TUM

INSTITUT FÜR INFORMATIK

Seminar: Sustainability in Software Engineering

Birgit Penzenstadler, Veronika Bauer, Andreas Fleischmann

TECHNISCHE UNIVERSITÄT MÜNCHEN

Seminar:

"Sustainability in Software Engineering"

Editors: Birgit Penzenstadler, Veronika Bauer, Andreas Fleischmann
Technische Universität München, Germany
{penzenst|bauervt|fleischa}@in.tum.de

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Abstract

Sustainability is becoming an important topic in IT—as contribution of IT to safeguard our future, and as evolving market segment. IT's high productivity in combination with short life cycles and, on the other hand, growing resource problems of our planet, lead to a necessity that software engineers take their share of responsibility for sustainability. Therefore, we need to include the concept of sustainability into the university curriculum of computer science.

The challenge is to motivate and interest students (and lecturers) for sustainability, to identify spheres of activity for software engineers, to build up competence fields for solutions, and to incorporate the topic into the syllabus. The first step is to find a core of interested people by offering a seminar. Our guiding goal is to bring the topic of sustainability to a broader recognition in software engineering. Our orientation goals is to motivate students for the topic of sustainability. Our coarse-grained goal is to explore the areas of sustainability related to software engineering. Our detailed goal is to let the students explore one topic in depth to interactively present it to the other students.

This report presents the results of our first Bachelor seminar on "Sustainability in Software Engineering" held in the summer term of 2011.

The deliverables to be developed by the students were a learning module of 90min prepared by each student as final presentation and the documentation of the learning module in an essay (content of this report).

The topics were:

- Topic 1: What is Sustainability?
  Elias Abud, elias.e.abud@gmail.com, Advisor: Andreas Fleischmann

- Topic 2: Sustainability in Legislation
  Christian Meindl, christianmeindl@gmx.de, Advisor: Birgit Penzenstadler

- Topic 3: Greenwashing
  Simon Wagner, wagnersi@in.tum.de, Advisor: Birgit Penzenstadler

- Topic 4: Sustainable Software Engineering
  Benedikt Hirmer, hirmerb@in.tum.de, Advisor: Birgit Penzenstadler

- Topic 5: Case Study Green Energy
  Martin Kuhn, martin.kuhn@in.tum.de, Advisor: Veronika Bauer

- Topic 6: Case Study Internet
  Shuying Dong, dongs@in.tum.de, Advisor: Veronika Bauer

- Topic 7: Green Car IT
  Valentin Koller, kollerv@in.tum.de, Advisor: Andreas Fleischmann

Contents

Chapter 1

What is Sustainability?

Author: Elias Abud

1.1 Introduction

It has been one hundred and fifty years since the Industrial Revolution and ever since the perspective of life has continued to change. Mass production and the success of capitalistic patterns around the globe influenced our society, environment and economy. Nowadays human beings are looking for more than just basic needs. Today humans are seeking things that can improve the quality of their lives.

Many people are not aware of the costs associated with such kind of lifestyles. Mass production without considering the restrictions of the nature, society and the economy threatens the ability of those domains to remain.

Sustainability is a mutual concept for many domains. Furthermore, the objective of sustainability is same for all domains. Sustainability is necessary in order to ensure long-term existence of those domains.

In this chapter, I will discuss the influence of computer science on sustainability and vice versa. As a computer scientist, my work aims to contribute to a sustainable world. Many inventions which help human beings to consume and rely less on natural resources that come from the software and hardware industries. At the same time, these inventions have a negative impact on society and nature.

In the first section you can find general information and definitions about sustainability. All the objectives of this chapter will be discussed with real cases.

1.2 Terminology of sustainability

Sustainability is translated from the German word "Nachhaltigkeit". It was first used in agriculture; sustainability consists of two words, 'sustain' and 'ability'. In other words, the ability of something to exist for a long time and to stay in the same state as it began [2].

Hans Carl von Carlowitz, a German tax accountant and mining administrator from Sachsen, Germany was the first person to write about sustainability. He wrote in his book that 'only as much wood should be cut down, as can grow by plants and sowing'[2].

He also claimed that wood was in his time the most important natural resource for producing energy by heating because it is not limited and can exist forever [2].

Nowadays energy prodcution is based on many raw material like oil and gas which are limited in the nature and could not be obtained forever. Unlimited resources for the production of energy such as renewable energy can reduce the dependence of the eoconomy on oil and gas.Hence, it is neccesary to develop this domain.

Limited and unlimited resources lead us to the question what are sustainable and unsustainable resources.

1.2.1 Sustainable and unsustainable resources

Sustainable resources obtained from nature are unlimited. However we should consider the growth rate of that resource. For example, if we cut down all the trees in the world and consume the wood, we would have to wait a very long time until the trees re-grow. Such sustainable resources are wood and water.

Unlike sustainable resources, unsustainable resources are limited in nature and cannot be produced or obtained after being consumed. Therefore we should be very careful when consuming these kinds of resources.

One should try to use renewable resources in order to ensure the existence of the human race on the planet.

1.2.2 Sustainable development

Since the term sustainability is dynamic, complex, and wide, scientist and politicians nowadays talk about sustainable development. The United Nations issued a report in 1987, in which it set aims and a world vision regarding sustainable

development[3].

The following quote demonstrates the importance of sustainable development in order to ensure enough resources for the generations to come: "Believing that sustainable development which implies meeting the needs of the present without compromising the ability of future generations to meet their own needs".[3]

Sustainable development is an multidisciplinary principle, which is in the center of the economic, social and environmental triangle[2].

Figure 1.1: mobil.TUM. Conference "Making Sustainable Mobilities - Interdisciplinary Perspectives

Some people believe that "sustainable development" is a paradox. On the one hand we are talking about sustainability which says we want to save something in the current state, but on the other hand development means we want to change, to make something better, newer. This paradox is the main issue of our seminar: how to develop new products, a sustainable life attitude, and also to consider the three elements of sustainability[4].

1.3 The Three elements of Sustainability

1.3.1 Sustainable economy

If we consider again the quote of Von Carlowitz, we can also analyze how sustainability impacts economies and businesses. As mentioned above, Von Carlowitz considered wood and trees as the most important resources because one is able to produce energy by burning wood which is infinite in nature. Hence, we realize how important was wood in that time for the economy because energy is the motor of the economy.

Nowadays we produce energy from oil and gas. Hence, it is necessary today to think about ways to ensure the remain of such raw material and to find sustainable solutions in order to be able to produce energy for long term.

Since sustainability concepts consider the long existence of this energy, it influences the economy directly and plays the role as an economic enabler. How does economic growth relate to sustainability? imagine a situation in which we consume the reverse of oil and gas at once in a short period. In this case we will not be able to produce energy. Lack on energy has negative impact on the economy.

Sector	Value added, 2001* ($, billion)	Percentage of gross domestic product, 2001
Renewable-resource industries		1.1
Farming	80.6	
Forestry and fisheries	17.2	
Renewable power generation	10.4	
Nonrenewable-resource industries		1.5
Oil and natural gas	110.3	
Coal	10.5	
Other nonfuel minerals:		
Geologically scarce[†]	8.8	
Geologically superabundant[‡]	2.9	
Stone, clay, sand, etc.	16.8	

Figure 1.2: Value Added 2001

The statistic in figure 1.2 shows the value added of different energy sectors in the United States of America. Though renewable resource industries and nonrenewable resource industries are only 2.5 of the GDP, industries and economics cannot exist without energy production. Thus, energy is indispensable for the existence of any modern country and especially industrial countries.

Energy crisis leads to in many cases of war and conflict between countries. For the U.S. and other industrialized countries, it is very important to have permanent and free access to oil, natural gas and other energy resources. The same is valid for water and other examples.

You may now ask yourself, why is it so important for the U.S. to secure sufficient oil and natural gas for a long time?

Ninety percent of the energy in the U.S. consists of oil and natural gas, and only ten percent comes from renewable energy such as wind, bio and solar energy. On the one hand renouncing oil and natural gas badly affects Americans and the world's economy, and on the other hand, dependency on unsustainable resources is not possible long term.

However, some economists have different opinions about the ability of the economy to exist without unsustainable resources. They argue that oil and gas stocks would not influence the economy if we began to develop new technologies that could replace oil and gas, and future stock of human capital would grow.
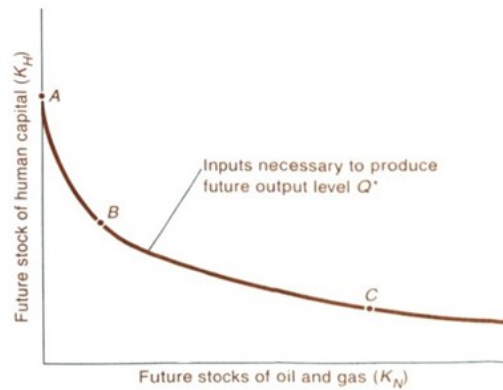
FIGURE 18-3. Natural Capital and Produced Capital Are Substitutes in Production

Figure 1.3: Indifference Diagramm,x - achse describs future stocks of oil and gas and y achse descirbs Future Stocks of human capital

The points A, B and C in figure 1.3 describe three different situations. The X-Achse describes the stocks of oil and gas. The Y-Achse describes the stocks of human capital.

Point A in Figure 1.3 describes the attitude of the people who think that one can use today all the stock of oil and gas, but in the same time to develop new

technology and means that can replace oil and gas in the future in order to keep on economic growth.

Point C describes a situation in which people think that we should not consume all the oil and gas, and we should be very careful with the use of such resources.And finally point B describes todays situation, between A and C.

Attitude A should be adopted if an only if we don't care about the environment. People with this attitude do not take into consideration the fact that by consuming all the raw materials on the planet, the status quo and the life chain can be broken and many species would become extinct.

In my opinion we should not only consider what is good for the economy, but we must also consider the rights of the different species to live and follow the sentence which says "Live and let others live". This point is a very good start for discussing the next element of sustainability: social sustainability.

1.3.2   Social sustainability

Social sustainability encompasses human rights, justice, labor rights, equality, diversity, democracy and governance, and health.[5]

Social sustainability is not easy and many times it isn't conceivable. Justice and human rights are not always welcomed in many nations. Sometimes it depends on the people, but in many cases we have absolutely no control. I will try to illustrate the difficulties we face by setting up social sustainable principles.

According to the definition above,some of the sustainable concepts are justice and equality. Hence I would like to demonstrate in the next example why does it not easy to ensure and set up those concepts in our world.

According to a study of "International Dairy Federation, Bulletin 423/2007" the milk consumption per person a year in China in 2005 was 8.8 liters/person, while in the European Union consumption was 92.6 liters/person, and in Finland 183.9 liters/person.[6]

Now imagine a situation in which the people in China will consume the yearly world's average amount of milk. Each person would consume about 80 liters/year. If we calculate the new total milk consumption, China milk consumption would increase by 91 billion liters of milk a year. The total milk production in 2005 was 388 billion liters. In the new situation the milk production would have be increased in the world by 23 percent.

Hence the costs of equity and justice can lead to a natural disaster like in the last example. Thus, the aim of "sustainable development" is to find and suggest solutions for such case. A solution can't be to prevent the people in

9

China from having a higher standard of living, because it is against sustainable principles.

The next example I want to illustrate is the Immigration of Africans to Europe and South Americas to the United States. Both examples concern human rights which say that every person has the right to travel and live wherever he want, and finally the right to be respected by others and by governments. Many people from Africa and Latin America immigrate illegal to industrial countries in Europe and in the United States of America. Many of them don't survive the journey of the immigration and if they do survive they will be returned to their countries.

The question what can be done in this case is very complex. However it is not acceptable to reject the immigrations of these people to industrial countries while industrial countries send their armies to control on the oil, golden and raw material in Africa, Middle East and Latin America. Sustainable world cannot exist unless we find honest solution for this colonialism problem.

1.3.3 Environmental Sustainability

I have already said that sustainability was founded as an environmental concept. When first talked about sustainability by 'von Carlowitz' in the nineteenth century, it was the beginning of the Industrial Revolution. No one expected climate change at that time. Today, after two centuries we can study the climate change and the reason for it in many regions in the world.

One of the reasons of the climate change caused due to the sharply increase of the concentration of the pollutants in the Earth's atmosphere in the last half of the 19th century. These pollutants are responsible for the "Greenhouse" effect. The greenhouse effect is today known as one of the main causes of global warming.

Although the greenhouse effect is a very important issue to discuss, I would like to emphasize the environmental problems in the oceans, which is less discussed than air pollution and the greenhouse effect.However it is such important as any other environmental problem.

Figure 1.4 shows fishing tends in the last fifty years. As we can see the fish rate in the world increased seven times in the last fifty years. China, with one billion citizens fishes alone 30 percent of the total number of fish. This is a question of equity and justice which are the principles of social sustainability.

Figure 1.5 represents the world population in the last fifty years. In 1960 the world population was less than 3 billion. According to the diagram, the world population today is about 7 billion, which is two and half times more than fifty years ago. If we make a fast calculation of the amount that has been fished in

Weltweite Fischerei und Aquakultur WorldWide fishing

Millionen Tonnen

China
Welt ohne China without china

Grafik aus: „The State of World Fisheries and Aquaculture 2008", Food an Agriculture Organization of the United Nations. Rom, 2009
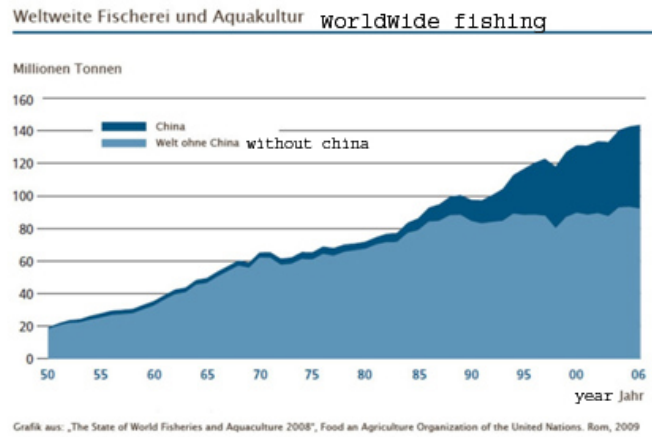
Figure 1.4: Fishing rate in the last 60 years

kg/person, in the 1960s each person fished 13 kg/year and today 20 kg/year.

The answer of why do we fish today almost twice more than in the 1960 is the consuming behavior, industry fishing and the increased standard of living in many countries like China.
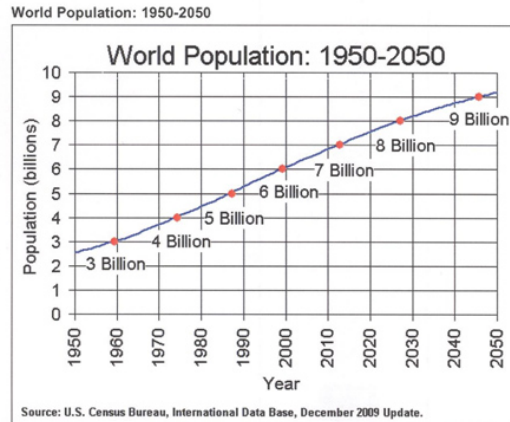
Figure 1.5: World Population: 1950-2050

1.4 Sustainability and Computer Science

In this chapter I discuss how computer science offers solutions for reducing the dependency on natural resources. First, how does computer science support the development of renewable energies, and second how can we develop environment friendly products instead of current products, which damage nature.

Computer scientists are proud of their contribution to science, the economy, society and industry. Ideas and inventions like e-books and e-government make our lives easier and our planet cleaner. Less pollution, less papers, more efficiency and creativity. In addition, Information Systems nowadays enable access to every event and topic in the world.

Also for social and equity, Information Systems and Computer Science made many contributions. Nowadays, Information Systems and social networks are essential in sharing events and opinions between people worldwide. A good example is the case of "Wikileaks" and its support for equity and justice in the world, and also the role of the social networks based on web 2.0 for the revolutions in the Middle East.

Since computer science is integrated in many engineering disciplines, I would like to demonstrate the sustainable development in urban transport, which is being researched by mobil.TUM Institute at the "Technische Universitaet Muenchen" (TUM). The Project is still in progress, and already has stimulating results.

Please note, that this research, like many others, is supported and possible thanks to computer science.

1.4.1 Making Sustainable Mobilities

"mobil.TUM Institute" is an interdisciplinary research and teaching center at the TUM. It focuses on sociological, ecological and economic questions for mobility. Together with "Berlin Institute of Technology", "mobil.TUM" develops a simulation model for sustainable mobility in the Metropolitan Region of Munich[7].

The main goal of the project is the simulation and evaluation of different transportation policies. The project considers local, global and individual specific emission levels. Therefore we need to sum up who emits, what does every single person emit, what kind of pollutant, and finally where will it be emitted. Collecting this information makes it possible to know how change unfolds when a policy is introduced.

Car user's CO_2 emissions per typical working day and home location

Figure 1.6: Example of the output

For input, the project includes the real survey data of drivers, there will be daily travel in Munich with cars and Lorries and also a network data of the streets and the infrastructures. After collecting the data, we make daily plans which will be used in the simulation and be scored.
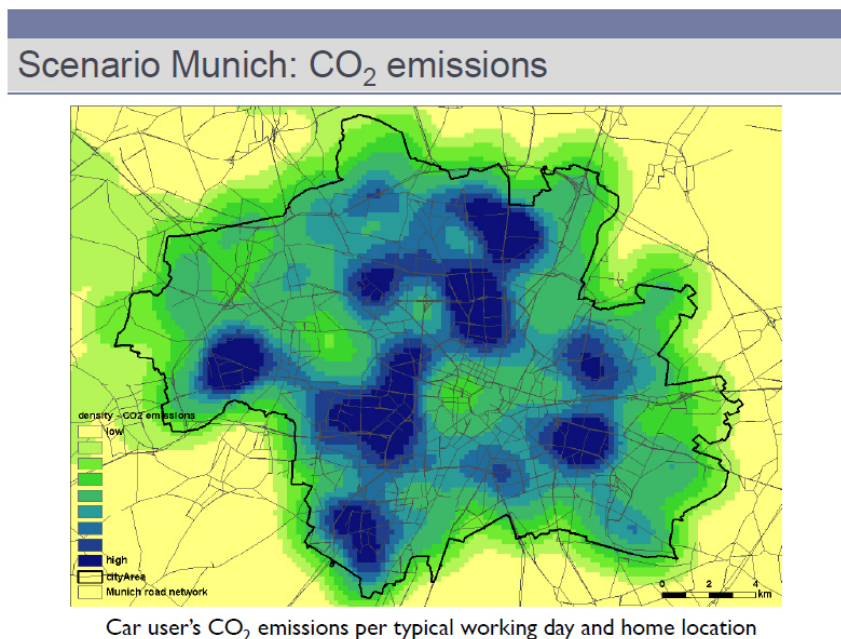
The output is the amount of emitted pollutants in urban districts. The flexi-

13

bility of the input-network data allows us to change the transportation polices and observes how the concentrations of the pollutant would be changed with the new condition and according to the simulation we can design sustainable mobility with low costs[7].

In addition to pollutants, the project emphasizes the social consequences that cars and Lorries cause. One more example which mobil.TUM examines is the noise which should be decreased inside the cities.

Finally, "mobil.TUM" can only with the help of computer scientists realize because of the huge input data and the millions of calculations which happen in the execution.

I would like now to give an example of how can we save water, wood, paper and some other raw material by developing computer-based ideas and concepts like the e-book and e-government.

1.4.2 Example of e-Government

Electronic Government (e-Government) is a relatively young concept, which offers computer-based governmental tasks so that they can be done with your own computer at home, far away from government offices. In some countries, people can vote in elections without leaving their home. Such technology is criticized from many people who claim that information in the web cannot be secured and personal information which they type can be read, used and modified from hackers and in some cases from terrorists. However, e-Government is becoming more common and used.

The profit of setting up of the e-Government is huge. In the following diagram I show which resources can be saved by using electronic government. One might save time, oil and money while changing their personal address in the civil registry from home. In many large countries like China, the next civil registry can be far away from home. Instead of consuming oil and traveling with the car, this task can be easily accomplished by putting the new data in the computer from home. In addition, the administration of the data will be also electronic, paper use can be reduced and data can be zipped and saved in minor size in data bases. With this solution we saved paper, oil and working time. However, we should not exaggerate and make every single process electronic. Weddings cannot be made at home! It is unsocial. We see once again that sustainable social is very important.

1.4.3 Example of e-Book

Electronic newspapers and books can replace the ordinary newspaper and teaching tools. By using electronic books and electronic newspapers, people can re-
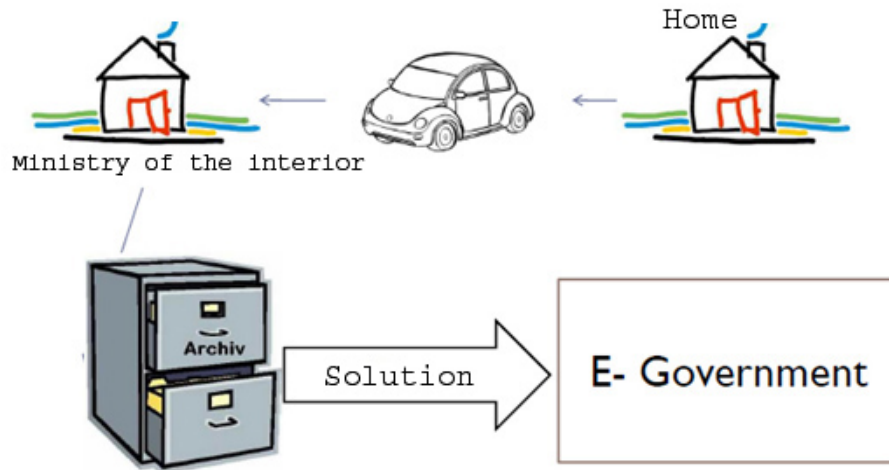
Figure 1.7: E-Government concept

duce the use of paper and the tools used for printing a newspaper or a book. In addition, costs of delivering the newspaper to homes can be saved. Electronic book are very environmentally friendly, like the new e-book from Amazon which lasts a long time on battery power.

1.5 Disadvantages of Computer based solution

In the last chapter we have seen how computer science contributes solutions for a better and cleaner globe. In other words how to suggest sustainable solutions for the environment, community and economy. Now we will examine the problems which can be caused by using such solutions. First, the issue of electronic waste will be addressed, and then discussion about energy consumption. Finally, the material used by producing processors and machines will be explored.

1.5.1 Intelligent energy algorithm

Many Internet businesses like IBM, Google, Microsoft and Amazon use many data base centers in order to save information and data of and for their customers. IBM offers cloud computing services for businesses. In cloud computing, the place in which the data will be saved is unknown and also irrelevant.

These firms make enormous data base requests in a second, which causes high processing costs. A study from researchers at MIT, Carnegie Mellon University, and the networking company "Akamai" suggests that such Internet businesses could reduce their energy use by as much as 40 percent by rerouting data to

15

locations where electricity prices are lowest on a particular day [8].

The aim of this algorithm is actually to reduce the costs of energy and not to reduce the use of energy. The algorithm looks for the cheapest data center in a given moment and saved the data in that service.

"You may think such a practice isn't helping to curb energy use, instead just lowering bills, but it could actually cut carbon emissions. Green energy is cheaper to produce so the more it is used the more data centers using it will be targeted by this algorithm. That means more of the work will be carried out using greener energy sources. In the end the savings from implementing this algorithm could be worth millions with the study produced suggesting as much as 40 percent cost savings. At the same time it would both encourage and target green energy use." [8]
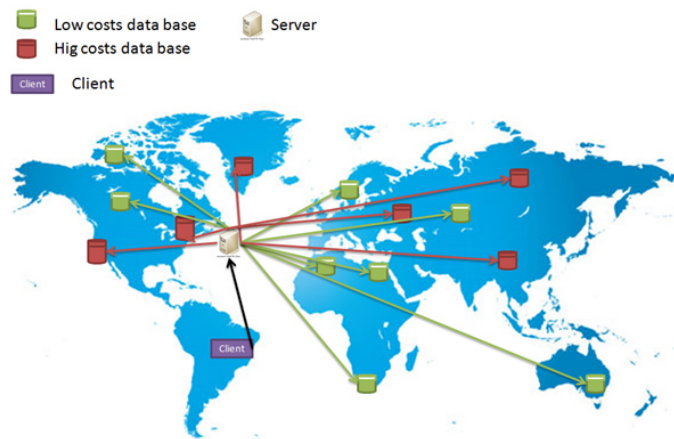
Figure 1.8: "In the end the savings from implementing this algorithm could be worth millions with the study produced suggesting as much as 40 percent cost savings"

"Green data bases" in the diagram are powered with renewable energy with low costs, while the "red data bases" have relatively high power costs. The power cost differences between the countries make the algorithm useful. A client in Brazil uses the services which are offered by Google in New York.

