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Bacheloreindopdracht

(trabalho final de graduação)

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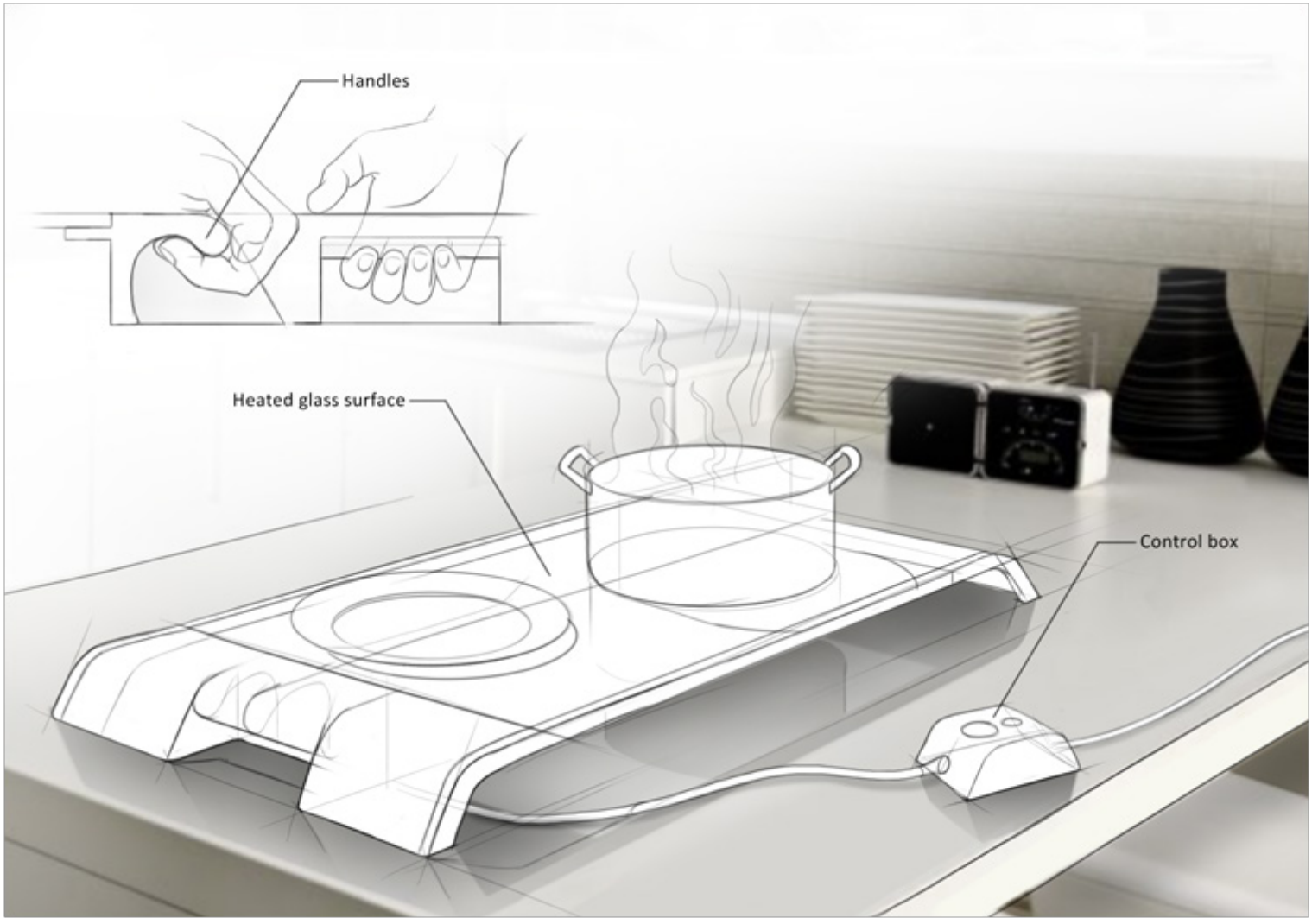

Preface

Behore you lays the final report of my Bachelor assignment Industrial Design. It is the result of a four month period with ABINFO stituated in Campinas, Brazil.

Via Bas Jan Kylstra I came into contact with the technical R&D institution ABINFO in Brazil. I emailed Professor Alaide Pellegrini Mammana, the former president of ABINFO, if it would be possible to do my bachelor assignment with them. In response she told me that they would be glad to receive me and that they had an electric tray that I could work on. Professora Alaide also let me know that I could also propose a topic. Hence, shortly after my arrival in Brazil, I gave a short presentation to Abinfo to explain what my expectancies and capabilities are in order to have a discussion about what the exact subject of the project will be. We discussed several ideas like an electric vehicle, 3D printing, a rainwater harvesting system, a transportation bicycle, a pilot production line for fluorescent lamps, a passive solar panel tracking system and an electric tray. The last three subjects where the most feasible given the demands and wishes of Abinfo as well as the University. The idea of a passive tracking system occurred to me just before my presentation and I had no idea if it already existed or not. Nevertheless the people at Abinfo were very enthusiastic about it. Quickly I found out that something alike already exists(bron) and therefore this project would mean a lot of research concerning patents and spending a lot of time developing a new technology. Still there was an interest for this project but I decided it was too big of a risk. Professor Mammana told me a lot about the fluorescent lamps they are developing at Abinfo. My job would be to design an integrated production line that incorporates all the steps that have to be taking during the production of these lamps. All the machines and software that are required are practically there and now it has to be put together. Although very challenging I found this subject too much focussed on technology alone. It would come down to very specific details like controlling the melting process of the glass etc. Finally there was the electric tray. This project met the demands as set by the university for it is a very broad project covering a lot of aspects. Abinfo already build a prototype and it would really be in their interest to continue with this project. Moreover the electric tray appealed to me more than the pilot line so I decided to work on the electric tray.

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Contents

H1 Introduction 6
1.1 Introduction 6
1.2 The principal question 7

H2 Market analysis 8
2.1 Are there going to be developers involved in the project? 8
2.2 What products already exist with the purpose of keeping food hot? 8
2.3 What kind of technologies are being used in these products? 11
2.4 Where are these products used? 12
2.5 What are the unique aspects of comparable products? 15
2.6 Which problems are there with the current products? 16
2.7 Are there products that also use thin film technology? 17
2.8 What are the current trends, in particular concerning kitchen appliances? 19
2.9 How about markets outside of Brazil? 23
2.10 Conclusion 23

H3 Target group analysis 26
3.1 What kind of social groups can be distinguished in Brazil? 26
3.2 Which group has the best opportunities? 28
3.3 What characterizes this group? 29
3.4 What is the behaviour of this group regarding cooking and eating? 31
3.5 How will this behaviour affect the use of an electric tray? 32
3.6 What are the target group's demands & wishes regarding an electric tray? 32
3.7 Conclusion 36

H4 Usage, surrounding and environment analysis 38
4.1 What surroundings are associated with the target group? 38
4.2 Where and how will the electric tray be used within these surroundings? 38
4.3 What environmental conditions are of importance? 38
4.4 What restrictions apply to an electric tray? 39
4.5 What are the possibilities for making the tray environmentally friendly? 39
4.6 Conclusion 41

H5 Technology analysis 42
5.1 What is the general principle behind this technology? 42
5.2 What are the possibilities and limitations of the thin tin-oxide film? 42
5.3 What is necessary for making the electrodes? 42
5.4 What possible ways are there for creating the electrodes? 44
5.5 What kind of substrates are possible? 45
5.6 What types of glass are possible? 46

5.7 What ways of treating and shaping the glass are possible? 46
5.8 What is necessary to guarantee basic functionallity? 48
5.9 What is the thermal behaviour of the tray? 50
5.10 Innovative Features 54
5.11 Conclusion 55

H6 Overall guideline and total list of demands and wishes 58
6.1 Total list of demands and wishes 58
6.2 Design guideline 59

H7 Idea generation 60
1. Simple 60
2. Design for advanced manufacturing 61
3. Freeform glass 61
4. Modular 61
5. Mobile 62
6. Super-decorative 62
Concepts in other directions 62
1. Deli cabinet 63
2. Cooktop 63
3. Heating utensil for hospitality industry 63
4. Floor warming tiles 64

H8 Concepts 70
8.1 Minimal concept 70
8.2 Concept for advanced manufacturing 74
8.3 Freeform 76

H9 Conclusion, future perspective and follow-up 78
9.1 Conclusion 78
9.2 Future perspective and follow-up 79

H10 Self reflection 81

H11 Acknowledgements 83

H12 References 84

H13 Appendices 87

H1 Introduction

1.1 Introduction

ABINFO, being an acronym of Associação Brasileira de Informática, is the principal for this project. ABINFO is small R&D institute working mainly in the field of informatics, engineering, (electronics, mechanics, chemical etc.), physics, chemistry and education. The ambition is to cover more areas of science and technology: as formulated in ABINFO´s mission statement:

> *"Our work is to unite efforts in research, development and innovation, aiming to strengthen and enhance the vitality and competitiveness of Brazilian industry in the manufacture of finished goods and materials, devices, instruments, equipment and assets for production resulting in a positive contribution to the areas of life, energy, education and environment"*
>
> - Alaide Pellegrini Mammana, former director ABINFO

ABINFO is an association founded in 1988 to promote cooperative R&D for the creation of new products and processes in associated companies, which means that its revenue does not come from selling products and services, but rather comes from cooperative projects. Likewise, ABINFO rarely has to do with the complete development of a product but rather focusses on the technical aspects. There are currently approximately 10 people working in ABINFO and the association is cooperating with several universities, research institutes and companies. Many years ago ABINFO tested the idea of applying a thin layer of electrically conductive material on a glass substrate with the aim of creating a new kind of heating element. A simple prototype demonstrated that the idea was realizable and now ABINFO wants to use this technology for creating a new feasible product. Of all possible applications ABINFO reckons an electric food warming tray is the best application to begin with. ABINFO does not have the intention to actually produce the product but seeks to co-develop or sell the rights to the product idea. Hence, the goal of this project is to show that this new heating technology can be converted into a feasible electric food warming tray that can go to the market. In order to do so there are several aspects that have to be covered. First of all, an elaborate market analysis points out whether an electric tray is truly a feasible direction and next what the most feasible market-segment is. Chapter 2 covers this analysis which will also reveal relevant trends and other interesting directions for further development. When the market has been explored it is possible to determine on what kind of people should be focussed in order to have the best opportunities. This is addressed in chapter 3. First, the main group is identified followed by a further, more specific selection of users that fit best with what the product under design has to offer. Subsequently, the implications this has for the design are investigated and determined. These first two analyses form a firm base for showing the feasibility and the

eventual concept later on. Yet there are environmental and usability aspects that still need to be covered and this is done in chapter 4. Also the effect of the remaining actors, like certification authorities, is treated in this chapter. Next is an elaborate technology analysis to gain insight in the possibilities and limitations of the technology itself. Also some important questions concerning the feasibility, efficiency and usability are answered. All the foregoing is condensed into a total list of demands and wishes accompanied by a design guideline in chapter 6. This allows for the idea phase i.e. chapter 7 which is a very creative phase with a lot of different ideas and iterations. From this wide range of ideas several main directions emerge which are subsequently ranked according to feasibility in chapter 8. Thereafter, these concept directions are converted into concrete concepts. How ABINFO should proceed and what remains to be done is covered in chapter 9 by making predictions and using hindsight. Lastly, my personal experiences, the acquired insights and things I learned are covered in the 10th called self-reflection. The remaining two chapters include the sources and appendices.

1.2 The principal question

The main question is:

"How can the thin film heating technology, as developed by ABINFO, be converted into a feasible food warming appliance? i.e. an appliance that can go on the market".

H2 Market analysis

This analysis gives answer to the question whether an electric tray is truly feasible and what the most feasible market-segment is. Furthermore, this analysis points out what the current trends and other interesting applications of thin film heating technology are.

2.1 Are there going to be developers involved in the project?

The initial idea was to involve seriously interested developers from the very beginning. In that case, the design would be more or less focussed on the ideas of the producer. About 20 years ago, when the prototype was created, there were several seriously interested developers but by now the company that had shown the most interest, Sensym¬, only wanted to make certain components. Therefore it was agreed upon that there weren't going to be any developers involved during the project. Furthermore, since thin film heating is becoming more and more popular it is important to protect the idea. Above all, convincing future developers of the product's feasibility is much easier when the product is developed further. Developed further in this case means: a sound market and product analysis that clearly shows the opportunities, a study of the technical viability and possibilities, taking the remaining aspects into account and converting all this research into several feasible concept directions.

2.2 What products already exist with the purpose of keeping food hot?

An overview of the wide range of solutions that already exist invokes new ideas and shows the opportunities for improvement. One can divide these products in two categories: passive and active. Passive appliances prevent as much heat loss as possible. There is no energy added i.e. no warmth generated to keep the food at a certain temperature. There are several ways to achieve this:

- Using material with a very low density. The air trapped inside the material has a low thermal conductivity making the material a very good insulator. Polystyrene containers are a good example of these kind of products.
- Air has a very low conductivity but a vacuum doesn't conduct at all making it the perfect insulator. A thermos consists of a container that is enclosed within a bigger container. The space between them is a vacuum so that the temperature (hot or cold) stays about the same over a long period of time.
- Besides minimizing conduction and convection it is also possible to focus on radiation. Aluminium foil wrapped around a certain object doesn't allow the energy dissipated by radiation to escape.
- There are also products , like delivery boxes, that combine minimal conduction by using double layers with a reflective interior to reduce heat loss through radiation.

Naturally there are a lot more products that prevent heat loss, but for the sake of the project this overview provides enough insight. Active solutions require energy to be converted into warmth in order to keep the food hot.

- Microwaves can be used to keep food at a certain temperature although they are mostly used to raise the temperature instead of maintaining it. An interesting advantage is the relatively homogeneous temperature because the object is not heated from the outside by but from the inside. The microwave itself is not really an appliance to keep food hot, but there are special plates for at home that stay warm over about one hour after being put in the microwave for 2 to 4 minutes. This proves to be a very primitive yet effective solution for keeping food warm over a short period of time.

Figure 1: Two examples of warming plates intended for the microwave

- Candles and burning gel are frequently used to heat a surface directly or via au bain-marie. There is a wide range of these kind of warming trays available. These trays, usually referred to as rechauds, are very popular, probably because of their low price, mobility and low weight. They are being used domestically as well as commercially. Commercially these are mainly used on events because of their mobility and simplicity.

Figure 2: Four candle heaters

- Besides candles there are also food warmers that are gas heated. These are usually big commercial devices. Because they don't rely on electricity they are commonly used to sell food on the streets or on events although they can also be found in restaurant kitchens etc.

Figure 3: Three gas heaters

- Electric warming trays convert electric energy into thermal energy by using an element with a high electrical resistance. This warmth can then be transferred to a surface area where the objects to be heated are placed upon. Most of these products are sold for domestic use. There are very few electric trays available that are developed for restaurants and hotels.

Figure 4: Some typical electric trays intended for domestic use

- There are also electrically powered au bain-marie heaters. These are usually not intended for domestic use but for walking buffets on events etc.

Figure 5: Two industrial electrically powered au bain-marie heaters

- It is also possible to use radiation to warm objects. Food warmers like this are used to display food in stores or in self-service environments.

Figure 6: Two food warmers that generate heat through radiation.

2.3 What kind of technologies are being used in these products?

It is difficult to determine exactly what technology and components are used in food heating appliances by internet. It is nice to see how others have tackled problems but stores in the proximity of ABINFO don't have trays that can be examined. Contacting factories and ordering tray etc. is just takes too much time and money. A simple overview gives sufficient insight and this overview is included in the appendices. All in all, it turns out that thin film heating elements are not used yet. Heating methods like chemical heating and retaining heat offer specific advantages like mobility or simplicity which cannot be offered by thin film heating since it relies on an electric power source. However, thin film heating can certainly compete with traditional electric heating elements because it offers a very homogeneous temperature and can incorporated in the surface to be heated. Also heating by radiation can be improved by thin film heating but further research is required to point out in what respect thin film can truly improve on these traditional heating methods. This will be treated during the technology analysis in chapter 5.

2.4 Where are these products used?

Now the kinds of products in general are identified it is time to look at the applications of these products in different environments. If it's known where different types of food warmers are applied and what the specific needs regarding this environment are it possible to determine where there is a market for a new electric heating appliance. Hence, the characteristics of these environments are used to determine in what direction the product should be developed.

- Hotels and restaurants without self-service mainly require practical warmers. Appearance is only important when the customer gets to see the product, which is not often since most of the food is served directly from the kitchen. Most of these warmers are powered electrically.

Figure 7: Three industrial food warmers. The one on the right is an electric cast-in heater.

- Self-service environments involve large quantities of food that have to be warmed. Therefore large warmers are needed and if these warmers are in a fixed environment electricity is usually the preferred power supply. In general, self-service environments are low budget environments with a practical point of view making fancy solutions etc. less important. On the other hand, especially in restaurants it's important that the food is presented nicely and this raises the demand for food warmers that contribute to an appealing appearance.

Figure 8: Food heaters intended for self-service environments

- Flexible user environments like outdoor events, conferences and receptions need mobile and practical appliances. Outdoor events and festivals often don't have a fixed power supply and therefore most of the warmers are candle or gas warmers. Indoor events usually use electrically powered appliances. The nature of these events can vary enormously. For some events appearance and presentation can be really

Figure 9: Mobile appliances to keep food hot

important but there are also those that don't require any fanciness.

- Snack bars, food stands, kiosks, coffee bars, bakeries, etc. want their products to be seen and displayed attractively. Food stands etc. usually don't have access to a power socket which makes them dependent of gas or candle heated warmers. Pre-warmed food on display is mostly takeaway food and correspondingly the appearance of these kinds of warmers is rather functional and cheap.

Figure 10: Several warmed food displays

- Some people bring their own food to work to heat it during lunchtime. Most of the times the food has to be heated and not so much kept warm but there are products developed to keep beverages warm at work.

Figure 11: Two electric mug warmers, usually USB powered.

- For domestic use it is important to have a portable appliance that is easy to store. Above all the appearance of the product itself is especially important since the product will take up a place in people's personal lives. Furthermore costs are also relatively important in comparison to the other environments since the product has to compete with other products in stores etc.

Figure 12: Two electrical trays and two candle heaters intended for domestic use.

An interesting direction is developing a warmed food display, i.e. deli cabinet, for the hospitality industry. Candles and gas will most likely remain the best option for environments that require a mobile appliance. Environments like bakeries, snack bars, pizzerias, road houses and coffee bars however could possibly use a new electric deli cabinet. These places, with pre-warmed food on display, are most of the times, fast-food like stores.

Therefore, like stated before, these stores put less emphasize on the appearance of the appliance itself and care more about an affordable functional cabinet that displays the food well. Electrically heated glass allows for a very simple and elegant deli cabinet which puts emphasize on the food on display. On top of that, shelves or windows that double as heating element will probably lower the overall costs and are likely to increase the energy efficiency. Hence, the hospitality industry has good opportunities but is specialised and unknown making it not so suited for a try out. Usually companies in this sector have their fixed suppliers. The hospitality industry puts high demands on their products concerning food preservation, sturdiness and being practical. Three things this product can hopefully offer but are not necessarily its strengths. Typical au bain-marie warmers, etc. will therefore remain the best solution probably. On the contrary, a domestic appliance or a food display is relatively simple to design and especially for domestic products the market is much wider. Moreover, in the past it has already been proven to some extent that a domestic tray is feasible and that there is a market for it.

Appearance is one of the most important aspects of this technology for it provides a very unique selling point. As the analysis of domestic products has shown there are no transparent trays or something the like available at the moment. Moreover all these products look more or less the same; black, grey and most of them are rather bulky. Especially products situated in a living environment have to be valuable itself rather than just functional. Besides its appearance, a thin film tray can be very slim which is very useful in a household environment where there usually is little room. Furthermore, the costs of fabrication are expected to be low, although this also strongly depends on the final complexity of the product.

Hence, it is possible to develop an application for domestic use as well as for the hospitality industry with pre-warmed food on display but the latter is less suited as a try-out. ABINFO's initial idea was to make a domestic food tray and a working prototype in this direction has already been made as a proof of concept. Given the amount of time, the goal of the project, the market and the relative simplicity a domestic application is the best direction. Developing both is also an option, but since time is limited this will probably result in two concepts that will still have a lot of uncertainties making it more difficult to convince producers. Because of the simplicity it's also easy to set up a pilot line to make the first small series of products. Also, bear in mind that a simple domestic tray can also be tested and used in the hospitality industry broadening the try-out environment and market. On the contrary, an appliance for an industrial consumer isn't suited for domestic use and will therefore reach a much smaller market.

2.5 What are the unique aspects of comparable products?

The sort of product, an electric tray for domestic use, has been determined. Therefore the analysis of comparable products is focussed on products intended for the domestic market. In order to provide a clear overview of similar products all the gathered information is organized in a table. In total 14 electric warming trays have been analysed, all of them via the internet. Actual stores close to ABINFO didn't have any electric trays in their assortment. Only some candle heated trays were available. The table is included in the

appendices. Stated below is a brief overview of common functionality and specifications followed by an overview of some truly distinctive design aspects.

Common functionality and average specifications:
- Temperature adjustment
- Handles that stay cool at all times
- Automatic keep warm function
- Heat-up/ ready to use indicator
- Power indicator
- Overheat protection
- Average power consumption of 556 W
- Average temperature range of 64°C till 113°C
- Average heated surface of about 56 cm x 36 cm
- Average weight of 5,2 Kg
- Average heat up time of 8 minutes

Distinctive design aspects and specifications:
- Allowing unplugged use for at least on hour by retaining heat
- Hotspots
- Removable power cord
- Cord storage
- Low weight, 3,5 Kg
- High temperature, 150°C
- Big surface area of 60 cm x 40 cm
- Low power consumption of 200W
- Digital temperature indicator
- Non-stick surface
- Tempered glass surface
- Sleek and clean design, see electric warming trays from Generic and Toastess

Concerning the price, the difference between the most expensive, 783 BRL, and the cheapest, 77 BRL, electric warming tray is big and the average price is 320 BRL. From this sample research, 13 items in total, one can conclude that these trays are cheap (around 175 BRL) or expensive (around 645 BRL) relative to the average price (see table in the appendix). There are no trays that are near the average price of 320 BRL. This provides a nice first indication of the possible price ranges. The target group analysis and concept generation will provide more clarity concerning the adequate product price.

2.6 Which problems are there with the current products?

Online customer reviews reveal some problems with the current electric trays. Knowing what problems occur during use helps in making an adequate design.

- The product doesn't heat up evenly even though it should, (Royle, 2011), (Powell, 2014).
- The food etc. placed on the tray dries out,

- The tray has one uniform temperature despite carrying multiple objects in need of different temperatures i.e. the tray doesn't has a hotspot, (Pittsburgh, 2011).
- The tray only has one setting: ON i.e. no adjustable temperature,
- The tray lacks a light that indicates if the tray is hot/ warm,
- The tray heats up slowly, (sjw, 2013)
- Using the tray over long periods of time results in breakage, (dlyy38, 2011).
- The power cord is too short, (PennyR, 2011).
- The temperature range is inadequate, (Frances, 2013).
- The surface scratches easily, (fanatic, 2010).

Besides these problems as indicated by consumers there are also some expected problems with the current products:

- The power cord forms a risk since it often runs from the table to a power socket at waist or foot height. People can trip over it and pull the electric tray from the table. Besides this risk the power cord can be very annoying, especially when it's only 1,2 meters long as is the case in some products.
- The tray takes up a lot of space.
- The tray heats up entirely, whilst only a small area has to be heated
- When only a small object needs to be heated, one is bound to use the entire electric tray taking up a lot of space and wasting energy.
- Most hotplates can be cleaned with a damp cloth but are not water resistant. This means that if one would spill a large quantity of, for instance, soup the product might short-circuit and/or the user is in danger of an electric shock. Furthermore it would be quite handy if the entire tray could just be washed under a tap or in the dishwasher.
- The average temperature ranges from 64°C to 113°C whilst the average pain threshold temperature for glass is around 65°C if one would touch the surface briefly. This means that the heated surface can potentially hurt or burn people.
- Especially candle heated appliances can have unwanted hotspots. This is mainly a problem when warming non-liquid food. Due to these hotspots the food gets heated unevenly or burned.

2.7 Are there products that also use thin film technology?

In general there are already quite some applications of thin film heated glass. These applications include windshields, terrariums, bathroom mirrors, LCD displays, a conceptual toaster, refrigerated display cases, anti-lens fogging, towel warmers, architectural windows, cooktops, a ruggedized computer, 3D printers and even anti-snow igloo's in Finland . A French company called SGG (Saint Gobain Glass) has developed a wide range of glass radiators. Their assortment even includes radiators with customizable screen prints.

These numerous applications show that thin film heated glass can be customized to fit specific needs and that it can be applied in varying surroundings. This makes it the more interesting and feasible to work with thin film heating technology. A quotation form 'appliancedesign.com' on the next page affirms this idea:

"An emerging technology promises to significantly increase design options for radiant heating applications where aesthetic attributes are important. This technology, which involves electrically heating a glass surface, has numerous advantages over traditional heating coils, gas flames, and radiator-style heating devices [...] Because this is an emerging science, only a handful of practical applications have been commercialized to date, but a number of application developments are underway for appliances, foodservice equipment, and the hospitality industry." (John R. Schrei, 2005)

The companies Viking Range and Hatco have already launched food warming products together with special glass manufacturer Engineered Glass Products (EGP)(see next page). These products use a glass called Thermique which is similar to the glass developed by ABINFO.

"Viking Range has introduced this technology in the heated glass high shelf on its 36-in. -W Designer Series range (model D36HS24). The glass serves as an attractive, transparent shelf for reheating food or keeping it warm until served. The smooth glass surface is sanitary and easy to clean. The heat radiates evenly throughout the entire shelf so that the food - no matter what its size or shape - is never too close or too far from the heating element, as can happen with coil technology or gas flames. The heated glass elements used by Viking were designed by EGP and are marketed under the name Thermique Hot Glass Technology." (John R. Schrei, 2005)

"Heated glass is both visually attractive and sanitary, making it ideal for use with food in a public setting. For example, Hatco Corp. has designed a heated deli cabinet using electrically heated glass. Since the glass is perfectly transparent, deli items are in full view of the customers, but they remain hot and ready to serve. Keeping meat and other food items warm improves the taste while preventing spoilage. The technology is much more efficient and effective than heat lamps, and it is a definite improvement over microwaving cold items just before they are served." (John R. Schrei, 2005)

The applications of Thermique also include wall towel warmers, warming shelves, free standing towel warmers, warmed food displays and separate glass heat plates which can be ordered to specifications. The website of EGP states:

"It provides uniform heat unlike an unsightly, hard-to-clean coil burner with minimal engineering changes. With temperatures reaching 350° F, these burners are easily capable of boiling water and other common stovetop heating and warming applications. Thermique™ technology can take the place of steam tables or flame-heated serving platters at a banquet or party. [...] it is ideal for reheating, food storage, and display of foods that need to remain hot between preparation and serving time." (EGP)

As far as is known, the warming shelve and deli cabinet are the only applications of thin film heated glass that focus on keeping food warm. Possibly companies like EGP and SGG might be interested in developing the electric tray as designed by ABINFO further. Given the expertise and experience with thin film heated glass these companies can provide valuable knowledge and advice in developing the product. However it is necessary to develop the tray further in order to be taken seriously. The tray must be at prototype level at least before it's possible to approach possible (co-)developers.

Figure 13: From top left to bottom right: Hatco food display, two glass radiators, a conceptual toaster, a towel warmer and an igloo with heated glass to prevent snow form piling up.

2.8 What are the current trends, in particular concerning kitchen appliances?

The purpose of this question is to widen horizons, find inspiration and assure the feasibility to some extent. It is a rather difficult question to answer directly, but by looking at some leading kitchen brands and fashion platforms it's possible to sketch an image of the current developments, ideas and contemporary status quo. However, the current trends and status quo must not be followed blindly. A designer can deduce from trends, demands and market opportunities how a product should function and how it should be shaped. Certainly these are important aspects for creating an artefact that fits the current context but it's also important to take responsibility and think about the consequences. A designer should not resemble a machine that just produces what is asked. Like everybody else in their own way, a designer can add a certain value that is more than just the sum of what is demanded. There is a balance between creating a financially feasible product on the one hand and a sensible product on the other. The sensible aspect will be explained later on when reflecting on this project.

When analysing current trends and looking at artefacts that are made nowadays it appears that there are two main directions in which products are developed: ultra-minimalistic and very decorative, (Craig, 2012). The former will be discussed first. Minimalistic products are functional, sleek and stylized. The aesthetics of these products are largely determined by simplistic, smooth yet often geometric shapes and a few strong lines. These minimalistic products often flaunt their innovativeness and have a serious,

futuristic character. Undoubtedly the sleek design is also a practical consideration since such shapes are easy to clean. Colours are usually sparse.

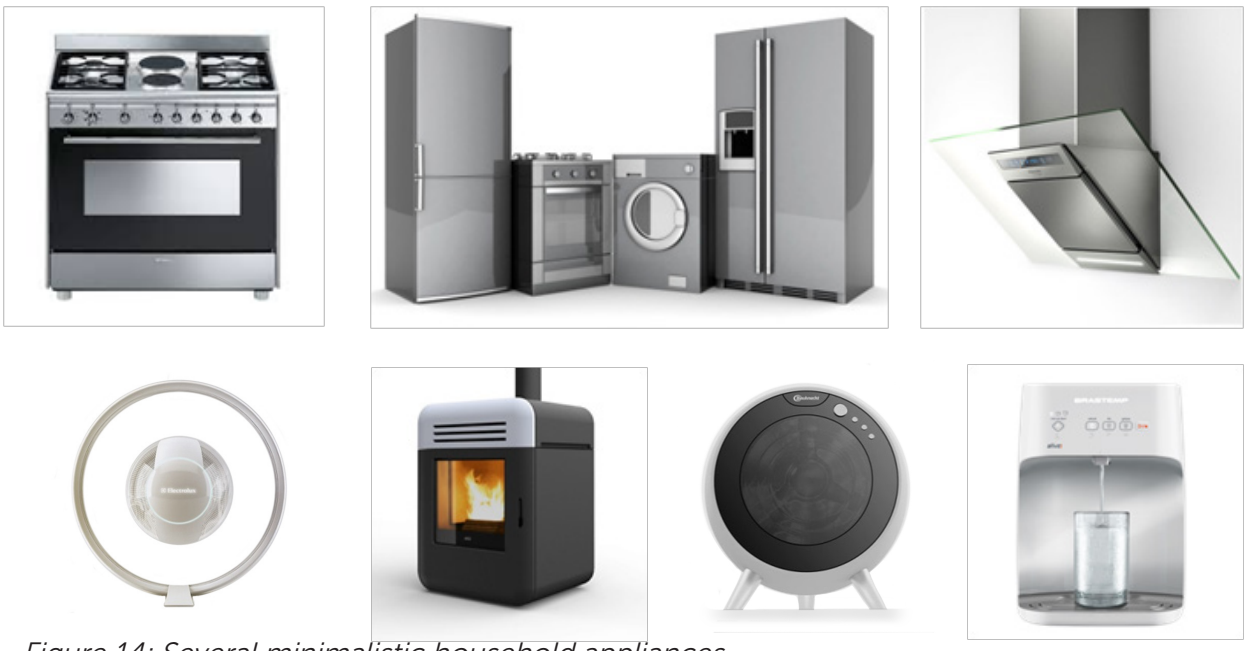


Figure 14: Several minimalistic household appliances.

The other direction in which products are developed is very expressive and decorative. Not surprisingly these products tend to be more colourful. Shapes are radical and vary from vintage 50's styling to bold constellations of geometrical shapes. Personalized and customizable products are among this direction. These products are playful and less focussed on physical functionality.

Figure 15: Expressive and decorative household appliances.

Most products are not strictly developed in one direction or the other but range between the two extremes resulting in colourful, curved and minimalistic products. Concerning the technology, glass is becoming an increasingly popular material in the design community, as its sleek transparency imparts a modern, upscale design element to a product (Babyak, 2006) and fits very well with the trend of minimalism and functionalism. The videos "A day made of glass" and "A day made of glass 2" by Corning give insight in the growing applications and trends of glass. The videos show applications of architectural photovoltaic glass, large durable displays, transparent smart appliances and environmentally friendly solutions. The videos show how glass can offer durability, hygiene, versatility and aesthetics. These are key aspects that must be taken up in the design of the electric tray. (Corning, 2011), (Corning, A day made of glass 2, 2012)

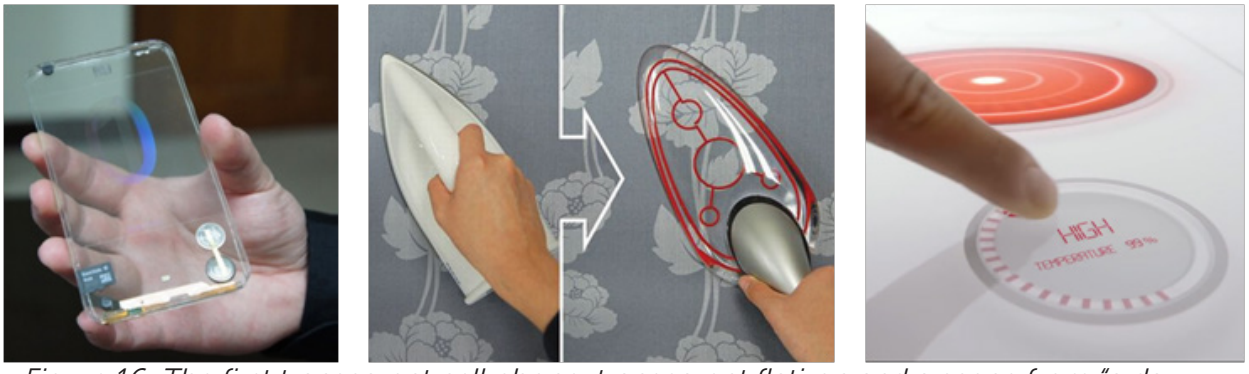


Figure 16: The first transparent cell phone, transparent flatiron and a scene from "a day made of glass".

Besides this physical shaping of the product there is also the digital aspect that may not be overlooked. Trends concerning social media etc. are of no significant influence on the design of the product. Naturally these media come in very handy when marketing the product but that is not included in this project. However smartphones and the like can be interesting. More and more products can communicate with smartphones and other smart appliances. Although it might seem overdone to implement this kind of technology in an electric tray, it is a development that at least should be taken into consideration. Smartphones, tablets, etc. are also good examples of the minimalistic tendency to integrate everything into one smooth appliance. This trend is also seen in kitchen appliances like cooktops and fits very well with the characteristics of a thin film heating element.

Figure 17: Application that allows for customized coffee and monitoring the oven.

