Proceedings World Geothermal Congress 2005
Antalya, Turkey, 24-29 April 2005

Service Development through Quality Function Deployment in Niche Markets with High Product Innovation

Davide Maritan and Roberto Panizzolo

Geotherm srl, Via Argine sx, 18 - 35024 Bovolenta (PD) Italy; University of Padova, DIMEG, Via Venezia, 1 – 35131 Padova Italy

maritand@geotherm.it; roberto.panizzolo@unipd.it

Keywords: QFD, Product Innovation, Service Development

ABSTRACT

The services provided along with a product designed, made or installed by a firm, are becoming more and more important in maintaining market position, especially in niche markets, where the high levels of specialization required raise customers' expectations and increase their demands for quality performance. Also, in a niche market there are few customers, so if just one is lost, it means losing a relatively large share of the market, thus, customer satisfaction is all important. The problems for firms which operate under these conditions are exacerbated if the types of products and services they offer are highly innovative in the geographical area where they operate and/or, if their organization and finances are limited. The case of Geotherm srl, a small Italian firm that concentrates on designing, assembling and installing geothermal heat pump systems, offers an excellent example of the problems the management of a firm might meet in this situation: highly innovative context, correct interpretation of customer demands and transferring these demands into specific techniques of products and services. This paper describes how the QFD method was applied in Geotherm srl. QFD is today widely recognized as a valid tool for planning products and services using the *Total Quality Management* (TQM) approach.

1. GEOTHERM SRL: COMPETITIVITY IN THE ITALIAN AND EUROPEAN MARKETS

Geotherm srl Earth Energy Systems was founded in the year 2000 after some years of groundwork and planning. The inspiration for the firm arrived by chance: in 1997 a short article in a special supplement to the scientific journal "Le Scienze" (Facca, 1997), gave a brief description of heating and cooling systems in the USA, that were "*plugged to earth*". The founders of the firm were interested and sought information and contacts from the Anglo Saxon world. It was not easy and there are two main reasons behind many of the difficulties met when starting up:

- the lack of technical know how, not only specific to this aspect but to the thermo-technical basis of such technology;

- the difference, sometimes considerable, between the systems and components developed in the USA and in Canada, and those that can be found in Italy and the rest of Europe, which are not dedicated and not specialized.

At the beginning, the time required to clear up design problems, to assemble and install the heat pump was high, critical was the help and support of a British leading firm operating in the sector of deep geothermal and ground heat exchange systems. Thus it was clear that a key factor was to improve levels of specific know-how. In 1998, a pilot plant with a heat pump and two vertical geothermal heat exchangers was used to heat and cool (using air) an attic room of about 150 sq.m at Bovolenta, Padua. This became the headquarters of the firm. A couple of years after, the firm was launched, and in the meantime two prestigious qualifications as systems designers and system installers for geothermal heat pumps were obtained in USA.

Over the past five years, but especially in the last two, people have become increasingly interested in this technology, consequently more and more installations have been set up. Geotherm has been active in disseminating knowledge about this type of installation, about the high levels of efficiency, reliability and performance, and is supported by information from other areas such as Switzerland, Germany, Austria and Scandinavia. The European market has been growing at a rate of between 15 and 20% per year and may be as high as 80,000 units in 2005. Mediterranean countries are lagging behind, especially when compared with countries like Switzerland and Sweden where, 30% and 90% of new houses respectively use heat pumps instead of conventional heating systems.

2. THE QUALITY FUNCTION DEPLOYMENT METHOD - QFD

Quality Function Deployment is today the most accurate and structured method for translating the desires of customers into product design or engineering characteristics, and subsequently into parts characteristics, process plans and production requirements (Akao, 1990).

The major features of QFD are the emphasis on the voice of the customer, and the provision of a systematic means of ensuring that customer or marketplace demands translate into accurate technical requirements and actions throughout each stage of product development. This uses the set of matrices called the Quality Chart or the House of Quality which form the core of the whole QFD method. According to Sullivan (1986), the benefits of QFD are:

- better customer satisfaction resulting from improved quality of design;

- shorter lead times due to fewer and earlier engineering changes;

- better linkages between various design and manufacturing stages;

- a reduction in the number of product components; and

- an improved work atmosphere through the horizontal integration of functions.

If the first applications of QFD regarded the new product development process, more recently QFD has also been introduced to the service sector and for strategic and business planning too (Chan and Wu, 2002).

