CHALMERS

The Value Proposition Development and Market Diffusion of the Two Products Push and Pull

A Comparative Case Study

Master of Science Thesis

Andreas Venneman
Jonatan Hedin

Department of Technology Management and Economics
Division of Innovation Engineering and Management
CHALMERS UNIVERSITY OF TECHNOLOGY
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Report No. E 2010:038

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Technical report no E 2010:038
Department of Technology Management and Economics
Division of Innovation Engineering and Management
CHALMERS UNIVERSITY OF TECHNOLOGY
SE-412 96 Göteborg
Sweden
Telephone + 46 (0)31-772 1000

Sponsoring entity: ABB Corporate Research, Västerås, Sweden
Reproservice
Göteborg, Sweden 2010

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A comparative case study of two new product development projects that were initiated in the late 1990s was conducted. The products were followed up until today. The value proposition development and global diffusion of the two products referred to as Push and Pull was examined. Data collection methods included semi-structured (in person and telephone) interviews, internal and external document reviews, and an online survey. The initial value proposition was realized to large extent for Pull but not at all for Push. The perception of the value proposition varies between the developing company and its customers, mainly on complexity and observability dimensions. Obstacles to adoption for both innovations were substantial. For Pull legal requirements and utility policies, problems in internal acceptance, and an apparent need for closeness to the development site were the most significant obstacles. For Push, poor customer perceived price performance ratio, problems with internal acceptance, and skepticism towards technology used were the most significant obstacles. Catalysts to adoption were strong for Pull in primarily the Nordic market but weak elsewhere. For Push catalysts were weak in comparison with Pull and obstacles faced. Catalysts for push were weak since the initial value proposition could not be realized. The global diffusion in the market has been relatively sparse for both products given the long time since launch. The diffusion and the maturity of the product differ substantially between different markets.

Keywords: Value Proposition, Diffusion of innovation, Product innovation, NPD, New Product Development

Contents

Acknowledgements

This thesis work was initiated by Christer Ovrén manager of Power Technologies at ABB Corporate Research in Västerås, Sweden. In addition to establishing the project, he has also been helpful in gaining an overall understanding of the new product development in ABB.

Mikael Dahlgren has been our manager at ABB and his input and comments has provided us with many opportunities for improvement. Furthermore, Mikael has been our cicerone in the internal corporate jungle.

Marcus Linder has been the supervisor at Chalmers University of Technology. He has put great effort into guiding this work to fulfill academic quality. We are also grateful for the work done by our thesis opponents, Madeleine Larsson, Sofie Hjelmberg and Malin Wegstedt. Their comments and constructive criticism have helped us improve this report.

Karin Titze, librarian, at ABB Corporate Research has assisted in finding much secondary source material and theoretical literature. Especially articles published in industry journals have been attained with her kind help.

Ivan Angsvik has assisted in checking surveys and testing survey forms. Last but not least all interviewees should be acknowledged for giving some of their precious time to us. Without them this thesis would not have been possible. In particular we are indebted to Carl-Ejnar Sölver who has put much effort in helping us.

Abbreviations

AIS – Air Insulated Switchgear
BU- Business Unit
CB - Circuit Breaker
CB+2*DS One circuit breaker surrounded by a disconnector on each side
CCIL - Current Conduction, Interruption and Limitation
Cigré - International Council on Large Electric Systems
CRC- Corporate Research Center
DS - Disconnector
GIS – Gas Insulated Switchgear
kV – kilo volt
IEC – International Electrotechnical Commission
IEEE - Institute of Electrical and Electronics Engineers, Inc
NPD – New Product Development
PASS – Plug and Switch System
SF_6 – Sulphur hexa Fluoride gas
STRI - Swedish Transmission Research Institute AB

1 Introduction

Companies of all sizes today like to talk about their innovativeness. Clearly, profiting from innovation is more about choosing the right ideas to develop, and smoothly take them from concept to product, than about generating the most inventions. “There are more ideas in any organization, including business, than can possibly be put to use,” Peter Drucker stated in his (2003) classic on innovation, "Innovation and entrepreneurship".

Although surveys confirm that most managers value innovation high, most are dissatisfied with the innovation management in their own organizations according to a study by Arthur D. Little (2005). As global competition is ever increasing, innovation is a necessity for keeping margins up and surviving.

Innovation can come in different forms, and whether it is product innovation, process innovation or business model innovation or another form, it seems essential for the sustained competitive advantage. Innovation drives organic growth, which is the basis for higher return to shareholders, faster sales growth and higher EBIT growth than other companies (Krogh and Raisch 2009). A company that does not change and improve will not be able to withstand fierce competition in the market over time since others will outrun it. This is true since innovations have the potential of destroying another company's way of making profit.

1.1 Background

Product innovation is often first thought of when discussing innovation in general. In Schumpeter's (1934) seminal work “The Theory of Economic Development” product innovation is the first innovation category. Product innovation can easily be seen by the customer and it is tangible, unlike process innovations for example. Most would agree that product innovation is essential for manufacturing companies that want to stay ahead of competition in their respective industries. Product innovation can come in many shapes, from the fine-tuning of a long established and successful product to the completely new and radical introduction of a product never seen before and everything in between.

To be able to apply the term as broadly as possibly a short definition of innovation is chosen as defined by the Innovation Unit at the UK Department of Trade and Industry 2004: “Innovation is the successful exploitation of new ideas” as cited in Tidd and Bessant (2009).

Sometimes innovation tends to be confused with invention which is only a part of innovation. The concept of innovation involves two sides, as seen in the definitions above: The inventive aspects, which one often comes to think of first intuitively. The other side however is not to be forgotten, the spreading of the product or commercialization, putting the product into use. An inventive product encapsulates a new idea of some kind. However, being inventive might not turn out to be the most difficult part in the introduction of a new product.

For a product to be a true innovation it also has to be accepted in the market, preferably replacing or displacing a predecessor product. In order to do so, the perceived attributes of the new product must be of greater value than the alternatives, at the very least to some users. Innovation management thus concerns translating technology and ideas into products and making them commercially successful. Innovation management in that respect integrates a technological, market, and organizational thinking of how the companies can strengthen themselves by innovation. One way of connecting the inventive phase of product development with the commercial outcome in the market is to link how market aspects were integrated and thought of in the development phase. The interconnection between the two sides of innovation is a matter of interest to this thesis, as will be explained in greater detail in the problem analysis and purpose.

The research was accomplished by conducting two case studies on new product development projects in ABB. This mode of research is chosen due to the complex structure of this problem. Therefore, emphasis is put on detailed contextual analysis of these two projects. Yin (1984, p23) defines the case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used".

There are two major reasons for conducting this research through a case study. The first one is that the case study is likely to generate novel theory. By juxtaposing two cases with sometimes conflicting features, there is a better chance of reaching novel insights than with other potential research methods. The second advantage is that the theories that result from case study research are likely to be testable and valid, because they have already been tested during the theory-building process (Eisenhardt 1989).

An objective of this thesis is to give recommendations for future new product development projects in ABB by scrutinizing two product development projects seen as representative for research and development efforts in the company. The thesis devotes much attention to describing how the products were de facto realized, launched, and sold to different customers with different sales channels i.e. the diffusion of the innovations. It is thus be a study that spans from initial product idea conception to the situation in the market today. The transition from conceptualized initial value proposition to developed and realized perceived customer value in these two products will consequently be of interest. Some of the factors that affected the speed of diffusion in the market will be studied.

1.1.1 Problem Analysis

Given the circumstance that innovation has two sides there is a need to look at both these to understand the success and failure of new products. The internal inventive product development phase thus ought to be linked with the commercial spreading of the developed product. Hines (2005) notices that within the new product development (NPD) literature there are two distinct groups: the first being papers related to development process effectiveness, and the second being papers related to market success. Since these two groups are so intimately interconnected in the innovation definition, we can presume that the development phase performance has great effect on the outcome in the market. A product with greater advantages will subsequently be adopted quicker by users than one with lesser advantages. Yet little literature deals with this linkage.

The problem to be researched is the lacking simultaneous understanding of the value proposition concept in product development and the concept of diffusion of innovation in the market. Now that we have established the scope of the inquiry, let us turn to what the purpose of the thesis will be.

1.2 Purpose

The purpose is to follow two products from value proposition development in new product development all the way through to the diffusion of the product in the market. This will add to the understanding of how value is created in new product development. The purpose is to be achieved by conducting a case study of two products that were first developed in the late 1990s and launched in the beginning of the 2000s. The thesis will thus examine the development projects and launch of these two products together with the subsequent result in the marketplace. Central in this investigation is the speed of diffusion as affected by the perceived customer value, which in turn is affected the underlying value proposition of the products.

Much focus will therefore be on the development of the value proposition, the potential changes over time in the value proposition, marketing efforts, as well as other possible causes of the disparate market success. To understand the relation between value proposition development and market diffusion the research will measure perceived value both internally and externally. The overall perspective will be of innovation management nature. This will mean a much market-oriented outlook, but with technology aspects certainly integrated.

1.2.1 The cases

As earlier stated, we have turned to study two products developed by ABB, a multinational corporation with approximately half its revenues stemming from its automation business and half from its electric power business. ABB has, within its electric power business, recently developed and introduced a number of innovative technologies pertaining to high voltage circuit breakers. These types of circuit breakers, very simplified, have the same function as electrical switches do in homes but must tolerate much higher currents and voltages, which is necessary in power transmission. Two examples of innovative products in this field are the products Push and the Pull. These two products were both first introduced in year 2000 are the two product development projects on which this thesis has its focus.

Push is an alternative component in circuit breakers, replacing a conventional spring drive.

Pull essentially combines two products in one. Pull has little new technology in it but its newness comes from the fact that it integrates two products in one and thus makes disconnectors redundant.

The perceived success of these two products in the market has been significantly disparate. Likewise the two products differ substantially in their type of innovativeness. A much more thorough description on these products will follow in the empirical results chapter.

1.2.2 Research questions

With outset in the previously stated purpose the following three research questions will be of central interest in this investigation:

1. In what ways did ways did the development process of Push and Pull differ in respect to the advancement of the value proposition?

2. Are there differences in how Pull’s and Push’s value propositions are perceived externally and internally?

3. Which were the catalysts and obstacles that influenced the market diffusion speed of Push and Pull?

1.3 Delimitations

The technological depth of this inquiry will limited due to the fact that this thesis has its outset in innovation management rather than in technology per se, e.g. mechanical properties or electrical withstand. It will not discuss what technical changes would have altered the value proposition. However, technical properties will be part in the investigation in the sense of understanding the products and what (economic) value they create for customers. This thesis is not an evaluation of the current marketing and sales effort. Nor is primarily intended to give recommendations on what should be done with the studied product today, but it is rather directed towards what can be done in general in terms of managing the innovation process at ABB more efficiently.

The empirical data used in this study is collected for two case studies within the high voltage branch of the power equipment industry. Thus the external validity, the possibility to generalize the thesis' findings outside of the industry cannot be verified for other industries without conducting further study (Bryman and Bell 2007). In fact, true conclusions can only be drawn on these two specific cases. The generality of the findings, extending outside the specific cases, could and should thus be questioned. Nonetheless, it is likely that the results will still be relevant for other industries sharing major characteristics in the product development and adoption of innovation.

The findings presented in this thesis have been significantly abstracted or generalized due to the sensitive nature of many key data.

1.4 Disposition of the thesis

This report is organized as follows. First hereafter comes an overview of previous research in the field of management of product innovation. It forms a theoretical framework on which the analysis will be built. The general innovation process will be delineated first to form a frame for the remainder of the theory section. From there the early phase will first be covered with subsequent phases immediately following. Afterwards comes a description of the methodology followed, outlining the methods employed to answer the research questions.

The results section will start with an introduction of the context in which the Pull and Push were developed. This will mean a short introduction of the electric power industry and also some basic information about ABB to get the reader quickly acquainted with the surrounding environment. The Pull development and diffusion will first be presented followed by the same disposition for Push. In the analysis which follows, the two developments and commercialization projects will be contrasted with each other but most importantly with the theoretic framework.

2 Theory

The theory chapter is structured as follows. First some general classifications of new product developments (NPDs) and innovations will be made. The innovation process from product idea to the sustainment of business is covered divided into three phases: Search, Select and Implement. This constitutes subchapters 2.3, 2.4, and 2.5.

The perspective on the NPDs is of value proposition development and market diffusion character, aiming to explain from a theoretical viewpoint how the value proposition evolves and how that can effect market diffusion.

2.1 Innovation process models

Following World War II during the 1950's and mid 60's many new industries were established based on seizing technological opportunities. Examples of such industries include semiconductors, pharmaceuticals, electronic computing and synthetic and composite materials (Rothwell and Zegveld 1985). In addition, several already established industries could be revitalized thanks to new technology. Based on this societal development, a simple linear model of technology push was developed. From the mid 60's and onwards an increased focus was put on marketing due to increased competitiveness. With that came the shift towards listening more to the demand side, i.e. the market. This lead to the second type of innovation model called market pull or need pull. (Rothwell 1994)

Innovations were categorized into a dichotomy of need pull, see Figure 2, and technology push, see Figure 1, (and still are by many). Need pull innovations are those products that stem from customers' needs' focused development. Thus, if a company asks some of its customers for improvement ideas and some of these are subsequently adopted in an existing product that would be a typical case of need pull. Technology push on the other hand, is the type of innovation where a company starts with a technology and looks for an application of it. The product on which the new technology is applied will in this case be a technology push type of innovation. This type of linear move from basic scientific discovery into sales is depicted in Figure 1.

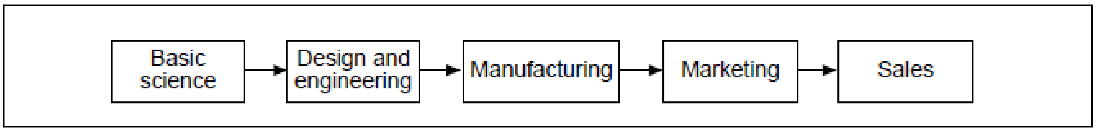


Figure 1 – Technology push (Rothwell 1994, p. 2)

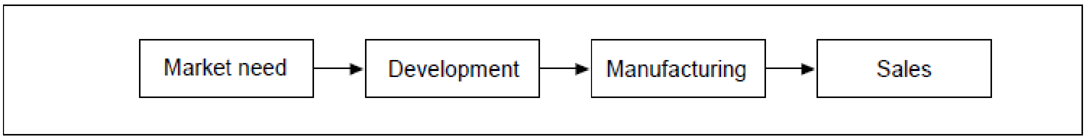


Figure 2 – Market pull (Rothwell 1994, p. 3)

This simple dichotomy has become very popular in industry and is often referred to by practitioners. Many times technology push ideas fail to realize into successful product innovations and this category must therefore often stand back for small improvements of existing products which are more likely to generate economic return. Nonetheless, there exist a large number of technology push innovations that have become very successful. Some include: nylon, radar, antibiotics, synthetic rubber, cellular telephony, medical scanners, photocopiers, hovercraft, fiber optic cables, transistor and integrated circuits (Tidd and Bessant 2009).

Linear models (LM) of innovations have been much criticized in the research community for being overly simplistic. Yet there are recent defenders (e.g. Balconi, Brusoni, & Orsenigo (2009)), who claim that most of the criticism directed towards the LM can be used in creating a more refined model. It is, they say, not so that model has been proven wrong as many claim.

The track that should be preferred is dependent on the novelty of the innovation. Less novelty is usually handled better in market pull developments. The problem is that customers do not always know their needs (or are at least not able to communicate to the manufactures) and that is where technology push strategy comes in. Technology push strategy does however not mean developing technology for the sake of it; the products must in the end fulfill customer needs.

Later on in the 70's a third generation model was developed based on the many systematic innovation studies by scholars well known today, such as Utterback, Cooper, and others. This model recognized that the technology push and need pull models were extreme and atypical. Instead it postulated the process of interaction between technological capabilities and market needs as being more true to reality. The third model is portrayed in Figure 3.

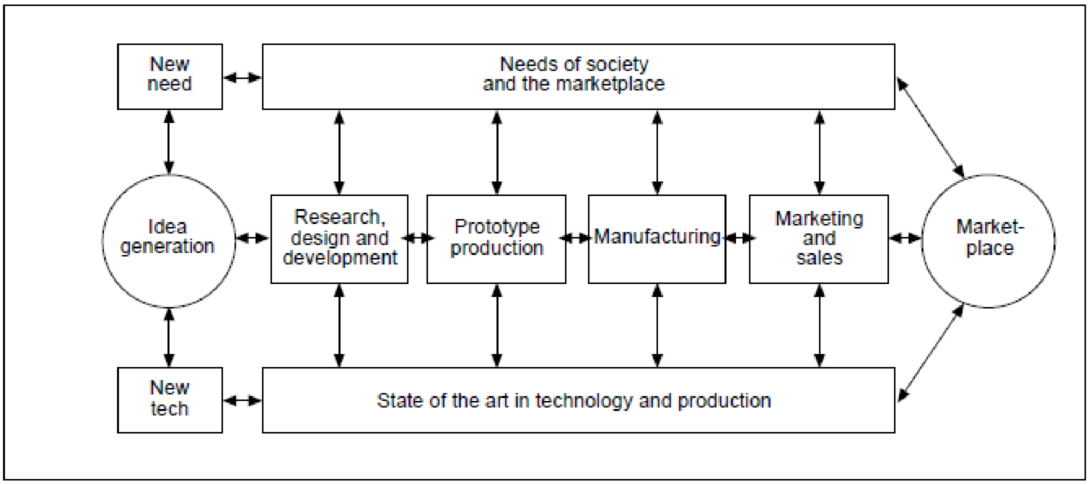


Figure 3 – The Coupling Model (Rothwell 1994, p. 4)

The model has been described by Rothwell and Zegveld (1985, p. 50) as "a logically sequential, though not necessarily continuous process, that can be divided into a series of functionally distinct but interacting and interdependent stages. The overall pattern of the innovation process can be thought of as a complex net of communication paths, both intra-organizational and extra-organizational, linking together the various in-house functions and linking the firm to the broader scientific and technological community and to the marketplace. In other words the process of innovation represents the confluence of technological capabilities and market-needs within the framework of the innovating firm."

A fourth generation model was based largely on the Japanese industry, because of its ability to innovate faster and more efficiently than Western companies. Key components include parallel development and integration. Parallel development means that different parts of the company works at the same project at the same time, not sequentially as was earlier the conventional way of working with NPD. Integration refers to the early stage involvement of suppliers. This model came about in the 80's due the success of Japanese firms. Yet today many companies struggle with implementing it. Figure 4 below shows the principle for parallel development.

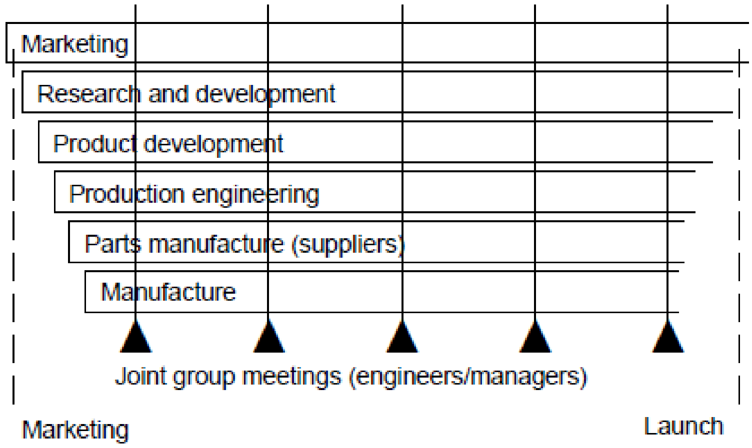


Figure 4 – The Internal part of fourth generation (Rothwell 1994, p. 6)

Table 1 gives a summary of the different generations of innovation models. Due to the ease of use and idealization, the need pull and technology push model are very much used to this day. A combination of push and pull, most agree, is needed for successful innovations most researchers argue. In this thesis the simple push and pull dichotomy will also be employed.

Generation	Key Features
First and second	The linear models – need-pull and technology-push
Third	Interaction between different elements and feedback loops among them – the coupling model
Fourth	The parallel lines model, integration with the firm, upstream with key suppliers and downstream with demanding and active customers, emphasis on linkages and alliances
Fifth	Systems integration and extensive networking, flexible and customized response, continuous innovation

Table 1- The five innovation models (Tidd and Bessant 2009)

The type of innovation model strategy being followed (mainly) has implications on the development of the value proposition. In the technology push strategy the value proposition is typically not well-articulated in the beginning of the development. Instead it is the opportunities in the new technology in itself that are seen. In market pull innovations the value proposition is usually relatively clear given that the idea of the product has come from the market in the first place. It is important to be aware of the fact that technologically advanced customers do sometimes have other demands than do the main market customers (cf. section 2.5.2.6). Elements of all generations of models have interesting elements to this thesis; however the first two are mainly used in the analysis for reasons of making the process more idealized.

Before turning to the innovation process model, the following subchapter dissects product innovations based on their composition and effect on the market.

2.1.1 Disruptive innovations

Clayton Christensen (1997) made disruptive innovation famous in his study of the disk drive industry. Before this publication the dominant view in technology strategy had been that established firms and technologies perished because of new products offering of superior performance (Adner 2002). Christensen took the opposite view looking at how products with inferior performance could win over established products with better performance, if judged on the conventional performance parameters. He introduced four criteria for distinguishing disruptive innovations:

1. They create new markets by introducing new products
2. The new products cost less than existing
3. Initially the product performs worse when judged by mainstream criteria
4. The technology should be difficult to protect using patents.

In the hard drive industry, disruptions came in the forms of new markets forming on basis of lower performance demands. These markets had needs that differed substantially from the mainstream market. The mainstream market manufactures had built relationships with customers and were able to deliver ever better performance, according to the needs of the mainstream customers. The existing manufactures could, however, not serve the needs of a small segment of builders of small PCs who wanted cheaper and less technologically complex products. Small entrepreneurial firms formed to meet their needs. As is well known now, the PC market grew remarkably and with that the reliability of smaller hard drives. Thus, what was first a niche market became the main market in which the previous market leaders could not compete. Once mainstream manufactures realized the need to enter what had earlier been in fringe market, it was too late. Figure 5 shows how the disruptive technology B (e.g. smaller hard drives) building on technology Y over time fulfilled the needs of and outcompeted technology X (e.g. larger hard drives) on its own market A.

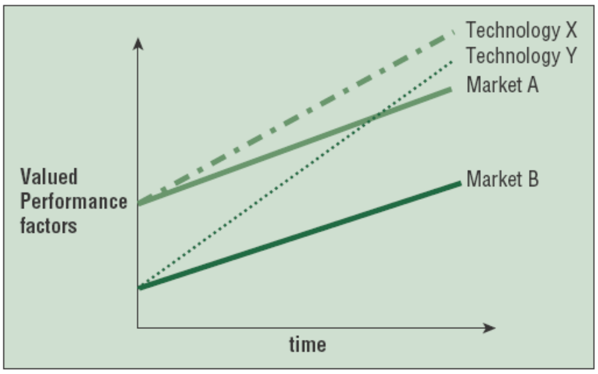


Figure 5 –Performance of disruptive innovations (Tidd and Bessant 2009)

New-market disruptive innovation is a second sort in addition to the low-end sort of disruptive innovation illustrated by the hard drive case. The new-market disruptive innovation does not cater to the least profitable customers of an existing market, but rather fits to a new or emerging market where there are no incumbents.

If a product is disruptive, it is not likely to have the same sales development as an incremental innovation. In the case of new-market disruptive innovations, the market appreciating the specific characteristics of the products has simply not been formed yet. In the case of low-end disruptive innovations, the market is from the beginning seen as unattractive because the customers are only willing to pay a minimum price, which means low margins for the seller. Thus, few incumbents produce low-end disruptive innovations.

Christensen (1997) states that because of low volumes, slow diffusion and low profitability in emerging markets, disruptive innovations are likely to die in large organizations. The antidote to fatal thinking is to form a separate organization with an entrepreneurial climate where the new product can survive while the market is being formed.

2.2 The Innovation Process in New Product Development

The innovation process can be likened with a funnel, as depicted below in the Tidd and Bessant's (2009) model, see Figure 6. The reason behind this is that in the beginning of the development of new products there is a need to look at many ideas. The first phase of the funnel is thus searching for opportunities. This involves scanning the internal and external environment for opportunities for change.

Quite naturally after having found a number of more or less promising ideas a selection process becomes necessary. Only few ideas are perceived to have enough inherent value to be considered worthwhile developing further. In the selection phase it is possible to form a tentative value proposition which will guide the further development.

