DELAYED MODERNIZATION: THE LONG AND WINDING ELECTRIFICATION OF THE GERMAN RAILWAY

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In Germany the electrification of the railways had been forced parallel to the reduction of the railway network after World War Two. In the 1950s the network of electrified lines grew slowly up to 2000 kilometres. And not before 1960 the *Deutsche Bundesbahn* started a more intense electrification program that resulted in 9000 kilometres electrified railway lines in 1970. O these tracks the Bundesbahn run three quarters of all transports.

This progress is modest compared with the great progress other countries had made electrifying their railways in the same or a earlier period. One could mention the Switzerland or Sweden, but also France, especially its South, and Italy. Sometimes their electrification programs reached back to the 1930s and covered 90 per cent of all tracks in the 1940s. The delay in the electrification of the German railways is astonishing because Germany once had been the leading country in the technology of electrical railways.

Indeed, the idea of railways powered by electricity is an old dream in Germany. Already in the beginning of the railway era technicians and engineers experimented with different kinds of railways like railways powered by compressed air or by a mechanical drive. Also some experimented with the just discovered forces of electromagnetism and tried to make use of them for railway engines. One example of this were the experiments of Johann Philipp Wagner, a Frankfurt citizen and bookkeeper, who presented a little electric mobile in the rooms of the Physical Association of Frankfurt in 1836. He declared that his facility had run successful up to one week without any problem. One should mention that Wagner belong to the pioneers of some electric technical instruments and facilities in Germany and he gained the knowledge for the making of several inventions in laboratories of the Physical Association.[1] His interest had not been technical progress alone. But the use of new technical facilities for the support of special social relationships. As president of the business association (Gewerbeverein) of Frankfurt he had been interested in a cheap power machine which should enable the survive of small industries that could not afford steam machines. His experiments had insofar the goal to develop an electric motor that could be an alternative to the steam engine.[2] However, he attracted a lot of public attention. With excitement members of the Senckenberg Society of Natural Sciences (Senckenbergische Naturforschende Gesellschaft) wrote: “That such an apparatus compared with a steam engine of equal power, would be less heavy,

[1] See Heinz Fricke, 150 Jahre Physikalischer Verein Frankfurt am Main. Frankfurt am Main 1974, 44–46, and Physikalischer Verein, in: Frankfurter Jahrbuch 7, H. 17, 1836, 105. For Wagner see Wihelm Stricker, Nekrolog des Herrn J. Ph. Wagner, in: Jahresbericht des Physikalischen Vereins für das Jahr 1878/79. Frankfurt am Main 1879, 18, and Helmut Lindner, Strom. Erzeugung, Verteilung und Anwendung der Elektrizität. Reinbek bei Hamburg 1985, 86-88. On the background see Ralf Roth, Stadt und Bürgertum in Frankfurt am Main. Ein besonderer Weg von der ständischen zur modernen Bürgergesellschaft 1760 bis 1914. München 1996, 392-394.

[2] For a description of Wagner´s experiments see Christian Ernst Neef, Über einen neuen Magnet-elektromotor. Vortrag vor der Freiburger Naturforscher-Versammlung im September 1838, in: Fricke, ibid. 49–52. On the context see Jürgen Steen, Frankfurt am Main und die Elektrizität 1800–1914. Die zweite industrielle Revolution. Frankfurt am Main 1981, 18-20, and ibid., „Eine neue Zeit ...“. Die Internationale Elektrotechnische Ausstellung 1891. Frankfurt am Main 1991, 16-18.

smaller, and pretty much cheaper in purchase (Anschaffung) and support (Unterhaltung). Also its use would be total safety and without any danger".[3]

For making the bankers and merchants of Frankfurt´s wealthy middle class interested in his invention Wagner decided to make use of the "railway mania", the exuberant excitement of the people for the new railways in these days. Between 1835 and 1840 Frankfurt got his first railway connection, a line to River Rhine, the so called Taunusbahn. He made use of the mania in his own way. "Although I had solved my task by the construction of my last machine (...) I saw myself obliged to find a solution for this special application and go ahead with the trial of an application for a locomotive."[4] He was successful. Already in 1840 he run an electrical facility on the rails of the Taunus Railway that transported no less than 1,5 tons of goods.[5] With some reason one could say that this was the first electrical railway.[6]

