INDUSTRY AND SCIENCE: POSCO AND POSTECH CASE*

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Abstract

Pohang Iron and Steel Company (POSCO) is a world-leading steel company, established in 1968 in Pohang, on the southeast coast of Korea [1]. In order to attract top talent to its remote location, POSCO decided to invest in education, establishing a small-sized university, Pohang University of Science and Technology (POSTECH), in 1987 [2]. POSTECH, in turn, soon decided to construct Pohang Light Source (PLS), a third generation synchrotron light source of 2.0 GeV, with support from POSCO [3] and the Korean government. Although only a few decades old, POSTECH is now considered a top university in the world. PLS was upgraded to 3.0 GeV in 2011, and a new PAL-XFEL of 10.0 GeV is now under construction. POSCO's consistent support has been the key to the continuing success of POSTECH and PLS. This is an unprecedented example of such a close relationship between industry and science.

INTRODUCTION

After the Korean conflict of 1950-1953, little was left but a country full of refugees living in poverty among ruins. To rebuild the country, President Park Chung-hee started modernization projects with an emphasis on infrastructure, such as highways and heavy industries, including the steel, heavy machinery and petro-chemical industries. One such project was the Pohang Iron and Steel Company (now known as POSCO), which started in 1968, and soon proved very successful. As the company grew, its pioneering leaders began to think about how to attract more experts and intellectuals to the small city of Pohang. As a result, they established a world-class university, Pohang University of Science and Technology (POSTECH) in 1987.

POSTECH was also remarkably successful, recruiting top faculty members and students. To continue to attract more technologists, POSTECH proposed building a world class user's facility on its campus, Pohang Light Source (PLS) in 1988, not only for campus researchers but also for national users.

PLS was the first large-scale scientific facility in Korea, receiving financial and administrative support from POSCO. When it was determined early on that even more funding was required for a 2.0-GeV third generation light source with a full-energy injector linac, this funding was obtained by securing support from the government.

This chain of events was the result of a vision for developing the nation and for contributing to the world.

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POHANG IRON AND STEEL COMPANY (POSCO)

One of President Park's top-priority modernization projects was the building of a steel works in the coastal city of Pohang. He appointed Mr. Park Tae-joon, shown in Figure 1, to be the Chairman of POSCO.

Chairman Park's accomplishments were nothing short of miraculous. Starting with no land, no funds, no technology, and no experts, only skeptical reports and pessimistic critics, he built a blast furnace with a 1-million-ton annual capacity, the country's first in 1973. POSCO was profitable even in its first year of operation. As steel is a critical basic industry, this was an important milestone in the modernization of Korea.

Figure 1: Chairman Tae-joon Park delivers a speech at the ground-breaking ceremony for PLS on April 1, 1991.

Figure 2: POSCO Steel Works in Pohang (top) and Gwangyang (bottom).

POSCO has since achieved many remarkable successes in the steel industry. When the Pohang Works site became saturated with four blast furnaces, producing 9.1 million tons in 1981, POSCO prepared a new site of 14 million

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m^2 in Gwangyang, which opened in 1985. Production capacity at Gwangyang, shown in Figure 2, grew to 20 million tons in 1993 and eventually to 37 million tons in 2012. POSCO is now the 4^{th} largest steelmaker in the world, and has been named the most competitive steelmaker by World Steel Dynamics for four consecutive years. Recently, POSCO developed a groundbreaking new steelmaking process called FINEX, which eliminates the coke-making process. The first commercial plant using this process is now in operation.

During the expansion period of the 1970s, POSCO realized that recruiting R&D staff to come to Pohang was very difficult. Without infrastructure, especially in higher education, experts were reluctant to move to a small city hours away from the national capital. POSCO had already built excellent elementary schools, and a secondary school that was one of the best in country. Thus, the next step was to establish an excellent university. It was decided that it should be a small, scientifically-oriented university, in keeping with the mission of POSCO, but also that it should become a world-class university.