The environmental impact is an increasingly important aspect of product design in general. There are several ways in which this aspect is addressed. The most common one is the reduction of energy consumption. This is achieved by technological advancements, power management systems and increasing user awareness. The product lifecycle includes all the different stages a product goes through, from manufacturing and distribution to disposal and recycling. These lifecycle aspects are also receiving increasing attention for they address the issue of the ever increasing waste and resource problem. Cradle to cradle is such a lifecycle trend that states that designers shouldn't strive to make products be less bad, i.e. generate as little waste as possible, but should think about ways to make products good i.e. a used product becomes the (in)direct source of something new. These environmental aspects and their effect on the design will be treated in more depth during the surrounding, user and actor analysis.
Another trend is customizability and flexibility. This trend is not so much driven by environmental reasons but mainly by a diverse population with individual demands that increasingly wishes to express itself through products. A radical example of the phenomenon is Phonebloks displayed below. When applying this trend to an electric tray this could mean a modular version or a certain level of customizability.

Figure 18: A modular phone that can easily be customized and upgraded.

In general people seem in search of their identity and this raises the demand for personal and characteristic products. Companies answer to this demand by emphasizing the corporate identity, creating lifestyles and offering a wide range of products that correspond to these lifestyles. Products affirm a certain affinity with a specific idea so that can people identify themselves with and via these products. During the target group analysis a specific group of people will be selected and their specific ideas will be examined further to create a product to fit this identity/ lifestyle.

Finally the idea behind a product is becoming more and more important. First of all, because lives are increasingly shaped by industrial products that are mainly focussed on functionality whilst leaving the question "why?" unanswered. Secondly, the price of a product is losing its meaning as an indicator of the quality of the product urging people to ask themselves and the company producing these products what makes them valuable. This makes the story and thought behind the product more and more important. In my design vision my specific thought about products will be treated further although it doesn't has direct consequences for the tray design.

2.9 How about markets outside of Brazil?

The main focus for this project is the Brazilian market but it is important to point out that there are also many opportunities available through Mercosur (Southern Common Market). This is an economic and political agreement between Argentina, Brazil, Paraguay, Uruguay and Venezuela which supports free trade. The agreement greatly simplifies exporter's ability to expand into all five markets. If a product is certified in accordance to Brazilian requirements it's relatively easy to get the product onto the other four markets. Also, there are big cultural similarities between these countries which make it easier to implement the product. Concerning the global market, the Brazilian legislation makes it very difficult to import products that are not from Brazil but it is quite easy to export. If the product turns out to be a success this might be a very interesting option.

Figure 19: The countries coloured green are Mercosur members.

2.10 Conclusion

There are not going to be any external companies involved during this project concerning the design of the product. The analysis of food warmers and the underlying principles showed that thin film heated glass cannot match, let alone surpass, certain appliances like candle warmers concerning mobility, weight and functionality. On the other hand, it also showed that thin film heated glass can provide an advantage over existing warmers like electric trays, concerning appearance, simplicity, costs and possibly energy efficiency.

The analysis of the different environments in which these kinds of products are used provided an image of what is important for which environment. From this it follows that there are mainly three feasible applications being: a professional catering appliance, a domestic appliance and a warmed food display. With the product analysis, project frame, try-out character and feasibility in mind, a domestic application turned out to be the best option. Problems with similar products and an overview of existing appliances showed what's important. Hotspots, wireless usage, low weight, a large surface area, adjustable temperature and temperature range are the most distinctive and important features of existing electric trays. Although the product will probably have other unique selling points, it must not be inferior to comparable products concerning these aspects. Because of that, the

corresponding specifications of these existing products will be of great importance when determining the target specifications later on. The biggest problems with the current electric trays is that the food dries out, the temperature is not adjustable, the temperature of the plate is homogenous i.e. doesn't has hotspots, there is a risk that people burn themselves and the tray takes up a lot of space. Further research will point out if these are real problems. If so, they will be taken up in the list of demands and otherwise they'll just be wishes.

When looking at the price, electric trays appear to be cheap, around 175 BRL, or expensive, around 645 BRL. The target group analysis is the deciding factor in terms of this target price. The application of thin film heated glass in food warming appliances turned out not to be new, but luckily the idea of applying this technology in a tray still is. Moreover, the analysis of the application of thin film heated glass provided a lot of technical information which will be very useful when developing the technology and yielded an overview of companies that work with thin film heated glass. EGP is one of these companies and it can possibly supply the thin film heated glass. The analysis of existing products and developments in general confirmed that there really is a market for an electric tray and that the application of thin film heated glass in this manner is very feasible.

Concerning the recent and future developments, the design trend of kitchen appliances covers a wide range between ultra-minimalistic and very decorative designs. Minimalistic products are sleek, functional and smooth, have strong lines and an innovative and serious character. The other direction is playful, colourful, bold, and diverse i.e. from vintage to spacy. This decorative direction also includes personal and customizable products. Not surprisingly, glass fits perfectly in the minimalistic trend given its sleek and modern appearance. Thus, when looking at the aesthetic potential of thin film heated glass, the product should be designed in a minimalistic manner.

The use of smart appliances is quickly gaining ground and this might be interesting, but not for the initial version. Environmental awareness is growing and this is addressed in product design by lowering energy consumption and paying attention to the entire lifecycle. Especially the first aspect, lowering energy consumption, can be addressed very well since thin film heating technology is likely to be more energy efficient. The story and thought behind the product are getting more important and this will be treated when developing my design vision. I'd like to emphasize that the reason for developing my design vision has nothing to do with obtaining a competitive advantage but is the result of some sincere worries about the current system.

Finally, if the product turns out to be successful it's quite easy to go to the Argentinean, Paraguayan, Venezuelan and Uruguayan market because of the Mercosur agreement. This shows that extra attention to international legislation can make the product more appealing for future development. Exporting the product to countries outside of Latin America can also be interesting but that is far outside the scope of this project.

H3 Target group analysis

In this chapter the target group will be selected. First, the main group is identified followed by a further, more specific selection of users that fit best with what the product under design has to offer. Subsequently, the implications this has for the design are investigated and determined.

3.1 What kind of social groups can be distinguished in Brazil?

It's not easy to determine exactly what group is best but, fortunately, an indication suffices since this is merely a try-out. When the final product is developed a more elaborate study will tell how the product should be marketed and, if necessary, small adjustments to the product can be made still. Also the try-out itself will most likely provide insight in the market. So, this first inquiry into the Brazilian market will serve as a guideline for design and a steppingstone for further research. There are several distinctions that can be made in order to determine groups. The first kind of distinction can be made by income and spending. Another good way to map the different target groups is by characteristics and behaviour. The distinctions by income etc. will lead to the first selection i.e. the kind of class to focus on. The characteristics and behaviour of this class are then investigated to determine the focus group within this class and form a guideline for the design.

IBGE (Instituto Brasileiro de Geografia e Estatística) investigates the Brazilian geography and statistics. They made a so called ABCDE division to map the economic classes in the Brazilian society where A represents the richest class and E the poorest class. According to IBGE and FGV class A and B represented about 13 %, class C represented around 50 % and class D and E together made up 37% of the total population in 2009. Figure 1, provided by IBOPE (Brazilian Institute of Public Opinion and Statistics), shows slightly different numbers, but what is important to notice is the enormous (predicted) growth of class C. This is underpinned by many other institutes like HDTKC and BCG (see next page).

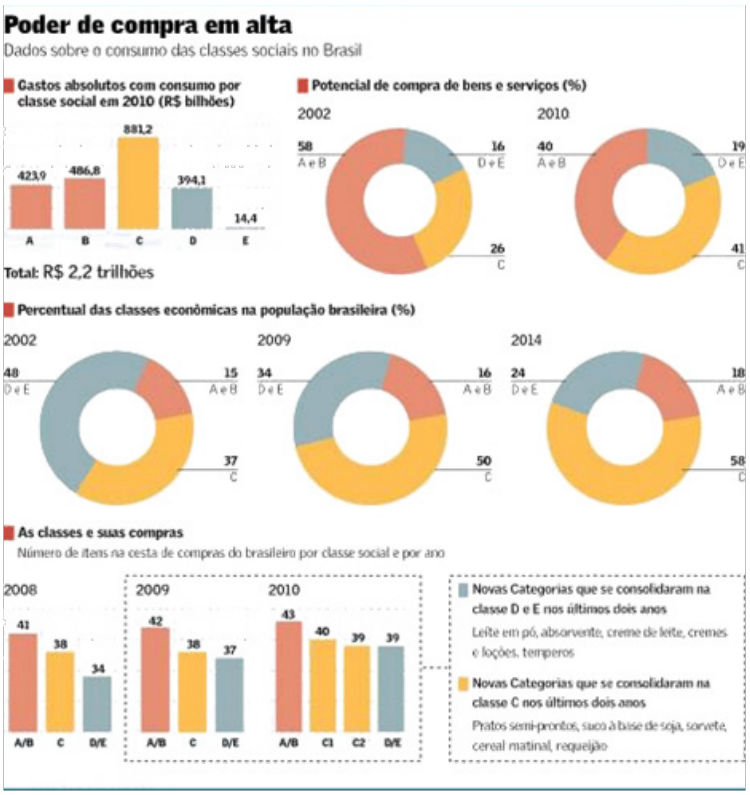


Figure 20: Growth of the ABCDE classes according to IBOPE (Carneiro, 2013)

"The unstoppable ascent of the middle class (or Class C) house-holds earning US$680-US$2,900 per month is fuelling the astounding growth of Brazilian private consumption and retail sales" (HDTKC).

"While the decade from 2000 to 2010 in Brazil was marked by the ascent of millions of households out of poverty, the current decade will be characterized by a massive shift into the ranks of the middle class and affluent. Some 5.3 million households will rise from the restricted to the emergent middle-class segment. An additional 1.6 million and 1.9 million will enjoy established middle-class and affluent lifestyles, respectively" (BCG).

What does this classification mean? This classification is mainly based upon income. It seems there are no universal standards and there are a lot of sources that contradict each other. It is not necessary to go into details, but here are some of the main reasons for the confusion as indicated by IBOPE. The first problem is that one of the main institutes concerning demographic statistics, FGV, did two surveys in 2008 that both showed very different percentages although the subject was the same. In the first case FGV used salary ranges and in the second case they used minimum salary to divide people into classes yielding completely different data. Another problem is the definition of the middle class. The middle class that the media talks about includes class B2 whilst the middle class is usually defined as class C. Another fact that somehow seems to be forgotten by the media is the increase in population over the years. Despite all this haziness one cannot deny that there is social mobility to the C class and that this class is the biggest by far. This is also showed in the foregoing figure provided by IBOPE, one of the more reliable sources out there. In agreement with Professor Alaide Pellegrini Mammana it is decided to average the criteria for determining classes and this resulted in the following overview.

	By average	in BRL/month		By range	in BRL/month			
A1	9.733	N.A.	7793	> 4807	> 2327	> 4591	> 10200	
A2	6564	17434	4648	> 4807	> 2327	> 4591	> 10200	
B1	3479	9897	2804	> 4807	> 2327	> 4591	5100 a 10200	
B2	2013	4681	1669	> 4807	> 2327	> 4591	5100 a 10200	
C1	1195	2674	927	1115 a 4807	618 a 1391	1064 a 4591	2040 a 5100	1485 a 6333
C2	726	1484	927	1115 a 4807	618 a 1391	1064 a 4591	2040 a 5100	1485 a 6333
D	485	1113	424	768 a 1115	403 a 618	786 a 1064	1020 a 2040	
E	277	854	207	< 768	< 403	< 768	< 1020	
Source	CCEB	SAE	IBOPE	FGV	FGV	Wikipedia	The brazilbusiness	HKTDC
Year	2005	?	2000	2008	2008	?	2011	?

By averaging the data by range it follows that:

Class A: more than 5481 BRL per month
Class B: between 3972 and 5481 BRL per month
Class C: between 1209 and 3972 BRL per month
Class D: between 740 and 1209 BRL per month
Class E: less than 740 BRL per month

This seems to be a good estimation since three of the biggest agencies together, Pnad, IBGE and SAE, defined the C class as having an income between 1000 and 4000 BRL which more or less correlates to the calculated numbers. Another way to determine the class is by property. For instance the amount of televisions, cars and bathrooms are each correlated to a certain amount of points and the total amount of points tells in which class a person is. This way is possibly even vaguer and the ranking systems differ per instance so the classification by income remains the best guideline.

3.2 Which group has the best opportunities?

On what class should be focussed? Class D and E are out of the question since the product is not a necessity and there are very cheap alternatives available. Of course one could try to make a very cheap electric tray but given the size of this market segment and the likeliness of succeeding, this is not really an option. Class A and B are very affluent and might very well be interested in a high end appliance of the sort namely if the product has an elegant and luxurious appearance. Class C is also very suited since this class is very big (about 50%), growing rapidly and it is diverse making it a good environment for a try-out. Moreover the product can be very functional and affordable. This, in combination with an appealing design, can make the product very suited for this class. Because of this and the fact that the product is likely to catch on in the big diverse middle class the product will mainly be focussed on this group of people. Also consider that, if the product would be a high end appliance for the A and B class then it wouldn't be suited for the C class since it is too expensive, but if the product is designed for the C class people from the A and B class might buy the product still. So class C will be the focus group.

To prevent confusion it's important to note that C class doesn't necessarily means 'middle class' as Vincent Bevins makes clear in his article 'What is 'middle class'?'.

> *"Anyone reading on Brazil in the last half-decade has heard about the rise of the 'new middle class'. It's one of the favourite topics amongst us foreign correspondents, the latest installment on which I did last week. But this can be an extremely confusing discussion, since we are often dealing with three, or maybe even four, very different definitions of the term. The way the British mean 'middle class' is different from the American definition, and the colloquial Brazilian use of the term 'classe média' is closer to the British version, but the discourse in Brazil around "Class C" and the 'new middle class' is based on something more akin to the US version, but not quite. Confused yet? We need to unpack the definitions, but by way of an advance summary, what we have mostly been talking about recently in Brazil is an expansion in the middle-income segment statistically speaking, not a new cultural class or the rise of millions into some international standard of comfort." (Bevins, 2013)*

The article shows middle class has several definitions. In this report (new) middle class means class C which is what most companies etc. also mean by middle class.

3.3 What characterizes this group?

The C class can be subdivided into C1 and C2 where C1 earns about 1,7 times more than C2. Of the total population of Brazil between 12 and 64 years old 30% is in class C1 and 20% is in class C2. Consumers in the C class require products that meet their desire to greater sophistication at an affordable price proportional to their purchasing power, which, although expanded, is still low.
This data provides insight in the quantity of people and their income but in order for this analysis to be really useful it is necessary to know more about the people themselves. Who are these people? IBOPE has executed an elaborate study about class C observing that this class represents half of the Brazilian people, about 100 million. Like stated earlier, this new middle class has the main role in the Brazilian economy. Concerning their personalities, class C people want products and services that consider their values, principles, lifestyle and attitudes. Most of the people in class C are very young i.e. most of the people are younger than 34. Relative to women in class A and B, women in class C are more dominant concerning their role in the family life. Because of this they have more socioeconomic autonomy meaning that they are the ones who decide what domestic appliances should be purchased. An article by HKTDC underpins this:

> *"The demand for female items in Brazil may not necessarily be higher than for male items, but it is worth noting that buying decisions for daily groceries, as well as most household and consumer goods, are usually made by females. Not unexpectedly, marketing and packaging of products in the market are generally aimed at female customers." (HKTDC, 2011)*

By the looks of it the product should thus be mainly focussed on women. IBOPE sketched a general image of C class people of which only the relevant parts are taken up in this report. People from class C tend to plan their purchases and compare the prices etc. They look for opportunities and the most desired are items that incorporate new technologies like computers, cell phones, microwaves, televisions and refrigerators which is good news for an innovative thin film heated tray.

IBOPE found 220 attributes of class C consumers and selected the 20 most important ones to evaluate. This evaluation yielded four characteristic groups within Class C:

- Conformists: these people are described by IBOPE as content with themselves, not really caring about much and being stoics. If someone is stoics he or she accepts what happens without complaining or showing emotion. Most of the people live in the present, don't make a plan when buying something and are men.

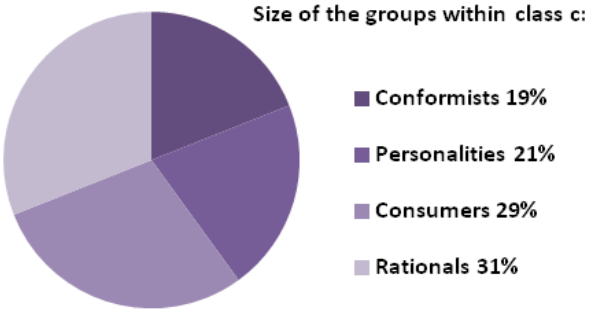
- Personalities: egocentric people that live in the present, don't like tradition and are easy going unlike the conformists. Consuming is not so important and plays the second role.

- Consumers: for these people consuming means self-esteem. They are mostly women and have their roots in tradition, culture and origin. This group is typified by frequent impulsive purchases, except when concerning expensive purchases. IBOPE characterises these people as valuing themselves, living in the present and easy.

- Rationals: mostly these people are 35 years and older. They are reflective, confident and care and think about the future. They value themselves, plan their purchases, search for advantages and have their roots in tradition, culture and origin.

The size of each group within class C is shown in the graph on the right, where the consumer together with the rationals represent 60% of the total group.

To create a more complete image of the target group IBOPE gave some typical examples of these characteristic groups within class C, which are included in the appendices.



Size of the groups within class C

Overall, this target group indexing performed by IBOPE provides a better and more reliable characterisation than could possibly be offered in this short period of time, although it is rather boorish. Now the question remains on what group with class C should be focussed? Rationals prefer a functional, usable, honest, elegant product that takes aspects like power consumption and reusability into account. Consumers like newness, comfort and affordability. They are susceptible to popular trends and most of them are women. This makes the consumer group important since women tend to make the calls about what products should be bought. Personalities like the name suggest appreciate character and style. They value trends but have a specific taste so not all trends appeal to them. Conformists don't have a distinctive taste and just want an affordable product that does what it has to do.

Appearance is the most important improvement of this technology. The costs are expected to be low and the product can be slim, light and possibly energy efficient. Moreover the product can be very clean giving it an elegant and sleek appearance. These characteristics fit well with consumers and rationals. If the product has a certain style, some of the personalities might also be interested. The conformists are the least suited. Consumers are extra interesting since these people are mostly women who, as mentioned before, tend to make the calls concerning which products should be bought. So, rationals and consumers are the focus groups. Personalities can be taken into account but are less important, partly because it is difficult to take them into account given their diversity. According to POF the family composition of class C people in 2008 was as follows:

14,19% = Single person
3,7% = Single parent with child(ren) younger than 15 years.
10,38% = Single parent with child(ren) over 15 years.
1,87% = Single parent with children older and younger than 15 years.
17,84% = Couple without children.
27,83% = Couple with child(ren) younger than 15 years.
16,28% = Couple with child(ren) over 15 years.
7,71% = Couple with children older and younger than 15 years
0,20% = Other

This means that about 68 % of the people in class C have children assuming the numbers haven't changed much since 2008. A household with children needs an appliance to keep food warm the most given the big meals and long dinner times. Also in such a household diner times between people can vary which increases the demand for something that keeps the food hot. So the demands as imposed by families are paramount when looking at the kind and amount of people that are most likely to use the product.

Knowing who these people are is good, but what is as least as important is to know what these people do concerning the product under design. What are their habits and what do they like?

It is very time consuming and unlikely to conduct a successful analysis of all the habits and tastes of people form the focus groups in such little time. Besides, keep in mind that this is a technology-push product which means that there is quite some freedom concerning the design. Above all, it's better to make a new design rather than making a different version of what already exists. So, concerning the scope of this project and the fact that this product is a try-out it is safe to say an overview of what comparable brands that also target the C class have designed provides enough insight concerning the taste of class C people. From the IBOPE target group indexation follows that the brands Electrolux, Brastemp, LG and Arno are popular amongst people from class C. IBOPE correlated these brands with the subgroups defined earlier. Rationals prefer Brastemp and Arno. Conformists like Electrolux. Consumers want LG and General Electric and the Personalities identify themselves with Brastemp and Arno. A collage of typical products, which has been used for inspiration, can be found in the appendices. Analysing these brands has led to an overview of the preferences, styles and design elements etc. which is subsequently condensed into a clear design guideline (see chapter 6). In short, comfort, functional, smooth, sleek, affordable, innovative, new/ modern, smart solutions, pragmatic, basic colours, emphasis on usability, elegance, durability and simplicity are the important terms for the design.

3.4 What is the behaviour of this group regarding cooking and eating?

Regarding the habits and corresponding needs, a small survey accompanied by some good old desktop research suffices. In general Brazilians eat three times a day and have several separate dishes. Breakfast usually doesn't include hot food although it is possible. Lunch is the more important meal and traditionally consists of rice, beans, meat, a salad and vegetables. Except for the salad most of these dishes are served warm and separately. In contrast to Northern Europe meals are really important, take up a lot of time and are very social activities meaning that people usually eat together. Diner is less elaborate and sometimes leftovers are reheated or a simple snack like pizza suffices. Brazilians usually eat at the table although eating in front of the television, especially in the evening, is also popular. Another big thing in Brazil is churrasco, which means barbeque. There are special restaurants called churrascarias and a lot of Brazilians have a churrasqueira at home which is often a big barbeque made out of stone.

3.5 How will this behaviour affect the use of an electric tray?

Since people usually eat together it might be preferable to make a big tray that can hold several separate containers with food. On the contrary, several small trays that can be spread over the table can also be handy since otherwise all the food has to be at a central spot. Having a number of separate dishes increases the need for an electric tray because each dish has a different preparation time and/ or it's not possible to prepare everything at the same time. Especially in Brazil eating is a very sociable event and this leads to longer diner times, bigger quantities of food and more sharing instead of individual plate service. This means the tray has to have a substantial size to hold at least three dishes or more. Eating with a large company results in passing dishes around and this raises the need for several small trays or a modular heating device. Eating in front of the television can be quite cumbersome and there are special trays that are designed to put over or on ones lap. This direction also has to be explored if only to show that it's not sensible. During a barbeque, large portions of meat are usually cut up and served on a big plate and, given the huge amount of meat, the last pieces of meat are usually cold. Therefore an electric tray that doubles as a cutting board might be interesting. The quality of the food seems to be relatively unimportant for class C people. This could mean that these people will settle for food that has been kept warm over a period of time instead of demanding freshly prepared food.

3.6 What are the target group's demands & wishes regarding an electric tray?

3.6.1 In general

An article on if and how to sell products in Brazil by "The Brazil Business" states some general characteristics of Brazilian people and companies to evaluate value proposition. It turns out that, in general, Brazilian consumers and companies emphasize durability, reduced maintenance cost and simplicity stronger than Europeans and North-Americans. On the contrary, product design, certifications like Fair Trade, ecological products and environmental friendly products (although quickly changing) are undervalued in comparison to Europe and North-America. In order to find out what the specific demands regarding the electric tray are a questionnaire has been carried out. The questionnaire and the corresponding answers can be found in the appendix. The following overview shows the relevant findings and insights provided by the questionnaire.

3.6.2 The people

A total of 25 respondents participated in the survey of which nine where women and thirteen where men (three unknown). The age of the respondents ranges from 19 to 60 years and averages around 39. The size of the households varies a lot from one person to six persons. Except for the one person household each of these households is represented by two or more respondents. Finally, most respondents are from class A, C and D. Note that the sample size is quite small and therefore the results should be taken with a grain of salt to prevent premature conclusions. There are no apparent differences between women and men concerning the answers to the questionnaire. Also, the size of the household doesn't seem to influence the amount of separate warm dishes sig-

nificantly. Future, more elaborate research might point to subtle differences that have gone unnoticed but for now these rough insights suffice.

3.6.3 The demand for an electric warming tray

Almost nobody would settle for eating their food cold whilst it actually should be eaten warm and most people indicated that they warm their food in the microwave whenever it is too cold. This shows that having a tray to keep food warm probably is a welcome solution but it also shows that the microwave might make a tray redundant. Therefore it is necessary to consider what advantages an electric tray offers over a microwave. 'Sometimes' is the most heard answer to the question if people would like to have an electric tray to keep their food warm during cooking. The explanatory notes reveal that people really could use an appliance like this once in a while because of the different preparation times etc.

3.6.4 The target price

The market analyses showed electric trays tend to be cheap (around R$ 175) or expensive (around R$ 645) and this tendency can also be seen when looking at the answers to the questionnaires. Eighteen out of twenty-one people believe a price between R$ 250 and R$ 30 is a good price and the other three consider R$ 400 to R$ 625 to be a good price. This gives the suggestion that there is a bigger market for cheap low-end appliances than there is for high-end ones. When looking at the average price as indicated by respondents from class C, which is about R$ 135, and since its decided in the market analysis to focus more on the cheap segment the appropriate price for the product will be about R$ 175 or less because that is the average price of the products in the cheap segment and this corresponds more or less to the overall average price that follows from the questionnaire which is about R$ 173. The R$ 135 mentioned earlier is a nice indicator showing that the product must be relatively cheap but there are not enough respondents to safely conclude that this should be the target price. Even if the product could be priced at around R$ 135 or less one must ask whether this is really necessary since a thin film heated tray already has a lot of competitive advantages like it's unique appearance, expected low energy consumption, sleekness and possibly other innovative features. In fact, depending on the eventual costs of production, etc., it could be considered to actually increase the price but that is something to decide in the future.

3.6.5 The shape and dimensions

Nine out of twenty-five people wished a rectangular shape and there were quite some people who didn't require a specific shape or liked a different geometry. The average dimensions for a rectangular shape according to the questionnaire are 23 cm wide and 42 cm long. A surface of this size is hardly big enough to hold two plates. From the product comparison it follows that rectangular trays, on average, are 36 cm wide and 56 cm long. When looking at how many separate dishes people usually have, namely between 2 and 3, this would mean the latter dimensions are far more realistic then the dimensions that follow from the questionnaire. The average shape isn't necessarily the optimal shape. Therefore the total surface area, which is 2016 cm2, will be used as an indication of the desired capacity without defining the proportions or shape. One respondent suggested that people should have several small trays instead of one big expensive one. This could be an interesting option to consider since people's needs vary per house-

hold and occasion. This kind of flexibility also goes well with the design philosophy, can lower energy consumption and increases marketability for it provides a very unique selling point.

3.6.6 Storage

Almost everybody, fourteen out of eighteen respondents, would store the tray in the closet. This urges the demand for making it slim and sleek so it can be stored easily. If the tray can double as a cutting board and serving tray people might keep it on the countertop, especially when it's not too bulky and voluminous which is the case with most comparable appliances.

3.6.7 Heat-up and cool-down times

When looking at the time people consider acceptable for the tray to reach the desired temperature it stands out that three people are content with more or less 30 minutes whilst the other 21 people demand a heat up time of 3 minutes and 29 seconds on average. Especially when looking at the average heat up time of 8 minutes that follows from the product comparison 3 minutes and 29 seconds seems to be a little optimistic. A target value of 5 minutes to reach the desired temperature is a good endeavour and if the product can't meet this demand it's important to keep in mind that 8 minutes probably also satisfies the demands of most people.
Concerning the cool down time, on average, people require the tray to be cold enough to handle after 12 minutes and 21 seconds. Some people require it to be cold after 1 minute whilst others are content with 35 minutes and, in contrast to the heat up time, there is no obvious common value but 13 minutes seems a reasonable target value.

3.6.8 The temperature

All but one require the temperature to be adjustable and a handful of respondents consider this to be an essential function for keeping the food in the desired condition. Related to this feature virtually everybody wants to have an indicator that tells the temperature although only a few really want to know the exact temperature. For most people a simple indicator light that tells when the desired temperature is reached suffices.

3.6.9 Hotspots

Hotspots are not necessary according to eleven people but four people find it an interesting option and nine have indicated that they require that the tray has hotspots. From the product comparison it follows that this feature is sometimes incorporated and sometimes isn't. Therefore this feature will be considered a wish rather than a demand. Whether this feature will be incorporated will depend on the eventual design and added costs. It can be a very useful function to ensure proper temperatures for each food and lowering energy consumption since only the required area is heated extra. Having these hotspots should be an option i.e. the user is left the choice between local temperature differences or a homogeneous surface temperature.

3.6.10 The weight

Whilst the weight according to the product comparison is around 5,2 Kg on average it follows from the questionnaire that the weight should be 1,5 Kg when averaging the answers. 3 Kg is mentioned two times as being the maximum weight and all the other

answers are below that value. The tray with the lowest weight weighs about 3,2 Kg. A sheet off glass with a surface area of 2016 cm2 and which is 5 mm thick already weighs around 2,4 Kg and if the tray also has to double as a serving tray the target value for the weight should be around 3 Kg.

3.6.11 Cleaning the tray

Having a tray that is dishwasher proof wasn't that important. Most people, fourteen out of twenty-four, answered no and from the people who answered yes a handful said it could be nice or an interesting option but not necessary. This feature can thus be considered a wish.

3.6.12 Power supply

Wireless operation is a very welcome feature when looking at the answers to the questionnaire. Eighteen people would like to have this function and only five don't think it's necessary. However, there are two big downsides to this feature and that is the increase in price and weight. What makes wireless usage so interesting is the possibility of using it everywhere, carrying it around freely and not having a hindering cable that might trip people. A removable power cord would also allow people to use the tray as a serving tray, although it requires the tray to be reconnected once at the desired location. Since the tray already has a few unique selling points and this feature would come at the expense of other important features wireless operation is considered a wish rather than a demand. Possibly there is a solution that is yet unknown that doesn't come at the expense of other aspects. Concerning the length of the power cord 1,56m is the average required length. The average length that follows from the product comparison is 1,2m. Gourmet grills are used in similar environments under comparable conditions and usually have a power cable of about 1,5m so 1,6m should be adequate. If the cable is removable one could consider providing two cables, a short and a long one.

3.6.13 Ideas and tips in general

Besides the specific questions there was also the possibility for the respondents to give suggestions and this yielded some interesting ideas and confirmed some demands defined earlier. The best ones are:

- An indicator that tells when one could burn himself
- Several trays instead of one big one
- Having three different sizes of trays
- Use the tray as a rechaud
- Use the tray during a churrasco
- The tray should maintain the desired temperature automatically
- A simple indicator light to show if the tray is ready
- Having an additional manual or guide book that tells what temperature is suited for which food and/ or container.

3.7 Conclusion

The ABCDE classification divides people in different social classes where A is the most affluent and E the poorest class. There are a lot of different ways to make this division but in this case a division based on income is used. Unfortunately there are no universal standards so the most prominent data was averaged and this yielded a pretty reliable subdivision for it turned out four of the biggest agencies together came up with more or less the same data. Class C is the most suited for a try-out product because it is very diverse, big (about 50% and growing) and the characteristics of a thin film heating element can fit the demands of this class. Thus, launching the product in this class will increase the likelihood that it catches on and it will yield a lot of insight. Another important consideration is the idea that if the product would be a high end appliance for the A and B class then it wouldn't be suited for the C class since it is too expensive, but if the product is designed for the C class people from the A and B class can buy the product still. According to the subdivision, class C has an income of about 1200 BRL to 4000 BRL per month and this class can be seen as the middle class.

From the market analysis it followed that, in general, electric trays turn out to be very cheap or expensive. Given the limited purchasing power of class C people it's better to focus more on the cheap segment (around 175 BRL) than on the expensive segment (around 645 BRL). One could justify an expensive product by its unique design but, as indicated by The Brazil Business, Brazilians don't value product design too much and an expensive product lies outside the purchasing power of the intended target group.

An elaborate study performed by IBOPE identified four focus groups within class C: rationals, conformists, personalities and consumers. The characteristics of each of these groups show that rationals and consumers are the more important groups for the features of thin film heating technology fit best with them. Women, especially in class C, tend to make the calls if it comes down to purchasing domestic appliances and this emphasizes the importance of the consumer group for they consist mainly of women. The product might also appeal to the personalities given its extraordinary character. Conformists are thought of being the least suited group. About 68% of the people in class C have children and given the needs of such families the demands as imposed by them are paramount. From IBOPE it also follows that the most desired items are those that incorporate new technologies which is good news and means the new thin film technology must be emphasized. Considering the scope of this project and the fact that this product is a try-out an overview of what comparable brands that also target the C class have designed provides enough insight concerning the taste of class C people. The IBOPE target group indexation shows what brands are popular amongst people from class C. An overview and enumeration of products by these brands with corresponding characteristics is condensed into design guideline. Comfort, functional, smooth, black, grey and white, sleek, affordable, innovative, new/ modern, smart solutions, pragmatic, basic colours, emphasis on usability, elegance, durability and simplicity are the important terms for the design. This textual guideline is accompanied by images etc. to provide inspiration later on (see chapter 6).

The identified behaviour regarding cooking and eating shows people usually eat together, eating in front of the television is quite common and that barbeque, i.e. churrasco, is a prominent aspect of Brazil's food culture. These identified behaviours will help in creating suitable and feasible concepts. The Brazil business emphasized that Brazilian consumers and companies emphasize durability, reduced maintenance cost and simplicity stronger than Europeans and North-Americans and that product design, certification like Fair Trade, ecological products and environmental friendly products (although quickly changing) are undervalued in comparison to Europe and North-America. Finally, a brief questionnaire provided insight in the specific demands and wishes regarding an electric tray. These will be treated further on in chapter 6.

The analysis that have been executed up to now show that there is a market for a new electric tray and in what direction it should roughly be developed in order to be feasible. This assures the project as such has perspective and will be very useful in showing the feasibility of the product.

Lastly, the initial goal of this analysis was to get insight in the consumers but it also shows what companies are important in this segment and what kind of companies they are. This will come in handy when contacting producers and determining the strategy for actual implementation.

H4 Usage, surrounding and environment analysis

Despite the elaborate former analyses, there are still aspects that need to be covered which will be done in this chapter. It starts out with the analysis of the direct user environment, continues with the restrictions and ends with addressing the general environmental impact.

4.1 What surroundings are associated with the target group?

The urban population in Brazil is growing rapidly and most of the class C people live in small apartments in urban environments. Most of these houses don't have a cellar and cookware is usually stored in cabinets on the walls or under the countertop. Therefore slimness is extra important. Most of these apartments don't have a garden so a barbeque i.e. churrasqueira is a rare commodity.

4.2 Where and how will the electric tray be used within these surroundings?

This preliminary scenario on how an electric tray in general is used will reveal important aspects that have to be considered. During cooking the tray will be placed near or on the countertop to keep the food warm whilst the rest is being prepared. Hot pans from the stove and dishes from the oven will be placed on the tray to be kept warm. Also meat etc. can be taken from the pan, placed on the tray directly and cut whilst still warm. Subsequently the tray could double as a serving tray to bring the food to the dining place. At the dining place the tray will be plugged in and the power cord will run from the table to the wall. Occasionally people will drop dishes, pans, etc. on the tray and the tray itself is also likely to fall at least once. Usually the tray will be used on the dining table but occasionally it might also be used outdoors at barbeques, on parties, in front of the television or for breakfast in bed. Food and liquids will be spilled on the tray. Afterwards the tray will be rinsed with soap and water. Since space is usually limited the tray will be stored in cabinets and possibly the oven. When stored people will roll up the power cord, wrap it around the tray or just leave it hanging. If the tray can be used as a cutting board or serving tray it might not be necessary to store it and people will leave it on the countertop or table. Then the tray is likely to have cooking utensils, etc. staked on top of it.