It were again the members of the Senckenberg Society of Natural Sciences who recognised the importance of Wager´s experiments. They discussed the results and passed them to a broader audience. Also the local business association supported the invention of his president. Impressed by the successful experiments representatives of the both associations asked the municipal government of Frankfurt, the senate, for an intervention at the German Union (Deutscher Bund). The German Union had been a common political organisation of all German states at that time. His seat had been Frankfurt. The senate should make the Union becoming interested In the invention of Wagner. That was why Wagner´s electric motor became a state affair. The senate took over the idea of the petition of the associations and between 1840 and 1844 he applied at the German Union for a protection of the invention of "Mr. Johann Philipp Wagner, for making use of the electromagnetism as power for engines".[7]

Although the system impressed the engineers and attracted a lot of attention it failed proof by a commission of the German Union (*Deutscher Bund*). The reason for the break down of the Frankfurt visionary attempt of an early electrification of the railway system was the unsolved question of electric power supply. The scientists in the commission drew the conclusion that the run of an electric motor dependent on batteries would cost twelve times as much as a steam engine of comparable power.[8] This was the end of the Frankfurt dream and the electric railway before the mid of the nineteenth century.

The solution of power supply had been solved by Werner von Siemens twenty years after Johann Philipp Wagner. So it was Siemens, the founder of the Siemens trust, who once again proposed electric railways that

[3] Daß ein solcher Apparat, verglichen mit einer Dampfmaschine von gleicher Kraft, im Gewicht viel geringer, im Umfang viel kleiner, in den Kosten der Anschaffung und Unterhaltung viel wohlfeiler werden wird, und in seiner Anwendung die vollkommenste Sicherheit vor jeder möglichen Gefahr darbietet." Senckenbergische naturforschende Gesellschaft, in: Frankfurter Jahrbücher 7, H. 24, 1836, 149–159, esp. 154.

[4] Obgleich ich nun durch den Bau der letzten Maschine meine Aufgabe als gelöst betrachten konnte (...), so fand ich mich doch aufgefordert, auch dieser speciellen Anwendung durch einen Versuch der Anwendung auf eine Locomotive voranzugehen." Johann Philipp Wagner, Auszug aus dem Abschlußbericht vor dem Deutschen Bundestag, quotated at Fricke, Physikalischer Verein, 60. See also Christian Ernst Neef, Über einen neuen Magnetelektromotor. Vortrag vor der Freiburger Naturforscher-Versammlung im September 1838, in: Fricke, Physikalischer Verein, 49–52.

[5] Johann Philipp Wagner, Auszug aus dem Abschlußbericht vor dem Deutschen Bundestag. Quoted in: Heinz Fricke, Physikalischer Verein, 60.

[6] See Protokolle des Deutschen Bundestages, 5. Sitzung § 74 vom 25. Februar 1841, Beilagen 1–5, and Fricke, ibid. 56-58.

[7] See Protokolle der Deutschen Bundesversammlung, 27. Sitzung § 321 vom 3. Dezember 1840. For the discussion at the German Union see Lindner, Strom, 103-104, and Fricke, Physikalischer Verein, 52-54. In October 1840 the business association of Frankfurt planned the foundation of a shareholder society for the construction of Wagner´s motor. At the same time they asked for the engagement of all German business associations. See Lindner, ibid. 102.

[8] On the commission see Lindner, Strom, 106. On the problems of Wagner´s motor see Steen, „Eine neue Zeit ...", 11-13. On the historical background see Wilhelm Treue, Die Technik in Wirtschaft und Gesellschaft 1800–1970, in: Hermann Aubin und Wolfgang Zorn (eds.), Handbuch der deutschen Wirtschafts- und Sozialgeschichte. Bd. 2: Das 19. u. 20. Jahrhundert. Stuttgart 1976, 58-60, and Carl Graf von Klinckowstroem, Geschichte der Technik. 5. Aufl. München 1972, 267-269.

should run as elevated trains through the big cities of the world. He offered this plan the first time at the Second World Fare in Paris in 1867.

Indeed there had been an interest in such kind of railways, especially for the city traffic market in the following decades. Because steam locomotives although they had permanent improved in its performance suffered, on some intern disadvantages. In the first run it was above all the small effectiveness of only five per cent (that could increased to eight per cent in the 1930s). This made the use of electric locomotives attractive. Their effectiveness were pretty much higher and could be increased up to 24 per cent after the problems of the beginning had been solved. Moreover they did not need very much support and they were clean-exhaust. Especially on gradient and curvaceous lines one could see their advantages. Because their start off performance was pretty much better than of steam locomotives. Moreover, electric locomotives could run forward and reverse without any problem and could easily be used as underground railways.[9]

But although the principle problems had been solved in the 1860s it was not before 1879 when Siemens demonstrated the advantages of electric trains by an experimental model in Berlin. But instead of an elevated train that he had proposed at the World Fare he paved the way for the creation of tramways and run the first line two years later in Berlin.[10] The tramways were an invention that speedily had been taken up for the traffic in many European and North American cities and many innovations had attached to the system in the United States, Great Britain or France. Indeed, with the tramways in the city space began the metamorphosis of railways.

