Case Study

Bosch Termo-tecnologia

Keeping the innovation track record

Vítor Corado Simões
Maria João Santos

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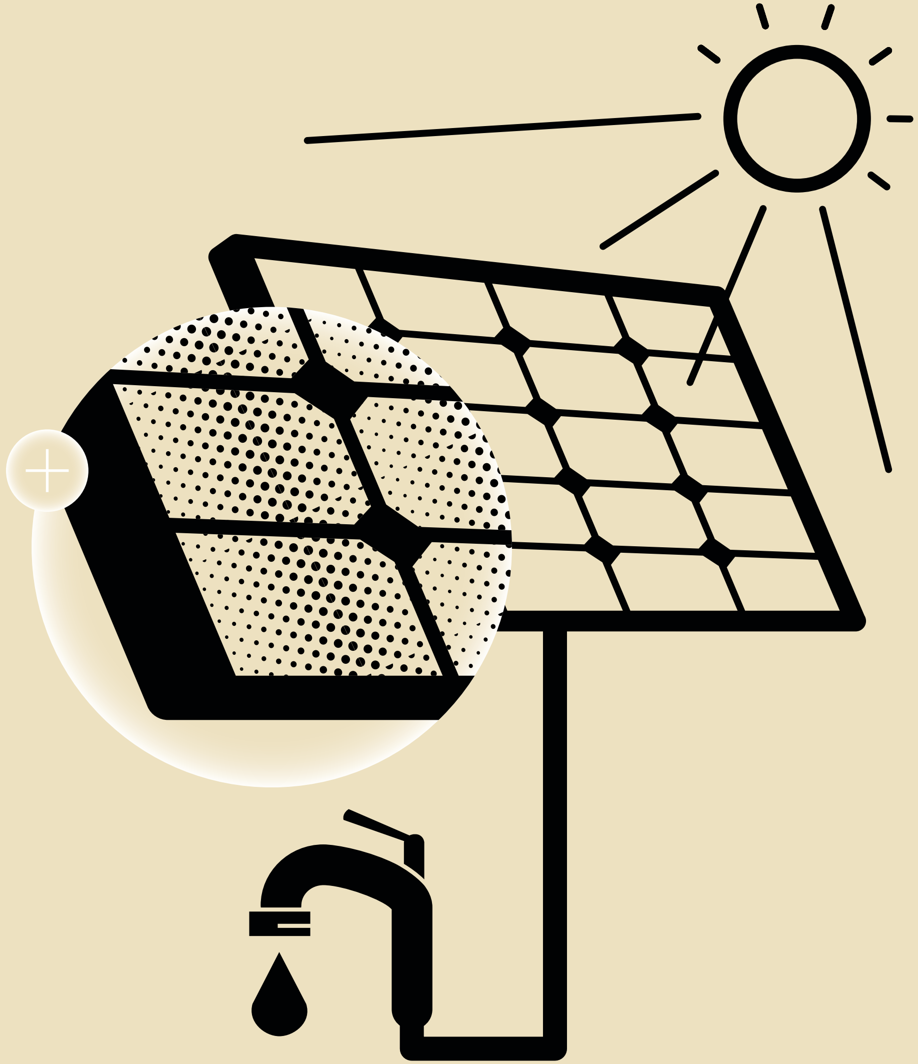

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Bosch Termotecnologia: Keeping the innovation track record

Abstract

This case is about ***Bosch Termotecnologia***'s process of capability accumulation and innovative performance. Located in Portugal, ***Bosch Termotecnologia*** is the domestic water heaters Centre of Competence of the German ***Robert Bosch*** Group, reporting to the Thermotechnology Division. It develops, manufactures and sells water heaters in more than 50 countries around the globe, with a turnover above 200 million Euros, and employs around one thousand people.

An historical retrospect of ***Bosch Termotecnologia***'s evolution is provided, including some landmarks in terms of product development. The company was created in late 1970s as a licensee of the ***Junkers*** division of ***Robert Bosch***, and was able to launch technological, marketing and organizational learning processes to become, after the takeover by the German group, the main water heaters manufacturing unit and later the Centre of Competence for this business. The development of R&D capabilities played a key role in such process.

Then, the case delves into the main product development tools used by ***Bosch Termotecnologia***, namely the 'Time to Market' project diagram and the 'User Experience' concept. These are illustrated with an important product development project: the Compact Advanced Electronics (CAE) Project. This was aimed at developing a new thermostatic water heater without recourse to electricity as additional technology source. The case discusses the main challenges and trade-offs faced in the product development process.

The case concludes with the challenges faced by ***Bosch Termotecnologia*** to keep its innovation track record with a view to foster company growth as well as to enhance its relevance in the context of the ***Robert Bosch Group***'s Termotechnology Division.

Keywords

Bosch Termotecnologia; Water heaters; Innovation Capabilities; Subsidiary initiatives; Centre of Competence; New Product Development; Subsidiary development challenges.

Acknowledgments

This case was written by Vítor Corado Simões and Maria João Santos, of ISEG – Lisboa School of Economics and Management, Universidade de Lisboa, for COTEC Portugal, between May and June 2015.

Personal interviews were held at ***Bosch Termotecnologia S.A.*** with the following executives (by alphabetical order): Evandro Amorim (International Product Manager, International Product Management Department), Marco Marques (Director, Product Engineering Gas Appliances), Pedro Cardoso (Director, Quality Management), Sérgio Salústio (Vice-President, Engineering), Tiago Bandeira (International Product Manager, International Product Management Department), and Vítor Correia (HR Development and Recruitment Department). Face-to-face interviews were held on June 2015. Selected quotes from those interviews are transcribed in the case. The interviews were held in Portuguese with the quotes translated into English by the authors. To avoid overloading the reader with very specific information, no reference is provided regarding such quotes.

In contrast, for other quotes, the relevant sources are explicitly acknowledged.

The authors would thank all the ***Bosch Termotecnologia S.A.*** executives mentioned above for the information and the support provided. They proved essential to improving the quality of the final product.

Thanks are also extended to Isabel Caetano, of COTEC Portugal, for the spirit of cooperation expressed throughout the project. The comments by our team mates Cátia Miriam Costa, Manuel Mira Godinho, Nuno Crespo and Sandro Mendonça, also members of the Project Team, but not directly involved in this case study, are gratefully acknowledged.

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Introduction

Aveiro, June 8th, 2012. Sérgio Salústio is proud of the ***Bosch*** Group tradition, a German combination of technical prowess, organisation and innovativeness. And he is also proud of the way how such tradition has been melded with the creativeness and the talent of Portuguese engineers and with the Japanese philosophy of continuous improvement. As Vice-President for Engineering at ***Bosch Termotecnologia SA***, the domestic water heaters Centre of Competence of the ***Bosch*** Group, one of his main roles is to spur innovation. His office door clearly shows his ***leitmotif***: innovation is there, in many languages, from Cyrillic to Chinese. ***Bosch Termotecnologia SA*** develops, manufactures and sells water heaters in more than 50 countries around the globe, with a turnover above 200 million Euros, and employs around one thousand people.

Looking at the different signs for conveying the word 'innovation', he recalls the 35 years of the company's history. This successful history, started out in 1977 as the licensee of ***Robert Bosch GmbH*** and went on to become the ***Bosch*** Group's global Centre of Competence in the field of domestic water heating appliances. A unit is only labelled as a Centre of Competence when it has specific capabilities in a given field, and provides services to other units within its specific regard; some Centres of Competence, as is the case of ***Bosch Termotecnologia SA***, have global product mandates for a given product scope.

Sérgio Salústio recalls several product development projects carried out by ***Bosch Termotecnologia SA***, from the advent of appliances with electronic ignition mechanisms, the launch of compact water heaters, the CAE (Compact Advanced Electronics), which has won the prestigious ***Produto Inovação COTEC Portugal***[1] prize, and the heat pump to the most recent, still underway: the fan pressurized (FP) water heater.

1 · *The Produto Inovação COTEC Portugal* is an award granted by COTEC Portugal, a private not-for-profit association aimed at promoting innovation, whose members include the largest companies in Portugal as well as innovative SMEs. The award is assigned to a product innovation, developed by a company located in Portugal, considered the most relevant in a given year.

EXHIBIT 1
Sérgio Salústio's Office Door

Source The authors

As he looks through the window, Sérgio Salústio recalls the title of a book by the Portuguese writer José Cardoso Pires ***(E Agora, José?)***, and turns the question to himself: ***And Now, Sérgio?*** Which new project to launch? Which new challenges to tackle? To justify its assignment as Centre of Competence, ***Bosch Termotecnologia S.A.*** has to keep up a continuous and sustained innovation track record.

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The global water heater industry: Trends and players

Bosch Termotecnologia SA leads the European water heaters market, and is ranked third globally in this sector. However, the world market is very far from homogeneous. Different national approaches to domestic water heating still prevail. For instance, in the United States, the use of water tanks is widespread, while in Continental Europe water heaters are the most common solution. In Japan, the market is dominated by local firms with some focused only on the domestic market. Growth prospects are mainly concentrated in emerging countries, particularly in China, Russia, Turkey and Brazil, with India still lagging behind[2]. The main features of the world water heating markets are provided in Annex I.

Energy sources wise, global water heater appliances can be broadly classified into seven categories: compressed natural gas (CNG) based water heaters; liquefied petroleum gas (LPG) based water heaters; propane base water heaters; electric water heaters; solar energy based water heaters; hybrid water heaters; and others. New energy sources are emerging. However, they still remain marginal due to cost/benefit considerations at the present level of technological sophistication and market breadth.

With regard to the technology, three main segments emerge: demand or tank-less water heaters; storage or tank water heaters; and heat pump water heaters. The increasing demand for tank-less water heaters is providing new growth opportunities for global water heater markets. In tank-less water heaters, water flows through a circulated large coil which is heated either by electricity or gas. Tank-less water heaters are more energy efficient compared to traditional tank based water heaters. The more sophisticated appliances also return better environmental sustainability, and more accurate temperature control. However these features are not generalized. A definition of water heater energy consumption levels, similar to what already happens for domestic electrical appliances (refrigerators, for instance) is still under discussion and will furthermore take a few years to be implemented.

