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SUSTAINABLE COOKING

Christoph DOBRUSSKIN, Loes WIJNOLTZ, Tessa BOUWKAMP

Abstract: TRIZ is often seen as a complex tool for engineering problems. The objective of this talk is to demonstrate the application of the basic principles of TRIZ in an everyday situation: cooking. Exploring the preparation of a simple meal, looking at the process with the eyes of sustainability, and solving problems on the way using the way of thinking as taught by TRIZ. It is shown how TRIZ thinking can influence individual daily choices in a constrained framework. Furthermore the set up may serve as a case study within an educational setting. In this light it is attractive as it refers to everyone's tasks and experience horizons, and is thus easy to understand and adapt in teaching environments.

Key words: TRIZ, cooking, sustainable, education, every day, everyone.

1. INTRODUCTION

The impact of human activity on our planet Earth has reached a level where it threatens the current balance of life [1]. Two examples of this are global warming spurred by increased CO₂ emissions [2] as well as the pollution of the environment with poisonous material [3] and plastic waste [4], all well documented. Consequently, changes in human activity and behavior are needed to halt and possibly even reverse these developments. One of these areas, and one which impacts each human, is nutrition. The question that many "average persons" are asking themselves is:

"What can I do, to improve my way of providing nutrition in order to put it on a more sustainable footing?"

The present paper investigates this topic. And just like an "average person", information on the topic is sought out from publicly available sources. To aid some logic to this quest, a TRIZ mindset and logic is applied throughout, and relevant TRIZ tools are referenced.

When working on this topic it quickly became apparent that, if analyzed in detail, the work would easily exceed the available space for this paper. Therefore, rather than taking an average Dutch dinner as a starting point, only the main ingredient of our "average persons" main course

was further investigated. So instead of looking at:

Starter:

- *Avocado halves filled with smoked salmon and cocktail sauce*

Main course:

- *Boiled potatoes*
- *Fried pork sausage*
- *Boiled Broccoli*

Dessert:

- *Crème Brulée*

only the fried pork sausage features on the following pages and is used as an exemplary carrier to analyze different aspects of sustainability. All supporting data can be found in the public domain, general strategies for improvement can be derived from the results and an alternative main ingredient for the main course is suggested and analyzed, and has with much success been tried.

2. FOOD, NUTRITION AND THE ENVIRONMENT¶

Certain parameters are of importance on the road to more sustainable and healthy eating habits. There are many different views as to what constitutes a "sustainable" food system, and what falls within the scope of the term

”sustainability”. Strictly speaking sustainability implies the use of resources at rates that do not exceed the capacity of the Earth to replace them [5]. For food, attributes like greenhouse gases, land use, freshwater use, eutrophication and the effect on biodiversity are the main components that determine the food production sustainability [6].

Food production is only the first step in the food supply chain, that also includes food processing (to add value), transport, wholesale and retail, before it arrives at the consumer. Food waste is an important factor along the whole chain. To improve food sustainability many different innovations are possible on the large scale. Also in the kitchen there is room for improvement. Other preparation methods or different food products might be more sustainable and healthier.

For the “average person” a lot comes down to the food choices he or she makes when buying the food. With respect to sustainability, certain things are known to the “average person”: e.g. meat has a high carbon footprint since the inefficiency that plant energy needs to be transferred into animal energy and the relatively large contribution to methane emissions [7]. Another example is the avocado. The largest production in Mexico involves already a lot of transportation costs, but the increasing worldwide demand leads to deforestation, soil depletion and biodiversity reduction. Next to that, social issues occur as the crops are now exported and become too expensive for the local population [8].

When buying food, the “average person” should also think about the nutritional aspect of the food. A balanced diet is necessary to provide for all the nutrients that the body needs to work effectively.

Overeating and unbalanced diets are well known aspects to affect health. But another, less known aspect that influences health is the amount of processing a product underwent. A rule of thumb might be that more processed foods have a higher environmental impact. Overall, processed foods are more energy dense and usually lead to

more energy intake per minute. This is correlated with overweight related diseases [9].

Organically farmed foods take cyclization of resources, promotion of ecological balance and the conservation of biodiversity into consideration [10]. There is no evidence that organic food is healthier, and there is quite some conflict in the literature about it. The production, however, is more sustainable.