Decisions in the selection process are typically based on the strategic intent of the company. Once ideas have been selected for further work the process of new product development reaches its next phase, the implementation phase. The implementation phase is certainly important but it is far from the only constituent of innovation management. This phase involves making the idea into a reality. This includes the technical translation and also includes the launch of the innovation onto a market.

Last but not least is the appropriation of value or capturing of benefits phase. This phase contains the improvement of the process management for future projects. This last phase has been found crucial in innovation management but it lies outside the scope of this thesis and will therefore not be covered. Although the initiation of this thesis itself can be seen as being part of the capture phase.

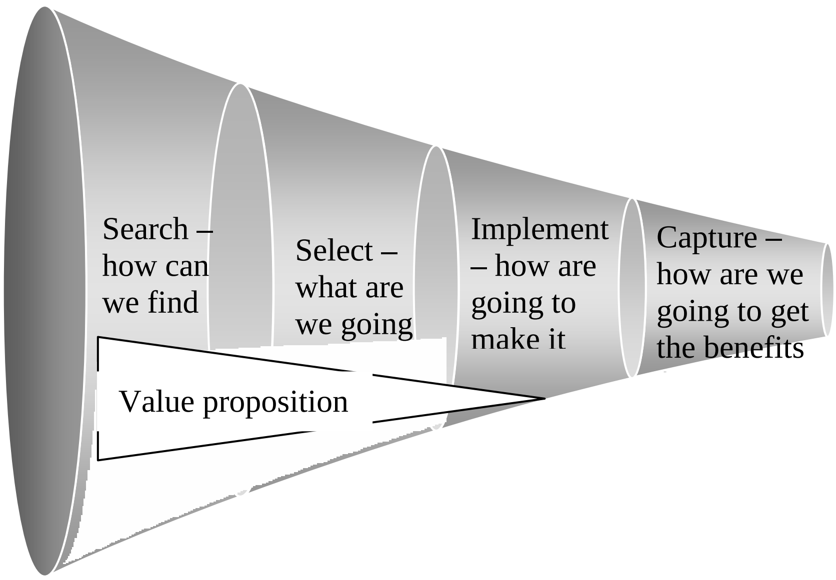


Figure 6 – The innovation funnel (Tidd and Bessant 2009) with the value proposition development integrated

A big name in new product development (NPD) literature is Robert Cooper. His research together with others focuses on the success factors in NPD. He is behind the term winners and losers research in which cases of successes and failures in NDP are studied (Cooper and Kleinschmidt 1993). The idea behind this genre of research is to find general success factors by drawing on several cases of best practice in large American companies (e.g. Fortune 500). Likewise, this research looks at factors that negatively affect the success of NPDs.

This type of winners and losers based research lead up to Cooper's (1988) stage-gate model which is commonly used in industry. Due to its widespread use in industry and applicability in ABB it will be briefly presented in the next subchapter. Thereafter, follows the model according to the funnel described earlier.

The stage-gate model refers to a structured way of carrying out a development project in distinct phases called "Stages". Between each Stage, a review called "Gate" is carried out. The Gate consists of a gate committee that decides if the project can continue on to the next Stage, and certain standardized documentation that is the basis for the decision. The stage-gate model is thus a linear model for structuring product development.

2.3 Search

The first step in any NPD project is to look for ideas which can be developed into products. These ideas can come from numerous different sources, such as for example employees or customers. The ideas are aiming at creating different types of innovation and they can be the result of several modes of overall innovation process (cf. with the innovation models in the previous section). These are some of the aspects that will be given attention in this section.

2.4 Select

The selection involves matching found opportunities with company strategy and customer needs. Decision making at this phase is no easy task given that uncertainty is substantial. This thesis will in this phase only cover the tentative value proposition at this stage since that is a key in deciding whether to go ahead or not with an idea.

2.4.1 Value proposition development

The concept of "value propositions" has been used since the 1960s. The interest increased in popularity from year 2000, when judged by published journal articles and conference papers found in Scopus. It is today the most frequently recurring element of companies' business models (Osterwalder 2004).

A value proposition is a company's configuration of its offer to create value across different internal customer roles (Kambil, Ginsberg et al. 1996).

The "value" part in "value proposition" is the sum of the customer's cost associated with adopting the product, and the customer's perceived performance of the product. The "proposition" part in "value proposition" suggests that the value is proposed to a certain customer or customer segment.

These are the three dimensions that Kambil, Ginsberg et al.(1996) use in their value proposition matrix portrayed in Figure 7.

Even within a single company, which would intuitively seem to be one single customer, different roles are played by different actors in the buying process. These actors will make different valuations of the offer, needing different value propositions. When analyzing how products' value propositions are perceived, it is as important to understand key characteristics of the products (performance and cost-related) as to understand where they fit into customers' organizations. The three dimensions will now be presented in greater detail.

Figure 7 – The three dimensions of the value proposition (Kambil, Ginsberg et al. 1996)

2.4.1.1 The perceived cost of the offer by the customer

The cost to the customers of a product is usually not equal to the price tag of a product or service. Kambil, Ginsberg et al. (1996) building on Murphy & Enis (1986) identify three main constituents of customer cost: price, risk and effort.

Price is the direct financial cost of acquiring the product. Among commoditized products, it is the key differentiator.

Risk includes a wide spectrum of uncertainties bundled with the acquisition – physical risk, financial risk, selection risk, delay risk functional risk and psychological risk.

Physical risk encompasses the actual danger of using a product.

Functional risk encompasses the potential failure under operation of a product.

The effort part of the cost is mainly an effort tied to the acquisition, operations/maintenance effort and complementary effort, e.g.effort to adapt other systems to the new product.

The acquisition effort is directly associated with the acquisition. It includes specifying requirements, evaluating alternatives and physically and financially acquiring the product. Financing and delivery assistance would be examples of a company's attempts to lessen the acquisition effort for customers. The operations and maintenance effort is the effort needed to keep the product operating during its lifetime, as well as disposing of it when it is no longer used. Routine service is one typical sort of maintenance effort.

The complementary effort refers to the cost and time needed to find complementary products needed to operate a new product.

2.4.1.2 The perceived performance of the offer by the customer

Performance refers to a products ability to match certain customer needs. To offer a value proposition with high value i.e. good performance price ratio, a company must understand the customer's needs. According to Albrecht (1993), customer needs can be divided into four broad categories; basic, expected, desired and unanticipated needs.

The basic needs are fulfilled by the core functions of the products. A circuit breaker must for example be able to break the current and a capable current conductor.

The expected attributes fulfill needs that all competitors in a certain industry feel obligated to fulfill in order to compete. Compliance with international standards could be an example.

The desired attributes are attributes that the customer knows exist for products of another market segment (typically up-market) but is not willing to pay for. It could be an extensive service package or a more technically advanced solution.

Unanticipated attributes of products respond to needs that the customer has, but is unaware of. They are by definition the hardest to cater to, but once successfully identified and responded to, the benefits can be huge.

2.4.1.3 Customer roles

Kambil, Ginsberg et al. (1996) divide the customer role into a buyer role, a user role, a co-creator role and a transferer role that all need to be linked to the product's value aspects. Lengnick-Hall (1996) points out specifically the buyer role and the user role as always present customer roles.

The buyer role is where the customer evaluates its needs, searches for suppliers, evaluates suppliers, buys and receives the product. Meeting the customer in the buyer role with a value proposition can mean streamlining the ordering and support functions, or making it easier for the customer to evaluate offers.

The user role, which is the most frequently thought of when referring to "the customer" is where the customer actually uses (extracts value from) the product. Meeting the user role with a value proposition can mean making the product easy to use under different circumstances, for example through scalability.

Meeting the co-creator role means involving the customer to create value, often also passing some value to another customer. A customer opening up its product installation for observation by other (potential) customers helps the causes of both the customer and the supplier. The supplier get to show a product well functioning for other potential customers to see. The customer helps making the product it just bought more widely adopted, thereby assuring the access to service, spare parts and over time possibly lower cost.

Meeting the customer in the transferer role with a value proposition means simplifying the product disposal or substitution for a customer at end-of-lifetime. Construction for easy disposal, service at dismantling and the possibility to make direct substitutions of worn-out products by backwards compatibility all cater to the transferrer role.

Osterwalder (2007) also pays special attention to, and links the value proposition intimately to the customer role. His view is that value propositions are unique to customer segments.

In order to be profitable, a company must avoid aiming its value proposition towards a segment that is overpopulated by competitors and thus underway to enter commoditization. There are mainly three ways this can be done. Firstly, by extending the value frontier towards lower cost, but at the same time providing a more basic offering. Secondly, by extending the frontier towards higher cost, but also giving higher service. Thirdly, unique value propositions can be created through shifting the whole frontier through the introduction of new technology.

The value proposition is the most common constituent in recent scientific descriptions of business models (Osterwalder 2005). Although there are a number of different definitions of value propositions in circulation, Chesbrough and Roosenbloom (2002) concludes that one of the four most important functions of a business model is to "articulate" the value proposition.

The most successful companies in the NPD process are according to multiple studies those who involve customers early in NPD, during the opportunity search and analysis phases where the value proposition is formed. In the SAPPHO Studies (Rothwell, Freeman et al. 1974) the understanding of customer needs was the most important discriminator between success and failure in NPDs. Cooper (1988) and Zien and Buckler (1997) both found that early customer evaluation was a major booster of product success chances. Intensive customer interaction and the number of new product ideas were shown to be positively correlated in the research of Murphy and Kumar

(1997). Alam (2006) points out that evaluation of concepts and the reduction of development cycle time were facilitated by customer interaction during the fuzzy front end.

2.5 Implement

Realization of selected ideas is a key part of innovation. In this chapter the diffusion process will be covered.

2.5.1 The process of adoption of innovation

For innovations of any kind it takes time to be adopted. The study of why and how innovations are adopted gives understanding of the diffusion of innovative products in markets. The speed at which a product diffuses is of particular interest. Roger's (2003, p 5) has defined diffusion as: "the process in which an innovation is communicated through certain channels over time among the members of a social system." The message of the communication concerns the new idea, innovation, and the sharing of information to create a mutual understanding. The theory has its outset in communication theory and it thus deals with how information about an innovation is transmitted by means such as mass media and personal communication (Mahajan, Muller et al. 2000). People have different propensity for utilizing personal communication versus mass-media.

For incremental product innovations regular marketing forecasting techniques (e.g. regression analysis with certain parameters based on earlier generations, or the use of indicators) often suffice to give a good picture of what adoption might look like. However, for more disruptive products it is more difficult to tell what the diffusion process will look like.

History has shown over and over again that forecasting disruptive technologies and products is next to impossible. Yet, forecasting is a central pillar in business planning for innovation. This is not so much for the reason that the forecasting is accurate but more for the benefits of going through the forecasting process. In trying to forecast adoption for radical innovations exploratory methods are employed. The most common are: customer or market surveys, internal analysis, Delphi or expert opinion, or scenario development (Tidd and Bessant 2009).

Ever since the 1960's there has been an academic interest in forecasting and modeling diffusion of innovation. The most prominent early contributions were (Mansfield 1961), (Rogers 1962), and (Bass 1969). By the end of the next decade 6 out of 8 of the basic models for diffusion had been employed. Since then the main development has been modifications such as the introduction of marketing variables, the flexibility of diffusion at different stages in different countries, considering successive generations of technology. These models are all aimed at being able to anticipate future development. The development has, however, been based on explaining past behavior. (Mahajan, Muller et al. 2000; Meade and Islam 2006)

In hindsight, empirical studies have shown that for scores of innovations of different kinds there is a typical adoption curve, the so called s-curve, depicted in Figure 8 below. A good fit to the shape of this curve can in most cases be found. Despite that, the difficulty to predict remains.

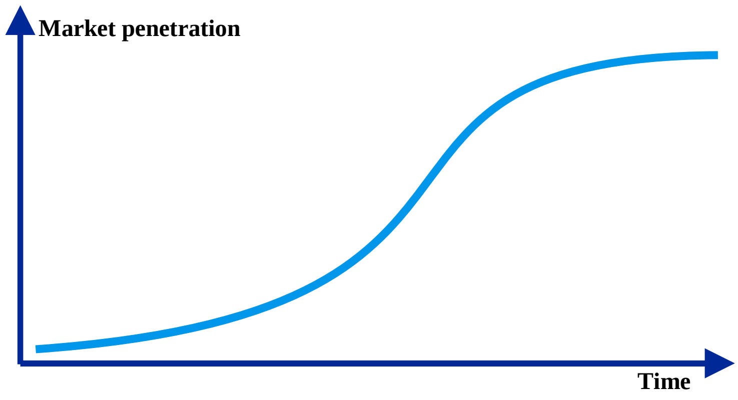


Figure 8 – The s-curve

The shape of the curve is dependent on demand-side and supply-side factors (Tidd and Bessant 2009). Those include direct contact with the innovator or imitation of prior adopters. Imitators often have different perceptions of benefits or risk than the former. For the latter factors such as relative advantage of an innovation, availability of information barriers to adoption and feedback between developers and users have been found to be of importance.

Diffusion of innovations is puzzling phenomenon given that sometimes those who stand to benefit greatly at adopting an innovation still wait seemingly unexpected long before adoption it. Rogers (2003) point to two phenomena which have both become famous examples of when an innovation has taken surprisingly long to diffuse in one case and has barely diffused in the other despite the obvious advantages of the products. The two examples are a cure for scurvy in the British navy and the Dvorak keyboard.

Tidd and Bessant (2009) mention four main factors that form obstacles to adoption: Economic, which include considerations of personal costs versus social benefits, incentives and adequate information. Behavioral aspects are motivations, priority, inertia, propensity for change and risk. Structural reasons consist of infrastructure, sunk costs, and governance. Organizational barriers are goals, routines, power and influence, culture and stakeholders.

The epidemic model is probably the most commonly used model to explain the S-curve, followed by the probit model (Geroski 2000). The former model is based on the assumption that there is a homogenous population of potential adopters. It explains the adoption in how information is transmitted. The latter one acknowledges heterogeneity in needs and utility of adopters. In doing so it is more sophisticated and it postulates that different customers and users have different threshold values. Yet, it does not acknowledge that the rationality behind the adoptions differs.

The commonality between both these models and others is they try to explain why the speed of adoptions tends to be slow. If a new technology offers significantly improved performance why is it that not all firms adopt it as quickly as possible?

Rogers (1962) explained the s-curve by the heterogeneity in the adoption population. This book has become the standard textbook on diffusion of innovations. He postulated that the population follows a standard distribution curve (see Figure 9), with those over 2 standard deviations (sd) from the mean named innovators, those 1 sd called early adopters and so on according to the normal distribution curve below, see Figure 9.

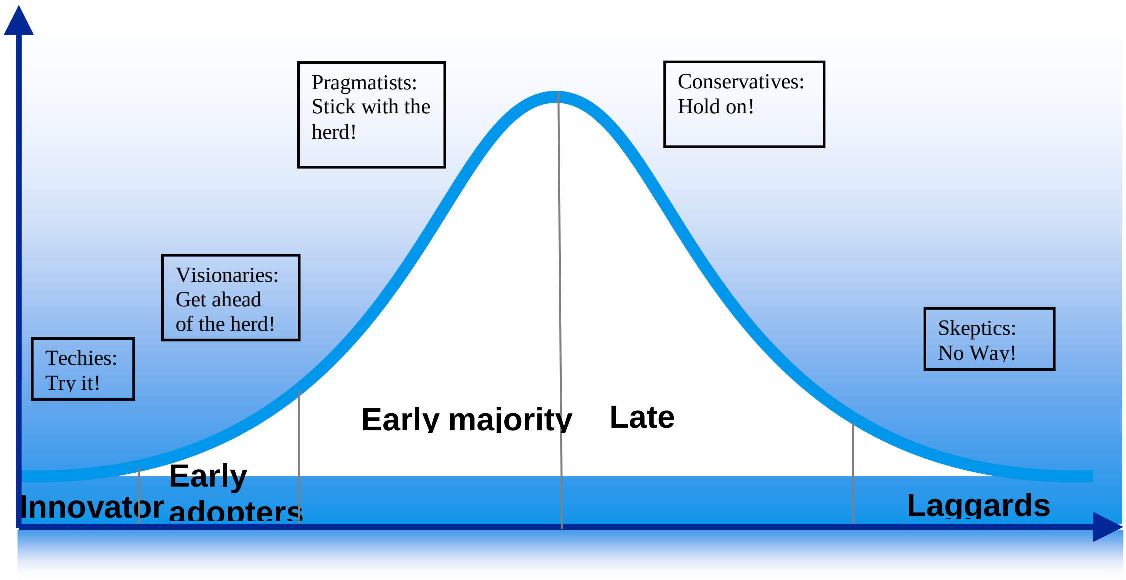


Figure 9 - Based on (Moore 1998)

Rogers (2003) and (Moore 1998) have in summary explained the categories in the following manner. Innovators are technology enthusiasts, who are venturesome and enjoy being cutting-edge. They tend to see the potential benefits and are thus eager to try out the new product. Innovators can be used to collect valuable input for development. Furthermore, they typically help out in debugging products. This group is relatively small and true to the normal distribution curve it only makes out 2,5% of the entire adoption population.

The early adopters group is the group within which most opinion leaders reside. This is so for the reason that they tend to have high demands and take well-informed decisions based on the performance seen among innovators. They are willing to pay well when they see the chance to achieve breakthroughs. Opinion leaders play an important role since most potential adopters are not capable or have no interest in staying in touch with the latest news. Instead a large share simply follows what opinion leaders have done.

The early majority is the start of the tipping point when the diffusion speeds up to reach a more self-sustaining paste. The rate rapidly picks up and also those with doubts will see themselves dragged into adoption. This is seen clearly in Figure 10 in which the S-curve and normal distribution curve are put together.

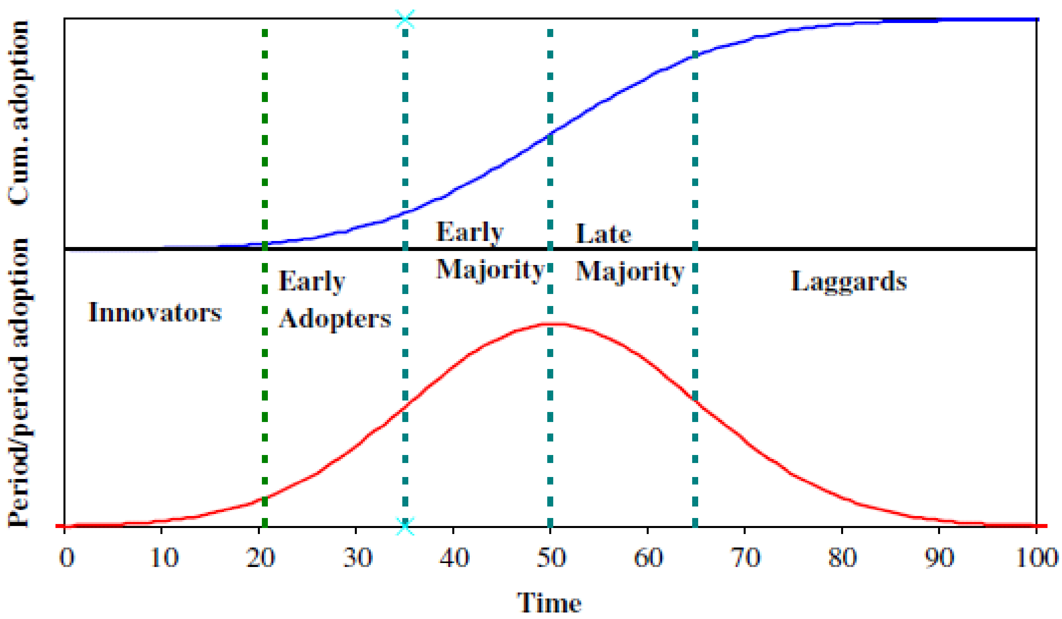


Figure 10 – Stylized diffusion curves (Meade and Islam 2006)

The early majority is mainly interested in improvement, not radical change. They are cautious and want to see reference cases from others who are alike themselves. This poses a problem in the beginning since there are mainly innovators and early adopter showcases. In addition this group is somewhat price-sensitive.

The late majority are conservatives who want simple and reliable solutions. Price is an important matter for them as they will not pay more than necessary.

Last to adopt are the laggards since they are in general skeptical to innovations and change. They are afraid of new technology and worry that it might create losses.

This model has been criticized by Geroski (2000) for only being useful at explaining a diffusion process after it actually occurred and not for predicting future diffusion. Overall, Meade and Islam (2006) conclude that there is some emerging convergence on the most appropriate ways on how to include marketing variables into the models, but that there are several viable alternatives. At this stage bad models can be disregarded but it is harder to say which one model is better than the other. In other words, there is no single model as of now that is far better than others.

Moore (1998) has in his bestseller "Crossing the chasm" emphasized the importance of taking into account the differing needs between innovators and adopters on the one hand and those of (early and late) majority customers, on the other hand. The two first groups have atypical needs and are often more technically proficient. That means that having won the acceptance of innovators and early adopters is not enough for success in the entire market. Likewise listening only to those two earlier groups can misguide because they have other needs than the rest of the market.

2.5.2 Affecting the speed of diffusion

Despite the fact that there is little agreement on the relative importance of the factors influencing the speed of diffusion, there is agreement on which factors are of most significance. Tidd and Bessant (2009) divide the factors into three clusters: characteristics of individual or organizational adopters, characteristics of the innovations itself, and characteristics of the environment. Individual characteristics include such matters as demographics and educational background. These typically can be said to play a greater role in consumer products than in business to business dittos. Environmental factors include market environment and communities' network as a sociological aspect.

Of greatest importance to this thesis are, however, the characteristics of the innovation itself. Rogers (2003) has outlined five categories (see Figure 11) that interact in determining the rate of diffusion.

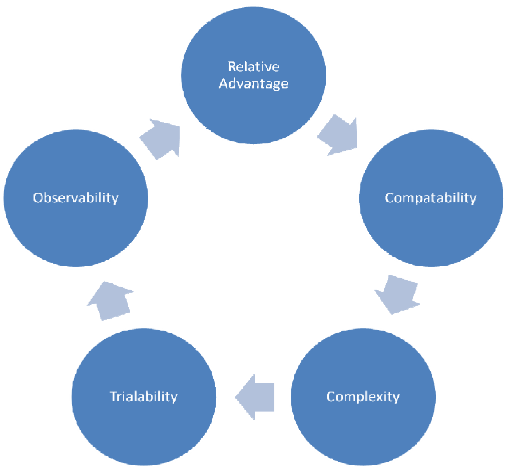


Figure 11 – Perceived Attributes of an Innovation (Rogers 2003)

Before describing more in detail what these factors are, the innovation decision process (Rogers 2003) is presented, see Figure 12. This will facilitate the understanding of the five factors. When an innovation of any kind is introduced there are five steps before wider adoption, e.g. by a company. First any potential adopter must learn about the new idea. Thereafter follows a phase in which an opinion about the innovation is formed. Once an opinion is formed a decision to adopt or reject can be taken. The innovation is then put into use with a large likelihood of adaptations being made. Last a final confirmation of reversion of the initial adoption decision is made.

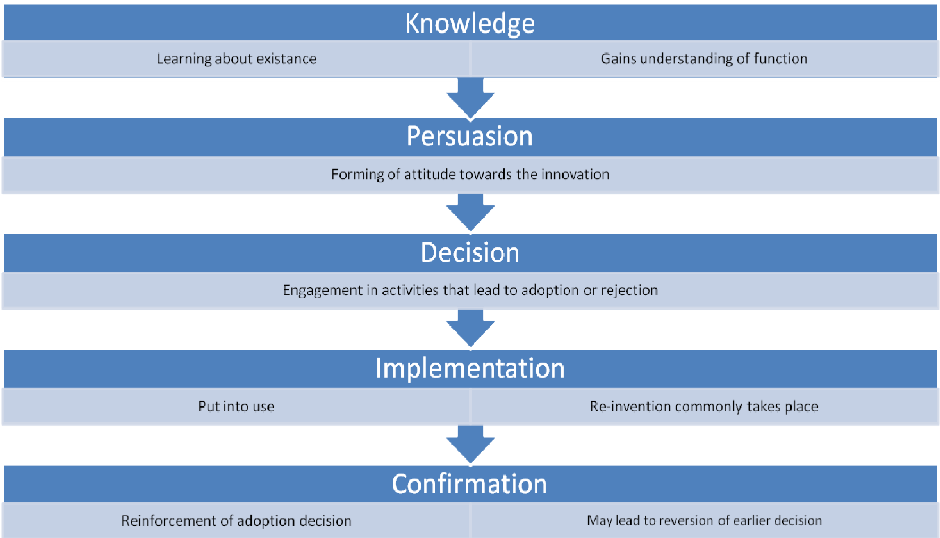


Figure 12– The Innovation Decision Process (Rogers 2003)

2.5.2.1 Relative advantage

The relative advantage deals with the subjective value that the customer believes the product has. This value can thus differ between customers as performance parameters are weighted differently. The relative advantage corresponds much to the utility analysis (cost/benefit) that the customer does, explicitly or implicitly. However, it is important to recognize that this concept is narrower than the value proposition concept presented earlier. For example the cost of adoption as postulated in the Kambil, Ginsberg et al.(1996) definition includes parts of what (Rogers 2003) include in compatibility factor.