The main competitors of ***Bosch Termotecnologia S.A.*** include companies such as ***A.O.Smith Corp, Rheem Manufacturing Co., General Electric Co., Siemens AG., Ariston Thermo SPA., Bajaj Electricals Ltd., Bradford White Corp., Crompton Greaves Ltd., Haier Water Heater Co. Ltd., Heat Transfer Products Inc., Noritz Corp.,*** and ***Rinnai Corp.*** It is important to bear in mind, however, that most of these companies are specialized energy, technology or market-wise. For instance, ***Rinnai Corp.***, which is one of the leaders in the Japanese market, is exclusively focused on the domestic market, after divesting from a joint venture with ***Bosch*** in China.

Bosch Termotecnologia SA: From licensee to centre of competence

The early years: *from the licensing agreement to Bosch acquisition*

Bosch Termotecnologia S.A. is an outstanding example of a continued and consistent process of capability upgrading and development. In less than 30 years, the company has been able to change from a small licensee of the ***Junkers Division of Robert Bosch GmbH*** to the water boilers Centre of Competence of the ***Bosch*** Group at global level. According Mr. Mário Pais de Sousa, a former company CEO, and the driving force behind its early history, ***Bosch Termotecnologia S.A.*** development has been able to follow ***"A course, which includes as steps of its main itinerary, the absorption of licensor's know-how, the assimilation and development of in-house capabilities in the***

2 · See Persistence market Research, Water Heater Market - Global Industry Analysis and Forecast to 2020, December 2014, https://www.linkedin.com/pulse/water-heater-market--global-industry-analysis-forecast-glen-hare accessed June 8th, 2015.

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manufacturing, marketing and management fields, the setting up of an R&D department and the carrying out of a globalization strategy of the domestic water heaters business" [3]

The firm was established in 1977 as ***Vulcano – Luso Ibérica de Termo-Domésticos, Lda.***, with the aim of manufacturing and marketing, especially in the Portuguese market, domestic gas water heaters. Portugal's economic environment at the time was characterized by heavy import tariffs, which might reach from 20 to 30% ***ad valorem***, thereby promoting import substitution strategies by companies. To profit from this context, a licensing agreement was established with ***Junkers***, involving the communication of know-how and the provision of technical assistance to assemble and manufacture water heaters under the ***Junkers*** brand.
As in many licensees in the metalworking and machinery industry, ***Vulcano*** started out as an assembler of components imported from the licensor.

Mr. Klaus Domes, at the time Head of the ***Bosch*** Licensing Department, recalls how the agreement emerged. ***Junkers*** wanted to expand the market in Southern Europe, since Northern Europe was becoming mature. He presented a lively account of the dating process leading to the license:

"[The Junkers division] had started to look for a partner to manufacture the products in Portugal. We wanted to have a strong position in the Portuguese market. We had identified some potential licensee candidates, but the opportunities found were not 100% satisfactory. Finally, we were approached by a gentleman who was on the board of a Portuguese manufacturing company, and who wanted to set up a new company and to launch his own business. He had marketing know-how, and his partner had an already established business and owned a piece of land where the plant might be set up. They wanted to launch a new business and [they were aware that] they had to invest a lot [for the business to become successful]" [4]

The account of Mr. Mário Pais de Sousa, member of the ***Vulcano*** founding team, was slightly different. A stronger emphasis was put on ***Vulcano***'s initiative in approaching ***Junkers***. He recognized, however, that ***"the licensor already had a portfolio of information about other Portuguese and Spanish firms with stronger economic potential"*** than ***Vulcano*** exhibited at the time. Be as it may, ***Vulcano*** was the final choice of ***Junkers***. Personal chemistry and trust in ***Vulcano***'s commitment played a part in the initial licensing decision.

Up to 1979, ***Vulcano*** sourced all the components needed to build water heaters from Junkers; the final product assembly and testing were carried out at a very small unit. Besides supplying components, ***Junkers*** also provided technological assistance, training, process improvement and surveillance of quality standards. In 1979, a new plant was built, providing the appropriate conditions for starting a process of gradually increasing locally produced components. Again, ***Junkers***' direct and indirect support was important. An example of the latter concerns the disclosure of information about international suppliers able to solve ***Vulcano***'s process difficulties.

Vulcano had, since the signing of the licensing agreement, a focus on assimilating the licensor's know-how as well as on developing capabilities in the fields of management, manufacturing and marketing; this is expressed, for instance, in the recruitment of a couple of engineers fluent in German. ***Vulcano***'s management philosophy also played an important role, as Sérgio Salústio underlines: ***"the adoption, by Mr. Pais de Sousa [...], of a rigorous management style, based on management and quality indicators, has ensured a good economic performance and led to the strengthening of the relationships between the Portuguese and the German firms".***

3 · Mário Pais de Sousa, 'O processo de internacionalização da Vulcano', *Economia & Prospectiva*, Vol. 1 no. 2, 1997, pg. 105.

4 · Personal Interview with Mr. Klaus Domes, at Bosch Licensing Division, Stuttgart (June 1991), by Vítor Corado Simões.

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Mr. Mário Pais de Sousa made a visit to Japan, where he became more aware of the advantages of applying a ***Toyota***-style management to the water heaters assembling process. He was very successful in transplanting it to ***Vulcano***, including the concepts of continuous improvement, ***kaizen***, and lean production. Market growth was leveraged by the 1983 launching of the ***Vulcano*** brand in the Portuguese market[5]; at the same time, ***Vulcano*** started to supply water heaters to ***Junkers***[6]. By the early 1980's, a small design and engineering unit was set up by ***Vulcano***. With hindsight, Sérgio Salústio perceives that Mr. Pais de Sousa was ***"a golden partner"*** for ***Bosch***.

In 1986, the 10-year licensing agreement was about to expire, and Portugal had just entered the European Economic Community. Looking at the future of its business, the Portuguese firm identified three options: to stand alone, following its own way; to renew the licensing agreement; or to strengthen the relationship with the ***Bosch*** Group, enticing the latter to acquire an equity stake in ***Vulcano***[7]. The third option was chosen. Portuguese managers thought that to respond to the challenges raised by European integration, namely the entry of competitors such as ***Vaillant***[8], a partnership with the ***Bosch*** Group was the best solution[9]. For ***Bosch***, investment in ***Vulcano*** also made sense: there was a very positive track record of collaboration, and Portugal provided production cost advantages. Negotiations began and resulted in the creation of a new firm, named ***Vulcano Termodomésticos***, in which ***Robert Bosch GmbH*** held a majority stake and in 1990 ***Vulcano*** became a wholly-owned subsidiary of ***Bosch***. In retrospect, Mr. Pais de Sousa stated that "***without such a relationship, [today] there would be no company left in Portugal: it would have disappeared in the strong move towards concentration which took place in the industry"***[10].

Forging ahead: becoming the Domestic Water Heating Worldwide Centre of Competence of the Bosch Group

The origins of the ***Bosch*** Group date back to 1896 when Robert ***Bosch*** (1861-1942) set up a "workshop for precision mechanics and electrical engineering". When it took control of ***Vulcano***'s equity, the ***Bosch*** Group had just completed its first century in business. Such longevity[11] seems to be based on three main inter-related features. The first derives from ***Bosch***'s culture of systematic innovation, encompassing significant R&D investments (around 8.1 per cent of sales revenue in 2010), focused on developing innovative solutions to improve people's life (***"Invented for life"***[12]). In ***Bosch***'s jargon, innovation has to meet four tests: (1) novelty; (2) uniqueness; (3) delivering new or improved tangible benefits to the customer; and (4) to be successfully established in the market[13]. The second has to do with the establishment of a global development, manufacturing and distribution network. The third concerns its governance model: 92 per cent of equity is held by ***Robert Bosch Stiftung***. ***Bosch***'s shareholding structure ensures the autonomy of the ***Bosch*** group, enabling long term planning, and the allocation of significant investments aimed at fostering future performance[14].

By 1992, ***Vulcano*** became the European water heater market leader, with a share of

5 · Even today, *Vulcano gains* the highest awareness among water heater brands in Portugal.

6 · Mário Pais de Sousa, 'O processo de internacionalização da Vulcano', *Economia & Prospectiva*, Vol. 1 no. 2, 1997, pg. 106.

7 · Personal interview with Mr. Mário Pais de Sousa by Vítor Corado Simões (Aveiro, May 1991).

8 · The French firm Vaillant was second-ranked in the Portuguese market, based on export entry mode.

9 · Vítor Corado Simões and Pedro P. Nevado, *MNE Centres of Excellence and Acquisitions: Long Evolutionary Paths or Capturing Opportunities*, Paper delivered at MESIAS Seminar, Madrid. 2001.

10 · Personal interview with Mr. Mário Pais de Sousa by Vítor Corado Simões (Aveiro, May 1991).

11 · For a general analysis of the main reasons leading to company longevity, see Arie De Geus, *The Living Company: Growth, Learning and Longevity in Business*, London, Nicholas Brealey, 1997

12 · Taken from *Bosch* logo.

13 · Presentation by Evandro Amorim (Bosch Termotecnologia) at the Workshop on 'Open innovation, creativity and knowledge networks', ISEG, July 2012.

14 · Taken from http://www.bosch.pt/pt/pt/newsroom_11/news_10/news-detail-page_53504.php accessed on May 30th 2015.

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20% as against 6% in 1988[15]. This achievement was based on a "sophisticated cost-based strategy"[16]. ***Vulcano*** has been able to change a labour-based cost advantage into an organizationally-driven cost advantage through the implementation of a lean production approach. Operational efficiency increased significantly, while management processes were improved, including performance measurement indicators. These initiatives led to a significant improvement in quality levels and key performance indicators. Recognising ***Vulcano***'s behaviour and performance and taking into account the lower costs in Portugal, ***Bosch*** headquarters took the decision to close the water heater plant in Wernau (Germany) and concentrate the manufacturing of this product type in Aveiro.

