Inventing the Future – The Development of the German Technical University System from the 18th Century to the Present

Prof. Dr. Helmuth Albrecht (Technical University of Freiberg/Germany)

Part I: A historical and theoretical introduction

The roots of the German technical university system can be traced back to the 18th century. Its historical development up to the present can be interpreted as a process of modernization within a complex network of interests and necessities. For over three centuries the main actors in this process have been – and still are today – three important areas of modern society: Politics, economics and science. These three social areas and their various groups, institutions and organizations played a major role in birth and growth of a system of education, which became famous during the 19th century and a signpost for the creation and reformation of technical education systems in countries all over the world in the early 20th century.

For a historical analysis of the development and dynamics of the German system of higher technological education it is useful to describe the system in terms of modern theories of innovation. In a first approximation this can be done by using Schumpeter's linear model of innovation with its steps of invention, innovation and diffusion. This leads to a simple but often told story of the consequent and direct development from poly-technical institutes to technical universities and a history of never ending success. But an analysis of the complexity of the system and its various stages over three hundred years in a changing social, political and cultural environment calls for more sophisticated explanations which can be found in the *Triple-Helix-Model of innovation* and in the concept of *Innovation-Culture*. Both models are trying to explain "innovation" in its social contexts and therefore are quite useful for a historical analysis of the complex development of the German technical university system as a part the German modernization in the age of industry.

The Triple Helix thesis states that the university can play an enhanced role in innovation in increasingly knowledge-based societies. The “triple helix” as a biological metaphor in this model is formed by the relations between university, industry and government. These relations are not expected to be stable. They are dynamic and this dynamics is the driving force of the whole system. The dynamics of the Triple Helix is explained by the cultural evolution of the society and of the system itself, driven by individuals and groups who make conscious decisions as well as by the appearance of unintended consequences. In the words of Henry Etzkowitz, one of the founders of the Triple-Helix-Model: *“The sources of innovation in a Triple Helix configuration are no longer synchronized a priori. They do not fit together in a pre-given order, but they generate puzzles for participants, analysts, and policymakers to solve. This network of relations generates a reflexive sub-dynamics of intentions, strategies, and projects that adds surplus value by reorganizing and harmonizing continuously the underlying infrastructure in order to achieve at least an approximation of the aims”*.

Whereas the model of the Triple-Helix was developed from economists as a theory for explaining current research systems the concept of *Innovation-Culture* was created by historians who tried to get an historical understanding of the driving forces of innovation in the development of society. Here the focus of interest was not a short term view of current developments, but an analysis of long term developments in national societies. The starting point of the concept of Innovation-Culture was an answer to the critical discussion about the concept of National Systems of Innovation, a concept which was developed during the 1980ies. It is based on the fact that obvious variations could be found in the technological ability of different nations. One main reason for these differences was identified in different institutional setups in each country which caused different national systems of innovation. It was criticized that this concept is based on an isolated view of the education system, of public and private research, and of the state policy aiming on both of them. It would focus only on the measurable parts of a much more complex system, and moreover would state a mechanism which could be used as a device to control the whole system. With this the concept of National Systems of Innovation was marked as

a child of the technocratic optimism of the 1960ies and 1970ies when the possibility of a planned “making of progress” was still out of question.

Nevertheless the theories about National Systems of Innovation opened up the way to new historical concepts of innovation. The concept of Innovation-Culture can be understood as an extension of the central paradigm of the National Systems of Innovation. Organizations like universities, industrial laboratories or public research institutions are also in the research focus of the concept of Innovation-Culture, but not only as structural components of the innovation system. These institutions are now seen as cultural components of the system with all their action and perception orientating functions. The concept of Innovation-Culture emphasizes that types of perception and action are based in cultural matrixes of the acting people in the innovation process. Therefore the main focus of this concept is not on organizations or formal institutions but on un-formal institutions which are for example manifested through common values of scientific-technical elites, research paradigm, or common identities of groups. One main aspect of innovation culture is the distinction between different systems of values and rules which are affecting the invention and the inventing strategies in different groups, societies or nations. The historical analysis shows us in many examples: Strong cultural values are creating institutional frameworks for innovation processes, and by that way they are forming structures for innovation. But these values and rules are not unchangeable. Their means are changing and they are replaced from time to time by new values and new rules. On the other hand traditional innovation strategies developed over long periods can create security and confidence in times of rapid changes of social values. The concept of Innovation-Culture leads us on one hand to analyse the perfection and action orientated cultural elements structuring the innovation process, and on the other hand to proof the innovation strategies which are generated by these elements. Most of these cultural elements could only be found by the investigation of long periods. Therefore history is a suitable place of analysis as I will show in this paper.

The history of the German university system can be divided into five major periods: The first period embraces the time of the search for first solutions for the problem of finding an education system for technical experts during the 18th century. This period of the pre-formation of the system ended with the French revolution and the Napoleon wars in Europe. The second period is the time of the birth of the early German institutions for higher technical education, the so called “Polytechnische Schulen” (poly-technical schools) as the basic elements of the system and their development into “Technische Hochschulen” (technical universities). This period lasted from the early decades of the 19th century up to the 1914/18 and ended with the First World War. It culminated in the struggle about the administrative, scientific and educational equality of the technical universities and the traditional German universities in the German system of higher education. During the 1880ies simultaneously the “high time” of the German technical university system began with the peak of its international acknowledgment and reputation. The third period from the end of the First World War up to the 1960ies was a period of dramatic economical break-downs, of devastating demolition during the Second World War, and of the rebirth and reconstruction of the “good old” pre-national socialistic German technical university system during the early years of the Federal Republic of Germany. The forth period began with the so called “student revolution” of 1968/69. It was a period of rapid quantitative and qualitative growth of the technical universities, a time of reformation and experiments and a time of a crisis of the whole German university system in a rapid changing social, economical and technological environment. The reunification of the East and West German states in 1989/90 led to the fifth and temporary last period in the development of the German technical university system. It is characterized by the accommodation to the meanwhile worldwide leading teaching and research standards of the American and British university system. At the very end of this story the demands of globalization seem to change what over at least two hundred years seemed to be unchangeable: The specific German technical university system.

Part II: The development of the German technical university system

In the second part of this paper I now want to take a closer look into the just indicated periods of the development of the German technical university system using the analytical instruments given by the Triple-Helix-Model of innovation and by the concept of Innovation-Culture. With that the historical analysis will on one hand focus on the part of the three social institutions university, government and industry and the interaction between these institutions in this development. On the other hand we will take a closer look into the cultural components of the system, the cultural matrixes of the acting people and groups as well as into the values and rules which were affecting the strategies of these people, groups and institutions.