The server looks up in that moment for the data base with lowest costs and save the data there. The development team assumed that green energy costs are lower than ordinary energy. This assumption can be right in some countries, for example in Africa with solar energy, or in North Europe with wind energy and so on.

1.6 Implementing Strategies

In democratic countries politicians set environment policies and design models to reduce pollution. In many cases, governments required factories to change their practices were forbidden to use the product contaminates. Unfortunately most politicians do not do so on their own, but after public demonstrations like in Germany with the nuclear energy.

The case of the nuclear energy is an excellent example for sustainable lifestyle. All the parties acted in sustainable way, the people who demonstrated friendly, the Government acted according to citizens willing and the goal is also a sustainable energy. The alternative of nuclear energy is renewable energies. The compulsion in this case came from the folk.

According to the "Sueddeutsche Zeitung" the use of renewable energies in Germany increased thanks to steps which have been taken by the German Government in this energy field[9].

Incentives are fast and effective way to implement strategies. States give incentives for sustainable investments in order to encourage renewable energies.

The best way and most sustainable way for implementing new strategy is Education. Unfortunately educating Adults is very difficult and impossible in most of the causes. By education we must focus on youth and kids. The disadvantage of education is the time. It takes long time to educate the new Generations but it is indeed.

In Germany there are many organizations for this aim. Greenpeace for example call for consuming products which not damage the environment. In Bavaria for example, "Deutscher Alpenverein (DAV)" cares for the mountains in the Alps and warns people not to damage the mountains.

Universities today offer new studying programs which related to sustainability. The "Technische Universitaet Muenchen (TUM)" for example offers a new program for sustainable civil Engineering in Germany, "Nachhaltiges Bauen". In Addition many conferences and Projects in the TUM aim to sustainable future.

Finally I would like to give an unique example for increasing the awareness for sustainable development between youth by foundations which encourages youth to initiate environmental solutions. Valeria Cortez Vaca Diez from Satnta Croz in Bolivian was eighteen years old when she won a prize within the completion "Carrying life" in "Goi Peace Foundation".

Cortez Vaca Diez was aware for the damage which plastic bags causes in her country and decided to initiate a solution to decrease the use of plastic bags. Her plan was to increase the awareness between the youth people in Bolivia with very low costs. Her plan was very simple and cheap.

"The project consists of producing 150,000 fabric bags and training 1,000 students (2 per school), who would be the facilitators and would make sure that each student in their school is given one fabric bag with an educational brochure, so they will then bring them home and explain its use to their families. Every facilitator would wear a special T-shirt and cap to be identified. The total budget for this project is USD $99,500." [10].

1.7 Conclusion

During the preparation of this paper I learned many facts about humans behavior,about our planet and about our facilities. Unlike how most of us think,human resources and facilities are limited. The nature is much more stronger than us, furthermore the nature decides how our life and our future will be.

After getting to know the subject very well I adopted many sustainable concepts, in many fields. As a computer scientist and as a programmer I'm trying to think about effective and power saved solutions while programming at work and in the University.

In daily life, I speak a lot about the Sustainability between the people and I try to aware them for the importance of this subject. I decided also to boycott all the firms which doesn't produce sustainable products.

While looking and choosing my bachelor thesis , sustainability was the base condition. I have chosen to do more in the field of smartGrid, which is discussed also in this paper.

finally i would like to thank everyone which took a part in this wonderful seminar.

Chapter 2

Sustainability in Legislation

Author: Christian Meindl

2.1 Introduction: Why we need rules for sustainability

To ensure that sustainability is an important objective for every legislation, rules of action must be declared. [11] This can be done by international organizations e.g. the United Nations or the European Union. Furthermore each government has to implement these rules in their countries or describe own laws.

These rules and laws are the general framework for every organization and company in which they act. Many organizations don't act in a sustainable way by themselves so they have to be forced by the government to do so. By following this general framework organizations are committed to grow and progress in a sustainable way or change their operational sequences so that they fulfill the rules.

Since the international community recognized that global warming is the result of human actions they started to push the sustainable development of the world. In big conferences they discussed what must be done to ensure a worth living future for everyone. The international resolutions shall ensure that every country develops their own sustainability strategy and realize them in the near future.

2.2 Contents: Regulations, general frameworks and laws for sustainability

2.2.1 Germany's National Sustainability Strategy: Prospects for Germany

The first big part of the topic "Sustainability by Legislation" is the German strategy for sustainability called "Prospects for Germany". [12] It was declared in 2002 and describes concrete tasks and goals for a sustainable development in Germany. Sustainable development is a central goal of the German government and is an important part of the political decision-making process and in the governments everyday activities. Since May 2009 ministries must execute a sustainability check for each draft law or ordinance. The strategy was developed in a broad dialog between important organizations, the German government, the "Advisory Council on Sustainable Development" and Non-governmental organisations. Seven key aspects where determined in this strategy:

1. Efficient use of energy: Script for a sustainable energy policy

2. Assure mobility: Road map for new ways

3. Healthy production: Consumer as the engine of structure change

4. Form the demographic change: New transfer to the third phase of life

5. Change old structures: Education initiative and academic reforms

6. Innovative companies: Innovation as the motor of sustainability, sustainability as the motor of innovation

7. Reduce claim of areas: Assist sustainable settlement development

Guidelines

There are also four guidelines that describe the goals of Germany's national sustainability strategy. The first goal is to try to restore and maintain **intergenerational equity** and develop a new intergenerational contract. The main goals of this aspect are the cutback of the national debt, a pension reform and the costs of health care. The **quality of life** must be ensured for everyone, now and in the future. This includes healthfulness, opportunity to develop individually, satisfying work and good schools. Another important goal is the **social cohesion** which means that everyone should live out solidarity, social equity and to prevent poverty. The last point **international responsibility** tries to achieve the availability of drinking water for everyone as well as fertile ground. One example for a goal is to reduce greenhouse gas emissions (compared to 1990 levels) by 2010. Since this goal was already achieved in 2008 the government agreed to reduce climate gas emissions by 40 percent by 2020. Another example would be to double the raw material productivity by 2020 compared to 1990.

These two goals are a great example that the "German National Sustainability Strategy" is based on quantifiable and clearly measurable indicators and concrete dates for target achievement. Also there are regularly reviews to monitor the goals and to get an overview to what extent the goals have been achieved.

Concept of Management

To realize these guidelines a concept of management has been developed which describes the general requirements for an ecological, economical and social development. It is divided into four categories which are the management rules, indicators and goals, monitoring and the sustainability check. There are ten management rules which define the general principle of sustainable development. The ground rule says that every generation has to solve their problems without imposing them on the next generations. Furthermore they have to take precautions for foreseeable problems and demands. This counts for the sustainment of the natural livelihood, the economic development, the social cohesion and the demographic change. One example of a rule is that every actor of the society is important for the sustainable development. Everyone should be part of the public dialog about the general principle of a sustainable development and everyone should try to make his decisions based on these goals. Another rule says that every company is responsible for their production and their products. They have to inform the consumer about relevant properties of their products and sustainable method of production. The consumer is responsible for the selection of the product and its social and ecologic compatibility. The German government regularly publishes progress reports which gives an overview over the progress of the strategy and therefore described 21 key indicators for a sustainable development. These reports are published every two years and are an important part of the permanent monitoring process. They evaluate the status of the 21 indicators of the sustainability policy. These indicators are rated with weather symbols to make the current progress easier to understand. The main topics of the last report from 2008 were "Climate and Energy", "Steps to a Sustainable Raw Material Economy", "Demographic Change and World Food Affairs".

In Germany they also installed the "Federal Committee of State Secretaries for Sustainable Development" which consists of permanent state secretaries from all federal ministries. This committee is responsible for all questions regarding the government's sustainability policy. The committee regularly discusses important topics of the German strategy for sustainability and thus is an important component in implementing the strategy and developing it.

Sustainability in Administration

The government is not only defining guidelines and laws, they also have to take care that they act in a sustainable way in its own administration. The administration should be a role model for acting sustainable. Thats why the government determined measures for a sustainable administration. Some examples would

be:

- Every new building must follow specific standards and requirements of sustainable construction

- Building the usage of renewable energy in public buildings is to be increased

- Bisection of the CO-emissions of the federal government until 2020 compared to 1990

Movable Solar Panels

One problem of the classic solar panels is, that the angle in which the panels are placed is very important. [13] The energy production can shrink to almost 50% of the maximal amount if they are placed in the wrong direction. To maximize the efficiency of the solar panels you have to orientate the alignment of the solar panel dynamically to the current position of the sun. This way it can be assured that the solar panel always works with the best efficency.
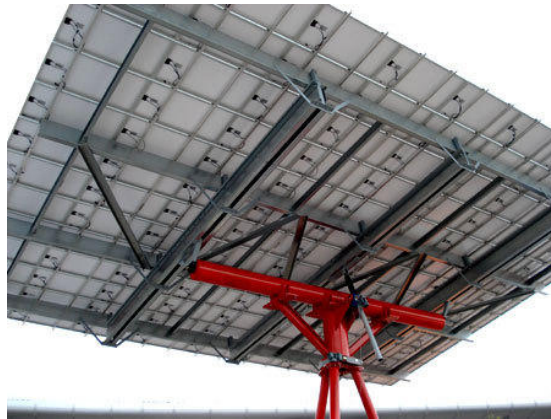
Figure 2.1: Movable Solar Panel

Another possibility of an innovative usage of solar panels is to implement them on the back side of a mobile phone. A perfect example for this is the mobile phone "Samsung Blue Earth". [14] Its casing is built by recycled beverage bottles. The solar panels are placed on the back side of the phone but sadly aren't the most efficient yet. If you put the mobile phone in the midday sun you will have enough energy to make a phone call of five to ten minutes. However it is not recommended to let the mobile phone roast in the sun all day. Thus this way of producing energy is a good idea but it still needs some work to make it suitable for daily use.

Figure 2.2: Samsung Blue Earth

Distributed Project Work

Traffic is responsible for 35% of energy related emissions. In a company or an administration department the amount of traveled kilometers is increasing linearly with the increase of employees. [15] Thus with possibilities to lower the amount of traveling a lot of energy can be saved. One increasingly popular method is divided project work.

One example would be "Cisco Webex" which allows a number of workers to work simultaneous on the same project. Every participant of a meeting just has to log in and everyone can see the same thing at the same time. It is possible to connect to a session from a computer or from a smart phone. If someone changes something on a presentation the other participants can see it on the fly. Another advantage is that you can have access to it from everywhere where you have an internet connection since it is a web based application.

Figure 2.3: Cisco WebEx

Another possibility is the "Cisco TelePresence" which creates a solution for

meetings with a live, face-to-face meeting experience and lets you interact with others. A big difference to the web based solution is, that there is a specific TelePresence endpoint in the organization and only there you can have access to it. As shown in the picture there are big monitors to realize the face-to-face interaction and to give everyone the feeling of a real meeting.

Figure 2.4: Cisco TelePresence

Sustainability Performance Management

If an organization develops and performs a sustainability program the stakeholders of the organization have expectations on the transparency and performance improvements of the actions taken. Organizations encounter a lot of obstacles, since it is not easy to measure the impacts of a sustainability program due to the fact that there is no real measurement for most of the decisions. Another problem lies in keeping track of an ever-growing variety of sustainability standards and guidelines and to align sustainability objectives with operations.

That is why SAP developed a sustainability reporting and analytics solution. [16] This helps an organization to keep track of their sustainability performance and to communicate it to their stakeholders. Other advantages of this solution are:

- Help reduce time and cost for reporting

- Model, forecast and quantify the financial impact of sustainability objectives

- Streamline reporting and focus on execution

With the "SAP Business Objects Sustainability Performance Management" application the organization is able to make reliable disclosures about their sustainability programs. It helps gathering quantitative and qualitative data with guided procedures and converts this data into actionable information to improve financial and sustainability performance.
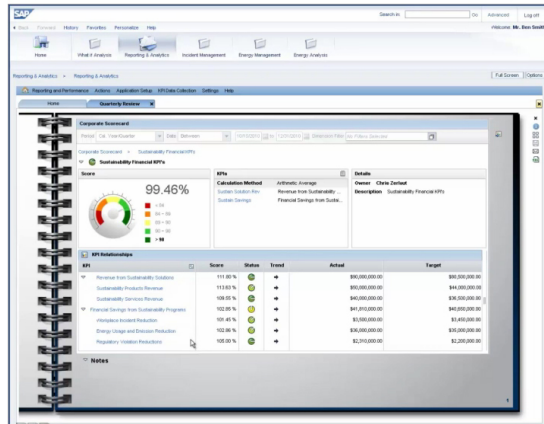
Figure 2.5: SAP BusinessObjects Sustainability Performance Management

2.2.2 European Union Sustainable Development Strategy

In May 2001 the European Union released their guidelines for a sustainable development in Europe. [11] The European Union has the self-conception to take international responsibility and therefore tries to be a catalyst to achieve an attitude change in the society. The European Union has played a leading role in supporting the ideal of balanced and sustainable development. It determines a general framework for sustainability is based upon four cornerstones. These four pillars are supposed to strengthen each other:

- Economic pillar: economic prosperity

- Ecologic pillar: environmental protection

- Social pillar: social equity and cohesion

- Global pillar: meeting international responsibilities

The guidelines are an advancement of the Lissabon strategy which was developed in March 2000. The goal of this strategy was to make the European Union the most competitive and most dynamic economic area in the world. A few years ago a replacement for the Lissabon strategy was released which is called "Europe 2020". The new main goal now is intelligent, sustainable and integrative growth. The European Union named seven basic policy guiding principles that correspond to the underlying values of a dynamic European model of society:

- Promotion and protection of fundamental rights

- Solidarity within and between generations

- Guarantee of an open and democratic society

- Involvement of the citizens,companies and social partners

- Policy coherence and integration

- Use best available knowledge

- The precautionary principle and the principle to make polluters accountable

Member states have to develop national strategys and regularly report about their improvements to the European Union. They also have to make a sustainability check before a law is being passed.

Actions to accomplish the most important Challenges

The strategy defines seven not sustainable trends that have to be countered. There are several measures to achieve that goal. The main body of the strategy is built around seven key challenges the European Union identified:

1. Climate change and clean energy: To limit climate change and its costs and negative effects to society and the environment.

2. Sustainable transport: To ensure that transport systems meet society's economic, social and environmental needs whilst minimizing their undesirable impacts on the economy, society, and environment.

3. Sustainable consumption and production: To promote sustainable consumption and production patterns.

4. Conservation and management of natural resources: To improve management and avoid overexploitation of natural resources, recognizing the value of ecosystem services.

5. Public health: To promote good public health on equal conditions and improve protection against health threats.

6. Social inclusion, demography and migration: To create a socially inclusive society by taking into account solidarity between and within generations and to secure and increase the quality of life of citizens as a precondition for lasting individual well-being.

7. Global poverty and sustainable development challenges: To promote sustainable development actively worldwide and ensure that the European Union's internal and external policies are consistent with global sustainable development and its international commitments.

Furthermore the European Union defined three interdisciplinary suggestions for good governance. The goal is to promote coherence between all European Union policies and coherence between local, regional, national and global actions in order to enhance their contribution to sustainable development.

- Policy coherence and effectiveness: High confidence of the citizens in institutions of the European Union. This confidence can be achieved by lowering cases of infringement.

- Openness and participation: Try to provide a high availability of E-government services and also aim for a high participation in elections.

- Economic instruments: Are an instrument to promote low-emission products and services and to change the behavior of consumers. The taxes should take into account the consumption of resources and the pollution of the environment.

Green Paper

In the year 2006 the European Union released a Green Paper called "A European Strategy for Sustainable, Competitive and Secure Energy". [17] Europe has entered into a new energy area and there are several aspects to counteract like an increasing dependency on energy import. The Green Paper names six priority areas:

- Completing the international European electricity and gas markets: Since 2007 every consumer in the European Union has the legal right to purchase electricity and gas from any supplier in the European Union.

- Solidarity between member states: establishment of a "European Energy Supply Observatory", improved network security.

- More sustainable, efficient and diverse energy mix: each member state chooses its own energy mix. These choices however have an impact on the energy security of its neighbors, as well as on competitiveness and the environment.

- An integrated approach to tackling climate change: trying to be a leader on energy efficiency and increase the use of renewable energy sources.

- A strategic European energy technology plan: development and deployment of new energy technologies.

- Towards a coherent external energy policy: agree at community level on the aims of an external energy policy.

SmartGrid

SmartGrids are a current approach to create an electricity network that can intelligently integrate the actions of all users connected to it. [18] SmartGrids are aiming to better facilitate the connection and operation of generators of all sizes and technologies. Consumers will be allowed to play a part in optimizing the system and consumers will be provided with better information and options

for choice of supply. By trying to get the source of the energy nearer to the consumer of the energy the environmental impact of the electricity supply system is reduced.

The European Union supports the SmartGrids European Technology Platform which is the key European forum for the technology research and development pathways for the smart grids sector.
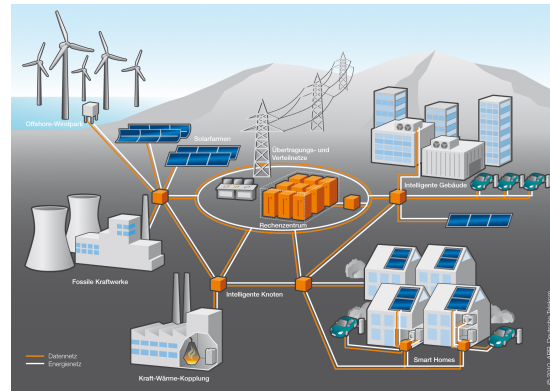
Figure 2.6: SmartGrid

2.2.3   Agenda 21

The Agenda 21 is a comprehensive blueprint that was developed during the United Nations Conference on Environment and Development in Rio de Janeiro on June 14, 1992. [19]It contains actions to be taken globally, nationally and locally by organizations such as Governments in every area in which humans have an impact on the environment. It was adopted by more than 178 countries. In December 1992, the "Commission on Sustainable Development" was created. Its goals are to monitor the implementation of the agreements of the Agenda 21 on local, regional, national and international levels.

Table of Contents

The Agenda 21 has four major sections which will be named here with a few examples of chapters of each section:

- Social and economic dimensions: Improve international cooperation to accelerate sustainable development, combating poverty, protecting and promoting human health conditions

- Conservation and management of resources for development: Protection of the atmosphere, combating deforestation, conservation of biological diversity

- Strengthening the role of major groups: Children and youth in sustainable development, Strengthening the role of workers and their trade unions, Strengthening the role of non-governmental organizations

- Means of implementation: Financial resources and mechanisms, Science for sustainable development, National mechanisms and international co-operation for capacity-building in developing countries

Local Agenda 21

"Think globally, act locally" is an important principle of the Agenda 21. The Agenda 21 asks from the communes, being the smallest political organizational unit, to develop their own Local Agenda 21. It describes measures that should be taken by the communes to ensure a sustainable development in their region. Typical properties of a Local Agenda 21 are:

- Participation of the local government

- Participation of the population

- Long-term planning process

- Mutual learning process

- Goal: Long-term action program

The importance of the Local Agenda 21 is described in chapter 28 of the Agenda 21. It describes the reason for the Local Agenda 21 as follows: "Because so many of the problems and solutions being addressed by Agenda 21 have their roots in local activities, the participation and cooperation of local authorities will be a determining factor in fulfilling its objectives. Local authorities construct, operate and maintain economic, social and environmental infrastructure, oversee planning processes, establish local environmental policies and regulations, and assist in implementing national and subnational environmental policies. As the level of governance closest to the people, they play a vital role in educating, mobilizing and responding to the public to promote sustainable development."

In Germany the development of Local Agenda 21 happened slowly. The most communes started the development at the end of the last century. In May 2002 only 16,2% of all German communes had an Local Agenda 21. [12] Until 2005 this number grew to only 20,4%. The differences between the German states are extreme. While in "Nordrhein-Westfalen" almost 65% of the communes developed their Local Agenda 21, in "Sachsen-Anhalt" only 1,6% did (all numbers from 2005). The next problem is that an existing Local Agenda 21 does not mean that concrete actions are being taken. A problem for the communes is the low awareness level of the Local Agenda 21 and that sustainability is only becoming slowly a media-friendly topic.

Kyoto Protocol

The Kyoto Protocol was adopted 1997 in Kyoto and contains legally binding goals for a maximum amount of the emission level. The emission of greenhouse gases is to be reduced by 5,2% until 2012 compared to the amount from 1990. Another objective is to "stabilize greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system."

At the end of the last century it became more and more clear that human activities are the main reason for global warming. [20] Thus the international community saw the need to take countermeasures against this trend. The Kyoto Protocol first emerged in 1992 on the Earth Summit in Rio de Janeiro and was finalized in Kyoto. But the Kyoto Protocol would not take effect until 90 days after it was ratified by at least 55 countries. This condition was met in 2002 when Iceland became the 55th country. Another condition was that the ratifying countries had to represent at least 55% of the world's total carbon dioxide emissions. It took until November 2004 when Russia signed the protocol and thus the agreement became official in February 2005. Another problem still exists, that with the U.S.A. one of the biggest producers of carbon dioxide emissions still hasn't ratified the protocol. The Kyoto Protocol expires in 2012 and despite years of negotiations there is still no follow-up agreement.

2.3 Seminar Session

The presentation was separated into three big topics which were "Germany's National Sustainability Strategy", "Guidelines of the European Union" and "International Agreements". I tried to arrange the topics according to their regional relevance and therefore started with the most local topic "Germany's National Sustainability Strategy". Afterwards I continued with the "Guidelines of the European Union" which are relevant for the most part of Europe. Then I finished the session with the "International Agreements" on a global view.

In the first topic I presented two interactive parts. The first assignment was about an implementation of an eGovernment system for the administration of Munich. The audience was separated into three groups. Each group discussed which functions the system should have. Furthermore they had to think about the right steps to make the system as sustainable as possible. The groups got fifteen minutes to brainstorm and gather their ideas. Afterwards every group presented their ideas. After the presentations I presented the eGovernment example of Hamburg which was awarded with a price as the most sustainable eGovernment system of the decade. Hamburg developed an eGovernment system that offered central planing and controlling. They installed Dataport as a special service provider for their IT-resources. In the end all of Hamburgs administrations used the same system with the same IT-infrastructure and the same base functions. Furthermore Hamburg formed an Inhouse-Consulting department for the proper execution of projects. For the future Hamburg plans to share its resources with Schleswig-Holstein for a more efficient use.
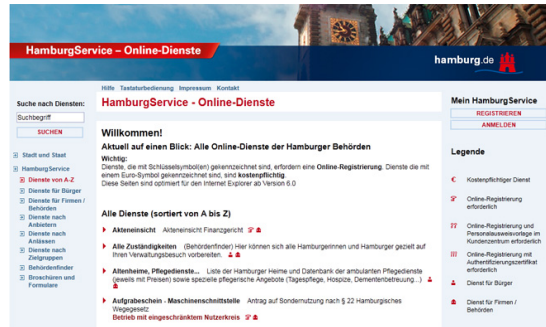
Figure 2.7: eGovernment in Hamburg

For the next assignment I presented a short video clip of the song "Guten Appetit" which was created by "Rapucation" on behalf of the "Advisory Council on Sustainable Development". I once again divided the audience into three groups and they got three minutes to discuss the major statements of the song. Then we discussed the topic together and came to the conclusion that the song is about consumers and their buying behaviors. Consumers have the choice to buy the most sustainable products but often don't make use of that. As a possible solution I presented a short clip which introduced an application for smart phones. With this application everyone is able to scan the bar codes of a product and gets sustainability information about that product and the company which produces it. We afterwards discussed the suitability for daily use. One good implementation for this method is "barcoo" which is available for all major operating systems.

The last interactive part was integrated into the topic "International Agreements". I presented the ideas behind the "Local Agenda 21". Afterwards we once again built three groups. Every group had to come up with a plan to develop a "Local Agenda 21" for a small commune in Bavaria. They should think of the chances and problems that come with a "Local Agenda 21". After fifteen minutes the groups presented their solutions. As problems we identified the reduction of sustainability to the aspect of environmental protection, missing willingness for the implementation and blind actionism. Chances lie in the possibility to bundle multiple interests and to counteract undesired developments early with a long-term strategy.

2.4 Conclusion: Will international agreements influence the development of sustainability?

In summary we can see that sustainability by legislation is a very important topic. Without guidelines and general frameworks it would be hard to bring sustainability into the minds of the people.