It was felt that increased manufacturing responsibilities, stemming from operational performance, had to be followed by improvements in product engineering capabilities. In fact, the closure of the German plant implied that responsibility for domestic water heating research and development activities was assigned to the Portuguese subsidiary. The director of water heater development was transferred to Aveiro; simultaneously, some ten development engineers came from Germany. The former product engineering unit was transformed, by 1993, into a Research and Development Centre (hereinafter, R&D Centre; an image is provided in Exhibit 2). This entailed a significant change in ***Vulcano***'s responsibilities: from operational excellence toward a combination of operational excellence and state-of-the-art product development capabilities.

In 1994, ***Vulcano*** launched ***Click!***, the first 'smart' water heater, with battery-powered electronic ignition. This became a landmark for the company, corresponding to the 'acid test' of the R&D Centre's innovative capabilities. In 1996, a new, challenging project starts: RÁCIO 96. The goal was to reduce the cost of the water heater by 10%! Sérgio Salústio remembered: ***"how to design a water heater with the same functions and performance, but with costs 10% lower?"***. As explained below, the challenge was met: by the turn of the century, a new product (labelled ***Compact***) was launched as a result of this initiative.

EXHIBIT 2
The R&D Centre Building

Source Bosch Termotecnologia S.A.

By 1997, the R&D Centre had a staff of 16 people, of which 60% were engineers, mostly with a specialization in mechanical engineering with the German expatriates gradually replaced by Portuguese engineers. The main challenges faced by the new department included not just the development of new products with increased performance standards and lower cost but also the adaptation of existing appliances to the new utilisation conditions, specifically installation regulatory requirements and changes in the gas supply. In this context, the introduction of natural gas to the Iberian Peninsula led to a significant increase in demand for water heaters: production output changed from two or three hundred thousand per year to

15 · Mário Pais de Sousa, 'O processo de internacionalização da Vulcano', *Economia & Prospectiva*, Vol. 1 no. 2, 1997.

16 · Monitor Company (Michael Porter and associates), *Construir as Vantagens Competitivas de Portugal*, commissioned by the Ministry for Industry of Portugal, Forum para a Competitividade, Lisbon, 1994, pp. 79.

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about one million, mostly sold in the Iberian Peninsula and Southern Europe. Meanwhile, ***Vulcano*** has become the ***Bosch*** group spearhead to approach non-European markets in which the prospects for water heater demand were significantly higher than in Europe. It correspondingly established licensing agreements in North Africa (Morocco and Tunisia), in Turkey, Chile and Brazil[17].

Vulcano was involved in the process of establishing a joint venture between the ***Bosch*** Group and local partners in Guangdong (Shenzu), responsible for the technical and economic analysis of the local partner as well as for all the product and process strategy[18]. This led to the transfer, in 1996, of a permanent team of three members of ***Vulcano***'s technical staff, then led by João Paulo Oliveira (***Bosch Termotecnologia*** CEO[19]), to China. These developments further strengthened the influence of the Portuguese subsidiary in ***Bosch***'s Thermotechnology Division, and its recognition at the ***Bosch*** group level. However, the first years in China did not prove successful. As João Paulo Oliveira recognized, the products launched by ***Bosch*** in the Chinese market were over-engineered, with quality and security patterns which were ***"not valued in the Chinese market"***. Only when the strategy was changed, and ***Bosch*** started ***"to manufacture in China products [similar to those] of the South America and North Africa markets"***[20] did the situation begin to be redressed.

At the same time, ***Vulcano*** was facing another challenge: to replace a Germany-based supply chain with a global one. This was a daunting task, taking into account the need for strict quality standards and the just-in-time, lean production system existing in the company. ***Vulcano*** established R&D cooperation in conjunction with international partners from Taiwan to the Netherlands. One relevant feature was the setting up of R&D and technical cooperation linkages with academic organisations, such as Lisbon's Instituto Superior Técnico (IST) and Oporto's Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial (INEGI). The company acknowledges the role played by financial incentives under PEDIP I and PEDIP II[21] in this regard. Sérgio Salústio remarked that this kind of public policy had a very positive effect, since ***"it contributed to increasing Vulcano's awareness about the capabilities of local partners, thereby strengthening the connections with them"***.

In 2001, ***Vulcano*** launched a new generation of compact water heaters enabling a 27% reduction in appliance size. Furthermore, in this same year, a new project was launched: the HDG. This incorporated an invention developed by the Portuguese

17 · Mário Pais de Sousa, 'O processo de internacionalização da Vulcano', *Economia & Prospectiva*, Vol. 1 no. 2, 1997.

18 · Mário Pais de Sousa, 'O processo de internacionalização da Vulcano', *Economia & Prospectiva*, Vol. 1 no. 2, 1997.

19 · Please remind that the case refers to June 2012.

20 · Quotes from *Diário de Notícias*, 'Vulcano chegou cedo de mais à China', May 18th, 2007.

21 · PEDIP stands for Programa Específico de Desenvolvimento da Indústria Portuguesa (Specific Programme for the Development of Portuguese Industry). PEDIP I ran from 1988 to 1993 and PEDIP II, between 1994 and 1999.

EXHIBIT 3

The *Click HDG* Water Heater

Source Bosch Termotecnologia S.A.

Centre of Excellence, and globally patented by the *Bosch* Group: the smallest hydrogenerator in the world. The result has since been the launch of *Click HDG* (see Exhibit 3), which was awarded the international industrial design 'IF' design award.

As a result of this process of capability building, the *Bosch* Group assigned to *Vulcano*, in 2004, the status of Group Domestic Water Heating Worldwide Centre of Competence. *Vulcano* became responsible for coordinating the worldwide water heater design and development as well as for manufacture and commercialization. Although this corresponded to a de facto situation, it entailed the recognition of *Vulcano*'s merits and became paramount in enhancing the subsidiary's influence in the Thermotechnology Division. According to Sérgio Salústio, ***"the founding of the Centre of Competence did not stem from the need to create something new, but rather amounted to the recognition of an existing capacity".***

Centre of Competence: Old and new challenges

The assignment of the Centre of Competence statute had two main consequences. First, it contributed to leverage *Vulcano*'s relative position in the *Bosch* network. Second, it strengthened the company's R&D commitment: ***"since then, R&D started to be a systematic and organised routine"*** (Sérgio Salústio). This commitment has been expressed in a stream of new product launches: the CAE (Compact Advanced Electronics), involving an electronic modulation of gas consumption, and entailing significant improvements in comfort and security, in 2008; the heat pump for sanitary waters, in 2011, followed by an improved version with outside air supply, in 2012; and the FP water heater platform, in which a fan pressures on the air in order to improve the combustion quality (hence, the FP: fan pressurized), thereby saving gas, whose market launch is expected for 2013.

On January 1st, 2008, the name of the Portuguese subsidiary was changed from ***Vulcano Termodomésticos S.A.*** to ***Bosch Termotecnologia S.A.*** to show a clear identification with the *Bosch* Group. In January 2009, *Bosch* Termotecnologia was assigned the worldwide responsibility for the group's sanitary hot water product line, reflecting the subsidiary's performance and competence in the field.

Gradually, the R&D Centre underwent a silent change. Originally, most staff corresponded to mechanical engineers. In fact, water heaters were traditionally based on a mechanic-hydraulic platform and hence the dominance of the mechanical engineering field. However, with the gradual introduction of electronic components and devices to that platform, mechanical engineering knowledge alone was no longer sufficient to respond to new demand and competitive challenges. Therefore, the company has increased its recruitment of electronics engineers.

Looking backwards, Sérgio Salústio was very satisfied with the path followed by *Bosch* Termotecnologia S.A. as well as with its ability to change the knowledge base and the perception of the water heater business. He recalls:

"We underwent a significant transformation (...). We have carried out this transformation through people and organic growth. This is one of the greatest achievements of our organisation and I am comfortable because I feel that we are prepared to do that what we think best, defending new projects but without putting into jeopardy our mission and values. (...) We had the opportunity to set about organic change".

This has been undertaken through a process in which the skill content of R&D staff has changed, with electronic engineering gaining ground with regard to mechanical engineering. Following this line of reasoning, he imagines a future in which Portuguese engineering talent might be made available, at a competitive cost, to other subsidiaries in the Thermotechnology Division. Might this be an opportunity for ***Bosch Termotecnologia S.A.***? Would it make sense to further expand the R&D Centre to respond to future challenges?

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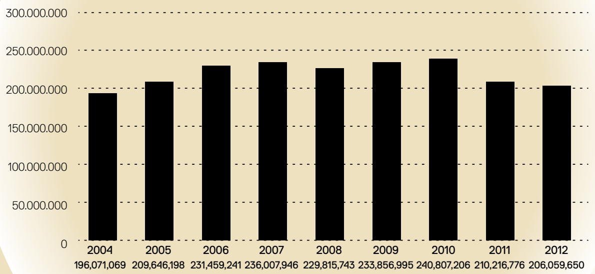
Bosch Termotecnologia S.A. in 2012

The outcome of the process portrayed above is a healthy company, employing around one thousand people (964 in December 2012), including around 65 in the R&D Centre. The company's turnover for 2012 was Euro 206 million, of which 80% was exported. Turnover declined with regard to the previous year, especially due to the contraction of Southern European (Portugal, Spain and Italy) markets. Profits reached Euro 16 million in 2012, which corresponds to a profit to turnover share of 7.6 per cent[22] R&D expenditures in 2012 amounted to Euro 1.6 million, below the 1.9 million recorded for 2011. The ratio of R&D expenditures to turnover corresponded to 0.77 per cent (2012 figures). More specific information on the evolution of ***Bosch Termotecnologia S.A.*** turnover and employment as well as the R&D Centre employment is provided in Exhibits 4, 5 and 6. The balance sheets and profit and loss accounts for the fiscal years 2011 and 2012 are provided in Annex II.