2.1. The pre-formation of the system in the 18th century

With the development of the *Ancien régime* and the absolutism as the common political, economical and social system in Europe since the 17th century the modernization of strategically important parts of the state became an urgent problem. The centralization of economic resources, of military power, of infrastructural planning, and of other major administrative functions in the hand of the monarchy caused the need of an effective and trained bureaucracy for all fields of state engagement. The primary resource for this new group of experts was the military as the most important basis for the power of the absolute monarchy. The first military institution for the education of experts in the construction of roads and fortresses had been the special corps of engineering in France and in the Austrian monarchy during the 17th and early 18th century with their special schools. The most famous of these schools was the French *Ecole des ponts et chaussées* (school for bridges and streets) founded in 1747. Other European countries followed the French and Austrian example but the French system of military schools or military academies with its high standard of theoretical and practical studies guaranteed by famous teachers and scientists remained the best on the continent up to the end of the century.

Besides the special military schools a second type of civil institutions became important for the pre-formation of the system throughout the 18th century: A new type of special schools for the education of experts for the expanding civil service of the European monarchies. In order to secure the economic and the representative demands of the absolute state special schools or academies for mining, economy, architecture, arts, forestry or medicine were founded especially in the German speaking part of Europe. For example the worlds first *Mining Academy* in Freiberg/Saxony in 1765, the *Economical Academy* of Hamburg in 1768, the *Architectural Academy* of Berlin in 1799 or the *Prussian Medical Academy* under the Latin name *"Collegium-medico-chirurgi-cum"* in 1724. One important point of these civil schools or academies was the fact that not only aristocratic were allowed to join them. The increasing demand of special educated experts for all parts of the administrative tasks of the modern state could no longer be covered by the small group of the nobility. The doors to higher education had to be opened up for new social classes, especially for the growing middle class. A system of grants paid by the government allowed even talented people out of the lower social classes to make their fortune in these new civil schools and academies.

With these military academies and these special schools a first step was done to a system of higher technical or practical education. Especially in Germany a second and third step towards the creation of a middle and lower basis for this system followed during the 18th century. For the mid-level of practical education a third group if institutions was created by private initiative: Schools for tracers, tradesmen, merchant's clerks, craftsmen etc. These schools aimed at the education of a new middle class for the beginning industrial revolution. A special school project within this group was the so called "Realschule" (school of realities) founded by reform-pedagogues like Christoph Semler in Halle 1708 or Johann Julius Hecker in Berlin 1747 as "first real citizen schools". These schools were planned as practical schools for the education of technicians, architectural craftsmen, land-surveyors, merchants and farmers out of the middle and lower classes of the society. With their mathematical, mechanical and economical teaching program they were the intentional counter-part of the traditional scholar system

of the Latin-schools with their focus on classical subjects of education. And from the beginning on these schools were planned as training schools for a following university course in science and technology. The basic ideas for this new type of education and school-system were based on the philosophy of humanism, enlightenment and philanthropy of the 17th and 18th century in Europe. This means that despite all social differences in the society every child should have the chance to become a useful part of the society. The main road to this aim was education – an education for the practical demands of the society, an education for a practical job, an education for social usefulness and in general an education to “industriality” (Industriösität) as the new concept of utilitarianism.

This new concept of utilitarianism led to the fourth institutional innovation within the system of practical education of the 18th century – the invention of “industrial schools” for the lowest classes of the society: the orphans, the children of the working class, of the homeless and the poor. “Industrial” in this context doesn’t mean “industry”, even though a large number of these schools were incorporated in manufacturing plants. Others were connected to orphanages, to working houses or to prisons with the aim to educate socially useful people for society – as philanthropists saw it – and social and politically inconspicuous people for the government – as politicians wanted it. Most of these schools were characterized by exploitation, violence and oppression against the scholars by bad or untrained teachers. The famous industrial school in the cotton mill New Lanark of the Scottish employer and social utopian Robert Owen (1771-1858) with its revolutionary pedagogical concept was an exception in the mostly dark history of the industrial schools. Like the “schools of reality” the concept of the “industrial school” failed in a social and political environment which wasn’t ready for philosophical, pedagogical and social ideas which should have their break through more than one hundred and fifty years later. The period of institutional experiments in the field of practical education in the German school system ended with the rise of the anti-utilitarian philosophy of new humanism at the end of the 18th century.

One interesting question in this context is: which role did the traditional system of academic education play with the universities at its top in this development? Why didn't the universities open their doors for the new type of practical education? Why was it a second system of higher education for the practical demands that had to be built up in Germany? The answer lies in the far-reaching inability of the traditional German university system during the 17th and 18th century to open itself for the necessities of the upcoming age of science and technology. The academic education remained in scholastic lecture traditions of the Middle Age, and the universities were widely unable to change their traditional research topics and methods. Most of the German universities remained in the old roads of classical learning, teaching in Latin and educating the academic class of the society in the traditional academic professions of religion, law and medicine. The new methods of scientific and experimental research born in the scientific revolution of the 16th and 17th century didn't find their way into the crusted universities burdened with religious preconceptions. In Germany as elsewhere in Europe the new founded scientific academies like the Royal Society (1660) in England, the Académie des sciences (1666) in France or the Prussian Academy of science (1700) in Germany with their motto "theoria cum praxi" (theory and practice) became the home of the new type of experimental research and the solving of technological problems. Only a few new founded universities like Halle (1693) and Göttingen (1736) opened themselves for the ideas of the scientific revolution and the methods of scientific research. For several decades they were the leading institutions in the effort to open the university to the utilitarian demands of the modern state in the field of mathematical, scientific, technological and economical education. German instead of Latin became the language of teaching. Scientific laboratories as well as new scientific research topics and academic disciplines were established. Among these new disciplines of the 18th century were economics and finance ("oeconomia et cameralia") and technology ("technologia") as new fields of education for the future elite of the state administration. But at least these efforts failed for two reasons: First because of the pure academic interest of the universities into topics like economy or technology which at the time of the beginning industrial revolution were driven by practical problems and solutions and not by theo-

retical reasoning. And second because of the above mentioned rise of the anti-utilitarian philosophy of new humanism which deeply influenced the development of the German university system and its reformation at the end of the 18th and in the beginning of the 19th century. The result in the university system as well as in the school system was an anti-utilitarian turn towards new humanistic ideals of education, teaching and research with the leading motto “loneliness and freedom” (Einsamkeit und Freiheit). On one hand this opened the way for an important and famous reformation of the German high-school and university system in the first decades of the 19th century. The new founded University of Berlin (1810) formed the master plan for a new type of university dedicated to the freedom of teaching and research and open for the development of new sciences like physics, chemistry or biology. Thus for a period of one hundred years the new humanistic German university formed the basis for the leading position of German research and researchers in the field of natural sciences in the world. On the other hand at the same time the idea of pure and anti-utilitarian research closed the doors of the universities for the utilitarian demands of technology and industry. For nearly one and a half century the German university system became the academic fortress against all efforts to establish an equally entitled system of higher education, teaching and research in technology.

