Chapter 5
Plant Engineering: Old Wine in New Skins

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Abstract Plant engineering companies design and construct power plants, petrochemical plants, steelmaking plants, drinking or wastewater plants, assembly plants, and production facilities for various other industries. Traditionally, plant engineering companies, in addition to their physical products, offer a large portfolio of pre- and after-sales services. Hence, servitisation is neither a new phenomenon nor rare in this industrial sector. Even advanced, result-oriented services such as the operation of newly constructed plants are frequently offered. In this chapter, different types of plant operation services provided by plant engineering companies are introduced. Because this type of service is transforming plant engineering companies into users of their own product technologies, the sources of value added for operational services are discussed in comparison to traditional business concepts of merely selling the plants and offering services such as training, maintenance, and the provision of spare parts. Furthermore, the economic performance of operational services will be depicted and the future relevance of this type of servitisation will be assessed. The empirical basis comes from the literature, case studies and firm documents.

5.1 Introduction

Among mechanical engineering companies, manufacturers of entire plants play a prominent role in this sector. Instead of merely producing machinery or equipment in the B2B business, plant engineering firms provide comprehensive solutions to their customers. These firms design and construct manufacturing sites for various industries:

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- Producers of electricity are supplied with power plants. Plant engineering companies are either specialised in offering fossil power plants (coal, oil, and gas), hydro power plants, nuclear power plants and power plants based on renewable resources or they simultaneously offer several types.
- Mining companies or oil producers are provided with mineral processing lines (crushing, grinding, flotation, filtration, conveying, etc.) and equipment for up-stream and down-stream business.
- The chemical industry is provided with petrochemical plants, polymer facilities, fertiliser production sites, air separation plants, drinking or wastewater plants or other specialised process lines. Plant engineering companies are also engaged in providing facilities for rubber and plastic producers.
- The metal industry procures iron and steel making plants from plant engineering firms. Plant engineering firms deliver hot and cold rolling mills for ferrous and non-ferrous metals.
- Cement producers are supplied with cement plants comprising technology for raw material handling and production, clinker production, cement grinding, storage packing and dispatch.
- Manufacturers of wood, paper and paper products are provided with plants for wood-based materials and integrated solutions for paper production comprising the entire value chain from the removal of raw materials from the environment to paper mills, the paper production line, stock preparation and reels.
- The automotive industry procures, e.g., body welding lines, assembly lines and coating lines from plant engineering companies.

This is not an exhausting portfolio of plant engineering companies and illustrates that all major industries are their clients. The performance of the industrial manufacturing sector is thus determined by the productivity, flexibility and quality of plant engineering companies.

The variety of clients, their stochastic demand for new plants and the specialisation of plant engineering companies for the needs of individual client industries imply a market fragmentation. There is no single market for plant engineering products but many sub-segments, each with few companies on the supply and demand side.

This oligopolistic structure creates bi-directional dependencies: The limited number of clients strengthens their bargaining position in contract negotiations. Clients often succeed in imposing contract terms and conditions on their suppliers that favour the demand-side interests. Plant engineering companies as suppliers have to compete with few competitors. Hence, the transparency of competing offers is obvious. Customer companies are internationally located. Thus, the share of exports reaches up to 80 % of plant engineering companies' sales.

Regionally, many plant engineering companies have their home bases in western and northern Europe as well as in the US. However, recently, Japanese and Korean plant engineering firms gained relevant market shares. Increasingly, Chinese competitors have appeared in the market. Their low price offers compete with high-quality and advanced technology offerings from traditional vendors of plant equipment.

Table 5.1 provides examples of major plant engineering companies by product and country. Because plant engineering is not addressed in the NACE code as a specific category, reliable data on the sales and employees of this sub-sector of mechanical engineering are not included in official statistics. Estimations indicate a sales volume of €175 billion per year (Stroh 2006).

Because the plant engineering business requires individual solutions for each customer, pre-sales services are necessarily part of each offer and contract. Analyses for requirement specifications, R&D, consulting and individual engineering services are traditionally fundamental elements of plant engineering. Additionally, after-sales services, such as plant construction, installation, training of customers' employees and start-up assistance, are generally provided. During the lifetime of the installed plant, equipment plant engineering companies have to offer spare parts, maintenance and repair services.