22 · Bosch Termotecnologia, *Relatório do Conselho de Administração - Exercício de 2012*, Aveiro, 2013.

EXHIBIT 4

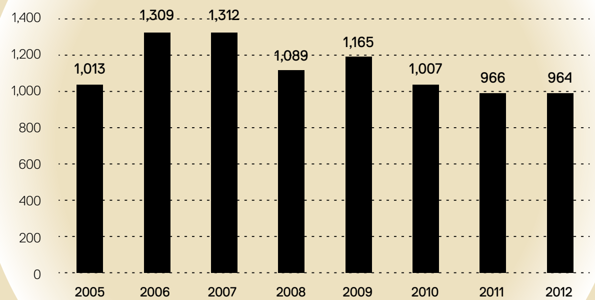
Bosch Termotecnologia S.A. Evolution of Turnover (2004-2012)



Source Bosch Termotecnologia S.A.

EXHIBIT 5

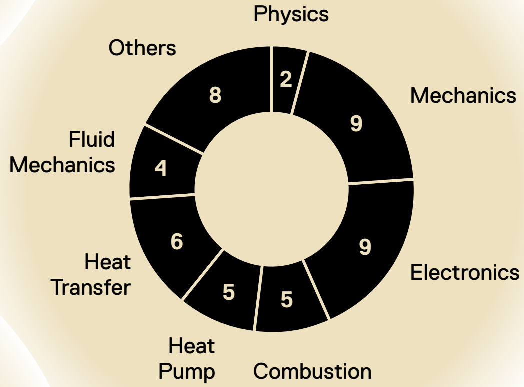
Bosch Termotecnologia S.A. Evolution of Employment (2004-2012)



Source Bosch Termotecnologia S.A.

EXHIBIT 6

R&D Centre Employment by Academic Field (2013)



Source Bosch Termotecnologia S.A., Inovação em Água Quente + Sustentável.
Presentation by Marco Marques at the University of Aveiro, 2014

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Product development at *Bosch Termotecnologia*: the key tools

Bosch Termotecnologia adopts, in line with the ***Bosch*** group guidelines, an integrated perspective to New Product Development (NPD) and market launch. This might be envisaged as an NPD 'blueprint', and includes three main tools: the Innovation Process, which is mainly related to idea management; the User Experience approach, intended to identify new (or improved) product ideas from user observation and other feed-back; and the Time To Market ('TTM'), which goes from product development to market launch. The following pages provide a brief explanation about these three tools.

It was shown above how operational efficiency has been a key factor in the ***Bosch*** Group assigning its Portuguese subsidiary with increased responsibilities. Nevertheless nowadays the challenge is not just operational performance. ***Bosch Termotecnologia***'s prospects of maintaining and enhancing its status in the ***Bosch*** group's internal network are dependent on its technology development capabilities, and especially on its NPD performance. Systematic technology development and efficient NPD are at the heart of ***Bosch*** group international competitiveness. Not surprising, therefore, NPD represents a central competence in ***Bosch Termotecnologia***.

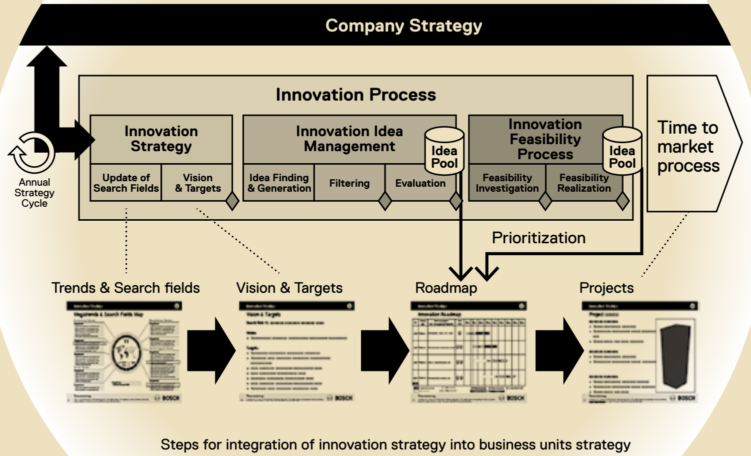
Innovation Process: From Technology Strategy to New Product Development through Idea Management

As mentioned above, the so-called Innovation Process focuses mainly on the emergence and management of new product ideas. It has also a role of ensuring compatibility and alignment between corporate orientations and subsidiary implementation. Its headlines are depicted in Exhibit 7 and developed in Box 1 below.

The innovation process should be consistent with the overall strategy orientations established at group level. These include nurturing technology with a view to "invent for life": "At ***Bosch***, the main drivers of innovation are resourceful and highly committed engineers, a high-performance yet efficient research organisation, and a historical background that is both an inspiration and an obligation, driving us on to further outstanding achievements" . Headquarters also set up targets on turnover growth and profitability. Provided that it meets such strategic orientations, each Centre of Competence enjoys, under the purview of its mission, autonomy to define its own development strategy. Such autonomy goes together with a process of systematic reporting of activities. Each year, ***Bosch Termotecnologia***'s management team has two meetings with the Thermotechnology Division management to assess and review prospective orientations, roadmaps, technology development projects, investment plans and business plans.

EXHIBIT 7

Bosch Termotecnologia's Innovation Funnel



Source Robert Bosch GmbH 2012 by Evandro Amorim (2012)

Such a process is envisaged as a "funnel" going through a stage-gate approach. As explained in Box 1, the process starts out on the basis of the megatrends assessment carried out at the ***Bosch*** group level. The ***Bosch Termotecnologia*** innovation process draws from general group guidelines and is aligned with the overall ***Bosch*** group innovation strategy. As mentioned above, idea management, including the generation of new product ideas, their selection and prioritization, may be envisaged as the main focus of the Innovation Process. In connection with the Innovation Process, it is important to remark that being granted patents hold a particular relevance to the company. They feature on the balanced scorecard and are also considered in the employee performance evaluation system. ***Bosch*** patenting policy is centralised. Patent applications are managed at company headquarters: they are initially undertaken in Germany. Their international application scope (EPO, USPTO...) depends on the analysis of patent relevance carried out at ***Bosch*** headquarters. Although the individuals who developed the invention are the patent owners, they assign the patent rights to ***Bosch***.

BOX 1.

The Innovation Process at Bosch

For Bosch, the Innovation Process precedes the New Product Development activity (called Time To Market – TTM. It encompasses three phases (Innovation Strategy, Innovation Idea Management, and Innovation Feasibility Process), each of them including sub-phases, as shown in Exhibit 10.

The Innovation Strategy phase is based on the definition of the megatrends identified at the Bosch group level. Subsequently, following a 'cascading' logic, each business, division and centre of competence identifies those trends which are more likely to have the highest relevance for, and impact on, its respective area of activity. This enables the identification of research fields and priority fields of action with a view to ensuring the future sustainability of the business. This analysis leads to the establishment of both the vision and the targets, which may concern financial and innovation targets.

The second phase (Innovation Idea Management) integrates the whole process of ideas and concepts generation. Internal and external sources may be mobilized. Regarding the former, an important role is played by the internal suggestions system that rewards the best ideas from employees and with workshops designed to solve problems. Earlier product development processes are another source of ideas for introducing new features on the appliances. In the case of external sources, the process draws on market studies and web tools for the gathering of ideas whether from suppliers or clients, and the analysis of user experience (this is detailed later in the case). The partnerships established with universities and companies for pre-development also take on significance given their role in contributing towards the generation of more mature ideas.

The ideas are then the object of sorting, aggregated and classified in accordance with their themes and maturity levels. Subsequently, they are subject to an evaluation taking into account various criteria including time, level of innovation, complexity and, fundamentally, their capacity to be adapted to meeting market needs. This generates an Idea Pool which is then complemented and checked against the Technology Roadmap and the knowledge about user experiences.

The result of this process leads to the third phase, the Innovation Feasibility Process. Ideas are subject to a more thorough evaluation, focused on their feasibility. As a result of this feasibility assessment, ideas are prioritized taking also into account the Technology Roadmap. The outcome of this phase is the identification of NPD Projects.

Source: Bosch Termotecnologia S.A., presentation by Evandro Amorim at the ISEG Conference "Open Innovation, Creativity and Knowledge Innovation" (3 July 2012).

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Most ideas come from internal sources and from the insights arising from the User Experience approach. But they may also have different origins, including technological solutions developed elsewhere in the Group. As Evandro Amorim, International Product Manager at *Bosch Termotecnologia S.A.*, mentioned[23]:

"For example, we recently got a pressure sensor that is used in the automotive industry and that we switched over into our product to achieve a function for which we had not yet found a solution."

Just ***"having innovative ideas is not enough"*** as Evandro Amorim remarked. He added in a challenging mood:

"The idea cannot just be new and unique. The idea has to effectively generate added value for the client. Should the idea not return that added value, then that idea does not progress.[24]***"***

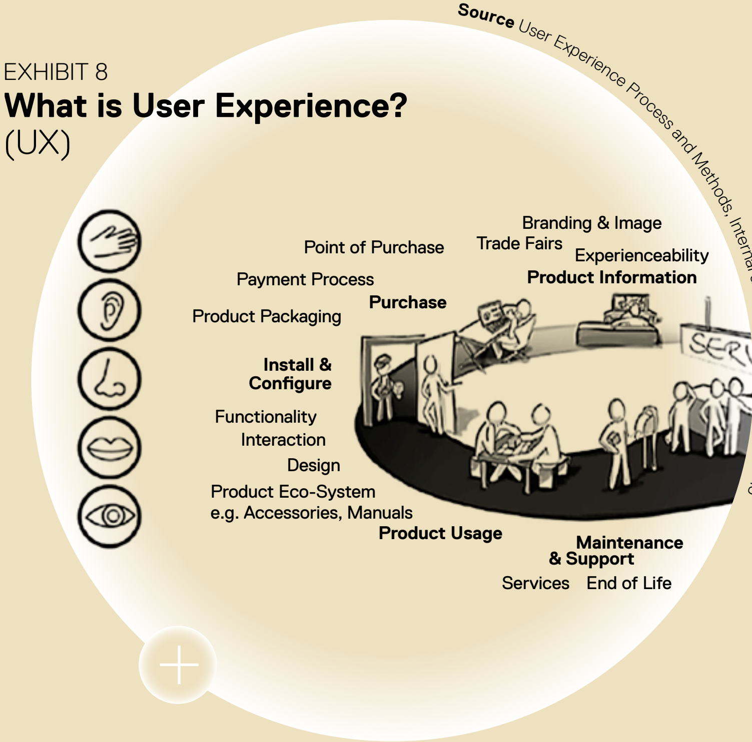
User Experience was pointed out above as an important source of new or improved product ideas. The User Experience analysis is a very important tool in ***Bosch Termotecnologia***'s NPD.