The tramways brought clear improvements in speed and transport capacity compared with horse driven railways. They avoided numerous disadvantages of small steam railways. They were free of smoke and quiet. Strong in acceleration and allowed short distances between stations. Also they were not heavy, they could easily be integrated into the system of streets and they could fit into the traffic flow of any city.[11]

But electric tramways were not sufficient for the traffic of big metropolis as Berlin, Vienna, Paris or London and they conflicted with the street traffic by expansion and more and more dense frequencies of trains that resulted in traffic jams in neuralgic streets and places.[12] Moreover the tramways did not solve the problem of far distances in the growing landscapes of metropolises. For these distances they were too slow. To sum up, the big European and North American metropolises needed more powerful electric railways with higher speed and capacity and tracks that were separated from the streets.[13]

One and a half decades after Siemens first experimental train the creation of electric speed trains (S-train) for the use in large metropolises were developed to practical use at first in New York and Chicago or in the European capitals London and Paris but not in Berlin.

It were above all the young gigantic cities of North America that crew out of nothing and had been planned with straight streets. This circumstance allowed the planners to handle the traffic problems in a very pragmatic

[9] See Hans-Joachim Braun, Überwindung der Distanz, in: Hans-Joachim Braun und Walter Kaiser, Energiewirtschaft, Automatisierung, Information seit 1914. Propyläen Technikgeschichte. Bd. 5. Berlin 1997, 97-149, esp. 98.

[10] See Sabine Bohle-Heintzenberg, Architektur der Berliner Hoch- und Untergrundbahn. Planungen, Entwürfe, Bauten bis 1920, Berlin 1980, 11.

[11] See Karl Heinrich Kaufhold, Strassenbahnen im Deutschen Reich vor 1914. Wachstum, Verkehrsleistung, wirtschaftliche Verhältnisse, in Dietmar Petzina, Jürgen Reulecke (eds.), Bevölkerung, Wirtschaft, Gesellschaft seit der Industrialisierung, Dortmund 1990, 219–237, and Wolfgang König, Massenproduktion und Technikkonsum. Entwicklungslinien und Triebkräfte der Technik zwischen 1880 und 1914, in: ibid. and Wolfhard Weber: Netzwerke, Stahl und Strom. 1840–1914, Berlin 1990, 263–552.

[12] See Erich Giese, Das zukünftige Schnellbahnnetz für Groß-Berlin, Berlin 1919, 37.

[13] Giese, ibid. 12.

way. In New York, Boston or Chicago they constructed elevated trains direct into the street space without taking into consideration the aesthetic shaping and the distress the trains put on the neighbours.[14] This did not meet the approval of the people in the metropolises of Europe. Here the concept had been altered and electrified trains had been built as underground railways. Because the densely populated city quarters with their narrow and winding street system would have caused too much problems for a transport facility of the American design. The way had been paved by railway planners in London who demonstrated the advantages of underground railway already in the 1860s by the construction of the steam driven Metropolitan Railway.[15] In 1890 followed the City and South London Line the first electrified underground railway. Paris and even a bit earlier the Hungarian city Budapest took this electric railway as model. In Paris the *Compagnie du Chemin de Fer du Métropolitain* (Metro) had been founded and it could set the first line into business at the World Fare of 1900.[16] Budapest opened its first line already in 1896. The Parisian Metro developed into the most attractive traffic system of the city in the short duration of only a few years.[17]

Even in Berlin that had experimented with an elevated train system the planners turned their attention to an underground (The decision making was accelerated by the protest of many neighbours against the construction of the first line of *Siemen´s Hochbahngesellschaft*).

Around 1900 the city planners developed the plan of a very ambitious network that in a bold vision should have dealt with the traffic demand of a city of ten million inhabitants (at this time Berlin had inclusive the suburbs somewhat around three million inhabitants) with all its intern traffic flows. But at first the decreasing immigration and then World War One stopped these flourishing fantasies. But also the ambitious goals could not be achieved the municipal government and private enterprises of Berlin laid ground for a very efficient and city railway system that served the demand on traffic of a city in the twentieth century very well. Electrified city railways and undergrounds as in London, Paris or Berlin had been constructed in many European cities in the 1920s and 1930s.

