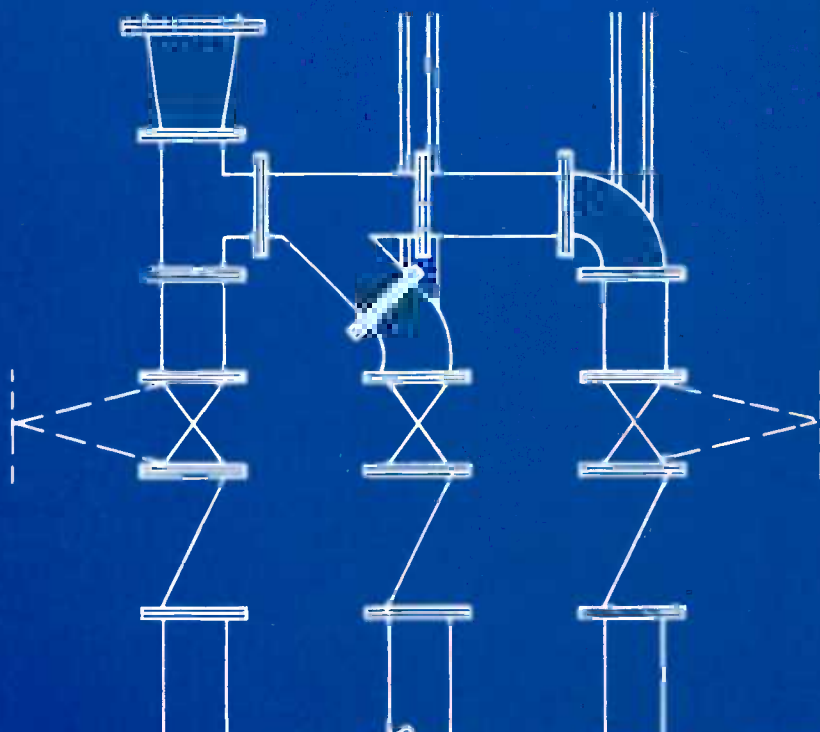


Consulting and Engineering Design in Developing Countries

Edited by Alberto Aráoz



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CHAPTER 4

BUILDING NATIONAL CONSULTING ENGINEERING IN THE CHEMICAL INDUSTRY: A CASE STUDY IN BRAZIL

SERGIO ALVES AND RICARDO BIELSCHOWSKY

SUMMARY

Brazil is building up technical capabilities in areas of modern technology such as petrochemicals. This case study deals with NATRON, a private CEDO in this field, and focuses on the process technology acquisition and the state support for it. NATRON was founded in 1967 by a group of chemical engineers from PETROBRAS, the state petroleum company. It started life, therefore, with a set of highly qualified professionals, who had good connections with the expected main client, PETROBRAS. An explicit strategy was adopted regarding the areas to be covered, the types of services, and the technology to be acquired. The two principal areas were petroleum refining and phosphate fertilizers. The first one had to be left aside because PETROBRAS founded its own captive C&E capacity.

Three stages are shown in NATRON's development: (1) 1967–71: rapid growth; many small projects; peripheral installations. The staff grew to 172. In terms of technological learning, little progress was made in sulfuric acid; NATRON had a full-disclosure licencing agreement with a U.S. producer, and it undertook two turnkey sulfuric acid projects. (2) 1972–75: sales multiplied by five, staff by three. Contracts became larger. In 1975 NATRON took up a sulfuric acid project for SULFAB, a firm controlled by NATRON itself. Technologically, in this period it consolidated its sulfuric acid know-how by working on three projects and particularly through the creation of its Department of Industrial Processes (DIP). This is seen as an important step toward acquiring the know-how of the phosphate fertilizers complex. The main clients were two large state enterprises, which chose NATRON because they considered it as a technically capable firm. Although the rate of expansion was high, there were limitations to technological progress. There was not enough repetitive work, and more importantly, NATRON mainly worked as a subcontractor to foreign CEDOs, which gave it little bargaining power and did not allow it to obtain the full-disclosure clause that was needed to fuel a learning process in basic engineering. (3) 1976–present: a new stage has been entered, with a few large projects, of higher technical sophistication. There has been a concentration in the phosphate fertilizers area and a beginning in chlorine–soda production as a first step in the pulp and paper area. The staff increased from 583 in 1975 to 1184 in 1977, and the firm now feels it is able to “carry out all stages of engineering for productive units related to phosphate fertilizers.”