3. PROBLEM DEFINITION

As stated earlier, the starting point for the exercise was a typical Dutch evening meal. The main course follows the age-old adage of AVG – the Dutch initials for: Potato (A aardappel), Meat (V vlees) and Vegetable (G groente), and the fried pork sausage, the centerpiece of the dinner, has been chosen for the investigation as to its eco-friendliness. Of course, the ideal solution would be to prepare and consume an ingredient that has no impact on the environment at all while maintaining a healthy diet. Realistically, however, the “average person” is looking for a - hopefully - substantial reduction of the present environmental impact that is also within its circle of influence. Thus, the analysis is intended to identify the environmental impact of the initial choice made for the meal. Subsequently, an alternative is to be identified and compared to the initial choice. Thereby, it is important to outline the methodology of achieving this in order to make it generally applicable. Ideally, also generally applicable guidelines should be used.

4. ANALYSIS

The initial task of the analysis is to do a detailed and exhaustive overview of all operations involved in preparing the meal and specifically the pork sausage; this with respect to materials as well as energy consumption and waste. In a business environment “function analysis (FA) tool for processes” would be the tool of choice from the TRIZ toolbox [11]. The FA is here used only in a rudimentary way (Table 1), to identify the main operations and functions involved in the food preparation, and those are then further investigated in the light of sustainability.

Table 1

Function Analysis process overview (high level)

	Operation	Function
1	Production of Sausage	Production
2	Transport to home	Transport
3	Storage	Refrigeration
4	Preparation	Prepare pan
		Add butter
		Add heat
		Unpack Sausage
		Place Sausage in pan
		Place Sausage on plate
5	Cleaning	Clean pan

FA would commonly continue with a categorizing function as useful or harmful, and also for useful functions to identify if they can be characterized as productive, measurement, support, transport or corrective functions. A final step would be to identify functions that are normal, excessive or insufficient. However, at this stage of the investigation it is unclear how much impact any of the operations actually have, and therefore more information about the respective environmental impact of any of the operations is sought. While the FA is a typical TRIZ approach, the “average person” would likely think along similar paths and may easily come up with a similar list of aspects that influence the eco-cost of the meal.

The ecological impact of material choices and transport can be calculated, for example using a freely available App called Idemat [12]. Using the App either the “Carbon Footprint”, or total ecological costs in euro can be calculated. The ranking in euro has been chosen here, as it includes the costs of the Carbon Footprint as well as resource depletion and toxic impact on the environment and on humans.

4.1 Analysis of main ingredients

Two main ingredients are used in the preparation of the sausage: the sausage itself as well as butter. Also, there is some packaging associated with the sausage; any packaging for the butter is

ignored. The environmental impact as indicated in Table 2 is calculated based on the meat, butter and plastic used. Specific data for butter was not available, so data for full cream was used as a substitute.

Table 2

Eco cost for production of the pork sausage, packaging and butter

Item	Weight, g	Price EU	Eco-cost manufacture EU
Pigs - sausage	200	1,89	0,33
Packaging, PVC	11	n/a	0,005
Butter	25	0,18	0,05

Total **0,38**

4.2 Analysis of Transportation

The transport costs of Table 3 are based on the distance from the producer to the authors house – as an equivalent of an “average person”. Bulk transport by lorry was assumed.

Table 3

Eco cost transport of the pork sausage to the average person

Item	Origin	Weight, g	Eco-cost transport Supermarket EU
Pigs - sausage	Zaandam, NL	200	0,0006
Packaging, PVC	Zaandam, NL	11	0,000033
Butter	Unidentified	25	0,000075

Total **0,0007**

4.3 Analysis of Storage

Assuming that meat needs 10 days of refrigeration, including the time during transport, the eco-costs of the electricity usage for cooling have been estimated and are presented in table 4.

Table 4

Eco cost for 10 days of refrigeration			
Item	Duration	Weight, g	Eco-cost cooling
Pigs - sausage	10 days	200	0,001

4.4 Analysis of Preparation Operation

Experiments showed that 20 minutes of heating the pork sausage in the pan allowed the “average person” to nicely fry and brown the sausage, ready for human consumption. This time was used to estimate the environmental impact of the respective energy consumption of a hotplate, as shown in Table 5.

