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Aller au sommaire du numéro

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Résumé de l'article

Dans les années 1980, la société canadienne de technologie nucléaire, Énergie atomique du Canada limitée (EACL), conçoit et tente de mettre en marché une nouvelle génération de réacteur nucléaire de petite dimension appelée Slowpoke Energy System (SES). EACL cherche des marchés où exporter le SES, et entrevoit des avenues prometteuses en Corée du Sud. Le projet SES doit toutefois compétitionner pour le financement, ce qui nécessite la formation de partenariats avec des agents des secteurs privés et publics de la Corée du Sud. L'expérience d'EACL en Corée du Sud suggère que les sociétés de la couronne sont plus orientées vers le commerce que ne l'admet généralement la recherche académique sur les politiques d'État, et que dans certains cas, les forces de la compétition contribuent davantage à émousser l'innovation plutôt qu'à la récompenser.

The Taegeukgi and the Maple Leaf: The Pursuit of South Korean Export Markets by Atomic Energy Canada Limited

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Abstract: In the 1980's Canada's nuclear technology company, Atomic Energy Canada Limited (AECL), designed and attempted to sell a next-generation, small-scale nuclear reactor called the Slowpoke Energy System (SES). AECL pursued export markets for the SES, of which the most promising was South Korea. The SES project was forced to compete for funding and this necessitated the formation of partnerships with private and public sector agents in South Korea. AECL's experience in South Korea suggests that crown corporations are more commercially oriented than established policy scholarship admits, and that in some cases competitive forces work to blunt innovation rather than reward it.

Résumé : Dans les années 1980, la société canadienne de technologie nucléaire, Énergie atomique du Canada limitée (EACL), conçoit et tente de mettre en marché une nouvelle génération de réacteur nucléaire de petite dimension appelée Slowpoke Energy System (SES). EACL cherche des marchés où exporter le SES, et entrevoit des avenues prometteuses en Corée du Sud. Le projet SES doit toutefois compétitionner pour le financement, ce qui nécessite la formation de partenariats avec des agents des secteurs privés et publics de la Corée du Sud. L'expérience d'EACL en Corée du Sud suggère que les sociétés de la couronne sont plus orientées vers le commerce que ne l'admet généralement la recherche académique sur les politiques d'État, et que dans certains cas, les forces de la compétition contribuent davantage à émousser l'innovation plutôt qu'à la récompenser.

Canada, in common with other jurisdictions, is undergoing a "nuclear renaissance." Rising concerns about environmental issues as well as the need for affordable energy have pushed policymakers in industrialized nations to reconsider the role of nuclear power. For the first time since the cautionary events surrounding Three Mile Island and Chernobyl, the commercial prospects for nuclear power are improving. Atomic Energy Canada Limited (AECL) is keen to find export markets for its CANDU

reactor and stands to benefit from this change in circumstances.[1] In addition, AECL is committed to the pursuit of next-generation nuclear designs, partly to increase efficiencies, but also to address design complications that have led to expensive re-tubing of its CANDU fleet.[2] A desire to increase the influence of the market on the industry accompanies Canada's nuclear renaissance, with calls for partnerships with the private sector and even privatization.[3]

AECL has attempted next-generation nuclear designs in the past. In the early 1980's the company attempted to market a next-generation, small-scale "inherently safe" nuclear reactor called the Slowpoke Energy System or SES. The SES was intended for both the domestic and international market, but the lack of sales prospects in Canada meant that the latter was the only feasible option. Export markets were pursued in Romania, the former Czech Republic, the United States, China, and Hungary, although the most promising market was South Korea, the focus of this paper.[4]

South Korea imported a significant amount of foreign oil, and this, combined with environmental concerns, led to a strong interest in nuclear power. In addition, South Korea had purchased a CANDU reactor (Wolsong I) in 1983 and thus had the requisite infrastructure and skill base to support further nuclear development.

This account of AECL's attempt to break into the South Korean market in the 1980's and 1990's serves as a cautionary tale for those who see the

1. AECL is also interested in the domestic market, but it remains the case that domestic sales are limited and international sales represent the largest market for its products. For more on the importance of export markets to AECL, see Duane Bratt, *The Politics of CANDU Exports* (Toronto: University of Toronto Press, 2006) and G. Bruce Doern, Robert W. Morrison and Arslan Dorman, *Canadian Nuclear Energy Policy: Changing Ideas, Institutions, and Interests* (Toronto: University of Toronto Press, 2001).

2. See "Pickering Reactor Back On-Line After Eight Years," *The Globe and Mail*, 28 September 2005, A.13.

3. Eric Reguly, "How Do You Price AECL If You Don't Know Its Value?" *The Globe and Mail*, 17 November 2006, B.1.

4. See for example, AECL archives, newc15-161\1420-3-5v2b, memo from Snell to A. R. Bancroft, Barclay, Campbell, McDougall and Ohta, 31 July 1991; AECL archives, newc15-161\1420-3-5v2b, memo from Snell to LES Team, 31 July 1991; AECL archives, c11-les4\hyundai2.max, memo from A.S. Bain to Bancroft, 12 October 1984; AECL archives, c11-les4\costs.max, meeting between AECL and Hyundai, 27 September 1984; AECL archives, C17-166\1420-10files\1420-10v8b, memo from Ian Glen to Lynch, 31 January 1989; AECL archives, C17-166\1420-10files\1420-10v8c, letter from Ian Glen to T.C. Edwards, 23 February 1989; AECL archives, C17-166\1420-7files\1420-7v2c, Program Manager's Report, 1 January 1987; AECL archives, C7-165\1420-4-2v1, extract from Report on Operations, 31 December 1981; AECL archives, C7-165\ 1420-4-2v1, letter from A.G. MacDonald, ECS Systems to J.E. Whelan, Boeing, 22 January 1982; AECL archives, C16157\1420-1V7, memo from Bancroft to Critoph, Green, Hart, Lennox and Robertson, 7 March 1984; AECL archives, C5-158\1420-1v10, memo From Hancox to A.F. Scott, 7 November 1984; AECL archives, C1-1205\5004-3v1, letter from Lennox to Major N.J. Dorff, DBM, National Defence, 2 October 1981.

future of the nuclear industry resting on international adoption of next-generation nuclear designs in a market driven environment. The case of the South Korean SES sale also reveals that commercial priorities had come to dominate AECL by the 1980's, contrary to the company's image as a primarily R&D organization. The SES case thus creates difficulties for the standard economic view of crown corporations, and state-owned enterprises in general, as organizations focused primarily on so-called "social welfare goals." This account follows AECL's interpretation of events, to better understand how personnel at state-owned enterprises conceptualize and operate in a competitive, market driven environment. Using Duane Bratt's analysis of AECL's export policy as a guide, it suggests that the South Korean SES sale is another example of the impact of commercialization pressures and neo-liberal market thinking on technological innovation by the state.[5]

The Slowpoke Energy System: History and Design

AECL considered small-scale nuclear reactor designs as early as 1952. Due to inefficiencies associated with low megawatt reactors, early designs favoured heat over electricity production.[6] Despite considerable technical support for a smaller-scale design, the concept was set aside as it was felt that nuclear was only competitive with coal and hydro power at larger sizes.[7] The small scale reactor concept was reconsidered in 1963 when Toronto City Hall was designated as a possible site for a nuclear heating reactor, but was subsequently rejected.[8]

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5. This account of AECL's South Korean initiative is based on interviews with AECL personnel and material shipped from the AECL archives in Chalk River to AECL Sheridan Park in Mississauga in 2001 and 2002 (I have followed AECL's naming conventions for all archival materials). These materials consisted of reports, correspondence (letters and faxes), memos, meeting minutes and external program reviews. Corresponding materials from the Korean side have not been used, as the primary focus of this research has been to reconstruct AECL's actions in order to evaluate the commercial dimension of the Crown Corporation's activities.

6. AECL archives, C1-1205\5005-1v1, letter from Ian MacKay, head, plant design branch, Canadian General Electric, to W.B. Lewis and G.C. Laurence, CRNL, 19 August 1952.

7. AECL archives, C1-1205\5005-1v1, letter from J.L. Grey, Vice President, to L.G. Williams, project engineer, Marathon Corporation of Canada, 26 September 1957; AECL archives, C1-1205\5005-1v1, letter from E.W. Bowness to D.D. Stewart, 17 October 1957; AECL archives, C1-1205\5005-1v1, letter from Stewart, general superintendant reactor operations CRNL, to E.W. Bowness, 29 October 1957; AECL archives, C1-1205\5005-1v2, memo from F.M. Sayers to Lewis, 28 January 1959. It is interesting to note here, in contrast with AECL's image as company primarily concerned with R&D, competitiveness trumps design from the beginning.

8. The existing City Hall system had two 18MW alternating electro boilers at a total capital and operating cost of about $450,000 in 1961. AECL estimated that a replacement nuclear facility would cost approximately $250,000 Canadian. See AECL archives, C16157\1420-1v1, memo from H.B. Merlin to G.A. Pon, 28 October 1963.

Another possibility that was considered in the early years was placing reactors in remote northern communities where the high cost of fuel transport would counterbalance the cost of training and hiring reactor operators.[9] A 1960 study done by Canadian Westinghouse investigated the possibility of constructing a small (40MW) thermal pressurized boiling light water reactor to be used in the Arctic.[10] This Westinghouse study produced cost estimates of 292 cents per million BTU, with a capital outlay of approximately $3.5 million, as opposed to a traditional oil fired system at 195 cents per million BTU. The proposal was not pursued.

The early call for small scale nuclear power ultimately foundered on competition with existing forms of power production. As one AECL engineer put it in 1963,

> Even when an optimistic approach in favour of the nuclear system is taken it is found that as heat sources nuclear reactors having outputs of 50MW thermal or less cannot compete with conventional oil-fired heat sources.[11]

Note that the *technical* case for small-scale nuclear power was not contested. Although designing an efficient small scale nuclear reactor was a challenging task, early decisions to set aside small scale nuclear were made primarily on economic grounds.