Two important policies of NATRON were to retain its personnel, thus minimizing turnover, and to apply regularly a good part of its profits for the expansion of technical staff ahead of new tasks. The major investment in technology has been in phosphate fertilizers. The efforts have been successful, as shown by the prestige obtained and the recent contracts awarded. The firm has a clear determination about technological learning and a good sense of entrepreneurial opportunities. It chose an area of rapid growth where technological

autonomy was within reach of a medium-sized CEDO and adopted an adequate path for technological learning, from the simple to the complex. It started with sulfuric acid and should have gone on to phosphate fertilizers but a good opportunity was seized for mastering "ahead of time" the technology of phosphoric acid. By mid-1978 the firm was doing well in both phosphate fertilizers and phosphoric acid, with a group on each in its Department of Industrial Processes.

This report analyzes the successive steps in the mastery of sulfuric acid, which shows the gradual learning process: 1967: technology contract with U.S. firm, with full disclosure; 1968-70: two turnkey projects with the simple-absorption process; 1972: participation in large plant with the double-absorption process; 1973: creation of DIP; technological research program on phosphate fertilizers cycle; by 1975 the double-absorption process mastered; and 1973-75: turnkey project for simple-absorption process; 1975 to present: turnkey project for SULFAB, using the simple-absorption process with provisions for conversion to the double-absorption process; prime contractor for large sulfuric acid plant with German basic engineering; basic engineering, detailed engineering, and management services for a small plant with the double-absorption process; in 1977, same for a large project; in mid-1977 SULFAB started production and provided NATRON with a "permanent laboratory."

The sequence for the mastery of phosphoric acid technology started in 1973 with participation in a project. In 1976, NATRON was prime contractor of a large phosphoric acid project and could open up the package to a considerable extent. In 1977, it was prime contractor in another project, and with the full support of a forward-looking client, it chose a technology that allowed it to have full disclosure.

In the case of phosphate fertilizers, DIP has a unit devoted to study and to the acquisition of experience through reading, visiting plants, analyzing projects, and interacting with foreign experts. The lack of projects has been a retarding factor; however, NATRON has announced it is able to undertake complete phosphate fertilizers projects, including basic engineering.

This report describes the SULFAB project. In line with a clear policy to support and strengthen C&E in this area, NATRON was given a turnkey contract for setting up the plant. Its performance was good: the project was finished on time, almost within the budget, and the operating performance has been good. The participation of local industry, however, was not higher than the usual 25% of the total equipment that is normal in similar projects.

NATRON was helped financially to gain control of SULFAB, and this has meant a strengthening of NATRON and has given it the opportunity to expand C&E activities, draw on its permanent access to production facilities, carry out tests and research, and demonstrate its capacity to prospective customers.

This report underlines the key role of government through its purchasing policy and its financial support policies. This and NATRON's strategy of specializing in technologies that could be absorbed were the principal factors in NATRON's success.

The subject of this case study is NATRON in Brazil, the most important national CEDO specializing in chemical processes. Among the projects it has undertaken, one has been singled out for analysis: the complete design of a sulfuric acid plant for SULFAB, where NATRON saw the successful culmination of its efforts to master all stages of project design in sulfuric acid, which had been one of the principal strategic decisions taken at the time the firm was founded in 1967.

The study examines the steps followed by NATRON to achieve its present stage of development and attempts to identify through the examination of the SULFAB project what is the technical and entrepreneurial level effectively reached at present. It traces NATRON's evolution over the past 11 years regarding its expansion and the services it renders and appraises the strategy of expansion in its chosen field of phosphate fertilizers. Finally, the SULFAB project is analyzed.