In Germany a huge increase of the topic sustainability can be seen in all

medias. It comes more and more into the focus of the people. Popular web sites already have special pages for sustainability information. The party "Bündnis 90 - Die Grünen" is experiencing a bigger popularity than ever before and companies try to improve their image with campaigns based on sustainability.

The problem is that many countries still don't have any real strategies for a sustainable development. Just because a country has ratified an agreement it doesn't mean that they take serious steps. One of the main points of criticism of the Agenda 21 is that it doesn't force the countries to do something and that the countries don't have to report about their progress.

Another problem of international agreements is that every decision must base on a consensus which might block the progress of a sustainable development in some regions of the world. It also slows down the global progress because every topic is discussed almost endlessly. Every government has its own interest and tries to get the biggest possible advantage from every decision. Many communes don't have or just don't want to spent the money to initiate a "Local Agenda 21" process. Thats why the visions of the Agenda 21 are stagnating in many regions of the world.

Chapter 3

Greenwashing

Author: Simon Wagner

3.1 Introduction: The root of greenwashing

In 1986 the environmentalist Jay Westerveld described in an essay, how in hotels visitors were asked to place their towels on the floor when they wanted them to be replaced. The reason given was that by reusing old towels, energy could be saved and the environment would be protected. However, the washing process contributes only a small percentage to the overall energy consumption of a hotel. Therefore, the hotel benefited from the reuse of towels and not the environment, the consumer was falsely led into believing he was doing something good for the environment.

Jay Westerveld used the words "green washing" to describe this behaviour. The term became soon popular to describe the contradiction between the environment friendly image presented to the customer and the real reasoning of companies.

Since the awareness of environmental issues has increased among consumers during the last decades, companies gradually discover environmentally friendly products as a new opportunity to differentiate themselves in the market. While most try to create better products and to change their policies, the amount of green washing used in marketing is remarkable. Especially under classical polluters (like energy providers or oil drilling companies), who are now challenged by the increased environmental awareness, the use of green washing methods has become popular to improve their image and developed into a response to criticism.

The environmentally conscious consumer is now faced with the increasingly difficult task to differentiate between green washing marketing and real efforts to protect the nature.

Figure 3.1: One of the cards used in hotels, reminding the residents to reuse their towels

3.2 Contents: Greenwashing - Paint It Green

3.2.1 Criteria for greenwashing

Greenwashing describes a marketing method were environmental "buzzwords" are used, to display a product or a company as more environmental friendly than it actually is. For example, a company that is active in environmental harmful sectors (like oil drilling or nuclear power) might create advertisements that emphasize its investments in green technology research and development, although most of the company's budget is still invested in its old polluting practices. The company's PR might also suggest much higher investments in environment protection measurements than what is really spend on environmental sound practices. Sometimes, even measurements which are required by the law are presented as initiatives by the company itself. Greenwashing marketing is also sometimes used to distract from lobbying against stricter environmental laws.

In summary one can say, that greenwashing is the attempt to present a more environmental image to the customer, while only caring about the image value and not really about environmental issues.

3.2.2 Greenwashing marketing methods

Greenwashing can work in several ways[21]: One popular method is the use of "green" labels with only loose criterias, which nonetheless suggest that the

labelled product is more environment friendly than competing products. Such labels are often used in advertisements with pastel colour, like green, yellow or orange and buzzwords like "eco-" or "natural". One example for the use of vague labels is ecopower: There exists a wide range of labels for ecopower but only few require a certain percentage of new renewable energy plants, which is necessary, because otherwise only the distribution of renewable energy in the providers network is changed.

Another popular method is the use of claims which are hard to verify for outsiders, e.g. a paper company might claim that it only buys wood from partners that have pledged to manage their forests in a sustainable way. This claim however can't be verified as the suppliers are not known to the public and therefore it is not known whether they really implement an environment friendly policy.

Furthermore, this example also shows another greenwashing method: hiding tradeoffs by exaggeration. Paper from forests with a sustainable forestry still destroys valuable trees, which could be saved if you use recycled paper instead. However, the consumer's conscience will be reassured by presenting him a green label for sustainable forestry.

Additionally, products are also marketed as green by the use of vague terms like, for example, "all natural", which is misleading, as even mercury or arsenic are natural occurring chemicals. Also, sometimes, measurements, which are required by law, are marketed as "green". "CFC-free" labels are a good example for this method, as CFC is already banned by law.

Improving environmental harmful products and presenting them as "green" is also another form of greenwashing. For example, Porsche developed an electric eco version of their cars, however, it is clear, that the car is still not environment friendly, as it still uses a great amount energy, which in the end might also be produced by CO_2 emitting plants like coal or gas power plants.

In the following, some examples of greenwashing campaigns will be presented.

3.2.3 CO_2 label for cars

New labels for the CO_2 production of cars will be introduced in 2012. The new label will show a rating like it is already common for the energy consumption of, for example, refrigerators: The cars in the best category will be labelled with A, the worst will get a G[22].

However the label is flawed: As the rating considers the CO_2 production as well as the weight of the car, big and heavy cars are allowed to produce more greenhouse gases than smaller cars. Therefore a Audi Q7 3.0 TDI, which weighs about 2.5t and has a CO_2 production of 189g/km is labelled as B, while a Citroen C1 with 875kg and 103g/km of CO_2 emissions gets into the lower category C. The label therefore prefers big and heavy cars and does not reflect the CO_2 production correctly, although the consumer might think that a car with a better label produces less CO_2[23].

This paradox has been criticized by various environmental groups and also raised discussions in the German parliament, nevertheless, the law for the label still passed without any fix for the described problem. The label can therefore be abused to greenwash heavy, fuel-guzzling cars with a green "A" label and to salve the customer's conscience.

3.2.4 Biodegradable plastic bags

Recent developments in chemistry made it possible to create plastic from renewable resource like corn starch, tapioca products or sugarcanes. Those new materials based on polylactic acid are biodegradable, in contrast to substances based on oil like polyethylene or polypropylene, which last several decades and pose a disposal problem. Especially plastic bags, offered by retail shops to their customers, are problematic as they are often used only once and then thrown into the trash. Some retailers therefore offer now biodegradable plastic bag. However this comes with its own set of problems: The decomposition of the bio plastic takes longer than the decomposition of other bio waste. Consequently, the bio plastic bags can't be disposed in normal composting facilities, because they interfere with the normal composting process. Hence they are disposed with other non-degradable trash in incinerators. So despite the best intentions, bio-degradable plastic is still disposed like normal plastic as the composting facilities are not yet ready to handle such materials.[24]

The offering of bio-degradable plastic bags can therefore be considered greenwashing, as they have no environmental impact at the moment and entices the customer to choose the lesser evil, while he could use linen bags, which are a better choices as they are used multiple times and are also produced from renewable resources.

3.2.5 Tetrapak

Tetrapak is a special paper packaging for milk and juice, which is coated with plastic and aluminium. It is produced by a Swedish company of the same name, who is the market leader for disposable packaging for beverages in Europe.

Tetrapak emphasizes the recyclability of its products and promote their environmental benefits in TV ads[25]: Tetrapak is portrait as a product that uses the easily renewable resource wood. However, the advertisement exaggerates the regeneration frequency of forests: Trees are gut down and regrow immediately. Furthermore the advertisement does neither mention that the packaging does also contain materials like plastic and aluminium[26] nor the energy that is wasted during recycling. Therefore the ad presents a grossly false image about the environmental impact of Tetrapak and consumers are mislead to believe that it is a valid alternative to other more environmental sound packaging like returnable bottles.

Tetrapak is also suspected of astroturfing in the 90s[27], which means that they supported a seemingly independent grass root movement via financial, personal or technical support. They were suspected to indirectly support the

Figure 3.2: Scene from the Tetrapak TV spot

"Waste Watchers" movement, a group that protested against environmental groups like the "Bund für Umwelt und Naturschutz Deutschland" (BUND), because BUND and other environmental organizations blocked the building of new waste incinerators. Waste Watchers argued, that if no new incinerators were built, the waste will be disposed in possible more harmful ways. However, it became known that the founders of Waste Watchers, Manfred Geisler-Hansson and Robert Polster, had strong relationships to Tetrapak: Manfred Geisler-Hansson was employed at Tetrapak until he became the managing director of Waste Watchers, and Rober Polster was a regular PR consultant for Tetrapak.

3.2.6 "Clean Coal" movement

The American Coalition for Clean Coal Electricity (ACCCE) is a lobby organization in the United States, that is dedicated to the message, that coal is a clean energy source for electricity and should therefore play a greater role in energy production as it is a domestic resource and, with the help of technology, its emissions could be reduced to near-zero.[28]

They claim, that the coal industry has already reduced their emissions by about 70%, however, this number only includes sulphur oxide and nitrogen oxide and does not include carbon dioxide. This reduction is also mostly attributed to environmental laws and not to the voluntary effort of the coal industry. They also claim, that carbon capture and storage (CCS) technology can be used to reduce the greenhouse gas emissions, while still most of the CCS projects are still in a planning phase and it is not yet clear whether CCS technologies can be economically successful. Furthermore, CCS technology reduces the efficiency of coal power plants, which means an increasing demand of coal and consequently damages to the environment through coal mining. Additionally the storage problem of the captured carbon dioxide is still unsolved: Current plans simply suggest to create final storages for CO_2, however this is not a sustainable

solution.

While trying to present coal as a "green" energy source, at the same time the ACCCE also invested \$2.6 millions for lobbying against environmental laws like the Comprehensive Energy Bill (which proposed a reduction of carbon dioxide of 17% from 2005 to 2020) and the America's Climate Security Act(which also proposed a reduction of CO_2 emissions).

3.2.7 The "Beyond Petroleum" campaign

In 2000 the oil company "British Petroleum" changed its name to "beyond petroleum". This change was accompanied by the start of a large advertising campaign that tried to present a new image of BP. BP, as first oil company, made the first inevitable move to admit that the climate on earth changed because of the greenhouse effect. Consequently, they tried to emphasize their investments in renewable energies and presented themselves as a more greener company that moved beyond its original field[29]:

Figure 3.3: New BP Logo

A new logo was introduced, changing the previous into a stylized image of a flower with green, yellow and white colours, symbolizing BP's new greener policy. Cooperations with newspapers were started, for example BP sponsored an online encyclopedia for SPIEGEL online, and even learning material for schools was distributed by BP[30]. Additionally, BP started a new advertising campaign, which emphasized the limited availability of oil and the problems of increasing carbon dioxide emissions. TV ads were produced, which showed man-in-the-street interviews, where people raised questions about energy security, global warming and other environmental issues. The spots concluded with a short text, describing BP's efforts to solve those problems and the campaign slogan "It's a start". The advertisements should present BP as a company

Figure 3.4: Old BP Logo

that recognized the challenges ahead and that committed itself to a a more sustainable policy[31][32].

There's 🔸 energy 🔹 security 🕇 in 🌱 energy ☀ diversity.

BP provides oil, natural gas, wind, biofuels, solar and options.

Figure 3.5: BP advertisement

However investments in renewable energy sources stayed rather modest. For example the acquisition of the competitor ARCO did cost $26.5 billion while BP payed merely $45 million for the solar energy company Solarex[33]. Furthermore even the amount of money spend for marketing was greater then the investments in renewable energies: 200 millions were spent for advertising while only 45 million went into renewable energies[30].

Therefore the campaign was soon criticized as greenwashing, especially as environmental disasters caused by BP became known, like a corroded pipeline that leaked 4,800 barrels of oil into the snow around a pipeline in Alaska's Prudhoe Bay. BP had been warned about the bad state of the pipelines, however, they choose to ignore the reports until it was to late. Consequently, BP's PR campaign became one of the most prominent examples of greenwashing and was only marginally successful in improving the company's image. Despite that, the logo and the basic campaign idea, stayed and BP is still trying to create an environmental image, for example by publishing Sustainability Reviews which portray their engagements. However even these reports show a rather low inter-

est in renewable energies as they forecast the use of renewable energies as only 6% at 2030[34].

3.2.8 Eco power

Eco power is a marketing concept, that makes a promise to the consumer, that the supplied power he uses, is harvested from renewable energy sources. However, as it is impossible for energy providers to guarantee a 24/7 supply of green energy at this time, Renewable Energy Certificates (REC) were invented: A Renewable Energy Certificate is a guarantee that a certain amount of renewable energy has been produced, thus separating the idealistic value of ecopower from the physical production of power. Those certificates can then be traded between power suppliers and can even be traded between different countries in the EU. Only certificates are exchanged, no power is transported between trading partners.[35]

Therefore, if a provider wants to offer ecopower, it has to earn enough certificates to guarantee that the consumption of its ecopower customers is produced by renewable energies. It, however, does not need to build the infrastructure, that would be necessary to guarantee a functioning power supply with renewable energies for its clients. It only needs to ensure, that the same amount of energy, that is consumed, is somewhere, sometime produced by a renewable energy plant.

This process however, can lead to paradox results: As long as the energy consumption of the ecopower clients is lower than the amount of green energy that is already produced in the provider's plants, there is no need for investments. However, the exact same power can be sold at a higher price to the ecopower clients. As RECs are even valid EU-wide, hydro power, that is very cheap to produce in northern Europe, can be sold at a higher price in other countries,e.g. Germany, which have a higher demand for ecopower. Only when the consumption of ecopower is higher than the amount of renewable energy that is already produced in the providers power network, it is necessary to invest in either more RECs or in new renewable energy plants.

This paradox is exploited by some companies. For example Naturenergie, a subsidiary of EnBW, a power supplier which has a high proportion of nuclear energy, offers ecopower to its customers, despite of the fact, that EnBW reduced its investments in renewable energy sources[36]. But as its parent company owns several hydro power plants in northern Europe that generate enough RECs, it is still able to sell power to customers, who actually hope that they promote the development of renewable energies.

However, their are alternative labels which a have much harder requirements: For example the "ok-power"-label require that a third of the energy that is sold as ecopower is produced in plants which are not older than 6 years[37]. There are even energy providers, which refuse to use RECs. like Greenpeace energy. Therefore environmentally responsible consumers should not rely solely on the term "ecopower" but they should take a close look, whether their provider invests in renewable energy sources and how exactly they define "ecopower".
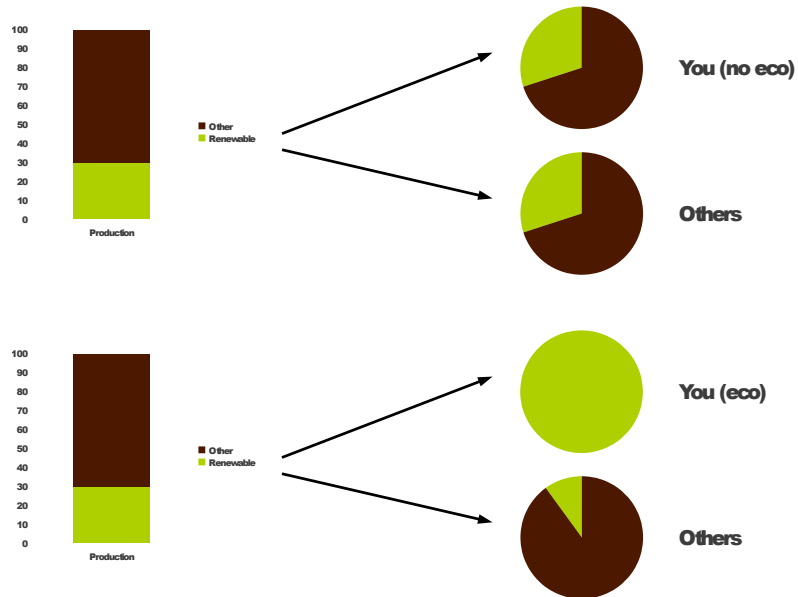
Figure 3.6: Redistribution of renewable energies: Users which do not use ecopower will simply more power from non-renewable power plants

Solely relying on the term is not enough for consumers who want to encourage a fast change in energy production .

3.2.9 Greenwashing of nuclear energy

Figure 3.7: CASEnergy: Nuclear power is safe and clean

Nuclear energy is often promoted as a CO_2 free energy alternative that can help in reducing global warming. The expansion of nuclear power is therefore seen as a "green" investment in some countries, like the United States or France. Consequently, when the United States announced to reduce the production of carbon dioxide, it was also planned to subsidize the construction of new nuclear power plants. For example, in 2010, the president of the United States, Obama, announced to sponsor the building of two new nuclear reactors in Georgia with

a $8.3 billion loan guarantee[38]. This support marks a change in America's energy policy as since the Three Mile Island incident at Harrisburg, where a core meltdown happened in a nuclear power plant an nuclear reactor coolant escaped and contaminated the nearer area, the construction of new nuclear power plants in the USA was halted. Now nuclear energy has become attractive again, as it is seen as a way to reduce CO_2 emissions without risking to increase energy prices for the American citizens.

The new popularity of nuclear energy in the US can be seen as a success for the lobbying from different groups sponsored by the American nuclear industry: The Nuclear Energy Institute (NEI), a joint lobby organization founded in 1994, ran different ads that claimed that nuclear energy is harmless to the environment and that it is indeed necessary to use nuclear power as a sustainable energy source to protect the environment from the damage other energy sources, like coal or oil, create.
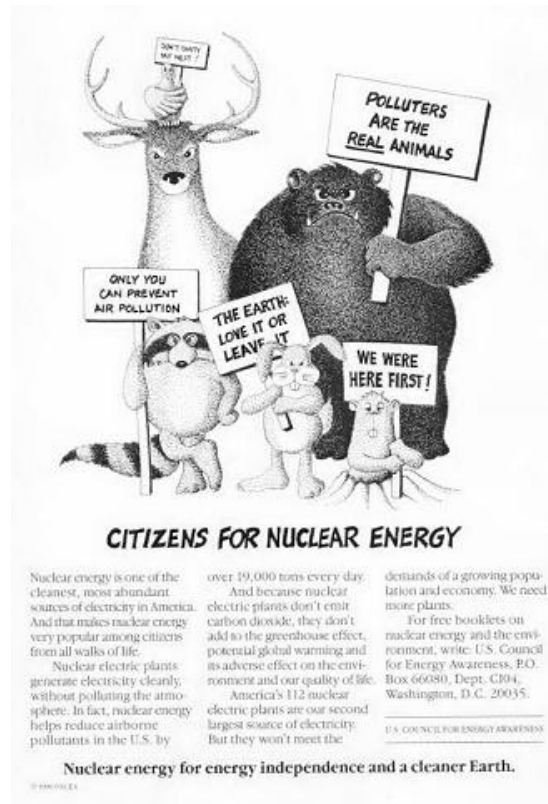

Figure 3.8: Nuclear Energy Institute advertisement

Because of this obvious misinformation, different environmental groups challenged the NEI to defend its claims before the Federal Trade Commision (FTC) in 1999. The FTC found the NEI guilty of advertising false claims, as the

discharge of hot water from the reactor's cooling system is harmful to the environment and as there is still no final disposal for radioactive waste, which poses additional risks to the environment[39][40].

The NEI also sponsors the CASEnergy (for Clean And Safe Energy) Coalition, a seemingly independent organization that is also dedicated to present nuclear energy as a safe, sustainable energy source and a job creator for America[41]. Notably they managed to hire Greenpeace founding member Patrick Moore, which helped to boast the reputation of CASEnergy, as they were able to present a former Greenpeace member siding with them. However, Patrick Moore's relationship with Greenpeace is rather difficult, as he differs from Greenpeace's position on genetically modified food and global warming. Consequently, he left the organization in 1986. Moore has also been criticized for advising firms, which cause harm to the environment. For example he worked for Asia Pulp and Paper (APP), a company that is responsible for a great part of forest clearance in Sumatra, according to the WWF. Human Rights Watch also reported several cases where villagers, who protested against APP, were attacked by company-funded militias. Moore's consulting firm however attested APP that they are "engaged in world-class sustainable forest management" and that APP's forest concessions act as a "buffer" between forests where tigers live and "human encroachment".[42]

But there are also examples for lobbying by the nuclear industry outside the US: For example in Germany, nuclear power is seen as a technology that the country wants to get rid of as soon as possible: In 2000, the current government and the four largest nuclear power plant operators agreed on a law that limited the amount of energy that nuclear power plants were allowed to produce. Once a nuclear power plant reaches the limit, it has to shut down. However, it was not certain whether this agreement would last, as the opposition, declared that they would reverse the deal. Therefore, the nuclear industry was in need for lobbying to ensure that the nuclear power phase-out would be reversed and the acceptance in the population would increase. The most powerful lobby group in Germany is the "Deutsche Atomforum", which was founded in 1959 to promote the peaceful use of nuclear energy. In 2010 the forum started a greenwashing campaign for nuclear energy, named "Klimaschützer unter sich" (Environmentalists among themselves): Advertisements were created that showed a photograph of a nuclear power plant beside a windmill[43]. The caption of the ad reads "Wind energy and nuclear power: CO_2 emissions = Zero", claiming again, that nuclear power plants are good for the environment because they don't directly produce carbon dioxide emissions. The depiction of the ad suggests that therefore, nuclear power is comparable to renewable energies like wind power, ignoring again the unsolved problem of the disposal of the dangerous nuclear waste. And even the saving effect of carbon dioxide is disputable, as the International Energy Agency (IEA) found in 2008[44][S. 5] that nuclear energy would only have a marginally small effect of 6% of CO_2 reduction. Despite those arguments, the Atomforum still claims that nuclear power plants are still climate savers and has even registered the domain klimaschützer.de which redirects to the Atomforum's site kernenergie.de.

Figure 3.9: Advertisement run by the Atomforum in Germany

Another argument brought forward by the Atomforum, is that nuclear power plants are inevitable because they are needed to compensate the fluctuations in the power grid, caused by renewable energy plants that can't produce a constant amount of power over the full day. However those claims are challenged by different studies, even a study commissioned by E.On found that nuclear power plants are less flexible than gas power plants and are therefore inferior for supporting fluctuating renewable energy sources[43].

But besides the classical greenwashing through advertising, some cases where the German Atomforum used astroturfing became known[45]. One prominent case involved the "Kerntechnische Gesellschaft" (KTG), which is financially supported by the Atomforum[46]: In 2001 in citizen initiative "Bürger für Technik" (BFT)[47] was founded, with the primary goal to ensure that more young

people get interested in science and technology. However on their homepage, besides articles about chemistry or agriculture, there are also statements endorsing nuclear energy and complaints about the false potrait of nuclear energy in the mainstream media. Additionally a list of written letters to newspapers, with complaints about the government's energy and environment policy, is provided. The letters are mostly written by the members of "Bürger für Technik". While "Bürger für Technik seems to be an independent group of citizens with a positive view about nuclear energy, a closer look shows its involvement with the KTG: The president of "Bürger für Technik", Dr. Ludwig Lindner, was a spokesman of the section "Nutzen der Kerntechnik" (advantages of nuclear technology) until 2004 and alternate spokesman until 2007 for the KTG. Eckehard Gring, also listed as a member of the "Bürger für Technik" team, was also a member of the KTG and in the "Nutzen der Kerntechnik" group[48][45]. The clearest evidence of an association between the KTG and "Bürger für Technik" comes from the 2006 report of the KTG[49]: On page 30 of the report, it is mentioned that KTG's newsletters are sent to journalists and politicians but with "Bürger für Technik" as sender. The website of "Bürger für Technik" is also explicitly mentioned. The report states that the website was created to reach technically interested citizens. It also shows no distance between the KTG and "Bürger für Technik". Other websites, which seem independent to the outsider, are mentioned, like `www.kernenergie-wissen.de` or `www.energie-fakten.de`. The report also states the success of letters to the editor, a PR method which is also used at "Bürger für Technik". Finally, the report is signed by two members of "Bürger für Technik", Eckehard Gring and Ludwig Lindner. These evidences show that "Bürger für Technik", and the other sites presented in the report are strongly influenced by the KTG and are not independent groups. Therefore the KTG can be accused of using astroturfing as a method to present nuclear energy as a reliable and safe power source and to spread fears that renewable energies won't be able to produce enough power to make a sustainable change in power production possible.

3.2.10   Measurements against greenwashing

As environmental awareness has increased in recent years, more and more companies are trying to adjust their marketing. However, this makes it more difficult for consumers to make distinctions between simple advertising and a true environmentally friendly policy. Therefore organizations, who take a look at company's environment policies, and journalists, who investigate the environmental value of new products, are necessary to detect green washing methods in the advertising industry. Several environmental organizations are already dedicated to this task, for example:

stopgreenwash.org It's a website run by Greenpeace that wants to educate people about greenwashing and lists several examples of companies that used greenwashing techniques.

klima-luegendetektor.de klima-luegendetektor.de focuses on topics about climate change and on climate friendly claims by companies.

greenwashingindex.com On this site users can post ads which are then rated by the visitors of the website as bogus or authentic.