The business case changed significantly in the late 1970's, thanks to the oil crisis. Concerns over the rising price of foreign oil and its politically volatile nature, encouraged the Canadian federal government to take action. It introduced the National Energy Program (NEP), a policy package designed to encourage alternative energy technologies and reduce dependence on oil. According to Desveaux, Canada took a "structured and strongly interventionist" response to the oil crisis, and this response was keenly felt in the nuclear industry.[12]

With secure natural reserves of Canadian uranium, nuclear was a good fit for NEP funding. NEP programs also favoured smaller scale technologies like the SES, for example, the Remote Community Development Program encouraged small Northern settlements to tap into a 24 million dollar fund in order to, "assess energy needs and alternatives to expensive off-grid non-renewable fossil fuel."[13] 153 million was made

9. AECL archives, C16157\1420-1v1, letter from L.R. Haywood, Vice President Engineering, to M.A. Smith, Toronto, Hydro Electric Power Commission, 4 November 1963.
10. AECL archives, AECL-1045 (also listed as CWAED Report 37), Canadian Westinghouse, "Small Reactors for Northern Canada," 1960.
11. AECL archives, C16157\1420-1v1, letter from Haywood to Smith, Hydro Electric Power Commission, 4 November 1963.
12. James Desveaux, *Designing Bureaucracies: Institutional Capacity and Large-Scale Problem Solving* (Stanford: Stanford University Press, 1995), 25.
13. The Remote Community Development Program encompassed over 325 off-grid northern communities. Providing heat and electricity for these communities took

available for the Canadian Oil Substitution Program, another initiative to replace oil with less sensitive resources.[14]

The NEP was a multi-departmental initiative, leading to some odd pairings. For example, the Canada Mortgage and Housing Corporation (CMHC) targeted Elliot Lake as a possible location for a small-scale nuclear heating reactor, to be owned and operated by Rio Algom. The plan was to use the reactor for heating and substance analysis.[15] This was probably the first time the CMHC made policy recommendations with a nuclear component. AECL identified approximately 80 communities, 23 Department of National Defense sites and several mines as sufficiently large to use a SES reactor, while at the same time qualifying for funding under one or more NEP programs.

The SES was born in this promising funding climate. Several design variants of the reactor were suggested, from an organic cooled design to a heating reactor to an electricity producing reactor (fig. 1). AECL ultimately focused on two main design variants, an electricity producing design and a heating design, with the latter being the primary focus for sales efforts.[16]

The SES thermal reactor design is a "pool-style" facility, moderated and cooled by light water. To avoid the need for high-pressure steam, the SES heats water to 85 degrees Celsius. This water circulates by natural convection, passing heat exchangers that transfer the heat to a hot-water distribution system that heats the facility.[17] In principle, the SES can be connected to any existing hot water system. Natural convection obviates the need for pumps, thus simplifying the design. The reactor was designed for 10MW(t-thermal) operation, about enough to heat a large university.[18]

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approximately 2.5 million barrels of oil a year, at a cost up to 200% more than grid power. The Program was administered by the Ministry of Indian Affairs and Northern Development, and Energy Mines and Resources, as part of the "Energy Policy for North of 60," a program that was part of the NEP. AECL archives, C16157\1420-1v3, EMR Communique, Remote Community Demonstration Program, 17 June 1982.

14. Ibid. For more on the viability of the Canadian Oil Substitution Program as a source of funding for the SES, see Ian J. Slater, "Atomic Energy Canada Limited and Next Generation Nuclear Reactors," *ICON: The Journal of the International Committee on the History of Technology* 11 (2005): 120-181.

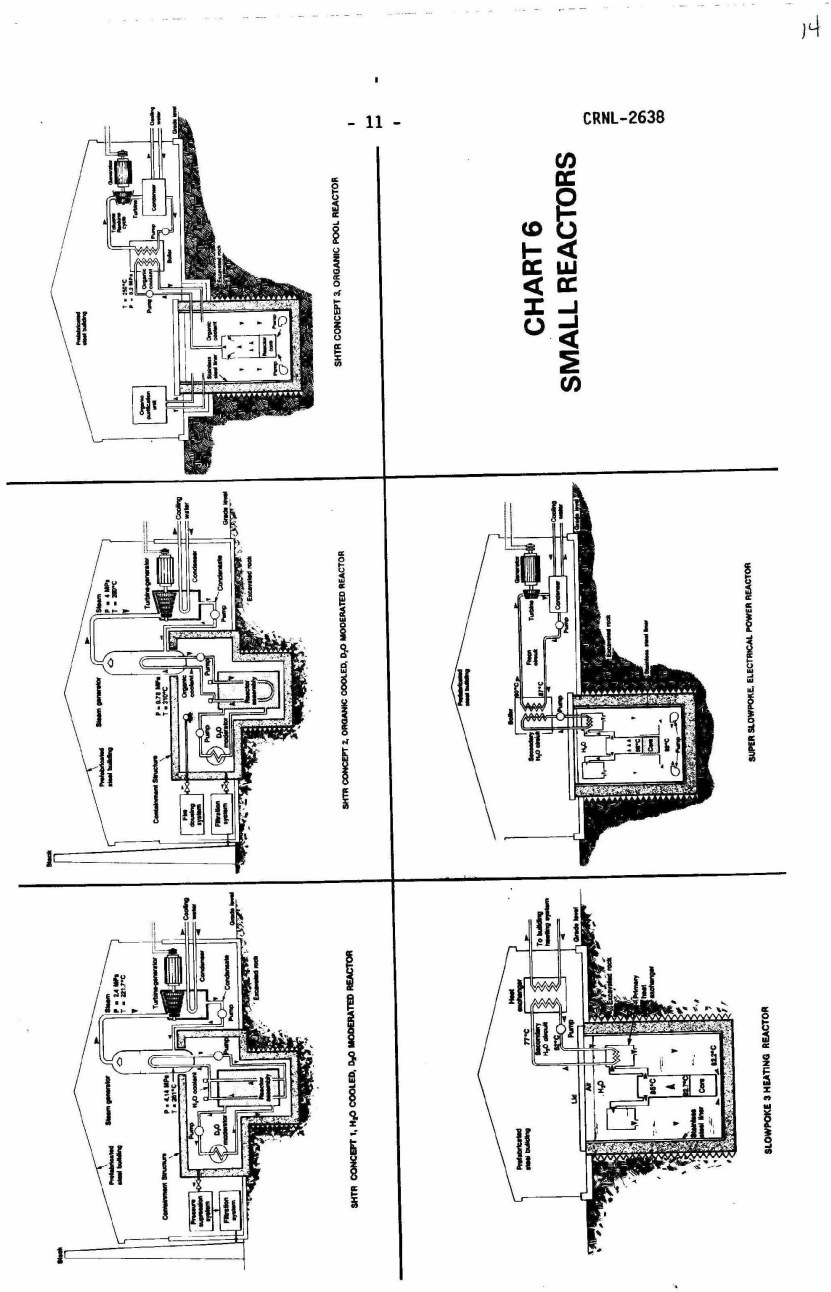
15. AECL archives, C16157, 1420-1v2, memo from D.J.R. Evans to A.B. Lillie–Visit of Peter Favot, Director of R&D, CMHC, and Peter Russel, CMHC, 20 June 1979.

16. AECL archives, C17-166\1420-10files\1420-10v4a, letter to Rovac from Business Unit, 24 June 1987.

17. Reactor parameters changed throughout the development of the product, the information given here represents a summary from various primary sources. See for example, AECL archives, z-oldimages\tempdoc1, letter from Hancock to Donnelly, 1 Jan. 1984; AECL archives, z-oldimages/Spexecsumm, Executive Project Summary, 1 October 1987; AECL archives, C12-LES2\folder9b, commercial specifications, 30 July 1990.

18. AECL archives, 1420-1/Slowpoke Overall, 10 January 1986.

Figure 1. Small Reactors.



Source: AECL archives, ID: CRNL 2638, © Atomic Energy of Canada Limited, 1981.

The SES design minimized core size by maximizing reactivity through the use of a uranium core surrounded by a beryllium reflector. AECL referred to the SES design as "passively" or "inherently" safe, as it had "no reliance on engineered safeguards."[19] In practice, passive or inherent safety was achieved through the use of:

1. A cooling pool that worked by natural convection (no pumps to fail) and was capable of diffusing the maximum heat the reactor could provide.
2. The use of CANDU-type fuel, with a high melting point, low operating temperatures, negative temperature reactivity coefficient (as temperature increased reactivity of fuel decreased) and negative coolant temperature reactivity coefficient (as temperature increased reactivity of coolant decreased).
3. Low reactivity addition rates and low fuel enrichment.
4. Lack of pressurization, making an explosive loss of coolant accident impossible

The small size of the reactor made it ideal for urban installations and remote community installations (fig. 2). In an industry that relies heavily on engineered safeguards and large scale to achieve economies of scale, the SES embodied the principle that "small is beautiful." AECL's design and marketing of a small scale nuclear reactor in the 1980's provides a glimpse into the fate of next-generation reactors, one well worth considering in today's political and economic climate.

The SES in South Korea

South Korea was a top candidate for an SES export sale in the 1980s. The country had an expanding economy, a strong commitment to nuclear power, a desire to reduce pollution, and an existing relationship with AECL through the Wolsong-1 CANDU reactor. Despite these advantages, there were stumbling blocks to nuclear development in South Korea. Increasing anti-nuclear sentiment, a new phenomenon in South Korea at the time, contributed to licensing problems and unexpected costs. AECL also faced rival bids from American, Soviet and European competitors.

