detailed information is presented on the Suppliers area of the EDF website.⁴⁵

4-3. GDF SUEZ

GDF SUEZ explicitly places supply chain governance in the context of its adherence to the United Nations Global Compact⁴⁶ principles in the fields of human rights, working conditions, the environment and anti-corruption. Their supply chain policy⁴⁷ seeks a ‘process of continuous improvement in the efficiency of the procurement Function’ both for industrial activities and for supplier relationships. While economic criteria of both price competitiveness and technical efficiency are cited, further criteria reveal that in the sustainable growth perspective, environmental and corporate social values too are prioritized. The fourth pillar of ethical behavior is valued through respect for the law and anti-corruption.

GDF SUEZ claims as its major procurement principles:

⁴⁵ Consult: <http://about-us.edf.com/strategy-and-sustainable-development/our-priorities/stakeholder-dialogue/working-with-suppliers-43696.html>
<http://prestataires-nucleaire.edf.com/edf-fr-accueil/prestataires-du-nucleaire-edf/organisation-54029.html>

Suppliers can also access a password-protected area in order to read the “Nuclear Safety Memento” for all persons including contractors who work in operating EDF installations.

⁴⁶ www.unglobalcompact.org/AboutTheGC/index.html

⁴⁷ <http://www.gdfsuez.com/en/commitments/responsible-purchasing/procurementsupply-policy/>

- Systematic competitive bidding of authorized (or qualified) suppliers for all purchases made in a competitive market
- Any engagement with a supplier must be a written agreement previously negotiated between the parties and signed by the authorized persons (contract or order)
- Management of suppliers' performance improvement (conformity and prompt supply of deliverables, responsiveness, greater competitiveness).

‘These principles are applicable in supplier relations, which must strictly adhere to ethical rules that define the reference framework applicable to all Group employees.’

4-4. Supervision by the Nuclear Safety Authority

Several examples can be given of control by ASN, the Nuclear Safety Authority, of the safety of implementation of supplier contracts. The prevailing nuclear safety principle is that prime responsibility for safety lies with the operator, who therefore guarantees the safety of contractor activities. The ASN performs various inspections and controls of the effective achievement of this guarantee. The Authority's own announced values are: independence, competence, rigor and accountability.

ASN gives publicity on its public website to all its control activities and inspection findings. 2300 official follow-up letters addressed to operators, relative to planned and unannounced inspections, may be searched and downloaded by any visitor. (Final results of major controls are also presented on site including with a press conference.) An easy-to-read, colorful two-page flyer, ‘*La Lettre de l'Autorité de Sécurité Nucléaire*’, is released monthly and sent to about 1950 subscribers. It too is easy to find and download from the ASN website.⁴⁸ It reports each month in 8-20 lines about current significant controlled issues. Below we mention recent ASN publicized follow-up letters and monthly flyer reports related to subcontracting (procurement).

In Dec. 2013 ASN performed its first inspection outside French bor-

48 www.asn.fr/Informer/Publications/La-lettre-de-l-ASN.

ders, controlling subcontractors participating in the manufacture of components for ITER.⁴⁹ ASN directed ITER Organization to improve the monitoring of subcontractors so that dysfunctions observed in this inspection would not be reproduced in future manufacturing activities.

4-4-1. Case of AREVA

In 2013, ASN performed 10 inspections on AREVA entities operating basic nuclear installations, focused directly on the company management of activities contracted to outside enterprises or performed by external agents.

Overall, the following needs for improvement were identified (AREVA, 2013):

- Terms of reference should explicitly formulate the safety requirements that are part and parcel of the expression of supply needs.
- Prospective risk analysis documents and prevention plans framing the sub-contracted activities must be rigorously completed and applied.
- A formal monitoring plan must be developed and filled out all along the lifetime of the service.
- Acceptance of works or services delivery must be formalized in such a way that acceptability is correctly traced and that useful performance feedback is gained for future operations.

The ASN publicized two pertinent events in 2013:

- ASN gave formal notice to the Atomic Energy and Alternative Energies Commissariat (CEA), as nuclear operator of the Plutonium Technology Workshop and of the Chemical Purification Lab at the Cadarache site, to respect measures for the oversight of providers and for the management of skills linked to dismantling safety. This

49 ITER is the international project to design and build an experimental fusion reactor based on the 'tokamak' concept; it is based in Saint-Paul-lez-Durance, France, adjacent to the CEA Cadarache Research Centre. Participants are China, the European Union, India, Japan, Korea, Russia, and the USA. www.iter.org/

notice followed the April 2012 inspection in which ASN found serious gaps in CEA's monitoring of AREVA NC, principal provider (ASN, 2013a).

- In the post-Fukushima context, ASN in 2012 prescribed certain material needs to be fulfilled by end of 2016 at the Tricastin and Romans-sur-Isère sites operated by AREVA subsidiaries. ASN that same year validated AREVA's 'cross-cutting crisis management studies' identifying the improvements to be made on these sites in capabilities for the management of extreme situations. In 2013, ASN observed that the capabilities installed by six named subsidiaries did not correspond to the validated studies. These operators were put on formal notice to deliver the agreed measures within four to eight months (ASN, 2013b).

4-4-2. Case of EDF (EPR Flamanville)

According to the News section of the ASN website,⁵⁰ the construction of the Flamanville-3 reactor encompasses the following:

- the detailed design: detailed design studies setting forth the required data for the implementation of structures, components and equipment
- implementation activities: activities relating to the manufacturing and assembly of structures, components and equipment on the Flamanville-3 Site and in the workshops of nuclear pressure equipment suppliers or manufacturers (e.g., reactor vessel, steam generators, pressuriser).

In accordance with nuclear safety principles, the purpose of ASN's supervision is to ensure that EDF assumes fully its prime responsibility and guarantees:

- the conformity of detailed design studies with safety requirements;

50 www.french-nuclear-safety.fr/Inspections/Supervision-of-the-epr-reactor/ASN-s-supervision-of-the-Flamanville-3-reactor-construction-EPR-News

- the conformity of implementation activities regarding equipment and the installation in order to assess the overall implementation quality, and
- the impact of the worksite on the safety of neighboring Basic Nuclear Installations and the environment.

ASN ensures the direct supervision of design and manufacturing activities regarding pressure equipment (such as the reactor vessel, etc.), notably in the case of supplier AREVA. ASN is also entrusted with a labor-inspection mission on the construction site.

ASN carries out its supervision activities through:

- a documentary review of detailed design studies;
- an inspection programme concerning EDF's engineering services, the worksite and manufacturers.

The number of inspections is adjusted in relation to the volume and diversity of the planned implementation activities and the lessons learnt from past inspections. On the basis of the elements brought to its attention, ASN may also decide to perform in-depth and/or unannounced inspections.

In order to carry out efficiently the supervision of construction activities, ASN relies mainly on:

- its pertinent Territorial Division, where a team is dedicated the worksite inspections and reviews how anomalies or non-conformities are being addressed;
- its Nuclear Pressure Equipment Department, where a team is in charge of supervising the manufacturing of nuclear pressure equipment, and
- its Nuclear Power Plants Department, which is responsible for reviewing the detailed design, inspecting EDF's engineering services and ensuring a sound co-ordination among the different ASN entities.

Those activities involve the equivalent of eight full-time inspectors to which are added the staff mobilized by the public expert IRSN.

5. Selected Technical Characteristics of Nuclear Procurement Process

Two typical and interesting technical characteristics of the French nuclear procurement process are examined: the use of incentives (for both buyers and contractors), and the Best Overall Value approach to supplier selection (from the point of view of buyers and challengers). A special light is thrown on the use, present and potential, of Job Assessment Records.

5-1. Incentives

The French nuclear procurement context uses several levels of incentives to foster excellence.

5-1-1. Incentives for Buyers

On the side of purchasers, sanctions for misconduct by figures in public life, including managers of public enterprises, were described in Section II on transparency and the prevention of corruption.

Monetary incentives, such as bonuses for cost reduction, are not used in France. The United States case of the Millstone NPP, belonging to Northeast Utilities, is known in France (Lévêque, 2013). With a low cost strategy chosen in the middle of the 1980's, accompanied by a weak safety level, the managers achieved an excellent financial performance and earned several millions of dollars in bonuses. Safety performance was degraded but the reactors were at full regime, and the regulators were misled by false information. In 1996, after several incidents and warnings, the US Nuclear Regulatory Commission forced the operator to stop the 3 reactors. State regulators ruled in 1997 that Northeast Utilities had mismanaged the Millstone complex (Haar, 1998).

Group performance assessment is preferred in the nuclear sector,

however, personal incentives for continuous improvement are used by the operators in the form of extended in-service training (which is an element of qualification for career promotion). In 2007, for example, EDF spent € 275m or 6,4 % of total payroll on training. This represents a spend of more than seven times the legal minimum (0.9 % of payroll). The 100,000 France-based EDF employees receive on average 40 hours of training per year. In 2007, 85 % of employees attended at least one course. Not only does this training environment provide an incentive to individual agents, promoting professional development, but also well-trained personnel is an investment towards the error free performance required by high reliability organizations.

Note that in direct connection to improvement of procurement processes, in 2013 AREVA defined a professional training program and a training module for 500 supervisors centered on operational supervision of subcontractors on its nuclear sites, including traceability requirements.

5-1-2. Incentives for Suppliers

Below, the example of EDF illustrates the use of positive and negative incentives in regard to the satisfactory performance of supplier contracts.

Penalties: these are always calculated and announced in contracts; the decision can be made not to apply them. Here, the incentive takes the form of avoiding sanction by good performance.

- If the required standard of provision is not satisfied, and this is found to be the fault of the supplier, the satisfaction of requirements must be achieved at the expense of the vendor.
- Penalties also may be applied for late delivery and may attain as much as 10% of the contract value.

Job Assessment Records. These itemized sheets record the evaluation given to each supplier for each and every provision of materials or service. They are filled out in partnership by the client and the Purchasing Unit. Scores are attributed ranging from A to D.

Note that through the special addition of clauses to the general EDF

contract language, the principal contractor (signer) is made personally responsible for the performance of subcontractors and for the execution of the totality of the contract. The list of subcontractors is itself a formal element of the contract and must be updated in case of any change. In the nuclear sector, only two degrees of subcontracting are permitted. According to the rules of public procurement (Ministère de l'économie et des finances, 2014) the 1st-rank subcontractor is forbidden to delegate the totality of any lot to the 2nd-rank subcontractor.

If the less desirable scores C and D appear on the Job Assessment Records, the sanction operates in two phases:

- The contracting enterprise is first placed on probation and obliged to engage an action plan to address the insufficiencies.
- If the recovery is unsuccessful, pre-qualification may be withdrawn, which prevents the supplier from replying to future calls for tender.

Withdrawal of pre-qualification was applied several times in the case of suppliers to EPR-Flamanville. Note that this withdrawal was not necessarily founded on safety breaches, but instead on observed issues of quality/price ratio.

Note that the Inspector General (EDF, 2013) insisted that improvement was needed in the actual use of the valuable tool known as Job Assessment Records. Regarding contractor relations, he wrote *'Some of the contractor staff raised the issue of the paucity or the total absence of interfacing after outages to gather experience feedback; the manner in which the Job Assessment Records are submitted is unsatisfactory. It does not allow the direct in-depth exchanges of ideas at the plant between the contractors and the EDF SA clients. The time taken to share information about what needs to be improved and the important issues is part of the continuous virtuous circle of improving the planning and execution of the maintenance activities. I call on the plant managements, the engineering centers of the Nuclear Engineering Division and the Plant Operation Department to address this question and to reinforce their checking.'* (p.46)

Positive integration of Supplier Performance Sheets. Presently operators are studying the possibility to integrate overall Supplier Perfor-

mance Sheets into the formal evaluation of bids and to reflect their performance criteria in the Best Overall Value assessment. A vendor's good record in this way would be positively incentivized because it formally improves the chances of winning future contracts. However, at the present time, integrating a score relying on these past performance sheets would strongly disfavor new entrants, thereby reducing desirable competition. The resolution of this dilemma is being studied now, because positive integration of good performance would indeed be a strong positive incentive and performance evaluation methods are concurrently undergoing strong development.

The use of supplier performance sheets or records is further discussed below in section V.2 on Best Overall Value.

5-2. Best Overall Value

5-2-1. Public Procurement Rules

As per the relevant European directives governing public procurement (see section II.4), State-owned enterprises in France are obliged to conduct an open tendering process. Such an open approach, in which any interested party can submit bids, is considered to provide transparency, to ensure good competition, and to minimize potential for collusion and corruption.