POHANG UNIVERSITY OF SCIENCE AND TECHNOLOGY (POSTECH)

POSCO Chairman Park met with Professor Hogil Kim, shown in Figure 3, in August 1985 to discuss establishing a new university. Chairman Park asked Prof. Kim, a physicist, to first set up the university, after which he would support Prof. Kim's vision of building of an accelerator.

Prof. Kim established POSTECH on December 3, 1986. He constructed a campus, recruited faculty members, and solicited applications from top-class students in the fields of science and engineering. The first class of admitted students were within the top 1% of students in the nation. The new university was deemed a great success, with classes beginning in March 1987.

Figure 3: Prof. Hogil Kim, POSTECH President.

As of 2012 POSTECH has eleven departments, four in science and seven in engineering, and about 270 faculty members and more than 700 research staff members, excluding the accelerator laboratory. The total number of students is now 3,100; 1,300 undergraduate and 2,100 graduate students. Still a highly competitive school, POSTECH admits a small class of 300 freshmen every year.

While POSCO has its own research unit at Pohang Works, it additionally sponsors the Research Institute of Science and Technology (RIST) on the POSTECH campus. The founders envisioned a campus with teaching and research adjacent, as shown in Figure 4.

Figure 4: POSTECH and RIST Campus.

POSTECH was the first research-oriented university to stimulate the modernization of higher education in Korea. In a 2012 ranking by Times Higher Education (THE), POSTECH took first place in the world among young universities less than 50 years old, as shown in Table 1.

Table 1: World University Ranking in 2012 by THE

WUR: World University Ranking, U50: Under 50

Ranking		University	Country / Region
U50	WUR		
1	**53**	**POSTECH**	**Korea**
2	46	École Polytechnique Fédérale de Lausanne	Switzerland
3	62	HKUST	Hong Kong
4	86	University of California, Irvine	United States
5	94	KAIST	Korea
6	84	Université Pierre et Marie Curie	France
7	110	University of California, Santa Cruz	United States
8	121	University of York	United Kingdom
9	131	Lancaster University	United Kingdom
10	145	University of East Anglia	United Kingdom

Recently, POSTECH's graduate school was strengthened in the area of materials research with the establishment of Graduate Institute of Ferrous Technology (GIFT) through a large of endowment from POSCO. This is yet another good example of cooperation in research between POSTECH and POSCO.

POHANG ACCELERATOR LABORATORY (PAL)

In order to cement POSTECH's status as a competitive university, POSCO Chairman Park and POSTECH President Kim decided to construct a third generation light source, PLS, on its campus. The project started on April 1, 1988 with POSTECH providing faculty members and POSCO contributing $100M (US), an amount comparable to the budget for building the Advance Light Source at Lawrence Berkeley Laboratory. The beam energy was set at 2.0 GeV with an option to upgrade to 2.5 GeV. As a full energy injector, PLS was to be a full-energy linac, since high-power klystrons of 60-80 MW were commercially available as well as the pulse compressor, and the SLED cavity. These could increase the available energy by a factor of 2.5 compared to existing linacs. In other words, the number of RF units was dramatically reduced and the total length was also reduced at the same rate. This allowed the cost of construction to be comparable to that of a booster injector at 2.0 GeV. It also made possible later energy upgrades to 2.5 GeV and 3.0 GeV while keeping the same tunnel. All the while, plan for a future Free Electron Linac (FEL), as shown in Figure 5, was kept in mind.

When the design team completed the detailed design, it became clear that the cost would be double what was originally expected, mainly due to conventional facilities. The design called for more land, which would require evacuating villages, moving earth, and bringing electricity from 8 km away and constructing 27 transmission line towers. This caused the project to be temporarily halted until funding issues could be resolved. Prof. Kim succeeded in obtaining the rest of the construction budget from the central government, through the Ministry of Science and Technology. The resulting collaboration between government and a commercial company to fund construction of an accelerator at a private university is unique in the world.