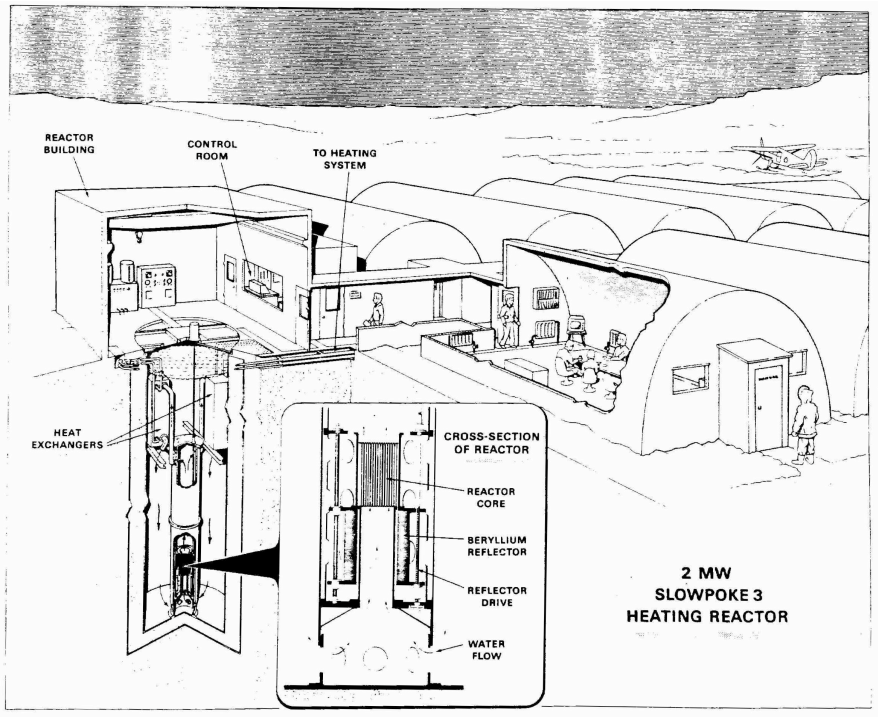
In addition, the SES was designed around certain "core parameters,"[20] one of them being simplicity of design for greater safety. Simplicity meant that the reactor could be copied, and in fact the SLOWPOKE Research Reactor, a design precursor to the SES, had been copied. After

19. AECL archives, z-oldimages/sesoverview, P.C. Ernst, Synopsis of Executive Management Technical Review of the 10MW SLOWPOKE Energy System (SES-10), 14 August 1990, p. 5. In the end, the SES relied on both passive and engineered safety systems, due in large part to the decision of the Atomic Energy Control Board (AECB) to regulate the SES like a CANDU. For more on this, see Slater, "Atomic Energy Canada Limited and Next Generation Nuclear Reactors."

20. See AECL archives, G.F. Lynch, Local Energy Systems Business Strategy, Internal Report (1988), p. 1.

several years of sending graduate students to Canada to learn nuclear physics, Chinese scientists created the Miniature Neutron Source Reactor (MNSR), a direct copy of the SLOWPOKE.[21] AECL was concerned that this could happen again and had to weigh the value of sales against the possibility that the South Koreans could reverse-engineer the reactor.

Figure 2. 2MW Slowpoke-3 Heating Reactor.



Source: AECL archives, ID: CRNL 3694-h, © Atomic Energy of Canada Limited, 1983.

Nuclear reactors produced approximately 40% of the power in South Korea in the early 1980's (Canada's level was approximately 12% at that time), reflecting the country's commitment to the technology, and in the beginning at least, little or no public concern was voiced about nuclear power. As CANDU had a presence in the country, AECL not only had technical facilities available to it, but also contacts at important firms,

21. The MNSR was an exact copy, right down to the colour of the control panel. For more on this, see Ian J. Slater, "The Bungling Giant: Atomic Energy Canada Limited and Next-Generation Nuclear Technology, 1980-1994," (PhD Thesis, University of Toronto, 2003), 55-61.

staff who were familiar with the South Korean market, and a large group of South Korean politicians and civil servants with whom it had done business. Pollution was an increasing problem, and the South Korean government had a mandate to pursue options that would reduce emissions. This included a government company (the Korea District Heating Corporation–KDHC) dedicated to the development of local or district heating systems for some of the most populated and remote parts of the country.

The Economics of the South Korean Market

As of December of 1985, over 40 million South Koreans occupied a landmass the size of the island of Newfoundland, with a GNP of approximately $80 billion (US). The country's exports took advantage of a cheap labor force, giving it a competitive advantage in labor-intensive industries,[22] but a disadvantage in skill-intensive high-technology industries, where international partnerships were gaining prominence. In the early 1980's the government's "fifth five year development plan" emphasized low unemployment and low interest rates for stability rather than growth. By the mid-1980's, the sixth five year development plan was being debated in the national assembly, and it focused on social welfare issues, rural development, and the expansion of the economy into high-tech and technology intensive areas. The US was South Korea's largest trading partner, followed by Japan, Hong Kong, Germany and Canada.[23]

South Korea was an oil and natural gas importer, taking in over $5.7 billion (US) worth of crude oil in 1984. One way to reduce both its trade deficit and problems with fossil fuel pollution was to substitute nuclear power for fossil fuel. South Korea participated in a number of trade agreements with Canada, including the General Agreement on Tariffs and Trade (GATT), the General Preferential Tariff (GPT) agreement, and the Canada/Korea trade agreement, and both countries assigned the other Most Favored Nation (MFN) status. Canada exported approximately $770 million worth of goods to South Korea in 1984, mainly raw materials (coal the most prominent), wheat, telecommunications equipment and some small manufactured goods. South Korea exported approximately $1.2 billion in goods to Canada in the same year, mainly cars, textiles, clothing and small electronics.[24]

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22. In order of export magnitude: textiles, ships, iron and steel, electronics, footwear, livestock, food & consumer goods, raw materials and fuel, machinery.
23. AECL archives, newc19-162\1420-3-7v2a, memo from R.D. Gadsby, CANDU Ops, to LES distribution, Korea Economic Evaluation, 2 December 1986.
24. Ibid.

Falling international interest rates and cheap labor costs were driving South Korea towards a trade surplus in the years following 1985. To encourage growth and diversification, the government planned more local investment in small to medium sized companies. Foreign investment, "in the form of joint ventures is being encouraged, particularly in areas of new technology, with the emphasis on technology transfer."[25] The focus of South Korean economic policy in the 1980's was to upgrade and improve export industries through foreign investment and technology transfer, particularly in the high-technology sector, while reducing imports.

Early Contacts with Hyundai

The first discussion of a possible SES sale to South Korea involved the Hyundai Corporation, or more specifically, the Hyundai Engineering and Construction Company (HDEC). HDEC worked on power plants and the various non-nuclear components associated with large-scale power distribution systems.[26] The first recorded meeting with AECL about the SES was in September of 1984.[27]

South Korea had initiated a nationwide program to reduce oil consumption and dependence on oil imports. HDEC had also contacted ASEA Brown Boveri, a Swedish company, concerning the possibility of developing a district heating system, but at approximately 400MW its SECURE concept was large enough to be outside of AECL's direct competition. During subsequent meetings, the possibility of using the SES for an "absorptive cooling cycle" during the summers was also considered. HDEC was keenly aware of the government's desire to encourage technology transfer and the development of local technological infrastructure, and the company requested that AECL consider a contract structure where reactor fuel could be manufactured in South Korea.[28]

AECL suggested a graded technology transfer structure for any partnership with Hyundai. For the first reactor (the commercial demonstration model), AECL would design and manufacture reactor components and fuel, and provide project management services. HDEC could provide the reactor building, prepare the site, deal with local project

25. AECL archives, newc19-162\1420-3-7v2a, memo from R.D. Gadsby, CANDU Ops, to LES distribution, Korea Economic Evaluation, 2 December 1986.
26. AECL archives, c11-les4\hyundai2.max, memo from Bain to Bancroft, 12 Oct. 1984.
27. AECL archives, c11-les4\costs.max, meeting between AECL and Hyundai, 27 September 1984.
28. AECL archives, c11-les4\hyundai3.max, memo from Bancroft to Bain, RCHO, R.D. Gadsby CANDU Ops, W.T. Hancox, WNRE, J.W. Hilborn, CRNL, A.T. Jeffs, AECL - Korea, C.G. Lennox, RCHO, J.W. Love, CANDU Ops., S.J. Pearce, AECL Corporate, H.K. Rae, CRNL, RE: discussions with Hyundai, 3 October 1984.

management, and provide the heat distribution systems for the reactor. Subsequent reactor sales would see more and more responsibility transferred to HDEC; ultimately, AECL would only be supplying the fuel directly, and receiving royalties on the design and construction information given to HDEC for local work.[29] It was even suggested by AECL that a joint venture company could be formed that would allow HDEC to manufacture the SES in Asia, rather than AECL.[30]

Initial discussions led to the draft of a joint venture agreement between the two companies in 1985. AECL agreed to provide a commercial demonstration reactor to HDEC, along with the first fuel load and initial training for personnel. Estimated cost to AECL was $4-5 million Canadian. In return, HDEC would provide local project management to AECL Quality Assurance standards, the conventional portions of the heating system (e.g. hot water distribution system, reactor building), and the local operating license for the reactor. The estimated cost to HDEC for this project was approximately $3-4 million Canadian. Revenue from heat generated by the first prototype would belong to AECL for the first year, and in subsequent years it would be split according to initial investment in the project (roughly 60/40 AECL/HDEC).[31]

AECL Goes Sour on HDEC

Private sector joint ventures had proven to be risky for AECL. In 1981 it had partnered with Vancouver-based submarine technology company ECS to build a nuclear battery for military sub applications. ECS become a "hostile partner" in 1984, forming partnerships without AECL's cooperation and threatening lawsuits.[32] AECL soon branded HDEC a hostile partner as well.

Discussions with HDEC had revealed that the chairman of the company was not even aware of the negotiations over the SES sale. Further inquiries revealed that HDEC interest in the SES was linked to a slowdown in work at the company, combined with a desire to secure subcontracting work on the Wolsung-II reactor. HDEC believed that partnering with AECL on the SES would give them a "strong advantage" in the competition for Wolsung-II work.[33] In short, the SES was not the focus of Hyundai interest; lucrative contracts for Wolsung-II were the prize. AECL also felt that Hyundai had the technical expertise to copy the SES.