The recent IAEA (2013) draft report on procurement engineering and supply chain guidelines discusses bidding, evaluation and placement of purchase order (their section 3.5, pp.36~44). This draft report submits that open tendering may ‘drive decision makers to a lowest (apparent or submitted) cost solution if care is not taken to [...] evaluate all factors (reliability of bidders, quality, lifetime or life cycle costs etc.).’ (p.37)

In order to assure safety within the required open tendering environment, the predominantly publicly owned nuclear actors in France therefore evaluate bids through an objectifying process which combines both formal technical and economic assessments, reported on a defined points system. It centers on identifying a **best overall value bid** (*‘mieux-disance’*) rather than a lowest bid (*‘moins-disance’*). To identify the most advantageous tender, a comparative evaluation is performed

first on the bids' technical acceptability and then on a diversity of economic criteria. The individual criteria do not necessarily differ from those used in other approaches; simply they are harnessed in a balanced and reproducible method.

Where the value of the call for tender surpasses a given threshold, an impartial technical commission is called in to examine the bids. This challenge process provides an extra layer of safety. Detailed information is provided here on the EDF Contracts Commission. The decree by the Minister of Industry on 24 October 2006 specifies that EDF public contracts valued over € 40m must be exposed to the prior opinion of the *Commission des marchés d'Electricité de France*. The same is true of any contract amendment worth over 20% of the original contract price, and, specified sensitive contracts valued at € 10m-40m. Contracts (excluding purchase of nuclear fuel) valued at € 100m or more, and specific amendment configurations, moreover are examined by the Board of EDF.

The Commission challenges the purchasing process on several dimensions. It relies on a written and oral report prepared and presented by a rapporteur who is independent of EDF (see section IV.2.2.b for an example). The Commission examines the conditions under which the competitive call for tender was constructed, announced and publicized. It verifies which panel of suppliers was consulted, taking into account their qualification including in nuclear safety procedures. It reviews the negotiations, whether the contract was attributed to the best overall value bid or on the contrary to the lowest bid. It verifies the objects entering into the contractual agreement. It records the level of price attained for the best overall value contract.

Note that this challenge approach is normal to the monitoring, implementation and control of procurement throughout the French public administration. Decree n° 2004-1299 dated 26 November 2004 on the commission of public contracts by the State details the general principles, organization and procedures both for aiding public purchasers in the preparation and conduct of call for tender, and for monitoring and challenge. The estimated contract value threshold activating such procedures in the general context is as low as € 6m (for bidding engaged by the State and its agencies excluding those organized as industrial and commercial establishments).

5-2-2. Examples of Criteria to Identify the Best Overall Value Tender – Operator Viewpoint

The example may be given of EDF's view on Supplier Performance Sheets (Fiches Performance Fournisseur) as one criterion in assessing best overall value for recurring contracts. These sheets formally record the operational feedback gained from experience in working with a given supplier. A note published by EDF on 29 July 2014⁵¹ considered that these sheets can be used in the evaluation of bids under condition that:

- A sufficient number of objective elemental evaluations has been recorded on itemized Job Assessment Records (Fiches d'Evaluation de la Prestation),
- These sheets were jointly reviewed at the time with the supplier,
- They are recent,
- A large majority of suppliers under evaluation possess an overall Supplier Performance Sheet or record.

The average of scores obtained on the full set of existing supplier sheets is attributed to new entrants.

The same note recognized that EDF's legal department judges that the use of this supplier performance feedback could be contested in light of current case law regarding contracts superior to the threshold established by the European directive in force. This case law concerns the use of supplier records that have been generated with other clients, and indicates that the performance feedback must be directly related to the contract object in order to suit evaluation of advantageousness. The jurisprudence accepts supplier record as a best overall value criterion for contracts inferior to the European threshold of application.

The 2014 note explained however regarding the call for tender in question that:

- EDF uses supplier records which have been established in recurring contracts with EDF

51 Personal communication to H. Boyé, October 2014.

- The new European Directive 2014/25/EU, which will come to replace the current 2004/17/EC, does foresee the possibility of using measures of personnel experience as an attribution criterion in cases where personnel quality can significantly influence the level of contract execution.

Given these facts, states the 2014 note, the EDF purchasing directorate did not decide at this time to eliminate the use of supplier sheets, a feedback tool used for several years in agreement with trade organizations and uncontested by suppliers.

5-2-3. Examples of Criteria to Identify the Best Overall Value Tender – Challenger Viewpoint

An example may be given of the criteria employed by the examining commission (see Box 9 above) called to challenge submissions to EDF calls for tender worth more than € 40m. The case concerns a call for tender in general worksite accompaniment services for planned unit outages (maintenance) and major refurbishment in the Atlantic Plaque group of 3 NPPs. Best overall value or most advantageous character is determined along five main dimensions laid down by the tender rules. Assessment on these dimensions is weighted as 20% of the overall evaluation with a maximum contribution defined for each (€ price figures as the remaining 80% of the evaluation). The diverse character of their application criteria reflects and addresses the complexity of safety assurance. (The needed full operational or checklist criteria are not detailed here.)

1. Working conditions - Improve living conditions for geographically displaced employees. Criterion: Value of indemnities granted for significant displacement, *maximum contribution 5%*

2. Human resource management - Prefer businesses that invest in skills. Criteria: seniority in trade qualification, percentage of employees aged under 30y, percentage of salary mass spent on training, *maximum contribution 5%*

3. Safety - Encourage best safety results. Criterion: Lost-time accident rate, *maximum 3%*

4. Technical performance -Prefer businesses where the quality of service has regularly given satisfaction. Criterion : Job Assessment Records established for the two years preceding the call, within the qualifying systems for activities addressed by the call, written up for services performed for nuclear power plants, *maximum contribution 5%*

5. Innovations – Prefer enterprises that have shown their capacity to innovate. Criterion: Number of technical innovations implemented on industrial sites within the past 3 years, reproducible in the activities addressed by the lot, *maximum contribution 2%*

Table 4-1 below shows how different bidding suppliers were rated and compared on these principal criteria. In the particular case cited, all the tendering enterprises obtained the same score of 0% on the Technical performance criterion inasmuch as this was a new criterion. The contract challenge commission envisioned giving weight in future to scores on Supplier Performance Sheets as discussed in the operator example above.

|| Table 4-1 || Example of Scoring Competing Bids on Best Overall Value Criteria by the EDF Contract Commission Rapporteur

		PGAC ATLANTIQUE									
		CLVAUX				BLAYAIS		GOLFECH			
	CRITERE	END	NVA	PNS-OMS	TEC	END	TEC	END	NVA	PNS-SMC	TEC
1	Conditions de travail	5%	0%	0%	0%	5%	0%	5%	0%	0%	0%
2	Management RH	0%	3%	5%	0%	5%	3%	0%	3%	5%	0%
3	Sécurité	2%	0%	2%	2%	2%	3%	2%	0%	0%	2%
4	Performance technique	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	Innovation	1%	0%	0%	2%	1%	2%	1%	0%	0%	2%
	TOTAL	8%	3%	7%	4%	13%	8%	8%	3%	5%	4%

Finally, the list of (adjusted) unit prices submitted by the bidder is assessed. In the 2012 example referred to above, the control commission used the unit prices quoted in the actual bids to calculate four different scenarios: under-consumption at 80% of expected draw, expected consumption at 100%, and over-consumption at 120% and 150%. The average value on the four scenarios was calculated for each bid, allowing the commission to verify whether the bid was tenable.

5-2-4. Example of Systematic Approaches to Identifying the Best Overall Value Tender – Price Revision Assessment Formula

According to IAEA (2013), time and materials contracts ‘typically provide for the acquisition of services on the basis of 1) direct labor hours at specified fixed hourly rates that include wages, overhead, general and administrative expenses, and profit and 2) materials, generally at cost, including (if appropriate) material handling costs.’ (p.186)

Part of the advantageousness evaluation verifies the coherence between stated prices and offers. It must be determined that these are balanced and that no dumping (under-pricing in order to obtain a contract) is practiced.

When the EDF contracts commission challenges bids, the following formula is used to verify cost variations on labor and materials:

$$P = P_0 \left[0,15 + 0,85 \left(0,95 \frac{ICHTrev - TS}{ICHTrev - TS_0} + 0,05 \frac{FSD2}{FSD2_0} \right) \right] \left(1 - \frac{TP}{100} \right)^{N - N_0}$$

P0: baseline price

P: adjusted price.

ICHTrev-TS: value of index of Hourly Cost of Work, including social charges, adjusted, for all employees. As per the index for mechanical and electrical industries published by the national bureau of statistics www.insee.fr. concerning the month of January in year N-1.

ICHTrev-TS0: value of the same index at the reference date, as published by the national bureau of statistics.

FSD2: value of the index of Diverse [Construction] Costs and Services 2 published by the Monitor www.lemoniteur.fr for the month of January in year N-1.

FSD20: value of the same index at the reference date, as published by the Monitor.

TP: Rate of productivity expressed as a percentage.

N: Current year.

N0: Reference year.

Application of such a precise, standardized formula allows meaningful comparisons between bids in a single year or across years. It also can be useful to assess actual price variations which are apt to be observed in multi-year contracts. It would not be sustainable for a contractor to absorb year-to-year changes in costs induced by factors outside its control, and at the same time, the purchaser should not bear unreasonable variations. This issue is recognized and well defined and regulated by national decrees on the management of public procurement (e.g., decree n°2008-1355 of 19 December 2008 modifying and completing the Code of public procurement dated 2006), and for decades it has been obligatory to apply such revision formulas to assess public sector contracts as well as variations between expected price and actual price.

EDF is seen as something of a national leader in the application and development of perfected price revision formulas. These are updated and improved at EDF by performance feedback, and each particular application takes into account the current data gathered from the national bureau of statistics, Chambers of commerce and industry, and the Ministry of Economy, Industry, and Digital's Directorate-General for Competition, Consumer Affairs and Prevention of Fraud (DGCCRF). The updated formula to be applied is announced in each call for tender. Of interest, the precise terms of the formula are often disputed by bidders, particularly the larger enterprises like AREVA or Alstom who have a strong legal department and whose economic interest it is to obtain the most favorable conditions on this aspect as well as all other contract aspects.

6. Safety of Nuclear Procurement: French Specifics and Comparative Strengths and Weaknesses

Earlier sections of this report have examined the contextual characteristics of the nuclear landscape in France (section II) as well as the legal and policy basis for transparency and prevention of corruption (III). Procurement policy was described (IV) and selected technical aspects of the procurement practice, including incentives, were detailed (V). In this section, we comment on two strong principles guiding nuclear safety in

France and, taking a cross-national approach, point out some strengths and weaknesses of the French context.

6-1. The Principle of Conformity

In France, procurement is integrated into nuclear safety by all actors by virtue of the principle of conformity ('it is this way and no other way'). The requirement is written, and its satisfaction (or not) is controlled. This conformity checking provides both intrinsic and extrinsic motivation for efficient and high quality procurement.

- As emphasized by the Nuclear Safety Authority ASN to AREVA, terms of reference – needs – must be expressed clearly in terms that also integrate the nuclear safety requirements (AREVA, 2014).
- Deliveries must satisfy needs or be rejected: the supplier incentive functions when (to use a metaphor from commerce) the goods are accepted and the 'clean bill of lading' is submitted.
- A clean bill generates in the French culture a sense of doing well at the first try, pride and honor, like receiving an A++.
- Without that clean bill, sanctions are applied to the supplier: the delivery must be brought into perfect conformity at own cost, and potentially, stiff late penalties must be paid.
- Not only does the good supplier receive full payment for the job (no extra work, no late fees) but the contractor also becomes a supplier with good reputation (the traditional Catholic culture says '*Good reputation is more desirable than great wealth, and favorable acceptance more than silver and gold*' – Prv 22:1; similarly, a French proverb says "*Bonne renommée vaut mieux que ceinture dorée*"). The good track record increases chances of winning a new contract.
- The EDF General Inspector (EDF, 2013) sternly calls on the purchaser to give full attention and full importance to the safety tool of Job Assessment Record, allowing all partners in the transaction to learn.

In this way the principle of conformity is a strong organizer, creating

relationships among the central actors of procurement (purchasers, managers, contractors). Each actor orients to this principle and has a particular distance to go at any time to honor it. Each actor has motivations (intrinsic and extrinsic; positive incentives and negative incentives or sanctions) to achieve conformity. Each actor can receive feedback (immediate job assessment; application of contract provisions; deferred evaluation by Safety Authority or General Inspector). All the elements in this virtuous process are needed to support continuous improvement (see VI.2 below) and constant reduction of the gap between performance and needs.

6-2. The Principle of Continuous Improvement

According to Lévêque (2013) the French approach to nuclear safety can be summed up by the regulator's approach. This consists of verifying that the operator has taken measures to 'prevent or limit in a satisfactory way the risks or inconveniences presented by the installations'. This 'satisfactory' way is not strictly defined; ASN completes its role by attending to the continuous improvement of nuclear installation safety. The importance of this principle of continuous improvement is explained by the authority's observation that safety is never fully achieved, and that scientific and technical knowledge evolve. Operational incidents signal new issues that both operators and regulators should watch and understand. Beyond the sole maintenance of conformity, the safety of French nuclear installations therefore rests upon the search for continuous improvement, embracing organization learning (WANO GL 2006-2 principle #7). Similarly, safety and conformity constraints which apply to procurement are regularly updated as new data and knowledge are integrated. This should be seen as one of the factors of overall efficiency and quality of procurement.