2.2. The founding of the technical university system in the 19th century

The impulse for the founding of the German technical university system came from the outside. One consequence of the French revolution and the following period of the Napoleon wars in Europe was the demolition of the old traditional university system of the Ancien regime in France and Germany. In France only the special military academies survived the revolution within a new concept of an engineering capacity building program with the 1794 founded Ecole Polytechnique. The basic scientific education in mathematics, geometry, physics, chemistry and other basic fields of study for future engineers was the task of the new Ecole Polytechnique. This first technical university in the world was still or-

ganized like a military academy but it was open for talented scholars from all social classes of the society. Its mission was the education of a new technical elite of the nation on the basis of modern scientific and technological knowledge. With its didactical concept of mathematics as basic science of technology and with its famous scientists and engineers as teachers the Ecole Polytechnique for founded the development of technology into technological sciences. Thereby the Ecole Polytechnique was the final point of the development of the old military and special academy idea of the 18th century as well as the starting point of the new development towards the technical university of the 19th century.

The concept of the Ecole Polytechnique deeply influenced the search for new institutional concepts of technical education in the Habsburg monarchy and in Germany in the early decades of the 19th century. The economical and social changes of the Napoleon wars led to a crisis of the traditional university system. A great number of smaller universities were closed and the rest new humanistic reformed. At the same time demands came up for new institutions capable to educate technical experts for the beginning industrial revolution and the modernization of the infrastructure in those countries which were mostly affected by the demolitions of the war. Therefore reform orientated citizens and entrepreneurs as well as leading civil servants in the state administrations called for the set-up of new institutions for a higher technical education following the example of the Ecole Polytechnique.

The first of these new institutions with the name “poly-technical Institute” (Polytechnisches Institut) was erected 1806 in the capitol of the Bohemian Kingdom Prague. At that time Bohemia was the most industrialized part of the Habsburg monarchy. Therefore the initiative for the founding of the new institute came out of the regional parliament which wanted to give new impulses to the bohemian industrialization by scientific education. The basic concept for the poly-technical institute was taken over from the Ecole Polytechnique but the new institution went further by combining the mathematical and scientific basic studies with the higher technical special studies in one educational program. Further more it replaced the military structure of the Ecole Polytechnique

by a university like structure and thereby became the model for the future direction of poly-technical education in Germany.

The basic ideas for all technical studies and university structures of the new poly-technical institutes came from the new Vienna poly-technical institute founded in 1815. Based on a plan from 1810 the Vienna institute got a faculty like organizational structure with separate departments for economy and for technology. The scholars entering these departments had to be 17 years old by minimum. A special section called “Realschule” or preparation school had to be passed before entering the special sections. Thereby it was intended to compensate the lack of any useful preparation school for technical studies in the ordinary school system. The claim of the new type of poly-technical institute as an equivalent institution besides the classical university was completed by the appointment of skilled and famous teachers at the Vienna institute. In this regard the concept of the Vienna poly-technical institute was the direct counterpart to the concept of the new humanistic university of the Berlin University from 1810. With the denial of the new humanistic universities to open their doors for the education of utilitarian technical experts on one hand and by birth of the new poly-technical institutes on the other hand the bipartition of the higher German education system was settled for more than one hundred years.

The model of the Vienna institute influenced the foundation of poly-technical institutes in other German states during the following decades. Similar institutions were founded in Prussia (Berlin 1821), Baden (Karlsruhe 1825), Bavaria (München 1827), Saxony (Dresden 1828), Swabia (Stuttgart 1829), Hanover (Hannover 1831), Brunswick (Braunschweig 1835) and in Hessen (Darmstadt 1836). The leading poly-technical institute in Germany became the Karlsruhe institute after its reorganisation in the year 1832. With its five departments for engineering, architecture, forestry, industry and economics, its two year preparation school, technical collections, mechanical workshops, laboratory for technical chemistry, botanical garden and library, and its first elements of a university structure with a “director”, with “deans” for the departments and with regular meetings of the masters the Karlsruhe institute developed into a university like institution. And for the first time

in Germany this institute was integrated as top institution into a new built system of practical and technical schools equally entitled to the parallel system of classical education with the university at its top.

All these German poly-technical institutes were founded and financed by the state. The prominent part of the state in the development of the German technical university system had several reasons: First of all the industrialization in Germany started late – with the exception of Saxony not before the 1830ies when the first railways were built – and only with massive support by the state administration. The main problems for an industrial development of the country lay in the territorial dissipation of Germany, in the lack of an economically unified market and in the crusted political system with its anti-democratic and anti-parliamentarian monarchies. Until 1871 there was no unified German state, no nation wide economical and juridical system and nearly no common infrastructure. Secondly for several decades the two biggest German states Austria and Prussia were fighting about the hegemony in Germany. Prussia won this fight in the wars of 1866 against Austria and of 1870/71 against France and it united the rest of the smaller German states under his hegemony in the new German Empire. Thirdly Prussia with two thirds of the territory and of the inhabitants became the leading state within the federal system of German states. The Prussian king was declared as German emperor and Prussian politics dominated every part of the new formed nation. These politics had two different sides – one modern and one orientated backwards. In the fields of economy, science, technology and education the Prussian politics aimed on a modernization of all structures and on a lasting promotion of the beginning industrialization. At the same time it orientated backwards on the extreme conservative ideals and culture of an aristocratic class with its social basis in the agricultural nobility of Prussia. On one hand this Janus-face of the Prussian-dominated German Empire led to the rise of Germany to the most powerful industrial and scientific nation in Europe at the end of the 19th century. On the other hand it led to extreme social and political dislocations in a nation and society which in the end caused the catastrophe of two world wars in the 20th century.