BASIC ENGINEERING IN BRAZIL

The mastery of project engineering, and particularly its basic engineering component, seems to be affected by three groups of factors:

- The technological characteristics of the sector served — the universality and complexity of techniques, the technological dynamism, and the importance of technology as a marketing instrument (it is more difficult to attain mastery in techniques that are complex, known by few, highly dynamic, and a key to market control);
- The behaviour of public enterprise on questions of national technological autonomy; and
- The continuity of investments in the sector, the source of funds for expansion, and the level of the capital goods industry in the country.

These basic influences have combined in Brazil in recent years in such a way as to help it attain a good level of technical capability in two sectors, hydroelectricity and railways; in other sectors such as iron and steel, petroleum refining, and petrochemicals, the level is still low.

In hydroelectricity, roads, and railways, technology is largely traditional, and technical information is easily obtained. Local CEDOs predominate and are able to assume global responsibility for a project. In fact, projects have been exported in recent years. Public enterprises have generally adopted a policy of preferring local CEDOs, and in practice this has almost eliminated the presence of foreign-owned CEDOs.

In iron and steel, petroleum refining, chemicals, and petrochemicals, the technology is almost always under foreign control. Foreigners prepare the "basic" project even when a local firm is the prime contractor; the latter, in such a case, will only have — in addition to the opportunity of carrying out detailed engineering design — a better "post of observation" of the basic engineering tasks entrusted to the foreign CEDO. In iron and steel, where technology evolves slowly, the participation of local consulting and engineering in the main units, or the core processes, is usually confined to detailed engineering. The same is true in petroleum refining, chemicals, and petrochemicals, where dependence on foreign process engineering and basic engineering is even greater. In addition, technology in these sectors is highly dynamic, and it is a basic instrument for market control. This fact further restricts the possibility of achieving local mastery of technology.

The building of a national engineering capability in these sectors is of fundamental importance, but the necessary teams have been formed only recently. The most important one is CENPES, within PETROBRAS, the Brazilian state petroleum company. At present, CENPES is concentrating efforts on basic and intermediate units in petroleum refining, ammonia and urea for fertilizers, and petrochemicals. Among the private CEDOs,

NATRON emerges as one of the three or four that are potentially capable of advancing into the areas of process and basic engineering. Its efforts are concentrated in the important field of phosphate fertilizers and their basic inputs, sulfuric acid and phosphoric acid.

EVOLUTION OF NATRON, 1967-78

NATRON was founded in 1967 by a group of chemical engineers from PETROBRAS; 11 years later it had grown into a solid and profitable chemical engineering enterprise, with almost 1300 employees. Three periods may be distinguished in NATRON's evolution: 1967-71, the initial period; 1972-75, when NATRON became medium-sized; and the period starting in 1976, when it became one of the largest CEDOs in the country.

Until 1971 there was a rapid growth, which took place through a succession of small projects. By that year the staff numbered 172. In 1972 sales grew sharply and were multiplied by five in 1975 in comparison with 1971, while staff tripled. The firm was able to create a technical nonoperational group, the Department of Industrial Processes (DIP), which would later show a high indirect profitability. Contracts became larger, and in 1975 participation in SULFAB was assured.

In 1976 a new stage started. The firm went on to work in a small number of large projects. Sales grew 113% in 1977. Staff grew from 583 in 1975 to 1184 in 1977; within this expansion, the highly qualified staff grew more than proportionally, showing a growing technical sophistication of the services rendered. The firm announced that it was able to develop all stages of the engineering services needed for various productive units in its priority sector, the phosphate fertilizers market.

Two more observations may be made. First, an explicit policy of NATRON was to retain personnel and minimize turnover. This policy, which was different from that of other CEDOs in Brazil, contributed to building its technological strength. Second, profits were regularly applied to a selective expansion of the technical staff ahead of new commitments. Whereas at first glance this gives the impression of an increase in current expenditure, it is to a large extent an investment in the most important asset of a CEO. Finally, there has been a high rate of profit in the most recent contracts, and this, compounded by higher sales, has allowed the firm to invest heavily in human and technological capital.

MARKETS AND TECHNOLOGY

The firm's "project book" gives information on 49 projects, 12 of them still in progress. Only small consulting services are left out. The firm's markets are state petroleum and petrochemical enterprises (PETROBRAS/PETROQUISA); users of phosphate fertilizers including sulfuric acid, chlorine and soda, and others. No data were obtained on the value of the projects, but it is clear from general sales information that 1967 projects were small and grew in size over the years.

