The End of the World we have known
How the digital revolution drives the energy *Wende*

Prof. (em.) Dr.-Ing. **Michael F. Jischa**
TU Clausthal, Clausthal-Zellerfeld

A young boy asks his father: Daddy, which kind of computer did you use when you were young? The Father: I had no computer. Astonished question: But how could you get into the web?

This describes "*the end of the world we have known*", that is the title of a book by Leggewie and Welzer "*Das Ende der Welt, wie wir sie kannten*" (2009). In the following I tell you *my story* about the end of the world we have known. Later I shall present main messages of the book.

Technology always has been the main driver for social changes. If we ask what engineers are doing, the simplest answer will be: They deal with the *media* material, energy and information, using the *processes* change, transport and storage.

In school we have learned the history of mankind using different materials, from the stone age to the iron age. I don't want to repeat this. I like to tell the story of information technologies for two reasons. At first because you have heard in will hear a lot about energy technologies. The second reason is more important: ***The digital revolution is the central requirement to realize the way towards sustainable energy systems!***

Technical innovations have always changed social structures. ***Civilization dynamics*** has been driven by four radical innovations concerning communication processes, the four **"Gutenberg-revolutions".**

Learning how to speak the, **"first Gutenberg-Revolution",** has been the central innovation at the beginning of development of human species. We are the only species they have developed the medium language. This has given us an enormous evolutionary advantage compared with other species. Because the transfer of experiences is much more efficient using languages compared with the extremely slow genetic transfer.

In the history of mankind three revolutionary transitions took place. (1)The **Neolithic Revolution** describes the process from hunting and gathering societies, organized in tribes, to agrarian societies, organized in ***feudal systems.*** (2) The **Industrial Revolution**, based on the **Scientific Revolution**, was a **European process**. It describes the way from agrarian to industrial societies, accompanied by ***nation- building***. (3) The **Digital Revolution**, where we just live in, describes the way from industrial to service societies, characterized by ***global structures***. The designation global does not mean that the service or information society will lead to a global state instead of national states. It suggests that the information society forces global structures.

The Neolithic Revolution took place about 10.000 years ago in different places of the world with appropriate climate conditions. Two processes, farming and the domestication of animals, were followed by settlements. This was the first great social and technical performance of mankind. How to handle irrigation and draining became necessary, therefore these societies sometimes are called "hydraulic societies". Oral instructions were no longer sufficient. It became necessary to quantify the stock of food and animals. So from the practical point of view numbers, measures and weights as well as documents were needed, this was the beginning of writing and counting. This is called the "**second Gutenberg-Revolution**".

In the following food staff *and* population increased rapidly. The social structure of tribes had been really democratic. Now the transition into feudal structures started in some parts the world. Different social classes came up, rulers, a caste of priests, writers and soldiers, and a caste of farmers and workmen. Therefore the first feudal systems had to solve a new problem, how to distribute the additional revenue. The result was an unequal distribution, the economic basis of different classes. Since that time we have a permanent discussion with various solutions, from capitalistic to communistic societies and something between.

The next radical communication innovation followed in the middle of the 15th century by Gutenberg, the printing with moving letters, the" **third Gutenberg-Revolution**". This new technology has led to massive social changes. In former times writing and reading was a privilege of the upper classes. Exclusive knowledge now became popular knowledge, if was democratized. Each kind of knowledge, in religion, science and technology became available for everybody. Books were published with breathtaking acceleration. So the basis for the **scientific revolution** and the following **industrial revolution** was prepared. "The European Miracle" (Jones 1981) started, the technology driven transformation and domination of the world by European nations.

Feudal states changed into national states. Capital, accumulated in the agrarian society, was *the* essential resource to make investments in starting industrial complexes. The age of coal and steel began. Again productivity and population increased rapidly. Interposed question: Could the Reformation have been successful without printing media, 70 years after Gutenberg? The theses of Martin Luther had been the first mass prints in history. Never before ideas could diffuse so rapidly into societies. Catholics like this assumption, Protestants don't.

Only some decades ago the (until now) last radical communication innovation started, the **Digital Revolution,** the "**fourth Gutenberg-Revolution"**. This has led to a **time-space-compression** of all processes, mainly economic processes. We don't have the fantasy to imagine the consequences about future developments. Nearly every day we are surprised by new messages. "*World Wide War*" (Clarke, Knake 2010) instead of *World Wide Web* is such a phrase.