Hence, servitisation is not a new trend for plant engineering companies. Plant engineering companies regard themselves traditionally as manufacturers and service providers. An analysis of service offerings of major plant engineering companies depicted in Table 5.1 supports this attitude. The homepages of almost all companies include a direct link to the services that they offer to their customers. Only a few companies lack a prominent link to their service offering on their homepage but describe their service offerings beyond their product offers. In our list of examples, no plant engineering company without a service offering was found. A comparison of this result with the data reported by Dachs et al. (2013) proves that plant engineering companies are at the forefront of servitization. Whilst Dachs et al. demonstrated that 74 % of manufacturers of simple products, 88 % of producers of medium-complex products and 94 % of manufacturers of complex products offer at least one service, we found that 100 % of the companies in the sample of plant engineering companies provide services. This result is in line with the findings of Leo and Philippe (2001), Oliva and Kallenberg (2003) and other scholars, who have reported that an increasing product complexity has a positive impact on the propensity to offer additional services to customers. Furthermore, the findings confirm the assumptions of Hobday et al. (2005) that product customisation stimulates product-related service offerings.

An in-depth analysis of the services offered by plant engineering companies clearly indicates that advanced service offerings are widespread in plant engineering companies. The application of Tukker's typology (Tukker 2004) shows that many companies do not merely offer product- or use-oriented services but are also engaged in result-oriented services. More than ten of the plant engineering companies listed in Table 5.1 provide plant operation services to their customers. This type of service transforms plant engineering companies into users of their own technologies. Customers taking advantage of this offer buy the final product of the manufacturing plant provided by plant engineering companies instead of the plant technology.

A closer look into operational services of plant engineering companies reveals that the motives for and arrangements of these services vary. The following sections introduce different types of plant operation services and illustrate the sources of

Table 5.1 Examples of major plant engineering companies by products, size and countries

Company	Products	Employees	Country	Website
ABB	Power pl., car assembly pl.	145,000	CH	http://www.abb.com/
Air Liquide E&C	Air separation plants	n.a.	F	http://www.engineering-solutions.airliquide.com
Alstom	Power plants	92,000	F	http://www.alstom.com/
AMG	Vacuum process plants	3,300	NL	http://www.amg-nv.com/
ANDRITZ	Power plants, pulp and paper and steel production plants	23,400	A	http://www.andritz.com
Ansaldo	Power plants	2,900	I	http://www.ansaldoenergia.it/
Bechtel	Petrochemical and mining facilities, power plants	53,000	USA	http://www.bechtel.com/
Bosch Rexroth	Assembly plants	35,000	GER	http://www.boschrexroth.com
Bühler	Food processing plants	8,000	CH	http://www.buhlergroup.com
Langley	Cement plants, welding plants	4,000	GB	http://www.langleyholdings.com/
Hillenbrand	Plants for plastic and aluminium production	4,200	USA	http://www.hillenbrandinc.com/
Dieffenbacher	Wood-based panel production plants	1,700	GER	http://www.dieffenbacher.de
Doosan	Power plants	43,000	KOR	http://www.doosan.com
Dürr	Paint shops and assembly plants	7,700	GER	http://www.durr.com
Eisenmann	Car body and assembly plants	1,400	GER	http://www.eisenmann.com
Ferrostaal	Power pl., petrochemical pl.	4,300	NL	http://www.ferrostaal.com/
FLSmidth	Cement/mineral plants	15,000	DK	http://www.flsmidth.com/
Hitachi Power	Power plants	1,100	JAP	http://www.hitachi.com
KHD	Cement plants	800	GER	http://www.khd.com/
Krones	Food industry plants	12,000	GER	http://www.krones.com
KUKA	Car assembly and welding plants	7,300	GER	http://www.kuka.com/
Linde	Chemical, petrochemical, air separation plants	56,300	GER	http://www.the-linde-group.com
Outotec	Iron and steel making plants, mining equip.	4,900	FIN	http://www.outotec.com/
Siemens Metals Techn.	Iron and steel making plants	n.a.	A	http://www.industry.siemens.com/verticals/metals-industry

(continued)

Table 5.1 (continued)