Lastly, QFD has been widely applied in many countries worldwide, while in Italy it is still a niche situation which makes its use even more interesting and competitive.

3. QFD PROJECT

The reason for using *Quality Function Deployment* in Geotherm was the need to clearly define the strategic priorities and the main performances of both product and services, within a set period (end of 2003 and early 2004) characterized by:

- commercial instability, because of the increased numbers of projects activated and the lack of available human resources; the commercial network is developing, but is still largely in the embryonic stage;

- progressive implementation of the concept of "network enterprise", both taking into account synergies with parts suppliers and for service firms, i.e. drillers, excavators, builders and plumbers.

The major objectives of this QFD project were:

- to develop the so-called strategic matrices;

- to carry out the customer analysis;

- to find out the characteristics of products and services that better satisfied the desires of customers.

3.1 Strategic Matrices

A work group was set up in Spring 2004 made up of the sales manager, works manager and after sales manager and coordinated by a consultant specialist. During meetings the following QFD matrices regarding the firm's strategies were compiled:

- AHP (*analytic hierarchy process*) matrix to define strategic targets (matrix A);

- Matrix targets – core competencies (Matrix B);

- Matrix internal competencies (Matrix C).

3.1.1 Analysis of strategic targets

Strategic target specifications were the fruit of a process of elaboration of ideas and intuitions. Five main targets were identified, shown in the lines and columns of Matrix A (figure 1). Using the *Analytic Hierarchy Process* (AHP) methodology the targets were compared pair by pair: a total of 25 relationships were analyzed in terms of a hierarchy of relative importance (for each pair: a 9 point scale, 9..7..5..3..1..0,33..0,20..0,14..0,11 with 9=extremely more important, 1=equally important, 0,11= extremely less important). The absolute results were normalized and shown in order of priorities (figure 2). For Geotherm, the most pressing problem has been to secure strategic suppliers. Indeed, since 2003, the need to establish partnership as regards the two main key components of Geotherm systems, the heat pump and the ground heat exchangers, has been sorely felt. In some types of design both these crucial components have to be imported from countries outside Europe, which leads to higher costs as well as to a lengthening of delivery times. Current strategy would seem to be to develop a close relationship with just

MATRIX A (QFD STRATEGIC TARGETS)

			Targets 1	2	3	4	5	1	2	3	4	5		
			Increasing profit	Consolidating a leadership position in	Synergy with strategic suppliers	Optimising the "make or buy" choice	Increasing the number of units	*Columns normalization*					Absolute weight	**Relative weight (%)**
Targets	1	Increasing profit	1.0	1.0	0.2	0.2	5.0	*0.1*	*0.1*	*0.0*	*0.0*	*0.5*	0.7	**14.8%**
	2	Consolidating a leadership position in the Italian market	1.0	1.0	0.2	0.2	0.2	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	0.2	**4.7%**
	3	Synergy with strategic suppliers	5.0	5.0	1.0	5.0	0.3	*0.4*	*0.3*	*0.2*	*0.7*	*0.0*	1.7	**34.0%**
	4	Optimising the "make or buy" choice	5.0	5.0	0.2	1.0	3.0	*0.4*	*0.3*	*0.0*	*0.1*	*0.3*	1.2	**24.2%**
	5	Increasing the number of units installed	0.2	5.0	3.0	0.3	1.0	*0.0*	*0.3*	*0.7*	*0.0*	*0.1*	1.1	**22.3%**
		Total	12.2	17.0	4.6	6.7	9.5	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	5.0	100.0%

Figure 1: Matrix AHP – Strategic Targets.

one supplier, through commercial agreements, prioritizing the advantages of one relationship, and giving up the chance of having access to the full range of products, so as to maximize standardization and the reliability of the installation. This was the main strategic priority. It is followed by optimizing the "make or buy" choice and increasing the number of units installed, both with about 20%. Increasing capitalisation is in fourth place and obviously is closely tied to the first three target strategies. Lastly, the fifth target is that of restructuring the organisation as a "network of firms" rather than remaining in its present position as a leader in the sector. In reality, this last target should be considered with a more "conservative eye" in the sense that the other targets are more pressing, more important in order to ensure the survival and future development of Geotherm.