The greater the relative advantage the faster the speed of diffusion will be. A new product that is perceived to be of much greater value than the product it supersedes, by many potential adopters, will diffuse quickly.

Although this factor could be strictly economic in nature, including financial measures of pay-back or NPV, other factors tend to come into play. Since uncertainty of the performance of an innovation is high, economic analysis can only give an indication and thus other factors will play an important role. These other factors include convenience, satisfaction, and social prestige.

2.5.2.2 Compatibility

Compatibility regards the values, past experiences and needs of potential adopters. If these aspects are perceived as being consistent with the innovation that will mean that the innovation will diffuse more quickly and vice versa. Therefore, how an innovation is positioned in relation to other products will affect the perception. Closely connected to this is how the product is named. The name can make a difference in how an innovation is judged, as it will determine against what products it will be compared with. In particular values and norms have been found to be of importance, more so than with existing products (Tidd and Bessant 2009). It is notably that few innovations initially fit the adopter's environment perfectly.

2.5.2.3 Complexity

"Complexity is the degree to which an innovation is perceived as relatively difficult to understand and to use." (Rogers 2003, p. 257). It follows that a product that is simple for users to understand will be adopted more quickly than one for which new skills and knowledge has to be developed. Expeditionary marketing, whereby potential users are educated by the seller, is a mean towards greater acceptance and reduced complexity (Hamel and Prahalad 1994).

2.5.2.4 Trialability

"Trialability is the degree to which an innovation may be experimented with on limited basis" (Rogers 2003, p. 258). Trying a product means an opportunity to dispel uncertainty for adopters. Furthermore, this will allow the user to learn from testing instead of first theoretically learning before adopting the product. The opportunity to test a product before real adoption will serve to enhance diffusion, given that the users find the innovation to have desirable characteristics.

For product innovators there is much value in having trials since this can give rise to input for further development and improvement. Another reason for employing user involvement in the process is to increase that particular user's commitment to the product, thus making it possible to transfer a product which is still not fully developed. As stated earlier, users can help out in the debugging of a new product. There is, however, a problem involved in using innovators and early adopters since their needs differ from more mainstream customers (cf. Moore 1998). The overall conclusion drawn by Tidd and Bessant (2009) is that not evolving customers is often associated with customer dissatisfaction. Yet, high involvement does not guarantee user satisfaction success.

2.5.2.5 Observability

"Observability is the degree to which the results of an innovation are visible to others." Moore 2003, p 258). Again the higher an innovation scores on this factor the faster it will diffuse. This aspect has much to do with communication between actors of a type of product. Generally, for some innovations it is easier to communicate the benefits between different users whereas for others the product has to be experienced. Earlier adopters can persuade not yet adopters through what is called vicarious learning. Vicarious learning means that users can experience a product through another organization.

2.5.2.6 The role of opinion leaders

Rogers (2003) states that there are some members of a social system that are more influential, called opinion leaders They tend to form other members' views of the innovations' characteristics. This influence can act positively or negatively on the diffusion of the products. In terms of the diffusion process proposed by Rogers, opinion leaders have their strongest influence in the evaluation stage of the process, where other members of the social system weigh advantages against disadvantages of the innovation. Later adapters are more prone to be influenced by opinion leaders' views than others.

3 Research Methodology

In this chapter, practical considerations for carrying out the case study in a manner securing its validity and reliability is presented.

3.1 Research Design

The research method for this report was chosen with the outset in the research questions in 1.2.2 above. As they are of mainly how or why nature and there is access to contemporary accounts from interview subjects within the unit of analysis (the company), a case study design has been found to be the most suitable research method (Yin 2009 p. 8). Some initial research propositions have been stated and then refined in an iterative fashion to reach the conclusions stated in this report.

The examination was conducted through a practice oriented comparative case study between two new product developments. The processes of development from idea conception and development initiation to marketing and sales were investigated and mainly by retrospective interviewing, which gives an injection of longitudinality. The research was carried out at a compressed time span (June 2009 - November 2009). Secondary data was employed to help gain deeper insight and provide a basis for better transferability (Eisenhardt 1991).

The comparative case study, also referred to as multiple-case study, makes it possible to explain the two products and draw a single set of "cross-case" conclusions (Yin 2009 p. 20). Eisenhardt (1989) argues that multiple case studies can generate richer theory.

In order to draw cross-case conclusions there is the need to compare the two cases throughout the entire development. Therefore an effort has been made to find as detailed historical data as possible, relating to the development. To achieve this, an extensive range of interviews was performed with ABB employees as well as customers. Databases and other document sources containing information about the product development were rummaged for relevant data.

The data collected was of mainly qualitative character, but containing elements of quantitative data like market results, cost of development and legal costs. Meanwhile, the data analysis has been quantitative to some extent. For perceived value to customers, qualitative data was obtained. To ensure the quality of the analysis, there was a need to make use of triangulation. The level of analysis is the organization as a whole, including corporate research, business unit development, marketing and sales, as many parts of the company have been involved in decision making around the product development.

The focus of this report is on the cases and explaining them building on their unique contexts, which differentiates it from cross-sectional research with more focus on general findings. The report findings in themselves cannot be seen as externally valid outside the product group of high voltage breakers, and any theoretical findings should be tested before assumed applicable in other environments.

3.2 Data Collection

To achieve high reliability, a clear chain of evidence has been established, connecting the case study questions with the case study report via a case study protocol and case study database. The case study questions/research questions are linked directly to 1. research topics 2. evidentiary sources and 3. references to theory, in the case study protocol found in 8.1 Case Study protocol.

By defining how operational measures are depicting the main concepts of the research (diffusion and value offered to customers) high construct validity is ensured. The concept of diffusion is operationalized by measures of order volume and geographical spread. How value offered to customers is operationalized in the contrast between internal and external views on the value proposition is explained in more detail under the definitions in the analytical framework.

A large case study database was collected and stored on ABB Corporate Research servers in Västerås. In the case study database, a broad range of sources have been collected.

The case study was carried out with documentation and interviews from Corporate Research, High Voltage Products business unit and from front end sales departments (in different markets). In case study research there is not always a clear cut off point for data, but the aim has been to have confirmatory data from at least two different sources. The primary method for data collection was that of semi-structured interviews. External sources include customers and in a few cases potential customers' views communicated through a separate set of semi structured interviews.

Four structured interview surveys were created. One template was used for Push staff and one for Pull staff. Another template was used for customers buying Push and yet another for Pull customers. Due to the fact that the response rate was low no meaningful separate statistics can be given for this survey. Instead the responses given in the survey will added to that achieved through semi-structured interviews.

Semi-structured interview transcripts are the most well used data source. Interview subjects were named and marked with affiliation. An example of interview template used for ABB employees and customers is attached (see interview template in 8.2) to this thesis, ensuring reliability of data. The interviews were recorded and later transcribed.

During the interviews, an effort has been made to both follow the case study line of inquiry and ask the actual questions in an unbiased manner. This was many times difficult as the thesis' proposition tended to influence the way of formulating the questions. Some interviews are ended in an in-depth interview manner, where the respondent (bordering to the role of an "informant") is allowed to propose his own insights to certain occurrences, and where these propositions have later on been a base for further development of the research propositions.

The collection and analysis of project documents is another source of qualitative (but also to some extent quantitative) data. The documents collected have included steering committee protocols, other meeting protocols, e-mail correspondence, PowerPoint presentations given internally and to customers, and sales data. There are also multiple Excel sheets filled with data on sales, financial approximations and project investment. Additional external sources include journal articles foremost published by Cigré. This ensures reliability and that the procedures used are so clear that they can be used by anyone afterwards (Bryman and Bell 2007 p. 41).

3.2.1 Primary Data

Approximately half of the interviews have been carried out over telephone. The remaining interviews have been carried out in person. Telephone interviewing required some additional considerations in comparison with "live" telephone interviewing. For example, there is little possibility to act on physical signs of puzzlement to clarify questions (Bryman and Bell 2007). Some respondents might not ask for repetition of the question if it is unclear. This problem has been tackled by formulating questions as clearly as possible and restating questions in cases of respondent hesitation.

3.2.2 Secondary data

Sales data has been collected from the products' ABB business unit, High Voltage Products.

Cigré reports are reports published by the International Council on Large Electric Systems (Cigré). They are written by one or more member organizations and published to facilitate technical exchanges among the actors of the power generation and transmission industry.

PowerPoint presentations have been used throughout the projects to communicate directives to working group. They have been found in databases and provide excellent insight to the direction of the projects.

3.3 Data Analysis

The unit of analysis is an organization, the company ABB. To achieve a high level of internal validity in the analysis, thorough pattern matching and extensive explanation building were put to use. The patterns of the two development projects were matched against current theory and then against each other. In terms of explanation building, important events and results from the two projects are first analyzed to some detail. This is done relying on a basic theoretical foundation and theoretical propositions made from mainly project management and diffusion literature. Then, some general conclusions are drawn at points where equal conditions were dominant.

In concluding on answers to the research questions, a clear and logical chain of evidence has been built to answer each of them. The logical chain analyzes the path from factors inside and outside the unit of analysis (the organization) to the measured end results, see Figure 13. The factors are identified by searching for patterns and themes in interview transcripts. To make the logical chain internally valid, each factor must be emphasized by independent informants, having different roles. They could be development staff on Push and Pull projects, sales people or managers. The informants must also indicate the causal links between factors and end results, directly or indirectly (Miles and Huberman 1994).

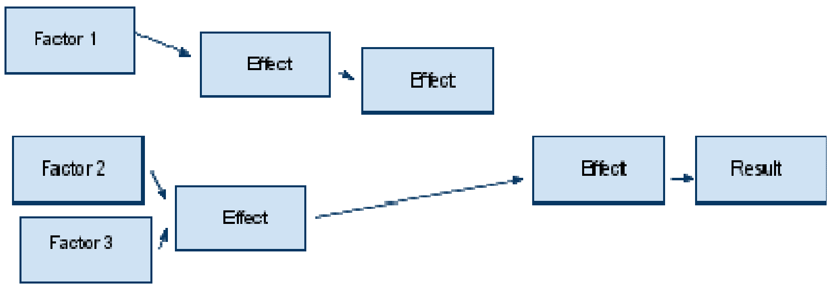


Figure 13 - Operationalization of measures (Miles and Huberman 1994)

To achieve high construct validity, clear measures for the constructs of the research questions have been created, see table Table 2.

Research Question	Constructs used	Operationalization
1. In what did ways did the development process of Push and the Pull differ in respect to the advancement of the value proposition?	a.) value proposition	First and subsequent mentions of customer value in a.) internal development documents b.) marketing material aimed at customers
2. Are there differences in how Pull's and Push's	a.) value perception	Count of interview mentions of product value

value propositions are perceived externally and internally?		aspects internally/externally for Push/Pull
3. Which were the catalysts and obstacles that influenced the market diffusion speed of Push and Pull?	a.) catalyst/obstacle perception b.) the market diffusion speed	a.) Count of interview mentions of product catalyst/obstacle internally/externally for Push/Pull b.) Sales data used for judging the diffusion state 2000-2009

Table 2 – operationalization of concepts

3.3.1 Semi structured interviews

The meaning condensation (Lee 1998) is used to abstract the most important themes from the semi-structured interviews conducted. It is a five-step method:

1. Read the entire transcript of the interview
2. Find "natural meaning units" consisting of words, sentences or paragraphs that relate to an identifiable theme
3. Label the meaning units, and perhaps, describe them with a short paragraph
4. Match the natural meaning units with the research questions
5. Integrate the natural meaning units to a more meaningful, non-redundant set of underlying themes

The method with its use of natural meaning units has allowed for making rough quantifications of interview answers in combination with the survey answers received.

3.4 Validity and reliability of analysis

In conclusion, construct validity, internal validity, external validity and reliability are the most common tests used to judge the quality of empirical social research. Their result is also the most critical conditions for case study quality (Yin 2009). Construct validity means connecting change with operational measures that match the specific concepts studied. Internal validity is the measure of direct and exclusive causality between two events, which means that left out influencing factors lowers the internal validity of the conclusions. External validity is a measure of how the findings generalize beyond this specific case study. Finally, good reliability ensures that the same case study could be done again and that author would reach the same conclusions. Table 3 summarizes how we have ensured that data collection and analysis holds a high quality.

TEST	Our tactics	Phase in which tactic occurred
Construct validity	• Specific constructs used in research questions • Measurable operationalization of constructs. • Multiple • Report and presentation reviews by cross-functional reviewers	Data collection

	• Logical chain of evidence in conclusions	
Internal validity	• Cases pattern matched against each other and against current theory • Explanation building based on triangulated facts • Rival explanations addressed in discussion	Data analysis
External validity	• Replication logic: corresponding data collection methods used for both cases. • Corresponding data analysis methods	Research design
Reliability	• Case study protocol with solid theoretical foundation used. • Well structured case study database with all collected raw data accessible	Data collection

Table 3 - Adapted from (Yin 2009 p. 41) - Case Study tactics for Four Design Tests

4 Empirical Results

In this chapter the empirical findings will be presented. First hereafter, follows a brief introduction to the context of the product development project. It starts with an industry overview, followed by a presentation of ABB and specifically its way of doing new product development. An introduction of the circuit breaker is presented before the case study results.

The remainder of the chapter is divided into subchapters according to the funnel model presented in the analytical framework. This will mean that the main divisions will be between search, select, and implement. To facilitate comparison, each subchapter will first treat the Push case, immediately followed by the Pull case. In this manner each subpart of the funnel can be easily contrasted against each other for the different cases.

4.1 Introduction

The energy industry counts to the world's largest industries. The electric energy sector is one part of this industry. Over the past years, the European and other electricity markets have undergone significant deregulation and consolidation, resulting in three out of four of the world's largest utilities now being European (Datamonitor_Group 2009).

4.1.1 Industry overview

The initial stage in the power system value chain is generation of electricity. From the power plant there is a need to transmit electrical energy to users. This is accomplished by transmission, at higher voltage, and distribution, at somewhat lower voltages as displayed in Figure 14. The objective of the grid system is to transmit electric energy at required availability (ideally with no interruptions), quality and cost with minimum environmental impact and personal hazards.

In deregulated power markets, generation, transmission and distribution are generally three separate lines of business. Each step has a need for profitability to sustain its business. The deregulated markets around the world function slightly differently. In general, however, the transactions between the blocks are steered by availability, quality and cost of the electrical energy. If a contracted supply is interrupted the vendor has to pay penalty. Interruptions of all kinds are thus heavily disliked.

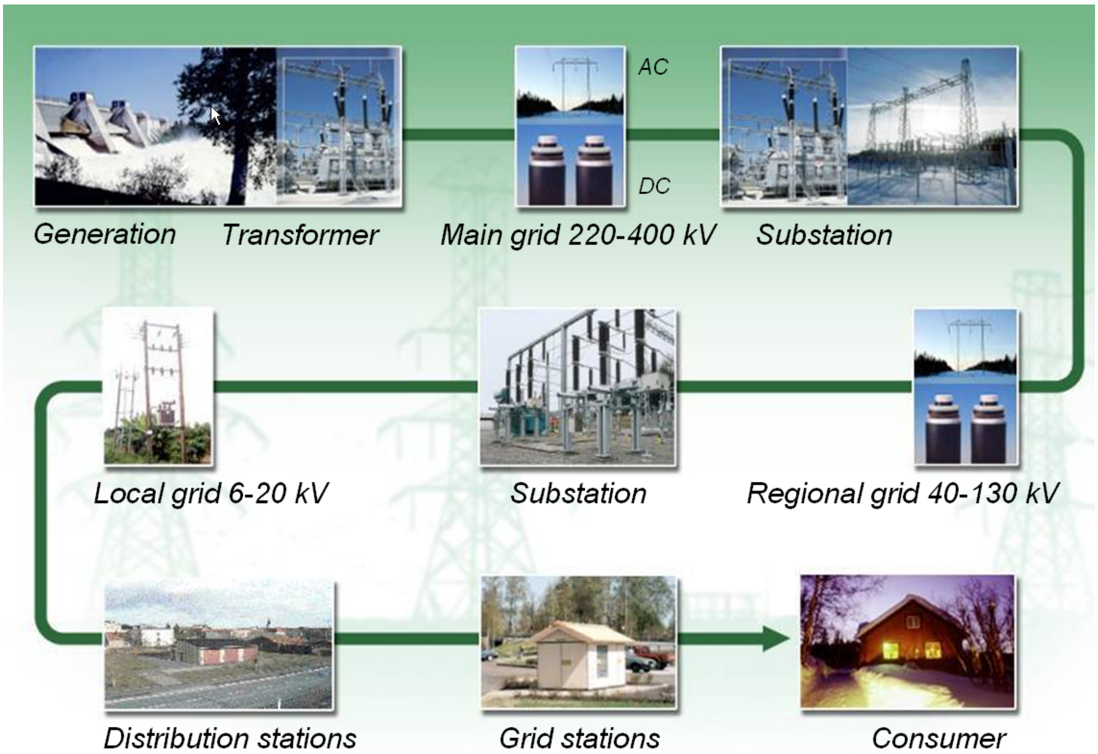


Figure 14 – Generation, transmission and distribution of electric power (ABB PowerPoint presentation)

Between different grid lines are substations that are used for switching and transforming purposes. During the last years substation component manufactures and solution providers have introduced much innovation in substation equipment. The benefits of those innovations range from reduced maintenance cost, ease of operation, to simplified substation layout design. However, for utilities to be able to appropriate the benefit, they are often required to revise old design policy and application standards. (Finn, Olovsson et al. 2009)

4.1.1.1 Conservatism in the industry

Utilities are conservative in their purchasing of substation components (and other part of the grid) and they tend to prefer proven and familiar designs. Given that grid operators must consider the entire lifecycle of their installed base, standardized apparatuses are preferred. They often view the introduction of new equipment as introducing risk. Furthermore, utilities see other benefits in standardization. These benefits include lower substation cost, proven operating procedures, proven equipment, and simpler spare parts stocking requirements. (Finn, Olovsson et al. 2009)

4.1.2 ABB and the organizational context of the development

ABB is one of the largest power and automation technology companies in the world. The name ABB is an acronym made up of the first letters of ASEA AB of Sweden and BBC Brown Boveri Ltd. of Switzerland. These two companies merged in 1988 to create ABB. It is a publicly traded company and shares of ABB stock are listed on exchanges in New York, Stockholm, Frankfurt and London/Zurich. The company has 120 000 employees in about 100 countries. The order value in 2008 was 38,282 MUSD and the revenues were 34,912 MUSD.

The company has five divisions among which two are of particular interest to this thesis. These are the Power Product and Power System divisions. The former includes ultrahigh, high and medium voltage products (e.g., switchgear, capacitors); distribution automation; and transformers. The latter includes electricals, automation and control for power generation; transmission systems and substations; and network management. This means that the Power System division uses and sells products developed by Power Products, including the two products examined in this report. In the Power Products division, the High Voltage Product business unit is of most interest since that is the unit that owns the circuit breakers.

When it comes to the development of new products, not only the business units are involved. ABB has several Corporate Research units spread around the world. One of these is located in Västerås, where some development of interest for this thesis has taken place. The Corporate Research center typically hands over a prototype to a business unit after concept development, for further development as seen in Figure 15 – ABBs R&D organization. The figure also shows the scope of what is done by Corporate Research and the business units, respectively.

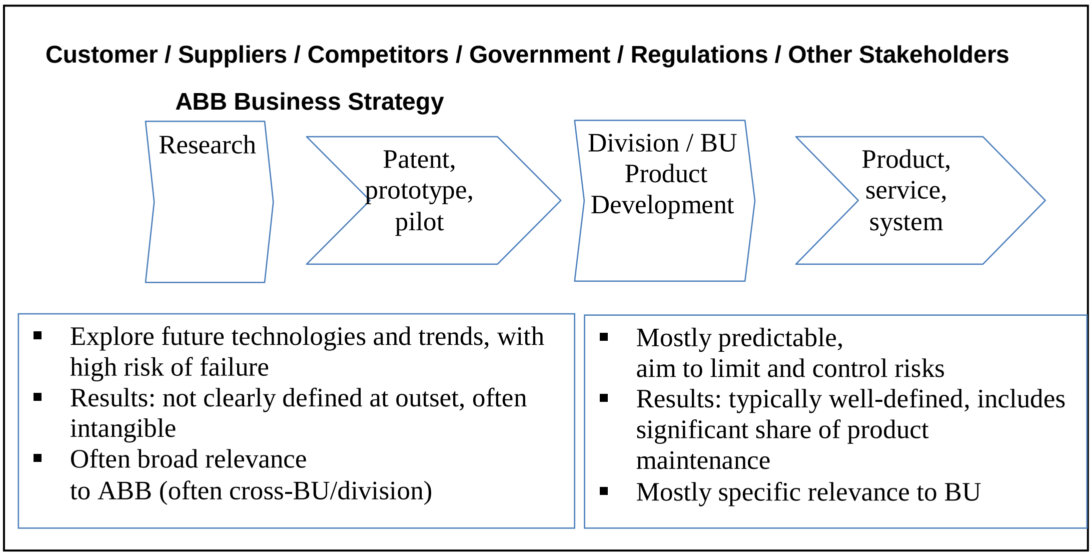


Figure 15 – ABBs R&D organization (modified ABB PowerPoint presentation figure)

When products are ready for the market, they are sold through Front End Sales (FES) to the customer. This is, however, not the only part of the company involved in the selling. An example of the internal sales chain is illustrated in "Svensk Försäljning" (Swedish Sales). FES is backed up by sales support at the manufacturing business units as shown in Figure 16 – ABB's sales .In addition, there is a separation based on the type of customer.

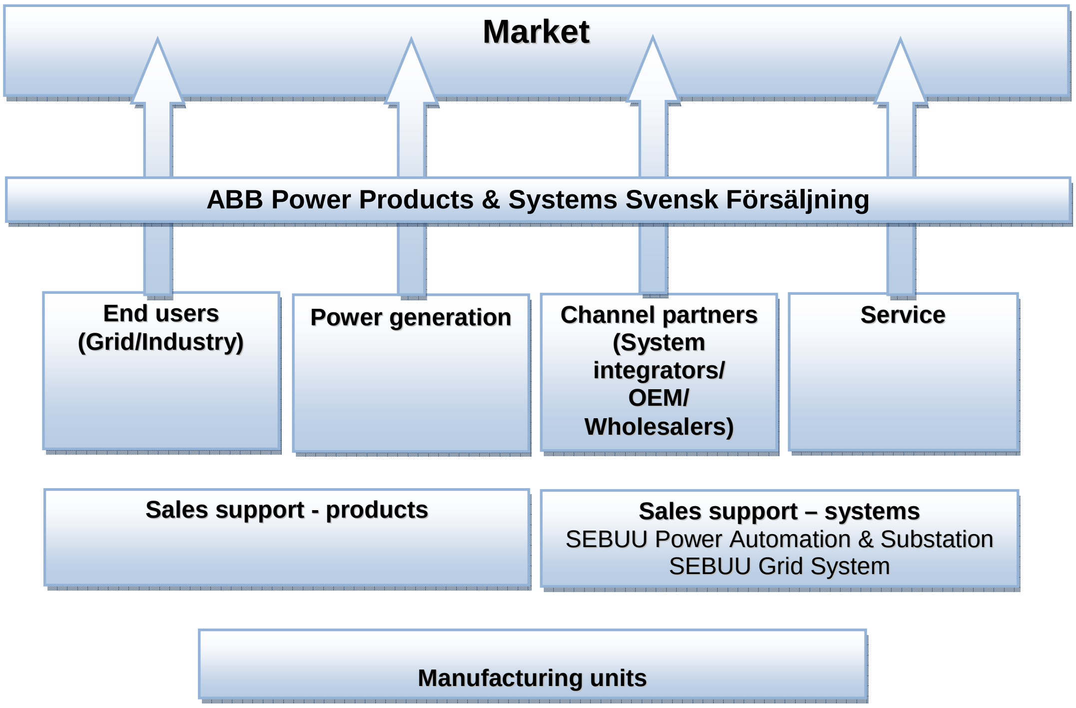


Figure 16 – ABB's sales approach for Power Products and Power Systems in Sweden (modified ABB PowerPoint presentation figure)

4.1.3 Circuit Breaker

Circuit breakers (CBs) in one sense have the same function as switches have in homes but must tolerate much higher currents and voltages, which is necessary in power transmission. To be more technically correct "a circuit breaker is an apparatus in electrical systems that has the capability to, in the shortest possible time, switch from being an ideal conductor to an ideal insulator and vice versa." (Application Guide - ABB Circuit Breakers, p 8) It should thus fulfill the following requirements:

"1. In the stationary closed position, conduct at its rated current without producing impermissible heat rise in any of its components.