In 1967-71, there were many small projects for the state firms and "other" markets, covering many types of engineering services for "off-site battery limit." In terms of technological learning, not much progress was made toward basic engineering and process engineering in these various

segments, because such progress would have required continuity in the same or similar tasks for the same process. But there was an exception: the preparation in 1968–69 of two turnkey projects for sulfuric acid units, for which NATRON had a licence agreement (1967–77) with a major foreign producer.

In 1972–75, NATRON consolidated its know-how in sulfuric acid production, with the development of the double-absorption process that had been introduced in the U.S. and Europe in the 1960s. For this it counted on DIP, and the opportunity of working almost simultaneously on three sulfuric acid projects. NATRON was starting to specialize, which it considered to be an essential step toward entrance into the phosphate fertilizers industry as a whole, and in fact the creation of DIP corresponded to the decision of advancing in technical knowledge in two basic areas, fertilizers (including sulfuric acid) and petroleum refining.

The latter area, however, was abandoned when it became clear that PETROBRAS would get directly involved in it. After the 1975 creation of CENPES, NATRON decided to concentrate its technological learning efforts in the fertilizer area.

The two state enterprises, PETROBRAS and PETROQUISA, were NATRON's main clients and accounted for 11 of the 17 projects contracted during this period. NATRON was frequently chosen by those clients because it was considered to be one of the two main national firms in the engineering of industrial processes (among some 20 CEDOs, of which several were foreign owned), on account of previous experience, technological level, financial solidity, and adequate prices.

NATRON had to expand continuously during its first 8–9 years, but there were limitations to its technological progress. These were partly a result of the variety of tasks undertaken, which involved little repetition; but they were principally because in most of the important, relevant projects, it acted as a subcontractor to foreign CEDOs, which were engaged as prime contractors by PETROBRAS as a consequence of a safety-first policy of this state firm. The policy greatly limited the possibility of transfer of foreign know-how to NATRON, which was left with little bargaining power and could not ask for a full disclosure that would allow a learning process in basic engineering.

From 1976 onward, NATRON's concentration in the phosphate fertilizer area has resulted in success. In 1976 and 1977, four of the seven contracted projects were in this market, and NATRON has had to double its staff. Also in 1977 production started in SULFAB, the sulfuric acid unit controlled by NATRON itself. Moreover, NATRON has become increasingly less dependent on the two state enterprises, as it has expanded into phosphate fertilizers and chlorine–soda.

Recently, NATRON has undertaken two contracts for chlorine–soda plants, products that are essential for the pulp and paper industry. It is likely that the firm will use these as a way to enter the pulp and paper industry market, where there is place for a local CEDO (most pulp and paper projects are now being absorbed by one CEDO of Finnish origin). The recent succession of detailed engineering projects, and the ability already shown by NATRON to absorb basic engineering know-how are favourable signs.

NATRON's main line of work is in phosphate fertilizer production, where it competes with subsidiaries of large foreign chemical engineering firms (Lurgi, Davy Gas Power) and with another local CEDO (EIM).

STRATEGY OF EXPANSION AND TECHNOLOGICAL LEARNING

The firm's founders envisaged two areas of expansion: one was in petroleum refining, a natural area for former employees of PETROBRAS, the state petroleum firm; the other was in chemical products related to the agricultural sector, especially pulp and fertilizers. The first area has been left aside, at least for the time being. The pulp area has not yet been properly explored, although a beginning has been made through the taking up of detailed engineering projects in chlorine and sodium. The major investment in technology of the firm has been in phosphate fertilizers, a successful venture as evidenced by the prestige acquired by the firm and the recent contracts awarded to it.

Looking back on NATRON's policy toward this sector, we note a clear determination regarding technological learning and a sense of entrepreneurial opportunity, shown whenever there was the possibility of an important qualitative jump. The firm made a good choice of its client sector, which grew rapidly during the last 10 years (about 25% a year in 1967-76), capitalizing on the expectations held in 1967 that large investments were soon to be made in phosphate fertilizer plants. So the market for NATRON's services could have reasonably been expected to be there, but there is another important dimension in the decision: the feasibility of technological learning by the firm.