29. AECL archives, c11-les4\hyundai2.max, memo from Bain to Bancroft, 12 Oct. 1984.
30. AECL archives, c11-les4\hyundai.max, memo from Bain to Bancroft, 16 Oct. 1984.
31. AECL archives, c11-les4\3.3.5.koreav1c.max, meeting minutes from meeting with HDEC in Seoul from Sept 23-27, 1985, 27 September 1985.
32. See Slater, "The Bungling Giant."
33. AECL archives, c11-les4\3.3.5.koreav1a, memo from G.F. Lynch to S.R. Hatcher, SLOWPOKE in Korea, 13 May 1986.

This information led AECL to assume that HDEC would not act in its best interests in the future. AECL decided that any partnership with HDEC should involve nothing more than the latter company's business expertise and knowledge of the local market, leaving all technical, operations and management responsibilities with AECL. The company believed that HDEC would attempt to use its government connections to gain total control of any partnership between the two companies, if the market for the SES proved promising. It followed that any business agreement with HDEC should be structured such that AECL would maximize its returns in the early stages of the business venture. More importantly, under no circumstances should outstanding technical and safety details be transferred at this early stage of the collaboration, as it was believed that HDEC could and would embark upon the design of its own reactor if the market seemed large. AECL's experience with the SLOWPOKE Research Reactor clearly had had an impact.[34]

Abandoning HDEC was not without risks, since "HDEC may have sufficient momentum to seek an alternative partner" for a small nuclear design, such as the SECURE reactor mentioned above. Beyond this, the agreement from 1985 would have to be broken in order to terminate the relationship between the two companies, and AECL had made commitments in this agreement and subsequent verbal agreements that would have to be withdrawn, hopefully without penalty.[35] However, as the SES project was unknown at the higher levels of HDEC, AECL believed that withdrawing at this point would not damage any later attempts to partner with the firm.[36]

AECL's ultimate decision was to put HDEC on hold, stop transferring technical information, and to pursue its market options without HDEC as a primary partner.[37] The existence of other potential partners for HDEC added competition from small nuclear sources to the SES plate for the first time.

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34. AECL archives, c11-les4\3.3.5.koreav1a, memo from G.F. Lynch to S.R. Hatcher, SLOWPOKE in Korea, 13 May 1986.

35. Commitments to joint studies, pricing of reactor systems, transfer of design details, performance reports on the SDR, financial and operational details from any other sales proposals, etc. For more detail, see AECL archives, c11-les4\3.3.5.koreav1a, memo from Lynch to Hatcher, SLOWPOKE in Korea, 13 May 1986; AECL archives, c11-les4\hyundai.max, memo from Bain to Bancroft, 16 October 1984; AECL archives, c11-les4\3.3.5.koreav1c.max, meeting minutes from meeting with HDEC in Seoul from September 23-27, 1985, 27 September 1985; AECL archives, c11-les4\hyundai2.max, memo from Bain to Bancroft, 12 October 1984.

36. AECL archives, c11-les4\3.3.5.koreav1a, memo from Lynch to Hatcher, SLOWPOKE in Korea, 13 May 1986.

37. Ibid.

Government Led Energy Reform and the SES

Various government policies in South Korea had driven up the price for bunker-C oil, the primary oil used in district heating, to about double that of the world average. In pursuit of economic stability, the government encouraged long-term fixed-price contracts for oil, which also drove up oil prices.[38] With the government introducing levies to deal with the environmental threat of burning fossil fuels, oil prices rose and nuclear power was seen as a potentially cheap substitute.[39]

As of 1986, the Korean Energy Utilization Act (created in 1979) had established a set of incentives and penalties around the "rational use" of energy sources. Efficient use and safe operation were stressed, as well as environmental concerns to reduce pollution. The Korean Minister of Energy and Resources was responsible for energy planning, and the government run Korean Energy Management Company (KEMCO) was in charge of obtaining facilities for energy distribution, monitoring and licensing of equipment, and research in alternative energy sources. Through KEMCO the minister had access to the Energy Utilization Fund.[40]

With the South Korean market for the SES defined, and negotiations with HDEC behind it, AECL still faced hurdles. In 1987 AECL Corporate stressed that the SES must be competitive at international oil prices, not at inflated South Korean prices, to be acceptable to the South Korean government. This necessitated "firming up" the cost estimates for the SES commercial prototype, which essentially meant pushing the development program in Canada in order to gain reliable performance information and cost estimates. It was also decided that the SES should be competitive on a unit-to-unit sale basis, rather than delaying profits by securing lucrative long-term heating contracts. This tactic was designed to put the profits up front, in part to minimize any losses due to unintended technology transfer or hostile actions on the part of a South Korean partner.[41] The only sort of long-term business to be sought was operations, fuel supply and maintenance work. This emphasis on short term profit by AECL is a clear indication of the impact of competition on the crown corporation.

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38. Fixed price contracts generally provide an item at a slightly higher price, the "cost" of price stability.
39. AECL archives, newc19-162\1420-3-7v2c, fax from Kay to G. Kugler, 5 Nov. 1985.
40. AECL archives, newc19-162\1420-3-7v2b, memo from D.S. McDougall to R.E. Kay, 7 November 1986.
41. AECL archives, newc19-162\1420-3-7v3a, meeting notes on Korea at RCHO Ottawa, 6 January 1987. Political persuasion and strong patenting were also suggested as potential protective mechanisms.

Any commercial demonstration reactor sold to South Korea would have to be installed at a government-approved site, and AECL anticipated that the Korean Atomic Energy Research Institute (KAERI) would be the site of the first sale. KAERI facilities were located in a temperate zone, so heating demand would be low, and existing systems were steam based, so efficiencies would be lower as well. This implied that the initial commercial sale in South Korea would be economically disadvantaged, so competitive, efficient design was absolutely necessary. The decision was also made to continue limited information exchange with HDEC to reduce the possibility of having "annoyed parties" in South Korea before the first sale.[42] It was thought to be to AECL's advantage to find a smaller partner with less technical ability, to reduce the possibility of copying.

As a nuclear technology, any South Korean SES would have first to be accepted by the government. Nuclear power was government run and regulated in South Korea, and government approval was a precursor to any commercial sales. To secure greater government support, AECL considered hiring a senior level political consultant with experience in any or all of the relevant government agencies, the Ministry of Science and Technology (MOST), Ministry of Energy and Resources (MER), and to a lesser degree the Ministry of Finance and the Ministry of Trade (MOT). $5,000-10,000 Canadian per month was allocated from the budget for the expected salary of such a representative.[43]

Striking While the Iron Was Hot: The Business Environment for Nuclear Heating

By March of 1987 it was decided that the next priority for the project was the formation of a joint venture agreement with someone other than HDEC. The main resources needed from a partner were market knowledge and knowledge of South Korean licensing requirements for the reactor. Despite the unsuccessful relationship with HDEC, securing a local partner was seen as an important step for successful sales.[44]

Though a joint venture agreement was seen as a necessary part of any commercial business in South Korea, AECL had some choice of dancing partner. AECL planned to go ahead with a SES prototype at a KAERI site, partnering with the South Korean government rather than a local business.

42. AECL archives, newc19-162\1420-3-7v3a, meeting notes on Korea at RCHO Ottawa, 6 January 1987.
43. Ibid. See Robert Bothwell, *Nucleus, The History of Atomic Energy of Canada Limited* (Toronto: University of Toronto Press, 1988), 430-436 for a discussion of AECL problems with sales agents.
44. AECL archives, newc19-162\1420-3-7v3c, LES memo from Kay to McDougall, 5 March 1987.

This decision was motivated by the troubles with HDEC and the increasing pressure to produce a commercial prototype to kick-off the business.[45]

The pressure to produce a commercial prototype in South Korea went beyond the general need for a SES demonstration facility. Three factors in the South Korean situation made it unadvisable to wait for an appropriate private sector joint venture partner. First, Canadian government support for further CANDU sales in South Korea was strong at this point, and high level lobbying of South Korean ministries was aggressively pursued, especially after the South Korean government considered an American company for the Wolsung-II bid.[46]

The successful collaboration between KAERI and AECL on the Korea Multipurpose Research Reactor (KMRR) and the Wolsung-I reactor had created a good working relationship between the two organizations and contacts with key players in South Korean government.[47] AECL was hoping to piggyback on government support and institutional familiarity. Any movement to reduce the political and economic barriers to CANDU nuclear reactor sales in South Korea could, in principle at least, encourage SES sales as well.[48] However, KMRR was a finite project, and the Wolsung-II bid had a limited time window, as AECL was well aware.[49]

Market analyses also suggested that a viable market existed for nuclear heating. Apartment complexes were important potential clients, and many of these ran on medium to low temperature distributed water, ideal for the

45. AECL archives, newc19-162\1420-3-7v3e, memo from Lynch to McDougall and Kay, 13 May 1987.

46. The American bid for Wolsung-II, led by Westinghouse, was not without its own problems. KEPCO, the Korean electricity utility, had recently discovered that Westinghouse had charged disproportionately large fees for spare parts and services for existing PWR reactors in Korea. This "gouging" practice was widely resented in the company and AECL's forthright business dealings for Wolsung-I parts and services were considered a strong competitive advantage in the CANDU and SES bids. AECL archives, C9-les5\3.3.5.vol3a, fax from Keating to Lawson, Gadsby, McCardle, LES Team, 27 March 1987.