The development of the German technical academic system from the poly-technical institutes into technical universities between 1830 and 1918 was deeply influenced by this special political, economical, social and cultural environment. Three parallel developments characterize the inner and outer evolution of the institutions in this period. The first development resulted from the technological and economical changes with a diversification of technologies and industries and led to a similar diversification of the technological disciplines and departments within the poly-technical institutes. New technologies in iron, steel and coal production, in engine building, in construction and architecture, in chemist production and new technology fields like transportation, communication or electro-technology demanded more and specially trained engineers and therefore a specialisation of the teaching system with new disciplines like material sciences and process-technology or mechanical-, constructional- and electrical-engineering. This quantitative growth was accompanied by a qualitative growth of complexity in the different disciplines and technology segments. The tools, the machinery and the products became more and more complex. Their construction and production demanded more and more scientific knowledge, skills based on new sciences, practical testing in laboratories and a mathematical management of the technological problems. Thereby the poly-technical institutes were forced not only to establish new disciplines, new departments and new lecture courses but also to raise the basic knowledge in mathematics and science, and with this the age of their first year students. Up to the 1860ies most of the institutions accepted students of an age between 14 and 16 and sent them into their pre-education programs in special departments for basic studies. These departments now were closed and the age of the first year students was raised to a minimum of 17 or 18 years. The basic scientific pre-education of the students was shifted back to the school system with its now reformed new humanistic Gymnasium (high-school) at the top of the traditional line of education and the newly built up system of modern “Realschulen” (reality-schools) for scientific and technological education with the “Real-Gymnasium” (reality-high-school) at its top. The final examinations of both types of high-schools opened the way into the poly-technical institutions.

The quantitative and qualitative consolidation of the poly-technical institutes led to their conversion into technical universities (Technische Hochschulen) during the 1870ies and 1880ies and at least to their formal parity with the classical universities between 1899 and 1918. This was not at first hand a consequence of the industrialization and the just described developments. Parallel to the technological and industrial changes the rise of the new profession of engineers and their growing importance for the development of the country raised the question about the social, economical and political importance of this new social class in the German society. As mentioned before the social values and standards of the society of the German empire were orientated on the conservative standards and values of the nobility. In the field of education and profession these standards were set by the classical humanistic education and the “good old” classical professions of military, law, medicine and religion. Among these four basic columns of the German state there seemed to be no room for a new profession like engineering which was born – like the new working class – out of industry and thereby out of the destruction of the “good old” pre-industrial times. This lack of social recognition became a central question for the self-consciousness of all engineers with the growing importance of the new profession of engineering and the new social group of engineers in the age of industry. The “German Society of Engineers” (Verein Deutscher Ingenieure, VDI) founded in 1856 made this lack of recognition to one of its leading programmatic aims. The problem of the parity of the poly-technical institutes and later technical universities became the main battlefield for this fight for social recognition and parity of the engineering profession in the German society.

The leading persons in the German Society of Engineers were engineering professors at the poly-technical institutes. This explains why the society tried to get the recognition through a formal comparison of the top technical education institutions with the social high ranking traditional universities. And this explains also why in their opinion this parity could only be reached by an acceptance and accommodation to the given traditional structures of the German university system. The consequence was to take over – step by step – the constitution and organization of the universities with rector, deans and faculties, with four

year courses, examinations, the new humanistic idea of freedom for teaching and research, with the final examination (Abitur) of the high-school as general condition for the admission, and the take over of all academic rites of the traditional university life. This accommodation was accompanied by the renaming of all German poly-technical institutes into technical universities (Technische Hochschulen) between 1877 and 1890.

But the change of names, structures and rites wasn't enough for a real parity of the technical universities with the traditional universities. Especially from the view of the universities and their academic staff the social newcomers of the technical universities could not be called real university graduates. They argued that the technical universities would only be teaching schools for engineers and not research institutions like their universities. This was partly correct because for decades the main business of the poly-technical institutes was to educate technical experts for the state administration in the fields of architecture, railway-planning and construction for the official licence and control of machinery and technical systems. The private market for academic trained engineers in industry and economy was very small at the beginning of industrialization because most of the technological development of the early decades based on tacit knowledge. Mathematical and theoretical construction as well as science based technologies for industry became not earlier economically important than in the second half or last third of the 19th century. Most of the graduates of the poly-technical institutes went into the state administration where they got special state degrees as mechanical or constructional engineers. For a long time there were no regular final examinations at the institutes. Not earlier than in the 1870ies the first technical universities began to establish final examinations, called diploma, for graduates who wanted to work in the private sector of the economy. With the growing demand of academically trained engineers in industry during the last third of the century these engineering diplomas of the technical universities became more and more important and finally replaced the state degrees at the turn from the 19th to the 20th century.

The most important argument of the universities against a parity of the technical universities was the lack of a research capacity at these institutions. This was important because since the new humanistic reform of the German university system the unity of teaching and research was the basic paradigm of a university. Of course, had there been research activities in single institutions of the technical education system even in the 18th century – for example at the Mining Academy of Freiberg – but indeed most of the poly-technical institutes remained to be educational institutions up to the second third of the 19th century. This slowly started to change with the foundation of the Zurich poly-technical institute in Switzerland in the year 1855. The Zurich institute was planned as a technical university and realized for the first time the unity of teaching and research within a poly-technical institute. Further more for the first time it integrated philosophical and economical departments into a technical university and therefore developed a future concept of an integrated university. But the most important aspect of the Zurich institute was the foundation of all technical studies on a mathematical and theoretical basis. Thereby the way for the development from a tacit knowledge based technology to a science based one was opened. Other new founded technical universities like the poly-technical institute of Aachen (1870) in the Prussian industrial area of the Rhineland or the Technical University of Charlottenburg (1879) in the Prussian and German capital Berlin followed this example.

But the mathematical and theoretical foundation of technology was only one step on the way of the technical universities to build up research capacities. Since the late 1860ies mechanical research laboratories were founded in every German technical university. Scientific testing of and technological research with machines and technical systems became a routine of teaching and research activities at the institutions. Especially the big laboratories for chemist-technology produced a growing number of graduates who had to leave the technical university to get the necessary doctor’s degree at a traditional university for a job in the chemical industry. For the technical universities this was an unacceptable situation and they demanded their own right to award their graduates with a doctor’s degree. The German Society for Engineers made the fight for this right to its own fight because it

opened the chance to storm the last fortress against the parity of the technical universities with the traditional universities. This battlefield was not undisputed in the group of engineers because a large number of engineers even in the technical universities were not convinced that they needed their own doctor's degree as evidence for their research capacity. But the traditional universities themselves helped the backers of an independent doctor's degree for engineering with their strict refusal against this request. At the end of the 19th century the question pro and contra an independent doctor's degree for the technical universities became a political problem within the German society with two nearly even strong pressure-groups on every side. Especially the powerful German Society for Engineers with thousands of members in the technical universities and in industry made this problem to a question of life or death. In this situation a special personal connection between the German Emperor and Prussian King Wilhelm II and one of the leading activists in the German Society for Engineers and professor for engineering at the Berlin Technical University Adolf Slaby decided the matter. Wilhelm II was enthusiastic about modern technology and sometimes visited the lectures of his personal friend Slaby who won him for the position of the technical universities. In 1899 Wilhelm II personally decided to give the right to award their scientific graduates with the special academic title of a "doctor of engineering" (Doktor-Ingenieur) to his Prussian technical universities. The other German states followed this example within the next two years. The only thing the traditional universities could achieve was that the new academic grade had to be written in old German letters and with a hyphen between the "doctor" and the word "engineer" (Dr.-Ing.) for a better distinction to the classical doctor's degree of the universities.