A first sum up: Mankind has lived for some 100.000 years in a world of hunters and gatherers. From an anthropological and psychological point of view we are still hunters and gatherers, but this is another topic. In the following mankind has lived some 1000 years in agrarian societies, 200 years in an industrial society and in the digital information society only since a few decades. So the timescales of societies decrease rapidly.

This leads to a **first conclusion**, described by the philosopher Lübbe as "***shrinking of the present***", in German "***Gegenwartsschrumpfung*** . If we define the present as the length of time of constant life and working conditions, then our lifetime in the present constantly decreases. The unknown future moves constantly closer and closer to the present. At the same time, the desire for steady circumstances in societies is growing. The increasing trade with antiques and classic cars describes the situation, because these products cannot become older, for they are even old.

At the same time, experts and managers in industry and politics realize the disillusioning fact, which I describe briefly as "***Popper-Theorem***": *We can know ever more and we shall know ever more, but we shall never know what we shall know tomorrow, since otherwise we should know already today.* In our time we know more and more, although we become blinder regarding the near future. On the other hand the number of innovations increases steadily, which change our life irreversibly.

We come to a **second conclusion**, if we discuss the world of labor as an indicator for social changes. Societies of hunters and gatherers don't exist anymore. Significant are changes in the three other sectors, the agrarian, industrial (including manufacturing) and service sectors, especially in the last 200 years. In 1800 about 80% have worked in the agrarian sector, and smaller parts in the manufacturing and service sector. In the 19th century the agrarian sector decreases constantly, and at the same time the industrial sector increases rapidly because of the industrial revolution, the service sector increases slower. In Germany 1885 the industrial sector overtakes the agrarian sector, this was the transition from the agrarian into the industrial Society. The industrial sector remained nearly constant at 50%

between 1910 and 1970, at the same time the agrarian sector decreases down to 10% in 1960, and the service sector remained at about 40%. In about 1975 the service sector overtakes the industrial sector, this is defined as the transition from the industrial into the service society. In 2000 the numbers are under 3% agrarian, 32% industrial and 65% service sector. *This is the end of the world we have known*!

The situation in Germany with a bit more than 30% in the industrial sector is much better than the situation in France and UK with about 15% and the USA with about 10%, where the phrase "Detroitirisation" was coined. This is one reason, why Germany could pass the way through the financial crisis better than comparable countries. A British newspaper recommended, UK should make more mechanical, electrical, and chemical engineering and less financial engineering.

The service sector is very heterogeneous. It includes traditional activities like government and Justice, internal and external security, education and research, medical and social care as well as culture and arts. Modern societies are described with additional adjectives like Multioptions, Event, Leasure, Affluent, Sense or Risk-Societies. This has led to a great number of new professions. But the increase from 40 up to about 65% in the service sector mainly comes from an increasing number of "symbol analytic services" in the words of Robert Reich: Analysts, consultings, broker, hedgefonds-manager. Ironically I call these dissipative or parasitical activities. They participate from the affluence and, and on the other hand they create new prosperity. This is a secret of capitalistic systems.

Another **indicator** describes the way into the **service society**: The **range of employers**, governmental and private ones. The list of the 10 greatest employers worldwide starts with the US Army and the Chinese Army. Not surprising, but surprising are the numbers 3 and 4, Walmart and McDonald's. The next five are China National Petroleum Corporation, State Grid Corporation of China, National Health Service GB, Indian Railways and China Post Group. All these nine employers belong to the service sector. On number 10 we find the greatest employer in the industrial sector, Hon Hai Precision Industry. *This is the end of the world we have known.*

The next **indicator** is the list of the **three top nations**, ranked in the part of **worldwide economic power**. In 1870 GB, where the industrial revolution has started, was number one, followed by Germany and France. This was the British century. 100 years later, in 1973, USA was first, followed by Japan and Germany. This was the American century. In 2010 USA were still on top, followed by China and Japan. The prognosis for 2030 sees China in number one, followed by USA and India. *This is the end of the world we have known.*

Now I would like to come back to the "The European miracle" (Jones 1981). About 1500 from the technological point of view China was the leading nation. Metallurgical processes, gunpowder, printing as well as compass and seagoing ships had been developed. The Biochemist Needham, later becoming an expert in Sinology, has described this in his famous book "Science and Civilization in China" (1954). Needhams enthusiasm for China has had the result, that after the death of his wife he married a former Chinese student.

At that time China was in a situation, to play the role that Europe started to play. But China as a great monolithic block with a very old and highly developed culture has had no interest at that time, to get in contact with barbarian nations. Keeping the big empire in stability was their main problem. Therefore they invested in the education of a governmental official class, to keep the doctrines of the classical masters Konfuzius and Laotse. To copy the old experts was the goal, not to think about revolutionary changes.