2. In its stationary positions, open as well as closed, the circuit breaker must be able to withstand any type of overvoltages within its rating.

3. The circuit breaker shall, at its rated voltage, be able to make and break any possible current within its rating, without becoming unsuitable for further operation." (Application Guide - ABB Circuit Breakers, p. 8)

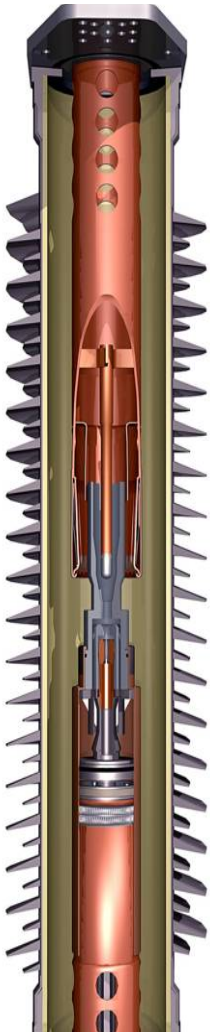


Figure 17 - The Circuit Breaker (ABB Image Bank)

Two examples of innovative products in the field of circuit breakers are Push and Pull. These two products were both first introduced in year 2000 and are the products that have been examined in this thesis report.

Pull essentially combines two products in one. Push replaces one part in the breaker. Push can thus be a complementary product to Pull.

4.2 Push's and Pull's Development and Diffusion

When Percy Barnevik assumed the role of CEO for ABB, after the fusion between Swiss BBC and Swedish ASEA, in 1988, one of the profitability related goals he brought with him was increased sales from new products (Carlsson and Ekwall 2003). Less profitable products should be replaced by new products with more value added.

In the years following the fusion, ABB's many national research organizations were organized into eleven corporate research programs for different technologies, a structure completed in 1992. The research programs had a program manager and a set of directives each. The directives pointed out focus areas and potential pathways for the technologies at hand.

4.2.1 Search - Push

One of the research programs, called Current Conduction, Interruption and Limitation (CCIL), was based in Västerås. The manager for the program gave a directive to "reconsider magnetic drives" in 1994.

In ABB and in the industry it had long been known that the drive mechanism was the number one failing component in circuit breakers, before SF6 leakage and breakdown of secondary and auxiliary circuits (CIGRÉ 1994), see Figure 19. As the cost of unplanned network failures was on the rise, emphasis for high voltage equipment development was on increasing reliability. The only drive mechanism available to open and close high voltage circuit breakers at the time was the spring drive, basically consisting of an electrical motor, a metal spring and a mechanism for the motor to charge the spring, see Figure 18 – Spring drive operating mechanism for circuit breakers. When operating to open position, the spring accelerates the breaker conductor areas apart and the resulting force is decelerated by the breaker construction. This causes heavy stress on the breaker construction and requires extensive concrete founding for the breaker.

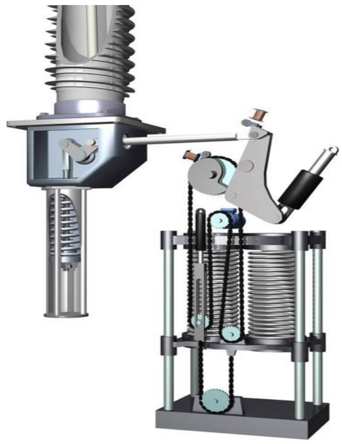


Figure 18 – Spring drive operating mechanism for circuit breakers (ABB Image Bank)

The magnetic drive called for in the CCIL program directive was an idea that had been around for some time, referring to a technical solution where an electromagnet is activated to pull a breaker to closed position and deactivated to let a mechanical spring retract the breaker to open position. The goal from ABB's side was clearly to produce a concept of a simpler drive mechanism with fewer mechanical parts that could wear down and break.

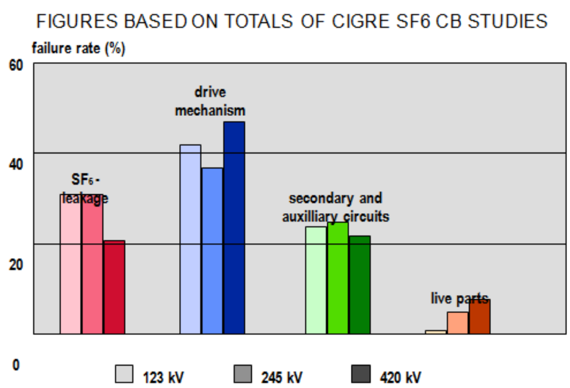


Figure 19 – failure reasons for SF6 breakers (modified ABB PowerPoint presentation figure)

From 1994 and onwards there were multiple concepts for new drive mechanisms developed at ABB Corporate Research (CRC) Västerås in cooperation with the switchgear business unit in Ludvika and business units in Italy and Germany. Ludvika raised interest for a Push type for 72-170kV (the volume segment for high voltage) breakers solution in 1997, and a technology development project commenced with heavy involvement from ABB CRC. The magnetic drive concept was later adopted by the medium voltage business unit in Arboga, but never prototyped for high voltage breakers. Italy's switchgear business unit and CRC Västerås both developed concepts with electrical off-the-shelf motors while the switchgear business unit in Germany went for a linear motor design.

In 1997 it was decided that a High Importance Project (HIP) called ModBreak should form the basis for the next technology step in high voltage breaker equipment.

> *"The task of this HIP is to prepare and prove the next technology step for high voltage circuit breakers for all applications. It introduces a new design philosophy into HV Transmission and Distribution Systems by decomposing the switching function into two parts- current interruption and dielectric withstand [...] The first pay off after the 2 years of HIP will be received by applying a low cost drive on the existing low end CB's for 145 kV."*

The project was managed from Zurich and the main staffing of the drive development part of the project was German. A linear motor concept for the drive mechanism part of the project was supposed to be prototyped in January 1999.

Starting a few years earlier, ABB Hybrid systems, a now divested ABB business, and a car manufacturer, had been working on an electric car concept driven by new regulation in California in the mid 90's. Special requirements of accelerating a heavy load quickly made it interesting to transfer the electrical motor, motor control and capacitor technology to what would become the Push project. This project was undertaken in CRC Västerås and in the applicable BU in Ludvika. In Västerås there was a transfer of software, hardware and competence from the ongoing electrical car project that was being deescalated because of yet again changing legislation in California.

The first prototype and feasibility study were produced at CRC Västerås during May to June of 1998. A document from late 1998 requests an immediate development of a functioning prototype of a Push fitting a LTB145D breaker for prototype testing and demonstration in February 1999 and product development. The manager at the time requested that technology (software and hardware) should be reused from the electrical car project to get a prototype ready as fast as possible.

4.2.2 Search – Pull

In the beginning of the 1990's Vattenfall, a large Swedish utility, had a project called substation 2010. The aim of the project was to present a concept for the future transformer station. In essence the objective was to consider how substations could be improved.

4.2.2.1 The Conception of the Idea to Integrate two Functions into one Apparatus

Within the substation 2010 concept group the idea of a Pull was conceived. This followed from the zeal to reduce the number of components in substations. It was well known that with increased number of components the risk for failure increases.

Disconnectors (DSs) in particular had been a troublesome story and had a large maintenance need. The DS had over time become the weakest link in the chain. Earlier DSs had been applied for the reason that CBs were very unreliable and thus needed to be disconnected when serviced or replaced (more about this later).

At this time (the early 90's) Vattenfall did not only, as today, own and operate a power distribution network but also owned major parts of the Swedish transmission network. Vattenfall Transmission was at that time seen as very technically advanced and progressive, leading the technical development in Sweden (and sometimes globally) for utilities.

In the early 1990's, there was an established intimate cooperation between Vattenfall and ABB for the development of gas-insulated substations (GIS) for 800kV. Therefore, the Pull idea was first discussed in that forum in the mid-nineties.

Short before those discussions the pursuant International Electrotechnical Commission (IEC) standard had been changed so that the requirement of a visible open gap was no more stipulated. The reason that the standard had been changed was that within the concept group for the 800kV GIS one had come to think of enclosing the disconnectors would mean less problems. Disconnectors typically have short service intervals due to pollutants of different kinds.

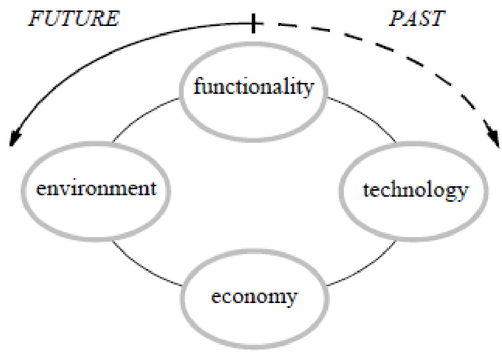


Figure 20 – The future substation (Wahlström, Aoshima et al. 1996)

Since it is not possible to see the gap within the breaker chamber it would have been almost impossible to think of a Pull without the change in the IEC norm. Although at first before the norm was changed, there was an idea to have an inspection window so that the old standard could be satisfied. However, without the change it would still be difficult at all to think of using a Pull. That change was most likely the reason that the idea was pushed, a project group member argues.

Another perspective to the context of the idea is given by the 1996 Cigre paper (Wahlström, Aoshima et al.) that deals with the topic of the future substation and gives an insight to the zeitgeist. It postulates there will be a shift from substation gear being technology and reliability driven. Instead economical and environmental aspects will play a greater role, see Figure 20. Furthermore, it will be hard to win rights-of-ways for new transmission lines and it will be difficult to extend present substations. Therefore there is a need to utilize present systems better with better monitoring, controlling and data processing.

4.2.2.2 Towards more Reliable Substations

Around 100 years ago the large-scale construction of electricity systems commenced. These networks were first utterly unreliable due to the fact that the circuit breakers had a complicated construction, both electrically and mechanically. This caused a large need for maintenance with frequent power outages. Outages were in the past a prominent disliked guest and to some extent still is (see 8.3, in the Appendix for one example).

The disconnector innovation could thus come in handy. By using disconnectors on each side of a circuit breaker, a particular breaker could be repaired while keeping the rest of the switchgear energized and in service. To this day, outages are a problem. Therefore improved reliability is a key in product development.

As much effort had been directed at improving the reliability of CBs, the typical service interval for new breakers had increased to well over 10 years with the new SF6 breakers, as shown in Figure 21 – Maintenance with different breaker generations. Disconnectors, on the other hand, had not seen any improvement in terms of reliability performance. Thus ironically, disconnectors which had earlier been used to facilitate the replacement or maintenance of unreliable CBs had become one of the major causes of failures in substations. Typically, ABB's circuit breakers require maintenance every 15 years, whereas the disconnectors (open-air) require maintenance every 4 to 5 years (Olovsson and Lejdeby 2008). The development of this evolution is schematically shown in the graph and in pictures (Figure 21 below).

Air blast

Oil minimum

SF_6-gas

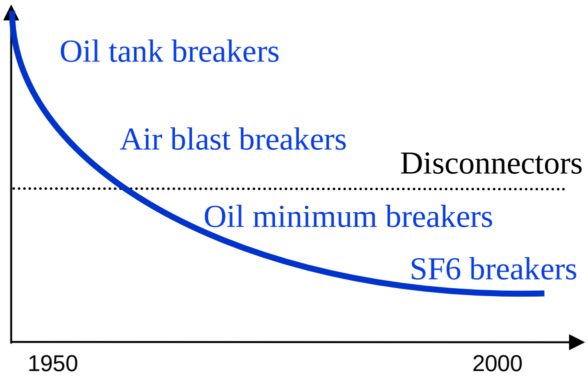


Figure 21 – Maintenance with different breaker generations (modified ABB PowerPoint presentation figure)

In the mid fifties compressed air was introduced as a new extinguishing medium to replace bulk oil breakers. Air had the advantage of high interrupting capability and short interruption times. The dielectric withstand was relatively low and therefore made it necessary to use up to 10 chambers in series for a voltage of 420kV. Since high air pressure had to be used, the risk of leakage was high and thus the need for service and maintenance was likewise high.

The next major step in the evolution of breakers was the minimum oil circuit breakers. These had higher withstand and needed less maintenance. Nonetheless, certain switching conditions required substantial maintenance programs. The next step was to start using gas, more precisely sulphur hexa fluoride (SF6). This solution meant major improvements on need for maintenance over minimum oil circuit breakers. With SF6 gas, voltages of up to 300kV can be accommodated with a single chamber and up to 550kV with two. (Application Guide - ABB Circuit Breakers, p 12). Although, it is to be noticed that SF6 is a strong green house gas.

This development meant that if the disconnecting function would be handled by the breaker, the unreliability of the disconnectors would not adversely affect the reliability of the substation system. Higher reliability translates into higher availability which to differing extent translates into money saved. Availability is thus a key performance indicator for substations and grid operations in general.

The reason for the unreliability of disconnectors is that they are affected by surrounding nature. Natural and artificial pollutants can easily affect the unprotected air-insulated disconnectors. In harsh environment, such as sandy, salty or industrially polluted areas, the service interval goes down considerably.

In Pull, however, the disconnecting function would be encapsulated in the breaker and is thus not air-exposed. The chamber is filled with SF6 gas encapsulated in a construction. This equates to lower maintenance requirements and higher switchgear reliability (Jing, Olovsson et al. 2008). In order to integrate the disconnecting function into the CB, the electrical withstand would have to live up to the standards for disconnectors.

Interestingly before the launch of Pull, KEMA, a Dutch consultancy, had studied the feasibility of an open air 150kV substation without disconnectors, the so called disconnectorless substation

The idea of omitting conventional separate disconnectors was not altogether new. Vattenfall was not the only organization which had the idea of somehow omitting the conventional solution of separate disconnectors on each side of the breaker.

The KEMA study (Timmerman and Groeman 1998) was published as a conference paper and by IEEE, so it would without doubt be possible for any one supplier of switchgear equipment to use the idea. The paper has it outset in the fact that disconnectors had come to need more maintenance than the circuit breakers. It moves on to say that eliminating separate disconnectors would reduce the investment and maintenance costs. There are safety issues concerning omission of disconnectors which can be mitigated through safety precautions such as: manual blocking of the circuit breaker and earthing, withstand voltage for CB equivalent with those for disconnectors, and clear CB contact position indication. The omission of disconnectors would lead to "great cost savings" due to: the elimination of the disconnectors themselves, fewer foundations, less control equipment, less land area, and the reduction of engineering and maintenance costs. Wahlström, Aoshima et al.(1996) reports the KEMA study to have found the disconnectorless substation to cost only 85% of what a conventional solution costs over the overall lifetime.

In 1998 Vattenfall published an article with the title Simplified Concepts for Future Substations - Some Case Studies (Norberg, Tapper et al. 1998) in Cigré, which sets the basis for Pull. It dealt with how to cope with environmental limitations while concurrently pursuing cost-effectiveness improvement. It concluded that reliability and availability of substations are of key importance in the development of the electrical infrastructure and prescribed development of simplified and more compact substations. In four out of five case studies some kind of reduction/omission of (separate) disconnectors is presented.

Areva, a competitor of ABB, also published an article on GIS which touched upon delineating an alike construction but with GIS. There was a small paragraph on a Pull inside the GIS unit. Nothing of this materialized however.

In general, the idea of making a more compact solution with integrated functions is not unique. On medium voltage applications there exist many such solutions. A IP manager said in regard to this that:

> *"The thought has most likely struck many. There is other type of apparatus with built in disconnecting function. There have existed products that were similar earlier."*

The competitors would relatively easily know that there was ongoing development, early on given the articles published in Cigré and the standardization work that commenced in 2001.

4.2.3 Select – Push

In February 1999 a committee benchmarked the available drive concepts within ABB at the time. The primary value dimension for the concept considered in the selection process was lowered cost by reducing the weight and number of components. It was decided to create a product based on the best ideas from the different concepts available. The choice made was that Push should be based on the Swedish concept that had been patented by ABB CRC in December 1998, and for which the original invention registration was made december 12th 1997. The decision was to develop the Push product in Ludvika (at the BU). The German concept was seen as too expensive because of little use of off the shelf products and heavy weight. A steering committee was appointed for the supervision of the new product, Push. It consisted of the responsible program manager, technology managers from Zurich and Business Unit development managers from switchgear in Italy and Sweden. A goal was set for the product to capture 90 percent of the market for the intended voltages.

Around the time there were also concepts developed for a smaller volume segment of higher voltages but they were never made into products. The reason for this was that focus was kept on a solution for the volume segment to obtain scale economies.

The electrical car project power converter initially used together with a standard motor in the prototype was replaced with an ABB constructed power converter and a motor designed in CRC Västerås and produced in the BU Switchgear in Lodi, Italy. The product development was finished in year 2000. Extensive testing was conducted in Ludvika where suitable testing equipment was available. The research was funded partially through corporate research funds (CHRES) and partially through Business unit development funds (CHTET).

4.2.4 Select – Pull

ABB had a first shot at going for the idea of integrated disconnectors when discussing the idea in connection with the joint group for 800kV GIS. At that point that idea did not catch on. ABB in Ludvika was not particularly interested as seen from Vattenfall.

On first of January 1992 Svenska Kraftnät (SvK) was established and old Vattenfall was split so that Vattenfall Transmission would become SvK and the distribution and generation capacity would remain in Vattenfall. For higher voltages, i.e. transmission, GIS-solutions were considered more cost-effective, whereas for distribution levels AIS were seen as generally more cost-effective.

As Vattenfall changed shape the corporation between Vattenfall and ABB had to take other forms. The work group for the 800kV GIS was thus terminated.

On transmission voltages the primary development had been targeted towards GIS-solutions since that was what the corporation group had set out to work with. However new Vattenfall (that responsible for distribution) had an interest in making a supplier develop an outdoor AIS primarily. In 1995 a project was started to look at some of the loose ends from the substation 2010 group. Pull appeared as one of the things to continue working on.

The enthusiasm for the product among manufactures was by no means great. Later it became evident in the fact that none of Siemens and AEG were interested in developing a circuit breaker which integrated the disconnector function. These latter two manufacturers were more interested in other concepts such as the containerized substation.

Thereafter, Vattenfall had discussions with the German part of ABB. This was still in the mid-nineties. The Germans would initially take on the idea to develop a circuit breaker with higher dielectric withstand that would fulfill the disconnecting standard. However subsequently, the project was transferred to ABB in Ludvika.

In 1998, an article (Norberg, Tapper et al. 1998) was published by Cigré coauthored by four authors from different parts of Vattenfall. The article was the conclusion of a study of how to design a future 145kV (a regional transmission voltage in Sweden) substation and tried to take into account the demands of the customer, owner, operation and maintenance organization, authorities, environment and public opinion. The article and study draws on the views of the 1996 Cigré paper discussed earlier.

In this article it is mentioned that Vattenfall has been in contact with three undisclosed possible suppliers and the concept being characterized as having been "fruitfully discussed with three manufacturers [(mentioned earlier as having been ABB, Siemens and AEG)] during four years and realization is foreseen in the near future" (Norberg, Tapper et al. 1998, p 3). It can thus been inferred that the thoughts on Pull started somewhere in the range between 1994, four years before the article was published, and 1998. The article suggests using disconnectors with integrated disconnector function since the disconnectors are the component in the substation that needs the most maintenance, at least in air insulated substations.

However, what is problematic at this time is the fact that a circuit breaker with disconnecting function does not easily comply with the current IEC standard for disconnectors. Therefore, it is suggested in the article that there is a need for revision of the standard.

The Vattenfall article states that the: "Development of such a component [circuit breaker with combined disconnector function] has a big economic advantage." (Norberg, Tapper et al. 1998, p. 4). The overarching reason is that by reducing the number of switchgear components the maintenance costs and investment can be expected to go down the authors assert. The discussion of economics was not taken further at the time. The statement that there is big economic advantage does not take into account the costs of developing and marketing a Pull, but merely suggests the value of the product to a potential customer.

An initial meeting between new Vattenfall and ABB Ludvika was held probably in 1997. From Vattenfall's perspective it then took a long while before a response was given. From the side of ABB there was a need to thoroughly consider this idea.

> *"I remember there was an idea meeting. People had spoken about this and X was an advocator. The initial discussion touched much upon safety aspects. Could it be guaranteed to 100% that it functioned as a disconnector? It takes time to digest that the safety will be upheld as one did not recognize the apparatus. Even if one took to the paragraphs for disconnectors that would not suffice."*
>
> (ABB Manager)

In the meeting minutes of a strategy meeting in October 1997, one point on the agenda is the question of whether a CB that suffices the disconnector function shall be developed. This meeting has the purpose of setting business goals for 1998. It is established that a goal for 98 is to in detail study the application of a CB with DS functionality. Yet, in a meeting held only three days later a staff member has discussed a potential Pull with an ABB Substation unit member. Furthermore, an idea of how a Pull could technically be designed is discussed already. From the protocol it seems that those in charge have possibly already made up their mind on developing Pull.

In a meeting of January 1998 it appears to be more certain, as it decided that (theoretical) availability studies are to be conducted for a Pull solution.

4.2.5 Implementation – Push

The implementation phase that took over after the selection of the Push concept in 1999 followed a somewhat structured model with gates and steering committee meetings. It did not however follow today's strict stage-gate model which was implemented in 2007.

After the concept selection was completed and it was decided that the Swedish concept should be developed, it was also decided that it should be fitted to the Ludvika-produced LTB 145 breaker as well as to the Italian PASS M0. The two initial trial installations by Birka Nät in Sweden and Enel in Italy are quite different customers, although both frequently buy ABB equipment. Birka Nät was a small utility, while Enel is Italy's largest energy producer. They were both chosen on the basis of personal contacts to ABB, and not on strategic plans to target opinion leaders on the market, although this is probably the case with Enel.

4.2.5.1 Execute – taking the concept to product in Ludvika through Push

Figure 23 shows an overview of the development of Push, described underneath.

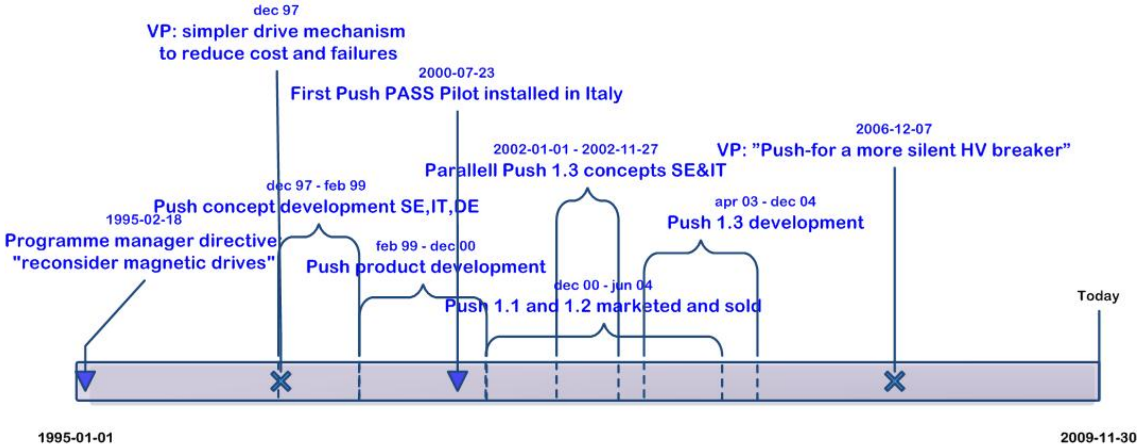


Figure 23 – Push Development Timeline based on ABB data

Figure 22 – Push BirkaNät Trial installation Nov 15th 2000. Application: 132kV line/transformer protection. (from internal ABB PowerPoint presentation)

The steering committee (STECO) for drives decided in June 1999 to move on to field prototypes for the rotating motor solution for LTB145D and PASS M0. These field prototypes should be installed at the selected customers' sites during the year 2000.