4.3 What environmental conditions are of importance?

Especially food coming from the stove can be very hot (280 °C) and if placed directly on the tray the thermal shock can shatter the glass surface. The kitchen is a wet environment, substances can leak or spill on the tray and people rinse the tray with water so the tray has to be water resistant to prevent damage or shock hazard. When the food is placed on the tray to be kept warm during cooking it's quite handy when the tray can also be used as a serving tray. Since people are likely to do so, the tray must support this function to ensure safe operation. This means it should be light, portable and stable. When serving several pans with hot food the tray is likely to become too heavy to carry.

An average plate with food weighs about 1,3 kg and a sheet of glass which has a surface area of 2016 cm2 and is 5 mm thick weighs around 2,4 Kg. This means that two plates with food and the tray together will weight around 5 Kg which is already quite substantial. Therefore, when looking at its function as a serving tray, it only has to be big enough to carry 2 plates and shouldn't weigh more than 3 Kg. Since food normally is served in several containers of different sizes and is passed around frequently it might be cumbersome to place everything on a tray of fixed size and shape. Kitchens and dining rooms virtually always have several power sockets so powering the tray will not be a problem. Since urban apartments are so compact the power cord doesn't has to be very long e.g. between 1 and 2 meters should be enough. A tray that doubles as a cutting board safes space and can be very convenient since it allows for food to be cut without it getting cold. Online research shows glass makes an excellent cutting board (Reviews, 2013-2014). Concerning the voltage and outlets there are some differences within Brazil. 127 and 115 Volts are found the states of Bahia, Paraná, Rio de Janeiro, São Paulo and Minas Gerais. Other areas are 220 V only, with the exception of Fortaleza which is 240 V. The outlets used to be of type A, B, C and I but since 2010 all devices and new buildings must comply with NBR 14136 type.

4.4 What restrictions apply to an electric tray?

The product is far from complete and detailed standards etc. are not important at this stage. However, it's good to look into the legislation and standards globally to prevent major setbacks and, as mentioned in the market analysis, it's good to keep the international legislation in mind because of the international market. There are different kinds of requirements that apply to products. There are mandatory versus voluntary and there are safety versus performance related regulations. Stated in the appendices is an overview of all the regulations concerning products in Brazil in general.
When looking into the specific demands that roughly apply to this kind of product it turns out there are no significant requirements that have to be taken into account at this point except for one. If a product meets the SELV standard (safety extra low voltage) it doesn't has to meet high requirements on insulation and grounding. The SELV standard states that the voltage between components or a component and the chassis cannot be higher than 42,2 V.

To get the mandatory certifications it's necessary to have a technical report including a description of the product, drawings and schematics, notes on these drawings and schematics, a list of applied standards and how these are met, design calculations and checks and test reports if available. Of course these aspects will not be covered during this project, but it shows the importance of documenting all findings etc. for they are needed later on. It also shows what needs to be done in the follow-up.

4.5 What are the possibilities for making the tray environmentally friendly?

This subject has already been treated to some extend in the trend analysis. From this analysis it followed that the best way to make the electric tray more environmentally friendly is by the reduction of energy consumption. This can be realized by technological advancements, power management systems and increased user awareness.

Concerning the technological advancements thin film heating can be very energy efficient and calculations during the technology analysis will point out whether this way of heating is truly more energy efficient. Dividing the tin-oxide layer in separate segments to be heated separately can save substantial amounts of energy. The user can select the area's to be heated manually or an automatic system could detect which parts need to be heated. Hotspots can also reduce energy consumption, because they can selectively heat a dish that needs to be extra hot. Thereby other dishes that don't need to be that hot are also prevented from overheating/ drying out.

Concerning the power management system there are several ways to address this aspect. An automatic timer that shuts off the tray after an hour or so prevents needles energy consumption and is also safer. For instance when someone forgets to turn of the tray when going for groceries and leaves a child at home. Making the timer adjustable ensures sufficient heating time, assuming a big enough range, and will probably safe even more energy. Another option is using sensors that detect usage and switch the tray on or off accordingly. Paramount for such a function to work and to be appreciated is quick heat up and cool down times. Providing different heating programs, as is the case with many microwaves, can stimulate adequate heating and thus safe energy. Soup will probably require a different temperature than cooked potatoes and most people probably have no idea what temperature is adequate. Instead of creating different programs which might be a bit of overkill and difficult to implement it is also possible to provide an analogue guideline that tells what temperature is adequate.

User awareness can be increased by an indicator that tells if the tray is powered and if the desired temperature is reached. A passive way of creating awareness is through energy labels, informing the user about the product's footprint and show the products (future) lifecycle. It's important to emphasize that most of these labels etc. are good initiatives but that sticking a label onto something doesn't necessarily makes the difference. The symbol that shows that a product is made of recyclable material doesn't mean it will be recycled and since there still is little environmental awareness in Brazil making the out of recyclable material will probably not change anything. However, if the product turns out to be very energy efficient it will be very smart to emphasize this with an energy label.

Strengthening the Brazilian economy is one of the mail goals of ABINFO and by producing the product in Brazil and not in China one also saves energy on transport. For these two reasons production in Brazil is a real ambition.

Finally one could emphasize the idea that keeping food at the desired temperature prevents the wastage of food. However, prior to making this claim, this effect should be studied and affirmed. For instance, the energy efficient light bulb ironically results in more energy consumption in contrast to what people initially expected.

4.6 Conclusion

Small urban apartments will be the most common user environment and therefore it's important have a slim and compact tray. The heated surface must be able to cope with thermal shocks and must at least be water resistant. Dishwasher proof isn't necessary since food won't get encrusted on the surface at the intended temperatures so cleaning the tray won't be difficult. It would be very convenient if the tray could be used as a serving tray but not strictly necessary. In order to be suited as a serving tray the tray shouldn't weigh more than 3 Kg and doesn't have to hold more than 2 plates. Since people usually eat in big companies it would be handy if there are several small heating surfaces across the table instead of one big tray in the middle but this merely an idea rather than a demand. Anyhow, this means the tray should be rather big. The power cord must be between 1,5 and 2 meters long and must have a NBR 14136 power plug. The mains voltages range from 115V to 240 V and the tray should be able to cope with these differences. When looking into the specific demands that roughly apply to these kind of products it turns out there are no significant requirements that have to be taken into account at this point except for one. That is, the SELV standard (safety extra low voltage) which states that the voltage between components or a component and the chassis cannot be higher than 42,2 V. If this is the case the product doesn't has to meet strict safety regulations. For product certification later on it is very important to document test results, etc. Separate heating segments i.e. hotspots can lower the power consumption. An automatic timer, heating indicator and power indicator are practical safety features that also help lowering the overall power consumption. Incorporating a heating program is too much but a temperature guideline will be very useful. Lastly, recycling is of no real importance but production in Brazil is.

H5 Technology analysis

This analysis will show the possibilities and limitations of thin film heated glass. Furthermore this analysis will show what is needed to ensure a realistic product and how this can be realized. Lastly, some innovative features that should be investigated further are mentioned.

5.1 What is the general principle behind this technology?

When an electric current passes through a heating element it encounters resistance resulting in the heating of the element. In this case the heating element is a sheet of glass coated with a thin homogeneous layer of tin-oxide (SnO_2). When a current passes through the SnO_2 layer, its temperature will rise and heat will be transferred to the cooler glass substrate mainly by conduction and radiation. Since glass is only transparent in the visual spectrum virtually all the radiated heat, which is mainly infrared radiation, will be absorbed by the glass (Kakaz, 2011). Subsequently, this heated glass substrate can be used to heat an object mainly through radiation and conduction.

5.2 What are the possibilities and limitations of the thin tin-oxide film?

To get insight in the possibilities and limitations of thin tin-oxide films it's necessary to know more about the process by which tin-oxide coated glass is made. Chemical vapour deposition is the process used for creating a tin-oxide (SnO_2) layer on a certain substrate. This process works as follows. Several chemical substances in gaseous form are led into a reactor where they react with each other when coming into contact with a heated substrate resulting in a coating on that substrate. Normally the substrate is heated between 400°C and 450°C. The Chemical Vapour Deposition (CVD) technology can be used in a continuous process to apply thin and homogeneous layers of SnO_2 on large surfaces at high speed. Although flat surfaces are the most simple to process various three dimensional shapes are possible. The tricky part is guiding the gaseous substances in such a way that the substrate is covered homogeneously. Only homogeneous thin films of SnO_2 are available commercially but it is possible to create patterns and/or differences in thickness to create the desired thermal and/or electrical behaviour. Differences in thickness can be made by applying masks during the chemical vapour deposition process but this is expensive. There are, however, several ways to create patterns in standard thin films. The best way to remove parts of the tin-oxide layer selectively is by photolithography. Subsequently these patterns can be used to create separate heating segments, circuits and possibly electrical components like temperature sensors and capacitive touchscreen technology.

5.3 What is necessary for making the electrodes?

In order to draw an electrical current through the tin-oxide glass, an electrical connection must be made between the power source and the glass. This is accomplished by applying electrodes to the tin-oxide glass. To heat the glass evenly the current has to be spread evenly across the glass. Therefore it is very important to use electrodes with an electri-

cal resistance that is at least 100 times smaller than that of the SnO2 layer. Otherwise the current will concentrate where the total electrical resistance is minimal (see figure X). To minimize the electrical resistance the electrodes should be thick in comparison to the SnO2 layer and/ or made of a highly conductive material.

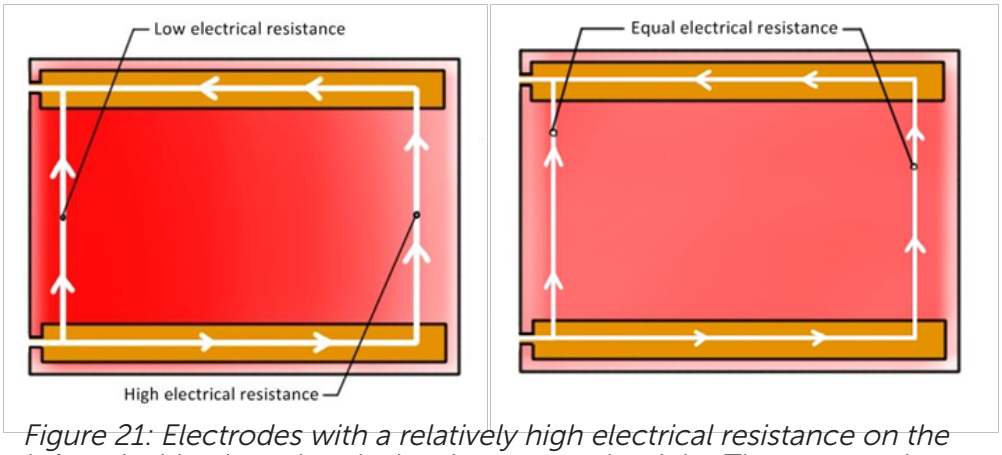


Figure 21: Electrodes with a relatively high electrical resistance on the left and with a low electrical resistance on the right. The warmer the surface the more red it is.

The coefficient of thermal expansion cannot differ too much from that of the substrate and/ or the material should be able to cope with repetitive altering strain. If this is not the case the electrodes could crack. Because the resistance has to be spread homogeneously, the distance between the two electrodes must be the same everywhere. Up till now this is solved by placing two electrodes parallel to each other in a rectangular configuration but there are some other solutions possible. A concentric configuration with one electrode in the middle and the other applied around the outer edge also meets the 'equal distance' criterion (see figure X). One could also try to compensate for an asymmetric shape by varying the shape of the electrodes. In that case the conductivity of the electrodes should be decreased. Also, one could use more than just two electrodes in order to vary the surface temperature locally or create several electrodes at the edges to allow for separate heated lanes. Another idea is having multiple isolated thin films to increase the maximum temperature. If this is combined with the idea of creating lanes then it would be possible to create a matrix, one layer from left to right and the other from top to bottom, allowing for controlling the temperature locally. These solutions open up a lot of possibilities but still need further research. For now, the original rectangular configuration suffices.

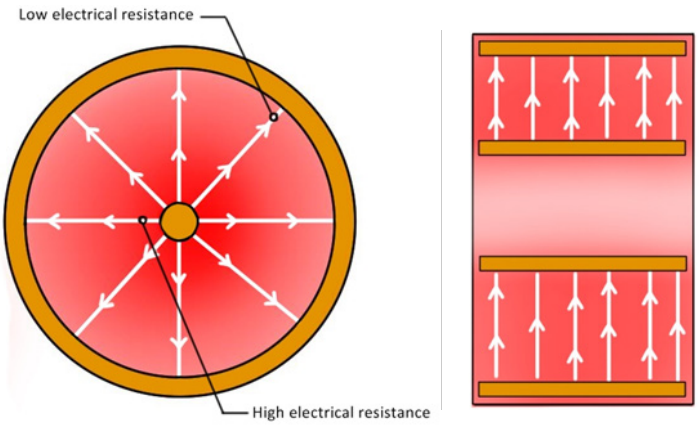


Figure 22: Two examples of different ways of applying the electrodes.

5.4 What possible ways are there for creating the electrodes?

There are several ways to apply electrodes to the tin-oxide layer each with its own spectrum of usable materials. The relevant methods will be discussed briefly in order to find the most appropriate method for prototyping and possibly production later on. Moreover, it's necessary to demonstrate the technical feasibility to some extent and this overview also serves as a steppingstone for further more elaborate research. Lastly, tin-oxide glass for heating purposes is already on the market but it's near to impossible to find information on how the electrodes are realized in these products. Therefore, investigating this aspect to some extent is necessary and might point out an even better process for creating suitable electrodes. Roughly one can divide the methods for creating a thin film in chemical and physical methods starting with the chemical methods. Note that many methods are not suited and will therefore not be explained elaborately.

5.4.1 Chemical deposition methods

Chemical vapour deposition is the process by which the SnO2 layer is applied to the glass and possibly it can be altered and used to create the electrodes. However, this complex process is relatively time consuming, over-accurate and expensive. The same holds for processes like: chemical bath deposition, sputtering, pulsed laser deposition, irradiating metal powders by laser radiation, electrohydrodynamic deposition and electron beam evaporation. Moreover, most of these processes are underdeveloped and rare. Hence, two chemical deposition methods remain, namely electrolysis and electroless deposition. Electrolysis or electroplating makes use of an electric current to deposit dissolved positive metal ions. The deposition of these metal ions yields a coherent metal coating on an electrode which is the SnO2 coated glass in this case. The glass cannot act as an electrode since it doesn't conduct electricity. Instead, one could use the conductive SnO2 to form an electrode or one could use electroless deposition. The former might not work for the resistance in the tin-oxide is too high resulting in a non-uniform voltage and thus an inhomogeneous layer. Electroless deposition is the process of depositing a coating with the aid of a chemical reducing agent in solution. Therefore it is not necessary to use an external electrical power source as is the case with electrolyse. This means the process is applicable to non-conductive substrates like glass. A combination of electroless deposition and electrolysis will probably work best. First the relatively slow electroless process is used to create the initial layer and then, because of the increased conductivity, it's possible to use electrolyse for thickening the layer i.e. finishing the electrode. The area where the deposition takes place can be controlled by applying masks. Femtosecond laser surface modification can also be used to create a specific deposition area but this process is over-accurate and too expensive.

5.4.2 Physical deposition methods

The physical alternatives to electrolyse and electroless deposition are metal spraying and applying a conductive ink, glue or polymer. There are two ways of metal spraying. One way of spraying copper on glass has been tested by ABINFO and yielded results that were acceptable but still far from perfect. The layer was rough, oxidized and not uniform. A company called Ogramac near Campinas can spray metal and subsequent tests will point out if this method is suited. There are several kinds of electrically con-

ductive adhesives like ink, glue, polymers and tape that are easy to apply and which can be very cheap. The conductive component in these substances can be silver, copper or graphite. An electrically conductive adhesive can double as a bonding material to join and seal layers. If two layers of glass are used a conductive foil can be sandwiched in between the two layers of glass. In that case the electrodes are hold in place by mechanical pressure. A conductive ink, glue or polymer can be applied through screen printing and this would, at the same time, allow for screen printed electrical circuits and possibly electrical components like temperature sensors (see 5.11).

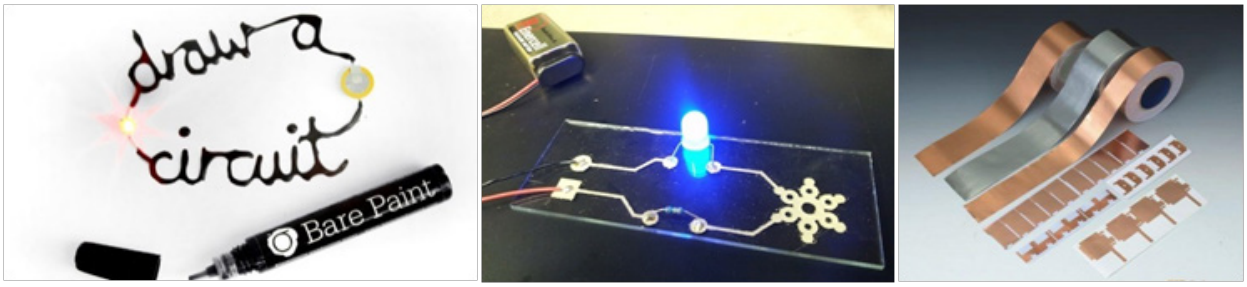


Figure 23: From left to right: electrically conductive carbon ink, conductive silver glue and conductive tape.

5.4.3 The best methods for creating the electrodes.

Hence the question remains; what is the best method and material to create the electrodes? Suitable methods so far are: electroless deposition, electrolysis, metal spraying and applying a conductive adhesive or foil. There are several important aspects that are decisive for choosing the most optimal method: the adhesion of the electrodes to the substrate, electrical conductivity, thickness, the coefficient of expansion, aesthetic value, maximum service temperature, possibilities for connecting the power supply and durability. Most of these values are still unknown so in order to select the best method calculations have to be made and tests have to be carried out, but this is outside the scope of this project.

5.5 What kind of substrates are possible?

In theory, any substrate that can withstand the temperatures required for the CVD process can be used as a substrate. However, if the thin film has to act as a heating element the substrate can't conduct electricity i.e. should be an insulator. The choice of materials is also limited tremendously if the substrate has to be transparent. In that case, the only suited transparent substrate seems to be glass. If transparency isn't required ceramic materials are a very interesting alternative since there are many types with varying properties. This would allow for a far more optimal material concerning the desired thermal, mechanical and electrical behaviour. However, only conductive thin film coated glass is available commercially and ABINFO isn't going to develop these new compositions. Therefore, glass is the only appropriate material concerning the scope of this project.

5.6 What types of glass are possible?

Glass in general has a very low thermal conductivity meaning that it is possible to have a hotspot of about 150°C and put your finger safely on the same surface at about 10 cm of the hotspot. The downside of having a temperature difference is the mechanical stress that arises in the material. Especially when hot items are placed on a cool surface and vice versa the thermal shock could break the glass surface. Thus, the glass should be heated evenly to reduce temperature differences or the glass should be able to cope with the difference. The latter is the only option really, because undoubtedly big temperature differences will occur during use. As a general rule, the coefficient of expansion indicates the thermal shock resistance of the glass. The lower the coefficient of expansion, the greater the resistance of the glass to sudden temperature changes. Borosilicate glass (Pyrex) has a very low coefficient of expansion and therefore it can withstand enormous temperature differences. Of course borosilicate glass is more expensive than ordinary soda-lime glass. Borosilicate glass costs about 25.31 R$/kg whilst ordinary glass costs around 3.74 R$/kg. (Grantadesignlimited, 2014)

Gorilla glass offers a combination of thinness (down to 0.8 mm), scratch and damage resistance and has about the same coefficient of expansion as borosilicate glass. Because Gorilla glass is so thin it is low weight, it will transfer the heat generated by the SnO2 layer more easily and, if necessary, it is possible to use capacitive touchscreen technology. The incredible damage resistance will increase the product's durability and safety. It would be the perfect insulating layer if it wasn't for the price of Gorilla glass. Another big drawback is its unavailability i.e. the manufacturer, Corning, only provides Gorilla glass as a part of the product's manufacturing process. Therefore it will be difficult and very expensive use this glass.

5.7 What ways of treating and shaping the glass are possible?

There are a lot of different ways to treat and process glass. Only the industrial manufacturing processes are taken into account for they are the most relevant. We'll start with mainly aesthetic treatments. To colour the glass one can add metallic salts to obtain stained glass in almost any desired colour. One can mix these additives into the glass itself or spray them on the glass surface later on. In case of the latter an additional layer of glass can be applied to protect the colour coating.

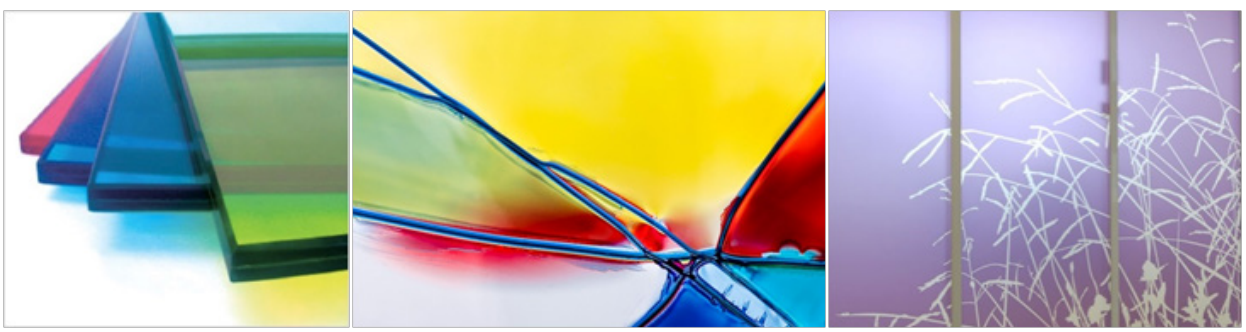


Figure 24: Mass coloured, painted and stickered glass

A cheap way to coat glass is by applying a foil or sticker to the glass surface. Normally these coatings are very weak and need to be sandwiched between two durable layers in order to be wear resistant.

Figure 24: Screen printed, sandblasted and chemically etched glass.

Painting glass is a very common way to colour glass and in industrial applications this is mostly done by screen printing. Screen printing allows for a very high level of detail and by using multiple screens it is possible to have different colours. As is the case with foils and stickers this painted surface can be protected by an additional layer. Another obvious solution is applying the coating on the bottom side i.e. the side which is least exposed to wear and tear.

Abrasive sandblasting gives the glass a matt finish. Another way to give the glass a matt finish or frosted look is by chemically etching the glass. To etch the glass an etching cream is applied which fluoridates the glass. Abrasive sandblasting and chemical etching can both be used to frost an entire sheet of glass homogeneously. By applying masks or stencils it's possible to create patterns, motives, etc. Laser engraving is a very accurate method for marking glass. Traditionally this technology is used to make engravings in the outer surface but it's also possible to make sub surface engravings. This enables three dimensional representations whilst leaving the outer surface intact maintaining a smooth hygienic surface. Edge lighting can highlight engravings and this can be used to create an interface or achieve a very aesthetic effect. The downside of subsurface engraving is the high costs.

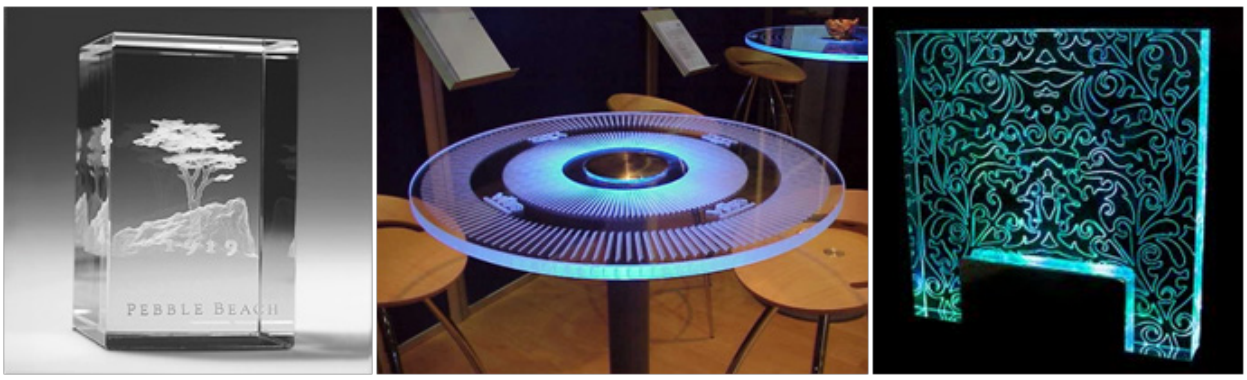


Figure 25: Some examples of subsurface engraving

The glass can be made into a mirror by applying non-toxic silver or aluminium to the back surface. The transparency would then be replaced by the aesthetic value of having a mirror. Having a mirror would also mean having a heat shield. All of the above is mainly concerned with creating a certain aesthetic effect but there are also a few processes to improve the mechanical and thermal behaviour of the glass. By tempering the glass it becomes four to five times stronger than standard glass and prevents it from breaking into sharp shards when it fails. Instead, the brittle nature of tempered glass causes it to shatter into small oval-shaped pebbles when broken. Tempered glass is manufactured through a process of extreme heating and rapid cooling, making it harder and more resistant to thermal shocks than normal glass. The required extreme temperature means the glass must be tempered before the tin-oxide is deposited because extreme heating would damage the tin-oxide layer. Tempering glass lowers its extreme service temperature drastically from 490°C to 290°C for borosilicate glass and from 460°C to 250°C for soda-lime glass (APGC, 2013). At or above this temperature the glass will be very vulnerable to thermal shock and physical degradation. However, Saint Gobain Glass developed tempered tin-oxide glass so apparently tempering the glass doesn't compromise the CVD process, which requires a substrate-temperature of between 400°C and 450°C. Once the glass has been tempered it cannot be re-worked anymore. Hence, actions like polishing edges and drilling holes must be carried out prior to the tempering process. Another way to make the glass safer is by laminating it. Laminated glass normally consists of two layers of glass with a flexible layer of polymeric material in between. When the glass fails due to impact or exposure to high temperatures, the broken glass will remain bonded to the polymer layer preventing loose shards of glass. There are two types of laminated glass. Polyvinyl butyral (PVB) which typically has a 0.38 mm thick layer of PVB sandwiched between the two glass layers and Cast in Place (CIP) laminate glass where a 1.0 to 1.5 mm layer of resin is poured into the cavity between the two layers of glass. The PVB layer could double as an insulating layer and incorporate graphic elements. Apparently, the maximum service temperature for PVB laminated glass is about 80°C (Dupont, 2013). Supposedly, above this temperature the optical properties of laminated glass change but Saint Gobain Glass advertises with laminated glass that can support temperatures of at least 105°C (Berger, 2013) (Edwards). Hence, additional research is required. One can shape the glass through laser cutting, water cutting, milling, drilling, grinding, dicing and polishing. Compression moulding, blowing glass and (re)heating are used to plastically deform the glass. These are very common processes for advanced manufacturing but not for ABINFO so the initial version shouldn't involve (much of these) processes.

5.8 What is necessary to guarantee basic functionallity?

5.8.1 Overheat protection

Most likely the tray will be fitted with a temperature sensor and this sensor can be used to switch off tray in case of a runaway situation causing the tray to overheat. However, the system that's needed to change this sensory information into output is quite complex and vulnerable. For such an important feature to function safely it's necessary to have another circuit interrupter that's more reliable. Therefore an additional bimetallic overheat protector is required. This analog protection kicks in at a certain temperature and when the temperature has dropped sufficiently it automatically reconnects

the power supply again, for overheating can also be caused by improper use rather than a faulty tray.

5.8.2 Adjustable temperature

Foods and their containers differ greatly and thus it is mandatory to have an adjustable temperature. The simplest way to power the tray is by connecting it directly to the mains and regulating the power supply, i.e. temperature, with a triac and potentiometer. This is roughly the same open loop system as is used in a conventional light dimmer. It is a very cheap and simple system and therefore very suited for the initial product. A transformer offers a more safe and elegant but also more expensive solution. It is safer because there is no direct electrical connection between the mains and the heated surface i.e. galvanic isolation. By increasing the frequency from 50 Hz to 20 KHz it is possible to use a very small transformer. This would allow for a small adapter and also makes it possible to integrate the power supply in the casing. In that case the power would be regulated by switch mode power supply (SMPS).

5.8.3 Automatic temperature control

When objects are placed on the tray, the temperature will change locally and the heat flux will most likely increase. By providing feedback about the tray's temperature these changes can be compensated for by altering the power supply accordingly. Because glass has a very low thermal conductivity thermal sensors at the edge of the heated surface will not provide an accurate measurement. Placing sensors underneath the tray comes at the expense of the aesthetics. Thus, it is very difficult to provide accurate feedback but one has to ask himself, is it really necessary to have such accurate feedback? Food containers differ greatly in their thermal properties so there is no fixed temperature for a certain food anyway. Providing a guide that informs people about the adequate temperature needed to warm a certain food in a certain type of container will prove just as effective and not nearly as expensive. Therefore, a simple temperature sensor at the edge that roughly guarantees that the set temperature is maintained suffices.

5.8.4 Heating/ power indicator

A heating indicator shows that the tray is still warming up and hasn't reached the desired temperature yet. Therefore it is necessary to know the temperature of the heated surface i.e. a feedback loop. As was the case with the automatic temperature control (see 5.8.3), a temperature sensor at the edge will provide sufficient feedback about the temperature. A power indicator can be combined with a heating indicator. For instance, a light that turns red when the power is turned on and turns green when the desired temperature is reached.

5.8.5 Short circuit protection

Virtually every house has a ground fault circuit interrupter so this doesn't has to be incorporated in the product itself. The product does need a short circuit protection however. This can be realized by implementing a simple fuse in the power supply.

5.8.6 Automatic fault circuit interrupter

If the heating surface breaks there will be shock hazard because of the high voltage between the two electrodes. To prevent this, an automatic fault circuit interrupter must be installed. If the surface breaks the tin-oxide layer also breaks meaning that the electrical resistance increases to virtually infinite. This increase in electrical resistance can be used to trigger a switch that turns of the entire system.

5.9 What is the thermal behaviour of the tray?

5.9.1 How energy efficient is a thin film heating element?

Preliminary calculations will give some insight in the power consumption, efficiency and required temperatures of tin-oxide coated glass. It will also show the relative importance of radiation, convection and conduction for heating a certain object. First it is important to define the thermal model. Let's assume the goal is to keep objects at a temperature between 25°C and 75°C. Figure 26 stated below shows the essential functional components of the thin film heating tray. On top of the tray sits an aluminium pan which has to be kept at 60°C.

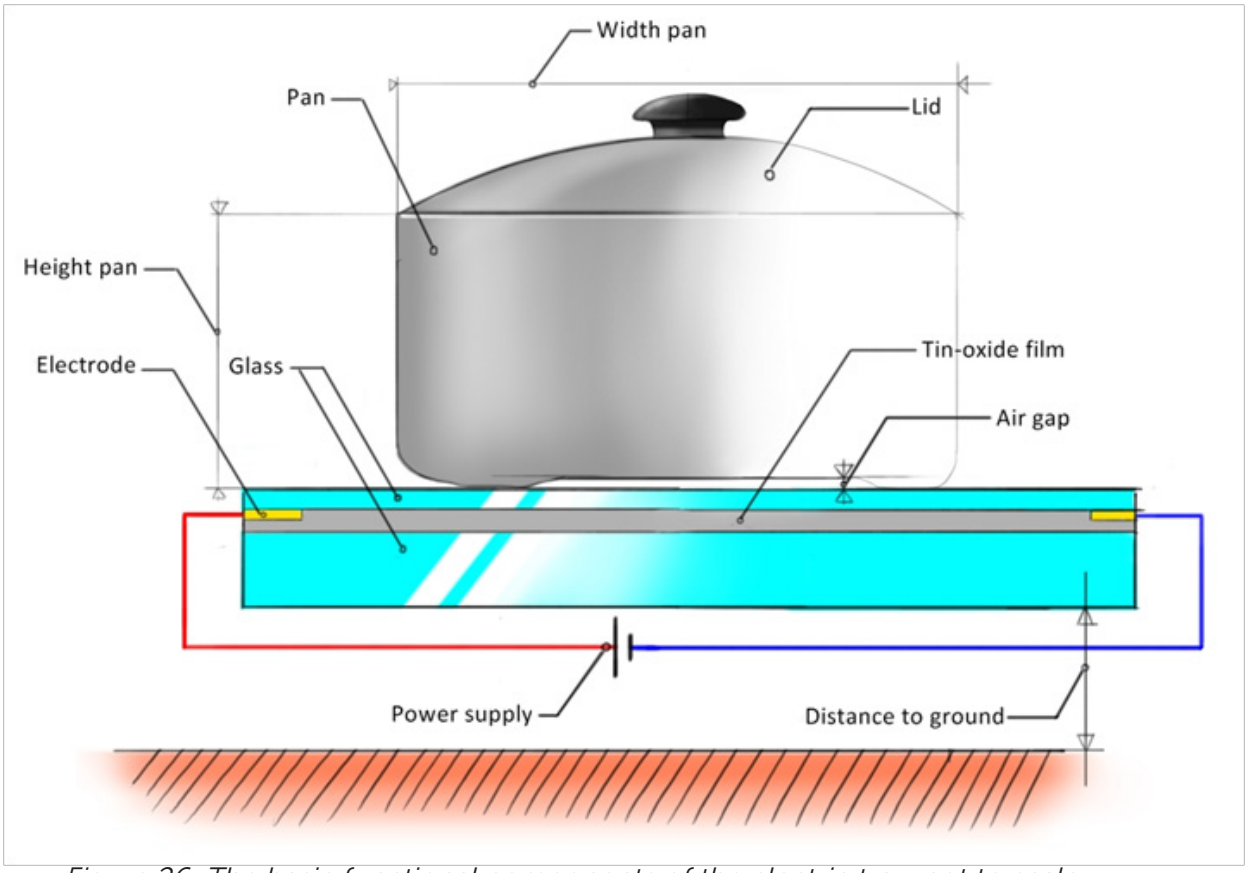


Figure 26: The basic functional components of the electric tray, not to scale.

The conductive tin-oxide film is insulated with a top layer to protect people against electrical shocks, prevent damage to the tin-oxide film and to prevent short-circuiting by metal objects (e.g. pans). Since the tray should be optically transparent the insulating layer is considered to be a thin sheet of glass although it may consist of another material. The generated heat is transferred to the pan mainly by conduction and radiation. The rest of the generated heat is transferred to the environment mainly through convection and radiation. From product comparison it follows that the average heating area for an electric tray is about 56 cm long x 36 cm wide. In order to fully describe the tray's thermal behaviour the behaviour is split up in four parts.