To summarise this development we have to consider that we have a steady development of electric railways from the 1880s onwards. And we have to consider that many of these lines had been constructed and set into business by independent private companies.

At the beginning of the twentieth century there had been achieved important metamorphosis of the railway by the substitution of steam with electric power. In the first run this found practical use in cities where railways soon formed a complex system with different levels and a lot of different functions. This was a clear distinction from the development on the electrification of the national railway network in Germany. Although the new forms of railways had the potential for a second transport revolution, the exciting possibility could only became reality in a very limited way. The state railway companies could not make their name as a shaper of the mass traffic.

At first the late beginning of the electrification of lines between cities is conspicuous. The discussion on the electrification of the whole railway network did not appear before the end of the century. Then we have to take into consideration that the modern forms of railways like the electric tramways and urban speed railways neither

[14] See Bericht über eine Reise nach Nordamerika und zur Columbianischen Weltausstellung in Chicago vom 30. Mai bis 5. August 1893, München 1896, 161.
[15] See Giese, Das zukünftige Schnellbahnnetz, 79.
[16] See Julius Kollmann, Der Großstadt-Verkehr. Modernes Verkehrswesen der Großstädte, in: Moderne Zeitfragen 3 (1905), 3–44, hier 10.
[17] See Elfi Bendikat: Öffentliche Nahverkehrspolitik in Berlin und Paris 1890–1914. Strukturbedingungen, politische Konzeptionen und Realisierungsprobleme, Berlin und New York 1999, S. 134 u. 178.

as concept nor as well running machines had been developed by the state railway companies. It was the result of private companies and their engineer capacity. At third the transformation and the discussion about the transformation of this innovation to the state railway network drew out and astonishingly enough there were less interest of the state railways in an electrification of their far distance traffic network, although experiments show impressively the possibility of a duplication of travel speed.[18]

So the first initiative came from private enterprises. And indeed they successful launched an intense public debate. Huge plans for a high speed network of electric trains were discussed in Germany in 1893. At this time newspapers wrote enthusiastic: "The advantages that could be expected from an electrical operation have been seen in the higher speed by save of row material and greater safety in operation. It is believed that speed up to 150, even 200 kilometres per hour could be achieved. The distances between cities and countries would vanish even more than it is the case now."[19] But the project initiated by private investors failed. They could not initiate a broad movement with numerous committees that organised a campaign for the implementation of modern railways as in the time of the railway mania in the 1830s. Instead of this we find a small minded scramble for the financing of a reference and experimental line between Berlin and Hamburg and some fearful suggestions on an eventual competition between state and private railway companies.

Although the ministry of public work (Ministerium für öffentliche Arbeit) responsible for railways developed the first plans for a German high speed network on electrified trains, although foreign enterprises offered their support to the Prussian state railway, although numerous experiments showed impressive results - we must consider stagnation in the development of a concept for the electrification of the Prussian and other German railways. It was not before 1904, more than ten years after the initiative of private investors, when the railway minister of the German states organised a meeting for the discussion on electrification. There they voted explicitly against the foundation of private railway companies for the construction of electrified high speed railways. It was the Prussian ministry for public work were the project then "had been laid to rest" (zu den Akten gelegt). This was a clear decision against the chance for taking part on the shaping of the future traffic market.[20] The conservative press applauded and argued: One would not have carried out the nationalisation of the railways by "making serious sacrifices" (mit erheblichen Opfern) to devaluate this by the creation "of a competition". The proposal to "create an electric high speed railway by private capital" must be "rejected in any case".[21] This decision had tremendous consequences for the German modernisation of railways.

Before World War One we have to consider less progress in the electrification question. Some progress in the big project took place after World War One. Beside some lines in South Germany it was especially the electrification of lines in the surrounding of the port city of Hamburg, the track between Dessau and Bitterfeld and some lines in Silesia. In the 1930s the Deutsche Reichsbahn worked intense on the electrification of a connection

[18] On the opposition of state railways against the electrification of their city network see Remy, Die Elektrisierung der Berliner Stadt-, Ring- und Vorortbahnen als Wirtschaftsproblem. Berlin 1931, 17–34.

[19] Die Vortheile, die man von dem elektrischen Betrieb erwartet", schrieben damals die Zeitungen, „beziehen sich in erster Linie auf die Erhöhung der Fahrgeschwindigkeit bei entsprechender Ersparung des Rohmaterials und großer Betriebssicherheit. Man glaubt, daß Fahrgeschwindigkeiten von 150, ja sogar 200 Kilometer in der Stunde leicht erreicht werden könnten. Die Entfernungen zwischen Städten und Ländern würden noch mehr, als dies jetzt der Fall ist, schwinden." Die Eisenbahn der Zukunft, in: Westfälischer Merkur v. 19. Juni 1893.