PLS was also fortunate to collaborate closely with other laboratories, such as IHEP (Beijing), LBNL, KEK, BNL, and others. On December 9, 1994, PLS commissioned the machine on time with Korean President Kim Young-sam attending the ceremony.

POSCO's contribution to project management, conventional facilities, and budget were key to the success of the initial PLS Project. As the project continued, issues of operating budget and beamline construction arose. The project is now mainly funded by the government with supplementary support from POSCO, at a ratio of about 80:20.

Since the injector linac had room to increase its energy to 2.5 GeV by increasing RF power, the storage ring has been operating with more beamlines since 2001. It became an X-ray machine from an extended VUV machine. A major upgrade program, PLS-II, was undertaken in 2009-2011 to increase its energy to 3.0 GeV with 30 beamlines. The injector linac in the same tunnel used more klystrons, and six RF units fed two accelerator sections instead of the traditional four accelerator sections. The storage ring was completely changed from TBA to DBA lattices. The RF cavities were also changed from normal conducting to superconducting cavities. It makes 20 insertion devices available and finally, the top-up operation is now the basic operational mode.

Figure 5: 3.0- GeV Pohang Light Source on PAL Campus.

While an FEL of 0.3-0.1 nm by modifying the existing injector linac to 3.0 GeV and using the third harmonic enhancement technique was proposed in 2003, the user community wanted to have a new XFEL of 0.1 nm. The government approved this new proposal with a budget of U$ 400M in 2010. The artistic view is shown in Figure 6.

Figure 6: Artist's view of 10-GeV PAL-XFEL.

Due to the available length at the existing site, a C-band linac was considered, in order to reduce the machine length by a higher accelerating gradient. However, it was decided to use a new site that is 1.1 km long by flattening hills along a ridge along the northeast edge of the current site, and to build the traditional S-band linac. It is expected to be completed in 2015. Again, POSCO Engineering & Construction is in charge of conventional facilities. For this project, all construction funds come from government. POSCO and POSTECH are not able to match funds due to the size of the budget. The local governments of the city of Pohang and Gyeongbuk Province will contribute supporting facilities of guest

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houses and the visitor center. Since all construction and operating costs are provided by government from 2013, the facility will become a government institute in the near future. Figure 7 shows the state of construction as of May 2013. The ground breaking ceremony was held on May 9, 2013 as shown in Figure 8.

Figure 7: Site preparation for 10-GeV PAL-XFEL in May 2013.

Figure 8: Ground-breaking ceremony for PAL-XFEL on May 9, 2013.

OTHER SCIENTIFIC PROJECTS

Shortly after PLS was commissioned, Hanaro, a research reactor funded by the Korean government, began operation at Korean Atomic Energy Research Institute (KAERI). With the success of these two large-scale scientific projects, the government was convinced that scientists would be able to undertake mega science projects. A super-conducting tokamak known as the KSTAR project was launched for fusion energy research. It became one of the leading facilities in the world, allowing Korea to join in the ITER project. Korean scientists are now preparing the next fusion machine, K-Demo, for an energy production machine to follow ITER.

More projects continue to follow, such as KOMAC, a high power proton linac, and RAON, a rare isotope facility using the Isotope Separation on Line (ISOL) and the In-flight Fragmentation (IFF) methods. In addition, a carbon therapy machine is under construction in Busan.

SUMMARY

The following slogan greets visitors from atop the main gate of Pohang Works: "Resources are Limited, Creativity is Unlimited." Korea has almost no natural resources, but the hard work and creativity of the Korean people have led to many successes. It is not easy to attract the best and brightest to a small city like Pohang, but by building an elite research and educational institution, along with a high-tech light source, Pohang has became a desirable destination, growing from a population of just 70,000 to half a million in two decades. In just 25 years, POSTECH has become recognized as one of the world's top universities, with world class facilities and top-notch faculty and students.

ACKNOWLEDGEMENTS

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[1] POSCO website, http://www.posco.com
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