I) The heat transfer from the pan to the environment.
II) The heat transfer from the glass surface to the pan.
III) The heat transfer from the tin-oxide film to the glass.
IV) The total heat transferred to both environment and the pan.

The elaborate calculations are taken up in the appendices. Concerning the heat transfer from the pan to the environment, it turns out it takes 51 Watts to keep the pan at the desired temperature whereby both radiation and convection are taken into account. In order to create an adequate heat flow the glass surface needs to be 87°C in this particular case. Of the total heat flow of 51 Watts, 47 Watts is accounted for by conduction and only 4 Watts is transferred to the pan by radiation. This shows that radiation is relatively unimportant for heating objects placed on the glass surface.

The thermal behaviour of the tin-oxide layer on glass is unknown, there are no formula's that can be applied to this scenario directly and there are a lot of factors unknown. However, by reason it's possible to give a satisfactory estimate of the thermal behaviour. It's assumed that all the electric energy that runs through the resistive tin-oxide film is converted into thermal energy. The heated tin-oxide film will be encapsulated in glass for safety and structural reasons, although other materials are also applicable. Therefore the heated tin-oxide film will transfer its heat only by radiation and conduction. At the average service temperature of 80°C the wavelength that is mainly responsible for heat transferred by radiation is about 8.2 microns. This is far in the infrared spectrum meaning that virtually all heat is transferred by infrared radiation.

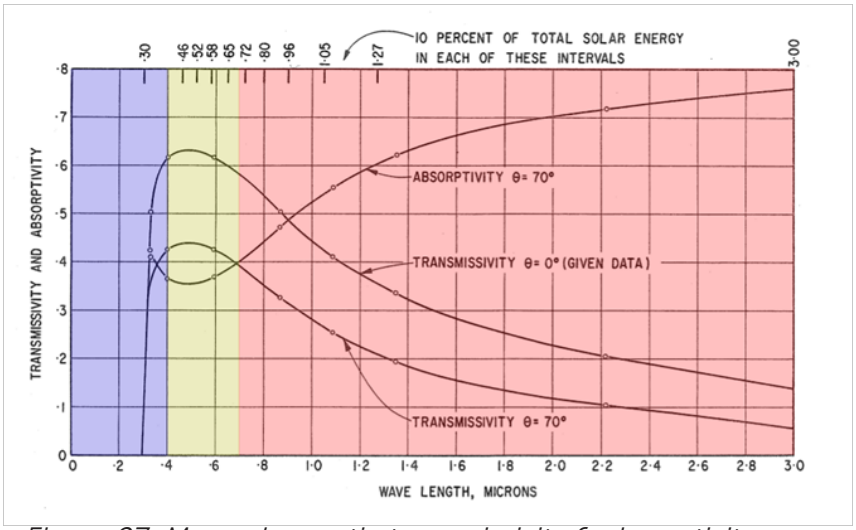


Figure 27: Monochromatic transmissivity & absorptivity versus wave length for single pane window (Cooleysekula, 2011)

Although glass is transparent for the visible spectrum it isn't for the infrared spectrum. Figure 27 stated on the previous page clearly shows how the absorptivity of glass gets bigger whilst the transmissivity gets smaller as the wave length increases. The graph only goes to 3 microns but the line propagates in a similar fashion up to 8 microns. This means that virtually all infrared radiation transmitted by the tin-oxide layer gets absorbed by the glass. Secondly, heat is also transferred from the tin-oxide film to the glass by conduction. It is unknown how much heat is transferred by radiation and how much by conduction but it is safe to say that virtually all heat generated in the tin-oxide will be absorbed by the surrounding glass.

From elaborate calculations (see appendix) it follows that the total heat transferred to both environment and the pan is 303 Watts for this specific scenario. This is quite substantial when considering that only 51 Watts is actually used to heat the pan. This would mean the tray only has an efficiency of 17%. There are two major culprits that are the cause of this low efficiency. The first is the high emissivity of glass. The glass has an emissivity of 0.9 meaning that it's not only a good absorber but also a very good emitter. Therefore, a lot of heat is transferred to the environment by infrared radiation which seriously lowers the overall energy efficiency As indicated before, radiation is of little importance for heating objects placed on the tray but radiation certainly has a big impact on the total energy consumption i.e. 169 Watts of the total power consumption is accounted for by radiation. There are several ways to address this problem. First of all, it's possible to apply heat shields. Tin-oxide happens to be an excellent reflector for infrared radiation and thus an additional layer of tin-oxide at the bottom and top side will help tremendously in lowering the overall power consumption whilst maintaining transparency. It is estimated that tin-oxide has an emissivity of 0.1 neglecting the transmissivity and assuming this number also holds for very thin layers of tin-oxide (Omega , 1996). If that is the case, these additional layers of tin-oxide would reduce the heat flow by radiation roughly from 169 Watts to 19 Watts. Another possibility is using a different substrate that doesn't have such a high emissivity in the first place but this is likely to come at the expense of the transparency. The second culprit for the low energy efficiency is the symmetrical heat flow. Heat is transferred to both the bottom as well as the top side whilst only the top side needs to be heated. By having a top layer of glass which is a lot thiner than the bottom layer it might be possible to direct the heat flow by condution to the top layer mainly (see figure 28, left). However, the sheets of glass are both still very thin. Therefore the heat will probably be distributed evenly after a while anyway (see figure 28, right).

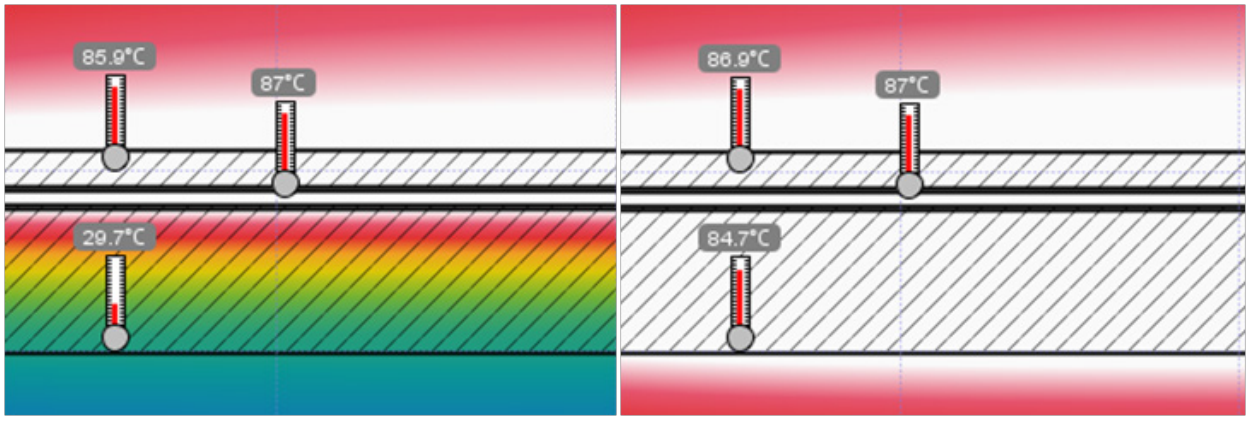


Figure 28: Crosssection of the heated surface witch the desired behaviour on the left and the expected behaviour on the right, simulated with energy2d.

Applying an insulation layer of air or synthetic material between the tin-oxide layer and the bottom glass layer could stop the heat flow to the bottom side to a large extent. Air is a very good insulator but in this particular case this layer also has a structural purpose i.e. supporting the thin top layer. A synthetic material like PVB, which has a thermal conductivity of about 0.3 W/m.K, can support the top layer whilst limiting the heatflow by conduction. A material like PVB is normally used to laminate glass and having lamited safety glass would be a major secondary advantage. Therefore, like stated earlier, the possibilities of using laminated glass at these temperature must be investigated further. All in all, it is thought that the optimal sandwich consists of three thin tin-oxide films, two layers of glass and one layer of PVB (see figure 29).

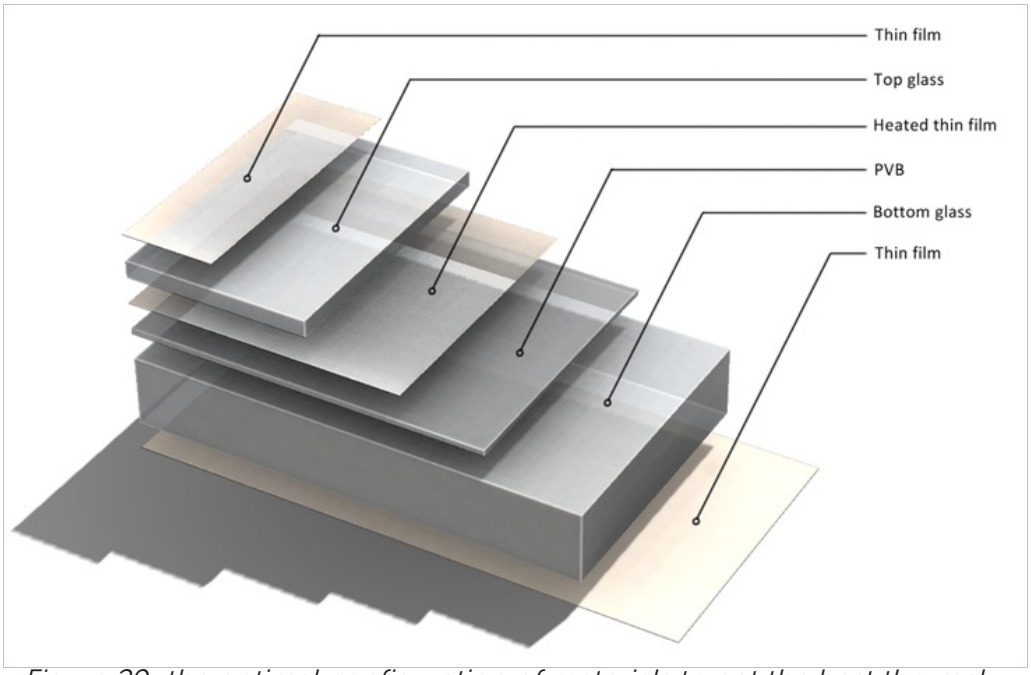


Figure 29: the optimal configuration of materials to get the best thermal, electrical and mechanical behaviour for this specific appliacation.

The top and bottom thin films reduce the heat flow by radiation whilst the thin film in the middle will form the heating element. The PVB layer limits the heat flow by conduction to the bottom side, supports the top layer of glass and will hold the surface together in case of failure. The top layer of glass insulates the user from the powered thin film in the middle whilst the thick layer of glass wil provide the strength. The total sandwich will need to be around 5 mm thick to ensure sufficient mechanical strength (Hu, 2013). The material can also be optimized to facilitate other thermal and electrical behaviour. For instance, by removing the top layer of tin-oxide the glass would act as a very good radiator that radiates mainly one direction only.

5.9.2 What is the power consumption?

From the former calculations, it follows that the power consumption is about 300W but this is without taking into account further material and structure optimisation and extreme use (see 5.9.3). Therefore it's not possible to make an accurate estimate of the power consumption at this point. However, it is safe to say the power consumption will

lie somewhere between 150 and 400 Watts. Theoretically the efficiency for this particular scenario can be increase from 17% to about 43% at most by applying heat shields and limiting the heat flow towards the bottom side. Hence, additional optimisation is highly recommended.

5.9.3 How big should the temperature range be?

From the product comparison it follows that, on average, the temperature range lies between 64 °C and 113 °C. However, a paper on serving temperatures of food shows that the highest temperature at which food is served is only 140 F or 60 °C. This is without doubt because some food containers conduct heat very poorly. For instance a ceramic dish has a thermal conductivity of only 0.80 W/m.°C whereas an aluminium pan has a conductivity of about 146 W/m.K. Moreover, the pocket of air that is created by any raised edge also limits the heat transferred by conduction dramatically. Therefore it is also necessary to calculate the required heat for a worst case scenario which will give valuable insight in the required temperature range.

Concerning the required power output; thin film heated glass radiators are capable of reaching 1000W/m2. This would mean that the electric tray can only produce a marginal 200 Watts. However, this maximum heat output is based on a radiator which only needs to reach temperatures of 60°C at most. Furthermore, ABINFO demonstrated that tin-oxide films can be used to create burners that were well capable of boiling water. Lastly, from some simple calculations it follows that the total electrical resistance of the tin-oxide layer is 64 or 156 Ohm depending on the orientation of the electrodes. Assuming the tray is hooked up to the mains directly, i.e. is supplied with 220 Volts, and the required power is 300 Watts, then the electrical resistance has to be 161 Ohms which is pretty close to the calculated 156 Ohm. Thus, it is safe to say that the tray will most likely be well capable of meeting the required power output.

5.10 Innovative Features

During the technology analysis several features have come to mind that cannot be implemented directly but that are certainly interesting for ABINFO to investigate further. ABINFO could receive funding from external parties interested in the technological innovations. Furthermore, there are innovations, like separate heating segments and temperature sensors integrated in the glass surface, that can possibly be patented which is in the interest of ABINFO and possible investors. Stated below is an overview of these features:

- An integrated touchscreen. By etching and varying the electrical resistance locally it might be possible to create a touchscreen interface in the glass surface. This would be a very elegant and hygienic solution that could also be relatively cheap since the conductive layer is present anyway.

- Piezoelectric crystals to measure weight. This feature could be used to create an automatic on/off function. If the sensor is accurate enough this feature could be used to regulate the amount of heat relative to the mass to be heated.

- LED integrated in the glass surface. If electrical circuits are etched into or printed onto the glass surface it might also be possible power very thin LEDs that are integrated in the glass surface. These LEDs can be used to indicate the temperature, lit up certain areas, etc.

- Separate heating segments that heat up only where necessary. As shown before, there is a substantial heat loss because the entire surface heats up whilst only a small part is needed. Through photolithography it is possible to create several segments and by powering only the necessary segments this heat loss could be prevented. At first this must be manually but possibly it could be done automatically but this would require an advanced sensory system.

- Integrated temperature sensor that is etched into or printed on top of the thin film. A wheatstone bridge can be etched into the tin-oxide layer, which would allow for several temperature sensors integrated in the surface without compromising the transparency. Likewise, it would be possible to measure the temperature where it really counts i.e. in the middle.

- An encapsulated liquid crystal to act as a temperature sensor. This technological feat has been developed by a student working at ABINFO. Little is know about this technology, but possibly, it can be used to create a temperature sensor for the electric tray.

- A subsurface engraved interface which is illuminated separately. This is mainly an aesthetic feature. By engraving the desired shapes, for instance a temperature scale, and lighting them up separately it is possible to make a futuristic and hygienic interface in the glass surface.

Some of the features like integrated LEDs, separate heating segments and integrated temperature sensors can be incorporated in the electric tray at a later stage. The other features can also be incorporated but these are so advanced that they would make the tray very expensive. Moreover, these other features are just overkill for such a simple device.

5.11 Conclusion

The principle behind thin film heating is the same as for traditional electrical heating elements. However, these types of heating elements differ a lot in how the generated heat is subsequently transported. Initially, only flat sheets of thin film coated glass can be used for these are the only ones available commercially and it requires a lot of process optimisation to coat non-planar surfaces. This is also the reason why it is not possible to create differences in layer thickness or apply masks. Electrodes have to be applied in order to draw an electrical current through the thin film. Essential for proper functioning is a very low electrical resistance in the electrodes relative to the electrical resistance in the thin film. Also the electrical resistance has to be homogenous throughout the entire surface to ensure an even temperature. There are various ways of applying the electrodes depending on the geometry and desired thermal behaviour, but for now a rectangular

configuration will be used. To demonstrate the feasibility, facilitate prototyping and gain knowledge the various ways for creating the electrodes investigated. All in all this has led to roughly five methods: electroless deposition, electrolysis, metal spraying, applying a conductive adhesive through screen printing and applying a conductive foil. Subsequent experiments will have to point out what method works best.
Glass remains the best substrate in this particular case although other materials are possible. This is because glass is transparent, hygienic, can withstand the CVD process and has the desired thermal and mechanical behaviour. Concerning the type of glass, tempered borosilicate glass is the most suited. There are many ways of treating the glass both mechanically and optically. The coating process called chemical vapour deposition (CVD) requires the substrate to be heated between 400°C and 450°C and, although the figures suggest differently, the tempered glass can still be used as a substrate for this coating process. Once the glass is tempered it cannot be reworked anymore. Hence, actions like polishing edges and drilling holes must be carried out prior to the tempering process. Laminating the glass is safer and also contributes to the desired thermal behaviour, but whether this is truly applicable at the desired temperature ranges is yet to be found out. To safely protect the tray from overheating a bimetallic overheat protector is required. The easiest way to make the temperature adjustable is by implementing a triac and potentiometer. A safer yet more expensive solution is by implementing a transformer and regulate the temperature by switch mode power supply (SMSPS). It is easy to implement a rough automatic temperature control but very difficult to make an accurate one because that requires a temperature sensor in the middle of the heated surface i.e. compromising the aesthetic qualities. However, for such a simple device, an accurate temperature is not necessary and a simple thermistor at the edge suffices. Subsequently this thermistor can also be used to create a heating indicator. A short circuit protection can be made in an ordinary fashion i.e. implementing a simple fuse in the power supply. However, it is a different story with the automatic fault circuit interrupter. Most appliances don't require such a feature but this one does because of the relatively vulnerable heating surface. If the surface breaks there will be shock hazard and to prevent this the sudden increase in electrical resistance can be used to trigger a switch that turns of the entire system automatically. To get insight in the power consumption, efficiency and required temperature range some preliminary calculations have been made. It turned out that the tray will have an efficiency of only roughly 17% if it is made in the fashion suggested. Luckily, there are some serious improvements like applying heat shields and lowering conductivity locally which could lower the energy consumption, required for keeping an aluminium pan at 60°C, from 303 Watts to 138 Watts. Also the material can be optimized to facilitate other thermal and electrical behaviour which will be important for other possible concept directions. From the product comparison it follows that the temperature range lies between 64 °C and 113 °C on average. This is the initial target value, since so little is still known about the exact thermal behaviour. Further research involving a worst case scenario will point out what is the optimal temperature range. All in all it seems that the thin film heated glass is very well capable of delivering sufficient power. This analysis has shown that, especially with further optimisations, this is a very feasible way of heating foods.

H6 Overall guideline and total list of demands and wishes

To have a clear basis for the design all of the foregoing is condensed into a list of demands and wishes. This list is supplemented by a textual guideline.

6.1 Total list of demands and wishes

In the appendices there is a complete overview with argumentation per every demand and wish for consideration.

Demands:

- Target price R$ 175
- The tray must be able to double as cutting board
- The tray must be slim and thin, around 30 mm
- Maximum heat-up time of 5 minutes
- Maximum cool down time of 13 minutes
- Temperature range between 64°C and 113°C
- Must be able to withstand thermal shock
- The glass must be safe
- The tray may not damage the underlying surface
- Cool area's that enable the user to move or carry the tray when hot.
- Adjustable temperature
- Heating indicator (an indicator light suffices)
- Overheat protection
- Maintain desired temperature automatically
- Maximum weight of 3 Kg
- Maximum power consumption of 350 W
- Automatic fault and glass breakage detection to ensure safe operation.
- A surface area of about 2016 cm2
- Power cord of 1,6 m
- Removable power cord
- The tray must be water resistant
- The tray must be usable as a serving tray
- Comply with the new power plug standard (NBR 14136)
- Meet requirements INMETRO

Wishes:

- Hotspots
- A guide that tells what temperature is suitable
- Automatic shut off function (can be adjustable)
- A heating surface that takes the thermal behaviour of the objects to be heated into account for maximum efficiency
- Dishwasher proof
- Voltage lower than 42,2 V
- Wireless tray
- Remote control through smart appliances like smartphones
- Different possible lengths of power cords
- Automatic switch on/off function that responds to usage
- Detecting objects and subsequently heating the corresponding area
- Production in and supplies from Brazil
- Providing visual feedback through edge and surface lighting
- An user interface that is integrated in the glass surface
- A heating surface which is flexible in size
- Energy label, if the product proves to be energy efficient

6.2 Design guideline

The design has to be consistent with the minimalistic trend. This type of styling mainly comes down to simplistic and smooth yet geometric shapes with a few strong lines. Products are composed of only a few simple shapes connected in an elegant manner resulting in a sleek appearance. The minimalist character is serious and innovative with a futuristic appeal to it. In general, women are the more important gender to focus on and the demands as imposed by families are paramount. The most key terms for the design are:

- Simple	- Functional	- Smooth	- Durable
- Sleek	- Affordable	- Innovative	- Comfort
- New/ modern	- Smart solutions	- Pragmatic	
- Basic colours	- Emphasis on usability	- Elegance	

In general, simplicity is valued strongly in Brazil. As this is a technology push product there is much freedom concerning the design of the product. Also, when implementing a new technology, creating something new works better than trying to make an improved version of what already exists. Thin film technology allows for a clean, simple and thin surface that heats up elegantly with a very innovative feel to it. This must definitely come into its own in the eventual design because people like products that incorporate new technologies. Microwaves and other competing products could make an electric tray redundant and therefore the electric tray has to have clear advantages over these products like mobility, relative low costs and continuous heating.

H7 Idea generation

During this creative phase a lot of different ideas and concepts came into being inspired by the preceding analysis. The result of this process is six main concept directions intended for domestic use and four other concept directions. These concept directions are ranked by feasibility and a textual explanation below will make clear what each direction is all about and why exactly it should be followed. To provide insight in the iterative process the sketches have been selected and grouped to show how the ideas evolved into these concept directions. These are displayed after the textual explanation.

1. Simple

This concept direction is about a simple design, which function is to test the technology further, get valuable insight for further design optimisation and showing the feasibility of this application in different environments without having to use complex processes. Essential for this concept is that it is very easy to develop, has no big uncertainties to it and yet incorporates the most important unique selling points: transparency, low costs, slimness and low weight. From the scenarios, (see appendix) it follows that it is very unlikely for ABINFO to get money for the project in the near future. However, the project will continue for at least a period of three months allowing for the further development of a simple concept up to prototype level. After that period, the continuation of the project strongly depends on funding and/ or collaboration with external parties. Therefore, this concept is the most important of all, because with this initial version and all the gained knowledge it will be much easier to convince funding agencies, developers and manufacturers to support or collaborate.

Because of the minimal functionality and minimal amount of components, it is possible for ABINFO to manufacture several prototypes within considerable time. Subsequently, these prototypes can be tested in different user environments varying from domestic to several hospitality environments because the product is not so strongly focussed on domestic use. These tests will show whether the product truly is suitable for the domestic market and if it should be developed for the hospitality industry also. To convince developers of the products feasibility costs have to be calculated. At this point, it is difficult to make an estimate of the eventual costs of production since there are still some uncertainties, especially concerning the price of thin film heated glass. Building the initial product will yield valuable insights. Thereafter, elaborating further on this concept will make clear what the unit price will be. Concerning the technology, this initial version will point out whether the thin film heating technology will live up to the expectations concerning energy efficiency, thermal behaviour and manufacturability. Also, usability tests will make clear what the required temperature range, dimensions, weight, water resistance is. Also its function as cutting board/ serving tray will be tested. Possibly this product could be sold, but further optimisation is preferable and will certainly be possible. All in all, this initial model will act as a go/ no go moment i.e. it will show whether it is wise to continue with the development or whether ABINFO should abort the project.

2. Design for advanced manufacturing

This concept direction allows for a more elaborate and complex design which cannot be manufactured by ABINFO. Advanced manufacturing refers to aspects like injection moulding, custom components, special processes, large series, etc. needed for this more complex version. A functional prototype can be made through processes like Rapid Prototyping and collaboration with local companies. This prototype level will be the highest level of development possible and desirable for ABINFO. As is the case with the former concept, a working prototype would help tremendously in convincing funding agencies and developers. However, if there is already a working prototype of the initial model then it is not necessary to make another one since this concept only differs in its complexity and not in its essential working principles. Improved functionality like an integrated interface, reduced heat-up times and an optimised heating surface will make this product an improvement with respect to the previous version. In addition, the test results from the former version will help in determining the optimal dimensions, temperature range and other important aspects. Features like edge lighting and hotspots are in reach because of the wider possibilities and could be integrated. Whether these features can be integrated depends on experiments and tests that are yet to be carried out. The main goal of this concept development is creating a feasible concept for mass production, which can be sold to an external party.

3. Freeform glass

In theory, the CVD process can be applied to non-planar surfaces but this requires a lot of process optimisation and research. This is no problem since ABINFO is very experienced in this field but it would mean a considerable time investment meaning this is something for the long term. However, the possibilities are tremendous. Freeform tin-oxide glass allows for way more radical designs, also outside the domestic segment. Besides developing a tray ABINFO can also focus on other products like heated tableware, water boilers and buffet appliances for instance. The tray in this case would be a nice steppingstone to future concepts that also require freeform glass.

A domestic appliance offers the best opportunities and that is why this direction is developed first but from the 3rd concept on it gets interesting again to look at other directions. Especially the hospitality industry has very good opportunities, which supersede the last three domestic concepts concerning feasibility. The latter three domestic concepts might still prove interesting but it is better to focus on other environments and concept directions first. The last three domestic concept directions are discussed below and after that, the other, more feasible, concept directions are covered.

4. Modular

Modularity forms a very unique selling point that can very well appeal to investors or co-collaborators but there are still a lot of unanswered questions concerning feasibility and marketability. Possibly this model can be patented which is in the interest of ABINFO and possible investors.

A domestic appliance offers the best opportunities and that is why this direction is developed first but from the 3rd concept on it gets interesting again to look at other directions. Especially the hospitality industry has very good opportunities, which supersede the last three domestic concepts concerning feasibility. The latter three domestic concepts might still prove interesting but it is better to focus on other environments and concept directions first. The last three domestic concept directions are discussed below and after that, the other, more feasible, concept directions are covered.

5. Mobile

There is a demand for mobile trays so people can eat in front of the television or in bed. However, having a glass heating element doesn't provide a clear advantage over comparable heating techniques besides the decrease in energy consumption and sleekness. Moreover, there are already plenty of trays available with the specific purpose of eating on the couch, in bed, etc. Therefore an electric tray specifically designed for this purpose just seems a bit superfluous.

6. Super-decorative

Super-decorative fits with the current and future trends in kitchen appliances but the unique aspects like sleekness and minimalism that a glass heating element can offer don't necessarily fit with this direction. Personalisation, as a form of super-decorative, could be an elaboration on former concepts but the necessary interaction between consumer and producer to create personalized products requires an established network that does not exist yet.

Concepts in other directions

Initially its best to design an electric tray for domestic use, but there are also other directions that might prove to be very feasible also and cannot be overlooked. As explained earlier, the first two concepts for a domestic appliance are relatively easy to develop and the third is also very attractive for ABINFO since it mainly focusses on technological innovation which is ABINFO's strength and expertise. From the fourth domestic concept on it gets interesting again to look at other directions like a warmed food display or buffet warmer for the hospitality industry because these concepts are more feasible than the, somewhat farfetched, last three domestic concepts. The hospitality industry includes bakeries, snack bars, pizzerias, coffee bars, etc. which often have warmed food on display. The thin film glass can be used to create an elegant, functional, hygienic, simple, cheap and possibly more energy efficient food display. Road houses, indoor events and self-service restaurants often have a buffet. For this purpose ABINFO could develop a new kind of food warmer that is more energy efficient, flexible and displays the food in a more attractive way. In the past, ABINFO has already been working on a cooktop and with the new insights provided in this project it might be interesting to continue with this application.

1. Deli cabinet

Food displays, usually referred to as deli cabinets, display food in an appealing manner and prevent food from spoiling and getting cold. Thin film heated glass can be used in various ways to create and improve food displays. A thin film heating element can lower energy consumption and has a competitive edge over conventional cabinets concerning appearance. The company Hatco has already launched a deli cabinet, which is heated by thin film glass, but there is still plenty of room for improvement when looking at their design. The following quotation taken from the website of EGP affirms the possibility of using the tin-oxide glass in deli cabinets etc.

> *"[the tin-oxide glass] features have led EGP engineers to develop a number of practical applications for the kitchen, restaurants, delis, caterers, etc. These include elegant glass shelves that can keep food warm until served or sold. This is not only because food tastes better warm but also for health issues. Heated shelves help prevent spoilage and retard bacteria growth. An entire display case can be made of Thermique™ glass to keep warm foods visible to customers in a shop or restaurant. The electrically heated glass would not be subject to condensation from steam, so the transparency would not be diminished and water would not drip back down into the food." (EGP)*

2. Cooktop

In the past, ABINFO has developed conductive thin film elements specifically for making cooktops. The project was funded by an external company but stopped because the company required a maximum temperature that could not be met. However, ABINFO can continue with this application since 'normal' tin-oxide glass currently used in glass radiators is already capable of temperatures reaching 177° C. According to EGP burners with this temperature are easily capable of boiling water and other common stovetop heating and warming applications. A thin film heated cooktop has several big advantages over traditional cooktops like a smooth surface which is easy to clean, uniform heating, it's powered electrically, an integrated interface and an aesthetic minimal appearance. There are already numerous glass stove tops on the market but a thin film heated stove top could be more energy efficient because the heating element is integrated in the surface and not placed beneath it. Moreover, thin film technology allows for a very thin cooktop whereas current glass cooktops still have a considerable thickness. Lastly, thin film heating can be applied to curved surfaces which makes it possible to create a whole new kind of cooktop where food is placed directly onto the heated surface.

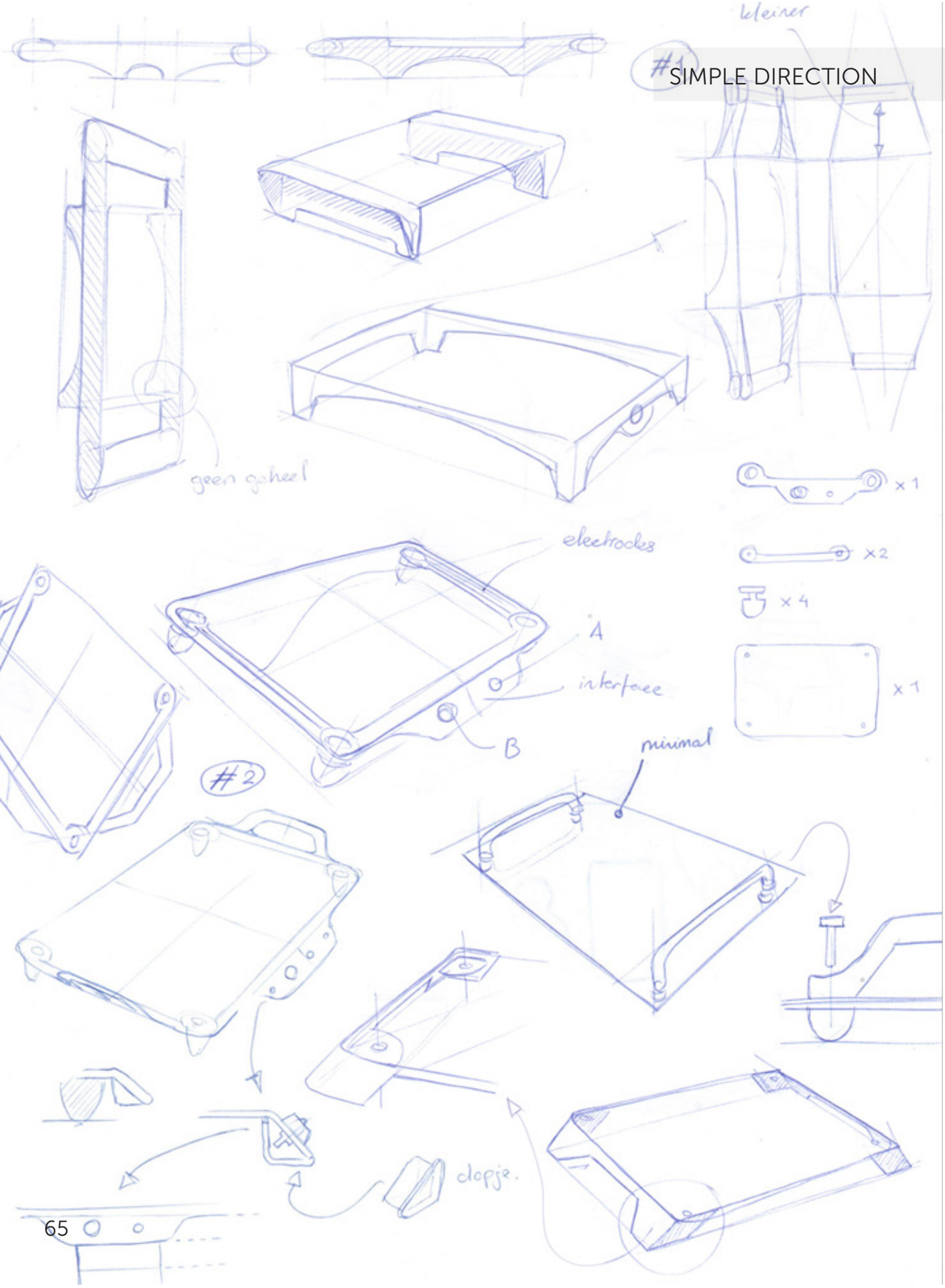
3. Heating utensil for hospitality industry

Besides deli cabinets there are a lot more product on the market intended for the hospitality industry. As follows from the market analysis, most of these products focus on buffet-like user environments. Up till now thin film heating is applied in a way that most heat is transferred to the food by conduction. However, thin film technology is actually also very suited for heating by radiation. Food warmers that use heat lamps usually are ungainly steel appliances. An elegant, minimalistic glass radiator would be a definite improvement. Thin film heating also offers new possibilities like circular shelves that are fixed to a central stand for instance.

4. Floor warming tiles

Traditionally floor warming is realized by installing a network of water lines and subsequently covering them with concrete and tiles. Another method is by building powered electric cables or mats of electrically conductive plastics in to the floor. Besides glass, ceramics can also act like a substrate for the CVD process. Thus, it is possible to create a floor tile with an integrated heating element. These tiles could prove to be very energy efficient because the heat is supplied directly to the floor instead of the heat having to go through plastics and concrete first. Furthermore, these tiles can be used to create exactly the required heated surface for each tile is powered separately. This prevents the unintended and unnecessary heating of furniture and allows for heated 'paths' throughout the house. Although, traditional electric heating is already about 60% cheaper (King, 2012) than hydronic heating it still requires a separate permanent network to be built in the floor. Hence, thin film heated floor tiles could be far cheaper than what is currently available.