Table 5

Eco cost for frying the sausage			
Item	Duration h	Power consumption kw	Eco-cost Frying
Frying	0,33	1,1	0,029

4.5 Analysis of Cleaning Operation

The assumption would be that the average person would wash the frying pan under running warm water for about 1 minute. Main costs for heating the water have been used for the calculation of Table 6.

Table 6

Eco cost for cleaning the pan			
Item	Duration h	Power consumption kw	Eco-cost cleaning
cleaning	0,02	2	0,003

4.6 Analysis Summary

Based on the assumptions made, the production of the main ingredients, the sausage (79%) and the butter (12%), as well as the frying operation (7%) account for the majority (98%) of the eco costs of the meal. Other operations such as the PVC used for packaging, the transport, cleaning and refrigeration contribute to the remaining 2% as shown in Figure 1.

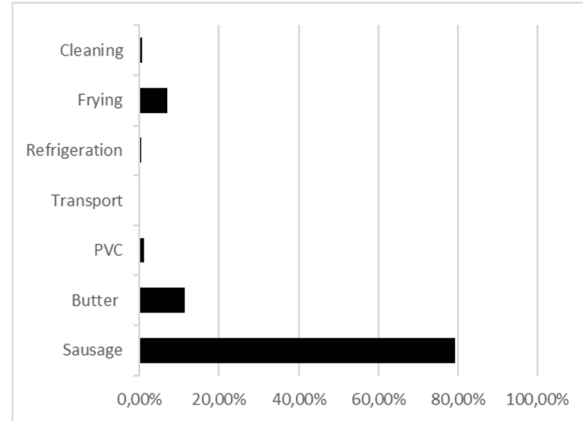


Figure 1. Comparison of the eco-costs of the materials and the different process steps

The overall eco-cost of preparing a fried pork sausage for dinner is estimated to be 0,42 euro.

5. SEARCHING FOR ALTERNATIVES

At this stage it cannot be determined if the ecological impact determined for the meal preparation of the pork sausage is high or low, because a comparison with alternatives is missing. A quick look at the TRIZ toolbox reveals two tools commonly used to identify alternative functions or features:

- Function Oriented Search (FOS) is used to identify functions that are used in other industries but that could be useful for the application at hand [13].
- Feature Transfer is used to transfer features from an alternative system to a target system [12].

There are detailed algorithms available for both tools, though a literal application of those would likely be unsuitable for our “average person”. The mindset of these tools is very suitable though: looking for proven alternatives elsewhere. This also fits perfectly well with one of the tenets of TRIZ [14]:

Someone somewhere may have solved your problem already: Most problems have already been solved, just in another application field.

Therefore, existing alternatives for each of the operations were investigated. All eco-costs mentioned are in euro and adjusted to the 200g of our “average persons” pork sausage.

With the search for alternatives, it should be kept in mind that the solutions available for the “average person” are quite different from that of a business. For example, to lower the cost of refrigeration of goods during the flight of a plane a business may easily come up with the idea that the cold air at high altitude during a flight should be used for cooling [15]. This is not an option that the “average person” could employ. The choice may then easier be directed at goods that do not need refrigeration or transport.

5.1 Alternatives for main ingredients

An overview of the environmental impact of a selection of foodstuff is given in Figure 2.

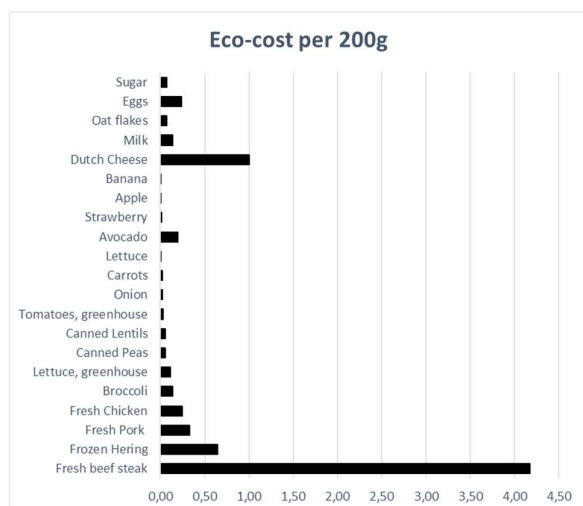


Fig. 2. Comparison of the eco-costs of alternative foodstuff [data from the App]

A number of guidelines can be derived here:

1. The consumption of vegetables instead of meat has a significant positive impact on the environment. Beef is particularly bad.
2. Preferably, seasonal produce should be consumed. The example of lettuce shows that the use of greenhouses can increase the environmental impact by a factor of 10.