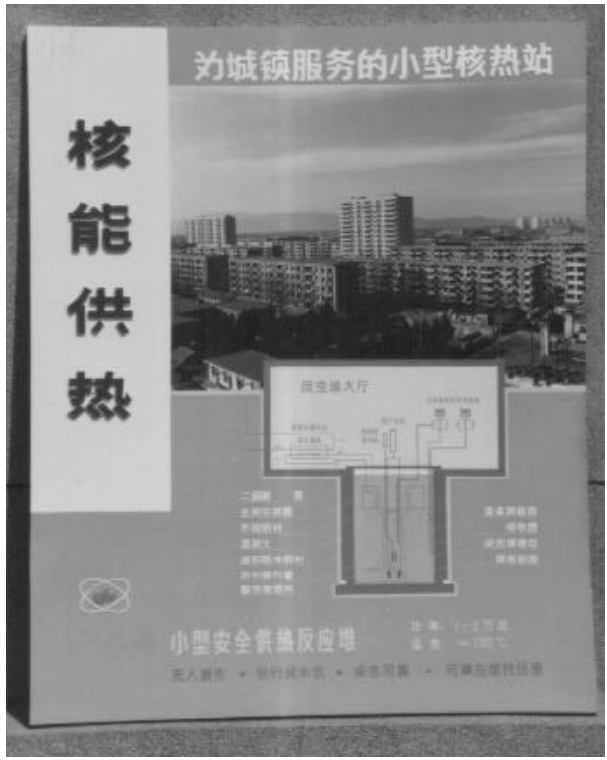
47. AECL archives, C11-les4\koreaprop, proposal for the Korea District Heating Corporation, 1 October 1988.

48. AECL archives, C9-les5\3.3.5.vol3a, fax from Keating to Lawson, Gadsby, McCardle, LES Team, 27 March 1987.

49. To qualify this claim of organizational and political familiarity, the AECL Korean office cited the following list of influential Korean politicians involved with AECL at some level through Wolsong-I and KMRR, "Deputy Prime Minister and Minister responsible for the Economic Planning Board Rha Woong-bae (well known to us)… Minister of Energy and Resources, Dr. Lee Bong-suh (quite well known to us)… Minister of Science and Technology, Dr. Lee Kwan (he is not well known to us but he has a nuclear physics background and is known to be a proponent of nuclear energy)… and Minister of Trade and Industry Ahn Byong-wha (known to us)." AECL archives, C9-les5\3.3.5vol4a, fax from Keating to Lawson, LES Team, 2 March 1988.

SES, rather than high-temperature steam.[50] There were some modifications needed with the heat exchangers in older apartment complexes, but these were due for replacement and could be paid for from the Energy Utilization Fund.[51]

Figure 3. A Chinese Promotional Poster for the SES.



Source: AECL archives, ID: C20-LES6, © Atomic Energy of Canada Limited,1985.

In addition, South Korea's desire for greater energy independence, combined with an increasing demand for power to fuel economic growth, made the government amenable to energy initiatives that reduced foreign oil imports and encouraged price stability. As district heating was responsible for a significant portion of oil use, and fuel price stability was an advantage of long term nuclear fuel contracts, the SES was uniquely

50. See figure 3 for a photo of an apartment complex taken from a Chinese SES promotional poster.
51. AECL archives, C9-les5\3.3.5vol3b, Korea Economic Evaluation, Scouten, Mitchel, Sigurdson and Associates, 1 June 1987.

placed to suit the needs of the South Korean government. Successful installation and operation of a commercial prototype directly at KAERI would most likely speed up government approval of the SES.[52]

The Korean District Heating Corporation, created in 1985 and 50% owned by KEPCO, Korea's electric utility, had recently embarked on a wide scale district heating study. The plan was to replace scattered small, inefficient local heating units with small-scale district heating systems for industrial and apartment building complexes and small communities. Traditional local heating methods for buildings in South Korea included individual charcoal fires, a source of serious pollution. KDHC had already started to integrate these local systems, replacing charcoal with oil heating, and it was hoped that the combination of higher capital costs, equivalent operation and maintenance costs, with much lower and more stable fuel costs, would make the SES an appealing substitute.[53]

In summary, the respective governments were willing and able to support nuclear development, there was a well-defined and significant market for the technology, a well-developed nuclear infrastructure, familiarity with both government and industrial sources of nuclear expertise, good working relationships with influential government ministers, and an existing South Korean district heating initiative to develop new power systems for off oil heating at the level of the SES.

The Korean District Heating Corporation as a Potential Partner

The SES project did not yet have an office in South Korea, so AECL CANDU staff working there did some of the legwork for the Korean SES sale. In early December of 1988, AECL CANDU representatives met with KDHC to discuss the SES bid. Much to its surprise, AECL discovered that KDHC had strong reservations about the SES. It listed several concerns:

1. AECL fuel price was too high
2. There was no working 10MW commercial prototype
3. Offering a subsidy on the first unit was suspicious, as KDHC had had past experience with, "foreigners cheating them."
4. The timelines for various SES projects were too long

52. AECL archives, newc19-162\1420-3-7v3f, memo from Lynch to Keating, Tighe and Kugler, 19 January 1988.

53. AECL archives, C11-les4\koreaprop, proposal for the Korea District Heating Corporation, 1 October 1988. In the winter of 1987-88 KDHC installed a large oil fired district heating system, "supplying some 40000 living units and several office buildings… in the city on the Han River." KDHC expressed interest in substituting an SES for this oil source. AECL archives, C9-les5\3.3.5vol4a, fax from Keating to Lawson, LES Team, 2 March 1988.

These concerns were quite unexpected, as KDHC had expressed early enthusiasm for the SES, and few initial reservations. Beyond accepting an AECL proposal for a heating unit in Tunas, it had said and done very little.[54]

Gerry Lynch, project manager for the SES, decided to visit Korea in person and discuss these issues. A face-to-face meeting produced improved results. Lynch was excited by the KDHC response:

> The deal for the first unit is within our grasp. It's not a big economic challenge and, with the bulk of the payment up front, AECL's financial exposure is very limited. Furthermore, the support from the customer and the Korean Government couldn't be better.[55]

What convinced Lynch that things had changed? KDHC actively discussed the program, and made several early concessions. AECL was told it could increase its fuel costs if oil prices continued to rise, as long as initial fuel costs were kept low to satisfy the public. It offered to design the hot water distribution system in Tunsan to meet SES-10 design requirements, even though it was not known if Tunsan would be the first SES site. Lynch returned to Canada for Christmas confident of the direction of the Korean sale.

New Years… New Troubles: Labor Unrest, Competition and Technical Progress

Korea ended 1988 with a $7.5 billion trade surplus and a thriving economy. Electrical demand growth in 1988 was 15.5%, with approximately 47% of that coming from nuclear power. KEPCO was projecting a growth in total Korean electrical capacity to 35.7 GW by 2001, and planned for the construction of at least three new nuclear plants (including Wolsung-II) by that time. With a booming economy and the promise of rising demand for power, the Korean government proposed the partial privatization of KEPCO.[56]

However, along with this growth and profit came labor unrest and concerns over the direction of government expansion. Large successful companies such as Daewoo, Hyundai and Samsung experienced damaging strikes and demonstrations in early 1989.[57] By March, police forces had

54. KDHC had recently been given the responsibility of providing the energy supply for Tunsan, a newly built industrial, R&D and residential community. AECL archives, C9-les5\3.3.5.vol5a, minutes of meetings in Seoul Korea, between KDHC and AECL, 5-8 December 1988.
55. AECL archives, C11-les4\4.13.1KoreaPropA, memo from Lynch to Hatcher and Lennox, 13 December 1988.
56. AECL archives, C9-les5\3.3.5.vol5b, fax from Keating to Lawson, 26 January 1989.
57. Ibid.

been authorized to use firearms to protect public property and the personal safety of the police, and a bill was being debated to provide strong prison sentences for the use of firebombs in public demonstrations.[58] Labor unrest was a relatively new phenomenon in Korea at the time, and both government and industry leaders were unsure how to react.[59]

This was the setting for a June meeting between the AECL and Yoon Myong Park, President of KDHC. Park expressed interest in the SES, but with caveats:

a) A commercial prototype at the 10MW level had to be built in Canada
b) AECL had to demonstrate competitive economics
c) Public approval in Canada had to be obtained
d) AECL had to successfully license a SES in Canada

If these conditions were met, KDHC was willing to go to the Ministry of Energy and Resources for funding. Park spoke of three new suburbs near Seoul, with projected populations of half a million each, which were ideal for a set of SES reactors.[60]

However, Park was clearly concerned with AECL's ability to deliver on its promises of efficiency and economy, thus the demand for a successful commercial prototype installation in Canada. He was further concerned with potential public resistance to the reactor, thus the demand for successful Canadian licensing[61] and public approval as a benchmark of SES acceptance. Park pointed out that KDHC did not have the technical resources to design its own reactor, with a staff of only 70 or so technical people, and no in-house nuclear experience.

However, it was very interested in nuclear power, and the recent Korean government decision to pass a law "preventing the burning of coal and high sulphur oil in Seoul" as of October 1989 only increased this interest. To ensure AECL of its commitment to nuclear, Park pointed out that KDHC had approached at least two other companies, General Atomics and ABB. The former had proposed to modify its Triga research reactor for local heating, the latter had an existing design for the SECURE reactor. Park suggested that twin SES reactors and an oil boiler would be ideal for Tunsan.[62]

58. AECL archives, C9-les5\3.3.5.vol5c, fax from Keating to Lawson, LES Team, 27 March 1989.
59. Ibid.
60. AECL archives, C9-les5\3.3.5.vol5d, meeting minutes, 21 June 1989.
61. Licensing models for other international clients, such as Hungary and Czechoslovakia, were less demanding. Both European countries demanded only that the reactor *could be* licensed in Canada. What this amounted to was approval from the AECB. AECL archives, memo to Bancroft, Barclay, McDougall and Ohta from Snell, Local Energy Systems Marketing, 31 July 1991.
62. AECL archives, C9-les5\3.3.5.vol5d, meeting minutes, 21 June 1989. Pairing non-

Several weeks after the meeting with President Park, the Korea-Canada Joint Coordinating Committee on Nuclear Energy met in Seoul to discuss collaboration between KEPCO and AECL. KEPCO announced that it was sidestepping the Canadian restriction on domestic reprocessing of yellowcake by purchasing uranium from Australia for the CANDU reactor at Wolsong-1. KAERI had recently completed a uranium reprocessing facility, demonstrating Korean technical skills in the nuclear field. AECL reiterated its strong desire to be chosen in the Wolsung-II bid. In response, KAERI requested expanded assistance and, "bilateral cooperation on waste management, nuclear safety, operations and maintenance needs at Wolsong-1."[63]

The meeting finished with a presentation on the progress of the SES proposal in Canada (at Sherbrooke and Saskatchewan), which was not encouraging, to say the least. By the summer of 1989 Sherbrooke had been abandoned, and Saskatchewan was progressing painfully slowly, despite apparently strong industrial and government interest. The appearance of public resistance to the sale in the Sherbrooke case discouraged the Korean representatives, due to the emergence of wide ranging public resistance to nuclear power in Korea as of the winter of 1988.[64] Public demonstrations, in many cases violent, had delayed construction on new nuclear plants and interfered with site selection surveys for low-to-medium-level radioactive waste depositories and away-from-reactor spent fuel facilities.[65]

Internal Reactions to Slow Development

The SES project was located within a "business unit," an independent division of AECL Research, created with a group of other business units to exploit the commercial potential of AECL technologies. AECL Corporate was established in the late 1950's and was the business end of

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nuclear with small nuclear systems was not uncommon, either as back up or as redundancy in case of technical problems.