The constellations of sketches on the following pages show roughly how the concept directions emerged.


kleiner
#1
geen geheel
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A
interface
B
#2
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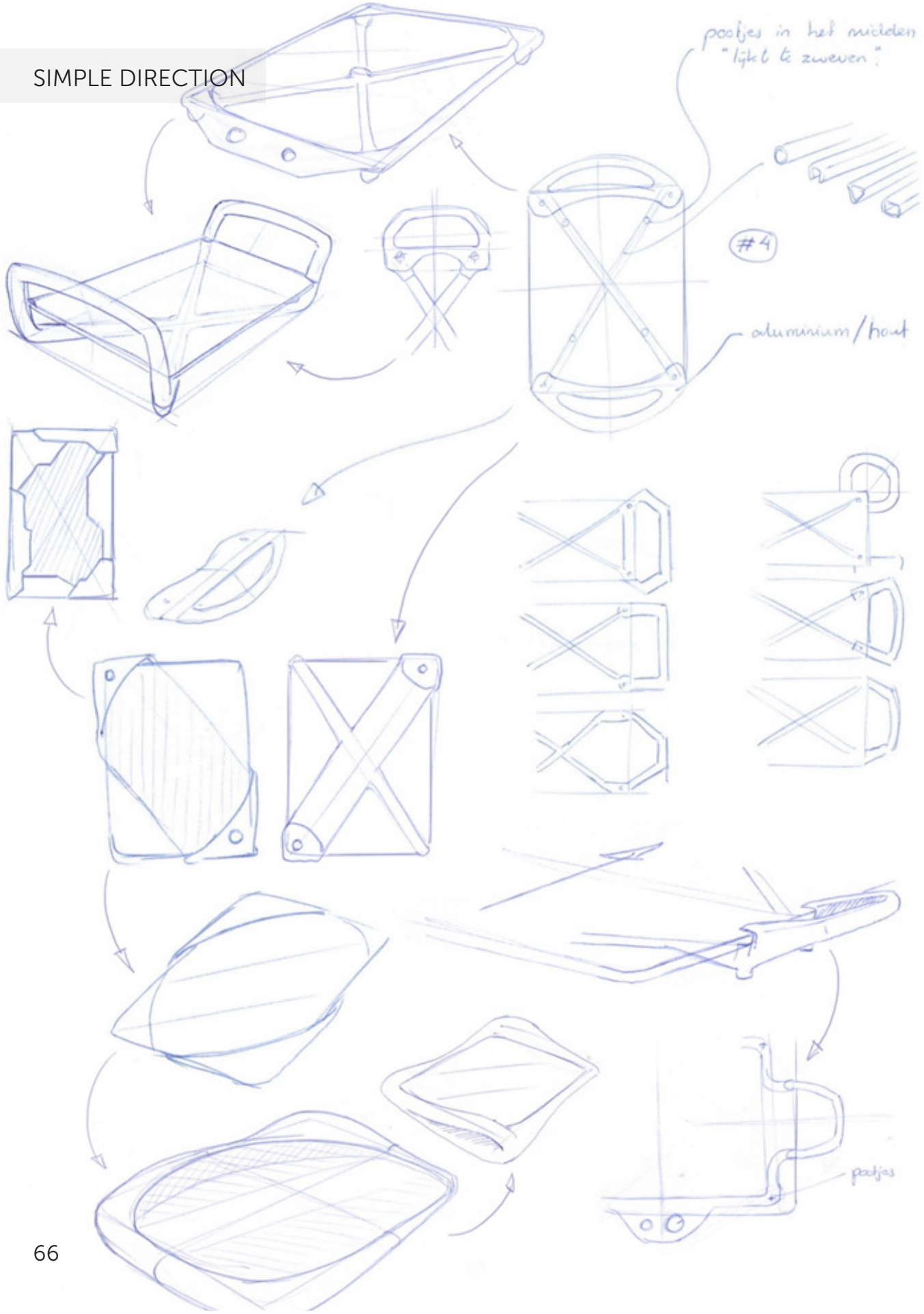
pootjes in het midden
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#4
aluminium / hout
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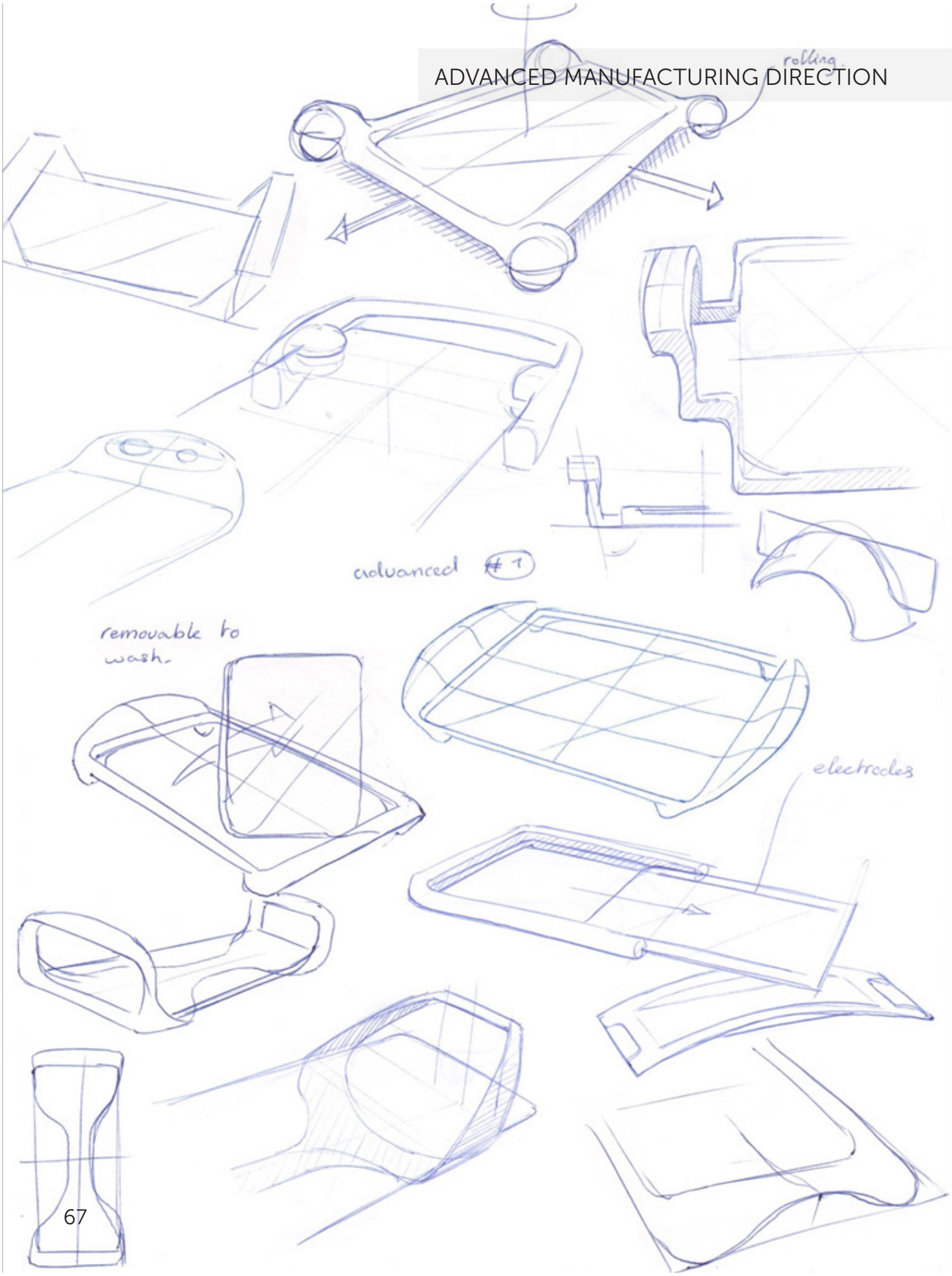
rolling
advanced #1
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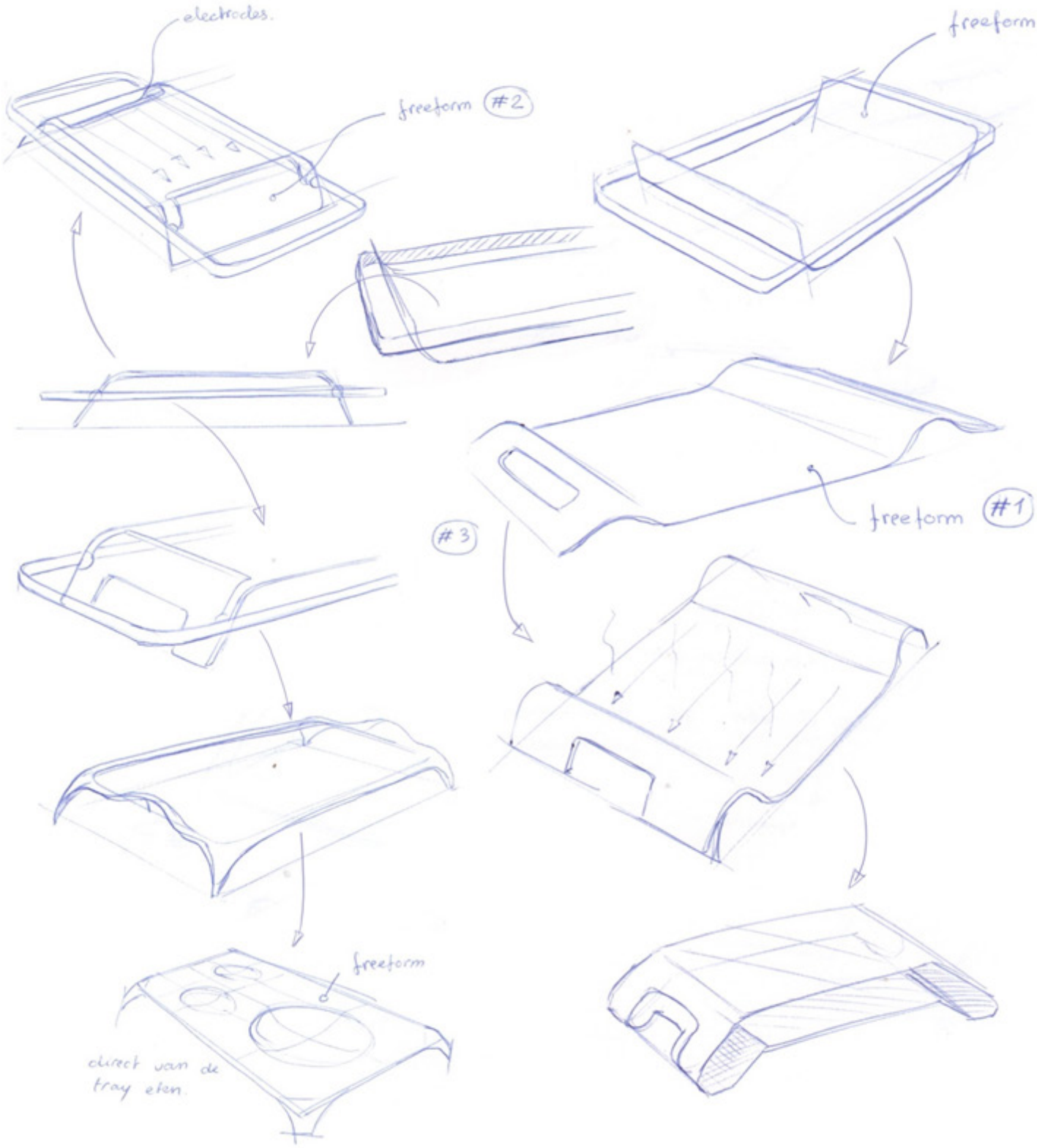
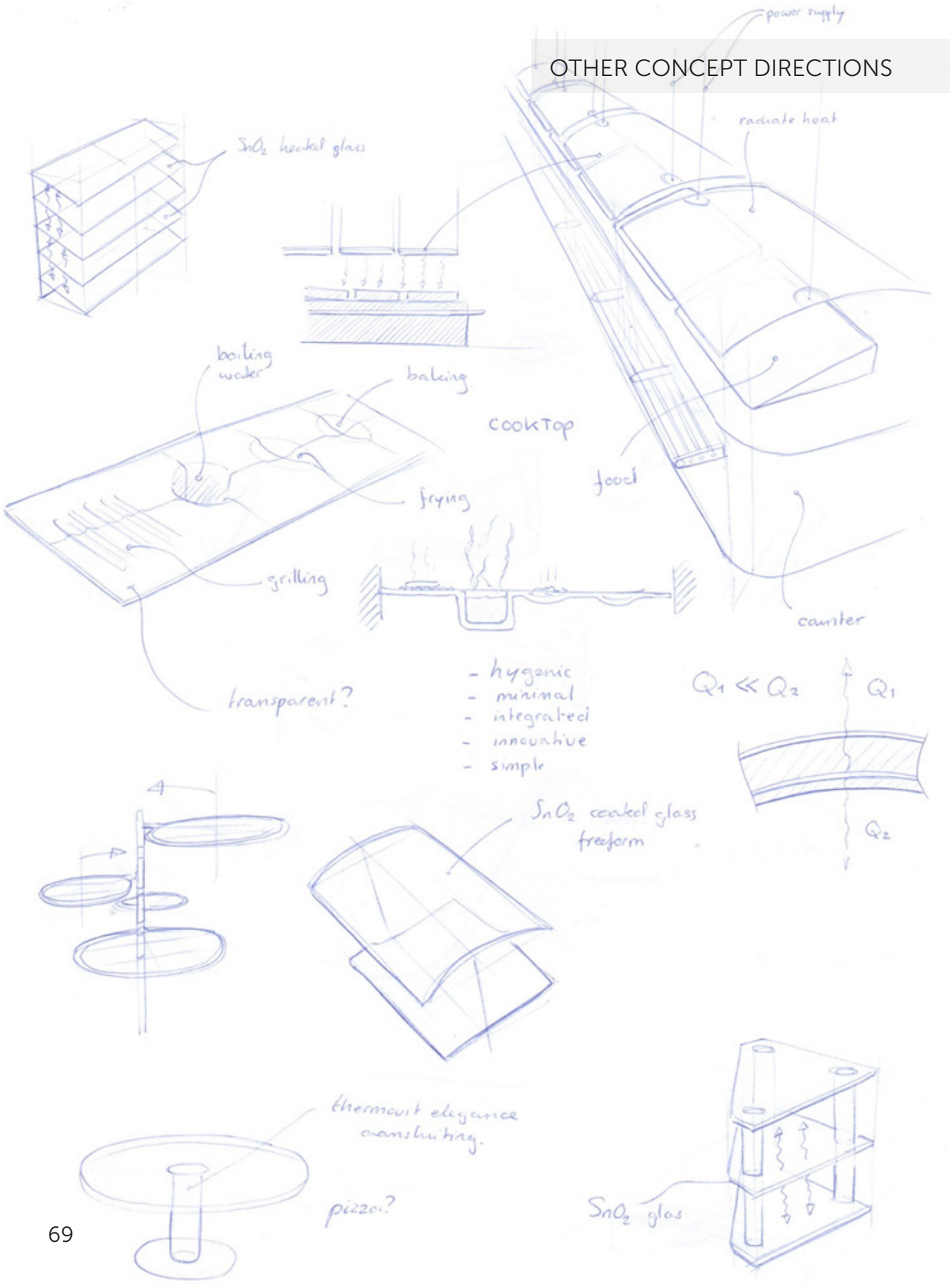

electrodes.
freeform #2
freeform
freeform #1
#3
freeform
direct van de tray eten.


power supply
radiate heat
SnO_2 heated glass
boiling water
baking
cooktop
frying
food
grilling
canter
transparent?
- hygenic
- minimal
- integrated
- innovative
- simple
$Q_1 \ll Q_2$
Q_1
Q_2
SnO_2 coated glass freeform
thermcuit elegance
pizza?
SnO_2 glas

H8 Concepts

In this chapter the first three concept directions mentioned in chapter 7 are elaborated on for these are the most feasible ones.

8.1 Minimal concept

In this concept direction, five simple concepts originated that were all easy to develop had no big uncertainties to them whilst remaining transparent, low cost, slim and low weight. Stated on the next page is an overview of these concepts accompanied by a brief explanation. Subsequently the final concept is presented. All of the concepts offer the following basic functionality:

- Usable as cutting board
- Slim and thin, around 35 mm thick at most
- Usable as a serving tray
- Cool area's that enable the user to move or carry the tray when hot.
- Adjustable temperature
- Heating indicator
- Overheat protection
- Power cord of 1,6 m
- Maximum weight of 3 Kg
- Automatic fault and glass breakage detection to ensure safe operation.
- A surface area of about 2016 cm2
- Removable power cord
- Target price R$ 175
- Maintain desired temperature automatically
- Comply with the new power plug standard (NBR 14136)

The requirements as set by INMETRO are not covered because they are not yet relevant at this stage.

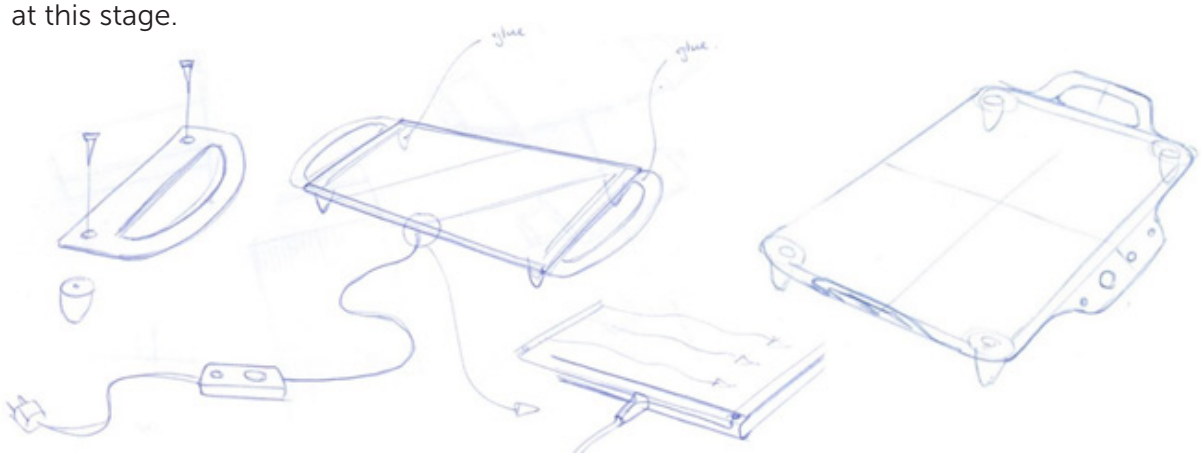


Figure 30: Concept Nº 1

This is the first concept. The heated surface can be ordered or manufactured by ABINFO and requires an electric connection on both sides. Therefore, a cable runs through a chute to connect both sides. This concept has laser cut aluminium handles bent under a slight angle for better handling. Simple tapered legs are screwed to the handles and this subassembly is glued to the glass surface. The interface and power supply can be inte-

grated in the casing of the tray itself; however, this would make the casing for more complex and bulky. Incorporating everything in a simple box integrated in the power cord is much easier to realize, saves space and keeps the electronics away from liquids, which is safer and more hygienic. Also with respect to the other concepts, this solution is the best option concerning this concept direction in general. It is a sleek and minimal tray but it looks rather standard i.e. not innovative and is not very sturdy.

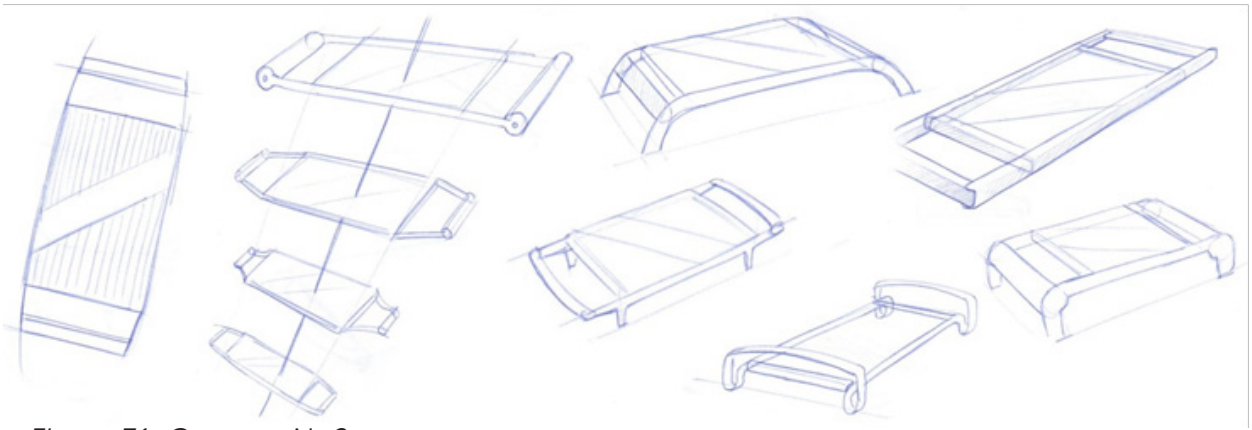


Figure 31: Concept N° 2

The concept depicted above encloses the glass surface in a sturdy casing with integrated legs. The frame is made of extruded aluminium profile on the short side along with laser cut parts on the long side. The handles are made of wood and pull the frame together. Although, this is a very interesting concept it has a certain retro feel to it, which does not resonate with the intended look. However, this certainly has been the basis for the eventual concept, as will become clear later on.

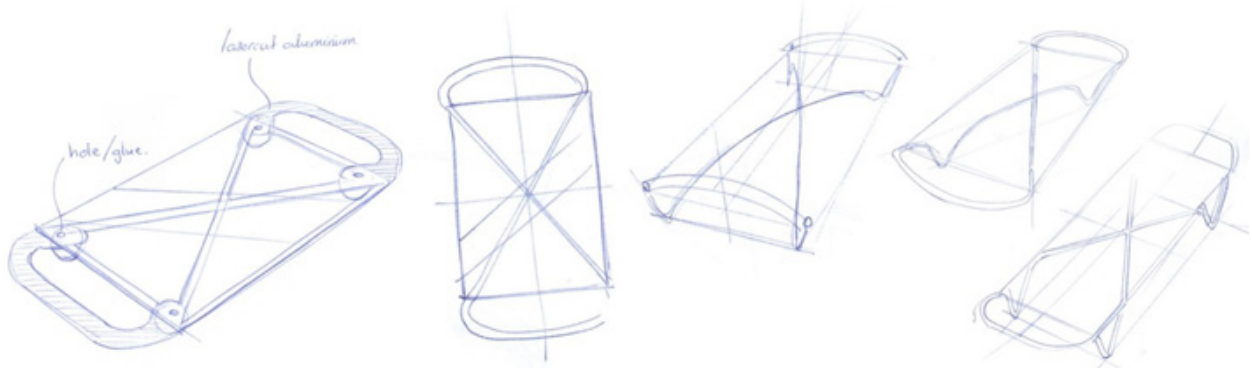


Figure 32: Concept N° 3

This concept revolves around an elegant and minimalistic frame but for the initial model this is just too difficult to manufacture. Also, this concept is likely to be quite flimsy. One advantage of this concept is the possibility of having the temperature sensor in the middle but this isn't really necessary. One could keep it simple i.e. easy to manufacture, as can be seen in the concept on the left, but then it more or less reassembles the first concept again which already has proven not to be optimal.

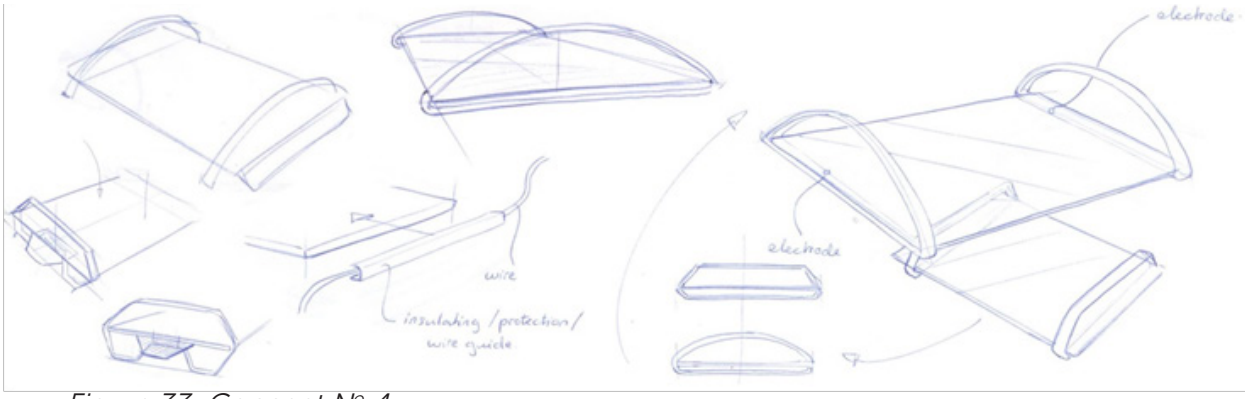


Figure 33: Concept N° 4

The concept stated above truly emphasizes the sleek and innovative glass heating surface but it just isn't very practical. The raised handles are inconvenient since they don't allow for plates, etc. to extend outside the heated surface. In addition, the handles are likely to get in the way when the tray is used as a cutting board. Lastly, for this concept to come into its own, the finish i.e. details are really important and this will be very difficult to realize with the available means. From all the former concepts, one final concept emerged which can be seen below:

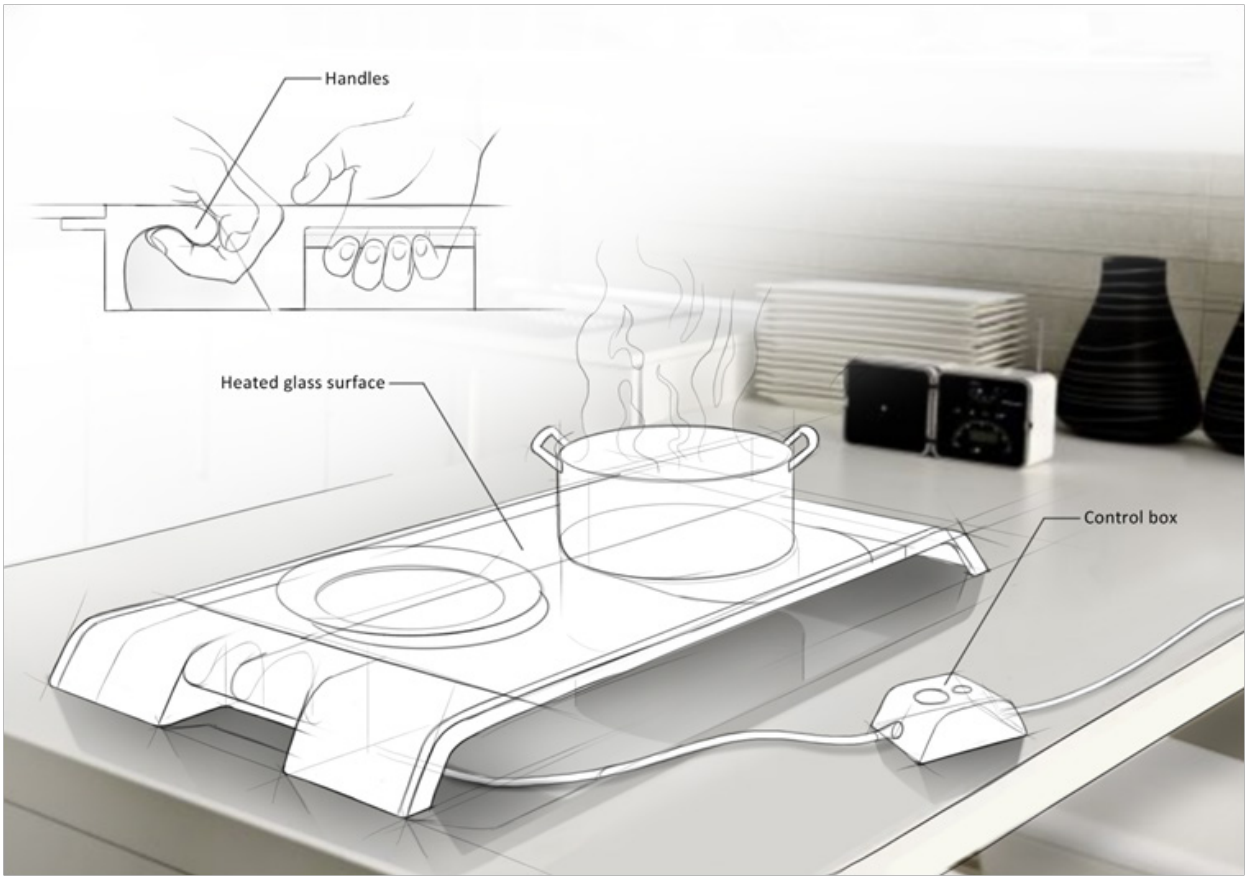


Figure 34: Final concept in user environment

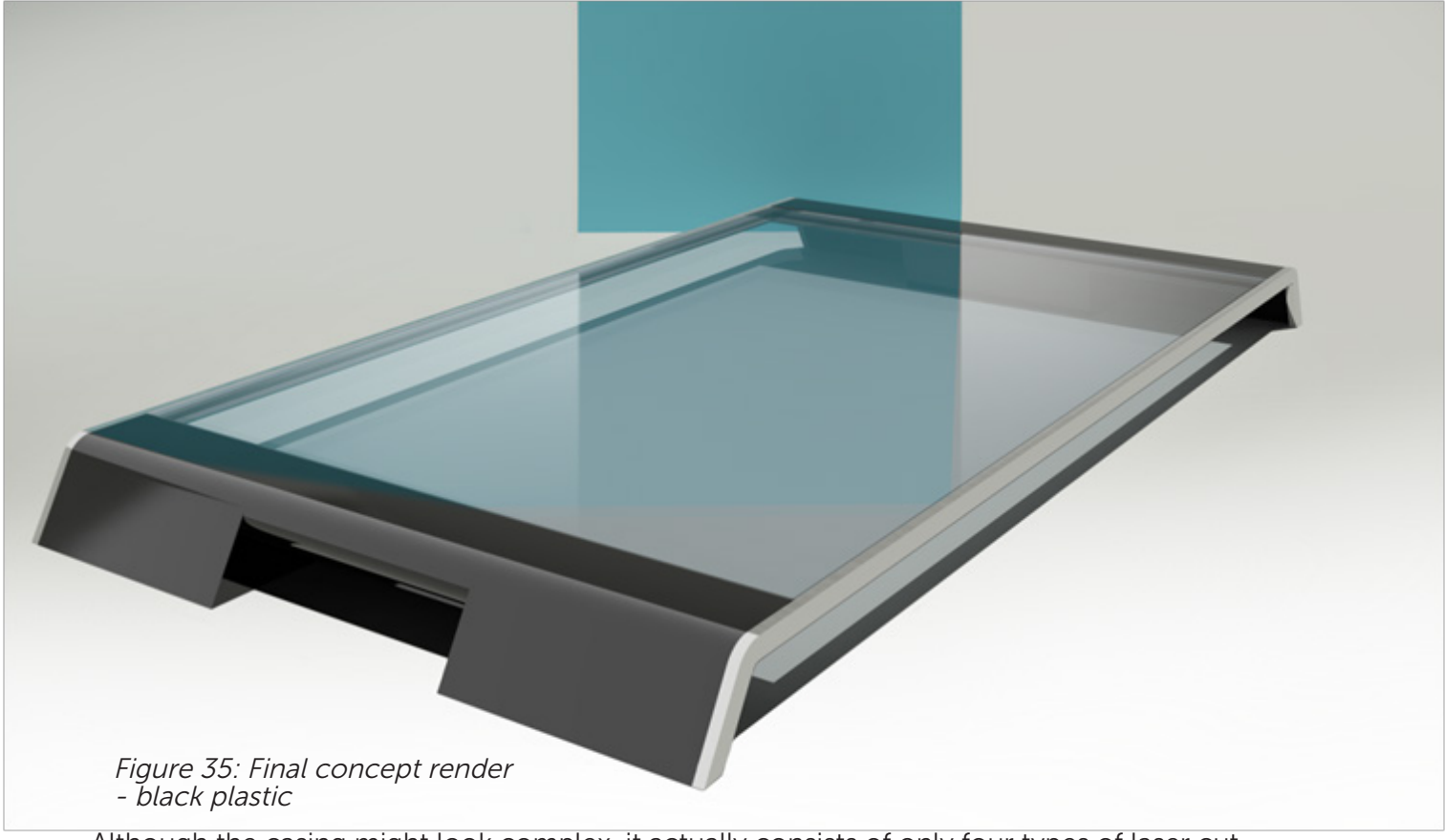


Figure 35: Final concept render - black plastic

Although the casing might look complex, it actually consists of only four types of laser cut slices of wood and two laser cut stripes of aluminium glued together. Subsequently this casing is painted glossy black. This results in a smooth, functional and ergonomic frame that incorporates all necessary functions.

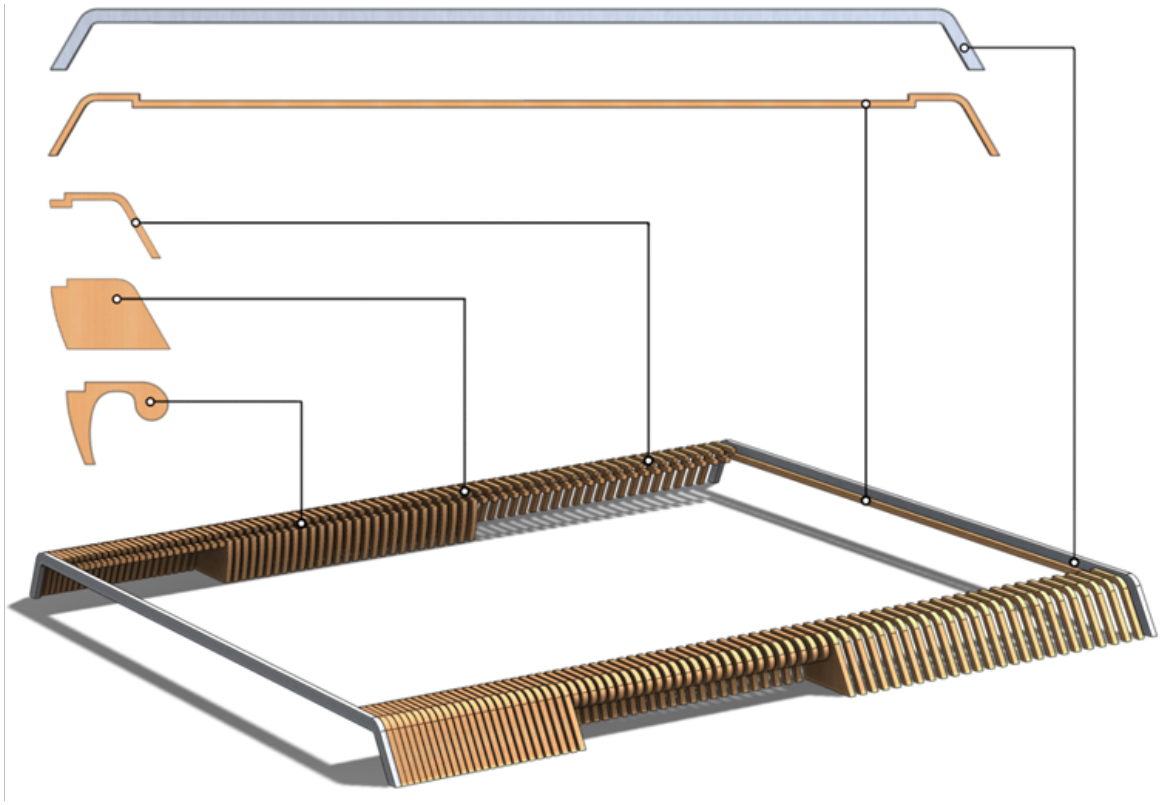


Figure 36: Prototype exploded view

The brushed aluminium combined with a black casing and glass surface give it an elegant and modern appeal that fits very well within the target group type of styling. The bimetallic thermo switch, thermistor and cables can easily be fitted in the casing in such a way that they are not visible. The glass surface is countersunk and sealed resulting in a flat and smooth surface that is easy to clean. The surface is 56 cm long and 36 cm wide. The overall tray is compact, 4 cm high, can very well double as a cutting board and is suitable as a serving tray. Although the laser cut casing allows for an integrated interface and power supply, it is still better to put these in a separate box incorporated in the power cord since integrating these things would impose a higher risk of shock hazard and make the overall product a lot more complex. The temperature indicator will be a simple thermo sticker applied on the glass surface to further reduce complexity. The control box has the same style as the tray and is also made by gluing layers of wood and aluminium together. The power supply will be taken from a standard adapter, customized where necessary and integrated in the control box. Ideally, this adapter can account for both 110 V as well as 240 V. The trays will be tested in varying user environments. Also the technical functionality will be tested including aspects like:

- Maximum heat-up time of 5 minutes
- Maximum cool down time of 13 minutes
- Temperature range between 64°C and 113°C
- The tray must be resistant to thermal shocks
- The tray may not impose an electric shock hazard
- The tray may not hurt or burn users during reasonable use
- The tray may not damage the underlying surface
- The tray must be water resistant (not waterproof).
- Maximum power consumption of 350 W

Appearance isn't really important for testing the technical functionality and operation but it certainly is for convincing future developers and finding users that are willing to test the tray.