To master a technology, one must make an investment. NATRON's choice of sector was adequate. The technology of sulfuric acid production is not too complex and is well known; it is therefore accessible to a local CEDO. Phosphoric acid production technology is also accessible, particularly if the purchasing power of state enterprises is properly used to support good procedures of technology acquisition. NATRON chose a sector where technological autonomy was within reach of a medium-sized CEDO, contrary to, say, ammonia, urea, or the FCC process, where mastery of basic engineering would have been hardly possible.

NATRON was also able to outline an adequate path for its technological learning. The strategy was to proceed from simple to complex — in this case, sulfuric acid to phosphate fertilizers to phosphoric acid. Good advance in sulfuric acid was made in 1967-76, and the next step would have been to initiate efforts in the second area. However, a very good opportunity came up for mastering the technology of phosphoric acid, and this altered the expected sequence. By mid-1978 the firm was making good progress in its technological learning in both fields and had two working groups in its DIP, one for phosphoric acid and the other for phosphate fertilizers.

A number of steps can be identified in the process of acquiring expertise in the sulfuric acid technology. It all started with a 10-year technology contract signed in 1967 with a U.S. firm, which included a full-disclosure clause. Two turnkey projects were carried out in 1968-70 with the simple-absorption process. After 1972, NATRON took part in a project for a large unit using the double-absorption process, where it

undertook the general administration, including the coordination of foreign contractors, and carried out the detailed engineering of utilities and peripheral facilities. In 1973 it created its Department of Industrial Processes, which started a technology research program. In 1973–75, NATRON carried out a turnkey project for a medium-sized sulfuric acid plant with the simple-absorption process, and in 1974–75, DIP mastered successfully the double-absorption process.

In a final stage of technological learning, from 1975 onward, NATRON executed a complete project for a medium-sized plant for SULFAB (simple-absorption process to be later adapted to double-absorption). Starting in 1976, NATRON became the prime contractor for all engineering and project management services for a large plant with German basic engineering, which will enable it to absorb German sulfuric acid know-how. In December 1976 NATRON undertook all engineering and management services for a small plant using the double-absorption process, including for the first time the basic engineering. Since March 1977 NATRON has been performing management and engineering services, including the basic project, for a large sulfuric acid unit with the double-absorption process. Here a foreign expert was brought in because sulfur was being reclaimed from residual gases from copper refining. In the second half of 1977 SULFAB (where NATRON has equity control) started to produce sulfuric acid and thus became a “permanent laboratory” for the study of the process.

In sum, NATRON was able to make good use of technical and commercial opportunities. It was able right from the start to negotiate efficiently foreign technology, which it could absorb as it applied it in two projects. At the appropriate moment it created its own department for the study of processes, which allowed it to systematize the accumulated knowledge and provide a backing to the technological competence of the firm. In little more than 5 years it signed contracts for six projects, of which four were large; in two of these large projects, it carried out the basic engineering; in one it became the prime contractor, and in the remaining one it coordinated the foreign process. In the two smaller projects it undertook all engineering steps and also the project management.

With its last two projects, NATRON can be said to have completed its cycle of technological learning in sulfuric acid. At the same time it carried out a first phase of learning in the other products of the phosphate fertilizers industrial complex. In fact, technology absorption in phosphoric acid started in 1973 with the participation in a unit for sulfuric and phosphoric acid, where NATRON was coordinator of foreign contractors. Contact with the same foreign technology was repeated after 1976 through NATRON's participation in a project for a large phosphoric acid unit, as the prime contractor, and in this capacity it obtained a larger opening of the technological package.