63. AECL archives, C9-les5\3.3.5.vol5i, minutes from the meeting of the 7th Korea-Canada Joint Coordinating Committee on Nuclear Energy, 30 June 1989.

64. For more on Sherbrooke and Saskatchewan, see Slater, "The Bungling Giant."

65. KAERI was bargaining hard with the Canadian delegation, perhaps as it realized what AECL had come to realize at the time, namely that international markets for CANDU were the company's primary option. So, when AECL pointed out during the meeting that Canada's restrictions on "further processing" of uranium outside of the country did not apply to the US, KAERI representatives pointed out that they might very well purchase processed uranium from the US rather than directly from Canada if the economics were competitive. AECL representatives could only respond that they were seeking "a ministerial exception" to the further processing rule for uranium to be used in Wolsung-1. AECL archives, C9-les5\3.3.5.vol5i, minutes from the meeting of the 7th Korea-Canada Joint Coordinating Committee on Nuclear Energy, 30 June 1989.

AECL as a whole. Corporate was responsible for the marketing and sales of all AECL product lines, from the CANDU to the SES to technical consulting services (e.g. reactor maintenance). AECL Corporate formed a nexus of marketing and commercial experience for the whole company. Its location in the nation's capital meant that AECL Corporate was well-placed to influence the federal government as well as international players in the nuclear power policy sector.[66]

Frank McDonnell of AECL Corporate was critical of recent progress in the Korean sale. McDonnell sent a memo to Al Bancroft, the Business Opportunity Development team leader for the SES project, detailing his concerns with the Korean proposal. McDonnell pointed out that contact with KDHC had been established in the summer of 1987, it was now the summer of 1989 and

> We are still in this preliminary assessment phase and have yet to: participate in a cooperative study with any Korean organization, assess a specific site to establish technical and economic feasibility, and consider the options for business arrangements in Korea.[67]

It was clear to McDonnell, based on the slow progress of the Korean business, that KDHC was not interested in nuclear power in the near future.

McDonnell felt that Korean experience with public unrest and anti-nuclear demonstrations was limited, and that this was scaring off KDHC from an untested foreign nuclear reactor. McDonnell went further, noting KDHC's interest in other nuclear suppliers and its treatment of AECL, arguing that KDHC only approached AECL as the Ministry of Energy and Resources (MER) requested them to approach several nuclear suppliers. In other words, KDHC's interest was forced by MER.[68] McDonnell recommended terminating the relationship with KDHC and pursuing one with KAERI.

Ron Keating was a staff member of AECL CANDU assigned to Korea as part of the Wolsung-1 bid. He was the primary Korean contact for AECL, and a source of local knowledge since at least 1987. Keating sent a memo to Bancroft, the SES Project Manager, explaining what he felt was the real stumbling block to Korean cooperation.

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66. "A policy sector is a matrix or cluster of government organizations that regularly interact and compete in an effort to defend or promote their policy interests, and that gain access to the policy sector on the basis of their control over organizational resources that are critical for policy sector activities." Laurent Dobuzinskis, Michael Howlett and David Laycock, *Policy Studies in Canada, the State of the Art* (Toronto: University of Toronto Press, 1996), 20.
67. AECL archives, C9-les5\3.3.5.vol5e, memo from McDonnell to Bancroft, 29 Aug. 1989.
68. Ibid.

Keating claimed that KDHC was holding back because AECL had yet to complete a 10MW commercial prototype of its reactor. Until a commercial unit was constructed and licensed in Canada, the Koreans were hesitant to move forward. He agreed with McDonnell that they were somewhat concerned about public reaction, another reason they were interested in AECL's technical progress.[69] Nonetheless they were keenly interested in nuclear power, and their attention to AECL and the SES was genuine, "KDHC invited the proposal because they wanted it; they were not coerced."[70]

According to Keating, the SES project was looking for a short cut in KDHC. Any nuclear development in Korea relied upon ministerial approval and the involvement of KAERI and KEPCO, dealing exclusively with KDHC was not an option. Progress with other organizations would bring KDHC back into the picture. Specifically, KAERI was needed to secure government approval, clear licensing hurdles, and cultivate public acceptance of the reactor.[71] Keating's comments had considerable influence with SES personnel, so they took him seriously when he claimed the game was still afoot.

Controversy Strikes: Economic Expansion and its Discontents

In order to do business in Korea, AECL needed more than just the approval of the Korean government, it also needed the cooperation of local industry and utilities in order to build and operate its technology locally. This made the SES project dependant upon the status of local organizations. November of 1989 brought more difficult news to AECL, with charges of negligence and bad faith bargaining in the Korean power industry.

The first charge was leveled in November of 1989 against KEPCO, Korea's electric utility. The Atomic Energy Bureau (AEB), the regulatory division within the Korean Ministry of Science and Technology (MOST), filed a criminal complaint against KEPCO for negligence on three occasions in 1988. The specific complaints related to regular safety checks at two different reactors, one at Yong-gwang and the other at Kori. Safety checks necessitated reducing reactor power. KEPCO did not perform three of these regular scheduled checks, as they occurred during special events, the Seoul Olympics, the Seoul Para-Olympics, and the National Assembly elections.[72]

69. AECL archives, C9-les5\3.3.5.vol6a, memo from McDonnell to Cowper, 2 Feb. 1990.
70. AECL archives, C9-les5\3.3.5.vol5f, memo from Keating to Bancroft, 7 Sept. 1989.
71. Ibid.
72. One check was skipped on the day of the National Assembly elections, a total of 50 checks were skipped between the two plants during the Olympic and Para-Olympic games.

KEPCO maintained that the checks were not urgent, and any dip in power during these events would have been extremely disruptive and embarrassing to the Korean government.[73] Fortunately for AECL, although Wolsung-1 also put off safety checks for similar reasons, station management had obtained the approval of the local Atomic Energy Bureau inspector prior to doing so, and as a result they were not mentioned in the press articles or in the Atomic Energy Bureau complaint.[74]

The second critical event occurred during an attempted "rescue" effort with the Korea Heavy Industries and Construction company, KHIC. KHIC was a government company that employed approximately 6500 people and specialized in the manufacture of power generating facilities for the government utility KEPCO. KHIC was heavily in debt (estimated at approximately 421 billion Won, or approximately $650 million Canadian), and the Korean government decided to privatize the company through an open bidding process between Korean industries.[75] The bidding started with four companies, and was quickly narrowed down to two major bidders, Samsung and Hyundai, and a smaller company, Korea Chemical.

Korea Chemical was disqualified from the bidding when it was discovered that the president of the company was the brother of one of the founders and senior board members of Hyundai. Then, at the last minute, Samsung withdrew from the bidding process, citing the huge debt load of KHIC as the stumbling block.[76] Within a day allegations emerged that Samsung and Hyundai had collaborated on the withdrawal of Samsung from the bidding. Supposedly, the president of Hyundai had contacted Samsung and asked it to withdraw at the last minute, which would spoil the bidding process entirely. Hyundai's motivation in this deal was a condition put on the sale by the government, namely that the successful bidder would have to "finance the purchase by selling its subsidiaries" in order to keep either of the already huge companies from getting bigger. Hyundai denied the allegations.[77]

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73. AECL archives, C9-les5\newsart, Korea Herald article, "MST Accuses Power Company of Neglecting N-Safety Checks," 12 November 1989.
74. AECL archives, C9-les5\3.3.5.vol5h, computer message from Keating to Lawson and LES group, 20 November 1989.
75. AECL archives, C9-les5\newsart, Korea Times article, "4 Companies Apply for KHIC Bidding," 14 November 1989.
76. AECL archives, C9-les5\newsart, The Korea Times, "KHIC Privatization Aborted as Samsung Bolts from Bidding," 18 November 1989.
77. AECL archives, C9-les5\newsart, Korea Herald, "Samsung, Hyundai, conspired to scuttle bidding for KHIC," 19 November 1989.

The truth of the allegations against KEPCO and Hyundai aside, they were another setback for AECL. Any nuclear project in Korea relied upon local industry and government cooperation, and public support. The government utility had been charged by another branch of government with negligence at two of its nuclear facilities. A company that supplied KEPCO, KHIC, was deep in debt and considered economically undesirable by two of Korea's most prominent industrial powerhouses. Public distrust in the government, and public suspicion surrounding the power industry, undercut public approval for a SES sale.