Company	Products	Employees	Country	Website
Siempelkamp	Plants for wood materials, rubber and metal forming	3,300	GER	http://www.siempelkamp.com
SMS Siemag	Metallurgical plants and rolling mills	6,300	GER	http://www.sms-siemag.com
Thyssen-Kr. Res. Tech.	Cement plants, mineral industries plants	5,500	GER	http://www.thyssenkrupp-resource-technologies.com/
Thyssen Krupp Uhde	Plants for fertilisers. base chemicals, polymers	5,900	GER	http://www.thyssenkrupp-uhde.de
Voith	Paper and power plants	42,000	GER	http://www.voith.com
WABAG	Drinking and wastewater pl.	1,500	A	http://www.wabag.com
Wärtsilä	Power plants	18,900	FIN	http://www.wartsila.com

value added for these business concepts in comparison to the traditional business concepts. The descriptions are based on literature, case studies and firm documents.

5.2 Types of Plant Operation Services Provided by Plant Engineering Companies

5.2.1 Plant Operation Services to Push Innovative Plant Technologies to the Market

A first type of plant operation services provided by plant engineering companies has been developed to overcome customer reservations against innovative technologies. If plant engineering companies want to introduce innovative technical concepts into markets, they have to convince their customers of their superior performance. Because innovative technologies often involve start-up problems and/or imply higher investments, customers may hesitate to switch from traditional and proven technologies towards innovative solutions. Hence, providers of these new technologies have to demonstrate their potential before customers will invest in these innovative plants.

The case of ALD Vacuum Technologies, Hanau, Germany, provides a conclusive example for this type of plant operation services. ALD was established in 1994, is now a member of AMG Advanced Metallurgical Group N. V. in the Netherlands and employs approximately 750 people. ALD has developed innovative vacuum furnaces and vacuum processes and regards itself as one of the leading suppliers of this technology. The applications of vacuum thermal processes are amongst others utilised in the tool industry and particularly in the automotive and gear production. (http://www.ald-vt.com/cms/en/vacuum-technology/company).

Vacuum heat treatment processes have been developed to cope with the problems of oxidation. Oxidation occurs on a part's surface when exposed to the atmosphere. Oxidation results in costly and time-consuming post treatments. Therefore, heat treatment is preferably conducted in an oxygen-free atmosphere. In addition to the use of high-purity protective gases, a vacuum allows the best protection against oxidation and thus is the most cost-efficient atmosphere.

The "new technology" vacuum heat treatment was developed by ALD in the early 1990s. When first introduced, ALD realised that the processes were not easily accepted because they were significantly different from established heat treatment processes using atmosphere and oil quenches. To improve understanding of the new technology by the global manufacturing community, ALD established their "Own and Operate Division".

This division installed several vacuum heat treatment facilities and operates them currently for various customers. One of these customers is GM Powertrain in Port Huron, Michigan, USA. Established in 2005, this plant started production in June 2006. The operation arrangement comprises the following aspects: ALD built the facility "fence-to-fence" to the customer's plant and remained owner of all equipment. The capital for this investment was financed by bank loans. The employees for running the facility were hired by ALD. GM pays for the vacuum heat treatment of the transmission gears according to the number of manufactured parts. The contract with GM includes no fixed number of parts to be delivered, which implies that the market risk of GM is partly transferred to ALD. ALD has accepted this risk to provide a showcase for the ALD brand equipment technology as well as the new process techniques. Furthermore, ALD acquires additional know-how from running the innovative equipment, which enables this plant engineering company to improve the equipment's performance and to gain an increased competitive lead (Lay 2007).

The value added of the type of operational service offerings illustrated by the ALD case presented above compared to traditional business models is at least twofold. First, customers avoid start-up problems and start-up costs possibly generated by an investment in innovative and unproven plant technology. However, this value added can only be achieved in the experimental phase of technology use. After having demonstrated the superior performance of new technical solutions, such a value added cannot be achieved permanently. Second, the plant engineering company can realise an enduring value added if its operational know-how exceeds the customers' know-how permanently due to the complexity of the technology, the speed of technological change and an inseparability of the producer's and applied knowledge. The latter frame conditions would imply that in the long run, plant engineering companies would have to decide if they should incorporate downstream businesses.