8.2 Concept for advanced manufacturing

This concept is based on more elaborate manufacturing processes and resources like injection moulding, custom components and optimized heating technology. Moreover, this concept will be improved upon based on the findings from the usability and performance tests carried out with the initial product. Aspects that are likely to be improved are energy efficiency, dimensions, thermal behaviour, safety and control features. For now, the shape of the initial product seems to be optimal. Therefore, there is no need to alter the overall design unless usability tests, etc. will prove differently. The wooden casing will be replaced by a plastic one because it is more hygienic, easier to shape, cheaper and more water resistant than wood. However, for a future stylized and/ or environmentally friendly version wood can prove to be very interesting (see figure 37, next page) and therefore should not just be left aside. In this concepts the requirements as imposed by the certification authority INMETRO (see appendices) must be met to ensure that the product can go to the market.

Figure 37: Final concept render - wood

For the initial model, it is best to put the power supply and interface in a separate box but, with respect to the usability, it is best to have the interface integrated in the tray itself. Advanced manufacturing processes and materials allow such an interface to be implemented in a safe, elegant and hygienic manner. Hence, this version has a touch interface with background lighting incorporated in the surface. The temperature is set with two buttons. Subsequently, the set value is represented in blue whilst the current temperature is displayed in red. One small correction concerning visibility and accesibility the positioning of the interface is more optimal on top of the tray than at the side.

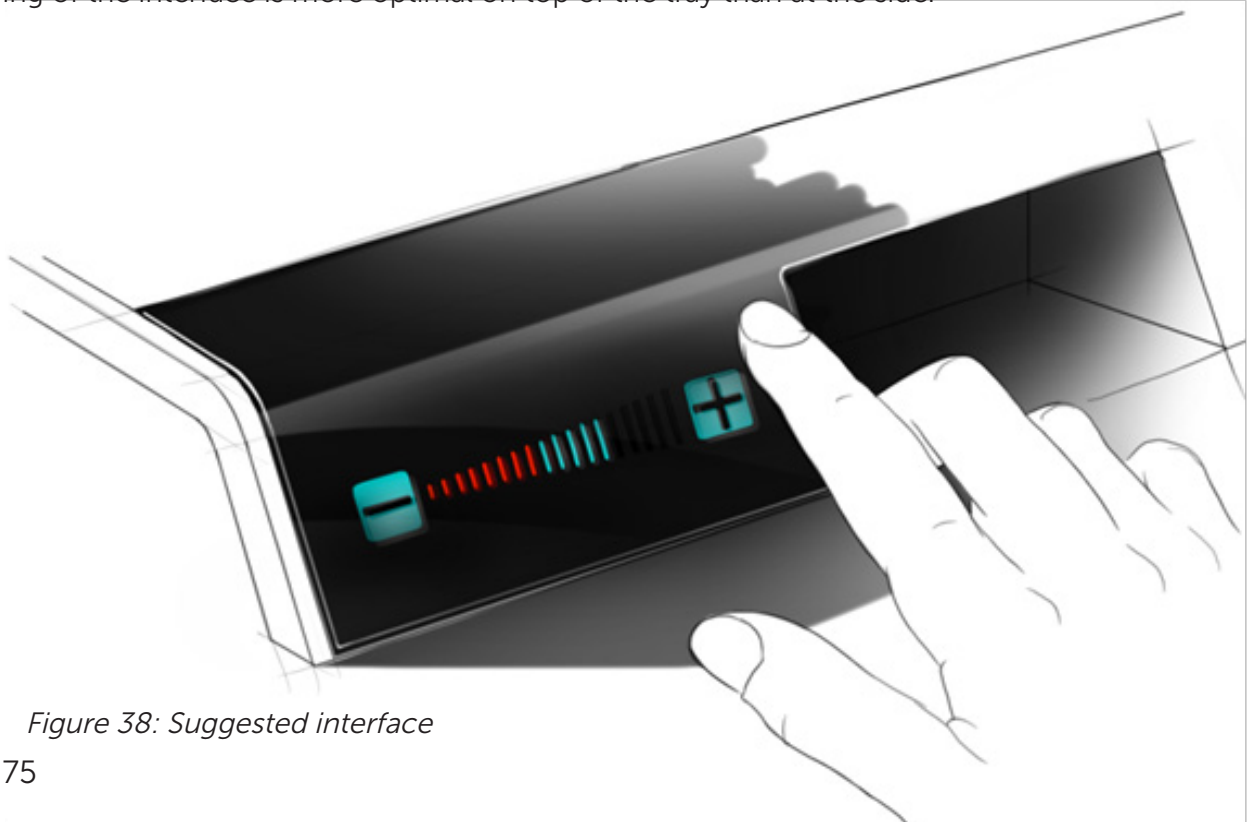


Figure 38: Suggested interface

8.3 Freeform

Whether this concept can be truly made is yet unknown. The former concepts will certainly provide some answers concerning the capabilities of flat thin film coated glass but not concerning curved applications. Hence, ABINFO will have to research the application of thin films on curved surfaces for heating purposes. Despite the fact that this would be a truly new sort of application, it seem improbable that this is going to happen when looking at the scenario's (see appendix). Bend glass can be used to create many variants of trays that, in essence, still offer the same functionality. However, curved heated glass can also be used to create a completely new type of tray.

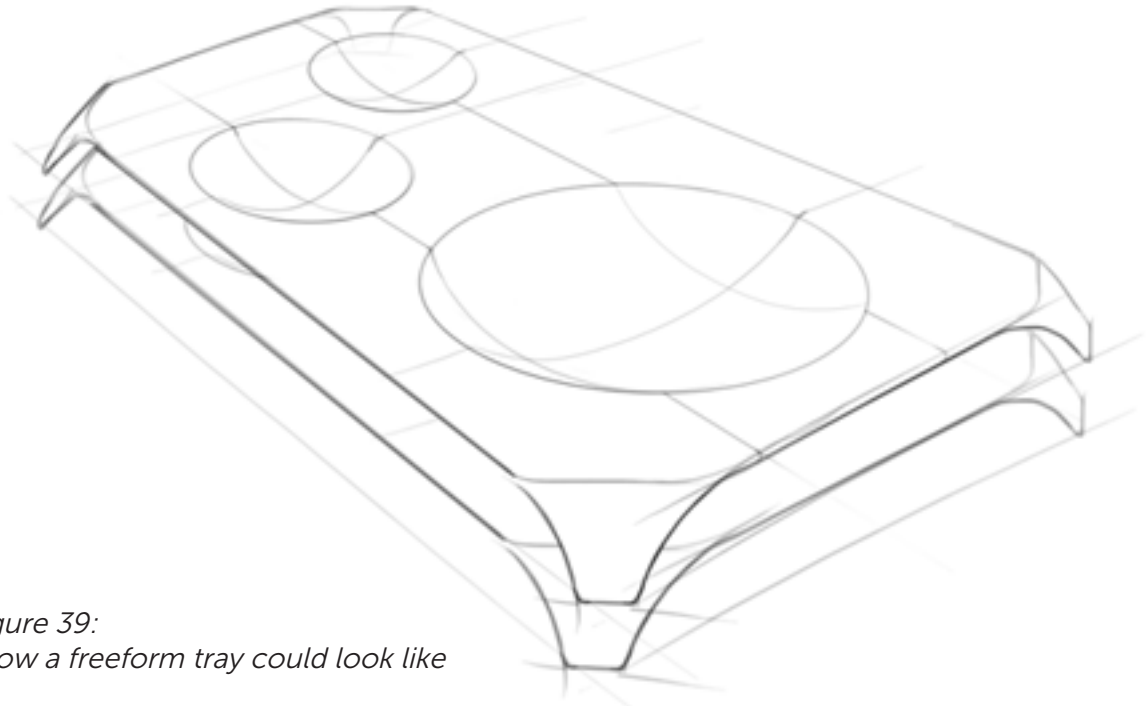


Figure 39:
How a freeform tray could look like

Concave compartments in the glass surface make it possible to put foods directly on the tray making separate plates and dishes redundant. This saves tremendously on dirty dishes. The heating will be far more efficient and the smooth surface is easy to clean. In this concept the advantage of a perfectly homogenously heated surface really comes into its own, because the food won't overheat locally as is the case with traditional heating solutions except for 'Au bain Marie' heating. This tray is also very suited for hospitality environments like hotels and retirements homes for instance.

H9 Conclusion, future perspective and follow-up

9.1 Conclusion

The principal question was:

"How can the thin film heating technology, as developed by ABINFO, be converted into a feasible food warming appliance? i.e. an appliance that can go on the market".

ABINFO only wants to develop the product up to prototype level at most. Therefore, ABINFO seeks collaborating parties for further development or possibilities for selling the idea. Hence, the underlying thought during the project was showing the feasibility towards possible developers and funding agencies. To do so several sub questions had to be answered. First, since this is a technology push product, the market had to be explored to demonstrate that there actually is a market for this product. This led to the focus on a domestic appliance. Next, a target group anlaysis provided a specific group, i.e. rational and consumeristic people from the middle class, that fits best with the intended product and has the most promising prospects. Along with a surrounding and user analysis, virtually all relevant aspects were covered and no major problems where encountered. The only thing that remained was demonstrating that the technology itself would not throw a spanner in the works. Luckily, the technology indeed turned out to be suitable for heating foods etc., although additional optimalistation is strongly recommended. All the former was condensed into a list of demands and wishes accompanied by a guideline for the design. Subsequently, numerous varying ideas led to three strong concept direction for a domestic appliance and also four alternative concept directions. These concepts were ranked with respect to their ability to go to the market, their interdependence and ABINFO's future perspective in mind. The first concept is about testing the technology and usability for further design optimisation and demonstrating that the product is already very close to production. This is achieved by a creating a prototype that comes very close to its advanced successor concerning functionality and overall appearance. The test results together with a fully functional prototype are crucial for convincing funding agencies, developers and manufacturers to support to project or collaborate. This, together with its function as a steppingstone for further development, makes this concept so important. The following concept, in essence, is not much different except for numerous enhancements that follow from the previous concept and that are made possible by advanced manufacturing processes. The products interface, thermal behaviour, dimensions and materials are expected to be its most important improvements over its predecessor. If these concepts are developed or ABINFO decides to focus more on technological R&D again the third concept comes into play. Thin film heated glass is already on the market but non-planar applications do not exist yet. This means that ABINFO, which still is mainly a technological R&D institute with a lot of experience in thin films, could qualify for research funding by developing freeform thin film heating elements. This way of heating would open up a wide range of possibilities also outside the domestic market.

The former three concepts are the main result of this project considering the initial principal question. In addition, several other concepts in other directions have been found and explored to some extent, including a deli cabinet, cooktop, heating utensil for hospitality industry and floor warming tiles.

9.2 Future perspective and follow up

In any case, ABINFO should develop the first concept up to prototype level and then decide whether this still is the most feasible application in contrast to the other suggested directions. This initial concept will be of great help in convincing developers and involving them in the project. During the course of this project an attempt to collaborate with LG has already been made (see appendix) but this did not work out, probably because the product was yet underdeveloped. As explained in chapter 8, usability tests must be carried out with the initial product. The first test involves preparing several prototypes, making a list of questions and handing these to people to test the product in a home environment. The second test is the same only this time the product is implemented in a hospitality environment i.e. local restaurant.
There are special types of funding intended for the investment in new energy efficient solutions. If ABINFO decides to explore the possibilities of thin film heated substrates further, they could very well qualify for such funding. However, additional research is required for there are still a lot of unanswered questions concerning the thin film heating technology, including its energy efficiency. Hence, for the sake of the tray project, other possible applications and the likeliness of receiving funding it is strongly recommended to perform tests and additional research about this technology. Probably many questions can be answered by EGP and SGG. SGG has also come up with a way of powering the glass with only one small contact point which is certainly worth investigating. ABINFO should try to gain knowledge from them or even try collaborating. If this isn't possible ABINFO should order some Thermique and/ or Thermovit glass to get the necessary answers. This will, hopefully, also reveal how the electrodes are currently made. If this is not the case or ABINFO believes there is a more suited solution, the following experiments can be carried out:

1. Test if conductive foils are suitable for creating the electrodes.
2. Try screen printing conductive adhesives like ink and glue to form the electrodes.
3. Test whether electroless deposition is suited for creating the electrodes.
4. Test if electroless deposition followed by electrolysis yields the desired result.

Keep in mind that, for the initial product, ABINFO most likely has to settle for an alternative, more primitive, way of creating the electrodes anyway if the glass can't be ordered to specifications. Therefore, ABINFO is probably bound to investigate these alternatives anyway. Also, the suggested sandwich of materials should be investigated further by answering the questions of the following page.

1. What is the emissivity of a thin tin-oxide film and how is this correlated to the layer thick ness? This will show whether extra layers will make a big enough difference in emissivity and whether this will significantly come at the expense of the transparency. The current films already reduce the transparency to 90%.
2. What is the thermal behaviour of thin film heated glass with additional layers of tin-oxide applied on the outer layers? This is especially important for testing the heat flow through radiation.
3. What are the thermal insulating properties and what is the maximum service temperature of PVB? This is to figure out whether this material is truly suited.
4. What are the thermal properties and efficiency of the entire sandwich of materials? This will show whether this composite material is truly worth the effort with respect to the added costs, etc.
5. What other substrates and combinations of materials are also suited? This is to broaden the field of possible applications like the suggested floor warming tiles for instance.

Apart from this ABINFO could and should explore the possibilities of having a 'freeform' heating element for this is truly something new, whereas heated planar glass already exists. Lastly, the features suggested in the technology analysis can be explored further. Two of these features, that is separate heating segments and integrated temperature sensors, would certainly improve the tray or an application of a thin film heated surface in general. The other features are also interesting but less relevant.

An analogue temperature guideline has to be set up and it must be verified if this truly is of added value. In addition, a manual must be written. Not only because users need one but also to tackle usability problem beforehand. The expected unit price is extremely important concerning marketability and should therefore be determined as soon as possible. Hence, contacting EGP and SGG to get an idea of the price of thin film heated glass is one of the first things that has to be done.

H10 Self-reflection

If there is one thing I learned in Brazil then it is living in the moment rather than in your head. Certainly structured thought has its advantages but I found that sometimes this do more harm than good. In Brazil things are far less parameterized, fixed and regulated. At first, this was sometimes difficult to deal with, especially when I wanted to get things done, but along the way I learned to be flexible. At a certain point I found that this acquired flexibility not only means that I was able to cope with unexpected situations but also that it opened my eyes to a lot of opportunities that I normally would ignore or would have missed. If you make a planning than you have some assurance you will spend your time efficiently. However, it also can make you blind to new things that arise along the way. The quote "Life is what happens to you, while you're busy making other plans" from John Lennon nicely articulates this. Altogether, I learned to be flexible at some times whilst remaining Dutch at other times for both have their virtues. Furthermore, I found it very instructive to do a complete project more or less on my own. This has been very good towards my self-reliance and decision making skills. I felt much responsibility during this project since I was really considered to be some kind of project manager and had to take most decisions by myself. Also, it was a good to experience to delve into a technology like thin film heating and chemical vapour deposition. It is good to know that I can get acquainted with such a specific topic within considerable time up to a point that I have enough in depth knowledge to make founded design decisions. In general, it was downright amazing to spend five months on the other side of the earth and to get to live there, meet people, explore the culture and even go and discover large parts of Brazil.

Using hindsight, I'd say I would have gone into another direction if I were to do this project again considering my personal interests and strengths but in some respect I'm glad I didn't. Initially I did went into the direction of rapid prototyping and during my project I tried to involve other subjects that have my interest like crowdfunding, rawshaping and philosophy but they just didn't fit with the assignment. That was not so much because the environment was not suited but more because I think I was not ready to set my own course yet. I already had many ideas and felt a strong affinity with certain things but just was neither able nor triggered to manifest these feelings. However, this project offered that trigger for I was confronted with myself by designing something I did not really felt good about. In that sense, I reckon this was one of the best projects that I could have done. This project triggered me to manifest and give rise to these feelings. The result is that now I know what I want and, more importantly, why I want it.
Already in the very beginning, I formulated that my personal challenge would be to find the balance between aimless but necessary capitalism and unrealistic idealism because I believe too much revolves around money in current design. From then on, this thought about how and why began to grow bigger and bigger, until at a certain point I could not continue with the project. The problem was not that I did not know what I should do in order to make this product a financial success. I knew that I should target a specific consumer group within the middle class and design the product according to these people's needs and definitions of what is good in order to create a financially feasible product. Subsequently, I would use my skills to transfer this idea into a manufacturable product.

The problem was that the main goal of my efforts would be making money. Whenever I would think of the product, I saw myself trying to create something nobody really needs, just to convince consumers they really need it and thereby getting as much money from them as possible. Naturally, I would make people "happy" with this product in some sense, but then these people have conceptions of what is good that I do not share. In fact, I rather wanted to prevent people from spending their money and energy on these kinds of things. Therefore, I told my mentor at ABINFO that I wanted to spend some time on rethinking the project and formulating my own design vision as to what is good in my opinion. Fortunately, she understood and agreed to spend time on this issue. The next week or so I thought about what it meant to design and I decided to start out with defining the problems that I encountered like money seemingly being the sole purpose of many products resulting in an ever-growing emptiness and regression into nothingness. Subsequently, I wanted to know what gives rise to these problems and how these can be improved upon. Lastly I wanted to find concrete solutions for so much is said and so little is actually undertaken. All of the former I planned to put in a paper and so I started writing. Soon, it got very philosophical and too big of a topic to cover if I ever wanted to successfully complete my bachelor assignment, that is, successfully according to the idea that I had to show I could successfully reproduce what I was thought at the university. The raw paper I started on is not finished and only covers the first phase i.e. 'criticism current system'. It is raw, straight form the hart and probably unreadable to most. Hence, I decided not to take up this part in my final report and just let it be for me to complete later on. The first part however, criticism current system, is taken up in the appendices for consideration. Despite not being complete, I can say that the cause of much pointlessness I experienced in design is the result of too much rational and utilitarian thinking. I'd like to affirm this feeling of pointlessness by quoting a passage from the book Zen and the Art of Motorcycle Maintenance:

"Our current modes of rationality are not moving society forward into a better world. They are taking it further and further from that better world. Since the Renaissance these modes have worked. As long as the need for food, clothing and shelter is dominant they will continue to work. But now that for huge masses of people these needs no longer overwhelm everything else, the whole structure of reason, handed down to us from ancient times, is no longer adequate. It begins to be seen for what it really is...emotionally hollow, esthetically meaningless and spiritually empty. That, today, is where it is at, and will continue to be at for a long time to come."

Exactly this emptiness, or pointlessness if you will, is what triggered me and made me seriously rethink the role of an industrial designer. I will continue this search and like to conclude this project with the following statement form Robert Pirsig:

"Peace of mind produces right values, right values produce right thoughts. Right thoughts produce right actions and right actions produce work which will be a material reflection for others to see of the serenity at the center of it all."

H11 Acknowledgements

First of all I want to thank Professor Alaide Mammana and Professor Carlos Mammana for offering me this internship with them and their tremendous hospitality. I also want to thank Daniel den Engelsen for his advice, support and company. In general, I had a great time at ABINFO and hereby I'd like to thank the entire staff of ABINFO.

Concerning the project completion, I want to thank Wouter Hoogterp for checking the spelling, reviewing texts and most importantly helping out tremendously with making the final report. My father, Ron Norp, I'd like to thank for his support and advice. Furthermore, I want to thank Marcel Kock for the good conversations, reviewing my work and helping me with rendering the CAD models.

Lastly, I want to thank Tom Vaneker for guiding me during the project and Ellen van Oosterzee for being of great help with the preparation.

H12 References

2030. (sd). Retrieved October 2013, from Future timeline: http://www.futuretimeline.net/21stcentury/2030.htm

APGC. (2013). Glass types. Retrieved November 2013, from APGCorp: http://apgcorp.com/type.htm

Babyak, R. (2006, July 1). HEATING ELEMENTS: clearly hot. Retrieved October 2013, from Appliancedesign: http://www.appliancedesign.com/articles/90544-heating-elements-clearly-hot

Berger, A. (2013). SGG Thermovit Elegance. Retrieved October 2013, from Saint Gobain Glass: http://de.saint-gobain-glass.com/thermovit/SGG_TE_PRESENTATIONS/SGG_TE_DUTSCH_NL.pdf

Bevins, V. (2013, March 22). What is 'middle class'? Retrieved October 2013, from From Brazil: http://frombrazil.blogfolha.uol.com.br/2013/03/22/what-is-middle-class/

Carneiro, T. R. (2013, November 26). Faixas Salariais x Classe Social - Qual a sua classe social? Retrieved October 2013, from Thiago Rodrigo: http://blog.thiagorodrigo.com.br/index.php/faixas-salariais-classe-social-abep-ibge?blog=5

Cooleysekula, S. (2011, August 16). The Greenhouse effect part 2: hot car, hot earth. Retrieved March 2, 2014, from Steve Cooleysekula: http://steve.cooleysekula.net/blog/2011/08/16/the-greenhouse-effect-part-2-hot-car-hot-earth/

Corning. (2011, February 7). A day made of glass. Retrieved October 2013, from youtube: http://www.youtube.com/watch?v=6Cf7IL_eZ38

Corning. (2012, February 3). A day made of glass 2. Retrieved October 2013, from youtube: http://www.youtube.com/watch?v=X-GXO_urMow

Craig, L. (2012, June 6). Combining contrasts. Retrieved October 2013, from Newsroom electrolux: http://newsroom.electrolux.com/au/2012/06/06/combining-contrasts-%E2%80%93-lyndon-craig%E2%80%99s-perspective-on-the-future-of-home-appliances-at-eurocucina-2012/

dlyy38. (2011, July 2). Cuisinart-CWT-240-19-by-12-Inch-Warming-Tray. Retrieved October 2013, van Amazon: http://www.amazon.com/Cuisinart-CWT-240-19-by-12-Inch-Warming-Tray/dp/B002LLOE7G

Dupont. (2013). Dupont glass laminating solutions sales and support. Retrieved March 5, 2014, from Dupont: http://www2.dupont.com/SafetyGlass/en_US/sales_support/technical-faqs.html

Edwards, M. (sd). Glass radiators. Retrieved November 2013, from DIY doctor: www.diydoctor.org.uk/projects/glassrads.htm

EGP. (sd). Thermique appliance. Retrieved October 2013, from EGP glass: http://www.egp-glass.com/literature/media/thermique_appliance_wp.pdf

fanatic, C. (2010, November 22). Hostess-Alficionado-large-hot-tray. Retrieved October 2013 , from Amazon: http://www.amazon.co.uk/Hostess-Alficionado-large-hot-tray/dp/B000QTBUG8/ref=pd_sim_sbs_kh_1/279-5158467-9878724#productDescription

Frances. (2013, August 28). product-reviews. Retrieved October 2013, from Amazon: http://www.amazon.co.uk/product-reviews/B000QTBUG8/ref=cm_cr_pr_btm_link_3?ie=UTF8&-pageNumber=3&showViewpoints=0&sortBy=bySubmissionDateDescending

Grantadesignlimited. (2014, March 4). CES EduPack 2013. Cambridge, United kingdom.

HKTDC. (2011, April 26). Brazil's samba-style spending spree. Retrieved October 2013, from HKTDC: http://economists-pick-research.hktdc.com/business-news/article/Economic-Forum/Brazil-s-samba-style-spending-spree/ef/en/1/1X000000/1X07FJLU.htm

Hostess Trolley world. (2008). Hostess, 'Cordon Bleu' Range Side Server :: Black Finish. Retrieved Okotober 2013, from Hostesstrolleyworld: http://www.hostesstrolleyworld.com/p_side_server_black.htm

Hu, M. h. (2013). gift set tempered glass tray. Retrieved March 4, 2014, from Alibaba: http://www.alibaba.com/product-detail/gift-set-tempered-glass-tray_389569673.html

John R. Schrei. (2005, July 1). HEATING ELEMENTS: Heated Glass. Retrieved October 2013, from appliancedesign: http://www.appliancedesign.com/articles/91396-heating-elements-heated-glass

Kakaz. (2011, March 23). Why is glass transparent? Retrieved February 2, 2014, from Physics: http://physics.stackexchange.com/questions/7437/why-glass-is-transparent

King, J. (2012, June 8). Radiant floor heating: electric vs. hydronic. Retrieved March 8, 2013, from Jeff King and Co: http://www.jeffkingandco.com/radiant-floor-heating/

Mammana, P. C. (2007). ABINFO. Retrieved September 2013, from Abinfo: http://www.abinfo.org.br/abf/index.php?section=1

Omega . (1996). Table of emissivity values. Retrieved March 3, 2014, from IB: http://www.ib.cnea.gov.ar/~experim2/Cosas/omega/emisivity.htm

PennyR. (2011, February 2). Cuisinart-CWT-240-19-by-12-Inch-Warming-Tray. Retrieved October 2013, from Amazon: http://www.amazon.com/Cuisinart-CWT-240-19-by-12-Inch-Warming-Tray/dp/B002LLOE7G

Pirsig, R. M. (1974). Zen and the Art of motorcycle Maintenance. In R. M. Pirsig, Zen and the Art of motorcycle Maintenance (p. 540). Penguin.

Pittsburgh, B. i. (2011, February 20). Cuisinart CWT-240 19-by-12-Inch Warming Tray. Re-

trieved October 2013, from amazon: http://www.amazon.com/Cuisinart-CWT-240-19-by-12-Inch-Warming-Tray/dp/B002LLOE7G

Powell, R. (2014, February 11). product-reviews. Retrieved February 26, 2014, from Amazon: http://www.amazon.co.uk/product-reviews/B000QTBUG8/ref=cm_cr_dp_see_all_btm?ie=UTF8&showViewpoints=1&sortBy=bySubmissionDateDescending

Reviews, M. (2013-2014). 16-Inch x 20-Inch Glass Cutting Board. Retrieved March 7, 2014, from Bed bath and beyond: http://www.bedbathandbeyond.com/store/product/16-inch-x-20-inch-glass-cutting-board/1010166160

Royle, K. (2011, January 18). Hostess-Alficionado-large-hot-tray. Retrieved October 2013, from Amazon: http://www.amazon.co.uk/Hostess-Alficionado-large-hot-tray/dp/B000QT-BUG8/ref=pd_sim_sbs_kh_1/279-5158467-9878724#productDescription

sjw. (2013, June 13). product-review. Retrieved October 2013, from Amazon: http://www.amazon.co.uk/product-reviews/B000QTBUG8/ref=cm_cr_pr_btm_link_3?ie=UTF8&pageNumber=3&showViewpoints=0&sortBy=bySubmissionDateDescending

H13 Apendices

Prototype

Stated below is a photo of the intial working prototype build by ABINFO to demostrate the functionality of thin film heated glass. The thin film has been made by ABINFO, the electrodes are realized by applying a conductive adhesive, the tray is powered directly and can reach a temperature of about 70 degrees Celcius within 20 to 30 minutes.

Technology existing products

- The first kind of products relies on absorbing and retaining as much heat as possible. A granite plate for instance, is exposed to microwaves and/or convection to acquire thermal energy. The object to be kept warm is then placed on top of the warmed item so it stays warm for about an hour mainly through conduction. In order to retain a lot of heat and gradually transfer the warmth a material is used with a high density, low thermal conductivity and high specific heat.
- The second kind of products use chemical energy (candles, gas, spirit) that is converted into thermal energy. Most of the heat is transferred by convection to a container or surface that subsequently transfers the energy to the object. Using chemical energy allows for mobile and simple applications.
- Electric trays use a conductor with a high electrical resistance to generate heat. In general, when a current passes through a conductor, work is done on that conductor, meaning that the electrical energy is converted into internal energy, causing the conductor's existing internal energy to rise. This is accompanied by a temperature rise and, because the conductor's temperature is now higher than its surroundings, heat is transferred from the conductor to the cooler surroundings. There is a wide range of these conductors, called heating elements, available. Virtually all of them use nichrome (80% nickel and 20 % chrome). Some heating elements are integrated in the surface and some are placed underneath it. Integrated heating elements can consist of screen-printed metal-ceramics deposited on ceramic insulated metal. Another possibility is integrating a nichrome wire into the surface. External heating elements usually consist of a fine coil of Nichrome wire in a ceramic insulating binder, sealed inside a tube made of stainless steel or brass. These are placed under the heated surface and warm the surface mostly by convection. So far, no trays make use of thin film heating.
- The last way of heating food is by radiation. High-powered incandescent lamps called heat lamps are powered in such a way that they radiate mostly infrared instead of visible light. This infrared light is then used to heat food etc. by radiation.

An integrated- and nichrome heating element and an incandescent heat lamp

- To distribute the heat evenly and prevent the container from reaching a temperature above 100 °C the container with food is placed in water that is being heated. This is called au bain-marie heating. This technique is often combined with chemical or electrical heating elements.

Market analysis

*Other than normal use.

Extreme values

Hotplate			
Name	Glass electric warming tray	Alficionado large hot tray	Hot tray
Brand	Generic	Hostess	Russel Hobbs
Technical details			
Maximum temperature	120°C	?	?
Minimum temprerature	90°C	?	?
Heat up time	?	8 min	?
Cooldown time	?	?	?
Technology	?	?	?
Product size	600 x 400 x 60 mm	?	?
Size heated surface	600 x 400 mm	600 x 300 mm	530 x 350 mm
Power (W)	320 W	1000 W	400 W
Power (V)	230 V	?	?
Power (Hz)	50 Hz	?	?
Weight	5,6 Kg	6,6 Kg	3,6 Kg
Usage			
Removable power cord	Yes	Yes	No
Length power cord	?	1,5m	?
Cord storage	?	?	Yes
Hotspot	Yes	No	No
Non-stick surface	?	?	?
Automatic keep warm function	Yes	Yes	?
Keeps food warm for approx.	?	?	?
Color and/or material	Silver and black	Black and silver	Black and silver
Adjustable temperature	Yes	No	Yes (3 modes)
Temperatur indicator	Yes	No	No
Heat-up/ ready to use indicator	No	No	No
Handles (stay cool)	No	Yes	Yes
Cordless	No	Yes	No
Rechargeable	No	Yes	No
Chargetime	N.A	8 min for 1 hour	N.A
Safety			
Power indicator	Yes	Yes	Yes
Over heat protection	Yes	?	?
Tempered glass surface	Yes	?	?
Waterresistant*	?	?	?
Certification	CE / CB / GS / IEC / RoHS / EMC / LVD/ SII(Only For 230V)	?	?
Market			
Price	155.40 BRL	204.89 BRL	180.12 BRL
Shop	Online retail store	Online retail store	Online retail stores




XL Cordless warming tray Swan products Ltd	CWT-240 warming tray Cuisinart	3-section buffet and warming tray Nostalgia Electrics	Cordless warming tray large Toastess
150°C	94°C	?	?
?	66°C	?	?
8-10 min (to 150°C)	5-10 min	?	8 min
?	?	?	?
?	?	?	?
690 x 230 x 63 mm	615 x 366 x 76 mm	648 x 381 x 153 mm	714 x 363 x 114 mm
600 x 200 mm	482 x 305 mm	N.A	594 x 294 mm
1000 W	?	300 W	1000 W
?	?	120 V	120 V
?	?	?	?
4,96 Kg	4,5 Kg	6,8 Kg	7,9 Kg
N.A	?	No	Yes
N.A	?	?	1,2 m
N.A	?	?	?
?	No	No	No
?	?	No	Yes
?	No	?	Yes
1 hour at 60°C	?	4 hours	?
Brushed chrome, black	brushed aluminium, black	Black and stainless steel	Steel, silver, black
?	Yes (min, 150, 175 and 200 F)	Yes (off, low, medium high)	No
?	No	No	No
Yes	No	No	Yes (green)
Yes	Yes	Yes	Yes
Yes	No	No	Yes
?	No	No	Yes
?	N.A	N.A	8 min for 1 hour
Yes	Yes	Yes	Yes (red)
?	?	?	Yes
?	?	N.A	N.A
?	No	No	No
?	?	ETL listed	?
143.74 BRL Online retail stores	783 BRL Online retail store	177 BRL Online retail store	218 BRL Online retail store




CHW-A1M Chunhe	Bandeja Térmica Elétrica Soprano	2260 Cotherm	STS 70 Hot tray Salton
95°C	?	?	125°C
30°C	?	?	?
?	?	?	?
?	?	?	?
?	?	?	?
653 x 335 x 45	530 x 280 x 50 mm	680 x 380 x 90 mm	?
533 x 333 mm	?	?	590 x 350 mm
200 W	800 W	400 W	500 W
220-240 V	110 V	110 - 230 V	230-240 V
?	60 Hz	?	?
?	?	3,5 Kg	?
Yes	Yes	?	?
1,0 m	?	?	?
No	?	?	?
No	?	No	Yes (350 x 170 mm, +30°C)
No	?	?	?
?	Yes	Yes	Yes
?	?	?	?
Metal casing, gold color	Ceramic	Stainless steel, black	Black
Yes	Yes	Yes	Yes
No	No	?	?
No	No	No	?
Yes	No	Yes	Yes
No	No	No	?
No	No	No	?
N.A	N.A	N.A	?
Yes	Yes	Yes	Yes
	?	?	?
Yes	?	?	Yes
	?	?	?
	?	?	?
			?
77 BRL Online retail store	207 BRL Online retail store	559 BRL Online retail store	637 BRL Online retail stores

		Hotplate	Average values
Glass warming tray VGHT-500	1480	Name	N.A
Sunbeam	Broilking	Brand	N.A
		Technical details	
?	96°C	Maximum temperature	113°C
?	68°C	Minimum temprerature	64°C
?	?	Heat up time	8 min
?	?	Cooldown time	?
?	?	Technology	N.A
?	565 x 387 x 57 mm	Product size	633 x 347 x 79 mm
?	520 x 356 mm	Size heated surface	561 x 356 mm
450 W	300 W	Power (W)	556 W
230 V	120 V	Power (V)	5 x 220-240 V, 5x 110-120 V
50 Hz	60 Hz	Power (Hz)	50-60 Hz
?	3,2 Kg	Weight	5,2 Kg
		Usage	
?	No	Removable power cord	5 x Yes, 3 x No
?	?	Length power cord	1,2 m
?	No	Cord storage	1 x Yes, 2 x No
Yes	No	Hotspot	3 x Yes ,8 x No
?	No	Non-stick surface	1 x Yes, 2 x No
?	No	Automatic keep warm function	6 x Yes, 2 x No
3 hours	?	Keeps food warm for approx.	1 - 4 hours
Black and grey	Porcelain, black	Color and/or material	ıainly black and metal, 2 cerami
Yes digital time and temp contol	Yes, 3 modes	Adjustable temperature	8 x Yes, 2 x No
Yes	No	Temperatur indicator	2 x Yes, 8 x No
?	No	Heat-up/ ready to use indicator	2 x Yes, 9 x No
Yes	Yes	Handles (stay cool)	11 x Yes, 2 x No
No	No	Cordless	3 x Yes ,9 x No
No	No	Rechargeable	2 x Yes, 9 x No
N.A	N.A	Chargetime	8 min for 1 hour
		Safety	
Yes	Yes	Power indicator	13 x Yes
Yes	?	Over heat protection	3 x Yes
?	N.A	Tempered glass surface	3 x Yes
?	?	Waterresistant*	3 x No
?	UL Safety & Sanitary, C-UL	Certification	N.A
?			
		Market	
600 BRL	223 BRL	Price	320 BRL
Online retail stores	Online retail store	Shop	N.A

Company collage


LG

Characterisation class C

Stated below are four characterisations of the four seperate groups with class C as indicated by IBOPE:

Conformists:
Lurdes Conceicao is 50 years old and she's a cleaning lady. She finds it difficult to save money for her retirement since she doesn't has FGTS (pension fund). She bought a refrigerator and a stove in installments that improved her life but not much.