However the funding of those projects is rather difficult. `klima-luegendetektor.de`, for example, ran into financial problems as they lost the support from Greenpeace Magazin. Financial pressure also can be a handicap for journalists who engage into investigations about greenwashing, as their employer might be in need for the money that comes with printing greenwashing advertisements.

3.3 Seminar Session: A short story of greenwashing

The presentation consisted of three parts:

In the first part, the term "greenwashing" was introduced: How it was created by Jay Westervald and how the term is usually defined as trying to present a green image while not really following environmental sound ideas.

In the following several examples of greenwashing campaigns were presented:

BP's greenwashing campaign was described by showing the change in the logo and advertisement. Also shown was their sponsoring cooperation with different media organizations to promote BP's greener image. BP's marketing efforts where then compared to BP's investments in renewable energies to unmask the BP's greenwashing efforts.

Afterwards a TV ad by Tetrapak was shown to the audience to demonstrate a subtle use of greenwashing in advertisement. The ad showed several fast regrowing resources like corn or sheep wool. All resources were shown as regrowing immediately after they were harvested, even the third resource, wood, which is used for Tetrapak, was portrayed as fast regrowing, although it takes several decades for a forest to regenerate. Also, the ad did not mention the use of aluminium and plastic in Tetrapak's packaging. Therefore, the advertising deliberately conceals the disadvantages of Tetra Pak.

After the first two examples the audience was asked to create their own greenwashing advertisement campaigns. They created a small presentation for the following products:

- Transatlantic flights

- Car tires

- A Porsche car

In the following the example of ecopower and the Renewable Energy Certificate System were introduced and it was described how the use of those certificates leads to a system that prevents ecopower from increasing the production of renewable energy.

Finally, the audience was asked to collect ideas on how to prevent greenwashing: Several ideas like the introduction of new laws to prevent greenwashing, as well as the creation of consumer portals, which are dedicated to investigate greenwashing campaigns, were suggested. Additionally, some webaddresses of internet portals that publish greenwashing cases were collected.

3.4 Conclusion: Future development of greenwashing methods

Greenwashing is a great problem for the environmental movement as it distracts customers from more environmental sound products and hides environmental harmful actions of companies. However, greenwashing seems no longer attractive, as the amount of greenwashed products seems to be shrinking[50].

Whether that's the success of all the projects, who are dedicated to unveil greenwashing, or simply the fact that green marketing is no longer so successful because customers show less interest for green products, remains to be seen.

Another new problem is the use of astroturfing, where seemingly independent groups are sponsored for lobbying in the interested of cooperations. Greenwashing via this way is often difficult to detect because it is rarely possible for an outsider to get an insight on the connections of such astroturfed groups.

In summary one can say that choosing environmental friendly products is a difficult task and needs a lot of insight on the customers side into production techniques and environmental policies of cooperations.

A possible way for us computer scientists to help with the current situation might be the development of mobile applications which might provide helpful environmental advices to the customer when, for example, he scans a barcode of a product he wants to buy with his mobile phone camera. Such applications which collect informations from consumer protection organizations and environmental groups, like Greepeace, might help the customer to discover greenwashing and to choose really environmental friendly products.

Chapter 4

Sustainable Software Engineering

Author: Benedikt Hirmer

4.1 Introduction: Can IT outweigh its own power consumption?

The continuous increase of power consumption through information technology is no secret. The power consumption of data centers tripled almost from 58 TWh in 2000 to 123 TWh in 2005 [51].

The fundamental question is whether the energy savings through IT can outweigh the enhanced energy consumption caused by IT hardware and software. Unfortunately, until now, there is no concrete answer because hardware and software is still rapidly changing and evolving.

So we have to develop products that are more efficient, more sustainable and we should bring the extra effort to make even the development of hard- and software more sustainable. Such efforts have already reached the hardware development of IT but still today sustainability is not established in software development.

4.2 Introduce sustainability into your software project

This chapter will show several opportunities for software development teams to introduce, gain and increase the sustainability of software projects. It will cover ways to make the project more sustainable by increasing the product quality and it will reveal metrics to increase the environmental sustainability of the software engineering process and the software product itself.

4.2.1 What is Sustainable Software?

A common definition of Sustainable Software is not present but the definition of M. Dick et al. is a good approach:

> "Sustainable Software is software whose direct and indirect negative impacts on economy, society, human beings, and the environment resulting from development, deployment, and usage of the software is minimal and/or has a positive effect on sustainable development."[52]

They sharpened this definition by interviewing five lecturers and practitioners of computer science about their understanding of Sustainable Software. Their answer leads to the following categories: software design and programming, need-based development, project management, special features, possible applications, and resource saving.

4.2.2 What is Sustainable Software Engineering?

Sustainable Software Engineering is characterized by a way of how a software product is developed, so that negative and positive impacts on sustainability that spring from the software product, are captured, documented and optimized over the whole product's life cycle.
Therefore a 'Green Software Label' for Sustainable Software has a major importance. This label can show the customer the quantity of exhausted resources during development, but also the power consumption during use. He can compare software that has this label to other software that might also have this label.

4.2.3 Sustainable Software Engineering through Agile Software Development Techniques

Agile software development is a popular technique to develop software, especially in small team sizes. Agile methods try to place the coding into the center of software development. When developing software through agile methods you should also care about planning your project. Although agile development propagates that requirements may change, you need to do detailed requirements engineering.

A metaphor for software development

In this chapter we want to find a good metaphor for software development because metaphors help us to improve the understanding of issues.

First, we compare software development to architectural engineering, e.g., building a building:

- Buildings are static, but software is not.

[53]   [54]

Figure 4.1: Searching a good metaphor for software development: Building or coral reef?

- It is very expensive to modify a building after it has been built. Software can be modified easily - you can add new features or refactor the foundations of your application, but of course there are limitations.

- It is easy to identify when a building is complete. After its completion no modifications will be done - if not necessary. Even successful software is never complete. With every release the software is changed - new features are added, some errors fixed, performance improvements, etc.

- The process of building a building begins with meticulous planning the building, after that building according to plan and finally the completion. The goal is to abide by the plan as far as possible. Software Development is not that static, e.g., requirements often change, the architecture has to be changed during development process, etc.

Therefore building a building is not a good metaphor for developing software. Let's compare software development to a coral reef:

- A coral reef is *continually evolving, growing and changing*. Software is also changing over time. After five years the source code for a software program is often completely unrecognizable from its original form.

- The reef is *very complex*, yet software is also. The complexity of software is a unique characteristic in comparison to other engineering disciplines.

- It is *vulnerable*. Software is also vulnerable. You can't ensure 100 percent security and errors happen quite often, because software runs on different machines in different situation with different configurations.

- The coral reef is an entire *ecosystem* for fish and plant. Successful software also build an ecosystem of customers, plug-in developers, reseller, service firms and hardware manufactures around them. These are tied to this software product.

As we can see the coral reef metaphor fits quite well to software development. Unpredictable changes, user requests, bug fixes or changing hardware/software that the software is dependent on change the source code or even the entire architecture of the software product. Therefore software development must aim to a high ability to respond to change.

Characteristics of unsustainable Software Development

Most software teams develop features and fix defects only in short-term and do not pay attention for long-term development of the software. The result is unsustainable Software Development that is characterized by a decreasing ability to respond to change. This leads to an increasing amount of defects and and an increasing cost of change in time, see Fig. 4.2.
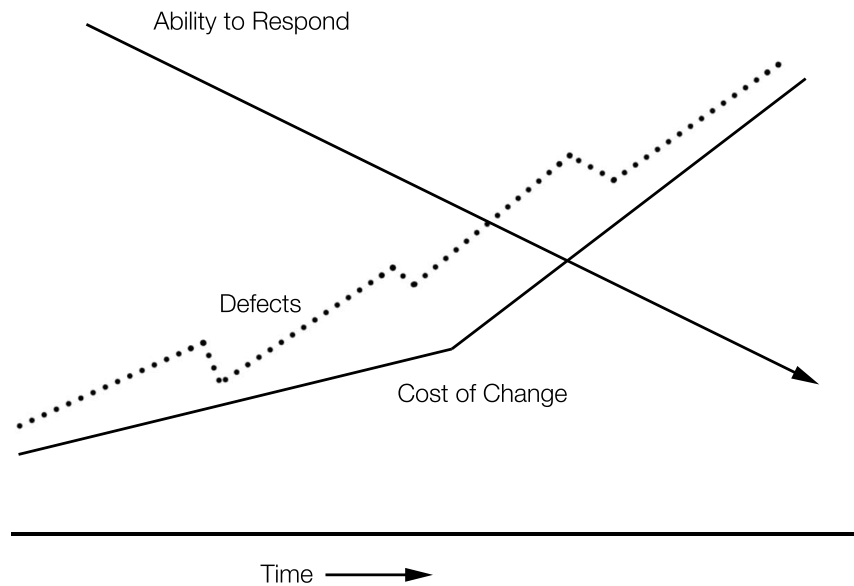
Figure 4.2: Main characteristics of unsustainable Software Development [55]

The cost of change and the number of defects increases because the software team is primarily developing in short-term and every new change is implemented as fast as possible without involving current software architecture. Over time the team is spending more energy fixing bugs than developing new features. In order to break this death spiral is a hard process for a software team, but the work is worth it.

However, there are more, for developer better recognizable, characteristics that indicate unsustainable development:

  - The development team reacts on bugs and errors rather than preventing

them. This is also known as the *code-then-fix*-mentality. The feature is implemented first and after that bugs or errors that appear get fixed until the feature works good enough.

- *None until few automated tests* are implemented. These tests catch errors in an early state, mostly even during implementation. The developer, who introduced the error, can fix it by himself. He knows the part of the source code, on which he is currently working on, and its structure very well.

- *Many workarounds*, so called "ugly hacks", can be found in the source code of the software. Mostly these are commented with a FIXME tag and a description, but in most cases they won't get fixed. Often these workarounds reduce the performance of the software while increasing its vulnerability.

- The development team is *working long hours*, especially when a release gets close. This decreases the motivation of the team.

- The developers start *blaming problems* on other developers and they don't trust each other.

Principles & Practices to obtain Sustainable Software Development

Your team members have to internalize the principles of Sustainable Software Development in order to obtain Sustainable Software Development. These principles are like a vision of the software product. They define the goal the software wants to meet. The practices are the way to this goal - like features in a project.

"Principles define what you want to accomplish and the practices how you want to go about it."[55]

The four main principles are:

- Working product
- Emphasis on design
- Defect prevention
- Continual refinement

In the following part I will explain each principle and demonstrate some sample practices how to reach this principle. These principles can also be applied in traditional software engineering when using i.e., the waterfall approach.

Software products should be in a **working state** at all times. This means that the product is virtually shippable and not that it is feature complete. The product could be shown to ambassadors to receive customer feedback. A working product has also positive effects on the development. The team receives more flexibility and agility. Errors can be caught in an early state and every member of the team can concentrate on his current task.

- *No "Broken Windows"* aims at the Broken Windows Theory. The name of this theory comes from the following example:

  "Consider a building with a few broken windows. If the windows are not repaired, the tendency is for vandals to break a few more windows. Eventually, they may even break into the building, and if it's unoccupied, perhaps become squatters or light fires inside."[56]

  This theory can be adapted to software development. You break the windows by introducing "ugly workarounds" and once this decay has started, it will continue and get worse over time. Ugly workarounds cause problems and are a symptom that the software is not in a working state.

- *Nightly builds* are an important factor to ensure, that your software is in a working state. Every day the whole project should be rebuilt from scratch with automated tests to catch integration problems as early as possible. The first thing in the morning should be to fix the problems that cause build or test failure to ensure that the team is developing on a working product. You should always pay attention to build times and optimize them. Long build times distract the concentration on the product because the developer has to wait until the build is complete.

- *Continuous integration* helps to catch integration problems as early as possible. It also prevents multiple works, e.g., when two developers could use one single helper method. Therefore the changes should be checked in as many times as possible.

Design has a critical role in software development - most software systems are over-designed or under-designed. Over-Design happens usually when developing software top-down. The outcome is mostly a fabulous design, but the project

can fail, because too many resources have been spent on design. At the other extreme, in code-then-fix development, is little or no design. The code structure is quite often bad and only the developer who has written the source code can understand his intentions completely.

Emphasis on Design means to find the balance between these extremes. You have to make the design as simple as possible with the documentation needed to derive the feature.

- *Refactoring* means that you change the software in a way that the structure of the code is changed but the code's behavior remains unchanged.

  "Refactoring is the process of changing a software system in such a way that it does not alter the external behavior of the code yet improves its internal structure. It is a disciplined way to clean up code that minimizes the chances of introducing bugs. In essence when you refactor you are improving the design of the code after it has been written."[57]

- *Design patterns* are very important for software developers. They deliver a solution for a known problem. Design patterns are known to work, they are tested, and they have a known behavior. They help to make the code reasonable because other team members know what pattern is applied where. Patterns also deliver a common vocabulary. A team member can visualize how the code structure might look like only by naming him a pattern. This extremely encourages the exchange in discussions.

- *Design for reuse* helps to reduce coupling and dependencies with other software modules and of course, it eliminates duplicated code. Duplicated code increases error-proneness and complexity: if you want to fix a bug you have to change the code in every module where this bug might appear. The probability to forget one change is very high.
  If you have to reuse a method or module at least twice or even if you think that it might be reused in future, make it reusable. The code structure stays clean when a second or third reuse is introduced.

Another important principle of Sustainable Software Development is **defect prevention** over defect detection. Defect detection is nowadays most common method to fix software errors in a code-then-fix development environment: the feature is developed, after that, testing is done by quality assurance (QA), and then defects are fixed. QA has to write the tests, execute the tests and find the defects, hence, it is often stuck with low-level testing Fig. 4.3.

The role of QA should not only be finding defects, QA should also ensure that new features work in ways that customers expect them to and that the product meets the customer's needs.

In a Sustainable Software Development environment are those who develop the feature, responsible for writing automated tests. Defects are caught even before the feature is complete and QA can work on tasks that can't be covered with automated testing, e.g., usability evaluation, user verification testing, visual

validation testing, and performance testing. This helps QA to concentrate on their actual tasks.
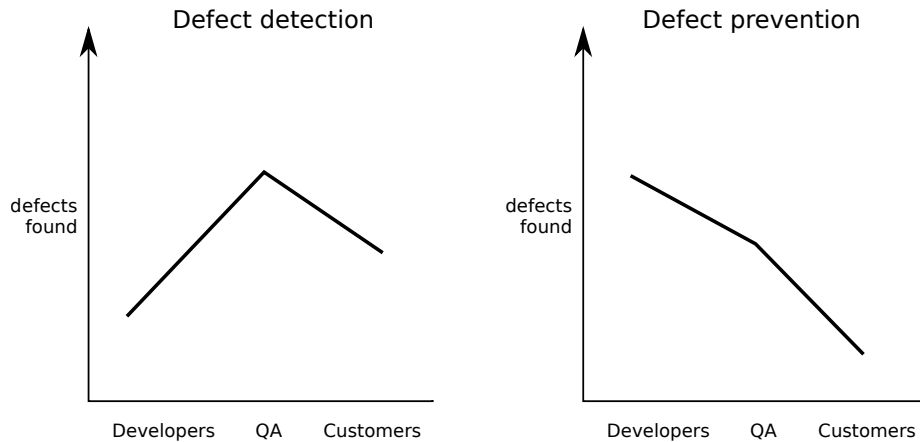

Figure 4.3: Defect Detection vs. Defect Prevention [55]

- *Ruthless testing* is primarily automated testing and one of the most crucial practices of Sustainable Software Development. Tests give developers confidence that their product is behaving as expected.

- *Pair programming* follows the double-verification principle. Two programmers work at the same computer on the same problem. When two people implement the same feature together, more defects can be caught during development and the chances that a third person understands the source code are high. Also the second person could think about tests while the first one is implementing the feature.
  However, pair programming isn't for everyone and not for everyday. Critical features, complex algorithms or inaugurating a new programmer are good incidents to do pair programming.

The last principle **continual refinement** means that the software team has to find a way to balance the short-term requirements, to ship the product as soon as possible, with the long-term needs, to anticipate change.

- *Daily standup meetings* should be held the same time every day for an absolute maximum of 15 minutes. It encourages the communication of the team members, problems can be caught early and everyone knows what everyone else is doing.

    In a daily standup meeting, each person answers three questions:
    * What did you do yesterday?
    * What are you going to do today?

* Are there any obstacles to your progress?[55]

- *Retrospectives* help the team to continually learn and adjust the project and the methods that team members use. The team members have to learn from mistakes but they should also know what went well. Team members need to exchange with each other - this meeting is a good place where they can ask any questions. This helps the team bond. Retrospectives should be held on a regular basis during project development, e.g., every second iteration.

These principles and practices can take developers by the hand in order to create a software product that is sustainable and successful. However, the principles have to be internalized and supported by the whole team. Also some practices can only be performed in small team sizes.

That is why we have to find a more generic way for every kind of development process to gain more sustainability in software projects.

4.2.4 A Model for Green and Sustainable Software Engineering

The Model for Green and Sustainable Software Engineering [52] was developed by Dick, M., Naumann S. and Kuhn, N. in 2010. The model addresses every single step during software development regarding impacts on sustainability. Moreover, it hands over starting points and examples for sustainability relevant criteria for three main roles: Developer, Administrator and User.

Process and Lifecycle Model

The Process and Lifecycle Model Fig. 4.5, formerly known as life cycle assessment, should deliver starting points for activities to identify, assess and improve sustainability of a software product. In the following chapter I will derive some examples of these starting points and clarify the relevance of each lifecycle step on sustainability.

The **development** is the most important phase when you try to make your software product and its whole development process sustainable. You have to assess the direct and indirect impacts on sustainability that occur during development of the product and by using the prospective software. These assessments are held continually and should deliver the following starting points:

The most common starting point is *efficiency*. The problem is that in most cases greater efficiency can't get implemented easily or is quite not possible. Another issue is *hardware requirements*. Low hardware requirements save investments and raw materials. You could also try to minimize the amount of *business trips*, but an *early involvement with (potential) customers* is a great principle to reach green software engineering. When you know the requirements and evaluate your software product continuously you can deliver a software product that meets the customers need.
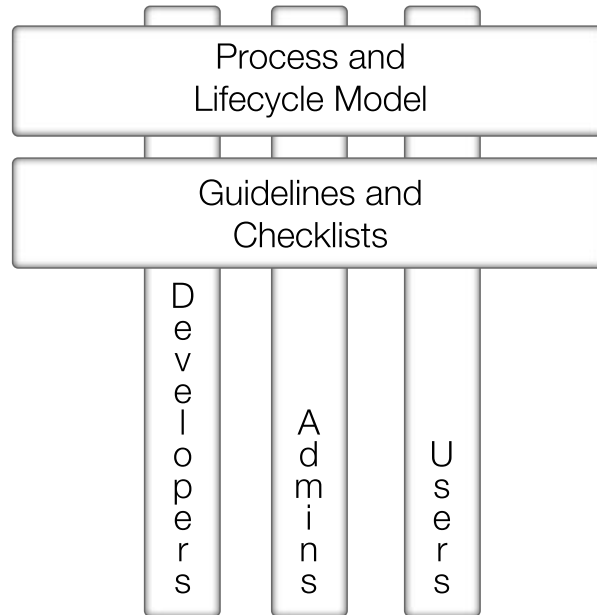
Figure 4.4: A Model for Green and Sustainable Software Engineering [52]

But there are also relevant criteria that affect sustainability directly while developing software. Some examples are the daily way to work, power consumption of workstations, lighting, heating, air conditioner and work conditions like working one day per week at home.

During **distribution** phase the development team has to decide how they want to distribute the software product, *via online download and/or via physical medium.* If they decide to ship the product on a physical medium sustainability relevant criteria are *printed manuals, transportation and packaging.* These relate directly to criteria for the disposal phase.

However, when you decide to ship your product via online download you also have to care about sustainability. Are the servers powered with *green energy*?

Figure 4.5: Process and Lifecycle Model [52]

How can the download size be reduced?

The **acquisition** phase discusses the decision process between different standard software products. The user should include n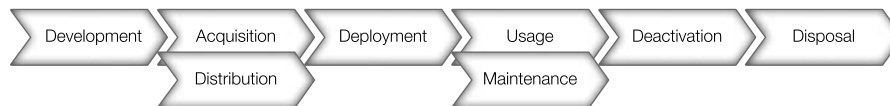ot only features but also impacts on sustainability that come from the software product during development and during its usage. An *eco-friendly software label* could help users to determine between green and not green software. Such a label could also help to make green software engineering more popular and present.

Deployment is relevant for administrators, e.g., in data centers. The software administrator has to configure the operation system in order to install the software. He also takes care for the correct initial configuration of the software product.

When the software is in **usage** criteria for sustainability are *cpu time, memory usage, hardware requirements*, but also the *size and frequency of updates*. It's unimaginable that many big software companies don't deliver delta updates for their software products. In many cases the user has to download the complete software package to perform an update. This is an important item to gain sustainability.
Furthermore, the *usability* plays a major role for Sustainable Software because when a customer can fulfill the tasks fast and accurate, the software is saving resources too.

The administrator is responsible for sustainable **maintenance**. His starting point is to take care of an *eco-friendly configuration* of the software, e.g., the size of the browser cache. He could also raise the awareness for sustainability by introducing *workshops for users*. These work shops could address sustainability how to configure and use software eco-friendly.
Additionally, the *number and size of backups* is a relevant criterion for sustainability.

Deactivation means the phase when the product is not in active usage any more. The customer has to decide what *backup files* they have to *archive*. Do these files need to be *converted* for other software? How long have the files to be archived for *legal regulations*? The main target should be to shrink the size of old data as much as possible.

During **disposal** the main point is the energy needed to recycle the software product. But in this phase no decisions have to be made because the decisions were made during distribution phase.

In summary, it can be stated that this model gives good starting points to gain sustainability for each phase of a software product.

Guidelines and checklists

Guidelines and checklists constitute an open knowledge database where you can find tips and assistance to

- develop,

- use,

- provide, and

- maintain

software products in a more sustainable way. This database enables the consideration of future developments, trends, and evolving technical expertise.

I will show you some exemplary guidelines and checklists for each role: Developer:

- The usage of *analyzer tools* is recommended. You can time-stamp your software to find performance issues and memory leaks. These issues can be fixed during development phase.

- As announced before *delta updates* play a critical role for Sustainable Software Development.

- Also the usage of *background services* is a guiding principle to gain sustainability. You should minimize the amount of background services as much as possible.

- Graphical design elements can be optimized for minimal file size. A JPEG file at 85% quality level allocates more than six times more space than a seven-color palette PNG file Tab. 4.1. This is not only an important criterion for web services because disk space is also saved in the executable software product and memory can be also saved during execution.

Table 4.1: File size for a graphical design element in different optimization levels (values in bytes) [58]

	File format	RGB living color	12 color palette	7 color palette
File size with text	JPEG 85%	8152	n/a	n/a
	GIF	n/a	2345	2248
	PNG	9036	1320	1290
File size w/o text	JPEG 85%	3895	n/a	n/a
	GIF	n/a	1528	1431
	PNG	3424	666	639

Administrator:

- *Caching* strategies are worthwhile for server administrators. Although caching does not reduce the amount of HTTP request, it does reduce the payload of the HTTP response of the server. Less data has to be transferred, hence, power consumption drops.

- In addition to caching, modern web browser support *compression* of web sites. This also reduces response sizes and transfer times, which results in lower power consumption.

- In addition to powering the data center with renewable energy, administrators can apply *virtualization strategies*. According to [59] it seems to be possible to save 4.1 megatons of carbon dioxide emissions by virtualization and by optimizing heating, ventilating and air conditioning in german data centers. But you have to take care that virtualization software consumes processing time in order to manage the virtual machines and not all services are well suited for virtualization. As an administrator you have to decide for every new service or software if it's consuming more or less power when being virtualized.

User:

- To achieve a greener internet, web users could install a browser add-on that indicates whether a web server is powered with renewable energy or not. GREENSOFT, a research project of FH Trier, has developed such a browser add-on for Firefox. It's called Green Power Indicator Fig. 4.6.