The situation in Europe about 1500 was completely different. Europe was not monolithic, a lot of small scale political structures existed. Kingdoms, Dukes, Earls and Counts, monasteries and self-confident towns in Northern Italy and Hanse towns, the big economic player in the Baltic region, competed which each other and made business transactions. The European processes Humanism, Renaissance and Reformation led to Enlightenment and Secularization. In the following the transformation of the world started forced by European powers. This is called "The European Miracle" (Jones 1981). There are a lot of books describing this fascinating process, some titles are my translations:

"The Birth of Modern Sciences in Europe" (Rossi 1997), "The Foundation of Europe" (Seibt 2002), "Why Europe" (Mitterauer 2003), "The birth of the modern world" (Bayly 2004), "Transformation of the World" (Osterhammel 2009), "Why the West rules - For now" (Morris 2010).

As former Professor for Applied Mechanics I like to describe this process discussing the change of conceptions about heaven and earth. The ***geocentric system*** of **Ptolemäus** dominated until the Middle Age. It corresponds with the theological argument, that the Earth is the centre of the universe. About 1500 **Kopernikus** formulated the ***heliocentric system***, which does not fit with the theological dogma.

About 1580 Tycho **Brahe** made the most exact observations about the movements of planets, without telescope. On the island Ven in the Öresund the Danish King Frederik II. sponsored the observatory Uranienborg. After the death of Frederik his successor King Christian IV. was not willing, to pay the enormous amount of 5% of the Danish budget. Emperor Rudolph II. offered Brahe to become the imperial mathematician and built a new observatory for Brahe in Prague.

Kepler became about 1600 an assistant of Brahe in Prague, who in the following dyed at a drinking bout. The aristocrat Brahe has been a bon-vivant and womanizer, who never would have except Kepler, the son of a farmer of equal birth. So Brahes death was a chance for Kepler. He became his successor and developed a mathematical interpretation of the movements of the planets. Based on the extensive and extremely accurate observations of Brahe in the following Kepler showed that Kopernikus was wrong:

1. The planets move on elliptic (not circular) paths.

2. The planets change their velocity, which is not constant.

3. The sun is not in the centre of the circular path, but in one of the focus of the ellipse.

These are the three famous Kepler's laws. This was a triumph of a scientific method combining observations, theory and mathematics.

About 1610 **Galilei** got the information about a telescope developed by **Lippershey**. Galilei improved the telescope and used it to observe the heaven. From an economic point of view the telescope was significant, therefore Venice merchants used it in order to get information about incoming ships earlier than the clients. Galilei was the first, who could see the mountains on the moon, the sunspots and the moons of Jupiter. He corresponds with Kepler and realized, that the existence of Jupiters moons confirm Kepler's laws.

It was **Newton** who completed this story. He formulated the basic laws to describe the dynamics of celestial and earthly bodies, the ***momentum balance equation***. Based on the semi-empirical Kepler's laws Newton argued, that there must be a general law describing the attraction between two bodies. He formulated the ***universal law of gravitation***, that the force between two bodies is proportional to the product of their masses, reverse proportional to the square of their distance and proportional to a universal constant, the gravitational constant. With these tools he could derive the three Kepler's laws. The year **1686**, when his basic scientific work "Philosophiae Naturalis Principia Mathematica" was published, is the starting point of the ***scientific revolution***.

When I derived Kepler's laws in my lectures Applied Mechanic this always has been a personal highlight for me. This scientific highlight inspired Alexander Pope in the 18th century to write:
"Nature and nature's law lay hid in night;
God said: let Newton be! And all was light."

About 1800 **Laplace** published his famous work "*Traite de Mecanique Celeste*". Napoleons question, why God doesn't appear in his book, he proudly answered: "Sire, je nai pas besoin de cette hypothese." In contrast to Newton, who sometimes recoursed to God.

Why do I tell this story? Kopernikus was Polish, Brahe Danish, Kepler German, Galilei Italian, Lippershey Flemish, Newton English and Laplace French. Europe was a continent with a very active

exchange of experts and ideas, new ideas were formulated. This exchange took place in politics and government, economy, science, art and culture. The opera "*Zar und Zimmermann*" by Lortzing stands for this. The variety of cultures, ways of thinking, habits and customs ***had been and still is Europe's treasure***. A French political lady (Mme Weill or Mme Cresson?) formulated: Europe can be the heaven or the hell. Imagine: A British cook, a German policeman, an Italian manager and a Swiss lover. This would be the hell. Or imagine: a British bobby, a French cook, a German engineer and a Latin lover. This would be the heaven on earth. We should keep this in mind in discussions about the future of Europe.