A most significant step toward the learning of the basic engineering in phosphoric acid production was taken in 1977, with a contract that gave NATRON the responsibility for choosing the technology for a new unit and that would appoint it as prime contractor for the later steps of the project. This opened an opportunity that was efficiently used. NATRON's purpose was to choose a technology supplier, from the four principal companies in the international market, that gave the new unit a technology transfer

contract with a full-disclosure clause, even though this technology had less tradition at an international level. The client, a state enterprise, went along with NATRON in this trade-off, as it had done in the case of a sulfuric acid project where the risk was smaller. The conscious position here was to enable the technological strengthening of national consultancy. (This enlightened attitude contrasts with that of another state client, which in a sulfuric acid project argued that NATRON did not have sufficient technical capability to undertake the basic engineering design and gave this to a foreign firm at three times the price.)

It can be said that by 1978, when this case study was made, NATRON was learning fast regarding phosphoric acid production, and in fact one of the two teams at DIP was devoted to this technical area. The other team was engaged in phosphate fertilizers, where there had been few opportunities to acquire experience; know-how was being gathered from the literature, visits to factories, analyses of projects to which access was obtained, and interactions with some foreign experts. Although the lack of projects has been a negative factor, NATRON has announced it is in a position to develop basic engineering in this area too.

THE SULFAB PROJECT

The SULFAB plant started operating in October 1977. NATRON's performance in engineering and managing the project has been very good, as measured by several indicators: work was finished on time and practically within the expected budget (other neighbouring chemical units built at the same time at the North East Petrochemical Pole were different in these respects) and has shown a satisfactory performance with hardly any technical problems. The project did not imply a higher than usual participation by local industry; the usual types of equipment were imported, amounting to about 25% of all equipment. The interest of the case study resides in the significance of the SULFAB project as a demonstration of the entrepreneurial capacity of NATRON.

COPENE, the North East Petrochemical Company, invited NATRON to take total responsibility for a sulfuric acid plant, including control of equity. This was a very good opportunity, technically and commercially. The participation of NATRON meant its strengthening as an enterprise, and a valuable economic support for the expansion and concentration of its consulting and engineering activities, which were subjected to the usual ups and downs of the trade. Strong financial incentives were offered. NATRON negotiated very well and got good support from industrial policy organs and from the government financial institutions. It argued that it would be strengthened as a firm, that through having permanent access to industrial facilities it would acquire a complete mastery of acid production from elementary sulfur, and that the plant would serve as a demonstration of NATRON's technical achievements, thus reinforcing the chances of obtaining new clients at home and abroad. NATRON's equity participation came from the engineering services it rendered and from an important loan by FINEP, which also participated in the equity along with other government financial agencies.

The 400 t/day plant employs the traditional simple-absorption process but is sufficiently flexible to be adapted to the more modern double-

absorption process. NATRON took complete responsibility for the project, which was turnkey. This, plus its equity control, gave it permanent access to the plant, from which several advantages follow: a demonstration effect on possible clients (this has become the main advantage); a continuous optimizing and feedback of process data; the possibility of verifying in practice equipment, materials, operating costs, etc; the constitution of a permanent team to render start-up services to other sulfuric acid units.

Recognition of the experience acquired by NATRON was a decisive factor in its being chosen more recently to carry out two new sulfuric acid projects, in competition with well-known foreign suppliers. In fact, it is possible to perceive a clear favouritism toward NATRON by the state policy and financial organizations, an attitude that will no doubt be a constraint on enterprises that favour foreign firms for the work on new sulfuric acid units.

The SULFAB plant will be employed by SULFAB and NATRON for R&D programs, for optimization of processes, and in particular for the development of know-how that may allow local production of the catalyst. For such purposes, 10% of SULFAB's net earnings will be allocated to a "technical fund." The incentives granted to NATRON for participating in SULFAB were not dissimilar to those granted to other investors in the petrochemical complex being built. There was, however, an important aspect that merited state support, i.e., the strengthening of national engineering capabilities.

CONCLUDING REMARKS

The case of NATRON is of great interest as an example of concentration of efforts to achieve the mastery of process engineering in certain areas. It also shows the key role of government through its purchasing power and its financial support policies in favour of technological development. These instruments, appropriately used, did bring about favourable conditions for the advance of basic engineering capabilities. NATRON's success is based not only on its strategy of specializing in technologies that can be absorbed, a strategy that was favoured by a succession of similar projects, but also on the support it was able to obtain within government organizations, notably financial agencies.