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In Search of the Networked Nation: Transforming Technology, Society and Nature in the Netherlands during the Twentieth Century[1]

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ABSTRACT *In the Netherlands, the simultaneous construction of society and network technologies has a long history, yet it is only in the twentieth century that the Netherlands has become a veritable Network Society. Drawing on the vocabulary of the research field of 'large technical systems' and the empirical results of the Dutch national history of technology programme, this article argues that during this century technological, social and even natural landscapes were reshaped in processes of material network building. An investigation of selected cases (the development of the electricity supply, the food chain, the petrochemical industry, and nature conservation) shows a variety of development patterns, motives, interests, conflicts, and negotiations behind the seemingly universal human obsession regarding circulation and network building.*

1. Introduction

In previous decades, an increasing number of authors have investigated how the shaping of modern societies coincided with the building of infrastructures or 'networks'. Their geographical units of investigation varied greatly, from the city to the global sphere. Urban historians spoke of the 'networked city' to emphasise how the development, functioning and vulnerability of the modern city depend crucially upon the circulation of people, food, freight, water, energy, messages and waste through expanding networks of wires, pipes, roads and railroad tracks.[2] At the global level, the thesis of the 'rise of network society' became particularly known in the 'narrow' sense attributed to it by Castells. He related the rise of a global, network-shaped society with the development of a single class of network technologies, ICT networks, in one very recent era, the Information Age.[3] Others, it should be noted, studied a larger number of network technologies in a longer time span. Mattelart, in a study published in English as *Networking the World*, investigated the legitimating ideologies and actual uses of transnational telecommunication systems since the late eighteenth century. He

1. This research was subsidised by the Netherlands' National Research Council and the Eindhoven University of Technology. It is part of the research programme *Technology in the Netherlands in the Twentieth Century*, organised by the Foundation for the History of Technology (www.histech.nl). A previous version was published in Dutch in the *Tijdschrift voor Sociale Geschiedenis*, 3, 2001.

2. Joel A. Tarr & Gabriel Dupuy, eds, *Technology and the Rise of the Networked City in Europe and America*, Philadelphia, 1988.

3. Manuel Castells, *The Rise of the Network Society*, Oxford, 1996.

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also traced the idea of shaping societies through network building back to Enlightenment and Liberalist thought.[4] Hugill goes back even further in an attempt to incorporate the 'material base' in the Wallersteinian *world systems theory*. In his view, the growth and structure of the transnational social system reflected the features of transportation and communication technologies in different era's, starting with maritime navigation in the times of the Portuguese Expansion.[5]

In this study I shall ask how such a network society was shaped at the geographical level of a single country, taking the Netherlands as an example.[6] Of course, also for individual countries the relationship between societal and infrastructural developments has been addressed. This is particularly true in the Dutch case, where the co-construction of society and networks has a long history. The development of drainage systems since the Middle Ages made much of the territory inhabitable in the first place.[7] Furthermore, inland navigation networks played a prominent role in the economy of the Dutch Republic in the early modern period, which has been the main period of interest for international scholars.[8] And as in many other countries, the process of Dutch nation building from the mid-nineteenth century was strongly connected to the development of modern transport and telecommunication networks with a national scope (earlier networks were often limited to the urbanised coastal regions).[9]

However, it is the twentieth century that makes Dutch society a truly worthwhile case to study the networked nation. During this century the Dutch territory became fully (that is, 100%) cultivated, following an—after Western standards—exceptional high density of population and intensity of agriculture and industry. This complete mobilisation of territory, which shaped the technological society *par excellence*, was achieved by building large and dense networks of many kinds.

My aim here is to explore this development of a Dutch networked nation conceptually and empirically, mobilising on the one hand the historical discipline specialised in the study of network technologies known as 'Large Technical Systems', and on the other hand selected cases from the national Dutch history

4. Armand Mattelart, *Networking the World 1794–2000*, Minneapolis, 2000 (French original 1996); *The Invention of Communication*, Minneapolis, 1996 (French original 1994); *Mapping World Communication. War, Progress, Culture*, Minneapolis, 1994 (French original 1991).

5. Peter Hugill, *World Trade since 1431. Geography, Technology, and Capitalism*, Baltimore, 1993; *Global Communications since 1844. Geopolitics and Technology*, Baltimore, 1999. Wallerstein, in his famous book, observed that the size of a world economy followed the transportation and communication possibilities, but did not investigate these. Immanuel Wallerstein, *The Modern World-System. Capitalist Agriculture and the Origins of the European World-Economy in the Sixteenth Century*, New York, 1974, p. 349.

6. A study for the spatial level of Europe is under preparation. Erik van der Vleuten & Arne Kaijser, 'Networking Europe. A theme plan', www.histech.nl/tensions, 2001.

7. G.P. van de Ven, ed., *Man-made Lowlands: History of Water Management and Land Reclamation in the Netherlands*, Utrecht, 1996 (Dutch original 1993).

8. Jan de Vries, *Barges and Capitalism. Passenger Transportation in the Dutch Economy, 1632–1839*, Utrecht, 1981.

9. See Hans Knippenberg & Ben de Pater, *De eenwording van Nederland. Schaalvergroting en integratie sinds 1800*, Nijmegen, 1988. In English see Hans Knippenberg, 'Dutch nation-building: a struggle against the water?', *Geojournal*, 43 (1997), pp. 27–40. These studies are inspired by Eugen Weber, *Peasants into Frenchmen. The Modernization of Rural France 1870–1914*, London, 1977.

of technology programme *Technology in the Netherlands during the 20th Century*.[10] The first ambition is to make visible the proliferation of very diverse networks in the twentieth century: next to the transport and communication networks often in focus in network studies, also a number of other infrastructural technologies, the material dimension of many important social institutions, and even Nature were transformed into nationally integrated material networks. Important events separately well-known in historical geography and technological, social and ecological history can thus be juxtaposed as part of one and the same societal movement: the human preoccupation, some would say obsession, for circulation and network building.