Personalities:
Carlos Eduardo is a levy supervisor. During the week he wears a tie and suit to his work and likes this because it gives him status. Accordingly he likes to buy top brand items. On the weekends he wears sneakers from foreign brands to show for everybody.

A consumers family:
Sandra has 5 children and is 46 years old. She lives in Morro dos Prazeres in Rio de Janeiro with her husband who's is a construction worker. Sandra would like to move to another place but she doesn't has enough money to do that, partly because she spends her money on a television and a stove that she now has to pay in installments.

A rational couple:
he is a postman and she is a girl who works in a non-governmental organization in Sao Paulo. The both have a childhood-dream to travel outside Brazil. To do so they partly paid for the trip and pay the rest of the money in installments. This financial agreement enabled them to travel to Chili for one week.

Questionnaire form

Ficaremos muito gratos se você puder responder este questionário cujo objetivo é conhecer seu interesse e expectativa em relação a uma nova bandeja elétrica para uso doméstico e profissional. Agradecemos, também, se puder justificar suas respostas. Observe que algumas questões têm explicações indicadas com asteriscos (*).

1. Quantos anos você tem?

……

2. Com quantas pessoas você mora?

……
……
……
……
……
……

3. Genero?

……

4. Qual é a sua renda mensal? Escolha uma das opções e marque-a com um círculo.

Menos de R$ 740,00 / entre R$ 740,00 e R$ 1.209,00 / entre R$ 1.209,00 e R$ 3.972,00 /

entre R$ 3.972,00 e R$ 5.481,00 / mais de R$ 5.481,00

5. Você gostaria de usar uma bandeja elétrica para manter alguns alimentos aquecidos enquanto prepara outros? Escolha uma das opções e marque-a com um círculo. Justifique sua resposta.

sempre / algumas vezes / raramente / nunca

……
……
……
……
……
……

6. Normalmente quantos pratos quentes são servidos separadamente em suas refeições? Descreva.

……
……
……
……

7. Você tem tido que comer alimentos frios que deveriam ser ingeridos quentes? Escolha uma das opções marcando com um círculo. Justifique sua resposta.
sempre / algumas vezes / raramente / nunca

……
……
……
……
……
……

8. Com que dimensões e formato uma bandeja atenderia suas necessidades?

……
……
……
……
……
……

9. Onde e como você guardaria uma bandeja elétrica?

……
……
……
……
……
……

10. Você gostaria que a temperatura da bandeja elétrica pudesse ser ajustável?

……
……
……
……
……
……

11. Você gostaria de saber a temperatura da bandeja elétrica ou se contentaria apenas em ser avisado de que ela estaria pronta para uso?

……
……
……
……
……
……

12. Qual seria um tempo razoável de espera para que a bandeja esteja aquecida no ponto de uso?

……
……
……
……
……
……

13. Qual seria um tempo razoável de espera para que a bandeja esteja resfriada a ponto de poder ser tocada?

……
……
……
……
……
……

14. Você gostaria que bandeja pudesse ser lavada em máquina de lavar pratos?

……
……
……
……
……
……

15. De seu ponto de vista, que peso seria aceitável para uma bandeja elétrica?

……
……
……
……
……
……

16. De seu ponto de vista, qual seria um preço razoável para uma bandeja elétrica?

……
……
……
……
……
……
……

17. De seu ponto de vista, seria importante que a bandeja pudesse ser usada sem estar conectada a uma tomada de energia *?

……
……
……
……
……
……

* Quer dizer que a bandeja pode permanecer aquecida por um period sem estar conectada a rede de energia.

18. Qual seria um comprimento confortável para o cabo de alimentação da bandeja*?

……
……
……
……
……
……

* Cabo que conecta a bandeja à rede de energia.

19. Você exigiria que a bandeja tivesse uma ou mais regiões operando a temperaturas mais altas para aquecimento específico?*

……
……
……
……
……
……

* area ou região com temperatura 30 graus acima do restante da bandeja.

20. Você gostaria de fazer alguns comentários ou recomendações sobre a bandeja elétrica?

……
……
……
……
……
……

Muito gratos por responder este questionário!

Questionnaire results

1. How old are you?	55	45
2. With how many people do you live?	0	1
3. Gender?	female	male
4. How much do you earn monthly? Please encircle	more than R$ 5481,00	more than R$ 5481,00
5. Would you like to have an electric tray to keep your food warm whilst cooking? Please encircle and explain.	sometimes, don't need it right now but it might be very interesting in the future	sometimes, I cook for two people and have few plates so I don't need a tray to keep my food warm
6.normally how much seperate warm dishes do you serve? Please desciribe	2	between 2 and 3
7. Do you have to eat food cold whilst it actually should be eaten warm? Please encircle and explain	sometimes, this always happens in restaurants and hotels	rarely
8.What size and format for the tray would meet your demands?	rectangular, 20x60 cm	big enough for two plates
9. Where and how would you store an electric tray?	inside the oven	kitchen closet
10.Would you require the temperature of the tray to be adjustable?	yes, it should maintain the required temperature automatically	yes
11. Would you like to know the temperature of the electric tray or would a simple indicator that tells you when the tray is ready to use suffice?	if it is possible yes and it should have the indication that you can burn yourself	yes I want to know the temperature
12. What do consider an acceptable time for the tray to heat up to the desired temperature?	more or less 2 minutes	2 a 3 minutes
13. What do you consider a reasonable time for the tray to cool down to the point of being touchable?	more or less 5 minutes	2 a 3 minutes
14. Would you require the electric tray to be dishwasher proof?	I don't think it is necessary but it is important that the material is easy to clean	yes
15. What do you consider an acceptable weight for the tray?	0,5 kg	not important
16. What do think is a good price for an electric tray?	between R$ 350 and R$ 500	R$ 200
17. Do you find it important that the tray can be used without being connected to a power outlet?	That would be perfect	no
18. What do you think is a good length for the power cord?	60 cm	150 cm
19. Would you require the tray to have hotspots that have a higher temperature then the rest of the tray?	That's not necessary, because one temperature is good enough for everything	no
20. Would you like to make some comments and/or recommendations on the electric	this poject is great, congratulations for all of the group	easy to clean

49 1 female	40 1 female	24 1 female	60 1 female
between R$ 3972,00 and R$ 5481,00	between R$ 740,00 and R$ 1209,00	between R$ 3972,00 and R$ 5481,00	more than R$ 5481,00
never, because I like to prepare or warm my food in the microwave	sometimes, if I would need I would use	sometimes, I would only use it in the weekends	sometimes, when I receive friends to diner
2	more or less 2 or 3	2 or 3	4, rice, beans, meat and vegetables
never, I immediately eat the food I prepare	rarely	never	never, I like to eat directly after preparing
I don't use trays	more than one plate	rectangular, 30x50 cm	rectangular, 30x50 cm
on the countertop in a fixed place so I don't have to move it al the time	the oven	the closet	closet
I don't use trays	of course, yes	yes	yes
I'm not interested in this product	Yes I would like to know the temperature	yes, I would like to know the temperature	yes, I would like to know the temperature
I'm not interested in this product	1 minute	5 minutes	5 minutes
I'm not interested in this product	2 minutes at most	10 minutes	10 minutes
I'm not interested in this product	not important	no	no
I'm not interested in this product	0,5 kg	2,5 kg	2 kg
I'm not interested in this product	R$ 30	R$ 110	R$ 100
I'm not interested in this product	It is better if it has a battery	yes	not necessarily
I'm not interested in this product	20 cm	3 meters	3 meters
I'm not interested in this product	interesting	no	no
I'm not interested in this product	no	no	It would be nice if only the top side of the tray warms up

1. How old are you?	41	43	45
2. With how many people do you live?	2	2	2
3. Gender?	male	male	female
4. How much do you earn monthly? Please encircle	more than R$ 5481,00	-	between R$ 740,00 and R$ 1209,00
5. Would you like to have an electric tray to keep your food warm whilst cooking? Please encircle and explain.	sometimes	might be interesting but I am doubtfull about the advantage over the mircowave. However it might be very useful for using during a churrasco	yes, always
6.normally how much seperate warm dishes do you serve? Please desciribe	2	3 a 4, rice, beans, some meat and some vegetables	4
7. Do you have to eat food cold whilst it actually should be eaten warm? Please encircle and explain	sometimes	always, I always eat some plates warm. When the food becomes cold I use the microwave. I think the prinicpal application should be to keep the meat warm during a churrasco.	always
8.What size and format for the tray would meet your demands?	25 x 20 cm	It is difficult to tell what shape it should have but for the application for a churrasco I think the perfect size is like the common tray. Maybe three sizes is a good idea.	round
9. Where and how would you store an electric tray?	closet	I will put it with the other kitchen appliances	closet
10.Would you require the temperature of the tray to be adjustable?	yes	yes, but the most interesting is that you can adjust the voltage with a PID control. This is perfect for frying eggs without oil.	yes
11. Would you like to know the temperature of the electric tray or would a simple indicator that tells you when the tray is ready to use suffice?	yes	It would be nice if you can adjust the Joules/sec in order to cook or fry eggs.	yes
12. What do consider an acceptable time for the tray to heat up to the desired temperature?	1 minute	Can't be too long, about 2 or 3 minutes	1 minute
13. What do you consider a reasonable time for the tray to cool down to the point of being touchable?	1 minute	2 or 3 minutes also	30 minutes
14. Would you require the electric tray to be dishwasher proof?	yes	yes	no
15. What do you consider an acceptable weight for the tray?	0,1 kg	The same weight of the common tray but can't be too light because then it can fall of the table too easily	2 kg
16. What do think is a good price for an electric tray?	R$ 100	between R$ 100 and R$ 400, depends on the quality	R$ 250
17. Do you find it important that the tray can be used without being connected to a power outlet?	yes	This is perfect, maybe you can combine the function of the rechaud with the electric tray	yes
18. What do you think is a good length for the power cord?	0	2 meters, should be very flexible	2 meters
19. Would you require the tray to have hotspots that have a higher temperature then the rest of the tray?	no	can be complicated for domestic use but great for professional usage.	yes
20. Would you like to make some comments and/or recommendations on the electric	no	I think the application for churrasco is great. Use the tray to fry things. Using the tray to cook the vegatables on the table can be interesting. It's important to think about cleaning the tray.	no

27	49	42	48	19	30
2	2	3	3	3	3
male	-	male	male	male	female
between R$ 740,00 and R$ 1209,00	between R$ 740,00 and R$ 1209,00	more than R$ 5481,00	between R$ 1209 and R$ 3972	between R$ 1209 and R$ 3972	less than R$ 740
never	sometimes	sometimes, when I recieve guests	Rarely, because I cook the things that have to be hot at the end	sometimes	always, it would be nice to have something to keep your food warm while I cook another dish
3: rice, beans and mixed	2	2: meat and pasta	2: meat and vegetables	2	1
never	rarely, just when I don't have some place to heat	rarely, normally I warm in the microwave when the food is cold	sometimes, because I like cold food	sometimes I prepare my food and at the same time I will do another activity like taking a shower. Therefore my food gets cold sometimes.	never, I can't eat cold food
-	all shapes	30 x 50 cm	rectangular 30 x 20 cm	rectangular 30 x 15 cm	rectangular
closet	closet in a box	vertically	in the closet	in a box in the closet or cellar	depends of the dimensions, I would put it in the closet
yes	yes because I want to keep the food at the desired temperature	yes	yes	yes sure	yes
I would like to have a something that tells me the temperature	I want to know the temperature	yes, I would like to know the temperature	yes I would like to know the temperature	I would like to know	I would like to know the temperature
2 minutes	30 minutes	3 minutes	3 minutes	between 5 and 8 minutes	between 30 minutes and 1 minute
5 minutes	35 minutes	15 minutes is acceptable but it should tell you when it's cold	5 minutes	between 10 and 15 minutes	30 minutes
no	no, I want to wash this normally	Yes that would be great!	I don't think is necessary	yes	yes
2 kg	the same weight as a big fryingpan	2 kg	3 kg	less than 1 kg	2 kg
R$ 50	R$ 75	R$ 100	less than R$ 100	between R$ 40 and R$ 60	R$ 250
yes	Yes but I wouldn't know how	This is not important but it would be great	yes, because I want to move around with the tray	yes	yes
1 meter	more or less 2 meters	more than 3 meters	10 cm	between 1 and 1,5 meter	2 meters
no	Depends on the food	This would be great to	I think it would be usefull for heating each food adequately	no	yes
-	no	It would be very innovative to be able to interact with the tray	I would like to receive information in the form of a guide about the time it takes for the food to get or stay	-	no, but the tray will be very helpfull

1. How old are you?	25	30	24	50
2. With how many people do you live?	3	4	4	5
3. Gender?	male	male	male	-
4. How much do you earn monthly? Please encircle	between R$ 1209 and R$ 3972	between R$ 1209 and R$ 3972	between R$ 1209 and R$ 3972	between R$ 740,00 and R$ 1209,00
5. Would you like to have an electric tray to keep your food warm whilst cooking? Please encircle and explain.	sometimes, depends on the food	Rarely, normally I don't prepare food.	always, could be something interesting to use in the kitchen	always, it would help a lot
6.normally how much seperate warm dishes do you serve? Please desciribe	1, one plate is warm the other is cold	1	between 2 and 3 plates	rice, beans, meat, etc.
7. Do you have to eat food cold whilst it actually should be eaten warm? Please encircle and explain	no, I choose well what I will eat	rarely, just in my home because I don't care if my food get cold	Rarely, sometimes I use the warmth of the oven to keep the food warm	never
8.What size and format for the tray would meet your demands?	the dimensions should fit one hot plate, one cold plate and one dessert	maybe 20 x 12 cm	Should be something I could fit in the oven	A shape big enough to serve food for six persons
9. Where and how would you store an electric tray?	I never saw this tray	in the kitchen	I can imagine that it should be something that is easy to transport. For instance the dimensions of a baking tray	closet
10.Would you require the temperature of the tray to be adjustable?	I don't like the food hot or cold but in between	no	yes, because I can use the tray to keep warm a lot of different kinds of food	yes
11. Would you like to know the temperature of the electric tray or would a simple indicator that tells you when the tray is ready to use suffice?	between hot and cold	maybe just to know if it's warm	a numeric indicator would be very suited for this essential function	yes, because that will show me that the temperature is right
12. What do consider an acceptable time for the tray to heat up to the desired temperature?	1 minute	3 minutes	between 1 and 2 minutes	4 minutes
13. What do you consider a reasonable time for the tray to cool down to the point of being touchable?	mere seconds	5 minutes	between 3 and 5 minutes	depends on the set temperature of the tray
14. Would you require the electric tray to be dishwasher proof?	not necessary	It will be interesting to have that option	could be good	no
15. What do you consider an acceptable weight for the tray?	light	2 kg	between 1 kg or less	as light as possible
16. What do think is a good price for an electric tray?	cheap, the person should have more than one tray	R$ 50 at most	I don't have an idea of the price, but between R$ 50 and R$ 100 would be a good price	depends, I really have no idea
17. Do you find it important that the tray can be used without being connected to a power outlet?	could be an option	not necessary	It's not important, because this technology will make the product more expensive	yes
18. What do you think is a good length for the power cord?	adapted and flexible	between 1,5 and 3 meters	2 meters	as short as possible
19. Would you require the tray to have hotspots that have a higher temperature then the rest of the tray?	controllable	no	for me it is not important but maybe there will be people interested in this	yes
20. Would you like to make some comments and/or recommendations on the electric	I am curious to see this tray working	the tray appears to be similar to a product we use during a churrasco	this product can be well price, easy to transport and very durable	I cannot say for I will have to use the tray first

53	29	26	52	19	41
5	5	5	5	6	6
male	male	female	-	male	female
between R$ 3972,00 and R$ 5481,00	between R$ 740,00 and R$ 1209,00	between R$ 1209 and R$ 3972	between R$ 3972,00 and R$ 5481,00	between R$ 740,00 and R$ 1209,00	less than R$ 740
sometimes, to warm the rice and the beans	Rarely, could be. I don't cook.	Rarely	sometimes, these kind of domestic appliances make your life easier	sometimes when you prepare multiple plates the plate you prepared first becomes cold	always
3: bean, rice and pasta	When I have luch in my home I always have 3 plates: rice, beans and meat. Sometimes I make more than 3 seperate plates	4	rice, beans, vegatables and souffle	2	4
never	never, when I eat warm food the remains hot enough to eat the food at the right temperature during diner.	never	never	sometimes, I really don't like cold food and because of that I spend to much gas	always
-	rectangular, 60 x 30 cm	round	I don't know if the shape will be of importance for I think the functional aspect is more important.	rectangular or square	round
-	at the kitchen with some protection	closet	closet	In a place that is appropriate and safe	closet
-	yes, some foods require different temperatures to be kept at the appropriate temperature	yes	yes I am sure	yes this is important for preventing the food from drying out, keepint it at the right temperature and maintaining the flavour	yes
I would like to know	I would like to know	yes	That would be great but just a simple light to show the tray is ready is sufficient	yes	yes
2 minutes	between 2 and 3 minutes	20 minutes	1 minute	between 15 and 30 minutes	1 minute
5 minutes	between 7 and 10 minutes	15 minutes	generally 20 to 30 minutes	between 20 and 30 minutes	30 minutes
no	yes, it will be convient	yes	I don't think it's necessary	yes because that would make the washing really easy	no
2 kg	less than 1 kg	800 grams	max. 300 grams	between 3 kg and 2,3 kg	2 kg
R$ 50	between R$ 60 and R$ 100	R$ 400	I don't have an idea	between R$ 500 and R$ 750	R$ 250
yes	yes this way I can safe energy and I can use it everywhere I want to	yes	yes I think it would be great	This is a really good feature because it will safe energy	yes
1 meter	10 cm	40 cm	70 cm	between 2 and 3,3 meters	2 meters
no	For me this is not necessary	yes	that is not necessary	yes because then it can warm a lot of kinds of food	yes
-	No, this is sufficient	-	the dimensions should be appropriate for usage in the kitchen and it should be	Easy to transport	no

INMETRO

Intertek

Valued Quality. Delivered.

Certifying Household Appliances and Consumer Electronics for the Brazil Market

Brazil Certification, In a Snapshot:

Mandatory Certification – Safety 	• Compulsory certification for household appliances in July 2011
Certification body	• According to SBAC, the mandatory certification for household and similar electrical appliances should be performed by the Product Certification Organization – OCP, accredited by INMETRO
Energy Efficiency Requirements	• Mandatory Energy Efficiency labeling is required for certain products
Safety standards	• Brazil National Standards (NBR) are primarily IEC-based standards • Power supply cords must meet specific requirements for conformity assessment • Household and similar single phase appliances - safety of nominal voltage not higher than 250 V • 480 V for all other appliances
Mandatory certification mark	• INMETRO Mark, plus the mark of the certifying organization
EMC requirement	• Not required at this time
User manual in local language	• Portuguese is required for mandatory certification • Portuguese, Spanish or English is acceptable for voluntary certification • Portuguese rating and label required
Delivery time at the certification body	• Varies between 1-3 months for product and certification requirements
Annual Requirements	• Follow up services • Annual retesting

Calculations

I) The heat transfer from the pan to the environment.

The pan has a diameter and height of 20 cm and the lid is closed. Mainly two types of heat transfer take place: radiation and convection. Convection can be split further into the convection of the cylinder wall and the convection of the lid. To model the thermal behaviour of the cylinder wall it is considered a vertical flat sheet of aluminium. The average temperature, i.e. film-temperature, is the average between the temperature of the pan and the temperature of the environment.

$$T_f = \frac{T_p + T_\infty}{2}$$

From this it follows that the film-temperature is 315.5 K. At this temperature the kinematic viscosity of air is $\vartheta = 1.702 \cdot 10^{-5} m^2/s$, the Prandt number is $Pr = 0.7255$ and the thermal conductivity is $k = 0.02662\ W/m \cdot K$. With these values it is possible to determine the Raleigh number and the Grasshoff number which is important for verifying if the cylinder wall can be considered to reassemble a vertical sheet. The Raleigh number is calculated by:

$$Ra_{L_c} = Gr \cdot Pr = \frac{g \cdot \beta \cdot \left(T_p - T_\infty\right) \cdot {L_c}^3}{\vartheta^2} \cdot Pr$$

with: $\beta = 1/T_f$ and $L_c = H$ which is the height of the pan. From that is follows that $Gr = 0.0945$ and $Ra_{L_c} = 2{,}18 \cdot 10^7$. As a rule of thumb a cylinder can be considered to reassemble a vertical face if the Grasshoff number is smaller than 0.2 which is true in this case. Also, if the Raleigh number is smaller than 10^7 and bigger than 10^4 then the following formula for the Nusselt number applies:

$$Nu = 0.59 \cdot {Ra^{1/4}}_{L_c}$$

The Nusselt number is found to be 40.3 and can be used to calculate the heat transfer coefficient *h* with:

$$h = Nu \cdot \frac{k}{H}$$

where $k = 0.02662$ and $H = 0.2\ m$. Then the heat transferred by convection can be calculated by:

$$\dot{Q}_{conv.} = h \cdot A \cdot \Delta T = h \cdot A \cdot \left(T_p - T_\infty\right)$$

From that it follows that the heat transferred from the pan's cylinder wall to the environment is 23.6 W. Roughly the same calculation can be made to determine the heat transferred by the lid through convection. The only difference is the horizontal orientation and this is accounted for by a slightly different correlation between the Raleigh and Nusselt number. Repeating this calculation shows that the heat transferred by the lid through convection is 7.6 W. The total heat transferred by convection is thus 31.2 W. Besides convection there is also radiation. The heat transfer through radiation can be calculated with the Stefan-Boltzmann formula:

$$\dot{Q}_{rad.} = A \cdot \sigma \cdot \varepsilon \cdot \left(T_p^4 - T_\infty^4\right)$$

where A is the heated surface area, σ is the Stefan-Boltzmann constant (5.67x10^{-8} W m^2 K^{-4}) and ε is the emissivity of the pan's surface. The total surface area of the pan 'seeing' the environment is 0.157 m^2. When applying Stefan-Boltzmann's formula with ε = 0.5, which is the emissivity of an aluminium pan with an oxide layer, it follows that P_{pan} = 20 W. Hence, the total heat transferred to the environment, i.e. heat flow, is approximately 51 W.

II) The heat transfer from the glass surface to the pan.

The pan requires 51 Watts of heat energy to stay at 60°C. This energy is transferred to the pan mainly by conduction and radiation. In order to determine how much energy is transferred by each of these it is necessary to find the required surface temperature of the glass. This temperature is found by solving the following formula:

$$\dot{Q}_{total} = \dot{Q}_{cond.} + \dot{Q}_{rad.} = k \cdot A_p \cdot \frac{T_g - T_p}{d} + \varepsilon_p \cdot \sigma \cdot A_p \cdot \left(T_g^4 - T_p^4\right)$$

where A_p is the surface area of the pan, $k = 0.028 \frac{W}{m} \cdot K$ at the estimated film-temperature of 70°C and σ is the Stefan-Boltzmann constant (5,67 x10^{-8} W m^2 K^{-4}). Concerning the thickness of the layer of air *d,* the bottom of the pan is never perfectly flat thus there will always be a small layer of air between the pan and the heated surface. It's assumed the air is trapped between the pan and the heated surface i.e. there is no free convection. In order to make an estimation of the required temperature T_g it's assumed that the air layer has a thickness of 0.5 mm. From the formula it follows that $T_g = 360\ K$ or 87°C. With this temperature it is possible to calculate the heat flow by conduction and radiation.

$$\dot{Q}_{cond.} = k \cdot A_p \cdot \frac{T_g - T_p}{d} \quad \& \quad \dot{Q}_{rad.} = \varepsilon_p \cdot \sigma \cdot A_p \cdot \left(T_g^4 - T_p^4\right)$$

By solving these equations the heat flow through conduction is found to be 47 Watts and the heat flow through radiation is 4 Watts. This shows that radiation is relatively unimportant for heating the pan.

IV) The total heat transferred to both the environment and the pan.

In order to estimate how energy efficient the tray is it's necessary to know the total heat flow of the tray.

$$\dot{Q}_{tray} = \dot{Q}_{pan} + \dot{Q}_{rad.\ glass\ top} + \dot{Q}_{conv.\ glass\ top} + \dot{Q}_{rad.\ glass\ bottom} + \dot{Q}_{cond.\ glass\ bottom}$$

The heat flow at the top side differs from the heat flow at the bottom side because there is a pan on

$$\dot{Q}_{rad.glass\ top} = \varepsilon_g \cdot \sigma \cdot A_g \cdot \left(T_g^4 - T_\infty^4\right)$$

where A_g is the total surface area minus the surface area of the pan. The emissivity of a blackbody radiator is 1 (by definition) while any real object will have an emissivity smaller than 1. Glass normally has an emissivity of about 0.9 and it is assumed this is not very different for tin-oxide coated glass. Consequently, the heat flow through radiation at the top side is found to be 77 Watts. The same can be done to calculate the heat radiated at the bottom side, only this time the entire surface area is taken into account. From this it follows that the heat radiated at the bottom side is 92 Watts. By repeating former steps in a similar fashion i.e. calculating the Rayleigh number, the Nusselt number and the heat transfer coefficient, the heat flow through convection at the top side is found to be 68 Watts. Now only the heat flow by conduction has to be calculated.

$$\dot{Q}_{cond.} = k \cdot A_g \cdot \frac{T_g - T_\infty}{d}$$

Where A_g is the total heated surface of the tray, T_g is the temperature of the glass, T_∞ is the environment temperature and The k of air is $0{,}024 \frac{W}{m} \cdot K$. The heated surface will rest about 2 centimetres above the ground thus d is 0.02 metres. The heat flow by conduction at the bottom side is found to be 15 Watts. All together the total heat flow of the tray is thus:

$$\dot{Q}_{tot} = 51 + 77 + 68 + 92 + 15 = 303\ Watts$$

Demands & wishes explained

Target price R$ 175

The market analyses showed electric trays tend to be cheap (around R$ 175) or expensive (around R$ 645) and this tendency can also be seen when looking at the answers to the questionnaires. Eighteen out of twenty-one people believe a price between R$ 250 and R$ 30 is a good price and the other three consider R$ 400 to R$ 625 to be a good price. This also gives the suggestion that there is a bigger market for cheap low-end appliances than there is for high-end ones. When looking at the average price as indicated by respondents from class C, which is about R$ 135, and since its decided in the market analysis to focus more on the cheap segment the appropriate price for the product will be about R$ 175 or less because that is the average price of the products in the cheap segment and this corresponds more or less to the overall average price that follows from the questionnaire which is about R$ 173. This price is a general indication and should be adjusted to fit specific concepts.

The tray must be able to double as cutting board

A tray that doubles as a cutting board comes in handy and can be very convenient since it allows you to cut food without it getting cold. This is especially useful during barbeques that take place all the year and are an important aspect of the Brazilian food culture. As a cutting board the tray can stay on the countertop because it will have a daily function.

The tray must be slim and thin, around 30 mm

Fourteen out of eighteen respondents, would store the tray in the closet. This urges the demand for a slim and sleek tray so it can be stored easily. From the product comparison it follows that the slimmest product is 60 mm thick, which is still quite thick when looking at the possibilities of having a sheet of glass for a heating element. In order to truly provide an advantage over comparable products the tray should be really thin i.e. around 30 mm thick. This thickness still provides enough room for handles etc. to pick up the tray.

Maximum heat-up time of 5 minutes

When looking at the time people consider acceptable for the tray to reach the desired temperature it stands out that three people are content with more or less 30 minutes whilst the other 21 people demand a heat up time of 3 minutes and 29 seconds on average. Especially when looking at the average heat up time of 8 minutes that follows from the product comparison this 3 minutes and 29 seconds seems to be a little optimistic. A target value of 5 minutes to reach the desired temperature is a good endeavour and if the product can't meet this demand one should keep in mind that 8 minutes probably also satisfies the demands of most people.

Maximum cool down time of 13 minutes

Concerning the cool down time, on average, people require the tray to be cold enough to handle after 12 minutes and 21 seconds. Some people require it to be cold after 1 minute whilst others are content with 35 minutes and, in contrast to the heat up time, there is no obvious common value but 13 minutes seems a reasonable target value.

Temperature range between 64°C and 113°C

From product comparison it follows that this is the average temperature range. Calcula-

tions have shown that it already takes a surface temperature of 87°C to keep a pan at 60°C so the maximum temperature of 113°C seems to be a good estimate.

Must be able to withstand thermal shock
Especially food coming out of the stove can be very hot (280 °C) and if placed directly on the tray the thermal shock can shatter the glass surface.

The glass must be safe
This is an obvious yet very important feature for it ensures the safety of the users.

The tray may not damage the underlying surface
Although quite trivial; this aspect may not be overlooked. Sharp edges and heat can damage the underlying surface.

Cool area's that enable the user to move or carry the tray when hot.
That the tray can also be used as a serving tray is not a real demand but naturally it's essential that users can move the tray at all times without burning themselves.

Adjustable temperature
All but one respondent require the temperature to be adjustable and a handful of respondents consider this to be an essential function for keeping the food in the desired condition. From the product comparison it also follows that virtually every product has an adjustable temperature range.

Heating indicator (an indicator light suffices)
Virtually every respondent wanted to have an indicator that tells the temperature and only a few really want to know the exact temperature. For most people a simple indicator light that shows when the desired temperature is reached suffices. The product comparison shows that this isn't a common feature which is remarkable since most products probably have a temperature sensor anyway for maintaining the desired temperature.

Overheat protection
This feature is probably obligatory and even if it isn't it is very wise to integrate this feature to ensure safe operation.

Maintain desired temperature automatically
This feature can be found in most comparable products and is essential for keeping the food at the desired temperature.

Maximum weight of 3 Kg
Whilst the weight according to the product comparison is around 5,2 Kg on average it follows from the questionnaire that the weight should be 1,5 Kg when averaging the answers. 3 Kg is mentioned two times as being the maximum weight and all the other answers are below that value. The tray with the lowest weight weighs about 3,2 Kg. A sheet off glass with a surface area of 2016 cm2 and which is 5 mm thick already weighs around 2,4 Kg, so 1,5 Kg is not a realistic target value. 3Kg is a nice target value which still allows the tray to be used as a serving tray. An average plate with food weighs about 1,3 kg. This means that two plates with food and the tray together will weigh at least 5 Kg which is already quite substantial but still light enough to carry.

Maximum power consumption of 350 W

The best way to make the product more environmentally friendly is by the reduction of energy consumption. More importantly, low energy consumption is one of the major considerations when buying these kinds of products. Therefore, the power consumption should be as low as possible. From a preliminary calculation it follows that it takes about 303 W to keep a pan at 60°C through thin film heating. However, this is without regard to extreme scenarios or further optimisations. The product comparison shows that the average power consumption is 556 W and that the lowest is 200 W but this is accompanied by a relatively low temperature range. Hence, 350 W is a realistic yet ambitious target value.

Automatic fault and glass breakage detection to ensure safe operation.

Because the heating element is inseparably attached to the glass surface this might result in a shock hazard and/ or short circuiting when the heating surface fails.

A surface area of about 2016 cm2

This is the average surface area that follows from the product comparison and with the questionnaire in mind, this is a good initial target value. When looking at the trays function as a serving tray, it only has to be big enough to carry 2 plates because more would become too heavy to carry.

Power cord of 1,6 m

From questionnaire it follows that 1,56m is the average required length for the power cord. The average length that follows from the product comparison is 1,2m. Gourmet grills are used in similar environments under comparable conditions and usually have a power cable of about 1,5m so 1,6m should be adequate.

Removable power cord

When storing the product this will come in handy. It also makes the product safer since the cord is likely to unplug when people trip over the wire. If the power cord fails it's not necessary to throw away the entire product. Lasty, this feature is essential for the trays function as a serving tray.

Voltage lower than 42,2 V

If a product meets the SELV standard (safety extra low voltage) it doesn't has to meet high requirements on insulation and grounding. The SELV standard states that the voltage between components or a component and the chassis cannot be higher than 42,2 V

The tray must be water resistant

The kitchen is a wet environment and substances can leak or spill on the tray so the tray has to be water resistant to prevent damage or shock hazard

The tray must be usable as a serving tray

If the food is prepared and placed on the tray it is very convenient to carry it to the dining place like that directly. This is a very handy function that naturally follows from the proposed low weight, removable power cord and cool area's for moving and carrying the tray. With some minor adjustments the tray can meet this demand. Most importantly, some people will probably use the tray as a serving tray anyway even if that wasn't the initial purpose. Hence, it's better to facilitate this usage in a pleasant and safe way.