A particular setting in terms of the latter frame condition occurs if the customers of plant engineering companies are not generally excluded from acquiring the necessary know-how of running innovative plant equipment on a high-performance level comparable to the providers' ability. If customers decide that acquiring specific knowledge for running an innovative plant technology is outside their core competencies, plant engineering companies could offer operational service only for this clientele without "going downstream" in general. Kujala et al. (2011) found such a case in their studies of a power plant engineering company in Finland. Such a "split business model", however, could raise the problem that customers of plant engineering companies could regard them as rivals in their markets. The business of engineering and selling plant equipment could conflict with the operational service business. Our interviews with ALD executives have clearly shown that they are aware of such a conflict and that the ALD management is eager to avoid this problem by segmenting markets.

5.2.2 Plant Operation Services Forced by Customers' Financial and Rating Motives

A second type of operational service provided by plant engineering companies differs from the first type discussed above in initiators and motives. Whereas the first type is an instrument actively deployed by plant engineering companies to stimulate the market entry for innovative technologies, the second type is predominantly customer driven. Particularly customers from the automotive industry in the nineties of the last century started to require plant operations from the providers of plant equipment. Customers aimed to improve their balance sheets by diminishing fixed capital, by developing new instruments for financing their investments or by cutting wages to gain advantages from the wage drifts between automotive and engineering industries.

The case of Dürr may illustrate this second type of plant operation services. Dürr is one of the major systems suppliers for automobile manufacturing. Dürr plans and builds complete paint shops and final assembly facilities. A Dürr project requires, on average, an investment of €100–€200. Dürr has its home base in Germany, is directly represented in 23 other countries and, with 7,700 employees, generates annual sales revenues of approximately €2.4 billion (2012).

In the nineties, within their business unit "services", Dürr established specialised department "operating models". Although the corporate policy of Dürr was not targeted towards an active offering of operating models, the demand for this type of result-oriented service required such a reorganisation. In 2001, Dürr received 39 inquiries to calculate and offer operating models. An internal analysis of Dürr proved that the majority of these inquiries was motivated by financial (optimised cash flow management) or balance sheet (provisions for rating issues) reasons. Only 3 customers intended to realise value added (Stock and Wende 2003).

The operating models developed by Dürr to meet the customer requirements consisted of 4 components, each with different options:

- Equipment: Brownfield or Greenfield, building included or excluded.
- Financing: Operating lease, joint venture or full ownership.
- Services: Managed services, different levels of maintenance, cleaning, and full service.
- Operation: Managed operation, full operation, supplier network management, and quality management.

These components can be combined individually: Some projects may include equipment, financing and service; other projects may include equipment, services and operations. Not all 4 components are necessarily part of a project. The distinction between the services component and the operation component is blurred: Within the service component, Dürr already guarantees that all parameters of a coating line are adjusted for a smooth coating process. Dürr personnel start the coating line, clean the blast pipes or supervise the drying process equipment, which is used to cure coatings and to turn the paint finish into a perfect surface. If the component "operation" is additionally part of the contract, the lacquerers are also on Dürr's payroll (Stock and Wende 2003).

Based on this modular concept, Dürr realised several plant operation projects. One of these projects has been contracted by IBC Vehicles, Luton (GB). In this project, Dürr was responsible for the engineering, manufacturing, delivery and financing of a final finishing wax line. Additionally, full services, operations, maintenance and cleaning tasks were transferred to Dürr. Twenty-two Dürr employees operated full time in 3 shifts at the Luton site of IBC. The operational contract was for 13 years, and the payment was arranged on a cost-per-unit schema.

In addition to the case of Dürr introduced above, several other plant engineering companies engaged in supplying the automotive industry with manufacturing sites have realised this type of plant operation services in the nineties of the last century and in the first years of the new millennium:

- KUKA (Augsburg, Germany) built a body shop plant to assemble the bodies for Chrysler's Jeep Wrangler in Toledo, Ohio (USA) and operated this welding line with 245 industrial robots since 2007. The investment of 142 million US dollars and the wages for 230 employees have been financed by KUKA. Chrysler pays on production (Eckhardt 2006; AMS 2006).
- Eisenmann (Böblingen, Germany) offers a build-operate-transfer model in which it operates the customers' Eisenmann plant with its own personnel and performs logistics, quality control and maintenance (http://www.eisenmann.com/en/products-and-services/service/full-service-and-build-operate-transfer-model/build-operate-transfer-model.html). Eisenmann provides references of operating models in Brazil (painting system for truck cabs and truck trailers), Belgium (operation/maintenance of EMS connecting a supplier park with final assembly) and Germany (operation/maintenance of an assembly line and EMS connecting a supplier park with final assembly).