The continuous improvement approach is not framed by quantified norms. As Lévêque (2013) points out, the only quantified nuclear safety goal in France dates from 1977. The ministry of industry sent a letter to EDF stating that the overall probability that a reactor could produce unacceptable consequences should not be larger than 10^{-6} per year. It was added that this threshold was not a regulatory measure and that EDF did

not need to demonstrate it by probabilistic studies. Hence, a quantified statement of ‘how safe is safe enough’ is foreign to the French conception of nuclear safety.

What matters in France is the ‘safety requirement rule set’ (*référentiel de sûreté*), a key concept to understanding French regulation. Concretely, the rule set takes the form of a compilation of safety requirements of all sorts (which will be used, inter alia, for procurement: norms and technical specifications, general rules of exploitation, best practices). These requirements issue variously from ministerial decisions, ASN guidelines, and operators’ analysis of operational feedback and detailed proposals analyzed in return by regulators. Each reactor class (900, 1300 and 1450 MW) has its own referential framework. The safety requirement rule set is used for inspections, both to detect deviations from conformity (in the ECOT or *Examen de CONformité de Tranche* approach) and to identify improvements that should be targeted even when conformity to present norms has been achieved. Thus, in all cases, inspection results in a prescriptive list of improvements that should be brought to existing performance. The next inspection will assess the improvement actually achieved, using the former and the most recent safety reference table, and so on.

6-3. Strengths and Weaknesses Highlighted by Cross-national Comparison

Nuclear procurement takes place within and is directly under the influence of nuclear safety regulation and culture. To understand this influence, the French regulatory approach is presented in contrast to that of the United States. Major characteristics differentiating the US and the French nuclear regulatory approach might be summed up as follows:

- On the American side: Quantified goals, common use of probabilistic studies, concern for limiting costs, search for efficiency (cost-benefit studies). The USA approach aims at settling a ‘safe enough’ safety level.
- On the French side: General goals are clear but not detailed, regulatory prescriptions are few, technical dialogue (e.g. between operators and ASN) is preeminent, no reference to cost-benefit studies.

The French approach aims at continuously improving safety.

A practical example and consequence of these differences might be seen in the case of Beaver Valley Power Station, Pennsylvania, United States. Beaver Valley 1 was used by as the reference design for the French nuclear plant at Fessenheim. While an extension was granted by the US Nuclear Regulatory Commission NRC to take Beaver Valley to 60 years of operation, in France such an authorization for Fessenheim is pending while awaiting the result of integrating new safety data (e.g. Fukushima lessons).

In spite of the differences, the French and American approaches are given as examples by experts and advice from both NRC and ASN are carefully listened to in the international nuclear community. But intrinsic shortcomings can be spotted in each approach.

- Briefly analyzed for the American side, the costs of establishing a heavy regulation appear very high, slowing down its evolution, delaying its implementation and diminishing its capacity to react fast. Some analysis suggests that too rigid a regulation was detrimental to the development of nuclear energy in the USA (Foasso, 2003).
- In contrast, the French regulatory establishment appears as a light-horseman: it moves fast when necessary and is not limited by heavy judiciary or procedural constraints, nor is it surrounded by multiple goals and norms. The principle of continuous improvement guides its action without being defined by a quantified goal.

The latent problems associated with the French approach can be anticipated as follows:

- The efficiency of the system rests in part upon the wisdom of the safety commissioners, and acceptance by the operators. So far so good, but will it be always the case? Some more precise and binding legal frame might be necessary (e.g. in the present situation the operator could refuse to apply the ASN verdict).
- Cost-related pressures will rise. Two thirds of reactors in France will be 30 years old in 2015. Safety and refurbishment will cost

more, because of the need to replace major components, some quite expensive such as steam generators. Updating of safety standards will further increase these costs. From a political decision side, the rate of electricity sold to French households is ‘administered’ (i.e. it does not fully reflect costs), which means that EDF costs will not be (fully) transposed to the electricity bill of households.

- The absence of quantified goals adds an unknown to the life span of French NPPs: 40, 50, 60 years ? This life span ought to be known to plan new installations (nuclear or other) to provide electricity on a continuous basis.
- Resources, even for safety, are not unlimited The principle of continuous safety without bounds can make safety appear unattainable; ‘safe is never safe enough’. For nuclear opponents, no level of safety can appear acceptable and the best safety improvement would be to close NPPs.

Bloom *et al.* (2012) surveyed comparative research with 10 000 enterprises in 20 countries to identify 3 basic managerial techniques. Assessment questions can focus attention on aspects of the French state-owned nuclear industries:

- **Targets:** does the enterprise set its targets? Does it evaluate whether these targets are reached? Does it take corrective measures when necessary?
- **Incentives:** Are employees rewarded (with income) and promoted on the basis of their performance? Does the enterprise aim at attracting and keeping the highest-performing employees? Does it know how to manage its talented members?
- **Monitoring:** Does the enterprise continuously evaluate its performance? Does it use this information to improve operations?

The monitoring of performance in French nuclear sector SOEs ranks high, particularly if we consider the principle of continuous improvement of safety (as described above). The focus on monitoring is part of an overall culture of learning and integration of new data and events.

Conversely, target setting by French SOEs in the nuclear sector is not the major principle in safety. In other managerial areas, basic targets are likely used as part of routine activities. It must be noted that State policy impedes upon some strategic targets, such as the price setting of electricity.

As for incentives, in section V.1 of this report we described how in France (in contrast to the USA), individual incentive in terms of bonus or income is less developed, while indirect incentive linked to training and career development is favored. It must be noted, for instance, that when GCR (Gas Cooled reactors) NPPs were closed down, no one was fired: the entire workforce was re-trained by EDF to work at PWR NPPs. In other words, life employment is guaranteed by EDF.

From this comparative grid, we can conclude that in the French context, the State limits strategic target setting, and the nuclear safety approach limits the technical and economical goal settings. On the incentives side, the individual focus is less developed, thus possibly limiting the capacity of enterprises to manage talents.

7. Conclusions and Future Research

Analysis in the preceding chapters has allowed the identification of several important features of the French context which shape nuclear procurement policy and practice.

While no particular fraud has been identified in the French nuclear supply chain, the **fight against corruption** is a high-level concern in Europe, France, and nuclear operators. National laws inside and outside the nuclear domain, as well as international frameworks, set the scene for **transparency and ethical behavior**. According to policy and practice in every sector, measures to fight against corruption must be matched by the actual enforcement of rules, and by publicity of identified cases of fraud. This culture starts at the top and trickles down. France's 2013 Law on Transparency in Public Life applies to public decision makers and notably, elected figures. Personal finance declarations by Members of Parliament are controlled by the national fiscal services in collaboration with the purpose-built High Authority for Transparency

in Public Life. The strength of such a law lies both in providing rules and incentives for good behavior, and, in giving opportunities for enforcement – which in turn provide a stimulating example. In October 2014, some 60 members of Parliament (out of some 1000) were being questioned on their declarations.

Both the 2014 European Nuclear Safety Directive and the 2006 French Law on Nuclear Safety and Transparency have specific provisions for transparency that influence, more or less directly, the context of procurement. These laws reflect the current ethos and will be more and more powerful in shaping the behavior of nuclear managers and operatives, as the workforce gradually turns over and becomes younger.

The ongoing **reform of public procurement rules** in Europe and its Member States is not specific or limited to the nuclear sector. However, reinforcing these rules to diminish conflict of interest, to exclude fraudulent suppliers, and to enhance enforcement, *de facto* provides strong operational tools to support the achievement on local level of a high level of safety in nuclear procurement. Properly competitive bidding minimizes ‘out of sight’ agreements, the favoring of a particular supplier, etc.: the decision among the received bids must be taken on a comparative basis and using transparent and objective criteria of evaluation. French nuclear operators have placed a strong option on obtaining not the ‘least expensive’ supply but instead, the ‘best overall value’ for money, which incorporates not only economic but also other criteria (e.g., environmental, technological, ethical, social responsibility...). Detailed (EDF) examples were given in this report of how the ‘most advantageous offer’ is assessed.

The relative play of roles and responsibilities in France’s nuclear procurement may be portrayed as follows. The operator has primary responsibility for nuclear safety, and guarantees the safety of contracted activities and materials. The purchaser controls the excellence of procurement using a challenge process proportionate to the economic, but moreover, the safety sensitivity of the supply contract. In practice nuclear procurement is controlled by the safety authority mainly during implementation of the contracted activities. The independent safety authority inspects and controls the operator’s actual achievement of safety on the level of both materiality and process. The twin **principles of con-**

formity and continuous improvement guide the dynamic assessment of safety. From each inspection emerges a new updated safety requirement rule set, embodying current achievement and operational targets to be reached for.

The present paper benefitted from review in November 2014 by two independent professionals. Their comments and questions highlighted several points that might well be investigated in future comparative research:

Is there any profound difference between nuclear procurement in state-owned enterprises, and other public procurement? Nuclear procurement in France is regulated by the same texts as are other public sector contracts. However, future research should show whether the nuclear operators' explicit supply chain policy and practices differ substantially from those of other large and/or high-reliability industries, public or private, and whether and how they differ from other public markets. Such investigation would be in harmony with the WANO GL-2006-2 Principle #5: *Nuclear technology is recognized as special and unique.* Such research could be conducted also in a cross-national comparative perspective.

Publicity around actual cases of fraud – Is this always desirable? In Europe and the OECD countries generally, and in the French nuclear operators' anti-corruption policies explicitly, active transparency around cases of fraud and especially the sanctions these bring are considered to be an important aspect of preventing future fraud.⁵² Not only does this

52 Confer for example the comments of OECD Director General A. Gurria (2014): '...Bribery of foreign public officials is a complex and covert crime. Both bribers and bribe recipients will go to great lengths to keep the crime hidden. (...) A lack of awareness about foreign bribery increases companies' vulnerability to bribe solicitation and public officials' susceptibility to engage in corrupt practices. (...) The recent OECD Report on Foreign Bribery, by highlighting trends, will be useful for law enforcement, governments, business and civil society stakeholders in their future actions to prevent, detect and punish the crime of bribery.'

Moreover, OECD (2011) guidelines for multinational enterprises suggest that to '[e]nhance the transparency of their activities in the fight against bribery, bribe solicitation and extortion [, m]easures could include making public commitments against bribery, bribe solicitation and extortion, and disclosing the management systems and the internal controls, ethics and compliance programmes or measures adopted by enterprises in order to honour these commitments. Enterprises should also foster openness and dialogue with the public so as to promote its awareness of and cooperation with the fight against bribery, bribe solicitation and extortion.'

publicity warn off persons who might potentially be tempted or pressured to participate in fraud, but pragmatically, it raises awareness in managers. They are better able to identify conditions that could lead to corruption, and to pinpoint any indications that fraud may be taking place. Publicity around cases of fraud reinforces the shared anti-corruption culture. However, there may be reasons why publicity around fraud is not always desirable, or value systems that reject publicity. These could be investigated if they exist in various contexts, and relative performance on preventing fraud could be assessed.

Is there a trade-off between safety-first culture and economic efficiency? In the French context, an awareness of such a possible trade-off is reflected in the explicit procurement option taken to prefer the Best Overall Value or Most Advantageous Offer, rather than the least expensive bid. Looking farther, other strong options are taken or discussed in France which may cost the taxpayer or rates payer more money in the short term, but which different actors consider vital to ensuring nuclear safety: examples include the intense schedule of site inspections and follow-up conducted by the Nuclear Safety Authority (ASN); the economic and personnel resourcing of the Institute for Radiological Protection and Nuclear Safety (IRSN); the empowerment and competence-building among civil society centered in, for instance, the High Committee for Transparency and Information on Nuclear Safety (HCTISN) and the National Association of Local Information Committees and Commissions (ANCCLI). These options seem to reflect several principles of safety culture as expressed by WANO GL 2006-2 such as:

#4 Decision-making reflects safety first.

#8 Nuclear safety undergoes constant examination.

#6 A questioning attitude is cultivated.

However, the options and philosophy favored in the French context may not exist in precisely similar form in other national settings. Future research could investigate both qualitative and quantitative aspects of (procurement) safety performance in the various contexts.