In December 2000, the first two pilot installations were running in Italy and Sweden and Push was about to go into series production. The first Swedish prototype is shown in Figure 22. The purpose was clearly to launch a product that was superior in cost and added some functionality. The product specification states that:

> *"The operating device technology of today uses several different operating principles, for example spring drive, hydraulic spring drive and magnetic drive. The use of the new servo motor technology gives the opportunity to create a common basic technology with lower cost and new additional features for all breakers."* (From background 2000-12-18)

As of 2009, there are two more documents required to run an implementation, in addition to the above mentioned Product Specification (PRS). The System Requirement Specification, which maps out requirements on the system and adaptations needed to facilitate the new product and the Market Requirement Specification (MRS), which gives a thorough picture of the market potential for the product, including market size and profitability. For the time of Push development however, there was no systematic approach to evaluating its market potential. One Ludvika manager explains in written correspondence:

> *"At the time (2000-2002) the marketing requirements had a less formal structure than what we try to do today and focus was more on the formal System and Product req specs (SRS, PRS), however these are highly technical documents, wigth not a great deal of market related data."* (sic)

Making Push into a product meant fitting the demands of customers and the demands of applicable standards. There are still as of today no special standards for drive mechanisms as standalone units, but Push was type tested for the IEC 60694/60255 standard on electromagnetic compatibility (EMC) and the IEC 62271 standard on temperature and breaking capability. All standards pertaining to push are shown in the table.

IEC 60056 (1987)	High Voltage alternating current circuit breakers specifications. The new proposal for IEC 56 should also be considered.
IEC 60694 (1996)	Common specification for high-voltage switchgear and controlgear standards.
IEC 60529 (1989-11)	Degrees of protection provided by enclosures.
IEC 68-2-11	Salt mist test
IEC 60255-5	Insulation tests for electrical relays.
IEC 60255-11	Interruption to and alternating component in D.C. auxiliary energizing quantity of measuring relays.
EN 61 000	Electromagnetic compatibility.
EN 50 081-2	Electromagnetic compatibility, Generic emission standard.
EN 50 082-2	Electromagnetic compatibility, Generic immunity standard.
EN 50 178	Electronic equipment for use in power installations.
IEC 60068	Environmental testing.

Table 4 – all standards related to Push

There was also a 10 000 mechanical operations test carried out in the Ludvika facilities to prove mechanical endurance. Even though there is no standard for Push, there is a Cigré paper from the 2002 session citing test results on EMC, mechanical endurance, temperature maneuverability and making and breaking. A published Cigré paper adds to the credibility of the technology. One project manager led the Push project through concept development in Ludvika. Another assumed responsibility in year 1999 when the product implementation project took over. In 2002-2003 the Switchgear BU in Lodi cooperated with Ludvika to develop the specifications for the final product version through a series of workshops. In 2001 as the first prototypes were installed and an updated cost picture showed that Push would not be on par with the spring drive, marketing began to focus on low noise levels, low stable power requirements and reliability (without actual figures but built on an argumentation of fewer moving parts). There was still an outspoken goal that Push should satisfy the needs of 90% of the drive mechanism market. It had however become clear that the cost targets would not be met at the moment, and the first known marketing material draft from August 2000 instead states the following advantages as cost reduction attempts continue:

- One (1) moving part

- Direct, inherent control of contact travel
- No dampers
- Less maintenance
- Totally modular design – future proof
- Low power consumption
- Functionality beyond conventional drives
- Software controlled – easy to change for special requirements
- Monitoring included
- Low noise
- Self compensating for ageing, temperature, etc
- Build-in watch-dog system

Push versions 1.1 and 1.2 saw a few successful pilot installations, but the price was too high to meet the market requirements. Therefore it was decided to develop another, cost reduced version of Push called 1.3. Interest for the Push concept was high, and both the Swedish and the Italian BUs that had developed concepts for the original Push now began to develop new concepts for a cost reduced version 1.3. After the second steering committee meeting in November 2001, three goals were set for the development group. They were:

1. Robust Design
2. Product cost [X]% lower than [Y] with possibility to reduce it [Z]% further.
3. Passing gate 5 in August 2002

There were two versions developed in parallel, one in Lodi and one in Ludvika. On 2002-11-27 the steering committee decided to support the Swedish design. The two BUs in cooperation should make a product of this design. A special committee developed System Requirement Specifications (SRS) and Product Requirement Specifications (PRS) for Push 1.3. There was also a Market Requirement Specification (MRS) developed. However, there was no pre-study or feasibility studies carried out, because as one Push1.3 development document reads “they were done in MD1.2”.

4.2.5.2 Launch

Before Push went into series production, it was prototype tested in Ludvika’s high voltage lab. In addition to this, there were a few field installations as shown in Table 5 – Push pilot installations.

Date	Application	Location
July 20th 2000	145kV PASS M0	ENEL, Florence, Italy
November 15th 2000	LTB145D	BirkaNät, Ådalen, Sweden
November 2001		PowerLink, Australia

Table 5 – Push pilot installations

ENEL in Italy got the very first pilot Push, fitted to a PASS M0 unit on July 20th 2000. BirkaNät in Ådalen got the first, then confidential, Swedish, LTB145D pilot installation on November 15th 2000. The first three-pole operated capacitor bank LTB with controlled switching was installed in Sweden in October 2001. Yet another single pole pilot installation was done with Powerlink Australia in November 2001. Sydkraft (now

E.ON) got some of the first pilot installations of Push. These three breakers are in place in Norrland and are still operating. Push1.2 was very similar to Push1.1 and was sold 2002-2004 and thus overlapped with Push1.3 to some extent.

The total price to the customer of a circuit breaker equipped with Push is about X% higher than if it is equipped with a spring drive. The Italian switchgear business unit has with some success marketed Push sold with PASS M0 installations to special applications, such as German railways where they have relative advantages because of odd frequencies. Popular applications where Push can sell on functionality are Capacitor banks and Wind Power.

A special marketing effort was conducted 2001 through 2007 by a person, who travelled 41 countries with a breaker-fitted caravan and trailer. The caravan with trailer weighed a total of 6-6½ tons and journeyed a distance equaling in total four times around the world.

At the 2002 Cigré session, a group of ABB employees presented a paper called "Push with Electronic Control for HVAC Circuit-Breakers" (Bosma, Thomas et al. 2002). The paper pointed out that the existing and widely represented pneumatic, hydraulic and spring drive units have been around for a long time, but still, even though containing advanced mechanical mechanisms, only perform the function of opening and closing the breaker. In addition, the paper points to the fact that from a statistical point of view, most major and minor failures originate in the operating mechanism. As an alternative to these inferior mechanisms, the paper introduces Push with its new features and proven capability.

4.2.6 Implementation – Pull

In the phase when it was decided that other potential Pull customers (than Vattenfall) ought to be contacted matters could have changed in terms of the value proposition. At this stage when other potential customers were approached there must have been some considerations on how to make SvK and VB Energi (the customers mentioned in a meeting protocol) interested. It has not been found that a more extensive value proposition was created due to this. The performance improvements were considered as being implicitly understood by those two potential adopters.

As for VB Energi it is clear that the approach was probably handled on an informal personal contact level. VB Energi is well known as a willing adopter of new substation equipment, nothing strange given its closeness and connections to Ludvika.

For SvK it is likely so that it was slightly different in terms of how the contact and selling of this new product was done. SvK, as a directly state owned national grid operator, knows that it has many eyes directed at its actions.

4.2.6.1 Development Execution

In November 1998, in a meeting protocol it seems the development of Pull is well under way. The product concept has now been baptized Combined. In order for the concept to be legitimate in front of the customers, rigorous testing is required to guarantee disconnecting data for the breaker. It is asked for how it can be proven that Pull will function over its entire service interval. Two proposals of solutions to this are brought forward. The conclusion is that: "we need to think more about this before launching the concept".

In February 1999, a meeting was held where Elsäkerhetsverket (the Swedish National Electrical Safety Board) attended with two persons and Vattenfall with three. Elsäkerhetsverket was an important institution to approach due to the fact that the new substation design would need approval. Vattenfall was mostly there as a supporter and to see how far the construction had gotten with the apparatus. Elsäkerhetsverket is mainly concerned with when it is safe to work on the substation and questions about when it is disconnected and earthed. The meeting itself had a more discussion like character.

Yet, there was later a formal request of approval sent followed by a formal letter of approval received thereafter as one manager recalls. This was, however preceded, by uncertainty. Elsäkerhetsverket's general statement was first something in along the line of since there no norm for Pull, it is not in our business to get involved. Creating a new international norm was however something that would take much longer (more about later on). A manager recalls that he wrote several letters to Elsäkerhetsverket before it was persuaded. After all, how could a product be tested if there was norm to test it against?

Vattenfall knew exactly what it wanted in terms of Pull's function in the substation. The technical demands in detail had however not been thought out. The blocking system would be needed to be worked out. The idea was to ensure that the breaker contact would be mechanically blocked. Vattenfall had always viewed the apparatus as a system component (apart from a single component) all the time. One project leader recalls that the objective given to him was:

> *"The criteria I got was to make a secure blocking mechanism. The challenge for me was to make a good such function. The first idea was to simply put a stick into the breaker."*

The project was considered more as an order construction than a proper new product development (NPD). With small technical adjustments a whole new apparatus would be created. The breaking technique or flows would not be changed. It was seen as an easy modification of the existing product.

> *"It was not like a project today, where you have a time plan and so on. We didn't have something like that. We had more of the approach that we developed something and discussed with [the manager], Elsäkerhetsverket and Vattenfall. Thereafter we got some feedback and adjusted accordingly. We then showed again and asked does this suffice."*

It turned out that the blocking would not be as easy as putting a stick through. In an internal meeting in April of 99, the business unit manager is part of the meeting and so is the head of the construction unit plus the two now appointed project leaders. The project had now been divided into two, one for a 145kV Pull and one for a 420kV Pull. The 145kV builds on the conventional LTB breaker and the 420kV is based on the conventional HPL breaker.

This was a technical meeting concerning construction design. Tests were being conducted. It is part of showing for the customer that the product makes sense. Two persons are reported to look at where Pull could fit best in. One of them comments in an interview to where the product would fit in:

> *"We're used to making component products. Discussing the substation design was not something that we were used to. What effects does the product have on the substation? How do we make it fit into the substation?"*

These two people are also given the responsibility to look at what (economic) savings that can be accomplished when using Pull. A promotional brochure is to be created. It is noticed that it is to contain general system functionality rather than the details of the construction. The reason for this is to stop the competitors from immediately copying the concept.

The protocol expresses that tests have been run successfully. The time plan decided in the previous meeting is followed. There is an idea for how a test that verifies that ageing properties conform to desired specifications should be conducted. Trials with either Vattenfall or VB Energi (now part of the Vattenfall group) are to be run as soon as possible. Preferably these plans can be discussed in June of 1999. The contact with VB Energi has not yet been initiated. Likewise it shall be discussed about whether Svenska Kraftnät (old Vattenfall transmission) and Powerlink (in Australia) are suitable trial customers.

At first the project was much seen as an order adoption rather than a fundamental new product development. Therefore the project was not as structured as a typical new product development, one of the project leaders asserts. Another development team member on the other hand says that: The project entered the formal approval process with time plan and a budget. What existed at the time was less structured than the current stage-gate model (ABB's is based on Cooper). Before the introduction of the stage-gate model there was an "instruction". The most essential part of it was the budget and it was followed. The market introduction, environmental aspects and such matters were more fuzzily expressed earlier.

Besides, since there was a customer in Vattenfall, it was viewed as being relatively simple in terms of what could be expected of the market. When a customer asks for the modification of a current product that does not encourage the same type of rigorous procedure of defining a value proposition and a market as for what is perceived as a completely new product.

> *"In the first place, a product was made for Vattenfall. It was first later that global customers were more thought of. We did think however that this something good enough to sell globally"*

There was thus no systematic collection of needs from other customers, domestic or international. Instead the mode of taking into account market requirements was dealt with in the following manner:

> *"One listened around a bit. It is hard to talk about a product that doesn't exist. You don't wanna talk too much if it isn't needed. First one wants to do one's homework before presenting something. The absolutely worst thing you can do is to go out on the market and talk about something that isn't developed. My conception was that the demands from Vattenfall was reason good if enough to get started."*

There was an uncertainty in whether this product could be sold outside Sweden. Nevertheless, that was to be worked on as time passed by. The group was aware that it would take time before sales volumes would go up in an international market As there was an agreement on that this is a good idea in which we believe in, it was natural to say let's go with it without having conducted a thorough market analysis. On the direct question of whether Vattenfall's demand were seen as enough justification of making this a globally successfully product. The reply was a hesitant: "yes, that was probably the case". With reservation that Vattenfall primarily wanted the 145kV and 420kV. Changing the voltage is however more of the same thing, thus not a big alteration.

In response to the question of the perception of how well the product would work on the market the response given by a long-timer is:

> *"We have probably throughout times been more optimistic than what has been achieved. We have throughout the journey thought; now we got this product let us guess on the market, this and that. We have made budgets saying that we will sell for x millions this year. We have actually never succeeded, it has always taken longer."*

The advantages of Pull were clearly understood from the very beginning. There have been only small changes in the product since the beginning. As with all products there has been a continued effort to lower production costs, e.g. by replacing certain components. Apart from this, due to customer requests there have been little adjustments made. One adoption has been made to suit the needs of SvK, allowing testing of breakers in service.

In an article co-authored between Sölver and Olovsson et al (2000) at ABB with staff at Svenska Kraftnät, Vattenfall and STRI written after some of the initial development had taken place, it becomes evident that high availability is one major benefit to substations that make use of Pulls (here for the first time mentioned as Pull in a journal article). The study compares the conventional solution of having separate disconnectors with that of the combined function in Pull. In all cases the new solution shows significantly higher availability levels than for the conventional solution. Also, the authors note that with the combination of the CB and DS function, the number of HV apparatus in the substation decreases. That will also come to mean that less total space is required for the same functionality. Less space required is something that customers can benefit from since space is often restricted.

With the publication of this Cigré report other interested parties would definitely get informed of the development efforts at ABB. The response was however not overwhelming. In fact one of the authors comments that normally one does not receive much attention after having written such a report. The normal procedure and utilization is instead that ABB takes the report to customers and let them see it and say look at this. When asked whether customers read these reports to track development the answer is:

> *"I think that maybe they read these report a little, and maybe discuss. Going as far as contacting the manufacturer with interest does not happen. The manufacturer has to push the product."*

4.2.6.2 Launching the product

One of the project leaders expresses the expectations of launch as having been:

> *"The expectation was that this would be a product that would shock the market. Already during the prototype stage the product was presented. Market people got engaged already before the product was fully developed. They started considering what applications it can be used for."*

The Substation business unit (part of the Power System division) developed a concept in which Pull would be the standard. The idea from Substation was to sell a standardized package. Normally substation applications tend to be custom made to fit the needs of each customer. This concept was meant to be standardized and very cost-efficient. Pull had been presented to substations before it was fully developed, since it was understood that it would make sense to sell it as part of a system rather than as an independent component product. It was recognized that selling Pull as part of a system would make the most sense.

“That has been easy the entire time [developing and selling new component products]. If one comes to speak about a new product that nobody recognizes it is a whole different things. One is talking about how to change the application and the design of the entire substation. Suddenly new questions arises that we are not used to. All such aspects were not covered initially. ”

No one wants to be the first to try an unproven product in the utility industry. Swedish utilities, nevertheless, have traditionally been willing to test new technology. In particular old Vattenfall has been good at trying technology early. Swedish references are often internationally well-renown (following a history of co-developments with ASEA). However, to say that foreign customers are behind is too harsh. What can be said is that they have partly different philosophies and follow other tracks. Using Vattenfall as reference customer works well but it is not enough to sell the product.

Yet, in the case of Vattenfall it was not an all easy transfer to make use of Pull. The operations units within Vattenfall had a large say and as they were against the product, so it was not an easy transition to make use of Pull. With the conventional solution with separate DS it is very clear for operations staff to see the physical gap, which is not the case for Pull where the gap is only inside the breaker chamber. Although Vattenfall had conceived the idea to make a Pull it was not easy to win acceptance within the company. It must be noted that the substation 2010 was initiated by the R&D department at Vattenfall. Nonetheless, also people from the operations units were present and were positive towards the idea of Pull. Vattenfall was, according to an employee much involved in Pull process, poor in following through with ideas that had been conceived.

It turned out Vattenfall would not be the first customer. An ABB manager involved in the project reported:

“The first idea was that of Vattenfall. Later on it died out a bit with Vattenfall. We also started talks with SvK. At first they were not particularly interested but after a month or two they came back with greater interest. The reason for this was that SvK was to refurbish a whole deal. There were some relatively progressive people involved who understood what it meant to able to shrink substations.”

As Pull was accepted by Elsäkerhetsverket, Svenska Kraftnät bought their first four Pulls, designed for 245kV. Those were installed in the Untra substation. This whole substation was designed with much new technology developed by ABB. An initiated person at SvK explains the whereabouts for the Untra substation:

“When we [SvK] came in contact with this [Pull] we had the plan to make a test substation with one of our most important substation builders. The results of these discussions were that in our substation in Untra, up by the Dalälven, We decided to test a number of technical ideas. Pull was one of these.[…] We had become mature to test out some new technologies in a substation that was not essential for the main transmission grid. Untra was chosen for this purpose and since it needed renewal […] The purpose was to test new technology in full scale. That could come to benefit us in our business in the long term.”

The decision taken by SvK to try these breakers had nothing to do with the work done in the Substation 2010 group in old Vattenfall. SvK is a state owned company and due to this, it has to follow the public procurement act. There are, however, opportunities to steer the purchasing in the direction of testing different new technologies (that can only be offered only by one supplier) without relinquishing from the public procurement act.

The old bonds that previously existed have however played out their role. SvK today is as likely to cooperate with Siemens as with ABB.

Later on the Hemsjö substation was the first major renewal project (in a long line of many such renewals) where Pull was being employed. The Hemsjö substation was completely rebuilt during 2002-2003. It was the largest order of transmission level voltage Pulls at that time with 13 420kV Pulls and still continues to be one of the largest orders for transmission Pulls. The reason for rebuilding the station was to increase reliability in southern Sweden (it is located in Blekinge county). It was thought that could the number of components decrease, reliability would increase. The basis for the argumentation to use Pull draws on the assumption on long maintenance free intervals. The product is not considered as new but as a modification of the original HPL-breaker.

This substation also incorporates a 130kV part owned and operated by E.ON. which was rehabilitated and refitted with LTB Pulls. In addition to the general statement of higher reliability and availability, it is explicitly stated that studies conducted by Svenska Kraftnät have shown that when replacing the conventional DS + CB solution with Pull the expected outage rate goes down and consequently the availability of the substation is improved. SvK describes the substation renewal in the following way:

> *"The main advantage of Pull compared to a conventional breaker is that the electrical contacts are enclosed […], thereby protected from […] ambient conditions […]. […] provides improved reliability and prolonged intervals between […] maintenance […]."*
> *"The new switchgear is an improvement from a safety point of view, since maintenance personnel will spend less time in the substation."*

In SvK's calculation, the cost of interruptions is quantified and that steers in what order investments are made. Expected availability is based on Cigré, Nordel and own statistics for HPL breakers. Having observed that the failure frequency of the new spring-drive (from 1994) is much lower than for the predecessor is a crucial criterion in deciding for Pull. Without a reliability improvement in the spring drive, using Pulls as is done today would likely not come into question.

As for investment cost, SvK notices the saved land need as a cost reduction advantage. In addition, less steel and concrete is needed when the separate disconnectors are not needed.

The way the purchasing is handled is that SvK specifies what it wants (Pulls) and places an ad in the relevant EU publication asking for quotations. In the case of Hemsjö there was only one offer made, that from ABB (only ABB could supply Pull). From a legal perspective this is not a problem, according to SvK. Everyone who sees the ad has the chance to submit an offer.

When Vattenfall first bought their Pulls, it had existed on higher voltages already. Vattenfall purchased their first in year 2000 for the Kolsva sustation.

In 2001, Vattenfall had an article (Svensson, Lord et al. 2001) published by IEEE. The title "Cost saving and reliability improvement by using innovative technique for refurbishment of a substation" speaks well of what the advantages Vattenfall saw in Pull were. In addition, it concludes that Pull was to be drastically better in regard to power flow and that maintenance and space would be halved. Furthermore, expected availability is higher.

SvK, it seems, is the only company who has taken the decision to go with Pull over the full line. Other customers seem to be testing the product before doing a full roll out. It is in this context noticeable that SvK does not significantly differ from other customers in any particular sense. It does fit well into their systems though. With regard to acceptance among Swedish utilities is important to point out that the large breakdowns in Sweden due to disconnectors have contributed to spurring the interest for a solution without open-air disconnectors (see Appendix, The power outage in 2003).

4.2.7 Sustaining business - Push

The market had gained some awareness of Push after the pilot installations, the presence at power equipment fairs, and other contemporary marketing efforts. To build sustain business a number of cost reduction initiatives were launched in order to pursue the cost leadership envisioned to lead to market success. Beyond the new product generations called Push 1.3 and Push 1.4, a 2006 report called “Concepts for low cost [Pushs] for HV circuit breakers”, the following statement is made:

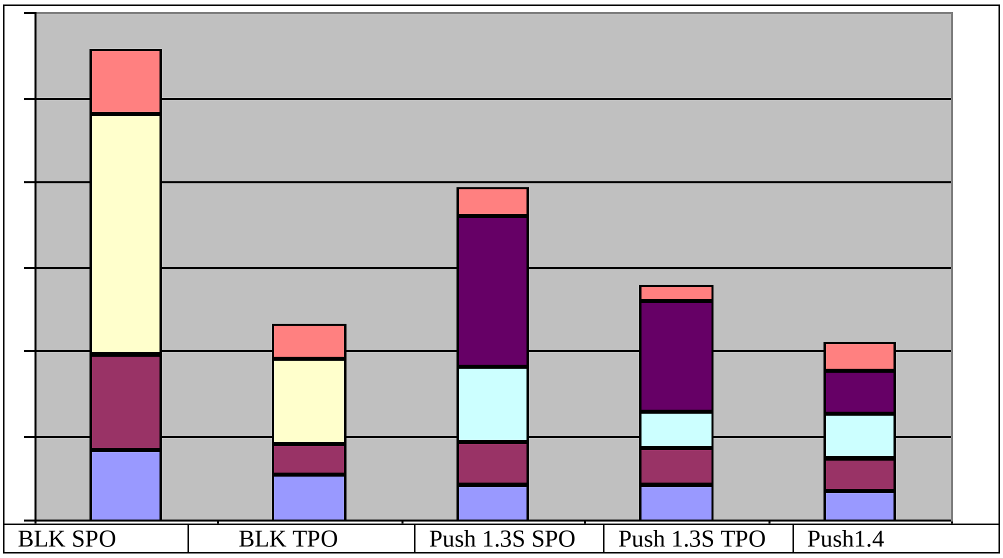
> *“The general conclusions of this report is that there is a potential to reduce the cost of Push Unit for High Voltage Circuit Breakers by more than X% if a combination of the proposed options are used.” (from Summary)*

Another report from April 2005 called “Push 1.3 Cost reduction brainstorm results” states that the contemporary Push 1.3 solution, still at volumes of Y units per year would have X% higher production cost than the spring drive. The report briefly mentions functionality aspects within the scope of system optimization in the longer time perspective, but the focus is on cost reductions.

> *“[The report] presents more than 60 proposals (generated in a brainstorm meeting) to reduce the cost of Push with a 145 kV breaker, ranging from small but significant modifications in the different modules up to long-term proposals that affect more than just the breaker.” (from Summary)*

Clearly, development focus beyond the original concept for Push has been on cost reductions. An early projection for the current cost reduction program is shown in Figure 24 – Original cost projections for the new Push 1.4 compared with other drive alternatives. Relatively little effort has been made to develop new functionality or improve existing functionality. (The graph legend has purposely been left out for confidentially reasons.)

Push saw a relatively slow sales start, but picked up in 2004 and 2005 when sold units grew with a factor of two to three. About one tenth of the customers that have installed a Push equipped circuit breaker since market launch have returned as Push customers.