5.2 Alternatives for Transportation

An overview of the environmental impact of different modes of transportation is given in Figure 3.

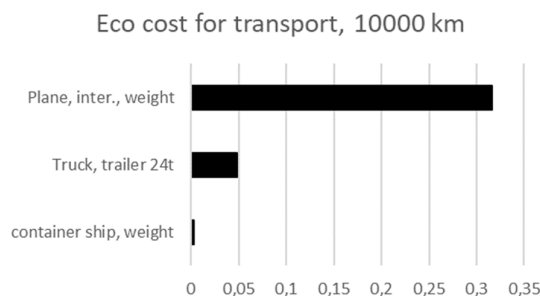


Figure 3. Comparison of the eco-costs of alternative means of transport

It is clearly visible that the eco-cost of transporting our “average persons” pork sausage by ship is significantly lower (by a factor of 112) compared to flying internationally, and compared to transport by truck (by a factor of 18).

It should be kept in mind that:

- these eco-costs pertain to bulk transport,
- that some produce is easily perishable and may need fast transport to reach a destination in time,
- that transport by truck is, in most instances the only way to reach the “average person” by road, and therefore the last miles can always be assumed to be transport by truck, and
- that refrigeration costs are not included here and may be higher for transport by boat due to the length of the journey.

The guidelines here are obvious:

1. In terms of transportation related eco-costs it is always better to use local produce which incurs minimal transport.
2. For long distances, shipping by boat is preferred over shipping by plane, if possible.
3. On a personal level, walking or taking the bicycle to the supermarket has the preference to taking the car.

5.3 Alternatives for Storage

Within the purview of this paper we look at refrigeration as the main function within the operation storage. Alternatives to refrigeration when it comes to preserve food for a long time in general involve preservation techniques. Some of these alternatives may apply only to

certain types of food. While refrigeration has been identified as a minor contributor to the eco-cost of our “average persons” pork sausage, it is always worthwhile to explore these alternatives. To name a few that are relevant for meat: cooking, freezing, vacuuming, canning, salting, fermenting, modified atmosphere packaging (MAP), smoking and drying. Most preservation techniques are changing to varying degree the taste and texture of the produce.

5.4 Alternatives for Frying

The most common way of preparing a pork sausage is frying in a frying pan. For a full analysis, a TRIZ function model could be built for this operation, though the “average person” would likely not be skilled enough to perform this. Searching the internet [16, 17] for already available alternative solutions leads to three possible strategies to improve this operation:

1. Improvement of the current frying process:
This could be achieved by improving the heat transfer to the pork sausage. For example, fitting a lid to the frying pan may shorten the cooking time - though it may also change the taste or structure of the sausage to some degree. Adjusting the size of the frying pan to the size of the portion and using the most efficient heating method (e.g. induction heating) are other avenues worth exploring.
2. Using alternatives for frying that are more eco-friendly. Other heating methods, boiling, steaming, boiling in a pressure cooker, microwaving or “slow cooking” at a low temperature over a long period of time may all be more energy efficient than frying.
3. Do not use any heating means in the preparation of the food. Those are often related to the preservation of food (see the previous heading), may vary depending on the type of foodstuff used and include such methods as salting, drying and smoking.

5.5 Alternatives for the Cleaning Operation

Cleaning dishes with water and detergent is a widely accepted standard throughout the world, and no alternatives for this main method are

suggested. However, there are several aspects that can lower the ecological impact [18, 19]:

1. Use a dishwasher that has been fully filled, instead of hand washing
2. If hand washing, use a sink filled with water instead of running water
3. Use an eco-friendly detergent to lower the impact on the environment.

5.6 Conclusion w.r.t. alternative solutions

By using publicly available data, improvement opportunities for all aspects of the process of frying a pork sausage for dinner could be identified. The question remains, however, if an “average person” would be willing and able to do this investigation beyond the usage of general guidelines. Also, no single “source of truth” has been identified to quantify the impact of such alternatives.

While looking for alternative solutions, the “average person” has limited use of classic TRIZ problem solving techniques such as the inventive principles. For many operations the options are reduced to readily available alternatives rather than the creation of radical new and inventive solutions.