Now I like to present some core remarks in the book of Leggewie and Welzer "*Das Ende der Welt, wie wir sie kannten*" (my translation):
- Why the West still believes, to be in the centre of the world and able to shape the future, other nations are drifting into that role.
- Our self-confidence and behaviour are, since 250 years of superior power, economy and technology, based on conditions, which don't exist anymore.
- Our perception limps behind the speed of transformation in a globalised world. This is obvious in all levels of our existence, regarding to critical developments concerning energy, environment and climate as well as economic and financial crisisses.

Finally I like to make some remarks about **energy research** in general, therefore I identify four different levels. On the first level we deal with components of change, transfer and storage of energy. These topics belong to classical scientific disciplines, here we have a great treasure of knowledge. But the central question is, how these different components can fit into existing or desirable energy systems. The energy system decides, which components are more or less useless. But the problem of finding an optimal energy system depends on legal and institutional frame conditions, on regulations, on management rules. But where do these frame conditions come from? ***Who values the guidelines and management rules and how?***

If **sustainability** is the guideline, the frame conditions have to follow this concept. This means that energy research must ***follow a reverse strategy***. Starting with the **concept sustainability**, we have to look for appropriate frame conditions. If we will reach in the year x an energy scenario y, than an appropriate framework will follow as well as the energy system and their components, which fit to sustainability.

From the technical point of view the ideal model sustainability can be operationalised by **Technology Assessment (TA)**. There are some universities in Germany which have introduced TA in teaching and research, for example the Clausthal University of Technology. The German Association for Engineers (VDI) published in 1991 their guidelines called "*Technology Assessment - Concepts and Foundations*". Similar activities exist in other European countries. Since 1989 we have an Office of Technology and Assessment at the German Bundestag, and we have a small scientific TA community.

Finally I like to talk about my **personal activities concerning technology assessment and sustainability management in teaching and research**. I started with **optional** (studium generale) **lectures** in the evening. In **1991/92**, just before the Rio Conference, I presented the first lecture "***Challenge Future***" (Herausforderung Zukunft), to make the students *sensible* for the "worldproblematiques" in the words of the Club of Rome. This lecture has been the basis of a book (Jischa 1993, 2005). The lecture "***Technology Assessment***" followed in **1994/95** to discuss how the ideal model sustainability can be *operationlised* from an engineering point of view. In **1995** the lecture "***Dynamic systems in nature, technology and society***" followed *to link up with control engineering*, a typical engineering tool. These optional lectures later became obligatory for different courses like Chemical Engineering, Energy Systems Technology , Environmental Engineering and others. Because of my retirement these lectures have been overtaken by former Ph.D. students Christian Berg, Ildiko Tulbure and Björn Ludwig, later they became external Professors.

From the beginning these lectures have been accompanied by **research** activities, some of them in cooperation with the industry. Therefore I was asked by Gerhard Kreysa, at that time managing director of the DECHEMA, who has initiated the "World Chemical Engineering Council" (WCEC), to

make a proposal for a "***sustainability project***" for the WCEC. So I became member of a WCEC working group to formulate this project. The short version is a good summary of my concept:

"*The pursuit of Sustainable Development (SD) is a major challenge for engineers. Chemical engineering is the profession most concerned with managing material and energy flows and, as such, is well equipped to address the sustainable use of resources. This can be achieved by identifying better ways of deploying technologies as well as economic and regulatory measures and by anticipating ways in which investment in process technology can help achieve sustainability.*

The WCEC wishes to promote a better understanding of sustainability for chemical engineers. Therefore the WCEC will ask all institutions teaching chemical engineering the following questions:

1. *How is SD embedded into your Chemical Engineering Degree Program?*
2. *What are the curricula contents of the material referred to in question 1?*
3. *How are the curricula related to SD supported by research?*
4. *If your answers are no, do you have plans to implement SD into the curricula?"*

An even shorter version I've given in my lecture at the ChemEng in Birmingham 2008:

-Teaching concerning SD and TA has to be embedded into engineering curricula. Otherwise we would have the „cappucino effect", that means lectures like „X and ethics" at the end of the courses.

- Teaching concerning SD and TA has to be supported by accompanying research projects. Otherwise it would be feature, that means „nice to have".

At the end: 25 years ago the question about common attributes of a watch, a photo camera and a telephone would be senseless. The smartphone is the answer!

This is the end of the world we have known.

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