User Experience: Listening to the Market

The concept of User Experience (UX) was introduced more systematically in the ***Bosch*** Group after 2000 and has since become a central feature to its innovation process. As Volkmar Denner, ***Bosch***'s CEO, underlined, ***"in the future, we want to put the user on the center-stage, and get a better feeling for his wishes and needs"***[25]. UX is a tool intended to follow the "user's route", taking into account the life cycle of user contact with the product, from the collection of information before purchasing to after-sale maintenance and support services until the end of product's life. Tiago Bandeira, International Product Manager at ***Bosch Termotecnologia S.A.***, argued that ***"it is not just a matter of interaction with the user", but rather "to follow the whole process (...) to identify stress points"***. Exhibit 8 depicts the headlines of the ***Bosch*** perspective on UX.

UX is based on two key principles. The first is an iterative consideration of the user, technology, and business (the market). The second interrelates with the "user-centered" approach espoused by ***Bosch***. According to the company "human needs are mandatory starting point, process foundation and target topic" for NPD at ***Bosch***. Information is collected through interviews, direct observation, market research and assays. These may be take place at corporate of subsidiary levels, and may be carried out internally or commissioned to specialized service providers. Information is then analysed to identify critical aspects. UX may be envisaged as the driver for focusing innovation efforts and the NPD process and therefore translated into new products designs and key features.

EXHIBIT 8
What is User Experience?
(UX)



Source User Experience Process and Methods. Internal document, Bosch Group, 2015

23 · Evandro Amorim, presentation at the ISEG Conference "Open Innovation, creativity and Knowledge Innovation"(3 July 2012).

24 · Evandro Amorim, presentation at the ISEG Conference "Open Innovation, creativity and Knowledge Innovation"(3 July 2012).

25 · Quoted from *User Experience Process and Methods*, Internal document, Bosch Group, 2015.

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The perception of user requirements is considered as the basis for developing products that *"excite and fascinate our customers"* (Volkmar Denner)[26]. User knowledge is complex, integrating three main perspectives. The first refers to an accurate understanding of user needs (for instance, efficiency, comfort, stability of water temperature, compatibility with renewable energy sources...). The second concerns the attention assigned to all users involved in the purchase decision chain. Technical people in charge of appliance installation are very important players in the chain since they have direct contact with the final customer and may have a strong influence over the purchasing decision. Marco Marques, Director of Product Engineering Gas Appliances, recalls how UX worked in the case of the fan pressurized model: ***"Talking with installation people, we found that the adjustment of the appliance to fit installing conditions was an important concern for them, requiring a lot of time and effort. Based on such user experience, we transformed an unspecified need into a product specification: the appliance should be designed so as to adjust to installing conditions".***

The third perspective is the definition of client profiles, taking into account not just the country or economic welfare, but also other factors (cultural or aesthetic) that may impinge upon the purchasing decision. The experience in China shows how solutions have to be adapted to local conditions and to user requirements and expectations.

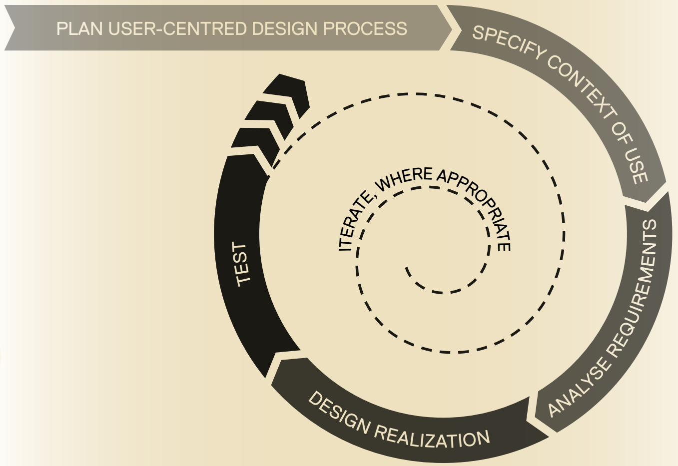
UX information feeds and is factored into the NPD process. The translation of UX into NPD is summarized in Box 2. These actions become key elements for ensuring the effectiveness of specific NPD projects throughout what is called in the Bosch jargon, the TTM process.

26 · Quoted from *User Experience Process and Methods*, Internal document, Bosch Group, 2015.

BOX 2.

From User Experience to New Product Development

The translation of User Experience (UX) into the New Product Development (NPD) process is envisaged as a spiral, which may involve, if needed, several iteration loops as a result of the user-centered design-test-redesign process. This is graphically illustrated below:



The basic process involves five steps: (1) Planning of the user-centered design process; (2) Specification of the context of use, involving additional interaction with key stakeholders (not just customers but also suppliers and installers, for example); (3) Analysing requirements, and their implications for product feasibility; (4) Design realization, transforming ideas into specific concepts, with a view to ensuring a fast translation of the requirements into prototypes; and (5) Testing the prototypes, including inter alia the observation on how users interact with the prototype, to derive inferences for changing technical specifications and further improvement rounds.

Source: User Experience Process and Methods, Internal document, Bosch Group, 2015 .

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The 'Time To Market' Process:

New Product Development and Market Launch

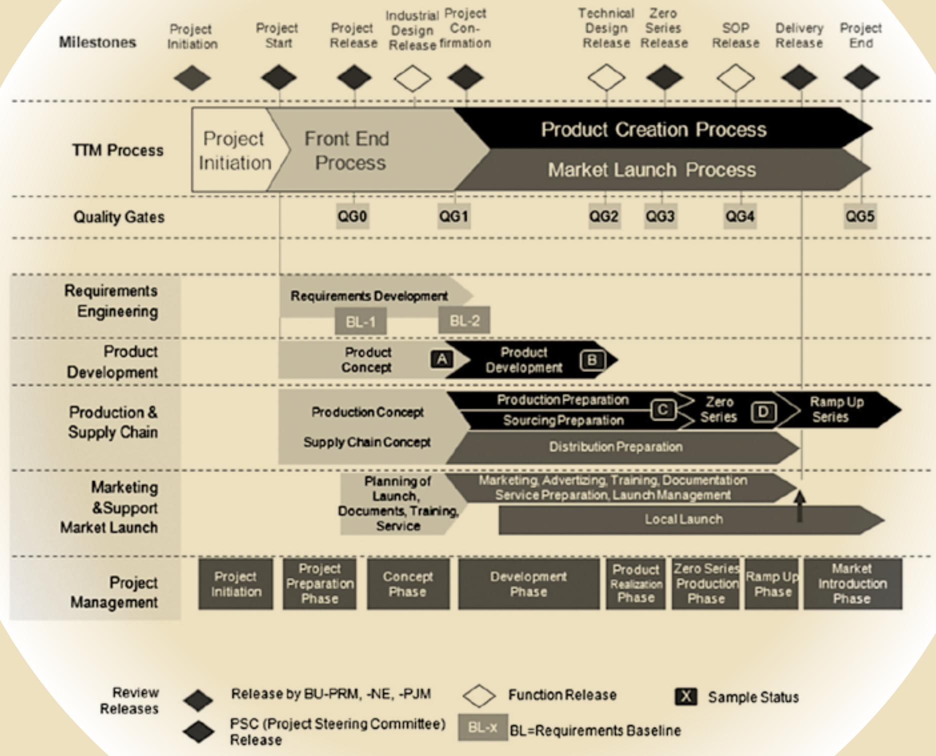
The UX is therefore integrated into NPD project applications. These need to get managerial clearance, including budget and time allocations, before being developed. The NPD development is based on a template established at the Bosch group level: the 'TTM' process. This may, however, be adapted, having in mind specific conditions and challenges.

The 'TTM' involves a stage gate approach, depicted in Exhibit 9. A more detailed description of 'TTM' is provided in Box 3 below.

'Time to market' is a stage gate routine process that provides the guidelines for NPD, clearly assigning responsibilities and defining the process flowchart. According to Pedro Cardoso, Quality Management Director and former project leader, this NPD template is ***"appropriate"*** and is a key tool for guiding the NPD. When the new idea generation (including UX) and the NPD processes are taken together, a logic of "disciplined innovation" clearly emerges. Another important facet of this process is the usage of NPD projects for learning at both the organizational and individual levels.

EXHIBIT 9

The 'TTM' Process



Source Bosch Thermotecnology (2015).

BOX 3.

The 'Time to Market' Process at Bosch Termotecnologia S.A.

As depicted in Exhibit 9, the TTM process includes eight stages and ten milestones, which correspond to decision gates. Both are briefly explained below:

I. Project Initiation: This is a preliminary phase, aimed at preparing the NPD project to be presented to *Bosch Termotecnologia S.A.* Management Board for approval. It encompasses the carrying out of a preliminary economic and financial assessment, an analysis of commercial feasibility, and an identification of target markets. Several issues are raised by the Board, in order to assess the soundness and relevance of the intended project. This phase ends with a Board decision (*Project Start*) regarding the budget allocated to the project as well as a time target for delivery of the new product.