As mentioned above, this type of plant operation service was not primarily targeted towards creating value added but was inspired by the off-balance sheet financing interests of automotive manufacturers. The attempt to improve their ratings by off-balance financing of investments was enabled by US GAAP regulations (United States Generally Accepted Accounting Principles). If the operating lease contracts did not comprise automatic transfer of ownership to the lessees at the end of the contract and no purchase option to the lessees at a low price, if the leasing term was beyond 75 % of the equipment's life time, and the discounted lease rates were beyond 90 % of the investment, off-balance status could be realised. After amendments to this regulation, this type of plant operation service lost its value for customers, and customer requests decreased. In addition, some plant engineering companies realised that operational business models established for financial reasons shift risks from customers to suppliers without an adequate compensation. In this environment, Dürr, for example, decided to stop offering operational services for their products in 2005 (Dürr 2005).

5.2.3 Plant Operation Services to Compensate for Deficits in the Qualification of Customers' Employees

A third type of operation service provided by plant engineering companies aims to compensate for existing qualification deficits of customers' employees in operating plants. Either customers can request offers for this type of service if they feel unable to exploit plant technologies with their own personnel or plant engineering firms can take the initiative if they want to tap new markets for their products, particularly in developing countries in which the skills of the workforce cannot guarantee the appropriate use of their technology and from which orders are consequently scarce.

The WABAG Group provides vivid examples of this type of plant operation services by its offerings and references. WABAG is one of the world's leading companies in the water treatment field. WABAG's key competences, which are based on over 80 years of plant building experience, lie in the planning, completion and operation of drinking water and wastewater plants for both the municipal and industrial sectors. The WABAG Group with international operating companies in Vienna (Austria) and Chennai (India) has a workforce of approximately 1,500 employees and is represented through companies and offices in 20 countries. Since 2000, WABAG has installed over 500 plants worldwide, which furnish more than 100 million people and over 200 industrial companies with water infrastructure (http://www.wabag.com).

WABAG has realised that the efficient management of their water treatment plants for customers frequently represents an unknown technical area. Business management requirements are increasing and technologies are constantly developing. Simultaneously, the legislation in many countries relating to water management is also becoming increasingly stringent. To meet all these economic, technical and legal demands, WABAG offers its knowledge and competence in the area of operational management of water and wastewater plants to their customers. The goal is to optimise the plant operation and thus contribute to their success (http://www.wabag.com/performance-range/operations).

WABAG offers a range of individual plant operation models:

- The "Build-Own-Operate and Transfer (BOOT)" model represents a complete solution for the financing, construction and operation of a plant. WABAG takes overall responsibility for the building and operational management of the plant, while at the same time securing the financing of the required investment using available grant possibilities. At the end of the contractual period, the plant becomes the property of the customer.
- The "Designs, Build, Operate (DBO)" model consists of the planning, construction and operational management of new plants. Customers are offered trained specialists, proven technology, secure operational procedures, guaranteed availability and high quality.
- The "Plant Operation/Outsourcing (O&M)" model transfers the operational management of existing wastewater plants and waterworks to WABAG. In this arrangement, a "pure" service agreement is concluded. WABAG is responsible for the technical process and/or commercial success of plant operation. This model is characterised by the training and integration of the existing skilled personnel as well as unaltered charges, investment control and ownership.

Table 5.2 summarises the operational models offered by WABAG. Today, plant operation services contribute markedly to WABAG's overall sales. An interview

Table 5.2 Operational service concepts of water plant provider WABAG

WABAG plant operation service concepts	WABAG responsibility				
	Engineering/ construction	Financing	Ownership	Maintenance	Operation
Build-Own-Operate, Transfer (BOOT)	x	x	x	x	x
Design, Build, Operate (DBO)	x			x	x
Plant Operation/ Outsourcing (O&M)				x	x

with WABAG's executive for operational services in 2006 indicated that this business segment at that time already had a share of approximately 10 % of the total revenues.