		"full" vol.	"full" vol.	SPO=TPO "full"

Figure 24 – Original cost projections for the new Push 1.4 compared with other drive alternatives. Numbers and legend have been removed for confidentially reasons.

From the ABB perspective the picture is that Push will not sell in significant volumes unless the price offered to customers goes down.

> *"For the main market, the only competition is on price for the final product. The functionality is hygiene. The basic requirements for drives didn't change during Push development. What happened was that the conventional drive cost came down. Cost of Push went up because it was more complicated […]"*
>
> (ABB Manager)

> *"The goal from the beginning was to achieve a lower cost with Push than with the spring drive. The lower noise level was a side effect that became a sales argument later on."*
>
> (Manager)

Beyond price, a few other reasons are cited by ABB staff for customer skepticism:

> *"There are many conservative customers"*
> *"There are no competitors with comparable products"*
> *"Push doesn't work as a spare part; the whole breaker must be changed"*
> *"There is a technology shift from mechanics to electronics – the interface is too advanced for the customer's staff to understand intuitively"*
> *"Electronics age even if they aren't used."*

Clearly the cost issue has been the dominant along Push's development path. Push in the current generation (Push 1.3) will according to different sources not be radically cheaper to manufacture even if the volumes came up to original target volumes. The spring drive has come down in cost with a two-digit percentage since the late 90's due to better logistics and cheaper manufacturing. At the same time there is a struggle with conservatism in the industry, looking for proven technology with demonstrated reliability.

For Push there have been multiple reports, fully or partially focused on cost reductions written at ABB. Two are notable at ABB Corporate Research: "Proposal for future activities and investigations in Push project at SECRC" (RM-99/119E) in 1999 and "Push 1.3 Cost Reduction Brainstorm Results" (TR-2005/070 9ADB00293-001) in 2005. On the same topic the report "Development ideas for Push" (PP/H/HV/BT/R 06-059) was written in Ludvika in 2006.

Another report, dated December 10th 2004 briefly states that the product was commercially launched in 2003, that it was based on technology from an electric car concept and that the current customer values are:

- Higher reliability
- Less maintenance
- Possibility for condition monitoring by micromotion

The second report, dated January 25th 2005 reports that the initial sales forecast had been sales of X MUSD per year , while actual sales for 2004 had been Y units (corresponding to a sales volume below a tenth of originally planned).

4.2.8 Sustaining business - Pull

> *"Over the years all types of marketing has been tested. Different segments and so on. All customers more or less have been approached. Yet some people still don't know it [Pull]. There is not one marketing strategy that has been employed for ten years. The reason it has been mainly sold in Scandinavia is not due to an intended strategy. However, what is clear is that it has sold best in systems where it fits in well"*

In general much resources and efforts have been dedicated towards marketing and selling of Pull, much more than its relative share of sales would motivate. It is clear that the product faces stiff competition. There are many other solutions to choose from that fulfill the same needs; GIS, Hybrid, and AIS solutions of other kinds. Pull does thus not only compete in the market but also internally with other possible solutions.
Figure 25 below shows some of ABB's solutions.

In South Africa for example all these four units are marketed together as solutions to space constrained substations situations. However, only Pull is offered on transmission level voltages. The Front End Sales typically offers the solution which best fit to the demands of the customers. Thus, if visible gaps are important the withdrawable CB or Compass will be offered instead.

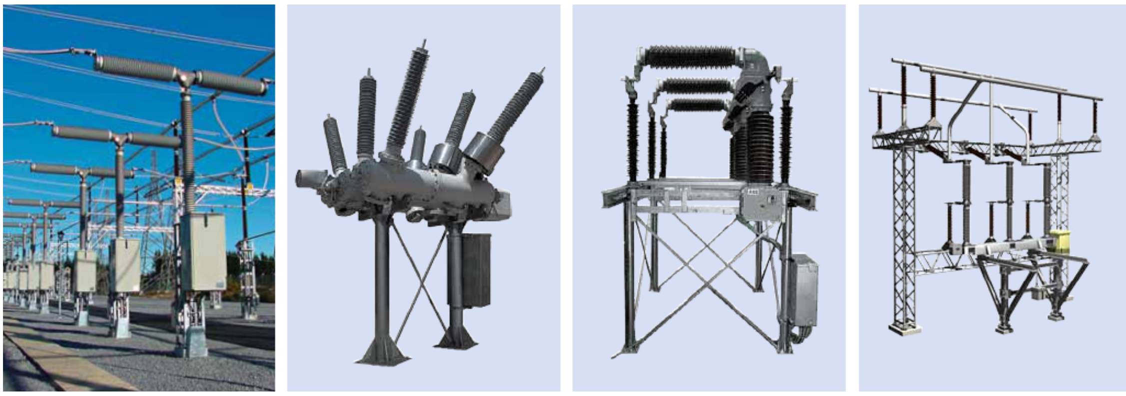


Figure 25–– from the left: Pull, the PASS, the Compass and the withdrawable circuit breaker (ABB Review)

Pull is not the best in every case. Under certain condition it is not necessarily. As a marketing manager puts it: "At least in over 90% of the cases there should be a good business case for Pull". This statement is later revised by the same manager to instead be in the majority of cases. It is clear that it all depends on what parameters are put into a life cycle cost analysis and how they are valued against each others.

During the launch of the Pull project there was not so much of a systematic approach to marketing efforts (as presented earlier in the launch subsection). This changed when a system group was established to look at applications. This group was established in 2001 to introduce new products with high potential. The group had the responsibility for Pull marketing and sales. It had its own profitability goals and budget. The group existed for about two years in 2001-2002.

Before this group looked at the market there was very little in terms of what could be expected from the market. The group started to evaluate what volumes the product could be expected to sell, a market perspective was forced upon it. The product could however not stand on its own legs and the group was consequently removed. The logic of this group was that it would be able to profitable by itself, by reaching volumes large enough to sustain its business.

Moving down the road, Pull hit another obstacle when the product lost support around 2002-2004 for reasons of risks for creepage currents and litigation due to that.

Some redesigns were made and the product later received greater support to be sold from the corporate headquarters.

When it comes to education of customers about Pull there have been many seminars over time. This has come in the form of open education and also special Pull events, Nordic user seminar, where all or many customers are invited. Customers are often themselves invited to hold presentations on how they perceive the product. From an ABB marketing perspective, “The best thing that can happen is when two customers speak with each others.” In particular SvK has been a strong advocator of the product. A company representative explains the rationale behind that in the following manner:

> *”We don’t want to be the only ones to use Pull. In that case, we know that if the market doesn’t get bigger, than the one we got in Sweden, then the product will disappear. We therefore would like this to become a standard product internationally. So that Pulls are developed and so that more manufactures construct and sell them, so that there is competition on the market.”*

The power of SvK as a leader domestically and internationally is expressed by several other ABB customers. One customer representative draws the following conclusion:

> *“With SvK being as respected as it is among national grid operators, others will likely follow, including other manufacturers. They understand that this will come. It is only a matter of time.”*

These types of educational seminars are appreciated for information reasons, several customers say. However, they do not help in educating the operations staff, which is asked for. An important aspect in gaining trust for Pull is to show maintenance personnel that it is an easy apparatus to work on.

Competing product have been introduced with the introduction of a 145 kV by Areva in 2006 and a 420 kV by Siemens in 2008. These products have however not been introduced globally.

In 2005 a milestone was reached in the standardization work. ABB managed to push through an IEC standard (62171-108) in October 2005 for Pull. Standardization is an aspect important to take into account in the industry when it comes to new products.

When the product development started it was an outspoken demand that the standardization aspect should be fulfilled. The IEC norms are very important in the industry. The testing program stipulated by IEC for Pulls was principally the same as ABB had developed, i.e. ABB’s ideas were accepted. That is why the product that was initially developed is still in principal the same as the present product today. The electrical dimensioning is still the same today as it was in the beginning.

In general it is crucial that the electrical withstand is not compromised over time. This should also hold true even though it has been affected by tear over the years. A testing protocol to show that would be the case was developed.

In March 2007 Pull received the Svenska Kraftnät environmental prize. A comment from an ABB employee was:

> *"It is very good that attention is paid to the environmental advantages of Pull in this way. We focused on availability and safety in the*


Frånskiljande brytare sparar plats och miljö 3

Företaget ABB får den andra halvan av Svenska Kraftnäts miljöpris år 2007.

De två ABB-ingenjörerna Carl-Ejnar Sölver och Hans-Erik Olovsson har stor del i utvecklingen av den nya kombinerade brytaren och frånskiljaren, Combined, för högspänning.

Den har blivit närmast standard för Svenska Kraftnäts nya och ombyggda ställverk.

installationer. Driftsäkerheten ökar genom att antalet komponenter minskar. Dessutom minskar elförlusterna som följd av färre avbrott för underhåll av komponenterna.

– Tekniskt sett är den en vidareutveckling av en konventionell brytare, men med högre krav på spänningshållfasthet eftersom den också ska fungera som frånskiljare, säger Carl-Ejnar Sölver.

Figure 26 – Article in SvK’s Nätkontakt

development work by decreasing the number of components. But the fact that it has also contributed positively to the environment with fewer energy losses and CO2 emissions is a bonus."

Utilities and industries using an ABB Pull instead of separate conventional technologies in substations can cut CO_2 emissions by more than 200 tons over the product's lifetime (ABB Annual report 2006).

Pull saves steel and concrete, demands less space and decreases the power losses thanks to higher reliability. In 2007 a life cycle analysis according to ISO 14040:2006 was conducted at Corporate Research in Västerås. It was found that the operation phase, after installation, dominates the environmental impact of the breaker.

To sum up the Pull business after launch, although many strategies have been pursued over the years, the initial value proposition has remained almost unchanged. The only major change is that environmental arguments have been brought forward. The primary reason for development was presumed improved reliability and that has been also the primary argument put forward in the value proposition. Other advantages understood in the initial development have also been part of the value proposition throughout the years since launch.

4.2.8.1 Slow diffusion of the product in the market

The product is 100% substitutable in both directions for new and refurbished substations, a marketing manager asserts. Possibly some minor changes must be undertaken to make Pull fit.

The grand problem is, according to ABB staff, that customers do not understand the product. For that, it requires system understanding of the substation. Pull is 100% substitutable in most situations but most customers do not understand it that way. However, to what degree a Pull is a full substitute for a breaker and adjacent disconnectors is perceived differently depending on the traditions that the customer has. A person who has been involved in marketing says:

> *"One can ponder over the fact that there is not a bunch of potential customers that show interest thinking that it is a great idea and something that they want. Instead it has been so that ABB has promoted the product heavily, stacking all the advantages on each other. The customer typically responds with thanks for the information, we will think about it."*

ABB thinks that it is a relatively easy task to substitute the CB and two DSs with a Pull, but the customers do not. The customer draws on their history and tradition of substation design. Each country has built its own history with norms and laws. In addition, routines and procedures follow with that.

Maintenance personnel have been trained on the conventional solution and therefore it is difficult to switch. This is especially true given that during last 50 years or so there have not been much change when it comes to how CBs are maintained. A major hindrance has been that customer maintenance personnel do not know how to precede with the new solutions. Each utility tends to have its own procedure for how clearance for working is granted. This instruction contains how disconnecting and earthing is accomplished. In most of the world utility companies have their own operations and maintenance personnel. This group is often a strong stakeholder in the procurement decision-making.

The problem with this is the following, as a utility manager reports: A reason for slow adoption is that the way of thinking has not changed except for in the Nordic countries plus parts of Australia. In many cases tradition is hard to change and when the

law and or policy foster a maintaining of status quo things do not get easier. The root of the problem for operations staff is likely the threat of losing their own job. Policies and laws are a legitimate way of obstructing the adoption.
A problem around this would be to approach the executive board in utilities. They ought to see the economic benefit and stand above the minority interest of maintenance personnel. However, that might not work nowadays since these people are finance people from the banking world, as this representative sees it.

> *"They understand the difference between asphalt, fence and entrance, but not much more. And that's when it gets… [like this].[…] The reason that [Pull] has not succeeded [outside the Nordic countries] is that the maintenance mafia say we don't accept it. And they get the last word, that's it. Except for Australia, New Zealand, and Chile, most utilities tend to have their own people, and that makes it a whole lot harder to get the discussion [about the advantages of Pull].*
> *"Scandinavia, in this with outsourcing, there we were the first in the world. And it is not that we are smarter but we were the first to get into an administration mode. When the expansion levels out, [the country is] already electrified. That's when you understand […] what we are doing. We continue to expand despite the fact that consumption isn't increasing. That's when you start trying to get a better grip of it. […] They [continental Europe] haven't done this outsourcing thing. Where we got two lines, the Germans have 4-5, just to be sure."*

An ABB manager says:

> *"The resistance depends much on the fact that maintenance doesn't like the product. Eighty percent of their work consists on grinding the disconnectors. Sometimes the maintenance organizations are so large they in principle make new work for themselves, whether needed or not. […] This cost is however negligible in comparison with the cost for non-delivery [of electric energy]."*

A large customer of Pulls in Sweden has been Vattenfall. Vattenfall has within the company tried to introduce Pull to the German market. It has been hard for Swedish Vattenfall to persuade the German engineers of any changes. Here are the learning and analysis of how to overcome this problem as expressed by one Vattenfall manager.

> *"It is almost impossible to force upon someone Pulls. It has to come from the bottom, people realizing that there is potential for having the product. The way to get around this with conservatism is to let people realize the potential. Vattenfall has tried to send down high manager to tell their equivalents in Germany about key performance indicators, this has failed. It is smarter to send out some young engineers in the organization who ask some naïve questions about matters. That's when they will realize that they are not doing the smartest thing."*

In old Vattenfall, when operations was still part of the organization, the people in the field had much say and tried to make substations fit their own needs rather than the end customer. Once maintenance was procured from external firms, Vattenfall could more easily take a more economic point of view.

There is a need to have a system view in order to sell the system. It has been much easier to sell Pull as part of a system than as a single component. It requires some additional thought to accept the new product and that a person in the customer's organization understands the technology. On a product level it is easier to switch to a regular CB, whereas on a system level it is easier with Pull. This was known from the beginning of the development.

Seldom is Pull sold directly to the customer, instead it goes through the Substation business unit, in Sweden, Germany or India. In addition, some are sold through substation contractors. For this to work out, also the substation construction staff needs to think that is a good idea.

When the customer has its own design department and thus buys independent components from the Power Products division in Ludvika, the customer normally does not reflect on changing the regular CB for a Pull. When instead the entire substation is offered it is therefore less difficult to make the customer choose Pull since there is no design layout department to fight with. In cases where the product is sold as part of a system, economic arguments of life cycle cost advantage can therefore more easily be given. In the Substation BU a simplified life cycle cost calculation algorithm has been created. This is given to customers so that they can themselves experiment with different input data and parameters. In a sense it is through this means easy for the customer to make a sensitivity analysis.

Not only has there been external resistance to the Pull innovation. It was already mentioned that the product was almost stopped from being sold for some time. Within ABB there has been doubt on grounds of if the system can be trusted fully.

Internal missionary work has thus been needed. Just within the High Voltage Power Products unit there are some 50 sellers for the BU that need to believe in the concept. For them the easiest thing to do is to offer a regular CB as requested. It is a thousand times harder work to go into the discussion of the new product Pull, a marketing manager says. It asks for extra effort and knowledge among sellers.

Another troublesome area has been the connection between Business Unit (BU) and Front End Sales (FES) in different countries. The FES representatives need to a have general knowledge about all ABB's power products and it is difficult for them to find the time to learn about Pull. Plus, to make an offer including Pull typically takes substantially longer than one with regular CBs. In the Nordic region it has been easier to facilitate learning and transfer of knowledge. It has taken some years internally to understand this, one manager asserts.

The fact that ABB has been alone with having a Pull has also been an important reason for the difficulty in selling the product, a marketing person expresses. This group tends to be all about saving costs and sees and saw a great problem in the fact that ABB is (at least in most places) the only manufacturer of Pulls. The purchasing departments generally want one standardized product that many suppliers stock.

The purchasing process is something that has been difficult to understand since customers differ substantially in terms of their organizational setup of purchasing.

It has in a sense been found somewhat easier to sell to some Eastern European companies. The reason is that eastern companies do often have deep technical knowledge about products and the system. A marketing manager says:

Figure 27– Composite insulation (ABB Image bank)

> *"It harder to make oneself heard in more slogan-oriented cultures. Western companies don't trust as much as they do in eastern countries. Especially in terms of support"*

Quite a few stakeholders can be identified in the purchasing decision. The operations and maintenance departments have already been elaborated on since this group tends to have the most influence in many customer organizations. Those in charge of installation are generally somewhat skeptical towards Pull. The people that switch the grid form their opinion based on what problems there have been in the past. It also depends on what system they have. Those with past problems with CBs are less likely to exchange to Pull, but vice versa if problem with disconnectors have been frequent (as mentioned earlier Sweden has seen much disconnector problems, refer to Appendix 8.3 The power outage in 2003). Project leaders for substation renewal might see some benefit in that it takes shorter time. Executives or those with a cost control responsibility tend to see the advantages. Although, as earlier mentioned it is seldom so that Pull is seen and understood at this level.

There are two problems of judicial and norm nature. First and most troublesome is the fact that there is not a visible gap as when using a conventional solution. In many countries it has been stipulated in either a norm or utility policy that so it must be.

For example in South Africa the local BU manager says that the reason that a sale to Pretoria municipality was possible was that its utility had a more lenient policy than most other South African customers do. In regard to other utilities he asserts that Pull is a hard sell.

> *"Our marketing has always shown that, you know this, this particular product is much safer than the discrete components [solution (CB+2*DS)] because of the interlocking etcetera. That hasn't been accepted as an argument."*

The second problem is that sometimes the insulation is not made of porcelain. Instead it is made of silicone rubber, a composite material (see Figure 27). In some countries this makes the product non-compatible with national law or norms. Often norms take much effort to change, so although the ISO norm has been changed that does not suffice.

Furthermore, there is a weakness in systems using Pull when maintenance is needed since the adjacent busbars must be deenergized. If Pull is to be serviced more other parts of the substation are affect than with a conventional solution.

> *"The basis for the Pull is that the device in itself must be very reliable. If not, we have quite some many problems, because all the outages are more difficult to get to Pull since we do not have disconnectors anymore. So you need that kind of isolating gaps, which you need to open when making circuit breaker service or whatever…This you have to understand." [sic]*

Concerning reliability there are large differences in how customers reason. Swedish customers seem to be persuaded in general that since Pull builds on the HPL or LTB conventional breakers that have been manufactured since long and have a proven performance record in the field, reliability and availability should only be expected to go up. Foreign customers tend to have another way of looking at it. One customer says:

> *"Within coming years we must analyze how it [Pull] really works. Whether there are lots of faults or if there isn't. It is [could be] a big problem then. If a new product comes to the market there is always the risk that there is some kind of type faults."*

Another customer says that one cannot know the availability and therefore Pull will not be run in important substations. The present installations are to be seen a pilots that are tested. The customer would like to see availability statistics composed by ABB and likewise life cycle analyses. Now the customer will have to initiate its own study. It would have appreciated very much would SvK publish its statistics for Pull since they have many that have already run quite some time. Another aspect in which there is not enough information as this customer sees it, has to do with snow and ice buildup on the outside of the breaker.

SvK, the overall greatest customer of Pull, is not across the line satisfied and has let other customers know that. The following critique has been expressed.

> *"During the journey, we have placed a number of orders; we have decided upon a number of changes that has, maybe, not ABB always lived up to. They have not executed in the way I think they should have. […] They have not always fulfilled their undertakings. That doesn't mean that the product is no good. We have had opinions on certain aspects that need further development which haven't been done on time."*

4.3 Customer views

Customers were asked what the greatest benefits with Push and Pull was in comparison with the conventional alternatives during semi-structured interviews and in surveys. Their answers were weighted according to their emphasis on the specific performance parameters. This was done to be able to compare perceptions with the current value propositions as thought of by ABB. The current value proposition for Pull focuses on increased reliability and availability, just like in the initial phase. The current value proposition from ABB on Push is increased functionality on a number of aspects, unlike the unrealized initial value proposition focused on lowered price to customer.

4.3.1 Push's performance attributes

For Push (six customers interviewed) customers were primarily buying the product for the interest in trying out new technology, and in the hope of increased reliability or less maintenance. Some customers did in certain environments find that they needed less foundation (concrete) for Push-equipped breakers as it creates lower vertical forces when operated. Customer buying motivations are summarized in Figure 28.

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Figure 28 – Customer Push perceived advantage based on performance parameters mentioned in interviews

The very most emphasized reason by customers who installed Push was the interest in trying out new technology. One ABB customer says:

“Part of it is that this is a new apparatus, and there is a joy to that. You don’t need to wait for everything to operate for twenty years before you dare to try it […] We did this partially to try out a new technology […] later on we noticed that there were more advantages that we didn’t realize initially.”

Customers also perceived an advantage for Push in expected increased reliability leading to less unplanned grid unavailability. This perception was primarily a consequence of the micro motion function, which provides diagnostic capability, built into Push. The enhanced monitoring functionality played in as well. One customer stated:

“Push has, well, a little more self surveillance, than a conventional drive unit. We think that this thing with the micro movements is very good, it minimizes maintenance.”

Another major reason for trying Push was the avoidance of planned net unavailability due to scheduled and costly maintenance. Here, again the surveillance and micro motion functions formed the base for the customer perception. As one customer put it:

“Principally, we shouldn’t have to do any maintenance at all, because it is supposed to alarm us if something goes wrong. At a regular installation we need to do service every 10th year.”

Some customers found new practical advantages in the smaller forces in the construction created by the more optimized Push movement:

“[…] then we built this substation equipped with Pull with Push. Had we chosen a traditional drive mechanism, we would have had to use drive piles. Less foundation is needed. […] That station is built on an old seabed, it’s softer and the surrounding buildings all need such reinforced foundation.”

4.3.2 Pull’s performance attributes

For the Pull (sixteen customers interviewed), the original value proposition was to minimize unplanned maintenance in the system caused by malfunctioning disconnectors. This was realized by merging the breaker and disconnector functions into the circuit breaker.

Figure 29 - Customer Pull perceived advantage based on performance parameters mentioned in interviews

The performance parameter most heavily emphasized by Pull customers was clearly the expected increased reliability. One of the customers who put great confidence in the reliability of Pull says:

> *"Before Pull came there were numerous discussions on how to improve reliability of the disconnectors since we had bad experience with disconnectors. […]There is no reason to view this as a new product. It is the same [HPL] breaker with the same spring drive. Statistics for this product is thus the same."*

Lower price or life cycle cost was another frequently cited advantage of Pull. By integrating disconnecting functions into the circuit breaker the purchasing price offered to customer for the same functionality has gone down. One Pull customer discusses this as one of the advantages that led to buying Pull:

> *".. .Pull is a bit economically advantageous, that is, costing less than the product it replaces"*

The third major advantage with Pull is that it requires less space in a substation layout. The disconnectors are removed and clear up "free space" at the customer as shown in Figure 30.

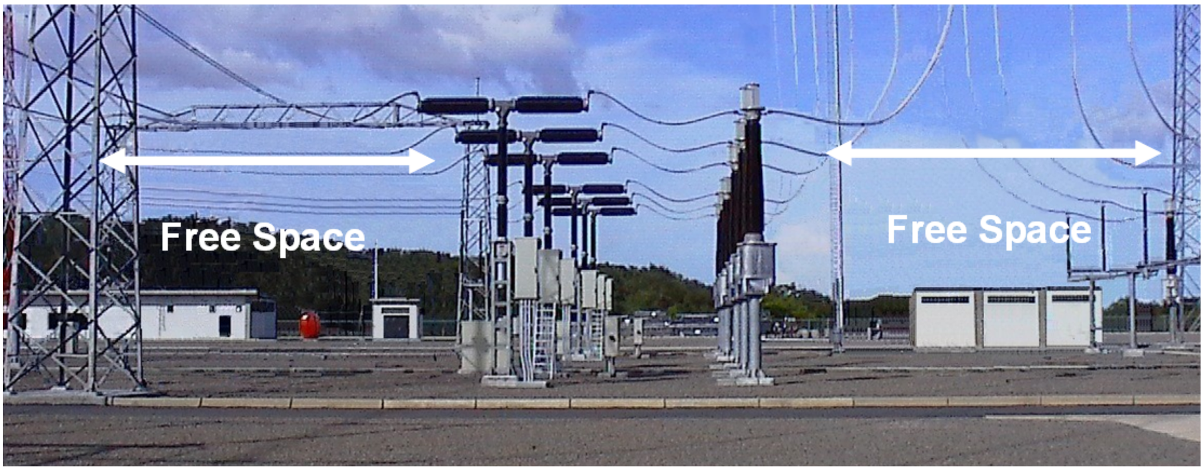

Figure 30 – Pull substation layout with free space from removing the disconnectors. (ABB PowerPoint Presentation)

4.3.3 Push's cost attributes

Push's cost attributes perceived by customers are primarily functionality risks and price. The cost attributes are summarized together with those of the Pull in Figure 31.