II. Project Preparation: This phase involves the assignment of the project leader and the selection of the project team. A clarification of technical specifications and market requirements is carried out. Especially for more demanding projects, initiatives are taken to involve different players in the intended new product's value chain, namely the suppliers of key components, tools and specific equipment. The phase end with a decision gate (*Project Release*).

III. Concept Phase: This is a very important phase, in which investments and the target product price are defined. The project team takes the formal responsibility for carrying it out in the target timetable. Key technical decisions may also be taken at this time. This phase includes on the definition and approval, in line with Bosch group guidelines, of industrial design concepts (*Industrial Design Confirmation*). The key criteria and features of industrial design are then established. This phase end with the *Project Confirmation Decision*, taken by the project Steering Committee.

IV. Development Phase: This is specifically focused on product development. The purpose is to 'close' all the technical concepts, meeting the cost, security, user-friendliness and technological requirements established. A sample B of the final product is prototyped. Industrialisation requirements are also an important feature, demanding interaction with suppliers. Together with the Concept Phase, this is the most important phase of the NPD process. Product development ends with another decision gate, the *Technical Design Release.*

V. Product Realisation Phase: This is characterized by fieldwork, testing the sample B of the product in different conditions, with a view to solving emerging problems. This process leads to the developing and testing of sample C of the product. This phase also includes a further analysis of consumer patterns and behaviours, in line with UX guidelines. Another challenge of this phase is the appropriate and efficient working of the new production line at *Bosch Termotecnologia*'s plant. To ensure appropriate industrialization, another Bosch tool is applied: the Bosch Production System (BPS). The NPD project has to work in close cooperation with Manufacturing Operations to ensure a smooth implementation of the BPS. This phase leads to another decision gate: the *Zero Series Release.*

VI. Zero Series Production Phase: After getting the Zero Series release, production starts on the basis of sample C. Upon confirmation that the product has no problems and the manufacturing process is ready, a decision is taken regarding the start of production, called *Start of Production (SOP) Release*. This decision is based on a report by the project leader regarding the status of the NPD process.

VII. Ramp Up Phase: The first units of the product are completed, and forwarded to the marketing and distribution department. If successful, the *Delivery Release* decision will follow. This paves the way for the market launch.

VIII. Market Introduction Phase: This phase starts with the Ramp Up series in the target markets. This phase usually extends for one and a half years. At this point there is the final gate, called *Project End*. This formally implies the dissolution of the project team, and the assignment of product responsibilities to the relevant functional departments.

Source: Bosch Termotecnologia S.A., 2015.

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The CAE project: a landmark in company development

The CAE Project

The Compact Advanced Electronics (CAE) Project has been one of the most important NPD initiatives carried out by ***Bosch Termotecnologia S.A.***. With a budget of about €10 million, it had significant direct and indirect implications for the company. The first was the launch of a new thermostatic water heater without recourse to electricity as additional technology source. The power comes exclusively from an HDG hydrogenerator, which has been developed in a way to enable total autonomy and to allow for the pre-selection of temperature. This innovation won the 2011 ***Produto Inovação COTEC Portugal*** award, and is now present in the international market under the trade name Sensor Plus (Exhibit 10). The main indirect implication, stemming also from the NPD concept adopted, was the setting up of the so-called CAE manufacturing platform.

The NPD process was carried out in line with the Bosch template presented above, encompassing two main stages: market analysis and pre-development; and development and industrialization[27]. As stated by Pedro Cardoso, who was the CAE project leader, ***"I reached the conclusion that the methodology that we have at Bosch Thermotecnology is a worldwide benchmark as regards project management. Throughout the life cycle, it ensures that the right questions get asked and the right tools are deployed to guarantee the project's final success".***

Market Analysis and Pre-development

Following the introduction of the first thermostatic water heaters, in 2003, ***Bosch Termotecnologia S.A.*** decided to deepen its knowledge about the users of this type of appliances, carrying out market research as well as research on technology trends, with a view to understanding consumer expectations. These initiatives, between 2003 and 2005, led to identify safety, economy and comfort as the key requirements to be met. Based on market forecasts, a preliminary assessment of financial feasibility was carried out, broadly confirming the scope of project opportunity.

Having passed the first hurdles, the focus turned towards the technical side. The new water heater should meet the following requirement: an electronic modulation of the water temperature at the level of Celsius degree without recourse to electrical power. Therefore, a pre-development phase was carried out between 2005 and 2007, focused on the analysis of alternative technological solutions. The outcome was a decision to develop from scratch a new electronic, instead of mechanical, system for controlling the gas stream, including a gas valve. This was a product innovation at the world level as nothing similar was available in the international market. The advantages of adopting a platform approach for the new product were also identified at this stage.

Pedro Cardoso recalled how ***"we had the idea that if we were able to do the electronic modulation of the gas flow, we might be able to get to a higher level"***. But this would be no easy task. In his words,
"The challenge that we set ourselves to achieve was not just big; it was really enormous. Doing this [selecting the temperature] without any electricity power supply (...). Technically, this meant that we had to design a 100 milliwatt system that would do all the gas control operations, supplying the valve, igniting the spark but with a tenth of the energy of that which was the state of the art at the time".

The ideas were mature enough to be transformed into a project application to be submitted to the Managing Board of ***Bosch Termotecnologia, S.A.***, in line with the 'TTM' procedure.

27 · This sections draws on the interviews carried out with several *Bosch Termotecnologia S.A.* executives, namely with Pedro Cardoso, as well as from the company'sapplication to the Produto Inovação COTEC Portugal award, by Evandro Amorim and Laura Frias (April 2011).

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Development and Industrialization

The project application was submitted to the Managing Board and approved on February 27th, 2007. It included not just the technical concept (see Box 4) but also a preliminary economic and financial feasibility study, an analysis of market feasibility, and the definition of the two initial priority markets: Portugal and Spain.

BOX 4.

CAE Project: Product Requirements

- Non-electrical thermostatic water heater, with electronic modulation, powered by a water turbine;
- Direct ignition;
- No water valve: a stream sensor incorporated into the hydrogenerator;
- Digital interface; uploading system;
- Product capacity range: 11 l/min., 14 l/min. and 17 l/min.

Source: Bosch Termotecnologia S.A., Application to the Produto Inovação COTEC Portugal award, by Evandro Amorim and Laura Frias (April 2011).

This project required a very high level of financial commitment by the company. Introducing a completely new and innovative concept into an already fairly optimised and standardised production process entailed significant changes in the testing systems, the setting up of new manufacturing lines, the development of new dedicated equipment and tools, and the recruitment of specialist technical staff or alternatively the engagement in partnerships for the design and the development of the gas valve.

At Project Start, it was decided to establish a multidisciplinary project team. The objective was to analyse the implications of each challenge from different perspectives as well as the identification of joint solutions. The size of the project team was variable along the project, ranging between 10 and 15 people.

The financial investment required by the project amounted to a level that authorisation, following the proposal from the project manager, had also to be gained from the divisional level (***Bosch Thermotechnology*** Division), and not from the ***Bosch Termotecnologia*** Board level alone as is normally the case.

On taking the decision to advance with the project, new challenges arose. These were mainly related to product specifications (for instance, compatibility with solar energy ***versus*** non-compatible solutions). As there were no market references for state-of-the-art low consumption valves, there was a need to identify alternative technological approaches regarding gas stream modulation. Three emerged as the most viable: (1) to develop a modulation motor; (2) to use piezoelectric micro-valves; and (3) to make recourse to micro servo-valves. Decision making on these alternatives was a critical process. Prototypes were made for the three possible solutions and, following analysis of the countless technical requirements that needed to be achieved (safety, cost, intellectual property...), decision matrixes were worked out. Such complex matrices have been very useful in assisting the decision making process. Sérgio Salústio warned, however, that ***"the maximum number of criteria to be considered in such matrixes should not exceed eight to ten; with more than ten criteria, focus is lost"***.

This was one of the key decisions taken in the Project Confirmation stage. The solution chosen to develop the gas valve was subject to a quality assessment as well as to a FMEA (Failure Modes Evaluation Analysis) with a view to also assessing the implications for the whole product development system. A first sample of the gas valve was produced (called in ***Bosch***'s NPD jargon, an 'A sample').

A feature which proved to be particularly critical was the involvement of the main suppliers in the development of core product components as well as in the design of specific tools and production equipment. This took place as from the Project Release and Project Confirmation phases. Simultaneously, an engineering

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process was launched. This implies, however, suppliers fully understand the specific functions the components are required to perform. Supplier involvement and commitment were important not just in terms of production feasibility but also cost-wise: ***"The decision was taken to integrate the suppliers into the development process right from the initial phase. This was indeed one of the factors that made the greatest contribution to the project's success."***[28]

In the Project Confirmation phase, the entire project team takes on formal commitments regarding the project timetable and budget as well as target product cost. One of the most difficult decisions taken in this phase revolved around whether or not to produce the gas valve in-house. It corresponded to one of the most critical of all components to the entire concept. Once again, Pedro Cardoso looked back at the decisions taken in 2007:
"The platform was all developed here. The gas valve, the electronics, the hardware, the software, all of it developed here. And that is an enormous strength that we have. As from the point in time when we master the competences to develop the key product components, a decision could be taken on the strategic alliances needed to bring about the industrial production of these components. From my perspective, this was the formula for success. We did all the development and industrial design of the key components either here at Bosch [Termotecnologia] or through long term partners".

Sérgio Salústio added that the decision to develop and manufacture the key components in-house is very important for raising barriers to imitation by competitors. When questioned about this, he pointed out that ***"patents are important"*** and ***"the Bosch group assigns them a lot of weight"***. He adds, however, that they are not enough by themselves:
"We combine them with two other factors. One is the verticalisation of production. We manufacture gas valves, electronic components and burners by ourselves, in our plant. The second is lead time. We are continuously innovating. This provides an edge over competitors".