There are various references for BOOT, DBO and O&M projects of WABAG: A BOOT wastewater treatment project with a contract extending from 2003 to 2017 has been realised in Alandur (India). DBO projects have been contracted, for example, in Adana (Turkey), Batna and Baraki (Algeria), Teheran (Iran), Vadakuthu (India) and Petrobrazi (Romania). O&M projects are reported in Macau (China), Windhoek (Namibia) and Arpechim (Romania). This reference list of plant operation service projects (http://www.wabag.com/projects) indicates that developing countries offer a promising market for this type of operational service from plant engineering companies.

This finding is confirmed by the experiences of FLSmidth, a leading supplier of equipment to the global cement and minerals industries that is based in Denmark. For example, in 2010, FLSmidth received contracts from the Angolan Fabrica De Cimento Do Kwanza-Sul S.A. for the operation and maintenance of its 4,200 tonne-per-day cement plant, by Carthage Cement for the operation and maintenance of its new cement plant to be constructed approximately 40 km southwest of the Tunisian capital Tunis and by the Arabian Cement Company (ACC) for the operation and maintenance of the second line at its cement plant near the city of Suez in Egypt (FLSmidth Company Announcements No. 04-2010, 18-2010, 32-2010).

The offering of operational services by plant engineering companies because the customers' personnel are unqualified appears to be a widespread phenomenon in plant engineering businesses. In addition to the water treatment plant and cement plant examples above, the literature also provides a case study from a power plant manufacturer (Kujala et al. 2011). In the case study of Consolidated Power Company (CPC, a pseudonym), two types of contracts were realised: first, an integrated project with a power plant delivery contract, and second, a stand-alone service contract composed of operation and maintenance services (O&M). Out of 5 CPC O&M-projects that are depicted in depth, 3 aimed to overcome skill level deficits on the customers' side.

To summarize, the operational services of plant engineering companies targeted towards overcoming deficits in customer qualifications appear to create sufficient additional value for both sides. Plant engineering companies can realise profits as providers of operational services, while customers can gain benefits superior to self-contained plant operation.

5.2.4 Plant Operation Services to Exploit Benefits from Combined Production

A fourth type of operational service provided by plant engineering companies addresses manufacturing facilities such as petrochemical plants and air separation plants. Whereas petrochemical plants produce bulk building blocks, such as ethylene, propylene and aromatics from fossil resources, air separation plants fractionate the air components oxygen and nitrogen as well as various rare gases. If customers need only one or two components from petrochemical or air separation plants, they need to handle the redundant results of combined production processes. Thus, the customers need to become traders of these products or dispose of the materials that are useless to them but perhaps useful for others. Some expenses can be avoided if the combined production of the plant is not operated by these customers but by plant engineering companies. Plant engineering companies can construct, own and operate combined production plants in optimised locations to serve customers in need of all the materials that result from combined production. Production costs per unit decrease if all materials from the combined production processes can be commercialised. The value added is obvious.

The German Linde Group offers an illustrative example for such a business concept. Linde has a workforce of approximately 62,000 employees working in more than 100 countries worldwide. In the 2012 financial year, Linde generated a revenue of €15.280 billion. Linde is organised into two divisions: engineering and industrial gases. The engineering division focuses on constructing plants for the production of hydrogen, synthetic gases, oxygen and olefins as well as plants for natural gas treatment. With more than 1,000 process-engineering patents and 4,000 completed plant projects, Linde Engineering ranks among the leading international plant contractors. The gas division offers a wide range of compressed and liquefied gases as well as chemicals, for the energy sector, steel production, chemical processing, environmental protection, welding, food processing, glass production and electronics, among others.

Both divisions are closely linked. More than one fifth of the engineering division's revenues result from the gas division's orders for building air separation plants (Linde 2012b). These plants have not been sold to customers of Linde Engineering but are operated by Linde Gas on-site at the customers' facilities, and Linde Gas provides them with the required gases. Two newly contracted projects elucidate this business model:

- In June 2011, Linde announced that Linde Engineering would build the largest air separation plant in Indonesia for Krakatau Posco's new steelwork. Krakatau Posco would build a steelwork in the Cilegon area, located approximately 100 km west of Jakarta. To support the gas requirements of the new steel plant, Linde Gas, not Krakatau Posco, would invest approximately EUR 88 million for the engineering and construction of the air separation plant. To meet the 1,680 tpd oxygen requirement of the new steelwork, the plant would also produce liquid products to meet the growing demand for industrial gases in West Java (Linde 2011).