The Korean Response: Back in Business

After this poor public performance, the Korean government came back to AECL ready to do business. Although KAERI had previously agreed with KDHC that a precondition of sale for the SES was a successful commercial unit demonstration in Canada, it now withdrew that requirement. It did not, however, withdraw its requirement that the reactor be licensed in Canada first. MOST, who were previously responsible for bringing a legal action against KEPCO, made a public announcement in an annual report to the President that it would be pursuing a joint development program with AECL to build a SES for the 1993 International Industry and Trade Exposition. MOST cited a budget of $34 million (US) for the project.[78]

KAERI's renewed interest was not lost on AECL, and a meeting was organized in Korea for April. The meeting, which included several hours with KAERI president Dr. Ham Pilson, went exceedingly well. Pilson mentioned that the use of liquefied natural gas in district heating initiatives put the SES in a favorable position, as it was fairly expensive in Korea. He even suggested the possibility of the Korean Energy Ministry "adopting" the SES as a "national fuel" for district heating purposes. This sort of exclusivity was exactly what AECL was hoping for.[79]

One thing was clear from the meetings with all KAERI staff, in addition to an expected doubling of the cost of heating in Seoul due to a switchover to natural gas,[80] "towns that could use the SLOWPOKE Energy System are being built without us because we are not ready yet. In other words, hurry up, the market is there now."[81]

78. AECL archives, C9-les5\3.3.5.vol6a, memo from McDonnell to Cowper, 22 Feb. 1990.
79. AECL archives, C9-les5\3.3.5.vol6b, memo from McDonnell to Lennox and Rummery, 11 April 1990.
80. AECL archives, C9-les5\3.3.5.vol6g, The Korea Times, "Apt. Heating Bills to Double This Winter, Fuel Switch Ordered to Less Polluting LNG," 8 November 1990.
81. AECL archives, C9-les5\3.3.5.vol6d, Korea Trip Report (emphasis in original), 11 April 1990.

There were, however, concerns with KAERI's renewed interest, no least amongst them was the possibility of "unintended technology transfer" if the Koreans were technologically advanced enough to reverse engineer the reactor from the prototype unit. This concern emerged after discussions with other KAERI representatives revealed an apparent lack of interest in commercializing the technology with AECL beyond the first unit. It seemed that AECL would provide the first reactor and then KAERI would build the rest, using AECL for consulting, operations and maintenance services, as well as fuel. AECL's experience with the copying of the SLOWPOKE research reactor suggested that KAERI might copy the design and then gradually phase out AECL.[82] Still, the market was large, and the desire to secure a commercial prototype overwhelmed concerns over the technology being copied at a later date.

AECL's Side of the Deal: Negotiation, Licensing and Joint Ventures

A lucrative market was available, KAERI was alongside as a potential partner, and AECL had made significant links to the industrial and nuclear infrastructure in South Korea. The company had good reason to pursue the South Korean market for its first successful international SES sale. In order to make this sale happen, it had to organize the South Korean initiative to deal with potential bottlenecks.

Even if there was a short term market for district heating, and a favourable relationship between the Korean government and AECL, this was still a competitive process with long-term marketing and business goals to be considered. Mitch Ohta, the engineering and projects manager for the SES, sent several memos to Al Bancroft in the summer of 1991 expressing concerns with AECL's negotiating position in Korea.

His first concern was the lack of direct knowledge of the Korean nuclear market in the SES project. The company had relied upon periodic visits to Korea, and the substantive input provided by representatives from AECL CANDU in Seoul. However, as it was about to enter into a more complex negotiation of long-term contracts and joint venture agreements, more than just information was needed. Its AECL CANDU contacts were occupied with Wolsung-I operations and the Wolsung-II bid, and they were not familiar with the project specifications for the SES.[83]

82. AECL archives, C9-les5\3.3.5.vol6b, memo from McDonnell to Lennox and Rummery, 11 April 1990. There were also concerns over what appeared to be unduly optimistic cost estimates by KAERI on siting proposals. Further investigation revealed that low Korean labor rates were the culprit. See AECL archives, newc19-162\1420-3-6v7b, memo from Joubert (CANDU Ops) to Kay, 10 July 1990.

83. AECL archives, newc19-162\1420-3-7v7c, memo from Ohta to Bancroft, 24 July 1991. This sort of marginalization of the SES project at the Crown Corporation (e.g. SES

Ohta's second concern related to the structure of the agreement with KAERI. He pointed out that AECL seemed too eager to define a business relationship with the Koreans before technical work was complete. AECL representatives such as John Barclay and Victor Snell[84] had pushed too hard to finalize various commercial aspects of the project as they were "project oriented people" and thus more concerned with project definitions and commercial agreements than with design, something that did not work well with their "research oriented" Korean partners.[85] Given that different Korean partner organizations (KAERI, KDHC) had requested a successfully licensed Canadian commercial prototype SES as a precondition of a business relationship with AECL, Ohta's concerns seem justified.

Licensing itself was another potential bottleneck. There were no guarantees that a successful license in Canada would mean a license in Korea as well. In the past Korea had taken successful licensing in Canada plus a letter from the AECB as sufficient. Wolsung-I, various research reactors, and later Wolsung-II, were licensed in this fashion.[86] However, the SES was a new reactor design, and the Wolsung reactors were CANDU-6 designs, with many years of successful operating history behind them.

Responding to these concerns, the licensing manager for the SES, Victor Snell, pushed for finalization of reactor design parameters as soon as possible. Late stage design changes for the SES (in the passive shutdown system and the riser duct) had been considered in order to make the reactor licensable in certain European countries (Hungary, Czechoslovakia and Romania), but Snell argued that these changes would only

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personnel were informed about AECL CANDU, but not vice versa) was endemic, it was a contributor to the slow technical progress of the project. See Slater, "The Bungling Giant" and Slater, "Atomic Energy Canada Limited and Next Generation Nuclear Reactors," for more on this.

84. John Barclay, formerly of CANDU OPS, was the overall Project Manager for SES construction, development, engineering, fuel, licensing and safety. Victor Snell was the Licensing Manager for the project.

85. AECL archives, newc19-162\1420-3-7v7c, memo from Ohta to Bancroft, 24 July 1991. Interestingly, one of the key weaknesses of AECL, according to both industry insiders and historians, has been their inability to transcend their origins as a research and development organization and become a competitive commercial enterprise. This interpretation is clearly flawed. The history of the SES project demonstrates that AECL prioritized the business case over the technical case consistently, demonstrating the reality of competitive pressures on government despite public ownership. See Slater, "The Bungling Giant" and Slater, "Atomic Energy Canada Limited and Next Generation Nuclear Reactors," for more on this.

86. AECL archives, 1420-1v33, memo from Ohta to Campbell, Hilborn, McDougall, 4 June 1991.

hold up the licensing process for viable current clients like Korea. Committing to a design and moving forward with the AECB was considered to be the best route to a Korean sale.[87]

A final potential bottleneck was the precise nature of the business agreement between the two organizations. Snell argued that AECL should model the agreement on a previous contract between AECL and KAERI for the KMRR. In this agreement, AECL was paid $2.9 million for "transferring the conceptual design technology" and $22.6 million for "designing and supplying the reactor."[88]

Snell suggested a research reactor contract as a potential model for the reactor sale, rather than a power reactor model. In the case of power reactors, profits are made through long-term fixed fuel price contracts and generous estimates of capital costs, as fuel is the cheapest element in the technology, and capital costs tend to be higher than initially estimated.[89] Smaller research reactors often offer "black-box" contracts, as production and manufacturing costs are manageable, and the technology is more reliable. Black-box contracts encourage up-front profits by providing a completed technology ready for installation and operation by the client, rather than using the partnership as an opportunity for further development. In this model, AECL's partners absorbed the relatively minor SES project costs, namely manufacturing and installation.[90]

Ohta pushed for a joint venture with a Korean company, and rejected the black-box option. A joint venture was a necessity in Ohta's eyes as:

a) It would draw on AECL's good reputation in Korea
b) It would provide some financial resources for AECL from the local partner
c) It would provide technical resources for AECL from the local partner

87. AECL archives, newc15-161\1420-3-5v2b, memo from Snell to LES Team, 31 July 1991.
88. AECL archives, newc19-162\1420-3-7v7d, memo from Snell to Bancroft, 7 August 1991. A fee was attached to transferring the conceptual design due to a policy initiated in the late 1980's by AECL Research President Stan Hatcher. Hatcher felt that AECL needed to become more commercially oriented by charging separate and significant fees for technical and scientific research done in-house. For more on this, see AECL archives, Stanley R Hatcher, President AECL Research, "The Role and Future of The Research Company, A Presentation to the Privy Council Task Force on AECL Internal Review," 21 July 1988.
89. Fuel costs are comparatively low to capital and operation costs for nuclear reactors, so a long term fixed price fuel contract can work to the advantage of both client and supplier. The incentive for clients is that they have insurance from fossil fuel price increases. For AECL more revenue is generated from the component of the sale that generates the smallest profit.
90. Keep in mind that the SES was not expected to need a reinforced or pressurized containment building.

These were immediate benefits, but the joint-venture would also involve close technical cooperation, and thus close monitoring of the technology transfer to ensure that the SES design was not appropriated by the Korean partner.[91]

There were other subsidiary concerns with a joint venture. There was the possibility that the technology would cease to be identified as Canadian if the Korean partner was sufficiently involved in the project, and visibility to the market was important at this stage of the project, with no commercial prototype in existence. Finally, Ohta stressed that the strong business orientation of the Korea sale could lead to the selection of a partner that "may meet marketing needs without sufficient project management and project engineering skills, construction and civil work experience."[92]

The End of the Road

KAERI came to the table in late 1991 with a solid proposal for AECL. It was interested in developing nuclear power as a general district heating technology, in order to meet MOST demands to reduce oil consumption. It proposed a partnership with AECL on the construction of an SES at Daeduk, to be completed by 1995.[93] This was a solid offer that would presumably result in a commercial prototype, one desperately needed by AECL as several of its other opportunities had fallen through.[94]

By January of the new year, things began to unravel. Funding opportunities on the Korean side were proving elusive. The minister of MOST put a freeze on funding for nuclear district heating, due to recent violent demonstrations over the siting of nuclear power plants. Until a satisfactory site could be located, funding was frozen.[95]

The appointment of a new president at KAERI had led to staff reorganizations at the company, reorganizations that had left no individual or group in the company specifically dedicated to the SES project or to district heating technology in general. Budget overruns on the KMRR, in addition to extensive project delays, had tarnished AECL's local reputation for delivering projects on time and on budget.[96] By the end of the year the SES had been abandoned by AECL as a product, and the Korea initiative was dropped with it.