- Another guideline could be to change the behavior during browsing the web in order to minimize the number of requests to servers. An example: many people address websites not directly by their url but by searching the website's domain name via a search engine. Search requests consume processing time which leads to more power consumption. If everyone would minimize his search requests by adding favorites instead of first searching every web site, a lot of energy could be saved.
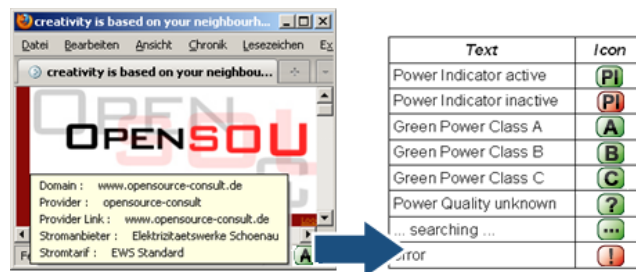

Figure 4.6: Screenshots of Green Power Indicator Browser Add-on [60]

60

4.2.5 A Generic Model for Sustainable Software Engineering

The generic model for Sustainable Software Engineering [61] has the objective to enable Sustainable Software Engineering by introducing several activities that have the objective to foreground sustainability. This model can be applied to several development processes. In this chapter I will show it for a waterfall-like approach and for Scrum.

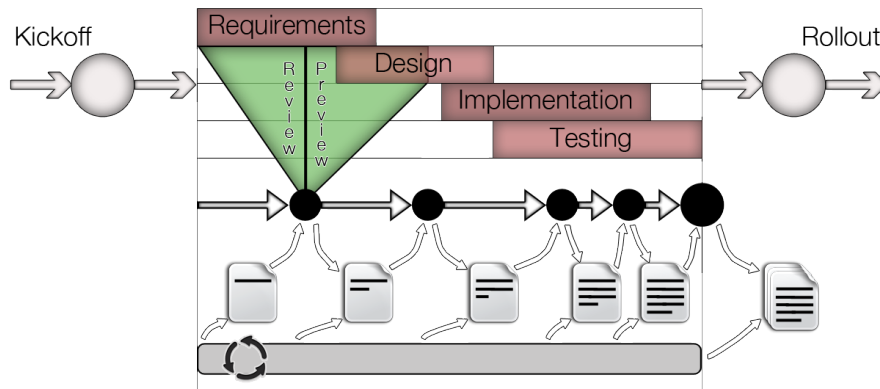**Tailoring to the waterfall approach**

Figure 4.7: A Generic Model for Sustainable Software Engineering tailored to the waterfall approach [61]

Sustainability Review & Preview addresses the *impacts on sustainability that arise during future use* of the software product. Therefore team members have to assess the current state of the product to sustainability relevant criteria. This activity is called review part. During preview they have to find ways to improve the assessed criteria regarding sustainability, e.g., improving the architecture or design, implementing a more efficient algorithm, etc. Then they will be assessed for their sustainable criteria. The improvements that will be implemented get checked during the next Review & Preview.
Sustainability Review & Preview enables team members to create alternatives that are more sustainable than the first implementation. It takes place after one-half or two-thirds of each process phase. In case of long process phases it is possible to perform multiple Review & Preview for this phase.

The **Process Assessment** is a continuous accumulation of sustainability criteria during the whole development cycle. It serves to estimate the impacts on sustainability *through developing the software product*. Sustainability relevant criteria are e.g. power consumption of work stations, heating, air conditioning, working conditions, business trips and even consumed food could be assessed

during Process Assessment.

At the end of the software development process, the *Sustainability Retrospective* takes place. It merges the results of Reviews & Previews and the results of Process Assessment. The final impacts on sustainability that arise from development and from future use are assessed in order to optimize sustainability issues for future software projects.
Furthermore, the Sustainability Retrospective considers assessment of teams, decisions for upcoming projects and lessons learned regarding sustainability. The outcomes could be provided for customers, stakeholders and users.

The *Sustainability Journal* is the collecting point for the three above-mentioned enhancements to gain more sustainability and, after the project has finished, the assessed impacts on sustainability i.e. it is a structured document where every step is recorded.

- Sustainability Review & Preview should be registered as short as possible.

- Process Assessment can be recorded twice. Once the data will be gathered and logged in their own chapter. Moreover, it can be logged when decisions of the Review & Preview part have influenced process assessment items. The collected informations will be assessed for a lifecycle analysis. This analysis itself will be retained into Sustainability Journal.

- The conclusions of the lifecycle analysis will be presented and assessed during Sustainability Retrospective.

- Furthermore, the results of Sustainability Retrospective will be recorded, too.

This model should be extended with tools, checklists and guidelines. They support the software development team with the result that during development phase a Sustainable Software product can be created.
Additionally, educational material is an important factor because sustainability plays a subordinate role in software engineering. This material could help to sensitize employees to sustainability and impart sustainability concepts. However, this material should serve to give them something to think about and that they reflect their decisions on basis of sustainability.

Tailoring to the Scrum

The generic model for Sustainable Software Engineering can be easily adjusted to Scrum [62]. Scrum is a very popular agile software development process. The framework provides three different roles:

- the *Scrum Master*, who maintains the processes,

- the *Product Owner*, who represents the stakeholders and the business, and

- the *Team*, who is the actual software development team. It is responsible for delivering the product. Usually the team is self-organized.
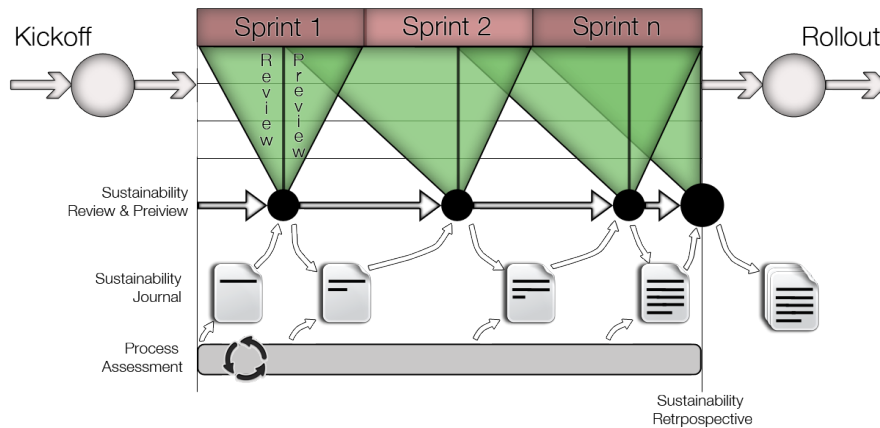
Figure 4.8: A Generic Model for Sustainable Software Engineering tailored to Scrum [61]

During each *sprint*, typically four weeks, the team creates a potentially shippable software product. These sprints are not separated into several development phases, i.e., requirements, design, implementation, etc.

At the beginning of every sprint a *Sprint Planning Meeting* is held. Here the participants select and prioritize what work is to be done during the current sprint. They estimate the effort for implementing each item and evaluate how many of the items can be completed during the sprint.

Each sprint ends with a *Sprint Review* where the results of the sprint are presented to the product owner.

As with the waterfall approach *Sustainability Review & Preview* should take place after two-thirds of a sprint. Thus, the team can create more sustainable alternatives within the current sprint. During sprint review they represent gained alternatives and the product owner decides which alternative should be taken.

The *Sustainability Retrospective* is split up into two parts. The first part held just before the end of the last sprint. Thereby the development team is able to report the combined assessment results to the product owner in the final sprint review.

After the project is finally finished, the team should hold the second part of the Sustainability Retrospective where decisions for future projects, lessons learned, and best practices regarding sustainability issues are discussed.

The division into two parts helps the team to reflect on these aspects without pressure.

4.3 Seminar Session: It's a hard task to insert new ways to gain sustainability

The presentation was split into four main parts.

First the evaluation what Sustainable Software Engineering means, and how it's distinct from Sustainable Software.

After that I showed how to gain more *Sustainable Software Engineering through Agile Software Development Techniques.* We acquired a metaphor for software development and compared software development to other engineering disciplines. The comparison between a building and a coral reef was done by two groups. Each group developed similarities and differences to software development and presented their results to the audience. Next I presented the characteristics of unsustainable Software Development. *Principles & Practices* followed.

The third main part was the *Model for Green and Sustainable Software Engineering.* During presentation of the *Process and Lifecycle Model* the audience had to find examples for sustainability relevant criteria. Afterwards I showed up *Guidelines & Checklists* and revealed examples.

The last main part was the *Generic Model for Sustainable Software Engineering.* First I introduced the model for a waterfall-like approach. Then the audience was split into two teams for a big exercise.
The assignment was to assess the requirements for a fully automated green coffee machine in a Sustainability Review & Preview. I showed each team following starting points and assisted them in discussion.

Team 1:

- What information should be shown on the display?

- What could be optimized when the coffee machine is in idle mode?

- One cup of coffee has to be exactly 0.25 l.

- We want to make multiple coffees at once.

Team 2:

- What could be optimized when the coffee machine is in standby mode?

- How can the warming plate be made more sustainable?

- Does introducing user profiles make our coffee machine more sustainable?

- How should the coffee be made? (capsule, filter, brew)

They discussed the starting points and developed own ideas how to make the coffee machine more sustainable. After 20 minutes they presented their results to the audience.

Finally I showed the group how to tailor this generic model to other development processes, like Scrum.

4.4   Conclusion: Focus of attention

This article showed several ways how to achieve more sustainability in a software project.

One way is by applying *Principles & Practices from Agile Software Development*. These principles create a reasonable foundation that helps software teams to build a healthy software product. The team anticipates change instead of freezing when unforeseen changes arise. The practices can be applied in every software development process, whether it's an agile one or not.

Another way is by *Process & Lifecycle Model* and *Guidelines & Checklists*. The Process & Lifecycle Model provides - with starting points for activities - a good way to determine sustainability relevant criteria for a software product. The Guidelines and Checklists as a big open data base help Developers, Administrators and Users to find rapidly solutions for their sustainability relevant issues.

In order to gain more sustainability the *Generic Model for Sustainable Software Engineering* shows a great way that sustainability becomes the **focus of attention**. The Generic Model tries to make the assessment and reduction of impacts that arise from developing and using the software a natural topic in software development. It is a guide for the development team and helps to organize sustainability issues in a structured way.

All methods showed that there are several ways to obtain more sustainability but without the sense for sustainability a software team will not incorporate these methods into their processes. Therefore education is one of the most important factors to distribute sustainability for software development.

I think that the main task of all sustainability enhancing models is to **consolidate the ambitions for sustainability** for a nowadays subordinate topic in the software engineering industry.

Chapter 5

Case Study Green Energy

Author: Martin Kuhn

5.1 Introduction

As we have seen sustainability includes many categories. But this one is the one that seems to really matter. You can prove and estimate it with numbers and some of the numbers represent money, which on the other hand matters to economy and interest groups. If we first hear the word sustainability, most people think of questions like: "Should I unplug my chargers when they are not in use or turn off water while brushing my teeth?" Looking at the problem in total these are only tiny gestures to silence our conscience. Other questions which make a difference will be answered in this chapter.

5.2 Contents

This essay comes in three parts, each of them describing a step to our, hopefully, sustainable future. We will look at what is done. Later we will see what could be done and finally what should be done.

5.2.1 Recent development

First of all, here are some examples for projects that are in progress in Germany today.

Traffic lights in Munich

A small step overall, but a big step for the city of Munich. The "Stadtwerke" decided to change all traffic lights from classic light bulbs to LEDs. The work is still in progress but the new lights can already be seen in many places. In an interview the mayor Christian Ude announced, that the consumption of one red light dropped from 100W to 7W, which is a decrease of 93%. [63]

"Atomausstieg" in Germany

On the 30th of June 2011 the German Government in Berlin decided to shut down all nuclear Power Plants until the year 2022. There has been huge discussion about that topic before, because of the nuclear disaster in Japan. But why do we care about nuclear plants? Don't the lobbyists tell that everything is alright with this technology? First of all the capacities of uranium are not endless. If we would stretch the total amount of Uranium to 1000 years we would only be able to extract about five percent of the total energy consumption. To make a difference and get up to 100% it would be necessary to use the unsafe fast-breeding technology that was used in Tschernobyl, and this would not be a good idea.

Sustainability doesn't only mean that it can last long time, it also means minimizing the burdens bequested to future generations.

Looking to the future, in about 2050, as scientists tell, we can see the cold fusion. Other than the classical method there is no uranium used to produce heat. The source of energy in this case would be Deuterium which is split to Helium. As in this scenario no toxic waste is produced and the capacities of deuterium would last millions of years, we can call this sustainable. But until 2050 many years have to pass. [64]

Facts

To describe all developments which are done nowadays in detail would need a whole book. All the efforts that are taken are visualized in the following pie chart:
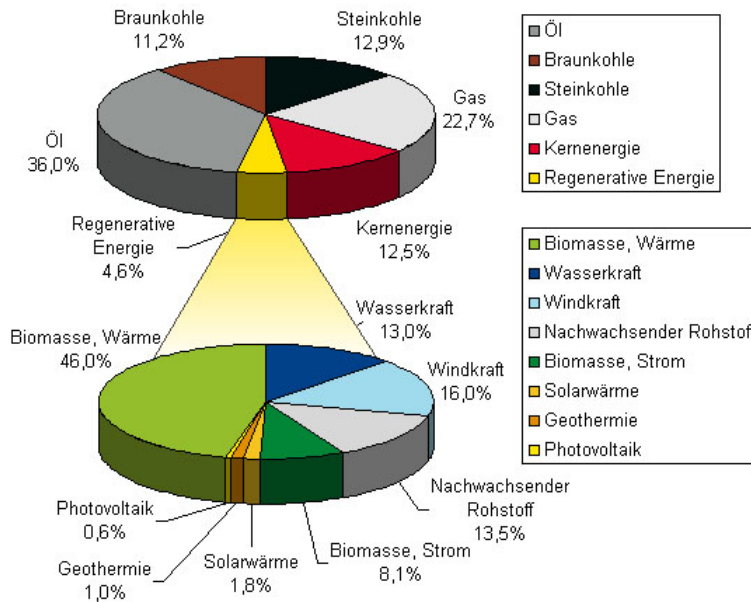

Figure 5.1: wikipedia.org [65].

This chart is remarkably honest. Some people tell us proudly that Germany produces around 16 percent of its "energy" sustainable. But what they really mean is "electricity". If we really want to get rid of all that oil, coal and gas, figure 5.1 tells the truth about our progress which is at about 5%.

5.2.2 Over-all Energy consumption in Germany

That was some small excerpt of what is done today. Now let's see what could be done. The main question is: **"If we do everything possible, will this effort lead to a country that produces all its energy itself?"**
We are going to do some easy calculations which won't be very accurate. But hopefully the errors done at one side are compensated by the ones on the other. There's no need to have complete knowledge about complex data. All we want to have is a rough estimation to get an idea of how much of our energy we are able to produce ourselves in a sustainable way.

Every time we end up with a conclusion we will add it as a box in red or green to our comparison stacks. All the energy production will add up to the
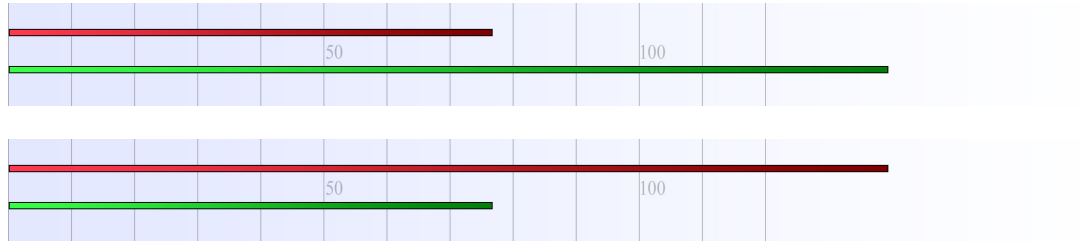
green and all the consumption to the red one.

Figure 5.2: Two extreme scenarios how our stacks could look like: Good case where green energy production is higher than consumption and the other way round.

Our preferred unit will be kilowatt hours per day per person (kWh/d/p) As the hours and the division by the days cancel out, they can easily be converted into each other:

from–to	kWh/d	kWh.
kWh/d	1	1/24.
kW	24	1.

Grey energy

Probably the last form of energy we would think off, but the first we will discuss is "grey energy". Every form of consumption creates some kind of subconsumption. For example if we buy some crisps we don't only use the energy that had to be used to produce the crisps themselves. The bag has to be produced out of oil and other resources. These raw materials also have to be extracted. Especially today a huge amount of energy is used to transport all the stuff around from one production step to the next. And when the product finally arrives in the stomach of the consumer, another procedure is started by trowing the bag away. As we see calculating this grey energy exactly might take huge effort.

The "Statistische Bundesamt Deutschland" luckily did some of the complicated stuff for us. They estimated that in the year 2003 the over-all energy intensity was 4,5 MJ/EUR. As one Kilowatt hour equals 3.6 MJ, the average amount of grey energy per one Euro can be estimated as one kWh. All direct forms of energy are not regarded as goods in this calculation. [66]

To calculate our final piece of "red stack" we just have to know the total consumer spending in Germany. This value also can be looked up at the database of the "Statistische Bundesamt". The value of 1929 billions is composed of the private spendings (1413bn) and public purchases (449bn). [67]

$$\frac{\text{consumer spendings} \cdot 1kWh}{365d \cdot \text{inhabitants}} = \frac{1,929.7kWh}{365d/81,802,257} = 65kWh/d/p$$

So our red stack starts with healthy margin of **65kWh/d/p**.


Cars

One of the biggest consumers of energy clearly will be the car. Most cars are driven by only one Person and therefore seem not to be very efficient. When we want to calculate the average kilowatt hours per day per Person we firstly have to know the amount of energy stored in one Liter of gasoline. David JC MacKay, in his book Sustainable Energy, uses 10kWh/l. This number is simple, easy to calculate with and afterwards we can compare our results to the ones from Great Britain. Therefore we will use it too. ([64] p. 29f)

Next, we have to know how much fuel is consumed. The average distance travelled by a German per day is 34 kilometers. [68]

A t-online news article tells us that the companies don't always tell the truth when estimating the fuel consumption of their cars. Measured by the companies the average car in Germany would consume 7.2 liters per 100 kilometers. The test revealed that this value should rather be around 7.7 liters. So this will be our number to calculate with. [69]

$$10kWh/l \cdot 34km/d/p \cdot 7.7l/100km = 26kWh/d/p$$

Without using more intelligent methods to travel, we sadly have to add a **26kWh/d/p** block to our red stack.
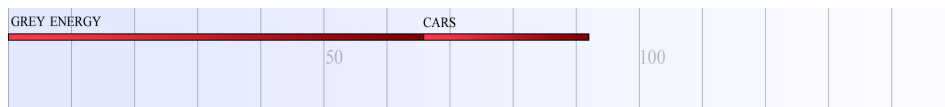
Household

As deduced from the chart below (5.3) the average household houses 2.13 people. But as every energy consuming person in Germany lives in a house, this value isn't needed for further calculation.
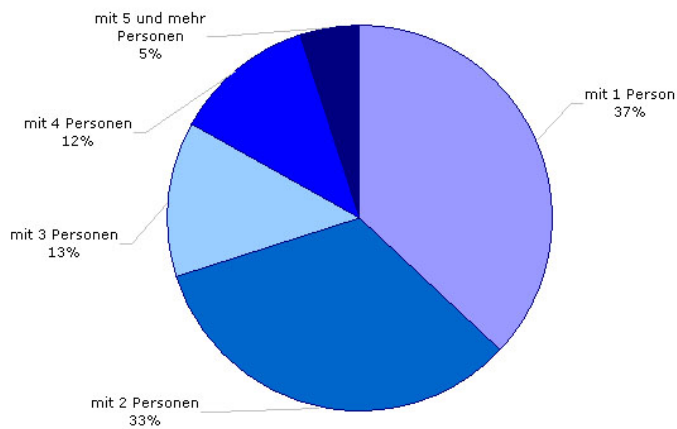
Figure 5.3: Households in Baden Wuerttemberg. Statistisches Landesamt Baden Wuerttemberg 2011.
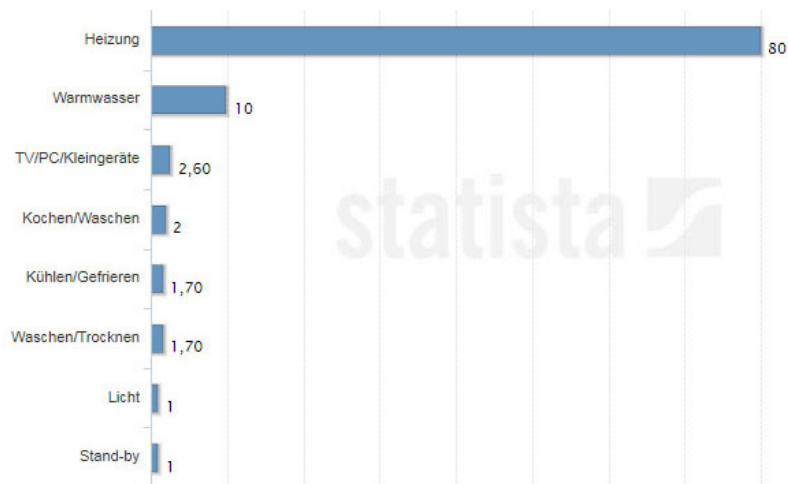
Figure 5.4: Energy partition in one Household.

In this part we want to know the amount of energy we would need to power one standard household. This includes warm water, washing, heating and all the other activities requiring electricity, that are done inside our homes.
Assuming that we take a shower three times a week and one Bath per week, we can finally start calculating.

$$\text{warm water} = \text{shower} + \text{bath} =$$
$$= \frac{1.69kWh \cdot 3}{7} + \frac{4.05 \cdot 1}{7} = 1.3kWh/d/p$$

71

This value can be projected to the whole consumption of one Household using figure 5.4.

$$\text{over-all} \cdot 0.9 + \text{warm water} \cdot 0.1 = 1$$
$$\text{over-all} = \frac{\text{warm water}}{100} \cdot 10 = \mathbf{13kWh/d/p}$$

GREY ENERGY					CARS		HOUSEHOLD					
				50				100				

Flights

Now we come to one of the most energy sucking consumers per usage. The plane. One Boeing 747 can carry 425 passengers and 240000 liters of fuel. On some flights not all the volume is used and on other ones the plane has to refuel. Let's assume that on every flight the whole tank is exhausted. The energy density per liter from the cars section above (10kWh/l) can be reused, as car and jet fuel are chemically alike. In the year 2010 about 71 million german passengers used a plane. That was 4.5% more than the year before. [70]
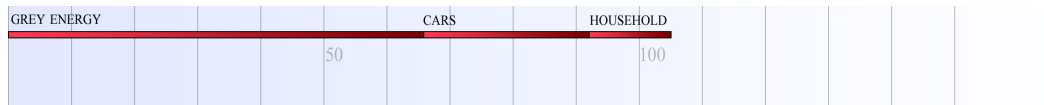When the total fuel usage is subdivided by the passengers per plane the calculation can be done quickly.

$$\text{kWh per passenger} = \frac{2 \cdot 240,000l \cdot 10kWh/l}{425p} = 11,341kWh/\text{passenger}$$
$$\frac{71 \text{ million passengers}}{81 \text{ million inhabitants}} \cdot 11,341kWh/p = 9,941kWh \text{ per year per person}$$
$$\frac{9,941kWh/a/p}{365d} = 27kWh/d/p$$

From these **27kWh/d/p** huge amounts could be saved by simply flying less.

GREY ENERGY					CARS		HOUSEHOLD	FLIGHTS				
				50				100				
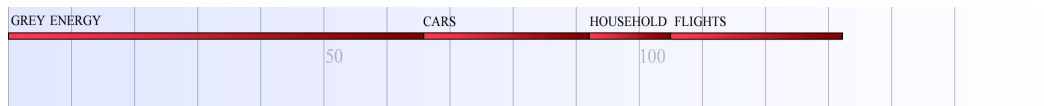
Food, Light, Gadgets, Defense

It isn't necessary that these rather small parts of our final stack are estimated very accurate. As European countries should have similar behaviour, we will

take the calculations for Great Britain from our main source "Sustainable Energy - without the hot air" and adapt them to fit german needs. ([64] p. 68-72)

Producing our food costs **15kWh** per day per person.

The lighting of our Streets and public buildings consumes **4kWh/d/p**.

Gadgets are using 5kWh/d/p but this should be clarified. With gadgets he means on the one hand all the chargers and standby products that he calls "energy vampires "which suck 0.01kWh/d/p and on the other hand things like computers, stereos, vacuum cleaners or lawn-mowers. But as we have a section discussing Household most of this is left aside. Even if the number of mobile phones will increase drastically (in case of smart phones all time in standby mode) it definitely is enough to add **one kWh** per day per person.

And finally for defeating our country or at least being able to do so **14kWh/d/p** are needed.