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CHAPTER 5

Nuclear Energy in the UK: Safety Culture and Industrial Organisation⁵⁴

William J. Nuttall
John E. Earp

1. Introduction

This paper is tasked with exploring the professionalism and the integrity of nuclear procurement in the UK. It is an interesting question rarely considered in Britain. Much attention has been given to building and maintaining a strong safety culture within the UK. Much of this has related to mitigating the risks and consequences of accidents. There has been little discussion, however, of the risks or impacts that would arise from self-interested criminal behaviour. Perhaps the closest that the UK has come to such issues in the nuclear sector has been acts of negligence and data falsification designed to hide negligence. These issues are explored via case studies later in the paper. We have also been asked to consider the role of state-owned enterprises and the relationship, if any,

54 We are very grateful to Il Chong Nam and two anonymous referees for helpful advice and comment. We are also most grateful to Raphael Heffron and Stephen Ashley for advice and assistance concerning nuclear insurance. We are enormously grateful to Nigel Buttery for sharing insights and ideas concerning the construction of Sizewell B. We have drawn extensively upon his input in that part of the paper. Nevertheless in that paper the text presented should be regarded as representing the opinions of the authors alone. Furthermore any errors and omissions are the responsibility of the authors alone.

between: on the one hand industrial organisation and ownership; and corruption or criminality on the other. In this paper we describe the profound journey that the UK has taken in recent decades from state-owned industrial national champions to private sector firms in a liberalised market. Today many of the firms operating in the UK nuclear energy sector are foreign entities. Again we see little, or no, evidence of impacts from criminality. As the UK admits more international companies into its domestic nuclear services market it exposes British companies to global competition. As UK nuclear energy firms are progressively serving global markets, general anti bribery legal measures become increasingly relevant and important. We shall consider these issues briefly later in the paper. Finally, we suggest that the main effect of internationalisation on British industry is that British firms improve their global competitiveness.

In this paper we suggest that a key driver of British nuclear professionalism is non-prescriptive nuclear licence via which individuals and organisations are given high degrees of formal responsibility and discretion for nuclear safety. With responsibility and discretion comes professionalism.

The UK was one of the first countries in the world to develop civil nuclear energy, following earlier efforts dedicated to the production of plutonium-based nuclear weapons. That history provides an important context for this paper, and we shall consider such things further in the next section.

2. UK Historical Context

While much of this paper will deal with issues facing civil nuclear electricity generation in a Twenty-first Century Britain defined by liberalised markets, globalization and private sector led innovation, it is important at the outset to make clear that Britain was not always such a place. In the middle of the Twentieth Century the United Kingdom faced an existential threat from Nazi Germany far graver than anything in historical memory. Germany was a continental-scale engineering-oriented superpower and somehow, and by the narrowest of margins, Britain tri-

umphed. In winning, however, national weaknesses and shortcomings were revealed for all to see and the returning troops demanded change. 1946 saw the election of a strong and radical Labour Government under the leadership of Clement Attlee.

Attlee's Government inherited no money, but it inherited victory and a mandate for deep reform and a major part of that would be industrial reorganisation. Attlee in the 1940s, and later Harold Wilson in the 1960s, took Britain to the point that it was a country in which fuel from state-owned coal mines would be transported on state-owned railways to be burned in state-owned power stations generating electricity transmitted and distributed over state-owned wires to be used in state-owned factories making cars and airplanes (1). There were also state-owned nuclear power plants. The consequence was that by 1975 Britain was a temple to state-owned enterprise. Three state-owned enterprises vied for influence over the post-war nuclear power programme: the Central Electricity Generating Board owner-operator of the power stations (of all types) and also of the transmission grid; the UK Atomic Energy Authority operator of an extensive network of nuclear national research laboratories and research reactors and finally, a UKAEA offshoot, British Nuclear Fuels Ltd (BNFL) provider of a full complement of fuel cycle services and associated research. In addition to these three state-owned enterprises the British Government held a one-third share (with Germany and The Netherlands) in the uranium enrichment company URENCO. All the nuclear power stations operating today in the UK are, in various ways, a product of this post-war economic model. While it is true that the most modern British nuclear power plant, Sizewell B (a modified Westinghouse SNUPPS plant) was completed in the mid-1990s, and hence after Britain had turned away from the model of state-owned-enterprises, it was also very much a product of statist thinking. It had been intended to be the first of a fleet of CEGB-led projects built for Britain with American help in the form of design (Westinghouse) and construction know-how (Bechtel). The successor plant proposed for Hinkley Point near Bristol in western England received planning approval and had substantial public acceptance, but it was never built for reasons we shall explain later. We suggest that more than anything else the British nuclear programme ground to a halt in the 1990s, not be-

cause it was “nuclear”, but because it was statist. Or alternatively one might say that British nuclear ambitions were not undermined by the actions of the green-left, but rather by the pro-market right with an agenda for electricity market liberalization.

Margaret Thatcher, first elected in 1979, was Britain’s first and so far only female Prime Minister. She entered office with a powerful political majority and a strong belief that things had to change. Part of her change was to rid Britain of statist industrial policy and she embarked on a wide ranging programme of industrial privatisations including in energy. First to go was the government’s stake in the oil company BP. More importantly, her second term government set about privatising British Gas which was sold off as a monopoly (albeit a contestable monopoly) missing an opportunity for true liberalization in the form of genuine market competition. In the lead up to the 1987 election Thatcher wanted to get it right for the next opportunity – electricity. Electricity privatisation featured in the 1987 Conservative Party election manifesto and her third term government went on to both privatise and break up the monolithic CEBG. Competing generator companies were established (albeit initially with a high level of market power) and the National Grid was sold off as a regulated private monopoly grid operator. The Thatcher government’s intention was to bundle the nuclear power plants into the larger of two electricity generation companies, together they were known in the discussions as “Big-G” and “Little G”, but it soon became apparent that such ideas frightened the merchant bankers tasked with delivering the privatisation and who had been hearing worrying noises from prospective institutional investors (2). The investor concerns focussed on the unknown economic risks associated with eventual plant closure and decommissioning. Later it would become clear that at market discount rates such costs are in fact small, even negligible, but in the febrile lead up to the planned sale there was great sensitivity to financial risk. Fearing that the privatisation would fail, the nuclear power plants were removed from the privatisation plans late in the process.

With the Conservative Party majorities eroded in the 1987 election there was a clear sense that electricity privatisation must be delivered before the next election, expected in 1991. The tight timescale was met. Interestingly if there had never been any intention to privatise the nucle-

ar power stations it would have been possible to establish from the outset the greater than five generator companies that economic theory suggests is necessary for market competition to work properly. In fact it would take many years after the privatisations of 1991 for Britain's Big-6 Generator companies of today to be established in the market. The nuclear power plants were eventually privatised in 1996 in the form of British Energy. British Energy had a very difficult time essentially going bust and requiring a state bail-out in 2002 – see section 8. Today all but one of Britain's nuclear power plants are operated by a subsidiary of the largely state-owned French electricity company Electricité de France (EdF) which acquired the operations of British Energy in 2009. Today it is EDF that is leading the way with its plans for a nuclear renaissance in Britain.

Trained as a scientist Margaret Thatcher had a certain enthusiasm for nuclear energy and much esteem for the leader of the CEGB, Sir Walter Marshall, who was bitterly opposed to the break-up of his empire. Despite her affection for the atom and for “Dear Walter” her love of the free market was even deeper and it was her leadership that caused Britain to turn away from coal-fired electricity generation (where Thatcher, in the mid-1980s utterly crushed her bitter foes in the National Union of Mineworkers) and nuclear power which frankly frightened her less-technically minded friends from the financial sector. Thatcher's government sowed the seeds of the 1990s “dash for gas” in British electricity generation and the first serious steps towards renewable electricity generation (in which context it must be acknowledged that Margaret Thatcher had an early personal belief in the risks from anthropogenic climate change). The “dash for gas”, made use of a flexible fuel in stations which could readily regulate output to suit market conditions (in particular operating on the margin) hence giving it a significant economic advantage compared to the nuclear fleet that typically operated at base load. The advantage of natural gas really emerged after the ending of the Pool market and the move to New Electricity Trading Arrangements (NETA) in March 2001. Prior to that shift all Pool generators (including nuclear) received the market clearing price. The ending of that pricing system with the shift to NETA allowed flexible generators at the margin to receive higher prices per kWh and this contributed to the

commercial difficulties of British Energy referred to above.

By the start of the Twenty-first Century, Britain had firmly turned its back on state-owned enterprise in energy and the nuclear power industry had to recognise that fact or perish. In the first few years of the new Century, say up to 2006, there was a sense that electricity market liberalization had worked – consumers, both industrial and domestic, were switching suppliers in ever increasing numbers, power supply reliability was good and prices fell. But there were also growing voices of concern because energy policy had by this time evolved to require progress in two emerging areas: decarbonisation motivated by concern for global climate change and energy security involving concerns for both fuel supplies and power generation capacity. With both challenges in mind, concern was growing more generally regarding the need for major energy infrastructure renewal. While it was clear that the liberalised market could supply electricity it was far from clear that the market would ever be able to build new power stations, once the initial dash for gas was done. By the second half of the decade of the 2000s there was much concern for UK “Generation Adequacy”. It was far from clear whether renewable capacity represented any form of comfort in that regard. Major blackouts in 2003 and fractious gas disputes between Russia and Ukraine (2006 and 2009) forced policy-maker attention towards an established and reliable source of low-carbon electricity: nuclear power. But how could the liberalized market of the 1990s be incentivized to build such things? The short answer is by a retreat from liberalization and towards a socialisation of economic risks, but without a return to nationalisation and state-owned-enterprise. The policy changes are summarised in the next section, but suffice it to say that in 2014 Britain is, once again, a place with strong government intervention in the energy sector, albeit largely free of state-owned-enterprises.

3. UK Nuclear Renaissance

The UK was one of the first countries to develop civil nuclear energy. While the Soviet Union was the first country to make civil use of nuclear energy with a small reactor at Obninsk in 1954, the UK was the first

to connect a large capacity generator to a power grid. The four unit nuclear power station at Calder Hall in the northwest of England was opened by the Queen in 1956 (3) (the site in Cumbria is adjacent to Windscale, now called Sellafield). The second four reactors were at Chapelcross in Dumfries. All eight of these reactors had an original dual mission of supporting the need for military materials and electricity generation although they progressively transferred to a solely electricity generation mission in their final years. These two sites were the fore runners of the programme of Civil/Commercial Magnox reactors constructed only for electricity generation which began at Berkeley in Gloucestershire and Bradwell in Essex both of which commenced operations in the early 1960s. These early natural uranium-fuelled graphite moderated and carbon dioxide cooled reactors were followed by a fleet of “Magnox” power stations operating on very similar principles. The title “Magnox” refers to the magnesium/aluminium non-oxidising alloy used for cladding the metallic natural uranium fuel.

In the 1970s the UK had the chance to switch to what was already an emerging global front-runner technology – light water reactors. Indeed a very wide range of reactor types were considered at that time, but it was the higher temperature graphite-moderated and gas-cooled concept the Advanced Gas Cooled Reactor, or AGR, that was selected for deployment. The AGR concept was technically advanced and severe problems were encountered in construction (e.g. Dungeness B – required 23 years to construct and commission) and operations (revealed by relatively poor reliability). As noted earlier, by the late 1980s it had become clear that Britain’s AGR concept could not compete with light water technology for reliability. It was resolved that the next plant, commissioned in 1996, would be a pressurised water reactor built at Sizewell on the Suffolk coast. Sizewell B was intended to be the first of a fleet of new Westinghouse developed power stations, but the political and economic events described earlier conspired to scupper such plans. For the next ten years there would be very little talk of nuclear power and over the same period electricity market liberalisation was consolidated, as described in the previous section.

As noted earlier, by 2006 it had become clear that while the liberalised market could indeed provide retail consumer choice and through

competition put downward pressure on retail prices, it could not raise sufficient capital for nuclear new build. UK energy policy would need major structural reform if policy goals relating to the environment and energy security were to be met.

Since 2006 UK policy has moved consistently and strongly towards incentivising a nuclear renaissance. Along the way some long-standing axioms of policy have been quietly dropped. For example the axiom *no subsidy for nuclear power* was adjusted to be *no special subsidy for nuclear power*. In the former case a conventional interpretation would suggest that no subsidy could be paid to those planning nuclear investments or generating nuclear power. Following the adjustment to a situation of *no special subsidy*, nuclear power would be allowed to receive subsidies as long as they were not only available to nuclear power. For example the UK might subsidise low carbon electricity generation technologies. Nuclear power would be eligible for such a subsidy, as would renewables. As such, the measure would not be a special subsidy for nuclear. Government suggested that the policy had merely been clarified, but arguably the logic for subsidies had been fundamentally redefined. The shift made possible the later moves that are enabling recent progress towards a British nuclear renaissance. While policy is deliberately incentivising new nuclear build the formal power of initiative remains with private companies and importantly, in energy at least, the UK has seen no sustained return to strong state-owned enterprises reminiscent of the former CEBG. While there was a relatively short-term intervention to rescue British Energy (described later in section 8), fundamentally the UK has a situation in which government has policy goals and government achieves those goals by incentivising private firms via market arrangements and risk guarantees. Actual investment decisions continue to be made by private companies. Government incentives include long-term subsidies (for renewables and new nuclear build) in a form known as contracts for difference. There is indeed an irony that the UK, which led the EU into energy market liberalisation and which for years spoke out against opaque long-term pipeline gas contracts is now seeking (and winning) EU state aids approval for a 35 year long-term contract for nuclear power. The UK is in some ways retreating from liberalisation recognising that stronger intervention is needed to ensure infrastructure

renewal and decarbonisation. For further information on the policy underpinnings of the UK Nuclear renaissance see report by W.J. Nuttall (3).