Looking at the main ingredients, for example, almost all persons in developed countries rely to 100% on foods they can readily buy, either in the supermarket or on a local market. Options to break out here would be for the “average person” to grow some own vegetables, on the balcony or in the garden. Keeping the stems of some salads or the seeds of tomatoes for example and replanting them is a simple way to both, reduce waste and becoming more independent on external food supplies. One must keep in mind however that not everyone may have this opportunity, due to limited living space or an irregular lifestyle for example.

Choices for the “average person” to influence transport and storage are even more restricted and are directly linked to the foodstuff chosen, and how those are dealt with before the actual purchase.

In all aforementioned cases, knowledge of the environmental impact is still crucial in leading to informed and conscious choices.

The operations concerning the preparation – or frying – of the food and the cleaning up afterwards are more within the circle of influence of the “average person”. While there are still limitations to what is available within an “average kitchen”, and also dependent on the actual foodstuff purchased, this is one area where problem solving, and creativity can be used to environmental advantage.

6. IF NOT PORK, WHAT THEN?

In order to identify alternative technologies a TRIZ person would look into resources [20] and databases for scientific effects [21]. With reference to cooking, the “average person” would look for alternative ingredients in the kitchen cupboard, and for recipes would search a plethora of websites. As an example without meat, a recipe for “How to make the best vegan sausage” was identified [22]. A brief calculation concerning the eco cost of the main ingredients is shown in Table 7.

Table 7

Eco cost of the “Best Vegan Sausage”		
Item	Weight, g	Eco-cost manufacture EU
vegan sausage	200	0,213
Butter	25	0,048
Packaging	11	0,005
Total		0,26

It would be expected that oil for frying – dependent on the type used – could significantly reduce the eco-cost compared to butter. However, as no eco-cost for any type of oil could be identified, the eco-cost for butter was substituted. The eco-cost of packaging was difficult to establish and was assumed to be similar to those of the pork sausage. Also, the

eco-cost of transport was estimated to be similar to those of the pork sausage at 0,0007. There are no refrigeration costs involved in the storage of the ingredients for this recipe. The same cooking time as with the pork sausage was determined to be sufficient. The cleaning of the pan was done together with other dishes in a bowl. The involved eco costs are shown in table 8 and show a reduction of 90%.

Table 8

Eco cost for cleaning			
Item	Duration h	Power consumption kw	Eco-cost cleaning
cleaning	0,03	2	0,0003

The overall comparison of the eco-cost of the pork sausage with those of the “best vegan sausage” shows an improvement of 29 %, as illustrated in Figure 4.

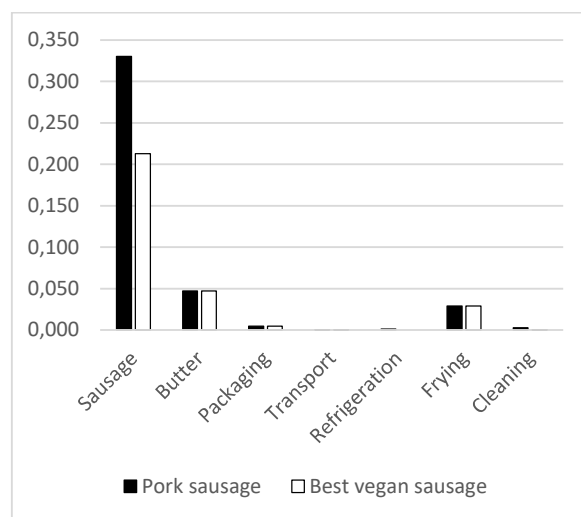


Figure 4. Comparison of the eco-costs of the materials and the different process steps, pork sausage and best vegan sausage

7. CONCLUSIONS

The starting point was to investigate if an “average person”, could improve the ecological impact of his or her nutrition, and how that “average person” could use TRIZ tools to accomplish this task.

The process turned out to be significantly more involved and complex than initially anticipated. Starting with the analysis and using freely

available resources the environmental impact of the food itself, its transport, storage, preparation, and the subsequent cleaning can be estimated. It must be said, however, that this is quite involved, and will not be likely performed on an occasional base by the “average person”. A few general guidelines can be clearly seen from the analysis:

1. Animal based food, be it meat, eggs or milk, has, in general, a much higher negative impact on the environment than vegetarian food.
2. The amounts of energy used for heating the food is a second, significant source of negative environmental impact.
3. All other investigated potential sources of negative environmental impact are comparatively small – though for a population as a whole, improvements here may still contribute significantly to a better environment.