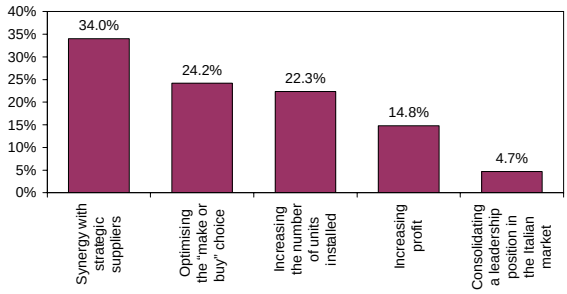

Figure 2: Strategic Targets, relative weights.

3.1.2 Matrix targets – core competencies

The second phase of the project regarded the relationship among the diverse internal core competencies of the firm and the targets identified with the AHP. Matrix B (figure 3) is a typical QFD matrix, where use of symbols allows for clear and efficacious communication within the organization. The Absolute importance level *wj* of each of the competencies is calculated by adding the sum of the products between the relative importance of each objective for the value quantified by the existing link between the j competence and one of the objectives that are in a relationship with this competence (Weak=1; medium=3; strong=9) (Akao, 1990).

The vector is:

$$wj = \mathbf{d} * \mathbf{Rj}$$

where: **d** row array vector-line of values of the relative weights of the targets; **Rj** matrix j column.

MATRIX B (TARGETS - CORE COMPETENCIES)							
Relationships : ⊙ : Strong ⊘ : Medium ⁂ : Weak			AHP Priority (%)	Core competencies A: Flexibility to customer's requests	B: Design and technical know how	C: Reliability during installation process	D: Lean organizational structure
Targets	1	Increasing profit	14.8%	⊘	⁂		⊙
	2	Consolidating a leadership position in the Italian market	4.7%		⊙	⊘	
	3	Synergy with strategic suppliers	34.0%		⊙		
	4	Optimising the "make or buy" choice	24.2%		⁂	⊙	⊘
	5	Increasing the number of units installed	22.3%	⊙			⁂
Absolute weight				2.5	3.9	2.3	2.3
Core competencies weight (%)				**22.5%**	**35.4%**	**21.2%**	**20.9%**

Total
10.9
100%

Figure 3: The core competencies *versus* the identified targets in Geotherm.

From the absolute weights the relative ones were calculated and the results reported in the histogram illustrated in figure 4. As is clear from figure 4, design and technical know-how is the main competency, followed by flexibility to customer's requests.

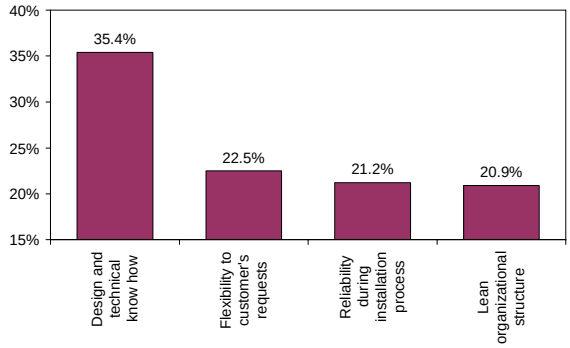

Figure 4: Core competencies relative weights.

3.1.3 Matrix core competencies – customer segment

The third and last strategic matrix developed (Matrix C, figure 5) defines the degree of importance (relative weight) of the customer's segments in function of Geotherm core competencies. The procedure used for calculation is similar to the previous one. Figure 6 shows that there is a high degree of interest in final residential customers and little relative attention paid to the "public" sector and the thermo-technical installer client.

MATRIX C (CORE COMPETENCIES - CUSTOMER SEGMENTS)								
Relationships : ⊙ : Strong ⊘ : Medium ⁂ : Weak			Core competencies weight (%)	Segments of customers 1A: Residential final customer	2B: Business final customer	3C: Public sector	4D: Business customer installer/plumber	
Core competencies	A	Flexibility to customer's requests	22.5%	⊙	⁂	⁂	⁂	
	B	Design and technical know how	35.4%	⁂	⊘	⊘		
	C	Reliability during installation process	21.2%	⊙	⁂			
	D	Lean organizational structure	20.9%	⊘	⁂			Total
Absolute weight				4.9	1.7	1.3	0.2	8.1
Customer segments weight (%)				**60.4%**	**21.0%**	**15.8%**	**2.8%**	100%

Figure 5: Different type of customers *versus* the core competencies.