While there has been clear progress over the last ten years towards a nuclear renaissance in Britain there have been some exceptionally difficult events along the way. Most notably these have been the global financial crisis of 2008 and 2009 and the severe nuclear incident in March 2011 at the Fukushima-Daiichi plant in Japan.⁵⁵ The fact that UK policy enthusiasm for highly capital intensive nuclear power plant investments has remained firm in the face of such pressures is quite remarkable (4). It is even more remarkable that UK public opinion, while divided, has on balance remained resolutely pro-nuclear through these difficulties. Arguably it is the powerful investor communities who have been most troubled by the external events mentioned earlier, thereby continuing the trend that in the UK it is not political concerns that raise the most difficulties for new nuclear projects.

It was originally expected that the lead investors for new nuclear power projects in Britain would be large European electricity generating companies, and indeed prior to the Fukushima-Daiichi accident three competing teams had expressed interest in new nuclear build. These were:

- NNB Generation Company a collaboration between EDF and Centrica
- Horizon Nuclear Power a joint venture between RWE and E.ON
- NuGeneration Limited a collaboration between SSE, Iberdrola and GDF Suez

It is noteworthy that all seven investing companies were large European energy companies. It was such companies that were originally expected to lead a UK nuclear renaissance. However, following the impact of the external pressures alluded to above these ventures have now

55 We use the term “incident” rather than “accident” because unlike all earlier severe nuclear accidents (e.g. at Chernobyl), the incident at the Fukushima-Daiichi plant was a consequence of an independent external disaster (the earthquake and consequent tsunami) and did not arise from an initiating event within the plant itself.

evolved greatly.

- NNB Generation Company is now collaboration between EDF, two Chinese generating companies, the French technology vendor Areva⁵⁶ and with some remaining space for a new entrant investor.
- Horizon Nuclear Power is now led by the Japanese technology vendor Hitachi
- NuGeneration Limited is now led by the Japanese technology vendor Toshiba

Noting the diminished role for energy companies UK nuclear new build (at least in the project planning and build phase) is less directly connected to the liberalised market than it once was. Furthermore if one wants to point to the return of state-owned enterprises in the UK nuclear story, then one observes that they are not enterprises owned by the British state. The front-runner nuclear new build project in the UK is led by NNB Generation formed from enterprises the majority of which are owned by either the French or Chinese State. Arguably therefore the UK is benefitting from the cheap capital enjoyed by state-owned enterprises, but is willing to forgo the political and state control that usually accompanies the use of domestic state-owned enterprises and national champions (1).

4. Development of the Generic Design Assessment Process

Within the UK and throughout the world nuclear power plant construction projects have been subject to construction delays. A prime cause of this referenced in many reports has been the practice of commencing build before the design was finalised, leading to changes being required during the build (5). Fortuitously this situation was alleviated at Sizewell B because the length of time taken over the Public Inquiry pro-

56 At the time of writing the commitment of Areva to the Hinkley C project appears to be in some doubt as a consequence of financial difficulties at the company.

vided sufficient time for the design to reach a mature stage prior to construction commencement.

We note that the Sizewell B Public Inquiry was conducted under arrangements now superseded, which allowed inquiries into large infrastructure projects to be wide ranging. The older arrangements had the consequence that at the Sizewell B Inquiry only 30 of the total 300 days were associated with local issues, such as the impact of the project on local infrastructure and related potential transport problems such as traffic delays. The rest of the time was taken up with national policy matters (6). As a result the Government has instigated, for the nuclear renaissance, changes to the legal arrangements surrounding inquiries in the UK and it is no longer the case that they are “wide ranging”. Station design and safety, national need, and siting are now handled by policy processes at a national level. Public Inquiries now are restricted specifically to local issues. That these new arrangements work successfully is evidenced from recent the much shorter duration inquiry into the proposed construction of Hinkley Point C.

The safety and environmental impact of a proposed power plant are now largely handled via a national and site-independent process known as “Generic Design Assessment” (GDA). The GDA process was introduced to reduce the risk of UK nuclear new build construction starting before project design had reached sufficient maturity (7). The GDA process is operated jointly by the regulators engaged in nuclear energy matters in the UK, specifically the Office of Nuclear Regulation ONR (who lead the process) the Environment Agency and the security regulator – the Office for Civil Nuclear Security (an autonomous part of ONR).

In order for a nuclear design to be sanctioned for build it must first go through the GDA process. Designs are submitted by a sponsor – generally a reactor vendor and are subject to detailed scrutiny by the regulators leading to an extensive dialogue on nuclear safety matters before the design is accepted for construction to start. The process, which can typically take up to 3 years, requires the sponsor to submit a significant number of design reports covering the detail of the proposed design set against a generic site. Hence the only design issues not assessed are those which are site specific. Utilising this approach it is hoped that construction delays deriving from design changes will be limited.

Currently in the UK the Areva European Pressurised water Reactor (EPR) has reached the stage of sanction for build having received a “Statement of Design Acceptability” (SODA), and the AP1000 is part way through awaiting its selection by a constructor before finalising the process. The Advanced Boiling Water Reactor (ABWR) is a late entrant into the GDA process motivated by the shift of technology choice following the acquisition of Horizon by Hitachi.

Because the GDA process is new and only recently introduced for the proposed nuclear new builds planned for the UK, we are not able to cite specific examples of where and how the process has reduced construction delays. However we have already mentioned that serious delays occurred at Dungeness B in the UK. Similar, but shorter, delays occurred on the other Advanced Gas-cooled Reactors. It is well reported in the technical press that delays due to design changes have beset the recent EPR projects at Olkiluoto in Finland and Flamanville in France. Also we have mentioned the fortuitous benefit of a delay to the commencement of planned construction of Sizewell B brought about by the extensive Public Inquiry. The delay allowed time for the design to reach a high level of maturity with the benefit that design change delays were significantly minimised. As a result there is a degree of confidence in the UK that the introduction of the GDA process, which ensures this higher level of design maturity as agreed with the regulators before commencement of construction, will mitigate construction delays due to design changes. It is also worthwhile noting that the COL (Combined Operating Licence) approach adopted by the Nuclear Regulatory Commission (NRC) in the US for their proposed new builds has a similar intent (8).

5. Development of the UK Nuclear Regulatory Arrangements

With the drive to construct a large programme of civil reactors in the early 1960s it became clear that there needed to be a set of regulatory arrangements vested within a civil authority charged with ensuring the safety of this unique technology. Following deliberations this led to an act of parliament The Nuclear Installations Act 1959 which was redraft-

ed as The Nuclear Installations Act 1965 as Amended (9) to take account of international arrangements and which is still in force today, although some changes have taken place since, notably in 1969. The Act established the Nuclear Installations Inspectorate (NII) as a specialist body to enforce matters related to nuclear safety on civil nuclear sites in the UK. This body, although effectively a standalone organisation, was integrated into the Health and Safety Executive (HSE) formed following the Health and Safety Commission of 1974.

The creation of the HSE formed part of a wider philosophy to health and safety at work that emerged in the UK in the early 1970s as a result of world-leading ideas and initiatives. Central to the new thinking were the ideas of Alfred Robens in his capacity as chairman of the Committee on Health and Safety at Work established in 1970 at the initiative of Barbara Castle the Labour Government's Secretary of State for Employment and Productivity (10). Central to Robens' thinking was a desire to make use of the fact that those who know most about industrial safety on a given site are usually those operating that site. As such he sought to avoid prescriptive and generic national checklists issued by a central safety regulator, but rather make it the law that owners and operators of facilities should be able to justify their safe compliance with requirements specified by the regulator. The requirement would be to meet a required level of safety, and usually not a specific intervention. Operators have a level of discretion in choosing how to demonstrate the required level of safety.

Resulting from the modernisation of British arrangements all aspects of health and safety on a nuclear site in the UK were regulated by the NII which established a Nuclear Site Licence granted to a body corporate in order for them to own and operate a nuclear facility (a Power Station or other facility such as irradiated fuel reprocessing or fuel manufacture) (11).

Subsequently in 2008 a review of the nuclear regulatory arrangements commenced in preparation for potential new nuclear builds. It recommended that the structure of the NII change and that it be returned to being a standalone organisation rather than being under the umbrella of the HSE. At that time it was renamed the Office of Nuclear Regulation (<http://www.onr.org.uk/>) and it assumed responsibility for all as-

pects of nuclear safety and security, some aspects of which had previously been outside of the NII. Notwithstanding these structural changes to the basis of regulation, the Nuclear Site Licence, although slightly modified, remains essentially the same.

The Nuclear Site Licence has 36 licence conditions (originally 35 but the last one was added in the 1990's to cover the "control of organisational change" when it became apparent that this aspect if not appropriately managed could have significant impact on nuclear safety). The 36 conditions cover all aspects of activities on a nuclear site which could impact nuclear safety. It also links closely with related aspects of the Radioactive Substances Act 1933 and the Ionising Radiations Regulations (IRR's) 1999 and has strong connection to the Environment Agency and their regulation of radioactivity released to the environment. Importantly this document, and the way it is enacted and enforced, is closely allied to all other safety regulatory arrangements in the UK in that it is permissive and not prescriptive. It requires Licensees to produce "Adequate Arrangements" to cover the detail of their activity and to be wholly responsible for them. Once adequate arrangements are produced these are approved by the ONR who then assess compliance with those arrangements in the regulation process and where appropriate give specific "permissions" for actions to take place (e.g. a consent/approval to re-start a reactor following a shutdown). This approach is very different from most other regulatory regimes where the regulators produce mandatory guidance documents (e.g. the Nuclear Regulatory Guides, or "NUREGs", issued by the Nuclear Regulatory Commission in the USA) with which a nuclear facility and its operators must comply. The US documents are a prescription of what, and how, activities must be conducted.

The implications of this for a nuclear facility owner/operator in the UK is that they need to have "in house" staff with the necessary skills and experience (Suitably Qualified and Experienced – abbreviated to SQEP) who are initially able to draft the "Adequate Arrangements" and the associated operating and maintenance instructions and supporting systems and to ensure that they are worked to. To do this they must clearly understand the nature of the plant its risks and associated hazards under all normal, abnormal and emergency conditions. They must also

understand the original design intent of the plant as a base line for any future changes; this role has evolved to be the “Design Authority”. Similarly they need to retain in house the ability to be an “Intelligent Customer” such that they can clearly specify for contractual purposes the plant or services they need, or any changes to it recognising the impact this may have on the overall risks and consequent hazards (or changes to them). The focus is on the Nuclear Site Licence holder who is totally responsible for nuclear safety, but this way of working also has major implications for those in the supply chain, who need to have clarity of understanding in the way the Licence works. As there are no clear mandatory regulations to follow, they need to be sufficiently SQEP to fully understand the impact on nuclear safety of any work they may be engaged to carry out. In this context having the right nuclear safety culture in the organisation is vital for success. Hence all people working on a UK nuclear site need to have a clear understanding of the impact of what they are tasked to do concerning nuclear safety. This understanding, usually necessary down to first line supervisor level, means that staff are conditioned to follow procedures and stop and ask for clarification if processes and procedures do not seem to meet the standards required. This way of working is generally termed “conservative decision making”.

Breeches of the conservative decision approach have in the past led to the regulators taking legal action against the Licensee. A very good example is the so called Parasol Grab event which happened at Wylfa power station in July 1993 (12). Whilst operating at normal conditions and undertaking refuelling (a standard procedure) on 31 July 1993 at around 21:00hrs, and using the standard refuelling equipment, the operator noticed that a grab (known as a parasol grab due to its shape and configuration) was missing from the hoist part of the refuelling machine (a large shielded “crane”) used to remove spent fuel and replace new fuel in the reactors fuel channels. There was no indication where the grab had gone and there were no alarms, so the reactor was held at power - generating electricity until about 04:00 the next morning. In practice the grab and its counterweight had become detached and had slid down a connecting chute (part of the refuelling equipment) into the top of one of the reactors 6150 fuelling channels blocking the gas flow in that

channel.

As a result of the blocked channel, cooling gas flow was compromised and fuel was damaged; although at the time no high temperatures or indication of contamination in the gas system were detected. However given the potential seriousness of a lost refuelling grab the conservative decision should have been to enter a controlled shut-down immediately, not several hours later with the final decision being affected by the loss of revenue from generation. This experience resulted in the regulator (NII at the time) seriously questioning the nuclear safety culture on the plant and to take legal action under the licence. The case was heard in Mold Crown Court in Cheshire and resulted in a fine for the then plant owner /operator Nuclear Electric of £250,000 with £138,000 costs.

It is important to emphasize that the regulator brought this case not on the basis of a failed weld (subsequently determined to be the cause of the dropped grab) but rather on the issue of concern about the safety culture exhibited by the actions of the staff following the dropping of the grab. In this context it is important to appreciate that the Office for Nuclear Regulation is concerned with issues of nuclear safety and security. It is not tasked with preventing crime and corruption within the nuclear sector except in so far as such issues might affect safety or security.⁵⁷

Readers interested in learning more about the UK Licence and, in particular the relationship to International Atomic Energy Agency fundamental safety principles are recommend to consult a recent paper by Buttery and Vaughan (13).