Together with the doctor's degree all German technical universities got the right to award their graduates with the title of an engineering diploma (Diplom-Ingenieur, Dipl.-Ing.) which now was officially acknowledged in all German states. At the same time the old state graduation system for engineers was abolished. With these regulations not only the formal parity of the technical universities with the traditional universities in Germany was realized. Further more in the year 1900 the system of higher technical education in all states of the federal German

Empire was standardized on the same qualitative level with similar regulations for the admission into the institutions, for the length and the quality of the study courses and examinations and with the same degrees for the graduates. With the beginning of the 20th century the long lasting birth process of the German technical university system was finished just at the time when the conversion of the former agricultural society into an industrial one was completed and Germany became the most powerful industrial state in Europe.

Around the turn from the 19th to the 20th century the German technical university system with its unity of high quality teaching and advanced technological and scientific research was the most famous and internationally highly recommended education system in the world. Students from all over the world came to Germany to study physics, chemistry, biology or engineering and technology in one of the technical universities or one of the equally famous universities. Among the German technical universities the biggest one, the Technical University of Charlottenburg in Berlin became an internationally illustrious institution. In the years before the First World War in the United States of America this phenomenon was characterized as “Charlottenburgitis”.

It was no accident that especially the Technical University of Berlin and the other Prussian technical universities played a major part in the rise of the German technical university system since the second half of the 19th century. During this period Prussia – as mentioned above – became the political and industrial hegemony power within the federal system of the German Empire. After the Napoleon wars the Prussian state developed a clear political concept for its reconstruction: The main instruments had to be education and industrialization. Both aims should have been realized on a high organizational and scientific level, with state support and under state control. Therefore the Prussian education administration tried to push forward the scientific level of the countries top teaching and research institutions with better study programs, with the appointment of famous scientists as university teachers and with excellent equipment for teaching and research. The French reparation payments after the war of 1870/71 were used for these aims. All Prussian technical universities got new and modern

buildings and research equipment. In the year 1914 five of the eleven German technical universities were Prussian institutions, and the Prussian technical universities of Aachen, Hannover and especially of Berlin were the leading ones in Germany. Since 1871 the standards for the development of the German technical university system were set in Prussia, and the rest of the German states had to follow them. Thus it was no surprise that the struggle about the parity of technical universities and traditional universities was decided in Prussia.

Further more the Prussian dominated science policy of the German Empire led with the foundation of first public financed non-university research institutions to a new component in the German research system. The “Physical and Technological Institute of the Empire” (Physikalisch-Technische Reichsanstalt), founded in 1887, and of the “Emperor-William-Society” (Kaiser-Wilhelm-Gesellschaft), founded in 1911, were dedicated to basic research in the field of physical and technical sciences. Beside the existing industrial and university research laboratories the two new federal research institutions created the third column of the famous research system in the German Empire. Only a few years before the First World War the triple-helix of the German research system was born.

2.3. New challenges, breakdowns and reconstruction – the years 1918 to 1960

The two Word Wars in the years 1914/18 and 1939/45, provoked and lost by Germany, caused far reaching consequences for the whole German university system. First of all it lost its leading position in the world. After the First World War the number of foreign students dropped dramatically. With the racial policy of the national socialist government after 1933 it went further down. Secondly the turbulences of the multiple changes of the political system from monarchy to democracy (1918), from democracy to the national socialistic dictatorship (1933), and back to democracy (1945) affected the German academic elites deeply in their political and cultural values. These values were formed during the time of the German Empire and were marked by a

strong conservative, anti-parliamentarian and state orientated position. After the revolution of 1918 most of the students, teachers and scientists at the German universities stood in political opposition to the new democratic system with its political parties and its parliament. The rise of the national socialist party with its “leader” Adolf Hitler found a growing assent especially in the group of the students. After 1933 the universities and most of the students and professors brought themselves into line with the racial and antidemocratic politics of the national socialist party. A great number of Jewish or political suspect students, professors and scientists had to leave the universities and the country. This decline of the German intellectual elite had catastrophic consequences especially in the field of the former international leading natural sciences of the country. Thirdly the runaway inflation after the First World War was accompanied by great financial problems for the universities. In addition the worldwide economical depression after 1928 ruined the labour market for engineers, and last but not least the total disaster of the Second World War nearly completely destroyed all buildings of the technical universities in Germany.

On the other hand there had also been challenges for the benefit of the technical universities and their graduates during this time of political and social turbulences. The development of industry with new branches like automobile-, aircraft- and electrical industry opened new fields for engineers, and most important, now for academic trained engineers. In this time of science based technology they conquered a growing part of the leading positions in industry. The technical universities reacted to this development with the creation of new disciplines, departments and study programs. The industrial claim for economical trained engineers led to the establishment of chairs for political economy and industrial economics. After 1933 the national socialist policy of autarky and war preparation opened further opportunities for the research at the technical universities. New technologies of the reuse of resources were developed in material sciences or energy production as well as new weapons for the military. But these profits for the profession of engineering were widely compensated by the general inability of the national socialists for an understanding of the general importance of modern science and technology for the society. Thus the

number of students at the universities was limited and during the war most of the scientific and technical experts were called to duty and sent to the battlefields.

Despite of all problems and interventions the German university system wasn't really changed after 1918, 1933 and 1945. The institutional, academic and personal structures in total remained remarkable stabile. In the terms of innovation theory this is called a persistent system caused by path-dependencies which are opening only a small corridor for future developments. This persistence of the German university system can be seen in the post-war East and West German state. While the newly formed Federal Republic of Germany in the west part of Germany under the influence of the French, Britain and American occupation re-established the university system of the pre-national socialistic Weimar Republic the east German Democratic Republic under the control of the Soviet Union tried to start a socialistic reformation of the system. But even in the eastern part of Germany under the dictatorship of the communist party the execution of this reformation took more than twenty years before 1968 the third university reform finally changed the bourgeois university system into a so called socialistic university system. In the Federal Republic of Germany in the west part of the country it took nearly the same time to start a reform of the university system. Here with no real break of the personal continuity of the national socialist times the old traditional university system was re-established with its bipartition into traditional universities and technical universities in the tradition of the Weimar Republic before 1933. One reason for this continuity in both parts of Germany was the urgent demand for technical and other academic experts for the reconstruction of the country after the war. Therefore the quick reconstruction of working university structures had been a main aim of the 1950ies. Questions of guilt and collaboration with the criminal Nazi-regime were of subordinate priority. Especially in West Germany the old tradition of the absolute power of the professors was re-established without any questioning. Within this reconstruction the technical universities accepted their traditional place on the side of the universities.