This analysis of customers is very important for Geotherm when defining its commercial tacticts in these years, in that two alternatives remain open, that of becoming a thermo technical firm within the traditional channels in the sector (special relations with equipment technicians, architects and engineering offices) or concentrating on relations with the *end user*: the choice seems to have fallen on the latter option, also because this is a niche market to be developed and probably the direct contact with end user is needed.

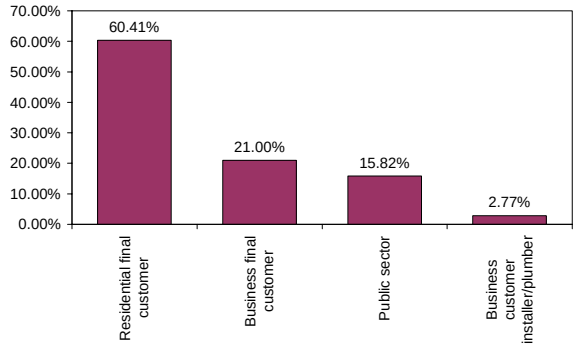

Figure 6: Customer segments relative weights.

3.2 Customer Analysis

In Spring 2004 a dual analysis was carried out in the field of Customer Demands. An initial survey carried out through a series of interviews, each an hour long on average, conducted with both existing and potential Geotherm customers. The interviews consisted of a series of open questions. This is the phase called *Gembà* in QFD terminology, that is "the place where the truth is known", the context in which the customer uses or could use Geotherm systems. Indeed, interviews were held in houses or buildings, inside the technical room, in air-conditioned environments, in the surrounding gardens/land where geothermal heat exchangers are or would be placed. *Gembà* allowed us to include Customer Voice in models structured on the lines of *5W1H* (*Who, What, When, Where, Why, How*). Using the Post-It *brainstorming* technique developed by Jiro Kawakita (1991), phrases identified through Gembà were re-examined and "re-worded" when defining customer "Demands" laid out in the *Demanded Quality Deployment Chart* (figure 7). The second stage of market analysis was carried out using a questionnaire in which the interviewee was asked to evaluate the importance (on a five point *Likert* scale) of each of the items; another question required making a judgment, again on a 5 point scale (1=worst 5=best) relating to Geotherm's ability to satisfy diverse customer demands. The data, expressed as statistical averages, are given in the first two columns of the so-called *Preplan* matrix. The *Preplan* offers criteria for assessing the importance of Customer demands: the first two columns on the left show the results of the questionnaire; starting from the judgment made regarding Geotherm (second column) the workgroup, helped by the consultant, decided which demands should be satisfied in order to improve customer's opinions of the firm. In this case benchmarking comparisons were not made, as would be usual in QFD, because it was not realistically possible to compare and evaluate two firms working in the same sector as Geotherm. The rate of improvement (third column) is an index that gathers information from the position of the "actual" and "target" judgments and it is calculated from the relation (division) between the values given in the second and third columns; lastly the sales points, which are effectively "reasons for buying Geotherm", is where the demands and the image of the brand developed by Geotherm overlap, in other words, these are elements that management considers important from the sales point of view. The strong sales points for Geotherm are the ability to satisfy the desire to "feeling one is saving" and the 'desire to have "two with one"'. On the other hand, the work group attributed average

values to the need to optimise space, independence from fuels and comfort.

	PRE PLAN						
	DEGREE OF IMPORTANCE	COMPETITIVE ANALYSIS	PLAN			WEIGHT	
DEMANDED QUALITY DEPLOYMENT CHART		Geotherm	Target	Rate of improvement	⊙=1.5 ⦸=1.2 SALES POINT	ABSOLUTE WEIGHT	***DEMANDED QUALITY WEIGHT (%)***
Safety demand during an heating/cooling system running	2.7	4.0	4.5	↗ 1.13		3.04	***6.0%***
Expectation to be indipendent from fossil fuels	4.1	4.7	4.7	→ 1.00	⦸	4.92	***9.7%***
Comfort in every season	2.7	3.5	3.5	→ 1.00	⦸	3.24	***6.4%***
Expectation of respect for the environment	3.5	4.2	4.2	→ 1.00		3.50	***6.9%***
"Natural" sensations during cooling	3.1	3.1	3.1	→ 1.00		3.10	***6.1%***
To be able to adapt the system to the existing one	3.7	4.1	4.6	↗ 1.12		4.15	***8.2%***
Demand for protection during after sale	4.1	3.2	3.2	→ 1.00		4.10	***8.1%***
Demand for optimized space	3.0	2.0	3.0	↗ 1.50	⦸	5.40	***10.7%***
To be able to simply control the system	3.6	2.0	2.5	↗ 1.25		4.50	***8.9%***
Demand for savings	4.7	4.0	4.5	↗ 1.13	⊙	7.93	***15.7%***
Demand for one system for heating and cooling	4.5	4.5	4.5	→ 1.00	⊙	6.75	***13.3%***
					Total	50.63	100%