57 There is perhaps an interesting parallel to be drawn with the Food Standards Agency. In 2013 there was a national scandal in the UK when it became apparent that horsemeat was illegally being passed off as beef in food products. This was a crime, but it had no implications for human health. Initially FSA representatives went on TV saying effectively “don’t worry – there is no problem for human health”. It was only some time later, and presumably following advice, the FSA realised that they were in fact the body formally responsible for preventing food crime. They were not just a safety regulator, but it appears that fraud prevention was a responsibility that they did not immediately know that they had. Despite this comment, to our understanding the ONR has no role in preventing economic crime. We expect that such matters would fall to the police and specialist crime agencies.

6. The UK Liability Regime

An important issue relating on the one hand concerns of nuclear safety to, on the other, the power of national governments is the issue of nuclear liability insurance. Insurance of nuclear sites in Organisation for Economic Co-operation and Development (OECD) countries tends to be divided into two main types of loss. The first, known as material damage insurance, is of greatest day-to-day significance to nuclear power plant operators while the second is third party liability insurance.

Material damage insurance protects the operator from losses arising from any incident on-site (perhaps even as small-scale as an employee falling of a ladder), through losses relating to damage to the plant itself, and in addition possibly including protection against risks arising from the operator's contract position in the market. In the event that a plant becomes unavailable it is likely that it will be subject to ongoing base-load contracts to supply electricity. In the event that the plant is no longer available the contract must still be honoured and substantial losses can be incurred needing to buy power in the open market in order to meet previously agreed base-load commitments to sell power (7). Material damage insurance can include protection against such risks. Such nuclear material damage insurance is an important business for both plant operators and specialist insurers, but fundamentally it is a private matter between companies.

The second major aspect of nuclear insurance is third party liability insurance and it is here that governments have a stronger role. This insurance importantly includes the risk of a severe nuclear accident with off-site consequences. In this case losses can arise in both the country in which the plant is located and, depending on geography, neighbouring countries.

The United Kingdom manages nuclear liabilities according to a set of core principles:

- A liability regime of “strict liability”;
- Operator Subject to a Limit of Liability; and
- Subject to the 1960 Paris Convention and 1963 Brussels Supplementary Convention which is legislated in the Nuclear Installa-

tions Act 1965 (9).

At the heart of third-party liability regimes is the notion of strict liability (i.e. the victim does not need to prove fault or negligence against the operator) and exclusive liability (i.e. all claims are legally channelled to the operator). The channelling principle means that the operator is responsible for all third-party losses arising from nuclear activities on their licensed site, even if the fault is traced to an external supplier. An example might be a severe nuclear accident in which a significant failure related to coolant pumping. Imagine if the pump failure was later found to be an error in design by the pump manufacturer. In that scenario the nuclear power plant operator cannot shield themselves from formal liability by pointing to the failure of a component supplier. The operator is responsible for, and hence incentivised to ensure, good quality component supply.

Strict liability is a cost burden placed upon nuclear power plant operators beyond the burden placed on other industrial systems operators including those in the energy sector. There is sometimes said to be a quid-pro-quo in that the nuclear industry receives a special benefit to offset its greater obligations. That benefit is that the operator is shielded from large-scale risk by a limit to its third party liability. Presently the United Kingdom is undergoing the process to ratify the 2004 Revised Paris Convention⁽¹⁴⁾ by amending the Nuclear Installations Act 1965 through secondary legislation made under section 76 of the Energy Act 2004⁽¹⁵⁾. Notably, this would raise the liability cap in the UK from £140 million to £1.2 billion. It would also affect the heads of damage (i.e. the definitions of loss, such as personal injury, loss of property, business continuity, etc.) that may be compensated, and may affect the priority and mechanism in which different heads of damage are subsequently handled. Third party losses above the threshold are not covered by the industry or their private insurers, but rather are covered directly by government. Some have argued that this represents a substantial public subsidy on nuclear power compared to other energy sources⁽¹⁶⁾. Some countries (e.g. India) do not yet have strict liability and some channelling may be possible to suppliers following a nuclear accident. Such provisions can represent major obstacles to international involve-

ment in nuclear projects especially in respect of the sale of components. Component manufacturers need assurance that third-party nuclear liabilities are subsumed by the operator via the provisions of exclusive liability. Otherwise, it may be impossible for these companies to obtain the necessary risk protection to enable a sale to take place.

Since the March 2011 incident at the Fukushima-Daiichi plant in Japan the European Union has been concerned with inconsistencies relating to third-party liability nuclear insurance between member states. Most notably the issues surround claims management (especially in instances where claims are trans-boundary); EU member states that are not members of any third-party nuclear liability conventions (as of 2014, there are 5); and the variation in the amount of financial security required across all member states that are party to the Paris or the alternative Vienna Convention, ranging from €5.6 million for Italy to €2.5 billion for Germany. It is also expected that member states who are party to the Paris Convention will ratify and enforce the Revised Paris Convention, although the original deadline (as mentioned in council decision 2004/294/EC) (17) has now lapsed.

The 2014 EU policy process has not sought to converge the whole of the EU to a single protocol (though this has been considered), rather the intention has been to achieve greater levels of harmonisation between member states on issues such as limits of liability and heads of damage. Internationally, one convention that aims at being a global nuclear liability regime is the 1997 Convention of Supplementary Compensation for Nuclear Damage (CSC) which is yet to be brought into force, although it has been signed by 18 countries including the USA and India. The CSC is a free standing instrument that aims to overarch the Paris Convention and the Vienna Convention. However, the provision in the CSC for legal channelling is at odds with for example India's Act on nuclear liability and there remains much debate as to the pros and cons of the CSC (18) (19). Overall, it is evident that civil nuclear liability regarding third party liability insurance at international and national levels remains a work-in-progress.

7. UK Regulators

The UK separates safety and security regulation (held within ONR) and energy market economic regulation held within the Office for Gas and Electricity Markets (OfGEM).

OfGEM's role is to monitor the trading markets for electricity and gas and to propose reforms where there is evidence that they are not functioning correctly. It ensures competition operates properly in electricity generation and supply and it regulates prices in the natural monopoly services of electricity transmission and distribution. OfGEM does not involve itself significantly in the organisation of manufacturing industry even in those cases where such capabilities affect national energy capacity. If such concerns feature anywhere in England it would be within central government in the Department of Energy and Climate Change (DECC) in coordination with the Department for Business, Innovation and Skills (BIS). DECC has, for instance, sponsored Technology and Innovation Needs Assessments (TINA) studies including of nuclear power but these do not look at the level of procurement and contractual procedures (20). TINA studies are more concerned for national capacity for maintaining critical infrastructures. TINA offers advice to government it does not necessarily reflect the opinion of government hence as such it has limited influence. We note that there is no single expert body outside government itself tasked with ensuring that critical national energy infrastructure projects are delivered efficiently and professionally. Here we mean to a quality that transcends merely safety, security an environmental protection. The need for such oversight is motivated by the fact that energy infrastructure projects (i.e. power station construction or Grid enhancements) are large complex projects which transcend electoral periods of office for members of the UK Government and hence also often the tenure of Members of Parliament.

We suggest that any attempt to seek to separate political risk (managed by government), economic risk (handled via the market) and engineering risk (responsibility of the constructor) is likely to fail as there are too many potential points of contact between these various risks. Hence we need a body that sits above all such concerns. We are not alone in thinking this way; such concerns have been whispered for sev-

eral years.

Earlier this year the Guardian Newspaper hosted a UK wide event known as the *Guardian Big Energy Debate*. Bristol was selected as the centre for the South West of England part of this event. The debate touched upon similar concerns to those discussed above and noted that such issues were a significant “detractor” from achieving a sound footing for long term energy projects. As a result the meeting advocated that an independent cross party infrastructure commission be established, that this should be technically led and charged with taking major energy infrastructure development decisions ensuring that these were out with the influence of party political activity (21).

8. Engineering Codes and Standards

The nuclear reactor business in the UK, which was once world leading (in the 1950/60s), focussed on the use British Standards as the basis of the design and for installation. However the reactor supply business is now global with reactors potentially being built in the UK with their design origins in France, the USA and Japan.

Typically the UK is familiar with the ASME/ANSI codes as these were used for the Sizewell B reactor, or more specifically the standard nuclear unit power plant system (SNUPPS) comprising the reactor and its supporting primary circuit. However the secondary systems were built to British Standards, hence the key issue was one of ensuring that interfaces between plant systems were correctly configured. This situation must no doubt be repeated when Japanese originated plants are built in the UK.

In recent years there has been growing interest in harmonising or even standardising engineering codes internationally. This comes perhaps as a consequence of first: the prospect of Nuclear Renaissance and second: a sense that new build projects would be more international than was seen in the early nuclear power programmes of the 1970s and 1980s. The range of engineering codes (US, French, Japanese, Russian and others) can be bewildering and risks adding cost and perhaps even undermining safety. The US (ASME) and The French (AFCEN) have both

been keen to explore prospects for greater simplification, albeit unsurprisingly with a preference for their codes to be the reference starting point. These issues matter acutely for the UK poised to construct French (EPR), Japanese (ABWR) and perhaps American (AP1000) nuclear power plant designs in the coming years. The question remains: what role, if any, will there be for UK engineering codes and standards?

The UK trade body for the nuclear sector is the Nuclear Industry Association (NIA). It celebrates the fact that it has more than 260 member companies spread across the supply chains of nuclear new build and decommissioning. The NIA has produced an import guide for companies entering the UK nuclear supply chain (22). We would recommend it to those seeking a second complementary perspective on some of the issues discussed in this paper. The NIA report for instance, says more about the role of engineering codes and standards than we have space to do here.

9. UK Case Studies – Learning From Experience

Although there appear to have been no examples of wilful self-serving fraud in the UK nuclear industry, there are examples of “innocent errors” at a working level due to working level staff being inadequately briefed by first line supervisors who themselves did not fully appreciate the implications of their activity on nuclear safety and the nuclear site licence.

We provide two illustrative fictional stories loosely based on real events. They are intended to capture the key learning elements that apply to companies contracting to work on a UK nuclear licenced site.

One can envisage a situation where a competent electrical contractor was contracted to upgrade the lighting systems in a new fuel store at a nuclear power station. Such facilities are covered by the licence and criticality certificates (which form part of the licence). Let us assume the work to be correctly specified and that the work area has proper barriers. Let us further assume that the new fittings can be delivered on pallets to an outside area adjacent to the external store door (usually roller shutter type). This allows for unwrapping of the electrical items before transfer-

ring them to the facility itself. The reasoning behind this would be to prevent wrapping material being taken into the defined reactor zone and hence having to be treated as active waste. However as the work commences let us posit that a major thunderstorm occurs having the potential to seriously wet the electrical equipment (not a desirable position). One can imagine the electrician taking the initiative to protect the equipment and moving it rapidly into the fuel store simply to keep it dry. He keeps the wrappers on while he does this to help keep the items dry. However the wrapping would most likely be polythene a hydrogenous material which is banned from fuel stores under the criticality certificate (as it is a potential moderator).

Hence an action taken with good intent would immediately breach the licence. There is no doubt that any subsequent investigation would clearly indicate that with the amount of moderator material involved there would be no real nuclear issue. However it highlights how a contractor electrician and his supervisor could adversely impact the site licence as a result of not clearly understanding the potential implication of their work on nuclear safety. Although in this envisaged situation the electrician could be praised for taking an initiative that in any other non-nuclear facility would have been the right thing to do, in this case it would highlight the need for enhancing the training for all future contractors.

In a similar way one can envisage a second separate fictitious scenario in which a Mechanical Craftsman (a contractor) is asked to service a sump-pump in the turbine hall (non-reactor area) of a nuclear power station. Finding the sump level controller faulty he replaces it with an equivalent (better) unit and successfully re-commissions the pump. This, as in the example above, might be an action which on a non-nuclear site would be praiseworthy. However on a UK nuclear site, replacing a unit with a non-identical spare becomes an unauthorised plant modification and breaches licence condition 22 (11). In this case the position could be even more confusing since the plant item is outside of the reactor area; however sump pumps are “claimed” as part of the flooding defence systems within the nuclear safety case.

These illustrative fictional examples demonstrate how contractors at working level UK environment need to have a good understanding of

the nuclear licence and its implications. They further illustrate the importance of incorporating such matters into the training programmes. Contracting organisations that do this tend to be favoured over those which do not. This commercial preference helps drive the UK safety culture forward.

The Wylfa parasol grab event discussed earlier also illustrates a situation where regulatory legal action was taken. The legal action was not in response to any mechanical failure or failure to follow instructions but rather simply because of a lack of nuclear safety culture. The issue of nuclear safety culture remains a major feature of any work both by owner operators (as was the case at Wylfa) and also by contractors. Hence this aspect features highly in any training for work on a UK nuclear site and is a feature of any contractual arrangements. Specifically a contractor who can demonstrate an understanding of, and evidence of, practice in nuclear safety culture will have an advantage in tendering situations.