All in all we end up with **38 additional red points** and finish with a total of 169kWh per day per person.

GREY ENERGY					CARS		HOUSEHOLD FLIGHTS			FOOD LIGHT GADGETS DEFENSE	169kWh/d/p
				50			100				
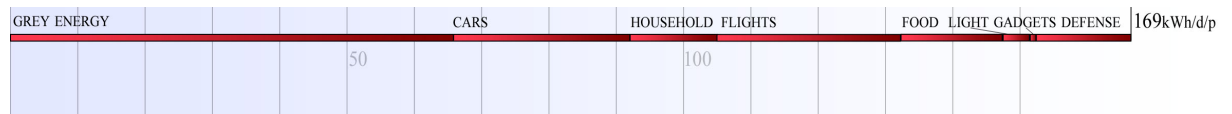
5.2.3   Over-all Sustainable Energy Production in Germany

Photovoltaics

Every sustainable energy source is, in some way, dependent on the sun. Each sunny moment 1000 watts of sunlight hit every square-meter on the equator. What amount can be used of this direct radiation here in Germany? We could look this up also but calculating is understanding. As Germany has a latitude of 50° we can use trigonometry. [71]

$$1000W/m^2 \cdot \sin 50° = 0.77kW/m^2$$

But not every day is a sunny day. The official figures tell that the energy delivered to Germany per year is $900kWh/m^2$ - $1200kWh/m^2$ [72] which equals to:

$$\frac{900kWh/m^2 + 1,200kWh/m^2}{2 \cdot 365d \cdot 24h} = 0.12kW/m^2$$

The purest use of sun-energy are photovoltaic cells, which produce electricity directly. Basically there are two kinds of solar panels. Amorphous silicon is

cut out of one cylinder of one single crystal. Therefore this technology is very expensive but can have an efficiency of up to 24%. The one used in most solar plants is polycrystalline silicon. The crystals inside are pointing in multiple directions, so the characteristic shades of blue are generated. If we buy the cheap ones we will end up with an efficiency of 11 to 14 percent. [73] For the calculation the average of 12.5% is used. This technology has huge capacities. It simply depends on how big the area is we cover with cells. Let's look at two scenarios. Firstly everybody has a roof, of let's say 10 square-meters, and with little effort this wasted space can be covered with solar panels. Secondly we are interested in what happens if we cover bigger areas, which is called solar farming. Taking $200m^2$ per person would influence regular farming. But thats not what we want to discuss now. Let's say we found these $200m^2/p$, what are the numbers?

$$10m^2 \cdot 12.5\% \cdot 0.12kW/m^2 = 0.15kW/p \qquad = 3.6kWh/d/p$$
$$200m^2 \cdot 12.5\% \cdot 0.12kW/m^2 = 3kW/p \qquad = 72kWh/d/p$$

With both of them (**75.6kWh/d/p**) the green stack starts faster than the red one. Hopefully this will proceed.
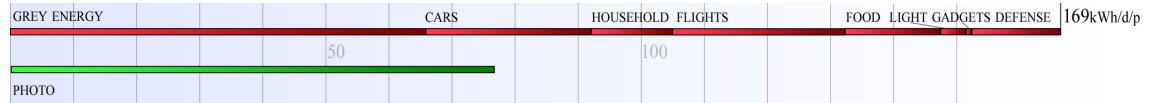
Wind

As we see in figure 5.5 the wind speed in Germany ranges between 3.5 and 6 meters per second. Let's say the yellow part covers three the green one two and the red part one fifth of the whole country. The average wind speed then is circa 4.6m/s. [74]

$$\frac{5.5m/s + 4.75m/s \cdot 3 + 4m/s \cdot 2}{6} = 4.625m/s$$

If we try to pack as much windmills into Germany as we can we have to consider several factors. Firstly there is something named the park-effect. When in a wind farm the turbines are standing too close they influence each other. This loss in efficiency is called park-effect. In the main wind direction a distance of five to nine times the diameter of the rotor is recommended. The cross-direction distance should be three to five times this diameter. To reduce the influence to ca. 20 percent we chose the larger distances.[75] The other factors are very insecure ones or hard to estimate. For example in urban areas and in protected forests the work would be complicated and sometimes ethically and practically impossible. Also some people feel offended if they see a wind farm and go to

court. But we possibly can't consider all of these people and interests. So let's do a rough estimation and say we could use one third of the total area.
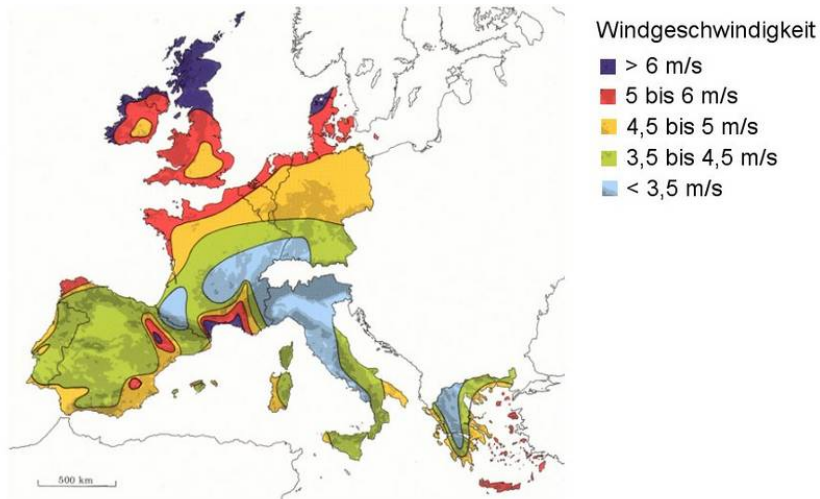
Figure 5.5: Average wind speed in west Europe.

To include offshore wind we will add part of the north and east sea to our homeland area. The total length of Germany's coasts is 2.389 km. [76] The territorial waters have a range of 12 nautical miles (22km) [77]. So the area to add is: $2389km \cdot 22km = 52558km^2$

Directly in our front yard, here in Munich, we have an example of one average windmill running at nearly the average windspeed we calculated. Let's build a lot of them. So how many are we able to plant?

$$\text{area per windmill} = (d \cdot 5) \cdot (d \cdot 9) = 45 \cdot d^2 = 45 \cdot 66^2 m^2 = 196020m^2$$

$$\frac{357,123km^2 + 5,2558km^2}{0.19620km^2} \cdot \frac{1}{3} = 696,026 \text{ windmills}$$

Each of them delivering 2.2 million kilowatt hours per year [78] we end up with a total gain of:

$$\frac{2,200,000kWh}{81,802,257p \cdot 365d} \cdot 696,026 = \mathbf{51kWh/d/p}$$

75
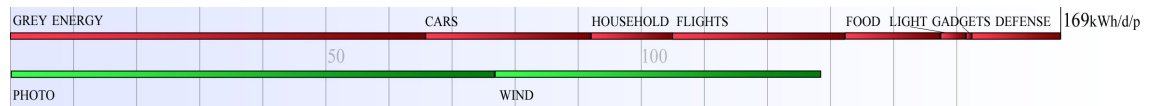
Solar Heating

The idea of solar heating seems interesting because everyone can do this at home and the electric grids are relieved. Also the efficiency is much better than photovoltaic panels. Solar heating reaches efficiency above 70% whereas the most expensive panels hardly reach 24%. As in the household section above we assume a washing behaviour of three showers and one bath per week. "Sustainable Energy - without the hot air" tells us that one bath costs 5kWh and one shower 1.4kWh.
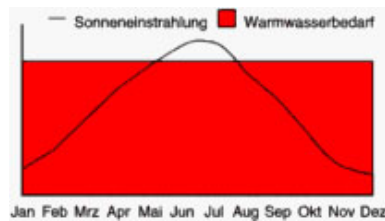
Figure 5.6: Warm water consumption and solar-heat production. [79]

In this graph (5.6) we see that the energy need for heating water, not room, is constant over the year. Only in the three hottest months there is a little surplus. The value we would estimate at first glance is 50% power that could be saved. Also the source of figure 5.6 tells that the savings are between 50 and 65 percent. If we totally mean it and install the machinery that will collect 65 percent we would do this calculation.

$$\frac{5kWh \cdot 1 + 1.4kWh \cdot 3}{7days} \cdot 65\% = 0.85kWh/d/p$$

This almost **1kWh/d/p** seems small but solarserver.de calculates with existing rather small collectors. With a bit more effort also the heating in autumn and spring can be done. Let's add 1kWh and keep in mind that absolute maximum of energy delivered by the sun exceeds the needs.
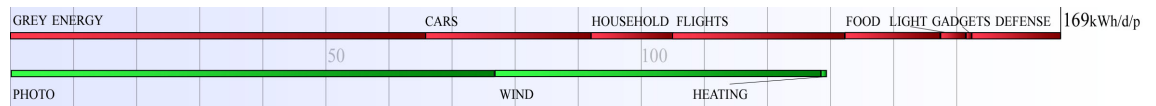
Hydroelectricity

As one side of Germany is bordered by the Alps we have great opportunity to use Hydroelectricity. The energy stored in the water is simply height energy which is transformed into kinetic energy and can then be extracted by slowing the water down. As this technique is very simple and was used in mills since long time ago, hydroelectricity is already very advanced in Germany. The VDE (Verband der Elektrotechnik Elektronik Informationstechnik e.V.) estimated that more than three quarters of the possible potentiality are already used. For example in the year 2006 mostly in Bavaria (57%) and Baden Wuerttemberg (25%) 21.6TWh

were generated. The total power available is assumed to be around 24 TWh annually. [80]

$$\frac{24 TWh/a}{365 d \cdot 81802257 p} = \mathbf{0.8 kWh/d/p}$$
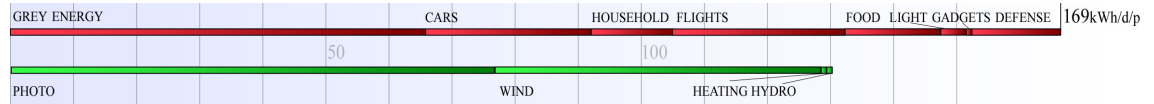
Wave, Tide, Biomass, Geothermal

And again the topics were too many to discuss them all in Detail, so we will stick to the main source one more time. ([64] p. 50-99)

Wave and tide have in common, that they are dependent on the length of the coast. This ratio is quickly estimated:

$$\text{coast length Germany} = c \cdot \text{coast length Great Britain}$$
$$2389 km = c \cdot 7500 km$$
$$c = 0.32$$

If we multiply the numbers of Great Britain with this constant we get the maximum energy produced by wave:
$4 kWh/d/p \cdot 0.32 = \mathbf{1.28 kWH/d/p}$
and tide:
$11 kWh/d/p \cdot 0.32 = \mathbf{3.52 kWh/d/p}$

Biomass should stay the same, because the values are given per person. So we can directly copy **24kWh/d/p** out of MacKays book "Green Energy" [64].

Let's say that **Geothermal** capability depends on the area that can be perforated.

$$\text{area Germany} = c \cdot \text{area Great Britain}$$
$$357123 km^2 = c \cdot 219331 km^2$$
$$c = 1.63$$
$$1.63 \cdot 1 kWh/d/p (\text{value for GB}) = 1.63 kWh/d/p$$

Doing the same calculation as before and some rounding up, because of better geological requirements, we gain the last **2 kWh** per day per person.

All four together make one final green step of **32kWh/d/p**.

GREY ENERGY				CARS		HOUSEHOLD	FLIGHTS			FOOD	LIGHT	GADGETS	DEFENSE	169kWh/d/p
50							100						
PHOTO				WIND		HEATING	HYDRO	WAVE	TIDE	BIOMASS		GEO	160kWh/d/p
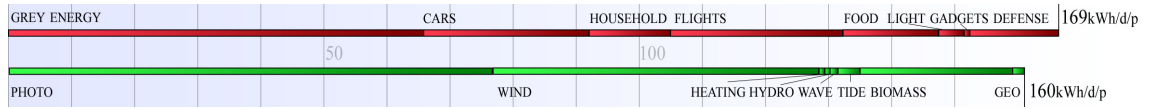
Figure 5.7: Our final scenario.

5.2.4 Summary

As clearly visible, even with some optimistic approximations and large fields of solar and wind farms, we won't get the green stack to win. So what to do? The clearly wrongest possibility is to say "If we can't achieve it, let's keep going this way." Some better conclusions are presented in chapter 6.4. But before we come to this part we will have a look on the results the students got in their attempt to do the same estimations in group work.

5.3 Seminar Session

5.3.1 The Quizzbreaks

To regain the student's attention, several breaks are inserted. When the "Quizzbreak" question appears every student has to decide on one of the answers and then move to one of the corners of the room to demonstrate their opinion.

Question 1: Record Car

"How many kilometers could the thriftiest car in the world do with only one liter of fuel"
A: 842.5km B: 3688.2km C: 135.9km D: 995.0km

Each year Shell organizes the "Shell Eco marathon" where international teams try to reach ultimate efficiency. This year the competition took place on 28th of May in Lausitz Germany. The winner in the class "plug-in", team Austria from the university of Graz, drove 842,5 kilometers with one kWh.
A bit closer to the pole position, but still not one of the top ten, was the team form Germany which scored 995,0 kilometers per one liter.

Figure 5.8: The vehicle that holds the world record in "distance per one liter"

The winning team, MICROJOULE LA JOLIVERIE, from France did the unbelievable **3688.2km**. Therefore the correct answer was **B**.
And finally the 135,9 km were taken from the bottom of the list. But even this last place looks great if you compare it to a normal car and if you know that team came from a public school in the Netherlands. [81]

Question 2: Energy-neutral flights

True or false: "The flight is taking place anyways, so I'm energy-neutral"
The first reason this fact is **false** is clear: Your weight is added to the Plane and costs minimal increase in fuel consumption. The second reason, not to think so, would be something like indirect energy consumption. The flight companies calculate the number of flights dependent on the passengers which were using their planes the years before. So if you take this "empty" seat, it is your decision if there is an additional airplane next time or if their number would eventually decrease.

Question 3: Cats vs. Wind turbines

"How many birds are killed per year by wind turbines in Great Britain?"

A: 300 B: 3000 C: 30.000 D: 300.000

The correct answer is 30.000 birds. ([64] p. 63f.)

Question 4: Cats vs. Wind turbines 2

"How many birds are killed per year by cats in Denmark?"

A: 550 B: 5.500 C: 550.000 D: 55.000.000

As we see, the numbers grew a bit. Some ecologists or simply people who don't like wind turbines or which are misinformed, argument that windmills kill "huge numbers" of birds. At first glance 30.000 birds seem to be a huge number. But if we compare it to the number of killer-cats in Denmark the cats definitely win, by killing **55 million** birds per year. ([64] p. 63f.)

5.3.2 Energy stacks calculated by the students

After the Introduction the Students form four groups. Given the facts and sources mentioned in the calculation chapter, each group tries to estimate the power consumption/production of one aspect. As the calculation was described in detail above I will only mention the main ideas and differences in the students approach.

Group work: Flights & Hydroelectricity

As the group had no Internet connection, they used an estimation to get the amount of energy stored in one liter of fuel. One block of "Andechser Bio Almbutter" has, as written on it, 744kcal per 100 grams.
The calculation they did was:

$$\frac{7 \text{ million passengers}}{400 \text{ passengers per flight}} = 175000 \text{ flights}$$

$$\frac{175000 \cdot 2 \cdot 241140l \text{ per flight}}{80m \text{ inhabitants}} = 1054l/person$$

Figure 5.9: Organic and therefore sustainable butter.

This amount of liters per passenger was converted to kWH/d/p using the butter-estimation.

$$1054l/p \cdot 744kcal \cdot \frac{1}{900} = 8721kWh/p = \mathbf{23.9kWh/d/p}$$

Estimating the total hydroelectric power they got the same 0.8kWh/d/p as in chapter 6.2.3 but decided to round it up to **one kWh/d/p**.

Group work: Grey energy & solar heating

This group firstly did an estimation to get the money spent per person per month on goods. They ended up with 1000 per person. Even when estimating very rough this value rather should be 2000.

$$\frac{1929,70bn€}{81.8m \cdot 12months} = 1965€/m/p \sim 2000€/m/p$$

To correct this, their final result (33kWh/d/p) has to be doubled. We add **66kWh/d/p**.

The students of this course seem to be very clean. Representing the whole population, they said everybody would bath two times a month and shower every day except Saturdays. This would remain two days a month being untouched by water.
Doing mental arithmetics, or perhaps having trouble with rounding, the values were slightly different than they should be.

$$2/30 \text{ baths per day} \cdot 5kWh = 0.33kWh/d/p \qquad \text{(group result: 0.32)}$$
$$6/7 \text{ showers per day} \cdot 1.4kWh = 1.2kWh/d/p \qquad \text{(group result: 1.1)}$$
$$0.3kWh/d/p \cdot 1.2kWh/d/p \cdot 65\% = \mathbf{0.975kWh/d/p}$$

Group work: Cars & Wind

The average distance travelled by a German per day is 34 kilometers. 63% of all the trips have a range less than 50km, but this was not used in the calculation of this group, as they did not consider special electric transportations. [68] With the classical transportation model (same calculation as in chapter 6.2.2), but more accurate energy density (11.5), they ended up with **30kWh/d/p**.

With their windmills the group covered less space, because of their lack of off-shore parks. A bit of this was compensated by the area per diameter, which got smaller as they used the average of the minimum and maximum recommended

distances. Also did they only assume one quarter of the land to be useful.

$$\text{min size of one windmill} = (d \cdot 3) \cdot (d \cdot 5) = 15 \cdot d^2$$
$$\text{max size of one windmill} = (d \cdot 5) \cdot (d \cdot 9) = 45 \cdot d^2$$
$$\frac{15 + 45}{2} \cdot 66^2 m^2 = 130680 m^2$$
$$\frac{357.123 km^2}{0.130680 km^2} = 2732805 \text{ windmills}$$

With the same 2.2 million kilowatt hours per year [78] the group was able to collect a total of:

$$\frac{2200000 kWh}{81.802.257p \cdot 365d} \cdot 2732805 \cdot \frac{1}{4} = \textbf{50kWh/d/p}$$

Group work: Household & photovoltaics

First of all the students decided to calculate the energy amount consumed by gas driven water heating:

$$\frac{2.42 kWh \cdot 6 \text{ showers a week} + 5.87 kWh \cdot 1 \text{ bath per week}}{7} = 2.9 kWh/d/p$$

Doing the same for electric water heating again, they got 2.03kWh a day per person, when showering six times a week and bathing one time. As intended they expanded these 2.03kWh/d/p for hot water to the whole household and ended up with **20.3kWh/d/p**.
In their second part the group discussed solar electricity and decided to cover about two percent of the whole area of Germany with photovoltaic panels. They made some errors in their calculation and so the piece of green paper was even longer than 200kWh/d/p. Doing the calculation again we see that these two percent are even smaller than the 200m^2 per person we have chosen above.

$$\frac{357123 km^2 \cdot 0.02}{81.802.257p} \cdot 0.12 kWh/m^2 \cdot 12.5\% = 1.3 kW/p = \textbf{31kWh/d/p}$$

5.3.3 Conclusion

Finally we put all the paper strips to the flip board and added the topics which were left aside. Additional 32kWh/d/p (Wave, Tide, Biomass, Geothermal) to the green and 38kWh/d/p (Food, Light, Gadgets, Defense) to the red stack. Doing this we saw a similar result to the stack in figure 5.7. The green one loses big-time with **83kWh/d/p** to **178.2kWh/d/p**. As the course discussed this chart we saw that huge potentiality is located in the photovoltaic section.

5.4 Plans for the Future

5.4.1 Thinking Global

Looking at our stacks and the photovoltaics calculation above we saw, that solar electricity could make a difference. The bigger the area, the more energy, but also less food, we can produce. The consequence is moving the power plants to other countries with more sun, more space and no possibility to grow staple foods. One plan describing this scenario is developed by DESERTEC.
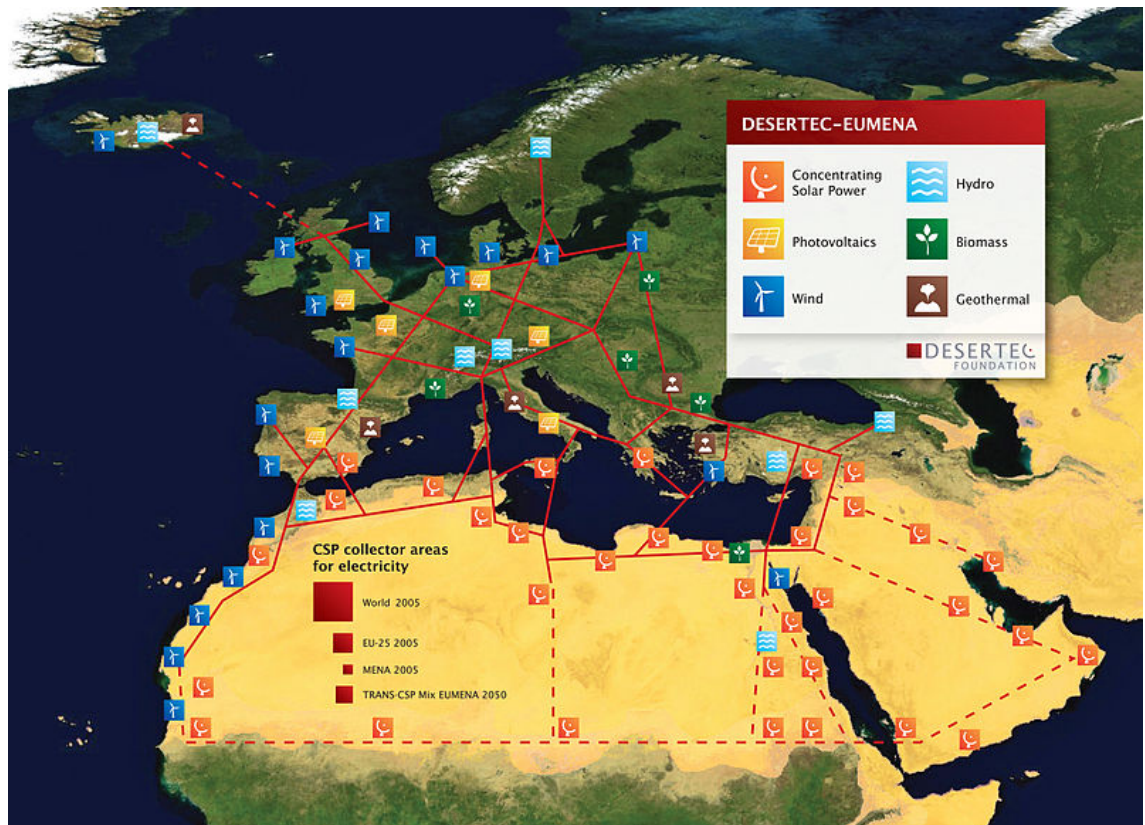
Figure 5.10: The DESERTEC plan.

In the calculations done in chapter 6.2.3 we saw, that two hundred square-meters per person would supply 72kWh/d/p. Doubling this value would produce enough to let our green stack win. The area we need would be:

$$0.0002 km^2 \cdot 2 \cdot 81802257 = 32721 km^2$$

That means, we would have to borrow a rectangle with a side-length of 180km from countries like Africa or Saudi Arabia. The main problem is not, as one

might think, the production of solar panels, because solar plants in these countries are made of huge fields of mirrors that reflect the sunlight to one central spot which is heated enormously. The transformation from heat to electricity is done as in every old-school coal, nuclear or gas plant.

As these facilities also have low maintenance, the main obstacle to overcome is the transportation of the energy. A standard HDVDC cable (high-voltage direct-current) can transmit a power of 2GW. If we want to import the energy produced by $400m^2$ per person, one of these lines would be sufficient. The grid planed by DESERTEC, connecting multiple countries, is marked red in figure 5.10. But, not only the worldwide grid has to be extended. Also the electric lines inside Germany need big changes. As our energy will not be produced at big spots inside the country but distributed across big areas, the grid has to behave intelligent. Such a "smart grid" would transport the electricity to to the places it is needed and use multiple possibilities to save and store energy.

Figure 5.11: Two different types of mirror-solar-farms.

5.4.2 Adaptive intelligent consumers

"Intelligent consumers" in this context doesn't refer to us, although it definitely helps if mankind behaves intelligent. It rather means the machines consuming the power. Installing the smart grid mentioned before doesn't make any sense if the machinery plugged into it isn't compatible. For example a refrigerator has to communicate with the grid, to know when to stop cooling (high general energy demand) or cool some more (huge offer of cheap energy during night).