- In February 2012, Linde reported a major on-site contract in New Zealand with the steel producer New Zealand steel. The agreement consisted of a new air separation unit constructed by Linde Engineering and the installation of gas supply systems. Linde Gas would invest in this air separation plant instead of New Zealand steel and supply air gases to the steelworks. The air separation unit would also produce large quantities of liquefied oxygen, nitrogen and argon for the regional market in New Zealand (Linde 2012a).

An expert interview with a Linde representative in 2005 further clarified the economic rationales behind these types of projects: Linde Engineering configures the on-site facilities to be operated by Linde Gas not only to meet the demand of the direct customers but also to supply regional demand. Thus, the on-site project can realise economies of scale. These economies of scale together with the synergies from combined production generate value added, which cannot be realised by the traditional business models of customers investing in plants of Linde Engineering.

The advantages of the plant operation concept described above are commercialised not only by the German Linde Group. The French Air Liquide has a similar structure consisting of gas-producing divisions and an engineering and construction division (Global E&C Solutions). The latter constructs the group's production units—mainly air separation units and hydrogen production units—and provides plants for third party clients.

5.2.5 Plant Operation Services to Increase Customers' Plant Utilisation Rates

The fifth type of operational service provided by plant engineering companies solves the customer problem of adequately dimensioning plant capacity. In the process of planning a new plant, customers can choose a configuration that is designed to meet the anticipated average capacity demand. Such a decision will lead to capacity utilisation rates that are temporarily beyond the economic optimum. Alternatively, customers can choose a smaller configuration, which is only able to meet the lowest anticipated demand. The economic optimum of running the plant at full utilisation rates would be guaranteed; however, spot demands could not be met. Thus, competitors would be able to enter the market and gain clients.

In this situation, the customers of plant engineering companies traditionally choose the former alternative. To enable customers to choose the latter alternative without risking the consequences, several plant engineering companies take advantage of flexible capacities in their own facilities and operate these plants to meet the spot demands of various customers.

The case of Rohwedder Micro Assembly GmbH in St. Leon-Rot (Germany) illustrates this fifth type of operational service from plant engineering companies. The focus of Rohwedder's activities, with its approximately 95 employees, lies in implementing assembly solutions for the automotive, medical equipment, electronics, consumer product and general industry sectors. Between 2005 and 2008, Rohwedder and its customer Jenoptik AG, an optoelectronics group with approx. 3,270 employees and sales of €585 million (2012), were collaborating on a project subsidised by the German Federal Ministry of Education and Research. The companies aimed to develop technological solutions and business models to meet Jenoptik's requirements for assembling regular and spot capacities. The project results accommodated three scenarios. One of these scenarios envisaged installing an automated assembly line at Jenoptik's facilities designed for regular capacity demand. Additionally, modular assembly technology that could be deployed for various customers' assembly tasks should be installed in another Rohwedder plant. Rohwedder remains owner of the latter assembly technology. When spot demands occur and Jenoptik assembly facilities are running at capacity, Jenoptik will ship the parts to be assembled to Rohwedder, and Rohwedder will perform the assembly with its own personnel and will be paid for the usage. In case of regular capacity demands, Rohwedder can use the line for the spot demands of other customers or for test and demonstration purposes (Müller and Schmidt 2008).

KUKA AG (Germany), a supplier of robotics as well as plant and systems engineering, offers a similar concept. Instead of only offering robot welding lines to their customers, KUKA AG additionally developed "subcontract welding" offerings. On their website (http://www.kuka-systems.com/en/products/job_order_prod/), the company states the following: "As a manufacturer of flexible robot cells for laser machining as well as friction and magnetarc welding machines, we have many years of experience in machine design and process applications. We have been carrying out subcontract welding work for renowned companies since 1970. We manufacture a wide range of thick and thin metal plates as well as parts, including drive shafts, hollow-spoke aluminium wheel rims, pipeline valves, bevel gears, piston rods, engine valves, trailer axles, rollers, turbine wheels, drawbars, and many more. Subcontract welding work is subjected to 100 % process monitoring."

The Swiss Bühler Group, a specialist and technology partner for plant, equipment, and services for processing basic foods and for manufacturing advanced materials, provides a third example of this type of plant operation service. The group offers their "Rent a factory" service, "a factory which only generates costs when it is actually used" (http://www.buhlergroup.com/global/en/services/manufacturing–logistics.htm).