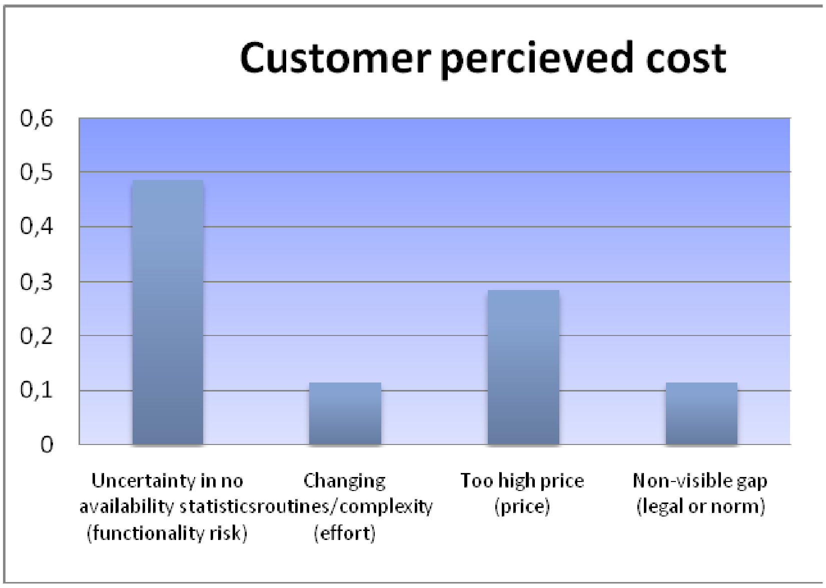

Figure 31 - Customer Push perceived disadvantage based on cost parameters mentioned in interviews

The largest cost or disadvantage that comes with buying Push is the risk of malfunction according to customers. This is mainly due to the lack of market experience of this conceptually new product. There is no extensive statistics from current installations available. One customer said:

> *"For Push, the reliability of service would be a minus. The technology is less proven than for example the combined breaker [technology]…"*

The second perceived disadvantage that customers tended to talk about was the price of Push. Clearly, it is higher than for a conventional standard, spring-based drive mechanism. Customers see this as a major disadvantage.

4.3.4 Pull's cost attributes

When asking customers about the perceived disadvantages with Pull, they are rather evenly distributed between legal or normative constraints, price, functional risk and effort in changing routines.

A major cost incurred by Pull according to customers is the lack of a visible gap in the power line. This is partly a regulatory problem, as transmission and distribution net owners simply are not allowed to install Pulls without installing regular disconnectors. The second part of the problem is the internal resistance to accept something that intuitively feels less secure for service personnel when the maintenance organization has decision power at purchasing.

As stated by a customer changed laws and norms would in consequence lead to higher acceptance for the product:

> *"If more countries accept Pull, ABB's competitors will be more active in the area [making the product more attractive for customers]"*

Functional risk is, just as for Push perceived as a consequence of the lack of statistics in the customer cases studied here. One customer explains:

> *"We have not seen figures of availability for Pull. If those existed and were good, that would surely have made the decision [to buy] easier"*

Price was an issue for customers as well. Some customers outside the western hemisphere found Pull to be a more expensive installation than CB+2DS because of lower disconnector prices, lower installation labor and less expensive ground.

The fourth disadvantage frequently associated with Pull was the effort brought upon the buyer in changing service routines and at some occasions substation designs.

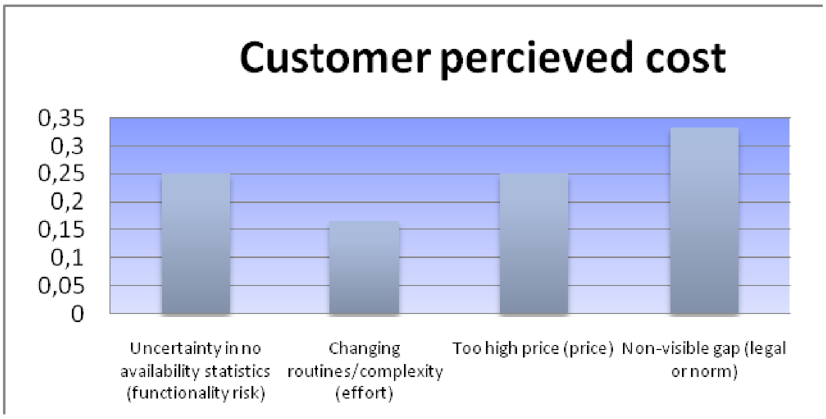

Figure 32 - Customer Pull perceived disadvantage based on cost parameters mentioned in interviews

5 Analysis and discussion

The analysis is divided into the sections development of the value proposition, the market diffusion and a comparison of the two.

5.1 Value proposition development

Push is clearly at the push end of the push and pull (thus the name) classification. Push originated from research program directives based on ABB management's estimated technology trajectories. Subsequently, as a go-ahead decision was made based on the first developed concepts, a rapid complete concept for testing under running conditions was developed. After testing the technology was pushed through the research and development organization to rapid product development.

It is quite clear that Pull belongs to the opposite side of the dichotomy. A user, in this case Vattenfall, made an analysis of what it would need in future substations and that spurred the development. Vattenfall tried to pursue several CB manufactures. It is noticeable how it first seemed as if Vattenfall would not succeed in securing a manufacturer of its demands. Since Vattenfall did not give up on its idea, it was eventually absorbed.

According to Tidd & Bessant (2009) market pull products run a higher chance of greater market results. The adoption rate can thus, in general, be expected to go further and faster for market pull ideas. This is true for an aggregate of products but not necessarily for the single product. This is, as earlier noted, not to say that technology push always fails. In the two cases studied it can concluded that the market pull idea, in fact has come further in the adoption curve and did have better market results so far. This has implications for the answer to research question one.

The push character of Push has made its value proposition development more difficult. To date, no value proposition has been found that translates into superior customer value than the conventional product. The pull character of Pull has helped make the value proposition more attractive from the time of the launch of the product. However, it could be that Push at some point in the future overtakes Pull thanks to its larger technical improvement, once a proper value proposition and application is found. This would then demand that the leap in technology can be translated into a greater value proposition to many customers.

Fitting Push onto Rothwell's coupling model (See section 2.1), it is clear that the connections of ABB's inner workings and both "needs of society and in the marketplace" and "state of the art in technology and production" are missing. As the marketing and sales functions still have not found customers that adopt the product on other grounds than curiosity, it must be concluded that the functionality Push offers is not well connected to the needs of the market. As production cost repeatedly has been underestimated in new product iterations, it is clear that the research and development functions and manufacturing functions are not connected enough and/or that the way in which cost estimation is done is systematically inadequate.

The initial Pull development was not carried out as a normal NPD, but instead it was handled as an order adoption first. In a sense this meant that the interactions between ABB and Vattenfall were frequent. In fact one of the project leaders stated that the process of development was of an iterative kind where Vattenfall had a say along the way. In this sense the development followed the coupling model to a large extent. Both parties in this manufacturer and buyer relationship influenced how the final product would come to look.

The connection to the market is clearly much greater in the case of Pull. It is therefore no surprise that those aspects of the value proposition that customers truly value have received more attention in the Pull case. Since the interaction between customers and the manufacturer were extensive, the value proposition was adopted to that the demands of SvK and Vattenfall. For Pull the third innovation model (see section 2.1) has to a large extent been applied but so has not been the case as much for Push. The employment of the third model can be expected to lead to the development of products that fulfill customer needs. Pull has in reality lived up to much of customer needs, whereas as Push has had a troublesome journey in this respect to today's date. This implies for research question one that the value proposition development of the two products differed in the way that Pull development focused on VP performance parameters that really mattered to customers, whereas Push's link to customer interest was weaker.

Push was, when comparing with the parallel lines model (the fourth model, see section 2.1), neither particularly involved with suppliers, nor with demanding and active customers. Contact with suppliers was carried out in a simple request for quotation manner, and even though pilot installations were carried out with active customers, these came relatively late in the development process and there was virtually no communication with customers before prototypes were presented.

As for the fourth model and Pull, there is certainly some promising evidence of parallel processes. It was made clear that since the product was seen as having great market potential, marketing people came and wanted information. It has not been exactly established when others than Vattenfall became interested. In a meeting protocol it is mentioned that others ought to be contacted, among them SvK, who later became the first customer. Despite the fact that other customers were thought of and contacted it seemed that there was no comprehensive marketing strategy laid out for the launch. For the development process it was great to interact with a customer, but it is questionable if that was only good given that the launch was based on ad hoc actions rather than a well-thought out plan. Yet, even though the product is to start with seen as only a modification of an existing product it would be wise to start following a more systematic system for marketing when the product is decided to be sold to not just to the initial requester.

One of the major advantages of the fourth model is the speed at which the NPD can be accomplished. Pull development did benefit from parallelization, whereas Push never reached such a state. This has implications for research question three, as faster development means earlier product launch and in many cases a competitive advantage and faster market diffusion. It can be concluded that both products could make better use of the fourth generation model. The fifth generation model none of the NPDs were close to reaching.

For Push, there were two clear selection processes. The first was in February 1999 when the first three concepts were benchmarked against each other. The second was when the Swedish and Italian concepts for Push 1.3 were contrasted in the end of November 2002.

When it comes to why the Pull project was taken on in the late nineties it is not fully clear. In a strategy meeting in the fall of 97, it is being considered whether the product should be developed, yet only three days later it seems that it is somewhat clear that it should be already. At this point of time, the product was seen as easy as "sticking a pole" through the breaker to block it from closing. With only one customer in mind it is natural that no extensive market requirement specification is written and that the decision to go-ahead was not controversial.

Even though Push did not have a market requirement specification stating the specifics, there was a consensus around the value proposition in ABB. From a cost perspective, the idea was that the price to customer should be lower than for the competing spring drive while other acquisition parameters should be equal, such as acquisition effort and physical risk. As it turned out, the price for the customer became higher and both acquisition effort and risk became unclear for the released Push.

As the main justification for the Push project was to lower cost, performance parameters did not play a major role from the beginning, although it was thought that a number of benefits could be achieved. The basic needs of opening and closing the circuit breaker should be performed just as for the conventional spring drive. Beyond that, it should comply with the same international standards for breakers as the spring drive, in order to simplify market diffusion. The performance potential was in adding some desired attributes from some parts of the market such as increased surveillance options and continuous status control. Beyond this, there was the possibility to add some unanticipated attributes that no one in the market was requesting because of unawareness. This was for example decreased vibrations because of the new design. There was essentially no shift in the customer roles targeted with Push in comparison with selling the spring drive looking at buyer and user roles. However, as the concept was quite new, there was an attempt to meet the customer in the co-creator role. The early Push installations set up as pilots in Sweden and Italy were subsidized, and in exchange the customer opened their sites to other potential customers who could observe the installations.

At the time of the go-ahead decision for Pull it seems there was not so much of a formal process. The product was deemed as having a clear receiver and the costs associated with development must have been thought to be low given that it was first thought to be a relatively easy adoption to be made.

From the very start it was clear that the major benefit of Pull would be higher reliability which could translate into substations with higher availability. The way the initial idea had come about in the first place was the zeal for less components leading to more reliable substations. Higher reliability would also mean less maintenance and less components would likely lead to a lower cost (of production) of the product compared to a standard CB + 2*DSs solution. Furthermore, it could easily be understood directly that the space required would be less and that the number of foundations would go down.

Thus, altogether it was clearly understood that Pull would come with some major benefits for the customer. In this initial phase the customer was Vattenfall and that only, at least to start with. The target was thus completely clear. With the target fixed on Vattenfall, the value part (of the value proposition) was relatively uncomplicated to appreciate. After all Vattenfall had stipulated what it wanted in terms of functionality and performance, the price of the product would have to be aligned with what the price for a conventional CB+DS solution would be.

Pull had been conceived on local level. There had therefore not been so much in terms of an ABB business strategy approach to what a thought market would look like when the decision was made. If that would have been made, maybe some of the major market obstacles would have been anticipated. It is clear that the decision was made on a local level, and as noticed ABB Ludvika had to stay competitive compared to other parts of ABB. At the time the decision was made to go-ahead with development, the overall global market had not been considered.

From an overall ABB perspective considerations of Pull would likely have looked different. For example the question of how well Pull would fit in the overall product portfolio (there were already other hybrid solutions) would have been raised. Would it enter an already somewhat crowded segment? Would the product likely sell globally or mostly to Swedish customers? Some of these questions might have been part in the corporate decision to limit the marketing and sales efforts for Pull not long after its market introduction.

Given the circumstances around the initial go-ahead decision it should not come as a revelation that the geographic diffusion is highly constrained.

For the overall value proposition for all potential customers, it was clear very early on what some of the major advantages for Pull would come to be. Those would be the same as those recognized by Vattenfall. The relative importance, for customers, of the different advantages would vary considerably. For example, it is clear that those utilities that had had previous trouble with disconnectors would put high relative advantage of integrating and thereby encapsulating the disconnectors in the CB. In reality it is so that not only does the utility company play a role but also what application that utility has in mind for the breaker. The reason that some utilities started to look at Pulls at all were that they had substations in which space was rather constrained and therefore needed a compact solution of some kind.

The value of an innovation is not only determined by its positives but the negatives play a role as well. In the case of Pull, how the negatives are perceived likely vary even more than do the advantages. One significant aspect is the cost that the adopting organization sees in changing routines for maintenance. As the Kambil, Ginsberg et al. (1996) model stipulates the cost is not simply the price tag of the product. The perceived risk of Pull will vary much between different markets, utilities and applications. In countries in which the law or norm is very clear on that there must be an open gap, the risk would be immensely high to make use of Pull. Put in Albrecht's (1993) (see section 2.4.1) four categories for product performance conformance with norms is an expected parameter. Pull does in many markets not live up to this criterion.

In addition, major risk is seen by those working on the maintenance of substations. For psychological reasons it is difficult to change from a visible gap disconnector to a Pull in which in it is not possible to view the disconnection other than by the means of an indicator.

In regard to the customer roles it is certainly clear that users in some utilities have a very strong say. As has been seen in those cases where users have a strong say Pull is seldom viewed positively and non are purchased. In the Nordic countries where utilities tend to purchase maintenance externally, outsource maintenance, the users do not have much of a say and instead they have to like the situation of having to maintain Pulls or they will not win the contract.

Another important aspect of the customer role is that in Vattenfall due to its co-creation of the product. Having been part of the product development it is natural to buy the product and being willing to promote the product among other customers (Kambil, Ginsberg et al. 1996). In the case of Pull it is interesting to see that the role has to some extent been shouldered by SvK who in fact was not the co-creator and idea-giver but came into the process later. It can be said that both Vattenfall and SvK have been promoters of the product but that the latter has received the most interest, perhaps given its strategy of full adoption of Pulls and with that it has more on stake.

Later on in this analysis all of major catalysts and obstacles will be presented. As for now it can be concluded the advantages of Pull were early on clearly conceived, but for the disadvantages, they were probably not so well thought out to start with. To put in the Kambil, Ginsberg et al. (1996) framework performance parameters were clear but the cost dimension could have been given more attention.

Value proposition is an integral part of the business model and in particular in business model innovation the value proposition is central. In this respect it noteworthy that Pull did enter a special group not long after its initial launch. This group, the system group, did not live long, but it did go in direction of business model innovation. The group was broken out from the rest of switchgear to form a group in which system advantages of new products could be offered to the customer. Had the group existed longer, Pull might had fared better than what has been the case.

5.1.1 Disruptive innovations

Push is competing with conventional spring drives. With new applications for breakers rising, there is potentially a separate market for products with frequent operations drives. Push today costs more than the Spring Drive, but should conceptually be able to compete if design, supply chain and purchasing were optimized – this was the initial idea. Push offers a relatively lower performance/price ratio than the current generation of mass produced spring drives. Push has been difficult to patent and is today only protected by one upheld patent. In conclusion, Push could be a disruptive innovation according to Christensen's framework (Christensen 1997) if the trend towards more applications with need for frequent operations continues, and if the cost is reduced.

This implies that the innovation would die in the mainstream company portfolio because of low profitability before the market where it can prosper has been created, which would have been the case at many points in time, had the project not been started over.

Pull is clearly not a disruptive innovation. None of the 4 criteria for being that is fulfilled. Most importantly, Pull does not perform worse on the main performance parameter, quite the opposite, at least that was the reason for initiating development. It does seem very likely that this objective, increased reliability, has been made met. Although, it should be noticed that far from all customers believe so. That is one root of the problem that Pull has faced in diffusing in the market.

5.2 Market diffusion

The overall diffusion in the market for products compared to the overall sales of Power Products and Power Systems Divisions over the last nine years is seen in the world map in Figure 33.

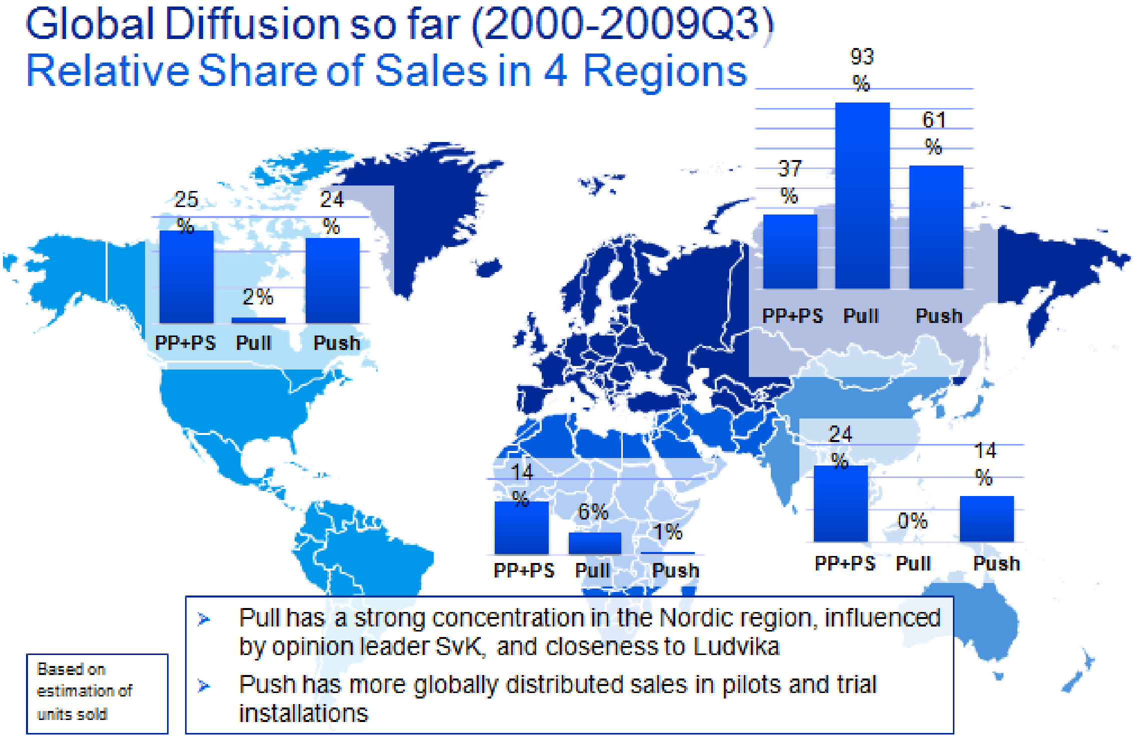

Figure 33 – Global Diffusion so far for Push and Pull. Percentages indicate share of total sales within a specific area. For example, "Pull" had 93% of its sales in Europe and Russia, which is more than its portfolio average (Power Product +Power System).

As Push was not an incremental innovation, its diffusion was difficult to forecast on basis of spring drive sales development. Instead, targets were set on basis of the current market and a replacement effect. There was a goal that Push should cover the functional needs of 90% of the BLK spring drive market. Given that the price to the customer of Push was meant to be lower than the price of the spring drive, 90% of the breaker market in the LTB 145 kV segment should easily be captured.

With this in hindsight, actual sales results have been remarkably low. When comparing Push introduction to the four factors that typically form barriers to adoption according to Tidd and Bessant (2009), it is clear that at least economic and behavioral barriers exist, possibly organizational. Economic barriers include the difficulty to explain and motivate the higher price to the customer of Push compared to the spring drive. Behavioral aspects that have played a heavy role are motivations, inertia, and propensity for change and risk. The motivation for exchanging a relatively well functioning spring drive in the basic substation layout is low, as it involves learning a new technology in exchange for speculative benefits.

Inertia is significant since the customer has standardized routines for requesting quotes on new components and these are built around existing technology. If not stated explicitly that the circuit breakers shall be equipped with spring drives, there is at least no room for giving additional functions a value. Propensity for change and risk is low because of extremely high costs associated with outages in the power grid.

Looking at how customer roles presented in Kambil et al. (1996) influenced the diffusion process, Push is more likely to appeal to the user than to the buyer. The user, at least at a higher level, can see the benefits of surveillance options built into the product. The buyer on the other hand can hardly be expected to contribute to the diffusion of Push, because Push's price became higher than for the conventional spring drive. The product is not only more expensive, it is also difficult to compare with other offers for the buyer, as there are no ABB competitors offering a corresponding product. In the case of a technically advanced customer, there is potential for a mutually attractive co-creator role, where the customer supplies ABB with statistics from the running Push and in return receives better maintenance plans. For research question three, this implies that an obstacle to diffusion was that the value proposition did not appeal clearly to more than one customer type, the user.

For Pull diffusion has been slower than expected. As accounted for in the theory chapter, the more radical an innovation is the more difficult it will be to forecast the diffusion (Tidd and Bessant 2009). Given that Pull was first considered as very much an incremental product it is not strange that the first expectations of diffusion have not materialized. The underestimation of the radicalism both in marketing and how the product is perceived by customers explains why the diffusion has been slower than expected. The fact that the product is technically incremental does not mean that the diffusion will be fast and smooth as has been seen in the case of Pull. In regard to connecting the value proposition development with diffusion not just the technical radicalism has to be considered but also other dimensions in accordance with the Afuah and Bahram (1995) framework.

No early market expectations projections have been possible to obtain and it is thus not possible to give a quantitative interpretation of the congruence in forecast and actual outcome. Finding out any incongruity between forecast and actual sales would not reflect negatively on the project team, as projections for innovations are inherently difficult to do.

Empirical evidence of the s-curve for diffusion has been found in a great number of studies. That does however not mean that it is easy to say where a product is in this s-curve until long after the product has diffused completely. In the case of Pull an attempt to plot the stage of the adoption will later be made in the comparison with Push.

From the perspective of many ABB employees Pull is a de facto major improvement over the conventional CB+2*DS solution in a good majority of the AIS cases. Given this perceived objective superiority, it is good to remember the famous example of the Dvorak keyboard (see section 2.5.1) in which diffusion has been very sparse. Pull and the Dvorak keyboard share one major characteristic. The adoption of the innovation necessitates the unlearning of old habits or routines and the relearning of the new.

In the case of the Dvorak keyboard the obstacle in unlearning has shown to be insuperable despite the fact that new generations hardly come in contact with typewriters. Closer to an objective truth of superior product performance than that for the keyboard is hard to come by. Yet, diffusion has been little. Could Pull be facing the same fate?

Again, the aspect of user versus buyer is deeply involved in this question. In those cases where the user has a say in the purchasing decision it will hardly let go of wanting separate DSs. In situations where users are outside the buying organization their say in the matter is constrained and thus a more rational approach based on important performance parameters can be made. This unwillingness of changing routines on behalf of the maintenance personnel can be categorized as behavioral inertia. At the same time it is an organizational barrier due to the fact that new instructions have to be written and taught.

Diffusion models take into account differences in customers' needs to differing extents. The previous paragraph has tried to explain the slow diffusion process from a perspective of different customs. However, in the epidemic model (see section 2.5.1) customers are seen as being alike and the adoption is explained by the communication between adopters and potential adopters. In the case of Pull some adopters have been promoters of the product to other users. Within Sweden for example it is clear that the adoption by SvK has had overall positive influence on other potential customers. In other countries this type communication has not been as prominent.