In the Industrial Design Confirmation phase, the CAE project industrial design was approved by the marketing department. This phase has also encompassed the adaptation of the technical concepts to the ***Bosch*** group's "engineering for design" guidelines.

The Technical Design Release phase was one of the most work-intensive, and extended from September 2007 to March 2008. The project team had daily meetings on the development of the product as a whole. A specific team was assigned to the development of the gas valve in order to reduce the pressure put on the other dimensions of the development project. Focus has also been put on the development of the hydrogenerator. This entailed thorough analysis and experimentation with a view to achieve an appropriate ***"energy budget"*** (Pedro Cardoso). In the process, ***Bosch Termotecnologia S.A.*** cooperated with an old, well-known partner, the Dutch company ***Cinetron***. 'B samples' were produced, and the first market tests were carried out. Simultaneously, close cooperation with the supply chain was pursued to ensure a steady industrialisation process later on.

After 'closing' the entire technical concept, the project advanced towards the next phases: Field test, and Zero Series Release. In the Field test, the first 'C samples' were built to be tested in real conditions. The tests enabled the collection of consumer feedback. Design, performance, ease of use and human-machine interaction have been among the main issues subject to analysis. After six months of field testing, the project proceeded to the Zero Series Release. The key question here is the production process. This specifically involves the training of plant operation staff to deal with a new specific production line. It was aimed at confirming that such a production line satisfied the process efficiency standards defined by ***Bosch***. An important tool in this regard was the ***Bosch Production System (BPS)***. Designed at the group level, BPS establishes a set of

28 · Quoted from *Bosch Termotecnologia S.A.*, Application to the Produto Inovação COTEC Portugal award, by Evandro Amorim and Laura Frias (April 2011).

guidelines to be followed in order to ensure the proper working of the manufacturing process (see Box 5 below).

The Start of Production was approved by ***Bosch Termotecnologia S.A.***'s Management Board on October 8th, 2009. In spite of the care taken to achieve no-failure industrialisation there are always problems to be addressed. The project team was still on duty, discussing with plant managers and operators the issues raised, and devising solutions to overcome them. The CAE project team was disbanded only when one and a half years had elapsed since the Start of Production. A thorough quality assessment of the whole NPD process, namely the whole 'TTM' procedure, was carried out to derive lessons that might be taken into account in future NPD projects.

Looking backwards, Pedro Cardoso, the CAE project leader, underlined how the advancement of project leadership capabilities is important for innovation-committed companies: ***"Project working is highly interesting. There are many factors driving pressure but it is a fantastic school for [human and organisational] capability development. (...). I think that from the point of view of managerial leadership competences, project management is absolutely fantastic. I have worked a lot in this area and it is very stimulating. I have always done it with great pleasure".***

BOX 5.

Bosch Production System

The Bosch Production System (BPS) is intended to make lean production possible. It enables the stimulation of the market and to ensure "customer and employee satisfaction". BPS is based on eight principles:

1. Pull system, supplying only what customers demand;
2. Process orientation, to ensure a streamlined response to customers;
3. Perfect quality, through faultless production;
4. Flexibility, to adapt to changing requirements and integrating a continuous stream of product system improvements;
5. Standardisation to enable reliable but flexible processes;
6. Waste elimination and continuous improvement;
7. Transparency, meaning "that everybody is aware of their tasks and objectives"; and
8. Involvement and empowerment "to utilise the creativity and extensive know-how" of Bosch's employees.

Source: Bosch Termotecnologia S.A., Lean Production – BPS, Internal leaflet, Robert Bosch GmbH.

The product

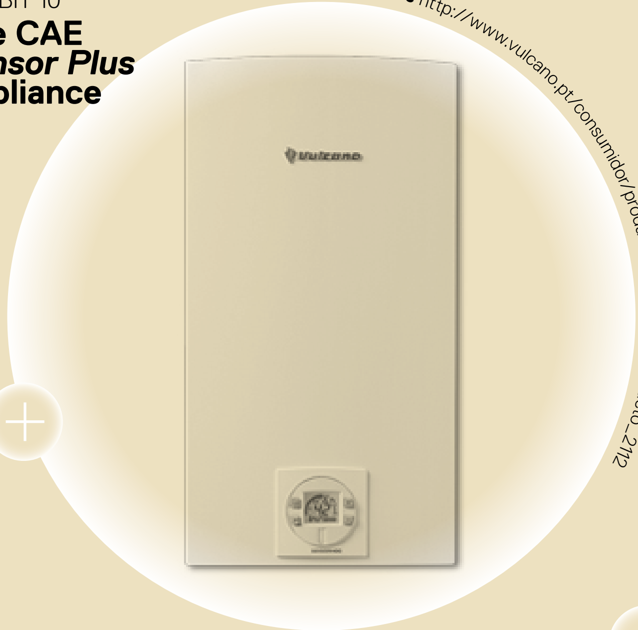
The outcome of the project corresponds to two new water heaters (***Sensor*** and ***Hydropowerplus***). These are characterized by the integration of the hydrogenerator in the hydraulic block, thereby reducing the loss of power charge in the circuit, and making ignition easier. Its image is provided in Exhibit 10; the main characteristics of the product are summarized in Box 6.

Bosch Termotecnologia states that CAE is ***"a revolutionary innovation: a combination of hydrogenerator with a low consumption gas valve to allow for an electronic selection and the modulation of hot water temperature (thermostatic system)".*** It further argues that "CAE technology is a world novelty", since existing appliances needed to have an electrical power connection or battery support. "The thermostatic function combined with the use of hydrogenerator and solar compatibility enabled a smart use of energy"[29].

29 · All quotes in this paragraph are taken from Bosch Termotecnologia S.A., Application to the Produto Inovação COTEC Portugal award, by Evandro Amorim and Laura Frias (April 2011).

In October 2010, one and a half year after the Delivery Release milestone, the CAE project reached its end (Project End). This entails a process of assessment of the product characteristics and the success of market launch. It is also time to identify the main 'lessons learned', with a view to taking them into account in future NPD projects. Project End formally implies the dissolution of the project team, and the assignment of product responsibilities to the relevant functional departments.

EXHIBIT 10
The CAE *Sensor Plus* Appliance



Source http://www.vulcano.pt/consumidor/productos/catalogo/producto_2112

BOX 6.
CAE Project: Product Characteristics

- Capacities of 11, 14 and 18 l/min., assuming a temperature increase of 25 degrees Celsius;
- Electronic ignition via hydrogenerator;
- Thermostatic temperature control (temperature selection with an accuracy of one degree Celsius;
- Compatibility with solar-powered systems;
- LCD display with temperature and watch;
- Natural exhaustion;
- Compact appliance: 580 x 310 x 220 mms;
- Advanced security systems: detection of flame failure; temperature control; gas exhaustion sounding lead, and temperature sounding lead.

Source: Bosch Termotecnologia S.A., Application to the Produto Inovação COTEC Portugal award, by Evandro Amorim and Laura Frias (April 2011).

Evolution of new product development processes from CAE onwards

The CAE project was followed by a stream of other NPD projects, always aimed at responding to changing technological trends, regulatory frameworks and user needs and demands. The purpose was keeping the leadership in the international water heater market based on continuous innovation.

Sérgio Salústio reminded how less than three months ago, in April 2012, ***Bosch Termotecnologia S.A.*** had launched a new product: the water heat pump, addressed to the German and French markets. The company considers that this is the start of a new generation of heat pumps for sanitary waters. In fact, as Marco Marques pointed out, ***"this project enabled Bosch Termotecnologia to create competencies about heat pumps"***. The pump is able to work over a wider range of atmospheric air temperatures and is compatible with solar energy systems. Technology-wise, the key improvement is the use of outside atmospheric air.

And nowadays, another NPD project is underway, having reached the Technical Design Release phase. It is aimed at developing the first hermetic thermostatic water heater, ensuring an automatic adaptation to the installation conditions. It will have a digital interface. Sérgio Salústio expects that by May 2013 market launch in the target markets (Spain and Italy) will take place.

This innovation strategy, now broadly consolidated, has enabled ***Bosch Termotecnologia S.A.*** to achieve continuous growth and to strengthen its position in the context of both the Bosch Thermotechnology Division and the global marketplace. Sérgio Salústio looked over at his office's door and whispered to himself: ***"Innovation does indeed pay off"***.

...and now, Sérgio?

Having proceeded to a review of the ***Bosch Termotecnologia S.A.*** history and landmark NPD projects, Sérgio Salústio took a look from the window of his office, and remembered that the June festivals were about to start. The next weekend would be Portugal's Day. He correspondingly thought: ***"Vulcano lost its independence. Was this good or bad for the Portuguese economy? Being fully owned by the Bosch group, is Bosch Termotecnologia S.A.'s contribution to the Portuguese economy less or more relevant than Vulcano's was? How to appraise such a contribution?"***

But this is not his main concern. As ***Bosch Termotecnologia*** Vice-President of Engineering, he has to devise strategic orientations that might lead to new projects, thereby strengthening ***Bosch Termotecnologia***'s status as Centre of Competence.

One of the clearest mega-trends is the ageing of the Western population. Even in China, ageing is becoming a concern, as a result of the single child policy. Therefore, designing and developing a specific line of water heaters for elderly people might be a good idea. Taking old people's UX into account, it might be possible to develop a basic water heater to fit elderly people's needs. However, a water heater has a long life cycle, and most old people's homes are already equipped with acceptable water heating solutions. Furthermore, market growth is elsewhere, not in Western countries. The United States is a different world, in terms of the domestic hot water appliances supply. The European market is relatively small. Would such a product be a potential 'winner'?

Why not address the issue from a different, more cross-cutting perspective? Why not profit from the experience gained from the development of the fan pressurised platform to design a new generation of easy-to-use, aesthetically appealing products? This might address every age cohort, while making the water heater an 'object of desire', capable of exciting and fascinating potential customers. However, this runs counter the dominant approach. In how many kitchens is the water heater visible? Is it feasible to transform an appliance that is behind the curtain or inside the cupboard into an 'object of desire'?