A further example of the impact of the Nuclear Site Licence on new builds can be taken from the Sizewell B build in the early 1990s (23). This plant was built to time and cost. Its cost was £1.9bn, when envisaged as part of a larger fleet, but when the rest of the planned fleet was cancelled a First Of A Kind (FOAK) cost of £390,000 was “back fitted”, making it appear to be overspent. The design was a Standard Nuclear Unit Power Plant System (SNUPPS) and a copy of the successful US plants at Callaway (Missouri) and Wolf Creek (Kansas), hence a proven design. However evaluation under the UK Nuclear Licence system led to changes (in some cases related to the siting position) such as the addition of an ultimate reserve heat sink; an emergency boronation system to ensure shutdown under certain emergency conditions and a hardwired (rather than software-based) nuclear safety protection system.

We now turn to another informative story from the British nuclear experience. In early 2000 a story emerged that revealed significant weaknesses in the UK nuclear safety culture at that time. The incident known as the Sellafield MOX Data Falsification arose within an international business operated by British Nuclear Fuels (BNFL). BNFL was a UK state owned enterprise responsible for fuel cycle research and policy implementation. It operated the large Sellafield site in Cumbria in the

north-west of England, home to the Thermal Oxide Reprocessing Plant (THORP). Today, in 2014, BNFL no longer exists. It was broken up by the Labour Governments of Tony Blair and its former functions are now handled by the Nuclear Decommissioning Authority (NDA) and the National Nuclear Laboratory (NNL) while site operations are handled by private site management companies such as Sellafield Limited. The NDA acts as a policy interface to government and the sites themselves are managed on a Government Owned-Contractor Operated (GOCO) model. However, back in the 1990s, at the time of the Sellafield MOX Data Falsification, the situation laid within the domain of BNFL a classic state-owned enterprise (SOE).

The decision of the UK to embark on the reprocessing of thermal oxide fuels (coming from AGR and pressurised water reactors (PWR)) has its origins in the 1970s. Even at that time it was clear that the economics of such a project would raise special issues. The solution to perceived economic difficulties lay in scale. The proposed plant needed to be large, so large that its capabilities would almost certainly exceed UK needs, at least initially. The need for scale drove the UK into international reprocessing services, notably for Germany and Japan from which the country (noting BNFL was an SOE) earned substantial fees. Rather than returning separated plutonium dioxide to Japan, via maritime shipments that raised security and non-proliferation concerns in the United States, the policy adopted was to return useful fissile material to countries of origin in the form of uranium-plutonium mixed oxide (MOX) fuel.

While the UK has researched and developed MOX fuels since the late 1960s the British experience has faced many set-backs and obstacles including the story told here. A later difficult story concerns the building, problematic operation and eventual closure of the Sellafield MOX Plant (SMP). That story comes later than the data falsification problems and as such we shall not dwell on it in this paper. The MOX fuels at the heart of the data falsification events were manufactured at the older, and smaller, MOX Demonstration Facility (MDF) started in 1991 and commissioned in 1993 (24).

The supply of MOX fuel pellets to Japan was governed by a contract that included a clause inserted at the insistence of the Japanese customers. While all pellets would be tested by an automatic laser interferome-

ter, 5% of the pellets that passed this automated test (and a visual inspection of all pellets) would also be subject to manual checking and data recording (24). The Parliamentary Office of Science and Technology (POST) has provided an excellent over-view of the events providing more context and detail than we have space to record here. The POST report stresses that on 21 July 1999 a shipment of MOX fuel was despatched to Japan under the special quasi-military arrangements adopted to assuage global, especially American, concerns with international plutonium trade. One month later, on 20 August, a member of the MDF's quality control staff noticed that measurement records from the final manual measurements looked suspiciously similar between batches. A few days later a worker admitted that the measurement data had been falsified (copied from an earlier batch). A second worker admitted he had been aware of the wrong-doing. In September 1999 the UK Nuclear Installations Inspectorate (then the safety regulator) wrote to the Japanese Embassy advising them of a problem. Meanwhile BNFL had shut-down the MDF pending NII advice. In early 2000 the story broke in the public domain and soon after BNFL Chief Executive, John Taylor, resigned from the company. Five lower level workers were dismissed from their posts.

The MOX Data Falsification Incident involves a set of considerations:

- A task (final manual measurement) widely perceived to be unnecessary by BNFL and its staff, but insisted on by a third-party customer far away.
- The manual measurement task was tedious and boring.
- Workers were subject to insufficient oversight – quality control officials saw the problem too late.
- The incident damaged UK international relations with a key friend and ally, Japan.
- The incident had severe economic consequences, for the company, the country and caused the Chief Executive of the state-owned enterprise to resign.

More positively two things can be observed:

- Once the problem has been spotted by MDF quality control in August 1999, the matter was investigated transparently and conscientiously. International partners were fully informed within one month of first awareness.
- There was, and is, no suggestion that any workers had received financial or other gains as a result of their behaviour. Rather the core issue appears to have been a lack of a conscientious safety culture on the part of workers who did not respect the task given to them. Difficulties were compounded by staff reductions and a lack of staff training.

Importantly the official investigation into the incident concluded that while the fuel that was improperly approved was in fact safe, the failure of the agreed systems illustrated a major failure of the institutional safety culture (25). In addition to being a formal breach of the terms of the commercial contract with the Japanese customer it was also a breach of the Licence of the MDF site.

The MOX Data Falsification had several long-term consequences for BNFL and the UK. It badly affected plans that existed at the time for the privatisation of BNFL. It caused great damage to the UK-Japan relationship and it had significant economic consequences as it involved the temporary closure of the MDF and the return to the UK of MOX fuel that had already arrived in Japan. The Japanese insisted that the job be done right. In conclusion small things can matter enormously to both reputation and safety-culture even if in fact there is no direct safety issue at a narrow technical level. The UK learned this lesson clearly in 2000 as the extent of the data falsification story became clear. Our fictional, but realistic, examples are intended to reinforce this point.

Finally in this section we would like briefly to comment on the boom and bust of British energy from 1996 to 2002. The story of how, in the early years, the privatised nuclear energy company was the darling of the stock-market and following a change of market circumstances (and some unwise strategic decisions by management) the company ended up close to bankruptcy has been ably told by Simon Taylor (2). In this sec-

tion we emphasise the reasons why the UK government did not simply allow the company to pass into administration and to be managed by a major accountancy company for a bankruptcy or a rescue process. Rather the government recapitalised the company effectively bailing it out and maintain management continuity and responsibility. This approach required the UK government to seek, and win, state aid approval from the European Commission in Brussels. In September 2002 The Guardian newspaper reported on the story with the words (26):

‘The government said it was in emergency talks with the company with “paramount objectives ... to ensure the safe operation of BE’s nuclear stations and security of supply.”’

Later the same report notes:

‘A Department of Trade and Industry spokeswoman [...] said: “British Energy asked us for help. We have started discussions with them to secure the government’s priority to safety and security of supply. There are not going to be any blank cheques. There is a possibility of restructuring within the private sector. It is very early to say.”’

Safety was the clear reason, or excuse, invoked by government to justify a state intervention. That nuclear-related intervention was the first step in government’s retreat from complete market liberalisation. Within the domain of nuclear power it is interesting to ask whether nuclear power is indeed special for safety reasons or whether Government’s invocation of safety was merely an excuse. After all other critical infrastructures (such as the East Coast main railway line) were taken into state control after a failed privatisation (1). It is perhaps merely the rhetoric of safety as a reason that is special in the case of nuclear energy.

The final case study we would like to mention relates to the construction of Sizewell B in the 1990s. We tell this story because it reflects the UK experience of large CEGB (i.e. state owned enterprise) initiated projects. The story illustrates well the concerns of those making decisions regarding the supply of major components and systems.

Sizewell B was a project conceived and initiated by the CEGB in the dying days of state-owned enterprises in UK electricity industry. We suggest it followed the norms of the CEGB era despite extending beyond it. The project had some important and interesting points of principle: first that the UK should not introduce a new reactor and a new turbine at the same time and second that no first of a kind major systems or components should be used in the project. The first idea was probably motivated by the bad experiences encountered in the introduction by the CEGB of 500MW turbines in the 1960s. These represented a doubling in scale of the established turbines and the change gave rise to a lot of problems. As a result the CEGB established the Marchwood Engineering Lab which had a large turbo-machinery aerodynamics section. At the time there were a number of UK turbine manufacturers, but the problem was that they relied mainly on learning from experience and so if the CEGB ordered the first of a new machine it was, in effect, getting a prototype because the manufacturer could not afford to build a prototype of their own. The CEGB, as a state-owned enterprise usually found itself in the position that it would be expected to build the first of a kind to help iron out any problems which would also help British companies export. The net result of the research and development collaboration was the development of the 660 MW turbine sets which had become the standard for CEGB power stations (both the AGRs and fossil-fuelled stations). Given that the Government was requiring a high UK content, UK manufacturers were given preference. In addition there were other operational arguments for favouring two turbines. The first and probably the most important was associated with strategic spares holdings. The steam conditions at the front end of the Sizewell turbine are quite different from those at the other stations so the high pressure and moisture separator/reheater stages had to be redesigned, but the steam conditions going into the low pressure stages were more or less identical to the other 660s, so the majority of the large rotors are the same. If need be the operator (especially if as large and wide-ranging as the CEGB was) could exchange rotors amongst the different plants (including even mothballed oil-fired power stations). The other argument which is rather dependent on turbine reliability is that with two turbines the power plant load factor should be higher, since on a spurious turbine trip you only

lose half the output. In early operation this was probably true since there were a number of teething troubles on the turbines and the plant suffered a number of turbine trips. Today it is highly reliable. Issues of single turbine failure also apply to the stability of the transmission grid. With two turbines the negative impact of a single turbine failure on the transmission grid would be less severe. In the late 1980s the transmission grid part of the CEBG was nervous of system oscillations that might be triggered by a large generator failure. Having two turbines at Sizewell B militated against that risk.

As regards the second principle: there was an intention to have no new technology and even the new smaller items were required to have an established pedigree at least at the component level if they were to be used. That was the strategy which was implemented in the procurement plan, but it proved impossible to hold to the plan. The protection and control system is a case in point. Westinghouse offered the Integrated Protection System (IPS), which integrated protection and control. Such approach was forbidden under CEBG rules (and we would suggest is now widely recognised as being contrary to the principles of independence of defence in depth). Thus the Sizewell project went for a Primary Protection System (PPS) which was the protection system from the IPS. To get the control system a choice was made to use the control portion of another integrated system: the one being used on the French N4 plants being developed by CEGELEC. At the time of ordering, Sizewell would have been the second application of each of these so it complied with the no first of a kind technology aim. However the first application of the PPS was to be as part of the IPS for the Italian plants, which were all cancelled following Chernobyl. This made the PPS a first of a kind which made licensing more difficult and forced a break with the hoped-for project philosophy, but was not an insuperable problem. The control system was more of a problem.

Control room design in the past has always had a large customer input and is the responsibility of the Architect Engineer (CEBG PPG in Sizewell's case) rather than the nuclear steam supply system or turbine vendor. The N4 control room was seen as being very innovative and was designed around a particular approach to operating procedures. The CEBG did not want to go down that route and was against the use of

“soft” controls, so the Sizewell B control room design was based on UK operating philosophy and was subject to extensive ergonomic review including the construction of a full sized mock up. The CEGELEC control system could be interfaced with this more conventional control room approach as well as to the more innovative N4 control room. The problem was that CEGELEC ran into difficulties in delivering the N4 computerised protection and control system and eventually EDF decided they were not going to achieve what was required on a reasonable time-scale and so cancelled the order. This led to a two year delay in Chooz B. CEGELEC argued that they could still deliver the control portion for CEGB on the required timescales, but the Sizewell team had concerns and chose to look elsewhere. Following the N4 route (developing a new system) would have introduced unacceptable delays. Westinghouse came forward offering their control system, which was the control part of IPS but as a non-integrated separate system. The system would again be a first of a kind (because of Italian policy developments) but the Westinghouse idea had some pedigree. Westinghouse was able to implement the system to interface with the existing control room design and although time pressures were acute the changeover was achieved without delaying the construction and at a cost that was still within the overall project budget.

10. The European Dimension

We now consider nuclear power plant contracts within the UK as part of the European Union. Contracting for new power station build works in the nuclear sector is a function of the structure and organisation of the builder (who may or may not be the owner and ultimate operator). There are a number of commercial models which can be used, such as the owner/operator acting directly as Architect /Engineer and letting contracts for aspects of the build and undertaking the coordination directly. This is the general approach used by EdF at Hinkley Point C where the plant configuration is broken down into many contract areas and individual contracts let to cover each area either singly or in groups. This model requires the owner/operator to coordinate all of the packages of work.