Heating

As in our plan every bit of energy will be produced sustainable, there will be no other form available than electricity. For example the heating of most buildings is done by gas or oil. Only in areas where both is not available or can't be properly used, electric heating is installed. The principle of electric heating is

simple. The electricity is directly converted into heat with efficiency of almost 100%. Surprisingly there are even more efficient possibilities available. With Heat-pumps, an efficiency of up to 400% can be achieved. But how is this done. A Heat-pump works like a refrigerator turned inside out. The cheaper models suck the heat from the air outside, the better ones take it from the ground. The medium that has been cooled down has to recollect its original temperature, therefore these heat pumps can't be packed to close. In areas which high population density still some classical electric heating is needed.

Transportation

Another sector, already in development, is the electric car. Almost every private transportation system nowadays runs on gasoline. But what if we take away this fossil, liquid energy storage. Some of the alternatives that are already in beta stadium are for example electric engines, hydrogen, air pressure or synthetic gas.
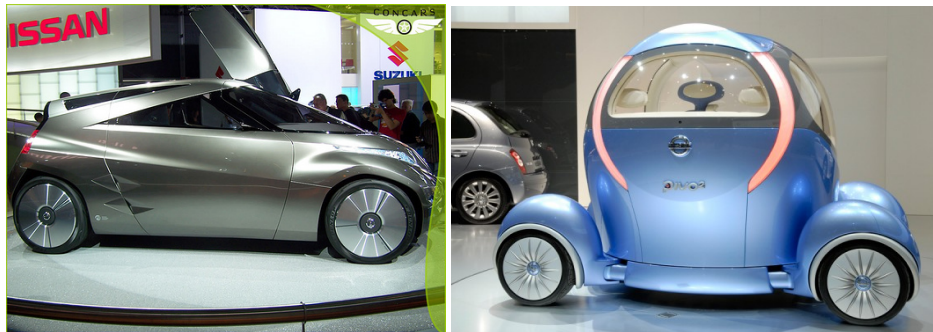
Figure 5.12: Beauty and the Beast. Two examples of attractive or rather ugly electric vehicles.

Home appliances

Not only the big engines in our lives, like cars, have to behave in smarter ways. All the appliances used in our daily life can be smartened. The washing machine should not be started immediately if not necessary. It rather should wait for the right moment in which the energy consumption of the surrounding consumers drop. If it is not necessary for a device to finish at an exact time it would be great if they were able to wait on demand gaps where over-all energy usage is low. If we carry this to extremes, the power drill would be able to return some electricity while slowing down.

Figure 5.13: Devices with high smartness potentiality.

5.4.3 Infrastructure

To manage the communication between the the Machines an the intelligent grid there have to be so called "smart meters". These device can already be bought. But there is little interest in them because of the lack of electricity tariffs with intelligent charging. The first step has to be taken either by the consumers, all buying the devices, or by the suppliers, providing the possibility to save money for example during night.

Figure 5.14: A smart meter. Picture from www.stromtip.de.

5.5 Conclusion

5.5.1 What can We do?

Our world can be saved, but it has to happen fast and it has to happen now. We as computer scientist can help to increase this "saving speed". Computer sciences are nowadays used in almost every aspect of social life, economy or services. For that reason we have huge influence on decisions that are made on the way to green energy.

Research

One part of the economy where our help is urgently needed is the research sector. Here are two examples of high-end research topics, and there are uncountable more. This wave-worm (fig. 5.15) uses hydraulic pressure to collect an average of 300kw when flexed by the waves.

Figure 5.15: Wave power station.

Also located in the ocean, this balloon (fig. 5.16) (www.ecogeek.org [82]) is used to store up to 70MW/h. As pumped-storage plants use lakes and height differences to store energy, the electric grid has to transport it the whole way to the mountains. In this case for example Wind power stations, or the sea-snake mentioned above, can directly be plugged to this energy bag.

Figure 5.16: Underwater high pressure energy storage bag.

As we see big developments bring huge advantages and with new ideas and creativity, constantly new solutions are found.

Personal

Not only the big changes matter. So do the small ones, we do in our private lives. For example, looking for sustainable alternatives when buying or consuming goods. Like in the case of buying water from the supermarket, you could use an Soda-club instead. Or simply eating organic food and less meat. All these little steps add up to one big and if the majority of the society does them, positive trends will be set.

Education

There must be a reason to do this course. And indeed there is one why this seminar and many others should be offered and visited: If everybody knows the need to behave sustainable and also knows the consequences if we don't do so, then he would add this behaviour as one of his social values. After that, in all everyday situations, or when making big decisions in his job, he would automatically behave value-oriented in the right direction. So in my opinion this topic is the most important one because it tries to change the roots of our problems.

Let's sum all this up with a quote:
"Live sustainable and prosper" (not exactly Spock 1966)

Chapter 6

Case Study Internet

Author: Shuying Dong

6.1 Introduction: Information explosion by Internet

According to the latest statistics on March, 2011 the estimated number of Internet users reached a new height with 2.1 billion active users, which is almost a third of the current world population. This number has explosively increased by five times in the last decade [83]. It has become obvious since its inception that the Internet is not only limited to its originally designated purpose in education and the academia, but has spread into commerce with great success. The development of the Internet is changing our lives rapidly. The ubiquitousness of the Web does not only provide a vast number of opportunities, innovative products and services, but also gave birth to a modern lifestyle and new forms of communication that was not possible twenty years ago. Both the development and the society form a mutually dependent virtuous circle and are essential parts when discussing the Internet's sustainability.

In this chapter we will introduce three aspects of sustainability related to the Internet, discuss the positive and negative impacts they imply and eventually name a few measures addressing the issues and problems at hand. By recapitulating some of the results of the seminar session, we try to sum up the standpoint of each of us as individuals and rethink how our behavior impacts the path the Internet is taking in regard to sustainability.

6.2 Contents: The Internet and sustainability

Let us reiterate the definition of sustainable development [84]:

> "'Development that meets the needs of the present, without compromising the ability of future generations to meet their own needs."'

This definition names three important aspects: development, society and environment. We will focus on each of these three aspects with regard to its influence on the Internet in the following and go more into detail.
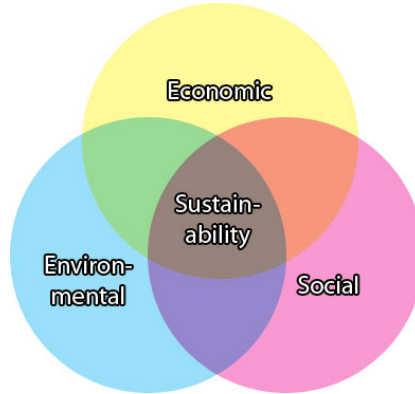
Figure 6.1: Three aspects of sustainability

6.2.1 Impacts

The Internet's Impact on Economy

It is undeniable that the Internet has transformed the global economy in both the macroscopic and the microscopic scale. Whether it is production chains spread over multiple continents or changing purchasing habits of individual consumers, the Internet irrevocably left its conspicuous mark.

Due to the way communication and logistics have been revolutionized, which were caused by the wide use of internet, globally distributed production has been facilitated or even enabled in the first place. For example, in just few years Foxconn Technology Group has become one of the biggest electronics manufacturers world-wide, producing among others for popular brand like Apple or Samsung, products that have been designed across the globe[85]. This does not only apply to hardware, but also software, as the trend to outsource software development to countries with cheaper intellectual labor such as India demonstrates. Today, a wide range of products from cheap clothes and shoes up to luxury brand products, intricate electronics and even cars are being manufactured in countries with low production costs that are very remote from their designated markets. The motivation to move production across borders are savings due to low cost structures at those locations and the benefits gained by economy of scale. The globally distributed production gives the poor countries a large number of job opportunities so that the pressure of employment can be eased to certain extend. The learning process during the production for the developing countries can bootstrap their further sustainable development.

However, there are also downsides to this. Many cases of dreadful work

environments in those cheap manufacture facilities have been revealed by the media. Most remarkable ones include the incident in 2010 at Wintek that assembles products for well-known brands such as Apple and IBM, in which as many as 137 workers were poisoned due to immature safety measures [86]. There are also reports on a string of at least 14 suicides among Foxconn employees that were not able to stand the high pressure put on them anymore and eventually decided to take their own lives by jumping off their densely populated dormitory buildings [85]. Those misfortunes happened not by accident but can almost always traced back to the ignorance and greed for profits maximization by people. On the one hand, the developing countries are learning in order to catch up to the developed countries, but on the other hand their citizens have to endure many hardships. We usually imagine a healthy development differently. And as has been noted, the Internet, for the better or worse, is one of the major enablers in this development.

An interesting phenomenon that deserves to be mentioned separately are copyright violations. The most blatant example is plagiarism, or the so-called "shanzhai" products ("shanzhai" literally translates from Chinese to "mountain stronghold"), often whimsically labelled KIRF for "keeping it real fake" by technology bloggers. Due to the lax copyright prosecution in China and because many of the world's famous brands produce in China, their design and technology are copied in order to produce similar looking products that are a lot cheaper. While this phenomenon was limited to low-tech goods such as bags, shoes, watches etc.[87]. In recent years more sophisticated articles such as the iPhone fell victim. The copycats would not only adopt the design of the originals, but would often also use the same internal components or even include features that the original does not have. Due to the way information spreads nowadays, the time a plagiarized copy is marketed is becoming shorter and shorter, in some cases even released earlier than the original. The "iOrgane" (fig.6.2), a mobile phone closely resembling the iPhone 3, was available on the market just a few months later than the iPhone 3 and had some remarkable features, such as removable microSD card , interchangeable battery, good processor performance, dual SIM card slots etc [88].

Figure 6.2: A plagiarism: iOrgane

Aside from the legal implications, what is interesting is that some companies formerly rooted in the plagiarism business began to acquire their own development capabilities and may one day drive innovation by themselves. Looking back at the history of other now established brands such as Sony, Toyota, Hyunday etc. we can see that they also started by copying the design of established competition [89]. Chances are that with plagiarism among others to bootstrap the growth of a domestic industry in a developing country, a healthy and sustainable technology industry can eventually be built.

The more microscopic aspect of the impact the Internet has on economy can be observed for consumer goods and in particular media of any kind. Just a few decades ago, physical media were necessary to distribute information and knowledge: think of newspapers, music CDs, movie tapes, encyclopedias in the form of books etc. Nowadays these media are all available in immaterial way. News sites have replaced newspapers by faster and cheaper delivery of news; downloading music - legal or illegal - has done away with the need to swap CDs; Netflix and Youtube offer higher quality and shorter delay of gratification than movie tapes ever could have; Wikipedia has become synonym for encyclopedias that take space and now collect dust in libraries. Even though some industries such as the music industry have long fought the changes that the Internet forced upon them, they eventually had to adapt or risk going out of business. Reducing the reliance on physical media produced with raw materials, virtual goods benefit our environment greatly. Consider, for once, that U.S. households receive around 90 billion pieces of commercial mails in their physical mailboxes each year [90]. Converted into electronic mail, this would be still as annoying in most cases, but at least have less impact on the environment and be more sustainable by saving both material and delivery.

Even goods that cannot be digitized cannot escape the grasp of the Internet. More and more people buy items online as opposed to go to brick and mortar stores because it is both cheaper and more convenient. And since the first reaction of many people to something is to look it up online, or by "googling", even small businesses cannot afford not to have their own presence in the Web anymore. The consequence is that setting up a business becomes less expensive, more individual tastes - the longtail - can be served more adequately. Smart new business ideas can be put into action more quickly, keeping even big players in consumer business on their toes - a healthy development.

Many things in the daily life have been simplified and made more comfortable in online form. There is an online service for almost everything, the Internet encompasses more and more aspects of our lives. A few examples are online banking, online shopping, online games, etc. With more and more moving into the online world, this also means that the Internet creates job opportunities for millions of people. On the other hand, new forms of crimes have been enabled by the Internet. They range from small annoyances like email spam, over trojans and botnets designed to infect many computers for a range of reasons, to serious hacker attacks threatening national security. Figure 6.3 shows how a so-called phishing site tries to collect log in credentials of banking customers by fooling them by appearing to be a genuine banking site.
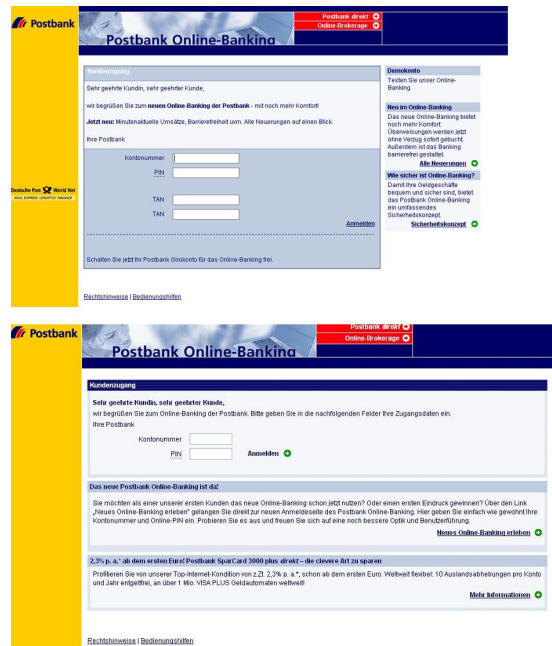
Figure 6.3: Above: phishing site. Below: real site.

The increased demand and cost for protection against online crimes may indicate that they already pose a big threat to enterprises, governments and individuals. Network security occupies a big part of the entire security budget, according to the report on security budget request from the U.S. department of homeland security [91].

Lagging behind the rapid speed at which the economy adapts to the benefits and idiosyncrasies of the Internet are often governments. But also in this area attempts have been made. The german government for example started to accept online tax declarations.

The Internet's Impact on Society

The society consists of many individuals. As already mentioned earlier, the Internet has dramatically changed many aspects of our lives. It is logical that in this process it also transformed society. As our daily habits changed, our social interaction takes different paths and forms as well. We will name some aspects.

One possibility opened up by the web is to meet people from all over the world. While having a pen pal is close to the only way to gain personal insight into another culture in the time before email, today we can communicate with a lot of people via chat, social networking sites, online message boards or even video call. The advantages of online communication are twofold. Firstly,

communication is no longer a costly matter anymore. Family members, friends, colleagues etc. can easily be connected at minimal costs over the Internet. Secondly, this form of communication enables more and more people to take part, offering a way for almost everyone in the world to get in touch with each other, creating a way for cultural exchange that never existed before, providing humanity with a big change at developing itself, which is one aspect in social dimension of sustainability [92]. In a certain sense, the Internet is a tool to unify the world, as it knows no borders. We may see it as the next step in the development of human kind, as important as the Renaissance or Industrialization. One of the extreme forms nowadays is Chat Roulette where random people meet on video chat - sometimes a rather unpleasant experience. On this field, not all rules have been established yet, as many forms are still too young. Many issues are hotly debated, such as using real identities for online interaction as opposed to allow pseudonyms or privacy of personal profiles. But only the future can tell how this will evolve.

In daily life, real life face to face communication has become only one of multiple options. This also applies to telephones. Many people prefer to use email, send texts over the mobile phone or use social networks. Those tools have in fact become so intertwined with our lives that many of us may ask ourselves how people managed a decade ago. This is not limited to private relationships. Enterprises also use modern media and the Internet to connect each other.

The other extreme becomes apparent when looking at people who were socially awkward to begin with and now have the means to shut themselves off from their immediate surroundings almost completely, becoming a recluse among people. In Japan and China those people are called "hikkikomori" and "zhainan" respectively. They trade in their real social life with an online one, emerging themselves into their virtual identity. Their usual obsessions with video games, cartoons etc. are accompanied by social and financial downfall. It is estimated that around 50,000 hikkikomori exist in Japan [93]. More and more, this phenomenon has become the focus of mainstream interest, as it points to obvious problems of the society when mostly young people with an average age of 26 years find themselves becoming socially reclusive. The heath of next generation is certainly responsible for the sustainable development in the future. [94].

The Internet also lowered the bar of requirements to publish news, information and opinions. Formerly a monopoly of newspaper publishers and TV stations, more and more people seek the Internet as their source for both information and entertainment. Publishing as an individual becomes as easy as setting up a publicly hosted blog. Even easier forms such as microblogs such as Twitter blurs the line between personal messages and public broadcast. Nowadays news are being spread out as it happens. The 2008 Sichuan earthquake or the Arab Spring are brilliant examples. In the former case people were able to quickly organize help and donations and using public message boards it was able to put together a list of victims in relatively short time[95]. The latter might have not been possible without the Internet as an uncensored medium that spread the revolution like a wildfire. Of course, fake news can spread equally fast, causing public panic. As pointed out before, the Internet as a communi-

cation channel ensures the liberalization of media, which fits our definition of sustainability in the widest sense.

The Internet has also enabled new types of movements that are formed quickly and remain anonymous, sliding away from the grasp of governments that try to get hold of them. Some of them are formed for fun. Other movements have more serious nature and are in legal grey area. The so-called "Anonymous" is one of such groups, operating almost without any leadership. The other famous example is Wikileaks which caused large impact in global politics, so some occasions changing the political landscapes forever. Even though these movements are often undirected, they sometimes reflect the current of the general population. The Internet becomes a tool for democratic expression.

Internet Impacts on Environment

As much as the Internet has changed the world we know it, it of course also had vast impact on our environment.

Starting from the most obvious things, the Internet is build on top of a infrastructure of computers, routers and connections. While some of them are distributed in our homes as personal computers and some in our pockets as mobile phones, some others are deployed as servers in huge data centers serving the content that constitutes the Internet at large. The longing for ever faster data connection and higher bandwidth of course also means that more and faster connections have to be built. This of course all requires energy and resources to build, power and maintain.

It is estimated that today already 2% of the electricity in the US is used to power data centers, with an upward trend [96]. Keep in mind that in an usual data center the actual IT equipment only consumes about half of the power, with the other half going into cooling systems, power supply or simply lost by voltage conversion[97][98]. This of course does not include all the other equipment such as telecommunication network or devices in the homes. A common but unverifiable saying claims that every Google search consumes enough energy to light an energy-saving light-bulb for an hour [99]. The hunger for energy indirectly drives up the carbon dioxide emission, as the world is still mostly powered by fossil energy sources such as oil or coal. This argumentational chain eventually ends at the risk of global warming.

The Internet also changes landscapes. Even today, real time trading on stock markets are largely controlled by computers. We can say that the world economy would crumble if computers across the world failed to work for just half an hour. In fact, trading information are exchanged at a speed that a difference of only milliseconds of latency can mean profit or loss. Scientists have computed a map (fig.6.4) where the optimal locations for trading nodes are to minimize latency. While a bit far-fetched from today's perspective, it may become reality one day that trading nodes are built into the ocean[100]. Even today, dedicated fiber optic cables are being laid for that purpose.

Another thing to consider is the waste generated by IT products. The materials used to build computers, mobile phones, monitors, etc. are often both
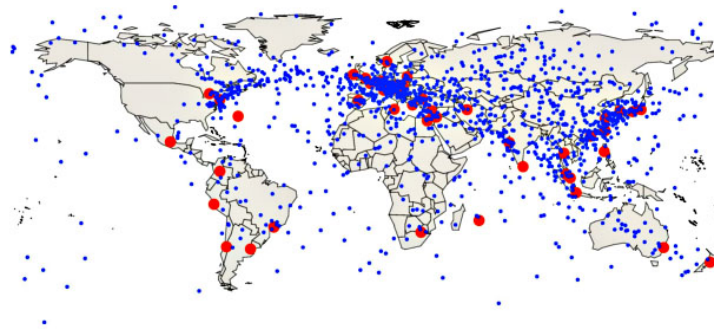
Figure 6.4: Blue dots: optimal intermediate trading node locations. Red dots: optimal location for securities exchanges [100].

rare, not naturally degradable and sometimes even poisonous. This immediately questions how sustainable the IT industry can be when the resources for production grows scarce and the recycling off decommissioned products is tedious.

Figure 6.5 shows Chinese children in a village in the Guandong province scavenging recyclable parts from thrown away computers. According to reports entire villages earn their livings by recycling digital waste. However, without proper training and equipment, health hazards are unavoidable. A recent investigation points out that over 70% of the villagers' children suffer from lead poisoning; there is an up to 62% higher rate of premature birth and six times more still births compared to the national average [101]. As the majority of digital waste is processed in poor conditions like that in Asia, it is urgent to pay more attention to this issue.

Figure 6.5: The industrial waste in Guangdong, China

6.2.2 Measures

We have realized that the Internet has touched almost all aspects of our lives, making many things better, but also creating pitfalls. It is important to be aware of the development and direct it into a meaningful path that is most beneficial to everyone. From the perspective of sustainability it is crucial to make sure that this development does not happen at the cost of the next generation and the boom that we are experiencing is not a short-lived one. For this, some measures have to be taken, some of which have already been successfully implemented, others drawing more and more interest. We present some ideas in this section.

Green Economy

The concept of Green Economy was first conceived in 2008 [84]. Unlike the mindset up till now, Green Economy focuses on a more harmonic interaction of human with technology. The economic model is based on sustainable development and knowledge of ecological economics. It tries to break out of narrow focus and instead consider every involved aspect including environmental concerns such as waste disposal, renewable energy research, greener logistics etc. At the same time it encourages governments to take initiative by creating laws and decrees to support a more ecologically responsible behavior in cases where the economy does not offer direct incentives.

Government Intervention

As previously discussed, the Internet takes influence in society in an unprecedented extent. Therefore it is the responsibility of governments to take action [84]. Sometimes, it needs to limit the Internet, for example when it comes to child pornography or software piracy. On the other hand, it also has to stand up for the right of the minority and make sure that freedoms that are major achievements of the Internet are not stifled.

It is hard to find the right approach, as the EU commission has often shown. Even though they are aiming for the best, their measures end up being far from reality especially when it comes to todays fast moving trends. One negative example is the banning of unsolicited cookies in Internet browsers[102]. Nevertheless, governments should get involved in governing the Internet, help developing standards for the Internet and create common rules especially since the Internet knows no national borders. This of course pressures countries to work closely together.

Energy-conscious Design

When talking about sustainable development, people often think of ways to reduce power consumption in order to save energy. Indeed there is a lot of room for improvements in this area when it comes to IT. As mentioned previously, data centers are an integral part of the Internet's infrastructure and are steadily growing in size and hunger for electrical power. Different approaches exist to

keep that hunger for more power in check and fortunately, electricity bills are a huge incentive for companies to do so. Electrical power can be saved along the entire distribution chain from power source to the data centers.

The first step that can be taken is to choose the correct size of the data center. An often mistake is over-dimensioning, designing the data center with a capacity that can handle much more load than actually required [103]. This does not only mean a higher costs for both building and maintaining the data center, but also an undesirably low efficiency: most server units would run at low load, while continuing to draw power. Of course in some cases a lower capacity is not a viable option. For example when the load heavily fluctuates depending on the time of the day or because there is no way to plan ahead with new business ideas. Risking under-dimensioning would affect the service availability and usually seriously harm the business. Outsourcing server capacity may help here, especially since established IT companies such as Google, Amazon and Microsoft with excessive server capacity recently started offering them to third party. Internet start-ups can avoid the risk of investments by using such services, all the while remaining flexible regarding demand for server capacity.

The often-cited Moore's Law also contributes to less energy consumption: the energy efficiency of processors, simplified as "performance per watt" has been growing dramatically, to an extent that not replacing old hardware regularly is less cost-efficient in the long run due to increased maintenance costs and higher power consumption[104].

Sustainability not only benefits from advances in hardware, but also in software. Modern virtualization technology decouple software from the hardware it runs on. This not only makes server outages and upgrades easier to handle, but also can contribute to achieving optimal load on the available hardware: services that cause low processor load can be moved to the same server hardware so that it does not idle, yet stay isolated from each other's interference. This way, the workload can be consolidated onto fewer running machines on off-peak times and left-over machines can be put in power-save mode or even turned off completely.

The non-computing parts in a data center are also subject to right-sizing: choosing the right capacity for both power supply (including uninterrupted power supply such as backup batteries) and cooling facilities are crucial to decreasing the power consumption since those components contribute a large part. Figure 6.6 shows an interesting concept: a data center can be divided into many self-contained units that each have its own power supply and cooling tailored to the requirements of that unit [105]. An additional benefit of this design is that a data center can easily be extended by adding more of such units. Companies that operate large data centers such as Google or Microsoft already recognized this and are spearheading the development for greener data centers. State-of-the-art data centers have an PUE (power usage efficiency, lower is better) of roughly 1.2 as opposed to the average of 2.0[105][106], so there is a lot of room for improvements in general.