2.4. Between reformation and revolution – the years 1960 to 1989

Around 1800 there had been no more than 7.000 students in Germany. During the time of the industrialization the number of students increased slowly to 23.000 in the year 1876 and from there to 72.000 before the First World War. Of these students 12.481 or 17.4 percent had been students of technical universities. During the time of the Weimar Republic the total number of students increased further on to more than 100.000 (1930/31) before it went down to less than 70.000 students because of the restrictive Nazi university policy. After the Second World War the number of students began to increase again. In the early 1960ies it reached 200.000, 16.6 percent of them in the engineering faculties. Ten years later more than 300.000 students studied at German universities, 36.000 (12 percent) of them in engineering programs.

With the growing number of students in the middle of the 1960ies attempts were started for a general reformation of the university system in West Germany. It was intended to harmonize the study and research programs of the universities with the development of science and technology by the establishment of new disciplines. Computer sciences, atomic energy, air- and space-technology, automobile-construction, communication-technology and other new branches of modern industry found their way into the universities. The number of students was growing because of the growing demand at academically trained experts in economy and society. The part of university graduates in the population doubled within only two decades.

During that time new research institutions besides the traditional industrial research laboratories and university research institutes were founded by the state. These so called “big science institutions” (Großforschungseinrichtungen) were financed by the federal government while the financing and controlling of the universities was a traditional right of sovereignty of each German state. The development of these new research institutions was a result of big military research programs during the Second World War like the American atomic

bomb project or the German rocket program. Because of the lost war Germany was not allowed to start research programs in advanced technology fields like atomic energy, electronics or air- and space-technology because of their military potentials between 1945 and 1955. After the fall of this restriction Germany had lost the contact to the research frontiers in these fields. A “research and technology lack” especially in comparison to the standards of the United States of America was the result, and German industry and economy threatened to loose positions in the most promising future markets. It was the aim and function of the new big science institutions to fill this “lack” and to bring German research and technology on an international standard again. The first of them were founded in the end of the 1950ies for research in atomic energy and air- and space-technology. Others followed during the 1960ies and 1970ies so that at the end of the 1980ies 13 big science institutions were working in Germany with more than 20.000 employees. Together with the Max-Planck-Society for basic research (founded in 1948 as following society for the Emperor-William-Society) and the Fraunhofer-Society (founded in 1949) for applied research with more than 80 research institutes and more than 10.000 employees the big science institutions became powerful rivals for the research capacities of the universities. As public financed non-university research institutions the big science institutions completed the construction of the triple-helix of research institutions in Germany. Since the 1960ies the dynamics of the German research system was determined by this triple-helix of industrial, federal and university research institutions.

The academic structures of the German universities in post war times weren’t very well prepared for this competition. The traditions of a nearly two hundred years lasting development had frozen their organizational structures and self-assurance in the age of industry. The upcoming post-modern age with its turn from industrial societies to knowledge societies and its change from national economies to global economies hurled the traditional German university system into a long lasting crisis. This crisis became obvious with the student revolution in the late 1960ies. The inability of the university system for a substantial change more and more annoyed a new generation of students which was borne after the war and grown up in the prosperity and social se-

curity of the so called “wonder of economy” (Wirtschaftswunder) of the young Federal Republic of Germany in the 1950ies and early 1960ies. This new generation revolted against the capitalistic structures of the political system and against the conservative social values of their parents. The Vietnam War and the fight of the communist Vietcong against the United States of America formed the international political background for a revolution of the students against the bourgeois establishment inside and outside of the universities. In 1967/68 the students tried to start a revolution against the political and social system with massive political demonstrations and street fights against the police. But this revolution failed because the rest of the society – especially the working class – wasn’t interested in a radical political change of the system towards socialism. Within the universities the students protested against the conservative structures of the system and against the absolute sovereignty of the professors. They called for democratic participation of all groups in the political and administrational leadership of the institution. And they called for a reformation of the teaching system, of the study programs and of the research topics in the universities. Combined with this was an unsparing discussion about the political and professional background of the careers of their professors and the entanglement of science and universities with the Nazi-regime between 1933 and 1945.

Both – the uproar of the students and the scientific and technological change in economy and society – influenced the further development of the university system in Germany. After decades of a conservative government the change to a social democratic government in 1969 opened the door to a period of reform-policy in the German society which affected the universities in several ways. First of all the social democratic program of equal education chances for all social classes led to an explosion in the number of students and a rapid growth of the universities: Had there been 527.000 students in 1970, this number increased to 1.4 million in 1987. This rapid growth was only possible because the number of study places at the universities was increased by the enlargement of the existing universities and the founding of new universities. Within the twenty years between 1960 and 1980 29 new universities were founded and the number of regular study places at

the now 64 German universities went up to 1 million. Since 1970 the number of professors was quintupled and the number of the research employees was quadrupled. Between 1960 and 1987 the number of employees at the universities went up from 59.000 to 210.000. In the same period the financial expenses for the universities went up from 1.5 billion Mark to 23.6 billion Mark.

But the most interesting point in the development of the German university system in this period was not the increase in the number of students, employees and costs. With the quantitative growth a qualitative change of the university structures and of the structures of the whole system set in after nearly one hundred years of stagnation. With the extension and the new founding of universities a reform began of the study programs and of the structure of the teaching stuff. All groups from professors, academic stuff and employees to students got participation rights in the self-administration of the universities. The administrational structures were modernized and a new nation wide political planning system for the German research and university system was established with consultative institutions like the “scientific council” (Wissenschaftsrat, founded 1957) or the “conference of the university rectors” (Hochschulrektorenkonferenz, founded 1949). In 1976 a unified basis for the further development of the universities in the whole country was formed with the so called “university-frame-law” (Hochschulrahmengesetz). Following this law it is the task of the universities in Germany to promote science and arts, basic research, scientific teaching for science based jobs and to participate in the political education of the students so that these students could act responsible in the democratic society.

Another important step of the reform of the structures of the German university system was the incorporation of the teachers education institutes (Pädagogische Hochschulen) into the universities and the decision to integrate the special high-schools (höhere Fachschulen) for the education of experts in technology or social sciences on a semi-academic level as universities for applied sciences (Fachhochschulen) into the university system in 1968. Thereby especially the old technical universities were faced by a new and more and more successful com-

petitor in the education of engineers. The study programs of the new institutions were less research and more application orientated and could be passed in a shorter time.