Another challenge would be to design water heaters prepared for the 'internet-of-things'. However, in spite of some visionary speeches, in June 2012 the internet of things is still to materialize. But sooner or later it has to be factored in water heater development. What might be the implications for ***Bosch Termotecnologia*** of falling behind the (potential) course? If the challenge is taken seriously, should the company go ahead alone or cooperate with other ***Bosch*** units, more advanced on this regard? Be as it may, a strong bet on the 'internet-of-things' would require changes in the R&D Centre's competence structure, and the recruitment of more electronics engineers.

Engaged in a self-dialogue, Sérgio recalled a talk with Pedro Cardoso a few days ago. He remembered Pedro's question by heart: how can ***Bosch Termotecnologia*** translate its capabilities and the talent of

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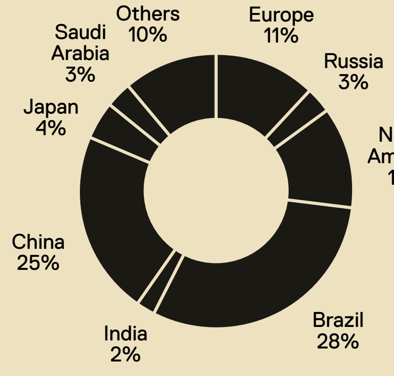
Portuguese engineers in terms of company growth and its profit-and-loss statement? As a Centre of Competence for domestic water heating, ***Bosch Termotecnologia*** scope is limited. Competing against other subsidiaries to get a wider product mandate does not seem to be an option. It entails risks, and may downgrade the company's influence at the ***Bosch*** Thermotechnology division level. Increasing the stream of new product development may not be worthwhile, taking into account the market structure and the patterns of product purchase.

So what now, Sérgio?

Continuing to look out of the window, Sérgio began figuring out responses to the questions he is concerned with...

ANNEX I
World market data

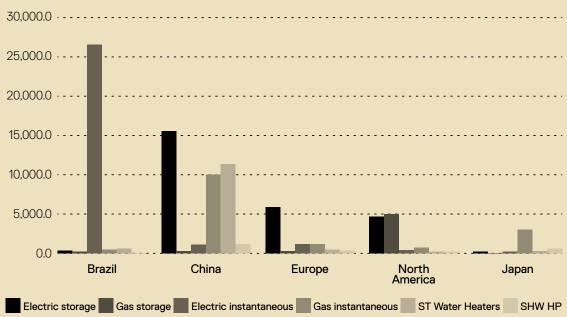
World Water Heating Markets
2013



Total: around 98.6 mln units
(include ESWH, GSWH, EIWH, GIWH, ST WH, SHWHP

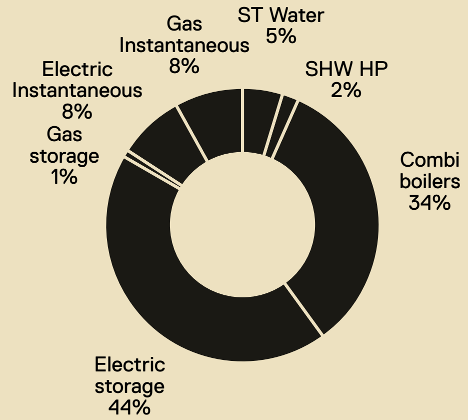
Source: Based on BSRIA market analysis for 44 countries

Largest Water Heating Markets
2013



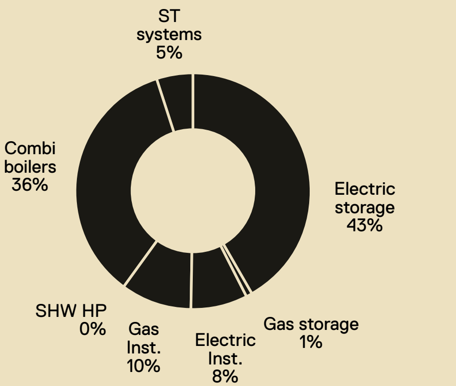
Source: BSRIA

World Water Heating Markets
by type of provision, 2013



Source: Based on BSRIA market analysis for 44 countries

Water Heating Market
by type of provision, 2010



- Electric storage have been the most popular product.
- The share of renewable WH systems is stable but SHW HP have increased at ST WH expense

Source: BSRIA

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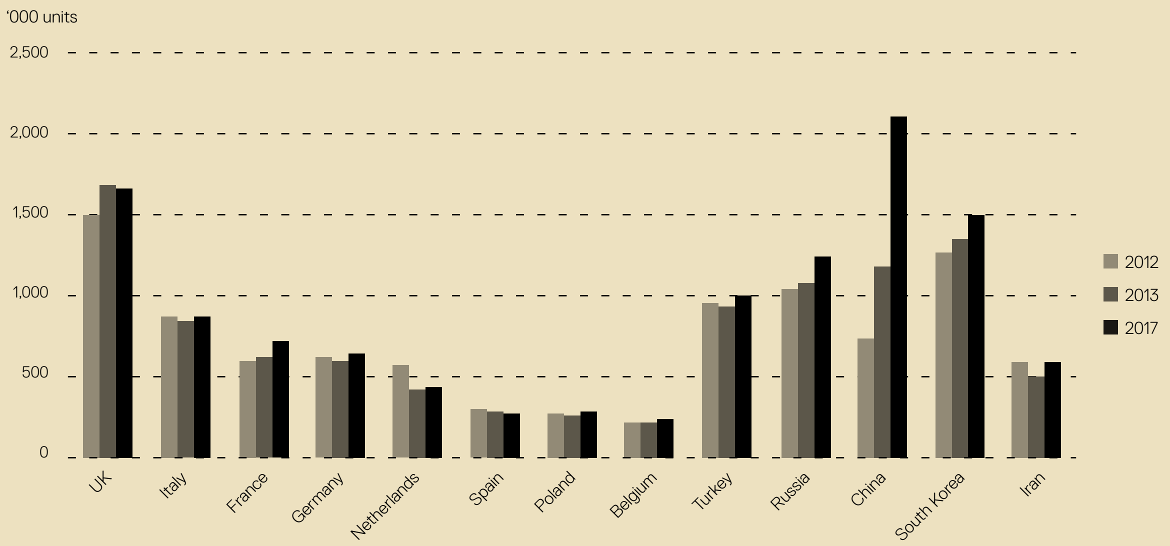
Domestic boilers
Main World Heating Markets



Source: BSRIA

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ANNEX II
Bosch Termotecnologia S.A. Accounts

Balance Sheet 2011, 2012
(Monetary unit: Thousand Euros)

	2012	2011
ASSETS		
Non-Current Assets		
Tangible Assets	17.803,10	15.613,30
Intangible Assets	131,90	98,20
Deferred Taxes Assets	4.653,30	4.762,20
Total of Non-Current Assets	**22.588,30**	**20.473,70**
Current Assets		
Stocks	12.032,90	14.480,80
Clients	44.077,40	42.701,40
Down Payments to Suppliers	174,50	572,00
State and Other Public Entities	2.068,30	1.600,70
Companies of the Group	16.059,90	21.406,70
Other Accounts Receivable	895,50	1.794,60
Cash and Bank Deposits	7.365,30	5.743,20
Total of Current Assets	**82.673,80**	**88.299,40**
TOTAL ASSETS	**105.262,10**	**108.773,10**
EQUITY AND LIABILITIES		
EQUITY		
Paid-in Capital	2.500,00	2.500,00
Statutory Reserves	500,00	500,00
Other Reserves	24.432,30	24.432,30
Revaluation Surpluses	641,40	675,60
Retained Earnings	6.692,90	6.658,70
Net Profit for the Period	15.611,20	16.064,70
Total of Equity	**50.377,80**	**50.831,30**
LIABILITIES		
Non-Current Liabilities		
Provisions	19.455,10	20.951,80
Obtained Loans	378,10	1.070,80
Deferred Taxes Liabilities	0,40	4,80
Total of Non-Current Liabilities	**19.833,60**	**22.027,40**
Current Liabilities		
Suppliers	26.206,70	23.424,00
State and Other Public Entities	1.283,60	759,30
Obtained Loans	116,80	502,70
Other Accounts Payable	7.753,80	11.228,40
Total of Current Liabilities	**35.360,90**	**35.914,40**
Total of Liabilities	**55.194,50**	**57.941,80**
TOTAL EQUITY AND LIABILITIES	**105.572,30**	**108.773,10**

Profit and Loss Accounts 2011, 2012
(Monetary unit: Thousand Euros)

	2012	2011
INCOME AND EXPENSES		
Sales and Services Provided	206.059,60	210.216,80
Operating Subsidies	91,20	90,20
Changes in Production Inventories	-1.232,00	-535,50
Costs of Goods Sold and Materials Consumed	-123.124,60	-126.203,70
Supplies and External Services	-35.488,10	-37.663,80
Personnel Expenses	-23.750,30	-25.256,00
Adjustments of Inventory	674,80	-330,40
Impairments of Receivable Debts	213,90	725,50
Provisions	2.190,60	3.484,60
Other Operating Income	4.352,30	7.056,90
Other Operating Costs	-4.831,70	-4.919,70
EBITDA -Earnings before Financial Expenses, Tax, Depreciation and Amortisation	**25.155,70**	**26.664,90**
Depreciation and Amortisation	-3.659,20	-4.271,20
EBIT - Operational Results	**21.496,50**	**22.393,70**
Interest and Similar Earnings	113,80	291,40
Interest and Similar Charges	-1.150,10	-564,80
Earnings Before Taxes	**20.460,20**	**22.120,30**
Income Taxes	-4.849,10	-6.055,60
NET PROFIT	**15.611,20**	**16.064,70**
Net Profit per Share	31,20	32,10

Source: Relatório do Conselho de Administração, 2012

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Keeping the innovation track record

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