Comply with the new power plug standard (NBR 14136)
The outlets used to be of type A, B, C and I but since 2010 all devices and new buildings must comply with NBR 14136 type.

Meet requirements INMETRO
Mandatory safety certification mark.

Wishes:
Hotspots
Hotspots can reduce energy consumption, because they can selectively heat a dish that needs to be extra hot. Thereby you also prevent other dishes, that don't need to be that hot, from overheating and drying out.

A guide that tells you what temperature is suitable
Providing different heating programs, as is the case with many microwaves, can stimulate adequate heating and thereby also safe energy. Instead of creating different programs which might be a bit overkill and difficult to implement because of the wide range of possible uses it is also possible to provide an analogue guideline that tells you what temperature is adequate.

Automatic shut off function (can be adjustable)
An automatic timer that shuts off the tray after an hour or so prevents needles energy consumption and is also safer. Making the timer adjustable ensures sufficient heating time, assuming a big enough range, and will probably safe even more energy.

A heating surface that takes the thermal behaviour of the objects to be heated into account for maximal efficiency
It is expected that heating certain area's more than others is more energy efficient because energy losses are not homogenous.

Dishwasher proof
Especially when food is encrusted on the surface this will prove to be a very handy feature.

Wireless usage
Wireless operation is a very welcome feature when looking at the answers to the questionnaire. Eighteen people would like to have this function and only five think it's not necessary. However, there are two big downsides to this feature and that is the increase in price and weight. What makes wireless usage so interesting is the possibility of using it everywhere, carrying it around freely and not having a hindering cable that might trip people.

Remote control through smart appliances like smartphones
It is said that about 19% of the C class people had smartphone in 2011 and by now this number probably is way bigger . Therefore using a smartphone as a remote control might prove feasible. A smartphone allows for a more elaborate interface with more control options like timers etc. which might come in handy when developing a very innovative version of the tray.

Different possible lengths of power cords
Having the adequate power cord length will improve usability.

Automatic switch on/off function that responds to usage
As a form of power management this feature will lower power consumption and improve the product's safety since people often forget to turn off these kind of products.

Detecting objects and subsequently heating the corresponding area
Only heating the required area will save a lot of energy.

Production in and supplies from Brazil
Strengthening the Brazilian economy is one of the mail goals of ABINFO and by producing the product in Brazil and not in China one also saves energy on transport. For these two reasons production in Brazil is a real ambition.

Providing visual feedback through edge and surface lighting
This will provide very intuitive feedback and will make the product more aesthetic.

An user interface that is integrated in the glass surface
Besides offering an elegantly integrated interface that will appeal to a lot of people this solution is also very hygenic. Quite possibly this way of creating the desired controls and feedback can be very cheap. For instance when the tin oxide layer is etched anyway, adding a few extra cicruits won't be that expensive. Moreover, adressing this aspect might result in new solutions that can be pattented by ABINFO

A heating surface which is flexible in size
Since food normally is served in several containers of different sizes and is passed around frequently it would be nice to have separate segments that can be scattered or combined to form the desired heating surface at the desired location instead of having one big central tray. Also, if developed further, this solution could possibly be patented by ABINFO.

Energy label, if the product proves to be energy efficient
This may sound a bit opportunistic and it is. When the tray proves to be more energy efficient than other comparable products this should be emphasized by applying a voluntary energy label.

Scenario's

In order to make a good assessment concerning the feasibility of the concepts it is necessary to look at the possible future courses of this project for, say, the next 6 months. This is done by enumerating the most decisive aspects for the future development. Combining these yields a series of possible scenarios that help in determining on what concepts should be focussed. To complete the overall image each scenario is graded by likelihood:

Confirmed
Very likely
Likely
Possible
Unlikely
Very unlikely
Near to impossible

I. No funding, no collaboration (very likely)
II. Funding to continue the project
  - funding because of technological innovation (very unlikely)
  - funding because of product (very unlikely)
III. Collaboration with external party (possible)

A. Just the current staff (very unlikely)
B. Employee/ trainee/ student with technical background (possible)
C. Employee/ trainee/ student with industrial design background (confirmed)
D. Hired professional/ expert in required field (very unlikely)

	I	II	III
A	1	2	3
B	4	5	6
C	7	8	9
D	10	11	12

Below are the expected consequences of the possible combinations of the former scenarios. Each consequence also has been given an indication of its likelihood to occur.

1. Project will stop (very unlikely)

2. - Technical innovation can be developed further (possible)
   - Product can be developed if simple (possible)

3. ABINFO will take up (part of) the technological innovation (unlikely)

4. Technical development will be continued, overall product design will only be continued if it is a simple concept (very likely)

5. - Technical innovation can be developed further (possible)
   - Product can be developed if simple (possible)

6. ABINFO will take up (part of) the technological innovation (possible)

7. The current project is continued and the concepts are elaborated in order of feasibility. ABINFO will be able to manufacture a simple version for testing. If this is done the concept is developed further to be sold to an external party. (confirmed)

8. - Technical innovations and development of concepts that incorporate these innovations (possible)
   - Quick development of the most feasible concept. The latter depends also on the interest of the investor. (possible)

9. ABINFO can cover both the technical development as well as the overall design. This depends on the size of the external party and the direction which is determined together (likely)

10. Depending on the skill of the expert the product or technical innovations can be developed (unlikely)

11. - Quick development technological innovation (unlikely)
    - Quick development of the most feasible concept. The latter depends also on the interest of the investor. (unlikely)

12. Depending on the size of the external party the direction is determined together. Could be technological innovation and/ or product development. (unlikely)

Nine sigma request

NINESIGMA
Accelerating the Innovation Cycle

PROPOSAL FOR REQUEST #70074

Request Title: Novel Design Concepts or Technologies for Home Appliances

NineSigma Point of Contact: Solution Provider Help Desk

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Additional Organization Information

- **Size :** ABINFO is a non-profit institution for collaborative R&D. ABINFO has laboratories of 100 m2 with facilities for R&D and prototype development in the fields of microelectronics, displays, covering materials, thin films, devices, processes, equipment and systems development and applications.

- **Years in operation:** Since 1988
- **Annual sales:** ~US$ 250.000,00
- **Contract/joint development with large companies:**
  - Contract with the energy company Bandeirante to develop an electric shower based on thin films.
  - Contract with the energy company Companhia Paulista de Força e Luz (CPFL) to develop heating elements based on thin films.
  - Cooperation with Multibras/Whirpool to develop a cooktop based on thin films.
  - Development of a voting system based on touch screens up to prototype level to demonstrate feasibility of an electronic election system to the Brazilian Government.

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- Development of advanced fluorescent lamps with Prest Vacuo (a company in Cotia, SP) in a project funded by the Brazilian Government.
- Development and production of prototypes of digital school desks for the municipality of Serrana City in the State of São Paulo and for Porto Murtinho, Mato Grosso State.

- **Extra information:**
  ABINFO has and had contracts and projects with funding agencies from the Brazilian and State of São Paulo Governments such as: Conselho National de Desenvolvimento Científico e Tecnológico (CNPq), Agência Brasileira de Desenvolvimento Industrial (ABDI), Ministério de Ciência, Tecnologia e Inovação (MCTI), Agência Brasileira de Promoção de Exportações e Investimentos (APEX), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Financiadora de Estudos e Projetos (FINEP) and Fundação de Amparo a Pesquisa do Estado de São Paulo (FAPESP).

Type of Response (place "x" below):

___Idea to be considered for prize money
___Patented or otherwise protected technology to be licensed
_X_Propose for a co-development opportunity

Submission Terms

By placing an "X" in the box below, I verify that I am submitting only non-confidential information. Further I agree to notify NineSigma, should this proposal result in a transaction with NineSigma's customer. (This effort is to ensure proper record keeping).

I agree to NineSigma's submission terms	**X**

Title of Proposal

Electric tray with a conductive and transparent oxide on glass as the heating element

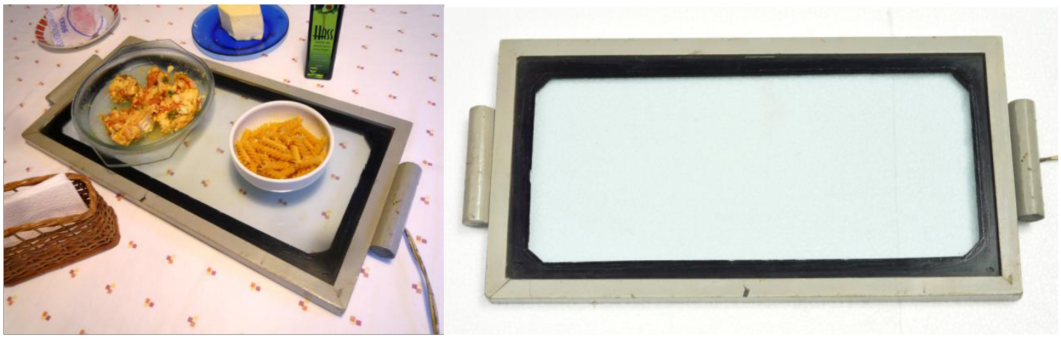
Proposed Idea or Technology

The general idea

ABINFO developed glass coated with a thin conductive oxide (TCO) layer to act as a heating element. When a current passes through the TCO layer, its temperature rises and heat is transferred to the glass substrate and subsequently to the objects and materials to be heated.

The application

Several applications of this technology have been developed by ABINFO, for instance an electric shower, a cooktop and an electric warming tray. These applications have been developed up to working prototypes and yielded promising results, i.e. the prototypes could adequately perform their functions. We think that, among them, the electric tray is the most feasible option because it offers a lot of room for further innovation, has promissing market opportunities, meets well the demands of several groups of consumers and it is easy to develop and manufacture because it is based on previous experience and developing of ABINFO. The initial idea is to develop this product as a try-out to further explore the market and possiblities. One of these future possibilites can be an improved version of the tray, a cabinet to store and display warmed food or a completely different product like a transparent flatiron. ABINFO is working towards patenting the technology and/or design concepts of these applications. Since this submission is not confidential we cannot go in detail yet.



Above: A functional prototype of the electric tray.

What makes this idea so special

What makes this application so unique is the possibility of having a transparent heating element, the expected low cost of fabrication and low energy consumption by heating the contact surface directly. The transparency and simplicity give it a very appealing, sleek and light appearance. The minimalistic look makes it less bulky and loud than most comparable appliances and a glass surface is, and also looks, very hygienic. Furthermore the tray can incorporate innovative features like:

- detecting objects and subsequently heating the corresponding area automatically.
- hotspots that take thermal behaviour into account for maximal efficiency.
- automatic fault and glass breakage detection to ensure safe operation.
- incorporating smart technology to program and control temperature and time to
- ensure optimal operation.
- visual sigaling through edge and surface lighting for improving functionality and asethetics.
- integrating sensors in the glass
- User interfaces integrated in the glass.
- Remote control also by smart phones.

These possible features will impart a modern feeling to the tray, increase its usabillity and provide comfort. The tray can double as a serving tray and a cutting board which comes in handy in cramped urban appartments. Because of these added functionalities and its elegant appearance the tray can sit quietly on the countertop without people feeling the urge to tuck it away immediately after use.

Where we are now

Market and targetgroup analysis have been carried out providing target specifications, demands and wishes. Moreover it yielded valuable and promising insights concerning price range, target group characteristics and market opportunities. These analysis have shown that the product is promising. The technology and additional applications have been explored resulting in a wide range of realistic concepts and possible features like mentioned earlier. Prototyping and calculations concerning the thermal and electrical behaviour have demonstrated that the product can meet the target specifications and demands. So far, five different concepts have been created:

- A super minimal version that fits perfectly in the current and future trend of kitchen appliances.
- A practival variant that emphasizes usability by nifty features like a detachable

dishwasher proof heating surface.

- A flexible modular system that enables the user to create the desired heating area.
- A product concept in response to people's tendency to eat in front of the television. This concepts is focused on making eating in front of the television less cumbersome and more comfortable.
- Besides the minimalistic direction there is also the more decorative and personal trend. This trend can be addressed also since the glass can be decorated in various ways allowing for a wide range of possible designs. Screenprinting, for instance, enables custom graphic designs to be printed on the glass surface.

Required technology

Mainly there are three different kinds of technologies required for making the electric warming tray:

- Coating technology for TCO
- Technology for creating the electrodes
- Conventional techniques for making the housing, shaping the glass, etc.

For future add ons, which will not be included in the first prototype, the following technologies are required:

- Technologies for integrating sensors, electrical circuits and other components.

All these technologies are known and to most technologies there are several alternatives.

Why collaborate?

ABINFO is exactly looking for an opportunity like this because ABINFO doesn't have the intention to actually produce the product but seeks to co-develop or sell the rights to the idea. The first reason for this is that ABINFO is a R&D association focussed in cooperative innovation and development and not in manufacturing on an industrial scale. Secondly, collaborating with a global leader in home appliances would drastically speed up the development and thereby the likelyhood of the tray actually going to the market within 2 to 3 years. LG is looking for novel concepts, designs and technologies that can be adapted to its product lines and we believe ABINFO can offer just that with this product idea.

Future

Several ways for creating the electrodes necessary for making a connection between the powersource and the glass have been identified and some of them have been tested already. Subsequent experiments are planned to test which of these methods is most suited for creating the electrodes. In the meanwhile a basic product will be developed up to prototype level

including presentation drawings and CAD models for rapid prototyping and calculations. The next step is creating a fully functional prototype to test the behaviour further and carry out usabillity tests. This will guarantee the basic functionality of the tray. ABINFO has a lot of expertise in the field of TCO and additional research and tests will point out what kind of features can be integrated in the glass surface and whether these are truly applicable. Then, depending on the results, more elborate concepts can be developed.

Although several relationships are possible ABINFO prefers co-developing the idea through collaboration with and sponsoring by LG. The budget and timing depend on the kind of product LG likes to see developed. ABINFO proposes to initially develop a basic product (5 prototypes) to be tested by LG, i.e. a tray with a TCO heating element without added functionallity. The estimated time for such a development is 1,5 year and the estimated budget is US$ 215.000. When this product is developed LG and ABINFO can collaborate further in creating more elaborate models possibly with the features mentioned earlier or LG can buy the ideas from ABINFO and continue with the product by itself.

Proposal Team Experience

ABINFO has a team of experts in several fields of science and technology, mainly in microelectronics, displays, materials sciences and applications, great part of them working together for many years. Besides experts, there are junior scientists, pos-docs, PhD and MSc. and undergraduate students from Brazilian and foreign universities. As a cooperative institution ABINFO aggregates, also, the expertise of professionals, companies, universities and institutions that cooperate with ABINFO.

The success of ABINFO in the various projects is principally related to the multidisciplinary composition of the team. The experience of the team covers thin films, devices, integrated circuits, displays, touch screens, tablets, heating elements, covering materials, processing, characterization, equipment and instruments development. Applications in several areas as in education, voting, TV and human-machine interfaces for disabled people were also covered by ABINFO. Furthermore, ABINFO has a substantial activity in developing knowledge management systems and distributed research environments in the Internet.

Two experts have long experience in working together and collaborated in most of the projects metioned above.

One of them, Prof. Dr. Carlos Ignacio Zamitti Mammana, was, for many years, the director of a federal research center in microelectronics and informatics, in Campinas, SP, Brazil (Centro de Tecnologia da Informação Renato Archer – CTI).

Another, Prof. Dr. Alaide Pellegrini Mammana, is the Director of the Latin American Chapter of the Society for Information Display (SID), the President of the National Academy of Military

Engineering (ABEMI) and invited professor at the State University of São Paulo. Both are retired from the Engineering School of the University of Campinas (Unicamp).

One more, Prof. Dr. Daniel den Engelsen, was RD Director of Philips Display Components, in Eindhoven, The Netherlands. He is a fellow of SID and an invited professor at the Southeast University of Nanjing, China, and at Brunel University, in London, UK. Prof. Dr. Daniel is collaborating with ABINFO since 2005.

The three mentioned above have scientific and technical expertise in Physics, Chemistry and Engineering, and participated as consultants and analysts of strategic programs of industrialization for the Brazilian Government.

The team includes a student in industrial design at the University of Twente of the Netherlands, who is skilled in design covering aspects of target group and market analysis, concept generation and development, sketching and drawing, usability design and 3D modellling.

There is a specialist with large experience in glass manufacturing and in making glassware that gave support in the development of the electric tray prototypes. He has a long term collaboration with ABINFO and can be involved in the project if necessary. Also, a technician with experience in making electro-mechanical prototypes will work in the development of the tray.

We include some resumés to illustrate of ABINFO´s broad expertise as well as a list of publications.

Design vision

Introduction

The first few weeks I worked on my project with ABINFO in a way I was expected to. I started out with a clear goal that is, showing the feasibility of our product to possible producers, and began with the market and target group analyses. Already in the very beginning I formulated that my challenge will be to "find the balance between aimless but necessary capitalism and unrealistic idealism". From then on the thought about how and why began to grow bigger and bigger till at a certain point I couldn't continue with my work. The problem was not that I didn't know what I should do in order to make this product a financial success. I knew that I should target a specific consumer group within the middle class and design the product according to these people's needs and definitions of what is good in order to create a financially feasible product.

The problem was that the main goal of my efforts would be making money which has very little to do with my idea of what's good i.e. Quality. Whenever I would think of the product I'd see myself trying to deceive brainwashed consumers with this product in order to expropriate as much money from them as possible. Of course I would make people 'happy' with this product in some sense, but these people have conceptions of Quality that I do not share. In fact, I wanted to prevent people from spending their money and energy on these kinds of things and open their eyes to, what I think is, Quality. The latter I will explain now.

Criticism current system

"The place to improve the world is first in one's own heart and head and hands, and then work outwards from there [...] I think that if we are going to reform the world, and make it a better place to live in, the way to do it is not with talk about relationships of the political nature... I think that kind of approach starts it at the end and presumes the end is the beginning. Programs of a political nature are important and products of social quality that can be effective only if the underlying structure of social values is right. The social values are right only if the individual values are right."
- Robert M. Prisig, Zen and the Art of Motorcycle Maintenance -

This is the general idea behind this manifest: to manifest my ideas of value and Quality. Subsequently it's possible to create something that has Quality, at least to my idea. For reasons that will be elaborately explained later on I don't believe in developing products or providing services mainly to make money. Money in essence is nothing; it is a tool, not a goal. I don't mean that you don't need money, but I think money should be the fruit of and helper in the pursuit of one's genuine intrinsic belief of what is good, whatever that might be. I realize this idea is very idealistic and not directly applicable because the current capitalistic society doesn't work this way. Nevertheless I stick to this idealism since it represents my true feeling and idea of what is good. Like stated in the introduction the challenge for me will thus be finding the balance between aimless but necessary capitalism on the one hand and unrealistic

idealism on the other hand. Why? Because I'm not afraid to care and convinced that this is the right thing to do.

So what is this idealism you're talking about and how does it conflict with the current system? A lot of my thinking is inspired by Robert Pirsig with his Zen and the Art of Motorcycle Maintenance (ZAMM) but, although it would be a fantastic surprise to me, I recon most haven't read ZAMM. Therefore I think it is necessary to highlight and explain Robert Pirsig's main ideas to make my story more understandable.

In his philosophical novel Pirsig shows that the traditional dualistic subjective/objective worldview is inadequate for creating a complete image of the world. Therefore Pirsig proposes a Metaphysics Of Quality (MOQ) which subscribes to traditional empiricism but differs from it by saying that the values of art, morality and even religious mysticism are verifiable and that in the past these have denied as sources of knowledge for metaphysical reasons, not empirical reasons. They have been excluded because of the metaphysical assumption that the entire universe is composed of subjects and objects. From that it follows that anything that can't be classified as a subject or an object isn't real whilst there is no empirical evidence for this assumption at all. It is just an assumption. The MOQ complements this traditional subject-object worldview by proposing a metaphysical trinity of mind, matter and Quality. By Quality Pirsig means value that cannot be defined because it empirically precedes any intellectual construction which makes Quality the leading edge of reality. The following quotations from ZAMM explain this Quality further:

"The past cannot remember the past. The future can't generate the future. The cutting edge of this instant right here and now is always nothing less than the totality of everything there is. Value, the leading edge of reality, is not an irrelevant offshoot of structure. Value is the predecessor of structure. It's the preintellectual awareness that gives rise to it. Our structured reality is preselected on the basis of value, and really to understand structured reality requires an understanding of the value source from which it's derived. [...] To put it in more concrete terms: If you want to build a factory, or fix a motorcycle, or set a nation right without getting stuck, then classical, structured, dualistic subject-object knowledge, although necessary, isn't enough. You have to have some feeling for the quality of the work. You have to have a sense of what's good. That is what carries you forward. This sense isn't just something you're born with, although you are born with it. It's also something you can develop. It's not just "intuition," not just unexplainable "skill" or "talent." It's the direct result of contact with basic reality, Quality, which dualistic reason has in the past tended to conceal." Especially the idea that dualistic reason tends to conceal Quality will prove to be very important for discovering and explaining problems in the current system. Keep in mind that Quality as such is thus undefinable since:

"Quality is the continuing stimulus which our environment puts upon us to create the world in which we live. This is why Quality cannot be defined. If we do define it we are defining something less than Quality itself."

To better understand this undefinable Quality Pirsig makes the distinction between static quality patterns and Dynamic Quality. As the initial Dynamic Quality gets habituated, it turns into static patterns i.e. traditions, laws, models, prejudices, expectations etc.

"It is the quest of this special classic beauty, the sense of harmony of the cosmos, which makes us choose the facts most fitting to contribute to this harmony. It is this harmony, this Quality if you will, that is the sole basis for the only reality we can ever know."

Dualistic reason conceals Quality:
Rational knowledge/ modern science is one of these static definitions of Dynamic Quality and although rational knowledge has proven to be a very useful tool it is probably the least suited tool/model to use for aesthetics, morality, spirituality and emotion for it strives to be as objective as possible i.e. eliminating value as much as possible whilst value is inherent to aesthetic, morality, spirituality and emotion. This is something I often mention when somebody describes these value related attributes like aesthetics or emotion as not being functional. If I reply with "what is functional?" this is often answered with "something is functional if it contributes to achieving a certain goal". I do not disagree with this but notice that the question to what this certain goal is remains unanswered and cannot be answered by this functional thinking that strives to be purely objective and valueless. In principle, functionality can be anything unless the goal is defined. Of course the goal of this functionalism is the Quality mentioned earlier. It would be paradoxical to think something like modern science can fully describe Quality for modern science is derived from Quality. It would be like box A that fits in box B which in turn would fit in box A.

Mind you, it's not meant by the foregoing that these static patterns, like science, should be abandoned for people need this static latching of Quality. It is what enables us to make plans, remember, achieve goals, speak a language, build up cultures, etc. Static patterns are some kind of asymptotical approaches to Quality. Now it may sound like static patterns are solely formed by some external quality but that is not the case for when pursuing Quality we create static patterns that are analogues to our previous experience since our previous experience is also part of this Quality. When you think of it, that makes a lot of sense because otherwise you (your previous experience in this case) would be excluded from being part of Quality resulting in the yet another subject object dichotomy. That we create patterns that are analogous to our previous experiences also explains why everybody sees Quality differently for people's experiences are different. The split between static and dynamic is thus not intended as a new duality but these manifestations of Quality represent a dialectical monism.

I know the foregoing can be quite a bit to comprehend especially given the relatively brief explanation but don't worry. This is essentially the metaphysical basis for my entire vision on industrial design so it will be just downhill from here. The MOQ shows the source of the problem I'm trying to address which is the pointlessness that arises from the predominant dualistic subject/ object world we currently live in.

In a subject/ object world rational or "classical" thinking requires people to express themselves rationally. Ideas that are not compatible with science don't get off the ground. Rational people see basic feelings, intuitions, emotions i.e. things that are closer to the direct unpatterned experience as something inferior, whilst this unpatterned experience is actually at the source of this rationality in the first place. This is not seen this way and instead of looking at the roots science tries to expand its branches to grasp and explain these values. This, of course, is impossible since these values are at the roots. Some passages from ZAMM show how this inverse view he calls a 'genetic defect in the nature of reason' results in pointlessness.

"The cause of our current social crises [...] is a genetic defect within the nature of reason itself. And until this genetic defect is cleared, the crises will continue. Our current modes of rationality are not moving society forward into a better world. They are taking it further and further from that better world. Since the Renaissance these modes have worked. As long as the need for food, clothing and shelter is dominant they will continue to work. But now that for huge masses of people these needs no longer overwhelm everything else, the whole structure of reason, handed down to us from ancient times, is no longer adequate. It begins to be seen for what it really is...emotionally hollow, esthetically meaningless and spiritually empty. That, today, is where it is at, and will continue to be at for a long time to come."

As a metaphor, Pirsig sometimes compares static patterns with ghosts. In this particular case he talks about the ghost of rationality and shows the pointlessness it leads to.

"a ghost which calls itself rationality but whose appearance is that of incoherence and meaninglessness, which causes the most normal of everyday acts to seem slightly mad because of their irrelevance to anything else. This is the ghost of normal everyday assumptions which declares that the ultimate purpose of life, which is to keep alive, is impossible, but that this is the ultimate purpose of life anyway, so that great minds struggle to cure diseases so that people may live longer, but only madmen ask why. One lives longer in order that he may live longer. There is no other purpose. That is what the ghost says."

This is what happens when Quality i.e. value is put aside and seen as an irrational anomaly. The values from old times are maintained (staying alive) but no new values are allowed to arise (only madmen ask why). Rational thought analyses the value by quantifying and parameterizing it and subsequently measuring it according to overall utility in order to decide what's best. One could say that rational thought itself might

be without much value but that the needs it responds to are very much based on value and that, in that sense, rational thought only amplifies the things that make life worth living and thus certainly has value. I don't necessarily disagree with that but then I would counter by saying that there is a certain balance between rationality and value and that currently there is too much focus on rationality. This results in the over quantified utilitarian world that looks "slightly mad" in which we happen to live nowadays. Having this said, I am tempted to say that design, in so many words, is dead because the way things are designed nowadays focusses way too much on rational thought and utilitarian thinking. What is considered design nowadays is nothing more than the endless recycling of the quickly diminishing remains of value we still have left. This pointlessness in design made it impossible for me to continue and urged me to write this manifest. I could continue, but then I would feel like a machine that is just well calibrated by the University in order to reproduce the design methodology correctly without end.

Another big thing that contributed to my feeling of pointlessness was money being the main goal since I had to show the feasibility of our product and feasibility in this case meant the likeliness of financial success. Money has become one of the most profound and dangerous representatives of ruling rational thought. Money is intended as a means to quantify Quality in order to represent a certain amount of Quality. A very practical invention indeed, but the problem is that money cannot really represent Quality. People tend to forget this resulting in a shallow society full of quantified objects without any true value. The laptop I'm writing this manifest with has a certain value to me that doesn't and cannot correspond to the price. Not because it is so difficult to put a price tag on this value but because only a small part of what this artefact means to me can be brought back by money and that is its objective functional presence. The remainder of the value the laptop has to me has to be put in it by me or others and money can be an aid in doing so but nothing more. When I think of it, ironically money seems to be the least valuable thing on earth for the value of money lies in what it could be and not what it is. Thus, if, by rational thinking, the goals of people (Quality) are made subordinate to the means (Money), that is, the money becomes the goal, you end up with the same pointlessness mentioned earlier. I'm not anti-money per se, it's just that money has come to play the main role and that is something I don't agree with.

Naturally money can be a goal when you need it in order to do something you want to do but then money is already becoming something i.e. part of the fulfilment of your intrinsic goal. If I earn and save money to buy a motorcycle I'm not just earning money but in fact earning that motorcycle which is part of my idea of Quality. That is the way it should be, but that is not the way it is. Earn money to live, don't live to earn money.

While money becomes the goal, the products that can be bought with this money seem to become less valued for what they are and more for what they stand for which is increasingly materialistic status.

Hence, design being dead and money turning into a goal rather than a means are for me, as an industrial designer, the most important manifestations of the pointlessness that follows from the ghost of rationality as indicated by Pirisig. Now it is time to take a closer look at how this applies to me as an industrial designer. How does all this apply to products in everyday life?

Companies sell products mainly through marketing. It is the main tool for communication and making people believe they need this product. Marketing in itself doesn't have to be bad at all. It can be very desirable to inform people about a service or product that you think is really good but that is normally not the case. The main goal of marketing is almost always making money, aimlessly. Whether you truly help people with your service or product is less relevant. Of course all products that are sold and services that are provided contain a certain aspect that fits with the people's ideas of Quality since marketing cannot compensate everything. Thus, these products still represent a certain intrinsic value, right? Yes and no. Undoubtedly, there are elements that truly match with peoples intrinsic idea and feeling for Quality and yes there are companies that (partly) follow their sense of what is good but a large part of people's conception of Quality is influenced and created by these companies in the first place in order to, guess what, make money.

When these conceptions of what is good are created it's like deliberately creating deceptive ghosts of quality. These ghosts of quality, unlike Quality, can then be used to control people. Two quotations from ZAMM help to make my point clear:

"There's this primary America of freeways and jet flights and TV and movie spectaculars, and people caught up in this primary America seem to go through huge portions of their lives without much consciousness of what immediately surrounds them. The media have convinced them that what's right around them is unimportant."

"Little children were trained not to do "just what they liked" but—but what? -- Of course! What others liked. And which others? Parents, teachers, supervisors, policemen, judges, officials, kings, dictators. All authorities. When you are trained to despise "just what you like" then, of course, you become a much more obedient servant of others...a good slave. When you learn not to do "just what you like" then the System loves you."

Please note that I believe a big part of the system we live in arose from genuine efforts of people trying to implement their ideas of Quality in order to increase the overall Quality of life. Needless to say, I only target the aspect of pointlessness of the current society with the preceding quotes.

Where are these ghosts of quality based upon? This is a very interesting question regarding industrial design because these ghosts dictate to a large extend how products nowadays are designed.

Similar to what I stated before I think these ghosts of quality are mainly a recycling of static quality patterns and any new patterns are gladly assimilated to obtain an even bigger market advantage. This parasitic relationship results in a downward spiral into a world with less and less Quality because, as a matter of speech, people only harvest and don't sow. Money was once intended as a practical representative of Quality but since money is becoming less meaningful companies increasingly focus on other static quality patterns to get people to buy their products as is shown in the following:

"Freemium pricing models and digital services are detaching the price of things from the cost of producing them. And while this gives companies more leeway in their business models, it raises a question: How do you determine a product's intrinsic worth? Increasingly, it's the idea behind the product and the philosophy of the brand that created it. If two competitors spend equal amounts on production, the one whose ideals resonate with the target market is the more valuable.
Your values are a competitive advantage. 2013 is when mainstream brands start asking serious questions about their philosophy and values. Knowing what you stand for and conveying that to the world is no longer an intellectual exercise for the touchy-feely fringes. It's a necessity."

At first you might think it's a good development that companies start to think about their values, but notice that these values are not intrinsically valued but looked upon as a necessity to obtain a competitive advantage. It's a subtle but very important difference. It's the same thing with liking something on Facebook. Companies advertise with rewards for liking them on social media. Intrinsic values should be the source and goal of one's efforts not the means. This parasitic tendency translates into an attitude of 'taking or be taken' i.e. consume or be consumed.

As an industrial designer you have a responsibility for the things you create and I believe a lot of designers don't feel this responsibility because of their rational point of view. Mass products are pre-eminently considered functional fruits of rational thought and not really considered to represent certain values although they do. To deny the values these products represent is to deny your responsibility and possibility for self-expression.
"The Buddha, the Godhead, resides quite as comfortably in the circuits of a digital computer or the gears of a cycle transmission as he does at the top of the mountain, or in the petals of a flower. To think otherwise is to demean the Buddha - which is to demean oneself."
Moreover, industrial designers create products for the masses and this is also something to consider if you think of products as representing certain values. If you believe in a democratic society you should consider the following:

"What human beings are and will become is decided in the shape of our tools no less than in the action of statesmen and political movements. The design of technology is thus an ontological decision fraught with political consequences. The exclusion of

the vast majority from participation in this decision is profoundly undemocratic"

Therefore, an industrial designer can be considered to reassemble a dictator to some extent. Of course you can choose what product you buy, but first of all this choice is heavily influenced by propaganda, secondly the diversity of thought behind these products is minimal and lastly the people who buy these products have no say in whether or how the product should be made in the first place.

Besides excluding people from the design process products nowadays are made in such a way you're pretty much fed up with the way they are. Unlike most older products you cannot open, alter or understand them easily. Part of this has to do with the increased complexity of course, but products are also deliberately designed this way so you have to follow the will of the manufacturer which comes down to you buying their replacement or newer version of the product. Besides, it's more expensive to make products that are flexible and since making money is the ultimate goal of most of these products it's not considered important. This last reason points to the prisoners dilemma the capitalistic society puts industrial designers in. If you are focussing more on your ideals and less on making money your product is less likely to get off the ground because then there are always cheaper competing products that sell better.

My final criticism is about the way products are valued. People identify themselves with products and brands and I don't necessarily see anything wrong there. In this world of abundance I'm glad to be able to outsource some of my decisions by putting trust in external parties. Being confident that these parties make decisions that are more or less in line with my idea of Quality allows me to have more time and energy to spend on things that truly make my life worth living. The problem is the ghosts of quality aspect discussed earlier. These ghosts of quality are brought to life in order to make people believe and ultimately consume. Therefore, it is not possible to put trust in these companies and even if it costs nothing you can be pretty sure that you're the product.

Concerning identifying oneself with products; there is nothing wrong with being proud, don't get me wrong. There is only a problem when status or self-glorification becomes the main reason you buy something in the first place or if the Quality represented by a company you are proud to be a part of turns out to be made up i.e. to be a mere ghost of quality.

This means you don't really care about what you use or buy as long as it gives you status/ self-esteem. In turn, this status and/ or self-esteem is mainly derived from materialistic values. What the product intrinsically stands for is not important as long as others admire it. This makes me think of an experiment with Joshua Bell, a famous violinist, who plays in a subway stop during rush-hour and almost nobody listens or notices. Now I don't mean by this that products should or can be valued solely for what they are. Things are always related to another and a great concert isn't great

just because of the performer. I mean to point out that people shouldn't neglect their direct environment and the thing itself should be valued more.

Status should be the by-product of the pursuit of your intrinsic values. If it's the other way around your status reassembles a false image that you have to maintain constantly and will never give you true satisfaction. If you consider products as status symbols and status is what you want out of the product then you'll end up with an endless stream of products because products only give you temporal status since the status they reassemble is largely based upon trends that quickly change largely by the same companies that make these products in order to ensure ongoing consumption.

"Any effort that has self-glorification as its final destination is bound to end in disaster. When you try to climb a mountain to prove how big you are, you almost never make it. And even if you do, it's a hollow victory. In order to sustain the victory, you have to prove yourself again and again in some other way, and again and again and again, driven forever to fill a false image, haunted by the fear that the image is not true and someone will find out. That's never the way."