91. AECL archives, newc14-les7\jointvent, fax from Ohta to Nieman, 30 August 1991.
92. Ibid.
93. AECL archives, newc19-162\1420-3-7v7e, memo from Barclay to P. Campbell, D.S. McDougall, M.M. Ohta, 2 December 1991.
94. AECL archives, memo from Barclay to LES Group, 24 December 1991.
95. AECL archives, newc19-162\1420-3-7v8a, meeting Pacific Palasades Hotel Vancouver, minutes, AECL and BC. Park (Korea Consultant–President of KDHC), 17 Jan 1992.
96. Ibid.

Contingent Factors in the South Korean Sale of the SES

A number of contingent factors contributed to the failure of the South Korean initiative. First, there were good reasons to believe that the SES might be copied. The Koreans were already familiar with CANDU technology through KEPCO and Wolsung-I, and CANDU design expertise had been incorporated into the SES (e.g. fuel bundle design). The SES was small-scale and much simpler than the CANDU, and thus easier to copy. Further, South Korea had demonstrated its ability to develop independent nuclear technology when it purchased unprocessed uranium from the Australians. Conflicting signals from Korean partners over the details of long-term partnerships signalled the possibility that they might intend to partner with AECL for the first few reactors, and then design their own version. Feasibility studies with other small nuclear suppliers fed this suspicion. Added to all of this was the fact that AECL had to rely on a Korean partner to do the local engineering and manufacturing work if a sale was ever made. Information transfer to Korean partners was restricted, and reactor contracts were structured to maximize up-front profits in the event that the technology was copied and the market was lost.

Public resistance to nuclear technology was also a factor in the South Korean SES sale, but an indirect one. Public resistance to government initiatives was new to South Korea, and the assumption was that the kind of resistance experienced with large-scale nuclear power would be applied to the SES. The South Koreans monitored the Canadian situation closely, and when public resistance emerged in Sherbrooke and Saskatchewan, they took it as a sign that Korean sales also have problems. Korea was experiencing labor unrest and violent public demonstrations. In this context, the SES was associated with the sort of violent protest that had never occurred in Canada.

These concerns led various South Korean partners to make demands that AECL could not meet at that time. A completed commercial demonstration of the technology and successful Canadian licensing were both required. The South Korean government was concerned about giving the growing anti-nuclear movement fodder for public resistance to further nuclear development. The safety-check scandal at KEPCO and the fiasco over the KHIC sale further reduced Korean tolerance for controversy with new nuclear technology. This was clearly demonstrated when MOST froze funding for nuclear district heating until public acceptance could be assured. South Korea wanted a technology that would be reliable, safe and economical before presenting it to the potentially hostile public. This required a demonstration of the technology at the requisite power level.

It is not quite right, however, to say that public resistance to nuclear power was a significant problem for the SES in South Korea. First of all, the "resistance" was entirely from the government, in anticipation of future public resistance to the SES. It was not known if something as small as the SES would have triggered violent protests of the kind that so intimidated KAERI. Secondly, the demand for a working licensed prototype was not only made to deal with public resistance, there was also the matter of wanting a safe reactor. The South Korean government was willing to do business with AECL as long as it had a licensed, operating product; public resistance to that product was still an unknown.

Impact of Commercial Factors in the South Korean Sale of the SES

Beyond these contingent factors, there is a more basic issue at stake in the South Korean story, one that is especially important if we are to understand the nature of innovation at state-owned commercial enterprises in Canada and abroad. Time and again, AECL's focus on the commercial side of the South Korean initiative was a stumbling block. Rather than coming forward with a completed prototype design and looking for clients, AECL sought to develop the basic design by first securing commercial partners. This approach led to various difficulties: concerns over partners copying the technology, licensing complications and reluctance on the part of South Korean partners to move forward until designs were finalized and the efficiency of a new technology was demonstrated.

However, AECL is a crown corporation, and the economic and policy literature on state ownership versus private ownership suggests that this sort of unitary focus on commercial goals by a crown corporation is unusual. It is generally regarded that state owned enterprises pursue "multiple and often blurred or ill-articulated objectives"[97] due to their prioritization of "social welfare goals."[98] For example, limiting unemployment, resisting foreign capital, subsidizing goods and services, integrating community, extending services, promoting protectionist policy, maximizing output, eliminating price discrimination and regional development have all been cited as examples of non-commercial goals pursued by state-owned enterprises.[99] The assumption is that "public

97. Stephen Martin and David Parker, *The Impact of Privatization, Ownership and Corporate Performance in the UK* (London: Routledge, 1997), 9.
98. David Parker and David Saal, *International Handbook on Privatization* (Cheltenham: Edward Elgar, 2003), 29.
99. See for example, Matthew Bishop, John Kay and Colin Mayer, *Privatization and Economic Performance* (Oxford: Oxford University Press, 1994), 35; Martin and Parker,

enterprises' association with the state shelters them from the discipline of market forces,"[100] allowing state-owned enterprises to set aside commercial concerns in favor of these broader social goals. Clearly this was not the case with AECL.

What could explain AECL's decision to focus on commercial priorities in this case? One possibility is that AECL was pursuing export markets, thus short-circuiting the normal social welfare goals associated with crown corporations, goals which are often national rather than international. Indeed, Duane Bratt's recent study of AECL's pursuit of export markets for the CANDU provides a possible context for the South Korean case. Bratt shows that various factors have shaped the fate of CANDU exports since the inception of AECL in the 1950's: the need to contain the spread of communism, concerns about nuclear proliferation, restrictions on sales to countries with records of human rights abuse, concerns over environmental impacts, and concerns over the extent of government subsidies to the nuclear industry.

Bratt claims that economic concerns, the containment of communism, and proliferation concerns have been far more prominent factors in CANDU exports than concerns over human rights, environmental impacts, and nuclear industry subsidies. He explains this using Cranford Pratt's dominant class theory: decisions related to the Canadian nuclear issues are heavily influenced by the pro-nuclear lobby, composed of members of Canada's dominant class. Thus, the concerns of that class—economic, proliferation and containment concerns—were primary (at different times and to different degrees), and the concerns associated with other classes (human rights, the environment and subsidies) were marginalized. This analysis goes some way to explaining the results in the South Korean case. Still, if his analytic framework is correct, then there should have been three factors influencing SES sales in South Korea, not just one. Why were proliferation and containment concerns not significant in the South Korean case? Two explanations suggest themselves.

With respect to the SES, its smaller scale and minimal fuel enrichment meant that it was a minimal proliferation risk. Even if the fuel core of the SES was removed and the uranium extracted, it would have proven impractical to attempt to enrich the fuel to weapons grade. With respect to the containment of communism, South Korea was not a communist

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The Impact of Privatization, 77; Jacek Tittenbrun, *Private Versus Public Enterprise: In Search of the Economic Rationale for Privatization* (London: Janus Publishing, 1996), 59; Allan Tupper and G. Bruce Doern, *Public Corporations and Public Policy in Canada* (Ottawa: Institute for Research on Public Policy, 1981), 11, 12, 27, 32.

100. Tupper and Doern, 24.

state, and there was no real risk of the SES technology falling into communist hands, and little consequence if it did. Thus the design of the SES itself obviated both of these concerns, leaving only economic concerns behind.

The other possible explanation for the dominance of economic concerns in the SES sale to South Korea is that the standard view of state-owned enterprises presented above is flawed. I have argued elsewhere for this conclusion.[101] In short, governments around the world have applied neo-liberal policies to state run organizations, attempting to apply the 'discipline of market forces' mentioned above to the business of the state. As a result, state owned corporations have become more and more like profit oriented private sector organizations, making the standard picture of government run industry appear increasingly antiquated.

Canada was no exception to this general trend, with the Canadian government enforcing fiscal discipline, commercial goals, and outright privatization on state owned enterprises. For example, between 1985 and 2003 the federal government in Canada privatized over $10 billion in public assets;[102] from 1986-2002, over $13 billion worth of provincial assets were privatized.[103] Writing in 1981, Tupper and Doern argued that the commercial focus of crown corporations had increased in importance "in recent years."[104] Doern and Phidd also cite the use of expenditure cutbacks, deregulation and privatization by the Canadian government to achieve a greater focus on profit and commercial competitiveness.[105]

AECL was a part of this larger trend. It has not been privatized (though every few years the suggestion is floated), but other tools have been used to shift its focus to commercial priorities. As early as 1978 AECL oriented itself towards greater competitiveness by adopting a "business unit" model used by successful US firms in order to create new businesses from existing technology.[106] The SES project was located within such a division, the Local Energy Systems Business Unit. Babin locates the shift to "commercialization and promotion" at AECL even earlier, in the mid-

101. See Slater, "The Bungling Giant" and Slater, "Atomic Energy Canada Limited and Next Generation Nuclear Reactors."
102. Parker and Saal, *International Handbook on Privatization*, 131.
103. Ibid, 137.
104. Tupper and Doern, 22.
105. G. Bruce Doern and Richard W. Phidd, *Canadian Public Policy, Ideas, Structure, Process* (Scarborough: Nelson Canada, 1992), 141.
106. Donald G. Hurst, ed., *Canada Enters the Nuclear Age: A Technical History of Atomic Energy of Canada Limited as Seen From its Research Laboratories* (Kingston: McGill-Queens, 1997), 411.

1960's.[107] AECL also experienced phased budget cuts in the 1980's, with the express purpose of forcing the company to behave in a more commercially oriented fashion.[108]

The larger project of assessing the extent and impact of neo-liberal policies on state owned enterprises is beyond the scope of this article, but it seems clear that the South Korean SES sale is a good example of the reality of these policies on the ground. The South Korean experience also suggests that future attempts to promote next-generation nuclear technology (by AECL and others) might benefit from a decreased focus on commercial goals. The road to approval for new nuclear designs will be long, with conflicting licensing regulations in different countries, and the need to secure partnerships and negotiate multiple demands that will influence design. The SES represents a straightforward example of the innovative costs associated with the choice to let "the market" shape the development of next-generation nuclear technology.

107. Ronald Babin, *The Nuclear Power Game* (Toronto: Black Rose Books, 1985), 61.
108. Hurst, *Canada Enters the Nuclear Age*, 37.