5.3 Summary and Outlook

The results depicted above clearly indicate that servitisation is neither a new phenomenon nor rare in plant engineering companies. Manufacturers of plants traditionally regard themselves as engineering and service-providing firms.

Product- or use-oriented services are available everywhere, and result-oriented services are prevalent. Several plant engineering companies are experienced in plant operation services as they have been offering them for many years. The types of plant operation services provided by plant manufacturers differ in their initiators, motives and value added. Table 5.3 summarises the types introduced above.

The synopsis of Table 5.3 shows that two types of plant operation services are supply-side driven, two other types are jointly initiated by plant engineering companies and their customers, and one type is predominantly customer driven. The motives for taking the initiative to offer or to require plant operation services in three of five types (3, 4 and 5) are deeply rooted in the untapped economic potential of traditional business models. If customers' employees do not have the skills to exploit advanced plant technology, if combined production processes inevitably produce materials that the customers do not need in their manufacturing or if investments can be adapted to enduring capacity demands of customers, then the value added of operational services is obvious. Plant engineering companies and their customers can realise benefits if they reach a fair agreement on how to share the value added.

One type of plant engineering service (1) is not directly linked to the untapped economic potential of existing business models but promises to open up markets for innovative plant technology. Hence, the plant engineering companies can realise the value added. If plant engineering companies succeed in stimulating additional demand for their plant technology by demonstrating their superiority, they can generate additional sales and profits. This finding implies that plant engineering companies do not need to offer operational services at lower costs or with an increased output compared to traditional business concepts.

In contrast, a final type of operational service (2) appears not to provide any value added. This type of service is initiated by customers trying to overcome their financial or rating problems. In this case, customers intend to impose risks on their suppliers, and suppliers can hardly refuse due to their dependency on a few large customer companies. The modification of the US GAAP regulations stopped this pressure from customers. Hence, this type of operational service, which boomed in the nineties of the last century, has lost its relevance to some extent.

The forms of operational services of plant engineering companies do not vary significantly. The ownership of the plant remains predominantly with the plant engineering company, the employees that operate the plant are recruited by the plant engineering company, and payment is based on the quantity and quality of parts or units manufactured in the plant. Only the location of the operated plant varies. The location is either at the customers' site, near the customers' site or even connected to the facilities of the plant engineering companies. In each case, the choice depends on the best way to realise the value added.

The economic performance of operational services appears to satisfy plant engineering companies. Interviews with executives from plant engineering companies engaged in operational services (Lay 2007) as well as (preliminary) results from the literature (Kujala et al. 2011) indicate sufficient profits, at least for types 1, 3, 4 and 5 of this business model. Because plant operation services provide

Table 5.3 Types and characteristics of operational services provided by plant engineering companies

Type characteristics		Type of plant operation service provided by plant engineering companies				
		1	2	3	4	5
Initiator of plant operation service		Plant engineering company	Customer company	Plant engineering company and/or customer company	Plant engineering company	Plant engineering company and/or customer company
Motive for supplying/demanding operational service		Marketing for innovative plant technology	Financial/rating problems on customers' side	Lacking employee skills on customers' side	Only partial demand for products from combined production on customers' side	Decrease of customers' plant capacity to increase utilisation rates
Form of operational service	Ownership of plant	Plant engineering company	Plant engineering company	Predominantly customers	Plant engineering company	Plant engineering company
	Personnel for operation	Plant engineering company	Plant engineering company	Executives and first-line management: plant engineering company	Plant engineering company	Plant engineering company
	Payment for operation	Pay per part/use/unit	Pay per part/use/unit	Investment plus pay per part/use/unit for suppliers' operational costs	Pay per part/use/unit	Pay per part/use/unit
	Location of operated plant	Fence-to-fence with customer site	Customer site	Customer site	Fence-to-fence with customer site	Plant engineering at company's site
Source of value added for plant operation service		Additional sales by developing larger markets	No value added (zero sum game)	Optimised exploitation of plant technology	Commercialisation of all products from combined production plants	Increased utilisation of investments

continuous revenues, they can additionally equalise cyclical sales in the engineering business. This advantage motivates engineering companies to extend their business into these areas. While operational services already generate important revenues for many plant engineering companies, the relevance of these services will increase in the future.

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