An alternative approach is for the owner/operator to let an EPC (Engineer, Procure, and Construct) contract with a large recognised contractor skilled in delivering large nuclear projects. The EPC contractor then issues all of the plant area contracts and ensures their coordination.

A “half way house” arrangement is also possible where the owner/operator lets an EPC contract for significant aspects of the work but then manages other aspects of the work directly.

Currently in the UK only the plant at Hinkley has progressed sufficiently for these types of decisions to be taken. The other prospective builders have yet to declare their contract strategies. As the UK is a member state of the EU, the UK contracting environment is governed by EU regulations established to ensure that bidding for work is conducted in a transparent way and provides opportunities for companies to compete on an equal footing from across the European Economic Area. These regulations are extensive and are best appreciated from the European commission’s document PRAG “Procurement And Grants for European Union external actions – a Practical Guide” – 07/04/2014. This document outlines the steps necessary for procurement of goods and services within the European Union. It defines the processes governing at what financial level Contracts (tenders) should be invited internationally (>300,000 Euro), or locally (>100,000 Euro and <300,000 Euro), and where competitive negotiation is appropriate (>20,000 <100,000Euro). It also explains when a single tender approach may be acceptable. The document also prescribes timelines for announcing the tender intent, through issuing the tender documents, the contract tender period, the tender evaluation period and the contract award. From the level of estimated contract values quoted it is clear that virtually all nuclear power plant contracts fall within the scope of these regulations.

In addition to the above regulations in the UK the Office of Government Commerce (OGC) around 2006 and following an EU Public Sector Procurement Directive in 2004 introduced the concept of “Competitive Dialogue” - a procurement policy for use in tender situations where the tasks were large and complex. Practical guidance on this approach was issued in Information Note 04/06 31 July, 2006 “Practical Guidance on the use of Competitive Dialogue”. The approach was adopted extensively by the UK’s Nuclear Decommissioning Authority (NDA) for all

of its major tenders for the management of the decommissioning of nuclear facilities throughout the UK. The process provides for the contracting organisation to enter into open dialogue with all potential bidders to ensure that subsequent tenders are all on the same basis. Again it ensures transparency. The document also provides a timeline for the process and how it complies with overall EU procurement regulations. This method of procurement is now established in appropriate sections of the UK's nuclear sector.

The above paragraphs refer to the “legal and commercial” aspects of tendering for work in the UK's nuclear sector however there are some practical matters which stand out as success criteria in acquiring contracts in the UK nuclear sector:

- I. Because nuclear construction projects are large undertakings they significantly impact local communities, therefore some of the larger contracts have requirements for engagement with the local communities and investing in local projects such as improving amenities at say schools and colleges.
- II. In common with most other countries there was a slowdown in nuclear construction over the period from say 1990 to 2005 hence recruitment was limited resulting in a skills shortage today. As a consequence companies demonstrably supporting training either directly or via local colleges tend to be successful in gaining nuclear contracts. A good example here is the dramatic growth of Bridgwater College (Local to the new build at Hinkley Point in Somerset) which has been funded to set up training facilities in support of the construction activities.
- III. Contractors who can demonstrate a high nuclear safety culture, preferably with some specific nuclear site experience tend to be more successful than others.

11. Bribery and Whistle Blowing

Although not developed with the nuclear industry in mind, there are two pieces of UK Legislation that relate strongly to professional integri-

ty and which are worth mentioning here. The first is the Bribery Act 2010 (27). This bold piece of legislation repealed all previous statutes relating to bribery and has domain over the following crimes:

- Paying bribes
- Being bribed
- Bribery of foreign public officials
- Failure of a commercial organisation to prevent bribery on its behalf.

For the UK nuclear industry the greatest concern would appear to relate to the third and fourth listed items and the activities of a firm engaged in UK nuclear work but also operating in overseas territories. The final provision motivates strong anti-bribery measures within the firm. Sanctions for infractions can be severe including up to 10 years in gaol and unlimited fines. The legislation includes important incentives for companies to disclose their own wrong-doings. In many ways the UK Bribery Act of 2010 mirrors equivalent US provisions.

Another piece of general legislation driving good practice is the Public Interest Disclosure Act. 1998 (PIDA) (28). PIDA is sometimes known as the “Whistleblower’s Charter”. This protects employees from aggressive actions of employers if the employee makes disclosures in the public interest, subject to some restrictions. One restriction is that the employee must not benefit financially from the disclosure – that is: they cannot sell their story to the newspapers. Generally in this paper we argue that the public or private status of organisations is of little material difference concerning nuclear professionalism. As regards PIDA there is an interesting and important distinction which proved contentious as the original Bill was being planned and debated. The issue is the status of civil servants under the Act. Their free disclosure is not protected, as they remain bound by the Official Secrets Acts. The most that they can do is report any concerns to the Independent Civil Service Commissioners. Civil servants can never go public revealing state secrets, even in the public interest.

12. Nuclear Professionalism in the UK

In this paper we have sought to consider the role of state owned enterprises in civil nuclear power and issues of safety relating to operators and the supply chain. We have attempted to learn from interesting and difficult British experiences and fictional scenarios typical of the issues faced in Britain. We have also been asked to consider issues of financially motivated self-interested crime and corruption, but we are unable to point to any such examples. Why are we in such a position? Perhaps because such criminality exists, but has not been uncovered, but we suggest that is unlikely. In order to make that suggestion, i.e. that such crimes are not occurring, we point to a wider literature on professionalism and corruption.

Extensive literature on corruption exists and cross-country comparisons are frequently made. There are several well established indices of corruption including the International Country Risk Guide (ICRG), a measure widely used by economists. Other well established indices include: the German exporter Corruption Index (GCI), an index from Transparency International (TI), the Global Competitiveness Survey (GCS) and the World Competitiveness Report (WCR). In 2012 Transparency International ranked the UK 17th best of 176 countries in its Corruption Perception Index. The UK scored 77/100, the same score as Japan. The UK tends to perform similarly well across a range of ranking measures. Much effort has been devoted to understanding why this is the case. Ali and Isse summarised the factors in 2003 with the words (29):

“The empirical results are consistent with the theory that higher judicial efficiency, higher level of schooling, greater economic freedom, smaller government, less foreign aid and decentralized government will lower corruption. Ethnicity has no significant impact on corruption.”

Only a subset of academic research on corruption has dealt with the behaviour of state officials. We suggest that we have no strong sense of a difference in professionalism between those working on nuclear matters under state control and those operating in the private sector. Today

the vast majority of UK workers associated with nuclear new build work for private companies. Academic work on bureaucratic professionalism indicates that the UK is in a relatively strong position (at approximately the 15th percentile position on a ranked list of countries) (30).

We also note the experimental work of Barr and Serra who studied the attitudes of those living in the UK but originating overseas. They show a correlation of high tendencies to corruption with those arrived from territories ranked highly for corruption, but also show that such attitudes are socialised away over an extended period living (and in the case of the sample, studying) in the UK (31).

Finally we comment in relation to the UK power industry. As stated elsewhere in this paper, the electricity sector was originally nationalized operating as a state monopoly until 1991. The CEBG operated essentially all generation plant including both nuclear and fossil (predominantly coal) plants. In the early days there were examples of corruption in coal-fired plants and senior personnel had their contracts terminated. However recognizing the requirements necessary for nuclear plant management the CEBG carefully selected senior personnel using a competency-based model with the aim of ensuring that those engaged were of the highest integrity and recognized the uniqueness of the nuclear technology they were managing within the legal framework of the licence.

This approach was reinforced by the training arrangements, which majored on the importance of the individual in ensuring that the permissive nature of the licence was internalized by all senior personnel. All personnel knew that if they allowed transgressions, whether from corrupt practices or not, they were then themselves liable to face legal proceedings. Furthermore any such transgression would also significantly damage the nuclear industry, an industry which received much respect from those tasked with serving it.

We hope by these remarks to have evidenced our suggestion that the UK enjoys relatively high levels of professionalism and low levels of corruption and this is related to factors such as education, societal openness and flexibility and culture. We further suggest that the nuclear energy sector should have even higher-than-typical levels of professionalism. In large measure this can be expected to be a consequence of the nature of UK safety regulation and the nuclear licence regime in particular.

13. Closing Observations and Policy Recommendations

Each country around the world generating nuclear electricity has a different set of experiences and lessons learned. In this paper we have sought to explore some of the key learning points around UK nuclear safety. We were asked to give special consideration to the role of state-owned enterprises. In the UK, today, such enterprises have only a minor role in nuclear electricity generation. Prior to the privatisation of British Energy in 1996, however, it was a very different matter.

We are unable to point to an example where state or private ownership makes a material difference to nuclear safety and we are not aware of any significant difference in law relating to ownership in the civil energy sector.

We relate the story of the near-collapse of British Energy in 2002 because it is an example of direct state economic/ownership intervention justified by concerns for safety. As described earlier the government was not willing to see the company enter into administration and be operated by an accountancy firm as an administrator. Citing concerns for safety the government bailed-out the company, before later supporting its sale to the French national champion electricity company EdF.

In many ways all nuclear power producing countries face similar issues; as such it can be hard to identify uniquely British lessons. One important lesson, however, is that nuclear licensing (and national safety legislation more generally) operates permissively rather than prescriptively. As such operator actions are presumed to be permitted on the basis that the operator can justify to the regulator that the chosen actions are indeed safe and environmentally responsible. The goal of UK safety policy is to achieve safety levels As Low As is Reasonably Practicable (ALARP). This aligns with the concept of ALARA or As Low as Reasonably Achievable as used in most other countries around the world in relation to their nuclear sectors. The difference relates in part to the principles of the nuclear safety legislation described elsewhere in this paper. Specifically the use of the word “Achievable” implies ‘achieving a specific prescriptive level’ whereas “Practicable” means ‘able to be achieved in practice’ and hence the UK use of ALARP aligns better to the permissive nature of the UK regulations. For all practical purposes

there is no significant difference between ALARP and ALARA in terms of outcome. Typically examples of the application of these principles relate to exposure to radioactive dose when undertaking particular tasks where the aim would be to reduce dose uptake for the worker. Dose can be minimised by changing the working practices or by additional shielding or a combination. An ALARA or ALARP assessment of the task would address both considerations. The ALARA route would target a specific low dose level whereas the ALARP approach would require incremental dose reduction set against the costs/benefit balance. Hence if a significant dose reduction can be achieved for little additional expenditure then it can be justified. While we recognise that the British approach to safety is unusual when compared to internationally widespread practice, we believe it to be superior. While there would be clear benefits in more strongly harmonised arrangements internationally, e.g. within the European Union, it would be unfortunate if that forced the UK to retreat from arrangements that were developed so carefully and which have been found to work so well.

We endorse the emerging idea for a strong infrastructure oversight body, the remit of which should extend further than merely safety regulation, security procedures, environmental protection or crime prevention. The body should also be able to anticipate delays and other problems impacting on infrastructure development. One could argue that the Office for Nuclear Regulation already has many, but not all, of these powers for the civil nuclear power sector. In principle the powers proposed could be applied to critical national infrastructure generally.

We have heard the suggestion of a new standing parliamentary committee and if that is the path taken we would recommend it to be given investigative powers (e.g. power of subpoena). Locating the proposed body inside parliament could lock-it to government election periods which already have enormous power in setting the timescales of policy decisions – not always in helpful ways (e.g. the rushed privatisation of the CEGB in the late 1980s). More than most other infrastructure projects, major nuclear projects are sufficiently large that they involve successive governments and span election periods. Hence, nuclear energy policy risks becoming a political issue. It is interesting to note, however, the resilience in the UK parliament of cross-party support for new nu-

clear build, matching widespread public support (3).

In respect of building and enhancing nuclear professionalism there has been much activity in recent years. For example the National Skills Academy Nuclear (NSAN), an industry-funded body tasked with skills development and human resource awareness, has been instrumental in developing, with The Open University, the Certificate of Nuclear Professionalism. Meanwhile, more focussed on new entrants to the industry there has been the Nuclear Graduates Scheme. The various engineering professional bodies such as the Institution of Mechanical Engineers, the Institution of Engineering and Technology and the Nuclear Institute (among others) are all actively engaged in continuing professional development in the nuclear sector. Following British tradition these institutions are private legal entities independent of government. They have been granted special privileges (by Royal Charter) and they have charitable status.

In closing we would like to say that in our experience there has been little or no difficult history of workplace crime in the British nuclear industry. We are not aware of corruption or acts of bribery. This leads us to ask: what militates against workplace crime? We suggest it must be a strong professional culture, and strong enforcement, or perhaps both. We speculate that perhaps the nature of interpersonal relationships in the UK workforce and organisational design help? The UK nuclear workplace is serious but relatively informal with short power distances and little deference to hierarchy. Workers operate as responsible individuals and the UK safety culture encourages this including in its formal aspects (the licence). We note that the UK nuclear industry appears to lack the sense of the elite *corps* seen in some other nuclear countries. Perhaps this militates against hubris and reinforces professionalism mixed with humility. Lastly the fact we are not seeing crime means we must be vigilant in our continuous search for it, and we must never become complacent.

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