An important innovation of this period was the partial loosening of the over two hundred years fixed border between technical universities and traditional universities. The initiative of the famous mathematician Felix Klein at the University of Göttingen to open the universities for the new technical sciences had failed at the end of the 19th century because of the refusal of most of his colleagues at the traditional universities. Now, more than half a century later in 1961 the new University of Bochum was successful with the incorporation of engineering sciences into the classical spectrum of university disciplines. Most of the technical universities followed this development in the late 1960ies and incorporated philosophical, social or medical sciences and faculties into their institutions. With this the clear border between the both classical types of German universities began to vanish. The old idea of a university of all sciences – first formulated with the program of the Zurich polytechnical institute in 1855 – became reality. Several of the old technical universities – like Hannover, Karlsruhe or Stuttgart changed their names into “university”. Others – like Berlin, Brunswick or Munich – named themselves into “technical universities” (Technische Universitäten) to show their technical profile although they also established philosophical and social faculties.

Despite all capacity building and reform programs the German university system went into a long lasting crisis during the late 1970ies and the 1980ies. One reason was that the number of students was growing much faster than the number of study places, of professors and academic employees or of the financing of the universities. They became overcrowded and the lament about the “mass-university” (Massenuniversität) could be heard everywhere. Another reason was the general crisis of the economy starting in 1966 with the crisis of the German coal-industry and intensified in 1973 by the international oil-crisis with dramatically rising energy costs. Suddenly the problems of the German industrial structure became obvious for everyone. The number of unemployed people was growing fast and even academic graduates were

getting problems to find a job. The crisis of the economy was followed by a crisis of the finances of the state. The budget for education on all levels was cut down. That caused new problems not only in the overcrowded universities. A third reason for the general crisis of the university system was the growing debate about the sense and the direction of scientific, technological and economical development in the world. It was the report of the Club of Rome under the title “The limit of growth” from 1972 which opened a discussion about the use and the allocation of the natural resources in the world. This discussion directly influenced the debate about the worldwide political and economical implications of modern science and technology for example in the field of atomic energy, bio-technology or communication technologies within the academic elites. More and more scientists and students called for a radical change in economic and science politics of the industrial nations, and they demanded the development of new human and ecological orientated sciences and technologies. “Small is beautiful” was one of the popular slogans of this movement which aimed directly against the development of “big science” in the last decades. As one result of this movement Students and young scientists demanded to set up programs for ecological sciences and technologies at their universities. After the catastrophe of the atomic power plant in Tschernobyl in 1986 this demand found a lasting support in all parts of the German society.

There is another aspect of the German university system necessary to mention: The political confrontation between the capitalistic western part of the world under the leadership of the United States of America and the eastern part under the leadership of the Soviet Union. The border between these two political and economical systems was the boarder between the two German states of the Federal Republic of Germany in the west and the German Democratic Republic in the east. The erecting of the Berlin wall in 1961 by the communist East German government was the material evidence of the “cold war” between east and west and the threat of a possible atomic third world war. But it also led to a quite different development of the school and university systems in East and West Germany with a much more application orientated so called poly-technical education system in the east. In contrast

to the West German education system the eastern system was centrally directed by the communist party and government in East-Berlin. This led to a school and university system which was strictly orientated at the political and economical necessities of the centrally directed economy of the German Democratic Republic. The number of students and academic employees was centrally planned as well as the number of graduates in the several academic disciplines and their jobs in industry and society. The whole system as well as the whole society was politically controlled by the communist party and the secret service of this dictatorship. Economically and politically this led to a disaster in the 1980ies and to the peaceful revolution of 1989 which ended with the reunification of Germany in 1990/91.

2.5. The German university system in the age of globalization

With the German reunification the West German political and economical system was transferred to East Germany. The result was political and individual freedom for the population but also the economical breakdown of the industry and a dramatically increasing number of unemployed people in East Germany. Together with the parliamentarian democracy and capitalistic economy the West German federal university system was transferred to East Germany. For one decade between 1990 and 2000 the East German universities were occupied by the reorganisation of their administrative, educational, personal and scientific structures. In the first years the number of students dramatically diminished but recovered since the middle of the decade. With the transfer of billions of Euros the totally ruined East German infrastructure was modernized including the universities. With the West German university system the unsolved problems of this system came to East Germany too. The number of students in whole Germany was still increasing. In the year 2004 more than 2 millions students were filling the lecture halls which were planned for only 1 million students. Big universities like Köln or Munich are overcrowded with 47.000 students today. The largest technical universities like Berlin, Aachen or Dresden are counting 28.000 to 35.000 students. The crisis of the German economy – intensified by the problems of globalization and the costs of the reuni-

fication – burdened the financial budgets of the federal government and – still more important for the universities – of the regional state governments. In 2001 the yearly costs of the German university system reached 19 billion Euros which wasn't enough to solve the most dramatic problems of the system.

The globalization of industry, markets and economy led to the perception that only a fundamental reform of the academic education system within a European solution could guarantee the future of the German universities in an international market for scientific education. 29 European countries – among them the federal government of Germany and the governments of the 16 regional German states – in June 1999 signed in the Italian city Bologna a declaration with the aim to create a homogeneous European university system until the year 2010. This so called "Bologna-process" determined that all academic lecture programs had to be changed into a two step system of three year undergraduate bachelor courses and of two year graduate master courses. Further more a European credit point system (ECTS) should guarantee the un-problematical transfer of study achievements and grades from one country to another. With this the international mobility of the students and graduates should be promoted. At least the signing countries agreed upon an intensive cooperation in the further qualitative development of the European academic education system. For the German universities this meant a complete change of the structures of their traditional study programs with its four or five year master, diploma or state degree courses. Especially the programs in the natural sciences and in engineering with their one hundred years old diploma-degrees have to be reorganized completely. This radical change of the system into internationally acknowledged and successful study courses and the change of the diploma graduation system caused a lot of critics and frustration especially within the technical universities and their engineering faculties. But today after long and controversy discussions one by one the German universities are following the European recommendations because they fear that they otherwise could be missing the train into the future of an international and globalized academic education market.