Figure 7: Demanded Quality Deployment Chart and Preplan.

The absolute weight of customer demands is calculated from the product of the Degree of Importance, the Rate of Improvement and the Sales Point; the aggregate index, which is then brought to percentage, reveals the propensity to buy a system based on renewable energy and the gap between current position as regards judgments and target and the elements which are of interest in relation to the sales and to the brand. From these results as expressed in percentages (figure 8), it is clear that it is important to know, for example, before investing, what total savings will be and what interest the concept of reversibility, i.e. the fact that just one installation can be used both to heat and to cool the building arouses.

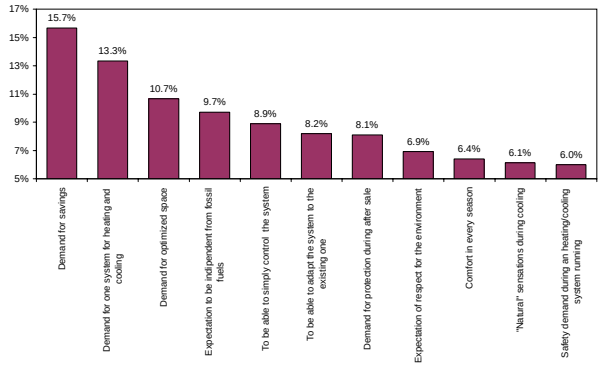

Figure 8: Prioritizing the demanded quality of the Geotherm's customer .

Also important is the need for systems to be compact so as to optimize use of space in the technical cabin/room.

3.3 Technical Analysis of the Characteristics of Products and Services

Once again using the KJ Post-it method, the work group identified eighteen characteristics of product and service performance and correlated them with the needs/demands of customers on the basis of how well the former could satisfy the latter. This gave the House of Quality Matrix which is crucial to the QFD method. This matrix is too large to include in this study, it also includes measurements of diverse items and their respective technical targets. (figure 9)

MATRIX House of Quality Dem. Qual./Qual. Char.							
	Quality Characterisitics						
Demanded Quality	*Demanded Quality Weight*	N. of tests before starting installation	Rate design lead time/installation lead time	Number visits on internet site	N. of documents that can be downloaded from the web	N. of publicity inserts in newspapers and magazines	Time for first estimate
Safety demand during a heating/cooling system running	0.06	⊙	⊙				⁂
Expectation to be indipendent from fossil fuels	0.10			⊙	⁂	⁂	⁂
Comfort in every season	0.06	⦸	⊙	⁂	⁂	⁂	⁂
Expectation of respect for the environment	0.07			⊙	⊙	⊙	⁂
"Natural" sensations during cooling	0.06		⦸		⁂		
To be able to adapt the system to the existing							

Figure 9: House of Quality, symbolic relations between customer demands and technical/service answers from the firm.

The main points of the *House of Quality* are summarized in figure 10, which shows the importance of the main characteristics identified by the work group. If one considers the characteristics of the items classified first to sixth, they are equally divided between products and services. The first two, however, concern the importance of services: internet and the level of personalization together account for more than 18% of relative importance. Different performances of the installation fall into the intermediate area and would seem, together with those related to reliability (see for example the position of the item "selectivity of suppliers"), to be balanced by those relating to services.

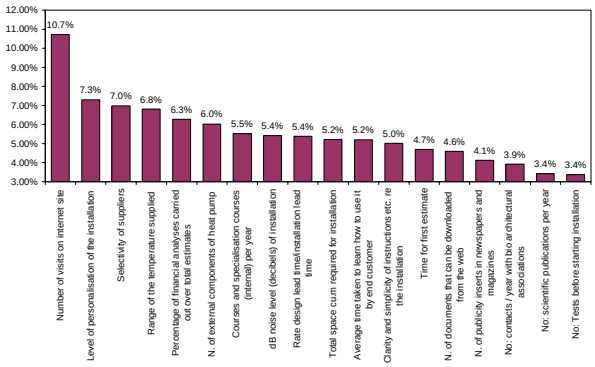

Figure 10: Priority of technical and service characteristics.