Compared to a business-style TRIZ implementation, the simplified analysis done here follows the same logical pattern and is fully suitable to identify the main contributors of negative environmental impact, in this case the use of meat as a base for the food. And while the “average user” may not be likely to do even the limited analysis as done in this paper, the basic, and well-known conclusions are readily available.

Problem solving as the next step in the process posed further challenges to the classical application of TRIZ tools. For the “average user” notions of formulating contradictions [23], searching for suitable inventive principles in the contradiction matrix [24] or constructing substance – field models [25] are anything between unknown and anathema (though in a classroom setting this could be different).

One of the basic notions of TRIZ, however, the use of readily available resources is very much applicable. While most persons are already using this to some extent, searching the internet for new recipes or rummaging through the kitchen cupboard in search of an ingredient, for example, it is the opinion of the authors that this

tool could offer even more solutions when applied with more rigor. In the vegan sausage recipe that was analyzed, for example, a binder is needed to “glue” together the ingredients. While in traditional cooking an egg would be employed to accomplish this task, the “average person” could conceivably look through his kitchen cupboard for a number of non-animal based alternatives, identifying anything from starch to chia seeds, and make his final decision after pondering a number of identified options.

Where in the technical TRIZ world databases of scientific effects, or inventive standards are used, in the world of cooking many websites provide free recipes for the preparation of tasty meals with lower environmental impact compared to traditional meat-based meals. The vegan sausage that was tested, and evaluated is, of course, only one of many possible alternatives.

Overall a number of guidelines have been identified that help to achieve the aim of cooking in a more sustainable way. Furthermore, it has been established that, while classical TRIZ tools are less likely to be employed by the “average person”, the basic principles of TRIZ, its way of thinking, is very applicable. With this in mind, the other aim of the paper – to serve as a case study within an educational setting – can also be addressed. The paper clearly shows that taking a meal as a starting point, and investigating different aspects of its entire value chain within the context of sustainability offers a rich playground for educational activity, ranging from the basics of systematic analysis to the problem solving capabilities of the “average person” and beyond.

There are, however, two potential improvement opportunities the authors would specifically like to point out:

- Currently most food bought is labeled with the country of origin. Additional information, such as the mode of transport are currently missing but may be necessary to fully evaluate the ecological impact.

- No single “source of truth” could be identified, where data related to the purchase and preparation of healthy and sustainable meals could be found. Individual elements exist, but they are not always comparable. This point may be worthwhile to explore further within a European project, for example by establishment of such a “source of truth” database, which could be useful in guiding consumers and businesses alike.

Finally, while the tests and tastings by the authors showed that the “Best Vegan Sausage” was clearly different from the pork sausage it replaced, it was found to be very tasty indeed.

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Prepararea sustenabilă a hranei

Rezumat: TRIZ este adesea văzut ca un instrument complex pentru probleme de inginerie. Obiectivul acestei discuții este de a demonstra aplicarea principiilor de bază ale TRIZ într-o situație de zi cu zi: gătitul. Explorarea pregătirii unei mese simple, examinarea procesului cu ochii durabilității și rezolvarea problemelor pe drum folosind modul de gândire așa cum este predat de TRIZ. Se arată cum gândirea TRIZ poate influența alegerile zilnice individuale într-un cadru constrâns. Mai mult, înființarea poate servi ca studiu de caz într-un cadru educațional. În această lumină, este atractiv, deoarece se referă la sarcinile și orizonturile experienței fiecăruia și, prin urmare, este ușor de înțeles și adaptat în mediile de predare.

Christoph DOBRUSSKIN, Philips MCC, c.dobrusskin@philips.com, High Tech Campus 37, floor 0 North, 5656 AE Eindhoven, The Netherlands,

Loes WIJNOLTZ, Philips Research, loes.wijnoltz@philips.com, High Tech Campus 34, 5656 AE Eindhoven,

Tessa BOUWKAMP, Tessa.bouwkamp@wur.nl, Wageningen University and Research, Wageningen, The Netherlands