Whether this has been due to foremost personal communication or mass media is not possible to say with confidence. However, it is likely a combination of both but with the emphasis on personal communication. Personal communication in this case does not only concern direct communication with SvK but with others who have looked at the actions of SvK (and possible Vattenfall) for direction.

The probit model acknowledges the difference in customers' propensity to adopt new technology and what needs they have. In this case VB Energi can be claimed to be a typical innovator when plotted in Rogers (2003) bell curve framework. SvK is harder to put into one category; it would fit into both the innovator and early adopter category. Innovator since it was the de facto launch customer, who in addition helped out in debugging the product. At the same time SvK seems to be an early adopter in how it is viewed as an opinion leader in Sweden and at times elsewhere. In Sweden it is no doubt that majority customers have started purchasing the product guided by the actions of opinion leaders. Figure 34 is an attempt to visualize in which phase customers from different nations are in.

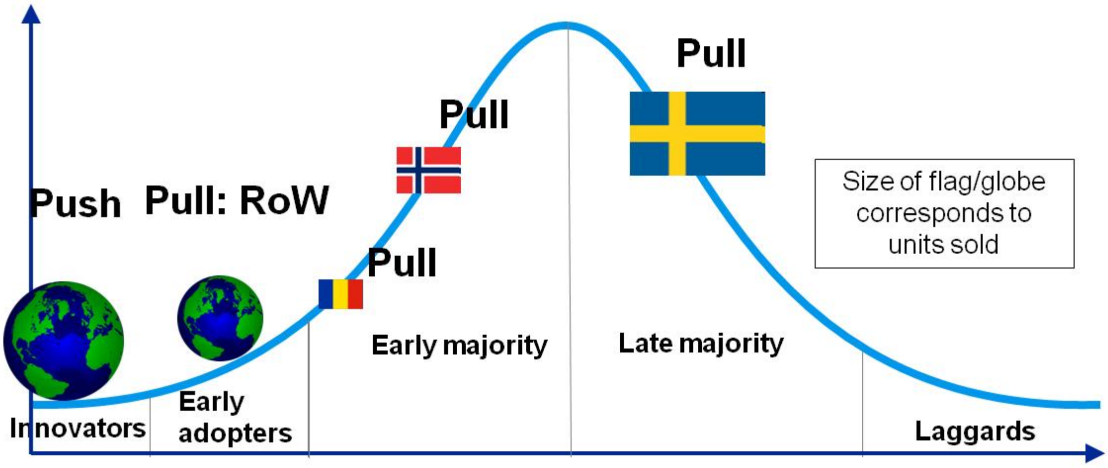

Figure 34 – Diffusion process in different markets

Although differing customer needs and lack of communication to some extent explains the slow adoption, it cannot fully explain the complexity of the problem. To better understand what affects the adoption speed Rogers (2003) five factors will be employed. These have been found in many cases to explain how fast an innovation diffuses in a system.

5.2.1 Roger's five factors explaining the rate of diffusion

Applying the five factors will bring insight into what has affected the speed of diffusion for Push and Pull. Each customer (and even each person in the customer organization) makes its own judgment. It is not possible to take into account every single opinion here but instead what will be presented is an aggregated level for each of the five factors. When applying this model it is important to remember that there is no absolute truth, instead it is much about perception. An aggregated level for customers altogether and for ABB employees altogether will therefore be presented.

Seen from ABBs perspective, the relative advantage of Push is large. All customers can benefit from the presumed higher reliability coming with the micro motion, and lower vibration level resulting in less need for heavy foundations. Many customers will benefit from lower noise, and quite a few will have great benefit from the surveillance functionality. For the customers, these advantages have existed to a smaller extent. Almost no customers quote the surveillance as a major advantage. Most have no problem with noise as substations tend to be placed far from urban areas. The foundation is still needed even if it can be made smaller with the lower vibrations from Push.

The compatibility of Push is high, both from ABB and customer perspectives. The spring drive can easily be exchanged for a Push when installing a new breaker. A Push can however not be fitted onto an already installed breaker as a substitute for a preinstalled spring drive.

The largest difference in view on a parameter of diffusion for Push is on perceived complexity. While ABB and especially Corporate Research, where the product was born, tend to see the product as rather easy to understand, the sales force finds it more difficult to explain Push and the potential customers can not in most cases understand the technology before buying it, nor operate all of the features themselves without help from ABB once installed.

The trialibility for Push is perceived as high by ABB. There have been numerous pilot installations around the world, and in a substation of multiple breakers, it is possible to install only one with Push. The customers also perceive the trialability as relatively high, although not as high as ABB does; they feel they need to understand the product thoroughly before buying it.

Observability is quite high for both ABB and customers. The installations already made with Push are well spread around the world, and customers are usually willing to open up their sites for prospective customers.

From ABB’s perspective the relative advantage of Pull is quite large. A marketing manager asserts that in most cases Pull is advantageous for AIS solutions. For those customers that have adopted Pull, it is clear that they perceive a good relative advantage given that the product does mean that some sacrifices have to be made. The relative advantage perceived is dependent on what problems the customer has had in the past. Those with previous problem with disconnectors will value the integration higher than others.

The compatibility is often quite high but varies with the substation layout. However, in most cases a CB+2*DS solution can be substituted with Pull. It can, nevertheless, due to space reasons be difficult to go the other way around, since Pull takes up less space in the substation. There seems to be good agreement between internal and external views when it comes to the compatibility.

The perceived complexity for customers compared to what that thought by ABB is an area where there is discrepancy. ABB in general and particularly the BU seem to view Pull as a relatively easy product to understand. Since customers need to learn new skills and develop new routines, complexity can be said to be quite high. Of course those who have already adopted the product have developed routines but for those who have not this is a major barrier to adoption.

The trialability for Pull is not very high given that in order to install it in a substation layout changes have to be made. In addition, trying it out during a year does still not say so much about its performance since reliability and availability must be measured over longer time periods. It is worth to note again that running trials with a customer, in this case SvK in Untra and later Vattenfall means an opportunity to make those users more committed towards the use of the product while at same time, it gives a chance to debug the product.

Obervability is a problematic area when looking outside Sweden. Although there are numerous examples of foreign customers visiting SvK’s Hemsjö substation to look at Pull, it seems this is not enough to persuade customers of the product’s performance. In fact most, with exceptions, non-Swedish customers seem to be not so certain with what performance can be expected, in particular reliability and availability (key performance indicators in the industry). Swedish customers, on the other hand, seem to either trust that the performance will be the same as for the conventional HPL or LTB breaker, which Pull builds on, or trust someone else who believes so. Foreign customers to a higher degree think that the product needs to be tested more as if it was something completely new. Within Sweden vicarious learning was possible and it might be mostly a matter of time before this happens more regularly on an international basis.

A summary of the overall situation for the five variables for both products is given in approximate quantitative form in Figure 35. The scale runs from 1 worst to 5 best.

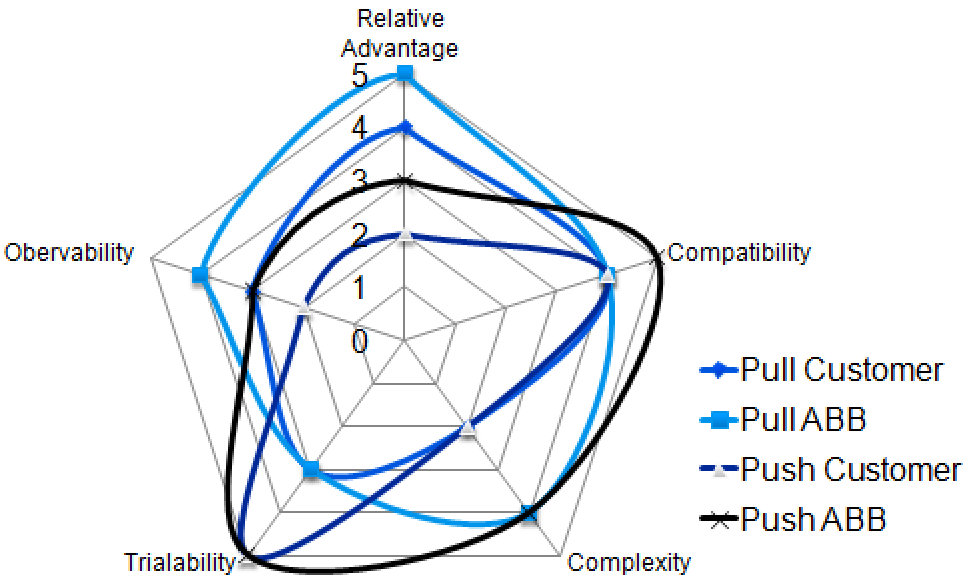

Figure 35 – Roger's five factors applied internally and externally

5.3 Congruence between value proposition and customer value

The Kambil 1996 framework explains how the value proposition to the customer combines product performance (advantages), product cost (disadvantages) and the customer role in which he or she receives the offer. This study shows that there is a significant difference between the original intended value proposition and the subsequent customer perception of value.

5.3.1 Customer value of Push

The primary value dimension for the Push concept considered in the selection process was lowered cost by reducing the weight and number of components. This would raise ABB margins as well as allow for a price reduction to customers. When compared with customer perceptions close to ten years after concept realization, it is obvious that quite the opposite is true. In fact, the product is more expensive than the conventional alternative, and when customers are asked about the disadvantages they mention the price as the second largest drawback.

What customers have come to appreciate in the absence of price advantages are the newness aspects of a fully electronic product replacing the mechanical, conventional alternative. This is a typical characteristic of the customers belonging to the "Innovator" adoption group (Rogers, 2003), a group that unfortunately only makes up 2,5% of the total adoption population. The second and third most valued attributes of Push are according to customers expected increased reliability or availability and "less maintenance". This is a logical consequence of increasing maintenance costs of power grids and penalty fines associated with grid unavailability. Following this, grid availability and equipment reliability is today the main issue for net owners. Push allows an improvement potential with the surveillance and micro motion functions. However, customers try to make offers comparable in price by sending out extensive "RFQs" Requests for Quotation. These specify the performance and sometime components requested, and pose a barrier to introducing products with new functionality.

The main disadvantage that customers found in Push is, beyond price, the lack of availability statistics. This is classified as a functionality risk in the Kambil framework, a major cost that is calculated into the value of the product.

5.3.2 Customer value of Pull

Major advantages with Pull stated by customers were increased availability, lower price and less space required for the installation. This goes well with the initial value proposition, which was to increase the availability in the grid by omitting the separate disconnectors that caused major faults in the 1990s. It can thus be said that the original value proposition was realized as Pull, as perceived by the customers, allows more availability while keeping other variables stable. A lower total initial cost has been realized by many customers because there is no need for separate disconnecting equipment, at the same time the foundation and space required is shrinking.

On the disadvantage side, just as for Push, lack of availability statistics and high price was quoted. It can seem contradictory that price is quoted as a disadvantage, but in some locations disconnectors are a minor expense and there is plenty of labor and land. The lack of a physical gap is quoted as a disadvantage for Pull. This is considered what is referred to as a physical risk in the Kambil et al (1996) framework.

Physical risk encompasses the actual danger of using a product. With power product this is a very important attribute. Products must not endanger personnel safety during installation and maintenance work.

6 Conclusions

The purpose stated in this thesis was to investigate how the value proposition development in new product development projects relates to the diffusion of the product in the market. Since the thesis was a case study of Push and Pull the conclusions are based on these two NPDs.

Push and Pull are fundamentally different new product development (NPD) projects to start with. Whereas, Push is a clear case for technology push, Pull is a clear cut case for market pull. In fact they seem to be so ideal type of cases that the critique of the linear models almost falls, at least in these cases.

This makes the two development projects interesting to contrast against each others. This major difference in type of project has large consequences for the development. For Push the needs that the product was to fulfill still have not been found by adopters of the product. For Pull it was obvious that right from the start there would most certainly be at least one adopter, namely Vattenfall who had placed the order for the product. As it was quite soon understood that other utilities might be interested in this solution this could have turned into a more regular NPD project.

The development of Pull was a fairly short iterative process to please the needs of the buyer. Push by contrast has been a long process of iterations to drive down cost to a level acceptable for customers. As the cost of producing the conventional spring solution has constantly come down, Push has never managed to catch up. Customer and supplier involvement has been set to a minimum in Push case during actual developments. Pilot installations have however been made along the journey.

The type of innovation that the two products are differs substantially. Push is technologically radical with the manner in which the function is performed completely altered. Pull on the other hand is technically an incremental innovation. In a system however Push performs exactly the same function as can a conventional spring drive. In fact the product has been made so that it would imitate the way the conventional drive works. Pull alters the way the system is put together. The layout of the substation changes with its introduction.

From a marketing perspective Push is in sense easier since it does what the product that it is meant to supersede does. In fact, it does what the old product does plus offers additional features. Pull demands greater explanation and greater system knowledge to sell. Push is a one to one change but Pull is not.

The potential disruptiveness of the two products cannot with any great assurance be said until long after the introduction. Although ten years may seem long, in the industry under scrutiny it is not long at all. However, it can be said that Pull will with certainty never be a disruptive innovation and it never was meant to be. Push could become disruptive if it finds special segments with frequent operations in where it can beat the conventional spring drive on what is now considered a secondary performance parameter.

Adherence to the stage-gate model has in the case of Push been relatively good. With exceptions for little attention paid to the MRS and gate 7, capture learning, at least to its full extent. Push has not followed a structured formal NPD process as it was merely seen as an order adoption process rather than a regular NPD.

The idea search process for Push was extensive with three different locations involved in finding solutions plus other alternatives that were later adapted to different applications. The search process for Pull was done externally, by the substation 2010 group in old Vattenfall and later on reopened by new Vattenfall for the application of

AIS distribution voltage breakers. In a sense ABB did not do much of search process itself therefore.

This is no surprise given that Pull was if not a user innovation so at least a customer innovation. It certainly was not the maintenance personnel, the users, in Vattenfall who had came up with the idea of a Pull but instead a cross-functional R&D lead development group. It should, however, be acknowledged that this group did not contain maintenance personnel. Their stance towards the idea at the time is not clear. Pull is thus more of a co-creation type of innovation than a user innovation. Later on as SvK became the first adopter it also took on the role as lead user and paved the way by testing the product in its Untra substation. The commitment to the product from both Vattenfall and SvK has resulted in promotion for the product in the shape of positive articles, demonstrations and seminars.

Push shows no traces of user innovation, nor is there a strong committed customer promoter.

The selection process for Push took the form of competitions between different local BUs. Basically different solutions to the same problem were benchmarked against each other's and the best solution received a go-ahead for development. This was done twice for different development versions. Pull go-ahead decision was not as definitive as for Push, instead it appears as if it was more of gradual consensus formed that this idea of Vattenfall's seemed to be good enough to do something with.

In the selection phase both products have in common that the primary justification for development is distinct. For Push the cost of the product with the same performance as the conventional spring drive is expected to go down. For Pull the reliability of the CB+2*DSs system is expected to go up. Beside of these primary reasons it is in both cases clear that the new products will come with some additional benefits.

In Table 6, the value proposition development of Push and Pull are summarized.

Categories	Push	Pull
Initial idea and its thought VP	Simpler construction, lower cost	Increased reliability most important parameter. Other advantages over conventional product were also known from the start.
Changes in VP over the development	Toward functionality aspects; less mechanical stress, less noise, surveillance functionality	Environmental advantages have been emphasized more during the later years
Final VP	Increased functionality, hope of better reliability	Better reliability plus additional advantages which were known from the start plus along the way.
Percieved customer utility	Stress and noise reductions	Differs substantially. Initial development reason most important. Total cost of ownership another important parameter that varies much depending on the customer's

		purchasing model

Table 6 – Summary of aspects of research questions

The value proposition for Push has changed drastically from project initiation until current market diffusion. The product value propositions initial focus was to reduce cost and the reference customers were chosen with geographical diffusion more than certain performance needs in mind. When the focus of the value proposition was shifted to performance, the reference customers in the innovator and early adopter categories, usually acting as opinion leaders, did not utilize the increased performance. Possible underutilization of opinion leaders could have caused a retarded diffusion process for Push due to the changes made in value proposition.

Push has some characteristics of a disruptive innovation. If that is the case, it will die in the mainstream organization because of low profitability. It would then benefit from being moved to a separate organization with more of an entrepreneurial climate to prosper.

6.1 Answers to the research questions

The research questions asked were the following three with concise answers directly following:

1. In what did ways did the development process of Push and the Pull differ in respect to the advancement of the value proposition?

Both had relatively clear value propositions right from the time of the selection process of or even earlier. The main difference lies in the fact that Push has so far never lived up to the reason for why it should be developed at all. Thus, the original value proposition for Push has not been realized. For Pull it has been possible to sell the product on the initial value proposition and that has been maintained. It has, however, been difficult to prove (statistically) that Pull does live up to its promises of higher reliability in the substation.

2. Are there differences in how Pull's and Push's value propositions are perceived externally and internally?

For both products there exist discrepancies. The most troublesome for Pull seem to be the fact that the main performance parameter has not been proven, at least not in the eyes of many customers. For Push, the original value proposition of lower price has never been realized. Instead, ABB has focused on added functionality and presumed performance increase. Technology savvy customers have embraced the new functionality, but few customers have bought into ABBs performance propositions.

3. **Which were the catalysts and obstacles that influenced the market diffusion speed of Push and Pull?**

Pull	Push
Catalysts	
▪ Incremental improvement of existing product (LTB & HPL, seems to hold true only in some cases) ▪ Perceived relative advantage over conventional solution ▪ Highly respected lead user	▪ Higher reliability in frequent breaking conditions, e.g. Capacitor banks ▪ Easy adjustment to odd frequency applications
Obstacles	
▪ Legal requirements & utility policies ▪ Discrepancies between value appropriation and creation ▪ Problems in internal marketing ▪ Need for closeness to Ludvika/Västerås	▪ Low performance/price ratio ▪ Not a first hand pick for the ABB Sales force ▪ Skepticism towards the use of capacitors (life time, security, electronics)

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8 Appendix

8.1 Case Study protocol

Our analytical framework is built on questions emerging in the case studies, resulting from our research questions as follows:

Analytical Framework content:	Literature:	Connection to case study data base:	Used to answer research question:
Analytical Framework	Lindmark's 2006 model of R&D from technology to sales projected on the value proposition		Gives structures for framework and result
Innovation process models	Rothwell's Pull/Push dichotomy (1994). Rothwell and Zegveld's (1985) "complex net of communication paths" innovation process. Rothwell's five generations of innovation models	Classification made by analyzing interview testimony	1. Different advancement of the value proposition depending on push/pull etc.
The chain-linked model	Kline and Rosenberg (1986) Chain-linked model	Classification made by analyzing interview testimony	1. Advancement of the value proposition
Disruptive innovations	Christensen (1997) 4 criteria for disruptive: 1.Create new markets by introducing new product 2. The new products cost less than existing 3. Initially the product performes worse when judged by mainstream criteria 4. The technology should be difficult to protect using patents. +Sailing ship	Program directives to replace existing technology	1. If an innovation is disruptive it is first percieved as having worse value to price ratio than standard product.2. What performance parameters are considered most important?
The Innovation Process in New Product Development	Tidd and Bessant's Funnel model.	Projects started/Total ideas registered	
Search			
The Fuzzy Front End	Reid & Brentani (2004)	Early development staff interviews, Cigré reports	1. understanding the nature of the front-end decision making process for discontinuous

			innovations and incremental
User innovation	von Hippel (2005)	Accounts for Pull UI from SVK/Vattenfall, C-E S & cigré reports	1. The customers direct involvement in the value proposition development
Select			
Value proposition development	Building on Kambil et al (1996)	Comparsion of customer and employee interviews	1. Defining the value proposition
The perceived cost of the offer by the customer		--"--	1+3
The perceived performance of the offer by the customer		--"--	1+3
Customer roles		--"--	1+3
The Implementation Phase		ABBs stage-gate model vs protocols from meetings	
The process of Adoption of the innovation	Rogers (2003)	Sales data Push&Pull compared to world HV breaker market data	1. catalysts and obstacles 1. opinion leaders as protagonists or antagonists of new technologies, 2. discrepancies in choice of performance parameters
Affecting the speed of diffusion	Rogers (2003)		1. catalysts and obstacles
Compatibility	Rogers (2003)	Interview questions based on Rogers	2
Complexity	Rogers (2003)	Interview questions based on Rogers	2
Trialability	Rogers (2003)	Interview questions based on Rogers	2
Observability	Rogers (2003)	Interview questions based on Rogers	2
Catalysts and obstacles in adoption			
The Capture Phase			
How to measure success in NPD	Wheelwright and Clark, 1992 Hines 2005	Profitability estimations from BUs in Ludvika	3. What diffusion is there so far?

8.2 Interview template

Intro

What is your current position? Which position did you hold during the product development? What role did you have in the development?

How was the product idea conceived?
Whose idea was it?
On what basis was the NPD justified?
How well was the customer able to articulate their exact need?
How were potential customers involved in the development process? (eg. co-development, inputs face-to-face, surveys)
How were costumers chosen as participants in development?
Several customers involved?

Could customer needs and benefits be easily identified intially?
When developing the product was a certain type of customers in mind, i.e. was the product tailored for a segment?
In general how well were customer's able to articulate their needs?
What kinds of market research were conducted?
What steps were taken to assure an understanding of the customers needs?'
How was the value proposition first thought of? Have there been changes over time?
How were customers involved in the development of the value proposition?
Was everyone in the development process well aware of the customers' needs? What mechanisms were put in place to assure that?
Were incentives created in the development process to ensure innovation directed at market needs?

What guidelines (if any) were followed in the concept and product development?
What deviations were made from guidelines?
Did the development project undergo gates processes that had to be passed?
What was the division of work between the Research dept. and BU product development?
Were learnings from earlier projects taken into account in any significant manner?
Is there any follow up report or partials written on the development of Pull / Push
Was there time allocated to review the development project? Reports?

In your opinion, how much better is the X product compared to the Y product that it supersedes?
a. from a economical point of view(eg. pay a back or ROI)?
b. from non-economic factors (e.g. convenience, social prestige, satisfaction)

How can the market be characterized in terms of maturity, real rate growth, marketing expenditures, investments in capacity, product margins

What percentage of customers buy the product compared to the conventional product?
Do the existing customers distinguish themselves from potential customers? How?
Have any adoptions been made to better fit potential customers, i.e. to better accommodate for their needs?

How well does the product fit in with existing systems?
Is there a cost associated with adopting this new type of product that does not come with the conventional product?

Does the use of the new product require a different type of skills or practices for the customers?
Do customers have all the information needed to be able to compare the new product with the conventional type? Is it possible for customers to obtain information about the product from other sources?
Does the innovation necessitate changes in the organization for the customers?
Do you believe that sales would have been higher, had the product benefits been more easy to understand for the customer?
Has there been any measure made to make customers try out the product, i.e. experience it themselves?
Is it possible to make of small-scale trials or would dysfunction be very costly?
Do customers typically talk to each others about the benefits of new products?
Can customers easily observe the benefits that other gain from using the new product?
Do potential customers come in contact with already established customers?

In your opinion, what would make the product sell better?
Thoughts of business model innovation for new products?

8.3 The power outage in 2003

On September 23rd 2003 a major power outage became eminent in Southern Sweden and eastern Denmark. Sweden south of the line between Varberg and Norrköping was left without electricity, meaning a combined effect loss of some 3000MW (Danell, Johansson et al. 2003). The duration of the outage was up to 5 hours which meant 10 million kWh not delivered (Larsson and Ek 2003). Svenska kraftnät estimated the cost to society to be in the region of 500MSEK.

An internal fault in the Oskarhamns nuclear power reactor 3 had lead to a loss of 1175MW in power at 12.30 That, however, was not the direct cause of the outage. Automatically because of the loss of power, reserve power in the form of instantaneously availably hydropower from Sweden, Norway and Finland restored the network power frequency to around 48-49hz (Danell, Johansson et al. 2003). Normally the network should be able to handle the close down of a nuclear power plant and so it did first. With the delivery of hydropower the network became more strained but nonetheless remained operational.

Due to the breakdown of a disconnector in Horred substation close to Varberg a short-circuit is created. This would mean that Ringhals nuclear power plant could no longer deliver to the network. The loss of Ringhals and Oskarshamn, totally 3000MW, means that the voltage could not be sustained (Larsson and Ek 2003). Therefore the southern transmission network was disconnected from the northern and there was no longer any chance to keep the balance between generation and consumption. A total breakdown within seconds was the result. This was not the first and will not by the last outage caused by a disconnector.