In reality, if one takes into account only the relative importance of the two areas, one finds that service performances cover more than 70% of relative importance.

Hence, Geotherm's New Product Development and Services will focus on more support for service activities, while seeking at the same time to optimize technical choices in order to improve the "reliability" of the installation.

Subsequently management evaluated the organizational problems, that could affect whether technical targets were reached or not. A five point scale was used (1=very easy…5=very difficult). At this point it is useful to draw up

a map of product and service performances based on two variables: weight and difficulty (figure 11). Four areas were identified in the map: zones A, B, C, D. Zone B is particularly important because it includes characteristics that could very easily be improved and are already in the upper part of the classification created with the *House of Quality*. Zones C and D contain characteristics with average or low weight and with increasing degrees of difficulty; Zone D includes characteristics (in this case services) whose improvement targets have probably been set too high given their perceived importance, these objectives should be re-assessed and lowered in order to move points in Zone D in the direction of Zone C. Let us look last at the bottleneck, characteristics with high, and therefore very important, relative weights for which the improvement targets set are very hard to achieve. These are in Zone A, here too, the objective values of the characteristics can be re-evaluated in order to lower the level of difficulty.

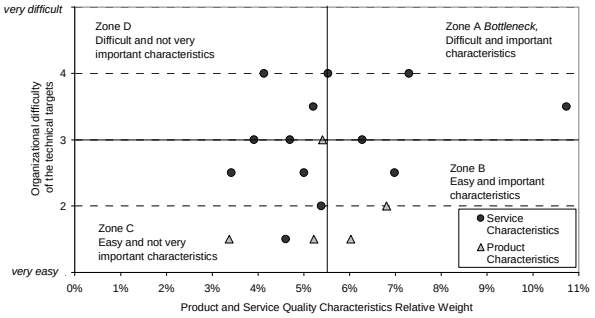

Figure 11: Two-dimensional map of the characteristics importance/difficulty.

4. CONCLUSIONS

A study of the dynamics and the problems connected to the question of services in manufacturing firms offers new points to ponder.

Service Performances. The study of service characteristics carried out using the brainstorming technique has led the work group to highlight a higher number of parameters associated with services than products even though these latter are easier to identify and measure. Why should there have been this "instinctive" prioritizing of services? Could it not be because there are already consolidated techniques for monitoring product characteristics, especially when there is a high technical content, whereas it is harder to measure the "vaguer" less concrete services? Whatever, it serves to highlight the fast growing importance of services, even in technologically sophisticated sectors such as those where Geotherm operates.

Service and bottlenecks. The high level of innovation in Geotherm, which is more apparent than real, in that this technology is already well-established at the global level, could lead one to think at first of the fact that product performances of the installed appliance and of the heat heat pump would be considered critical. In reality, figure 11 reveals that the technical characteristics of the product are in the lower part of the map and have technical targets that are considered to be relatively easy to reach. Bottlenecks only concern services and, if we consider Zones A and B the number of aspects connected to services is twice those regarding products and plant.

QFD and services. QFD was considerably different from traditional design, evaluation and control of quality systems (see for example PZB Model of Parasuraman, Zeithaml and Berry, 1987). Indeed, these systems tend to minimize negative aspects of service. Furthermore, in a highly competitive situation like this, the positive aspects of the firm should be emphasized, so as to offer high value service and it is here that this methodology is relevant. The Geotherm case highlights the active approach rather than a "defensive" one which would be based exclusively on reducing customer dissatisfaction.

Perspectives for analysis. One research theme could clearly be further analysis of the data elaborated regarding Geotherm services through an integrated approach such as in the *Service Blueprint* model which is based on two cardinal concepts (Shostack, 1984): on the one hand the line of visibility that separates the production/supply processes customers can see from those that are invisible, front office activities from back office activities, the fail points from processes and subprocesses that often fail, offer a disservice, that must be monitored, corrected and even re-designed if necessary so as to increase the reliability of the system and to ensure homogeneous supply conditions firstly in terms of reactive quality and then of active quality.

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