Yet another way of reducing the carbon dioxide footprint is to choose the location to build data centers wisely. Some are built next to hydroelectric power

Figure 6.6: A container representing a data center unit with its own power supply and cooling.

plants or wind power stations in order to cut transmission losses and obtain energy from a cheap and green source. Other data centers take advantage of the cold climate of their location and use ambience air for cooling. An extreme example is a data center built by Google in Finnish town of Hamina where they use the existing infrastructure of a former paper factory to cool the servers with ocean water. In longterm, the investment to gain the know-how, for example to deal with saltwater corrosion, will pay off[107].

6.3   Seminar Session: A process to judge generally and personally

The seminar session on this topic lasted about 90 minutes. The presentation and the interactions involving the audience were intertwined. In several rounds of discussions each participant of the seminar had a chance to talk about their own experience in the role as an Internet user. The results are new perspectives on the Internet activities of each participant under the light of sustainability and also yielded new ideas for improvements thereof. While the presentation acted little more than a general guideline how the session develops and gave hints to bootstrap group discussions. Even though the presenter proposed solutions at the end of each discussion, participants came up with some alternatives on their own.

For starters, the definition of the three aspects of sustainability was presented, guiding the discussions about the personal impressions on the impacts of the Internet on sustainability into three categories.

Keeping the relationship between the Internet and sustainability in mind, a small role-playing game was performed in-between. Note that since all the participants have a background in computer science and thus come into touch with IT and the Internet on a daily basis, this cannot be regarded as a reflection on the general society but merely a niche group. We can only guess how people whose lives do not center around IT professionally or vocationally would relate to this topic. Four roles were randomly chosen for the participants to act: a

software engineer at Google, a shop owner on eBay, a researcher at the Leibniz computing center and a 17-year old high school student who is passionate about digital media and online games. The goal is to identify the contribution and damage to sustainability that is possibly done in each of the roles. For example, a high school student with a low budget may resort to software piracy without having a bad conscience, but in the process of doing so cause damage to a healthy and sustainable software industry that is harmed by piracy. The discussion became heated when the eBay owner and the high school student were the focus. This might indicate that while most of us have a similar mindset when it comes to computer scientists, the opinions can differ greatly on the involvement of common users with the Internet. Also revealed was the fact that as normal Internet users most of us spend a lot more time and energy on online interactions than previously consciously aware.

The last part of the session involves judging the world in general in terms of sustainability at the present, 30 years ago and in 30 years from now, in third-person perspective. For this exercise the participants were put into three groups according to the timeframe. Interestingly, the general outlook on the future is not all that bright and more of a pessimistic nature. The group dealing with how sustainability will evolve in the next 30 years picture a rather dark scenario in which on the one hand technology has advanced very much, but at the same time the world is plagued by natural disasters caused by environmental problems. The group dealing with the present summarized the problems that are already apparent today, but have hopes in improvements in the future. The third group surprisingly found many virtues stemmed from having a simpler life without the Internet and lower level of technology 30 years ago.

The session came to a close when the participants were to judge their own personal impact on environment and society, most gave themselves low scores for unnecessarily owning and running too many devices. Hopefully the introspective gave each participant a small wake-up call.

6.4 Conclusion: A better future by ourselves

The Internet created an unprecedented way for people around the world to exchange information and ideas, starting a digital revolution that affects all areas of our daily lives. Today, many things that were impossible a few decades ago became a matter of course, and we are left to struggle to understand how things were done in the first place when Internet did not exist. The explosion in information at one's fingertips created invaluable benefits and opportunities for all of us, providing us with new perspectives on the world and cultures different than our own. But there are also disadvantages and risks as we have mentioned, including environmental, economical and social problems that have to be tackled.

Still, we would like to emphasize the value that the Internet holds and that have not been unleashed yet. It is not an exaggeration this the information age. History cannot be rewinded, but the future that includes the Internet can still

be formed towards more sustainability. While the single action each of us makes every day may have little impact on its own, the sum can make a difference. It might be enough if everyone involved is aware of the implications his or her actions and take the aspect of sustainability into account when making decisions.

Chapter 7

Green Car IT

Author: Valentin Koller

7.1 Introduction: Does IT play a role regarding sustainability in the car sector?

Nowadays, software and IT are an enabler for innovation and increase in value in the car sector. Using modern computer techniques, intelligent and automated systems support the driver in many different situations during the drive or make it more comfortable. It is claimed, that already IT is the most important and expensive field in the car production. At the same time, a great change in the transport sector is taking place. Companies, supported by the governments of countries, are researching greener technologies and methods to build and drive a car. With the battery-driven electric vehicle becoming more and more efficient, a paradigm shift seems near. Due to the great importance of IT in the sector, the question raises, what role does it play regarding sustainability. Or: how can IT help to make the car 'greener'? This paper wants to give an overview of several projects, studies and possibilities that already exist. While not explaining everything in detail, the reader should get an idea, where IT can have great influence to support greenness and where it seems like it only can change little or nothing.

7.2 Contents: IT helping the car become more sustainable

7.2.1 Alternative drive technologies

For several years, the car industry is in transition from using the classic combustion engine to alternative drive engines. The reasons are the fear of staying behind in the development of new techniques, the knowledge, that the oil, that

is needed to produce fuel for the cars won't last forever and will therefore become irrevocable more expensive over the time and the increased environmental awareness in general.

The U.S. Environmental Protection Agency estimated CO_2 emissions of 1,812.4 million tons in the country produced by the transport sector in 2009 [108]. The total CO_2 emissions in the whole country is estimated with 6,633.2 million tons. That means, that the transport sector is responsible for more than 27% of emitted CO_2 in the U.S. Looking on this sector in detail, 'the largest sources of transportation greenhouse gases in 2009 were passenger cars (35 percent), light duty trucks, which include sport utility vehicles, pickup trucks, and minivans (30 percent), freight trucks (20 percent) and commercial aircraft (6 percent)' [108]. This shows the great impact that a change to more environmental friendly car engines could have, as the report also says 'almost all of the energy consumed for transportation was supplied by petroleum-based products, with more than half being related to gasoline consumption in automobiles and other highway vehicles'.

On a middle- and long-term basis the classic consumption engine needs to be replaced by alternatives. Hybrid vehicles, electrical vehicles and hydrogen-powered cars are therefore a promising approach. In this chapter, a first overview of the different engines should be explained roughly. Later, the prospects and practicability will be compared.

Technical comparison

Technology	Fuel	Energy Storage	Engine
battery-driven electric vehicle (BEV)	electric current	battery	electric motor
fuel cell electric vehicle (FCEV)	hydrogen	hydrogen tank	electric motor
fuel cell hybrid electric vehicle (FCHEV)	hydrogen	hydrogen tank	electric motor
hydrogen-powered vehicle (HPV)	hydrogen	hydrogen	combustion engine
hybrid electric vehicle (HEV)	petrol (diesel)	fuel tank & battery	combustion engine

Table 7.1: Comparison of different drive engines [109]

The table 7.1 shows the basic differences between the alternative drive engines. There are more types of hybrid vehicles, that differ only in detail so they are not explained any further. In recent years, hybrid cars have become very popular due to economic reasons as new energy storage and engines are still in early development stages. But the more interesting part to analyze are the opportunities and difficulties of the so-called 'zero-emission' engines, which do not need limited resources (locally) anymore. Namely, these are the BEV,

FCEV, FCHEV and the HPV.

Hydrogen-powered vehicle (HPV)

Hydrogen powered cars share more or less the same advantages and disadvantages. Using the gas H_2 means that only few changes to the existing infrastructure need to be made. Gas stations can use their already installed systems to fill up cars with fuel, which is economically practicable. Also, the refill can usually be done in a fast and uncomplicated way by the customers. The use of hydrogen in engines doesn't emit harmful substances, which makes it possible to build cars that have zero local emissions.

Hydrogen can be gained in several ways. Unfortunately, the most feasible way to produce it, is fossil fuel reforming, which again needs limited natural resources. However, it is also possible to produce H_2 using electrolysis of water. This procedure needs a lot of energy and isn't practicable yet. Nevertheless, by using alternative energy sources, it would be possible to produce the fuel in a completely sustainable way.

One of the greatest problems lies in the storage of the H_2. It is highly volatile and cannot be stored efficiently yet. Although the energy density of H_2 is much higher than that of classic fuels, its energy content per volume is lower than that in petrol or diesel, which makes the engines in total less effective. To use H_2 liquid, it has to be cooled down to less than -253C. To cool matters down to such low degrees, a lot of energy is needed so that the overall energy consumption (for the usage) increases. Also, the storage tanks need special materials, which are expensive and frequently need high energy consumption during their production.

The first HPV's that were more or less ready for the market were produced in the late 90's. The big advantage of the HPV compared to the other technologies is the fact that only very few changes on current engines need to be made. Hydrogen is used as fuel in a classic internal combustion engine. The resulting hydrogen-oxygen reaction applies force to the pistons to move the vehicle. With few modifications, it is even possible to use the same engine for both types of fuel, hydrogen and petrol. The primary emission of the oxidation is steam without any particulate matter. Nevertheless, by-products are NO_x and others that are produced during the oxidation of lubricating oils.

A popular example of the feasibility of H_2-Engines is the BMW CleanEnergy project [110]. Already in 1999 a BMW Hydrogen 760Li was built. It uses the same motor as the 760i, but runs on both hydrogen and gasoline. It is rated up to 260PS and can reach 200km using only the H_2 fuel. Additionally, a 80l gasoline tank is integrated to support reaching higher distances with classic petrol using the same engine. Since spring 2007 it is possible to lease a BMW 745h which is hydrogen driven.

If it was possible to save and produce the gas efficiently in future, it would be a much more environmentally friendly system than the one we use now. However, the fuel cell electric vehicle (FCEV) fights with same problem while promising more effective energy per liter of hydrogen and absolutely zero emis-
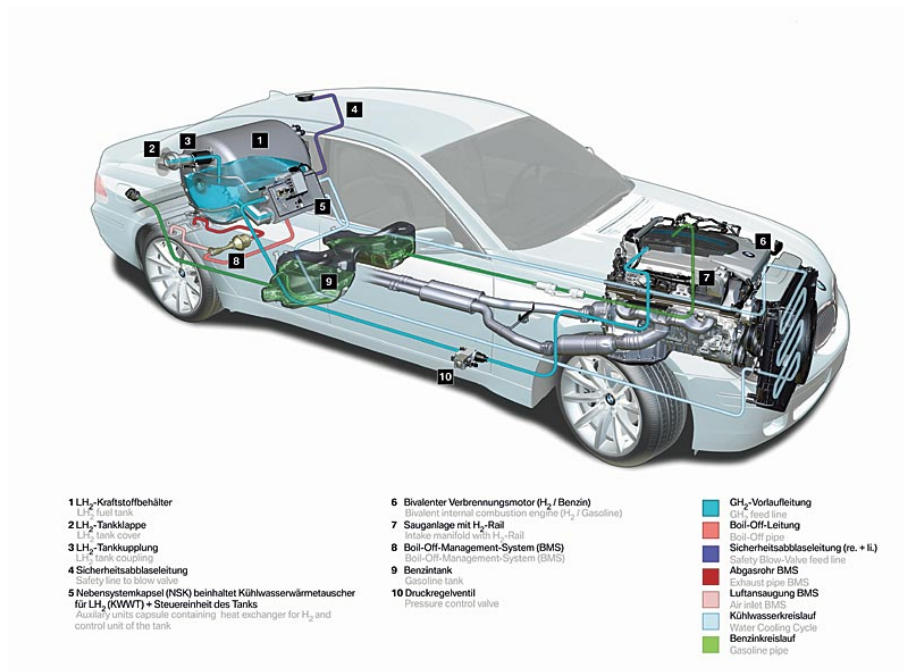
Figure 7.1: Concept of the BMW Hydrogen 7 [111]

sions. The HPV was easy to build since the basic technology has already existed mostly and therefore it was the first alternative driving engine that actually seemed to be ready for the market. However, the main focuses in research moved away to more promising technologies.

Fuel cell electric vehicle (FCEV)

The FCEV uses a fuel cell to drive an in-line electric engine. The fuel cell converts chemical energy from hydrogen into electricity through a chemical reaction. In contrast to an HPV the hydrogen doesn't get oxidized so that no soot is produced. There are still no fuel cell cars sold on a commercial base, but several prototypes from different cooperations were presented. 'By 2012, Hyundai plans to begin manufacturing FCEVs in the low thousands and delivering them to fleet customers in Korea.'[112] Yet nowadays the FCEV can be driven completely sustainably. But the expensive production and storing techniques make it unpractical for the market. The Bundesumweltamt in Germany sees hydrogen cars and the FCEV as an option for the year 2050 and later.[113] They recommend the official promotion in this field to focus only on the research sector. For them, for the next few years the battery-driven electric vehicle seems more feasible. However, some companies still believe in the potential of FCEVs in near future. One of them is Daimler, who presented a concept of a Mercedes

S-Class called F125 at the IAA 2011[114]. They think that the hydrogen tank can use its advantages especially at long distances. A batch production of the B-Class Model using fuel cell is planned for 2014. [115]

Battery-driven electric vehicle (BEV)

Like the FCEV, the BEV uses an electric engine to drive. However, the energy is not provided by a fuel such as hydrogen but a standard lithium-ion (polymer) battery. Since electric engines have a very high effectiveness, the performance of the car depends more or less on the battery. Therefore it is the main focus of research activities these days. Researchers have to challenge many weak spots of the battery:

- Low Capacity

- Long recharge times

- Low lifetime

- High weight

- Expensive production (costs and emissions)

- Expensive disposal (costs and emissions)

Heavy research is taking place regarding all of these problems. Virtually every week technique labs around the world publish news showing new approaches or solutions to solve these problems. For example, IBM is researching on a so called Lithium/Air Cell, which replaces the cathode with oxygen, providing up to ten times more capacity compared to batteries sold today while also being more heat and cold resistant.[116] In Ulm, Germany in January 2011, a new institute for electrochemical energy saving and transition was founded to research battery specific causes like performance, lifetime, system-technique and safety.[117] On a middle-term view, the battery-driven electric vehicle seems to be able to become economically and environmentally suitable. The government of Germany shares this opinion and tries to support electric mobility with a program called 'Regierungsprogramm Elektromobilitaet'. [118] This includes tax exemption, extra parking spots and the possibility of using dedicated bus lanes for electric car users.

Besides the battery, there are more problems that have to be solved. The infrastructure for 'refilling' needs to be changed dramatically. Though there are a few proposals it does not yet exist one way that seems to solve all problems. The long recharging times of batteries make it difficult to stay with the old gas station system, because the people dont want to wait for hours until their car is fully recharged again. This and the low capacity of the batteries make hybrid vehicles attractive as long as now true alternative is found. Also, a question which is frequently raised is, how much more electric power must the supply network provide to have sufficient reserves. Experts are not completely in agreement concerning the numbers, but the 'Deutsche Gesellschaft fuer Sonnenenergie' calculated a greater need of only 10 percent in Germany

if there were 40 million hybrid- and electric cars in the country. [119] Other issues are the disposal of a great amount of batteries that come with the launch of the electric vehicle and the missing taxes on oil that are used to build the infrastructure.

7.2.2 Alternative mobility concepts

Better Place

One approach to deal with problems the BEV is facing is the 'Better Place' [120] project. It's the first decisive attempt to provide a complete infrastructure for electric vehicles. The basic idea of the project is to rent car batteries, that can be changed rapidly in special 'switch stations' that replace the classic gas station. There the car owner can change a low charged battery for a full one in a short time, being able to reach long distances without caring about recharge of the battery. The project started in Israel in 2010 and expanded to more countries like Australia, China, Denmark, Japan, North America and parts of the E.U.

Figure 7.2: A 'Better Place' switch station. [121]

To realize the project, new and expensive technologies are used. Thus IT plays an interesting role here. The founder and leader of 'Better Place', Shai Agassi, was one of the founders of the SAP AG, one of the biggest Software providers in the World. On the Website of the project, an extra page explains the use of software to support the network:

> 'Our EV network software (...) allows Better Place to monitor all the batteries in the network (residing inside vehicles and in switch stations), aggregating data on each battery's state of charge and anticipated energy demand. EV network software can communicate this data to utility partners in real-time, allowing them to optimize the allocation of energy based on available supply and EV drivers' demand. By leveraging the single point of contact with our EV network software, utilities can ensure that EVs serve as a 'distributed storage

mechanism,' absorbing under-utilized, off-peak electricity, while at the same time meeting driver expectations in terms of charging time and pricing.'

'The distributed storage mechanism is a perfect complement for renewable energy, which is generated intermittently and unpredictably. As utilities plan to ramp up renewable energy generation, our EV network software will deliver major added value, as it helps them allocate intermittently-generated energy to a broad network of EV batteries for storage and use.'[122]

While the used software itself is not in any way more sustainable than usual, its tasks are to enable a more sustainable system. To do so, modern software techniques such as monitoring, wireless communication and network analysis are used. A second idea, also supported by the Better Place project, is to use car batteries as distributed energy storage device. This can be realized by smart grid technologies that use a network in which many cars participate. For example, wind farms provide a great amount of energy at night, when the demand is low. 'If a critical mass of EVs is plugged in at night, they collectively serve as a distributed energy storage device that absorbs renewable energy as it become available, which then powers transportation the following day.' [123]

Car sharing

The collective usage of cars is no new idea. The basic premise is to see the car as a transportation utility without an exclusive ownership. Systems that provide such services can have several advantages to its users and the community in general. They 'offer the potential to '1) reduce a users transportation costs; 2) decrease the need for parking spaces in a community; 3) improve overall air quality; and 4) facilitate access and encourage use of other transportation modes, such as rail transit.'[124] The advantage is, that the user can still profit from the flexibility of a car compared to public transport while avoiding or minimizing many of its disadvantages.

Many different systems of car sharing services exist. Although IT can help support probably all of them, a special interest goes into a new kind of car sharing system, that is enabled by newer IT developments. The spread use of so called intelligent phones or 'smart phones' that are always online make it possible to create a dynamic network of cars the user is always connected to.

Using an example can explain this further. The 'DriveNow' [126] car sharing system from BMW and Sixt in Munich started in August 2011, using the phone as main tool. The whole system of DriveNow is based on newer IT technologies. The users can download an App for the popular mobile operating systems to participate. All around Munich inner city, the user can find a car using his smartphone. The position of the cars is always updated automatically. The user can drive the car all around in the city and leave the car for free in the inner city area. Many aspects are running self-controlled using modern IT techniques. To find a car via the smart phone, the GPS position of the user is sent to the

Figure 7.3: User searching a car using the DriveNow App [125]

DriveNow servers via internet. The server sends the user data of near cars available. It is possible to reserve a car for a given time with the phone, so that no other user can take the car before you arrive. The finding of the car can optionally be support via Augmented Reality Apps. To enter car, nothing but a personal DriveNow card with included RFID-chip is needed. Before starting the car, the user must rate the cleanness and state of repair of the car via a so called 'inCar-System'. It is also used to calculate costs and provide other functionalities.

UbiGreen App

The 'UbiGreen Mobile Tool for Tracking and Supporting Green Transportation Habits'[127] is a mobile phone application, that tracks, how 'green' the user is using different transportation. It can be regarded as a small example, how IT may support sustainable behavior. The App, installed on the users mobile phone, tries to detect automatically the way of the users transit activity to give a visual feedback, how environmental friendly it is. To do so, the background image of the mobile phone display changes. For example, if the user takes the bus instead of his/her car to go shopping, he/she will be rewarded. So does using the bike, walking or using car pools.
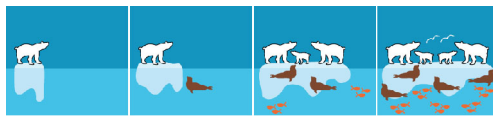

Figure 7.4: Different mobile phone display backgrounds according to the greenness of its user. [127]

To evaluate the influence of using the App, the developers used a field study with 13 persons. During a time of up to 27 days (21 in average), persons using

109

the App were tracked, triggering a total of over 8.4 million sensor events. These data was analyzed and can help to get information about general transportation behavior. The potential behavior of change is described by the developers as follows:

> 'Our formative work showed that participants would value feedback about their transportation choices and identified forms of feedback that might help to support and sustain greener transportation choices. Our field study clearly demonstrated the viability of our concept, to which participants responded positively (...). In fact, 7 of the 13 participants continued using the software beyond the planned end of the study.'[127]

Though the UbiGreen App is nothing that can be regarded as a big project with great expandability, it shows very well the many different ideas that exist to use IT in general to support sustainable behavior.

Driving Assistances for more sustainability

At first, automated driving assistance helps to drive more save and comfortable. Nevertheless, some of this systems do also support the environment. For example, the 'BMW Green Driving Assistant' analyzes the road using on-board and off-board functions to find the most eco-friendly route. [128] It is embedded into the navigation system and its algorithm serve as an indication to the most fuel efficient navigation route. 'The artificial intelligence built into the feature, allows the Green Driving Assistant algorithm to continuously learn the typical fuel consumption and the values can be used each time the driver is planning a new route. Future enhancements to the iDrive navigation system are likely to take advantage of this feature, but BMW has yet to commit to a specific timeframe.'[129]

Another example is the 'VW Temporary Auto Pilot'[130], which was mainly produced to provide more security to the driver. On highways and country roads, it lets the car drive semi-automatically up to 130 km/h to lighten the users load. It controls automatically the speed and the distance to the car ahead. Thus, unnecessary and too strong breaking are avoided, which saves gas. Also, if more people were using the system, the traffic in general would run more fluently, decreasing accidents and traffic jams.

7.3 Seminar Session: Overview of existing and future technologies for the sustainable car and IT

The seminar session was divided into three main chapters. The first two are strictly theoretical chapters that describe what chances IT can offer to make cars more sustainable and furthermore, what problems still exist. Strictly speaking,

the first chapter of the presentation gave a small overview of the reasons, why one should care about sustainability in this specific sector. It gave the audience an idea of the impact that the car and its industry have on our environment. This impact is also compared to other industry sectors, such as air traffic. A great amount of the CO_2 emissions that are produced worldwide every year comes from sources that are not directly connected with car driving. Furthermore, other factors must me taken into account. For example the extraction of resources, production of materials, energy combustion during the production, industrial refuse, scrapping, recycling and other emissions such as CH_4, N_2O, particulate matter and so on.

In the second chapter, several drive technologies were described and compared. Mainly, the techniques of the hydrogen-powered-car and the electric vehicle were explained roughly. The audience was given an overview of the advantages and disadvantages of the hydrogen combustion engine, the fuel cell car and the electric alternative. Aspects regarding their potential of sustainability and the feasibility nowadays were examined. Therefore it became apparent that a lot of challenges exist that still need to be met.

The third chapter started with a trailer of the 'Better Place' project, which faces one of these challenges. It is also a good example of the important role IT plays. So it does in some further projects, which help to understand, where IT can help making cars more sustainable.

The interactive part consisted of 30 minutes during which two tasks had to be solved in group work:

- Group 1: The group should model an App that enables the user to use a one-way car sharing service with a simple and efficient method. For an easier support, one can also think of using technologies, that already exist.

- Group 2: With regard to the App: how can Software and IT help to deal with the problems of rush hours and an uneven distribution of cars? Would it be possible to extend the software in a way, that people that have the same destination could use a car together? Also, how else could the App be extended to offer more sustainability?

After that, the groups presented their solutions and discussed further possibilities with the course. The solutions and ideas were compared with the DriveNow Car Sharing System, which started just one day after the seminar. The example shows clearly, how even old ideas can be taken into consideration and improved using new possibilities enabled through IT.

In the end, some small examples of software solutions that provide enhanced sustainability for the car and the mobility sector, such as the UbiGreen App were presented. Again, the course discussed the practicability and chances of such projects.

7.4 Conclusion: The power of IT supporting other technologies

Though in this paper only a small overview and few examples could be given, it shows the general possibilities of IT enabling sustainability in the transport and car sector. The most potential lies not in increasing the greenness of IT and software itself. Of course it might be possible to use hard- and software that uses lower electricity consumption, but compared to the emissions that are produced by non IT products in the transport sector, this is just a drop in a bucket. The great power of IT is to link up technologies and information. This can be seen very well in the example of using a smart grid together with an intelligent and great battery network by 'Better Place'. The DriveNow App shows how even older ideas for more sustainable transportation systems can get a significant boost by using new IT techniques. But also one could see, that the combination of IT and sustainability is still a very young field in the transportation sector. Most of the projects are either the first ones in their field, or even just studies, prototypes or general ideas.

A greener future of the car sector and the transportation sector in general depends greatly, among other things, on new IT developments. But until now, IT just did its first steps on the way to realize more sustainability in this field.

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