The question of globalization does not only concern the teaching but also the research capacities of the German universities. The traditional division of labour between public and private research institutions in the triple helix of the German research system with its industrial, university and big science research institutions lost its balance in the enduring economical and financial crisis. The industry reduced their cost intensive research capacity and tried to shift this burden to the publicly financed research institutions in the universities and the big science institutions. The everlasting demand of the industry for a more application orientated research at the universities now got support from politics and from inside the universities which more and more tried to substitute their decreasing public finances with research money from the industry. At the same time the future chances of the national industry in the global competition of rapid growing markets like computer technology, medical technology, bio-technology or nano-technology was identified as a problem of the production of sufficient and trained academic graduates with international standard. Therefore industry and politics in Germany called for a qualitative offensive in the research and teaching programs of the universities. “Profiling” (Profilbildung) is the magic word of this new development. This means profiling of all capacities in the universities towards the future technologies and their basic scientific disciplines. Because money for education is short in Germany the federal government and the regional state governments decided to create a founding system for financing so called “lighthouses” (Leuchttürme) of science and research within the German university system. Since last year all universities were invited in an open competition to present their programs for profiling in research, graduate and doctoral programs. In a complex step by step competition controlled by the German science foundation this should lead to a selection of the best and most future orientated university programs. The program called “initiative for excellence” (Exzellenzinitiative) is divided into three categories with limited places: 40 “graduate schools” for structured doctoral programs, 30 “excellence cluster” for the creation of international competitive research and teaching institutions within the universities, and “future concepts” for the enforcement of international leading research capacities within 10 selected universities as future “lighthouses” of the German university system. For the realization of their programs the

winners are getting 1 million Euros per year for each graduate school, 6.5 million Euros per year for each excellence cluster, and an average of 21 million Euros for each future concept. The program with its all together 1.7 billion Euros is financed with 75 percent by the federal government and with 25 percent by the regional states. If a university could win by minimum two graduate schools and one excellence cluster it could get the top honour as an “elite university” (Eliteuniversität). End of last year the first three German universities in this competition were prized with this title – the University of Munich, the Technical University of Munich and the former technical university and now University of Karlsruhe with all together 85.630 students.

In Germany this European reform program of the university system is linked with a national reform of some very old traditions in the administrative and personal structures of the universities. During the last years the hierarchy of tenured full professors with its two salary levels was supplemented by the position of a non tenured junior-professor. Thereby a second way with doctorate, junior-professor and full professor was opened beside the traditional academic career of doctorate, assistant, habilitation, private lecturer and full professor. New professors now are not automatically tenured. They have to pass a three to five years time of scientific and teaching proof before they become tenured full professors. At the same time the fixed salary system for German full professors was changed into an efficiency orientated salary system. This “more money for better professors” program has the aim to give the universities a chance for recruiting high qualified scientists for their teaching and research programs in competition with the higher salaries in industry. But one problem of this salary reform is the lack of money in the present university budgets. In this situation it can only be solved by taking away the money from one “minor” professor and giving it to the “more important” professor. Such a shifting of money within the university was nearly impossible in the old academic structures. The current reform of the financing system of the German universities is aiming on more flexibility. Although the German university system in the near future will remain a state system with a basic financing by the regional states the organizational structures begin to change. Now there is more freedom in using the state budget and for

organizational experiments like the transfer of the University of Göttingen from a state institution into a state controlled foundation. Other universities like the Technical University of Freiberg are successfully trying to copy the American system of establishing private foundations for the financial support of their institutions.

With the Bologna-process, the initiative of excellence and the national university reform programs the German university system will be changed completely within the next years. In 2010 the teaching and graduation system will be harmonized with the European academic education system. It is planned that at the same time the teaching and research standards at least at the elite universities should have a leading international position in the world. – So far the promising picture of the golden future of the German university and research system. But there still are some uncertainties. One point is the development of the German population. The birth-rate is low since several decades and it became even lower since the German reunification. Within the next years the number of students will decrease dramatically. This is a special problem for the technical orientated universities and at least for the national industry and research capacity because most of the school graduates prefer to enter the university courses of the human and social sciences and not of the “hard” disciplines like natural sciences and engineering. Only a radical reform of the by international standards only mean German school system and a rise of the equally mean percentage of school graduates who are joining the universities could help to solve this problem within the near future.

Another problem is the consequence of the academic lighthouse policy and the way of financing the initiative of excellence. The excellence program for the universities under regional state control is mostly financed by federal money because the regional states don’t have enough money for an effort like this. In order to avoid the taking over of the control of the universities by the federal government the regional states dispensed the federal government from the 50 percent financing of the capacity building program for their universities. Considering the problematic financial situation of the regional states this will cause great problems for all universities in their need of new building and

renovation programs. Another problem lies in the fact that the 25 percent of regional state money for the initiative of excellence will be paid out of the mostly frozen budgets of the regional university systems. If one local university wins two graduate schools, one excellence cluster and becomes an elite university it will get around 30 million Euros per year. 25 percent of that or 7.5 million Euros per year have to be paid by the regional government which will take the money out of the budget of the other universities. More over the elite universities have to invest large parts of their own frozen budgets into the profile disciplines – money which they have to take away from other disciplines in their university. “We are winning to death” is the sceptical comment of some professors at the winning universities to this development. Especially for small academic disciplines which are not in the research mainstream of the moment or which are not very important for industry are getting into rough seas. They are threatened in their existence because their universities have to put all their money and resources into the profile disciplines. Critical observers of this development are predicting a few lighthouses in an otherwise dark country.

3. Conclusion

There is no alternative to the current process of accommodation of the German university system to the European and international standards. Only the way and the instruments of this accommodation could be questioned. The “lighthouse-concept” of elite-universities and research-clusters can be a chance to win back the former leading position of German university research. It will strengthen the position and the influence of university research in the triple-helix of the national research system. But two main problems can be identified: The insufficient finances of the German school and university system and the traditional federal structure of the education and research system with its constant rivalry between the interests of the federal government and the regional state government on one side and the lasting contradictory interests of the regional states on the other side. One can predict that the success of the German university system in a globalized interna-

tional research and education system will depend on an effective solution of these problems.

Coming back to the historical development of the German technical university system we can state the end of this special system with its integration into a larger national university system during the 1960ies. On the other hand we can observe a still strong corporate identity among the old traditional technical universities. In these days it is leading to an interesting international cooperation between European and American technical universities in the new formed T9-groupe of nine technical universities – among them the German Technical Universities of Munich and Aachen, the Swiss Technical University of Zurich and the American MIT. These technical universities pretend to be the worldwide leading technical teaching and research institutions and they are forming an international club of excellence with the mutual acceptance of their study programs and grades and a close cooperation in their research projects. Another indication for a possible future of the technical university system is the growing importance of a scientific and technological education in a world at the border between the modern age of industry and the post-modern age of knowledge. In this new and future world an academic technical education will be more important than ever. Last but not least a cultural phenomenon – first formulated by the British physicist and philosopher Charles Percy Snow in the 1960ies – seems to give the technical university system a chance for the future: The traditional gap in modern societies between a culture of humanities on one side and a culture of natural sciences and engineering sciences on the other side. Both cultures are recruited out of different social groups, are formed by different socialisations and educations, and are speaking different languages. As these two cultures exist and seem to persist in the future at the very end one might say: The technical university system is dead – long live the technical university system!