[20] See Geheimes Staatsarchiv Berlin. Rep. 93 (neu) 15538.

[21] Der Vorschlag, „die Schaffung elektrischer Schnellbahnen dem privaten Kapitale" zu überlassen, müsse deshalb „a limine abgewiesen werden." Elektrische Schnellbahnen, in: Deutsche Tages Zeitung v. 9. August 1904.

between Munich and Berlin. But nobody could assess that the technological leading country in Europe fell far behind countries as the Switzerland and Sweden or Italy and France in the question of the electrification of railways.

It was above all the Switzerland with a lack of coal deposits that invested on a large scale in electric railways to make them independent from coal imports. Because of the geographical conditions electric power could be produced relative cheap.[22] Also electric locomotives had clear advantages on gradient and curvaceous lines from which the Switzerland had many. Already in the 1920s Swiss electric locomotives achieved more than 4000 horsepower around 1000 more than the average steam engines. And already in the 1940s ninety per cent of the network had been electrified.[23] This was absolute contrary to the German situation were the Deutsche Reichsbahn shrank back from the enormous costs for the construction of an electrified network. Instead in further development of electric locomotives the German railways experimented with diesel engines or a combination of diesel and electric drives.[24]

So we have the astonishing situation that the electrification of the German railways had been only of local importance for a long time. In a once leading country for the technological concept of electric railways we can consider serious attempts for the electrification of important parts of the whole network not before the 1960s as mentioned in the beginning. This was nearly one hundred years after the visionary project of Werner von Siemens at the World Fare in Paris.

What was the reason for this enormous delay? In the literature one could find military suggestions and argues. The destruction of the overhead cables would lame the whole track. This is convincing but it is also true for the tracks itself.

A greater role played the argue that two lost wars, the wear and tear of the railway stock and the lack of capital for reinvestments because of the reparations Germany had to pay to the allies ate up the resources which the construction of tracks and overhead cables afforded. But what then about the period before the war? Not the war and its aftermath stopped the electrification. It were the German railway ministers itself who showed less interest in this kind of modernisation before World War One.

So in my opinion there exists a third line of argumentation to explain this phenomenon. On the national level the state railway companies were focussed on coal as the main deliver of energy. In countries like Sweden and the Switzerland the substitution of expensive coal by cheap electric power seriously decreased the operating costs because water power enabled cheap production of electric power. In Germany we have a the contrary situation. The large coal resources of Germany seems to be the main argument for the preference of steam locomotives for a long time.[25]

But this was a short running view. Because with this decision the range of speed of German railways stagnated at 100 and max. 150 kilometres per hour. This was not much enough to compete with the increasing possibilities of air traffic. Also it was a speed dimension that could be reached step by step by automobiles as second competitor of railways.

[22] See Ralf Roman Rossberg, Geschichte der Eisenbahn. Akt. Neuaufl. Frankfurt am Main 1984, 280–282.
[23] See Braun, Überwindung der Distanz, 98.
[24] See ibid. 99-100.
[25] See ibid. 99-100.

Indeed after World War Second the political support of the private vehicle traffic by street construction and low vehicle taxes dominated the flow of investments into the traffic sector with the consequence that the electrification of the railways again became delayed up to two decades.[26]

The consequences were tremendous. Between the 1950s and 1970s there had been an enormous decrease in the importance of railway traffic in the society of Western Germany. This trend was of course no particularity of the German railways. Similar tendencies could be found in many Western societies. But one reason for the speedy decline of the once so mighty railways might be that the German railways could not make advantage of high speed traffic beyond 200 kilometres per hour. As a result for the electrification during the 1960s the German Bundesbahn reached the 200 kilometres per hour margin and surmounted it in the 1980s by the implementation of the ICE trains.

This progress came too late. Meanwhile other traffic systems had come through and dominated the traffic market. Of course a decline in the importance of railway traffic would not have been hindered by electric high speed trains in an earlier decade. Beside the speed range there have to be taken into consideration other problems and disadvantages of railway traffic as the low density of the network and the less flexibility of point to point connections. But the starting position for the fight against meaningless of railways and for a renaissance in the 1990s would probably have been better.

[26] See Walter Kaiser, Flächendeckender Verkehr auf allen Ebenen, in: Hans-Joachim Braun und Walter Kaiser, Energiewirtschaft, Automatisierung, Information seit 1914. Propyläen Technikgeschichte. Bd. 5. Berlin 1997, 426-454, esp. 426.