The second ambition is to investigate critically the logic of network building in these very different fields. A study of network builders and their motives may reveal whether or not these different networks were shaped by a single concern. In addition, special attention will be given to opposition to dominant network builders and alternative development routes, so as to research if developments seemed self-evident, or indeed were socially contested and the result of power struggles. A third important question, that of the consequences of the development of networks for individuals, cannot yet be investigated systematically on the basis of the available material.[11]

2. The New Geography of Infrastructural Technologies

Studies of Large Technical System Building

In search of the proliferation of human-made material networks, the development of infrastructural technologies is obviously a first event to analyse. In the history and sociology of technology, research on this type of technology has been bundled in the subfield of 'Large Technical Systems' (LTS), credited with the ability to accommodate research results from many other fields.[12] The LTS-field managed to place itself firmly on the agenda of technology studies with reference to both the historical significance of its subject and its methodology. Following the American historian Thomas Hughes, often considered a founding father, large technical systems are regarded as a *front* of twentieth century technical development. This derives partly from their systemic character, which separates them from the artefacts traditionally in focus in the history of technology, and partly from sheer size, as many LTS grew to embrace entire societies. With reference to Valéry, Bloch and Braudel, Hughes argues that LTS rather than 'the machine' greatly shaped the way modern people live, work, play and make war; they constitute societal 'deep structures', which may have surpassed even politics and natural geography in prominence.[13]

10. Running from 1995 to 2002, this project involves some 70 researchers. Among its products is a seven volume book series, see www.histech.nl.

11. This topic is only beginning to be explored in technology studies. Erik van der Vleuten, 'Étude des conséquences sociétales des macro-systèmes techniques: une approche pluraliste', *Flux. Cahiers scientifiques internationaux réseaux et territoires*, 43 (2001), pp. 42–57.

12. Paul Edwards made this point for the history of computing in 'Y2K: Millennial reflections on computers as infrastructure', *History and Technology* (1998), pp. 7–29 on p. 15.

13. Thomas Hughes, *American Genesis. A Century of Invention and Technological Enthusiasm*, New York, 1989; Thomas Hughes, 'Historical overview', in Todd La Porte, ed., *Social Responses to Large Technical Systems. Control or Anticipation*, Dordrecht, 1991, pp. 185–89 on pp. 185–86. Compare Paul Valéry's

In addition, what became known as 'the' LTS approach (it actually exists in many variations) is acknowledged as a key methodology for analysing the simultaneous construction of technology and society.[14] It is one of several analytical frameworks that renewed the field in the 1980s by strictly avoiding *a priori* distinctions between analytic categories as 'the technical', 'the economic', or 'the social'. Instead it follows particular historical actors known as system builders. These actors shape technical and non-technical elements into one messy sociotechnical whole regardless of such categorical borders. Contrary to several other system theories, the LTS-approach thus unites the study of structures with that of actors.[15]

LTS-studies helped expand the interest for infrastructural technologies from communication and transportation technologies to a broader set of technologies with a network character, ranging from electricity supply systems to water control systems and organ transplant systems (see below). Admittedly, many authors operate with a more narrow definition. Following Hughes' original inspiration by the management discipline of *systems engineering*, they presuppose not only human-built physical networks, but also central control by dominant actors. Thus systems like road transportation tend to be neglected in want of central control of the elements of flow.[16] However, this narrow definition does not take into account LTS-authors implicitly or explicitly studying 'loosely coupled systems', or those interested in self-regulation instead of hierarchical control.[17] Certainly for my purpose of developing a broad view of the proliferation of networks, it seems unwise to limit the concept unnecessarily.

As mentioned above, the rapid development of communication and transport networks is very well known. In the Netherlands, too, a fine-meshed telecommunication network was built within some one and a half centuries. Wire and beam links, carrier waves, and transmitter conglomerates for telegraphy, telephony, telex, radio and television services constitute modern infrastructures for the transmission of speech, pictures and sound. And even though mankind has always moved over long distances, and parts of the Netherlands already had an impressive transport network during the seventeenth century, the nineteenth and particularly the twentieth centuries witnessed a veritable transport revolution due to the construction of networks of waterways, railroad tracks, paved roads, air corridors and ever faster vehicles. For details I shall refer to other studies.[18] Here I shall consider in detail a network technology less familiar to outside business- and technological history, the electricity supply system.

footnote continued

vision of electrification as a phenomenon having 'greater possibilities of shaping our immediate future than all the political events combined', cited in Marc Bloch, *The Historians Craft*, Manchester, 1954 (French original 1949), p. 66.

14. Wiebe Bijker, 'Sociohistorical technology studies', in Sheila Jasanof *et al.*, eds, *Handbook of Science and Technology Studies*, London, 1995, pp. 229–56.

15. This connection lacks for instance in general systems theory, adapted by for the study of technology in Günter Ropohl, *Eine Systemtheorie der Technik: Zur Grundlegung der allgemeinen Technologie*, München, 1979.

16. E.g. Alain Gras, *Les macro-systèmes techniques*, Paris, 1997, p. 35.

17. For a plea to study loosely coupled LTS see Arne Kaijser, 'Technological systems in the natural world: water and windmills in the Netherlands', in Jan Odhnoff and Uno Svedin, eds, *Technological Systemic Changes and Economic Theories*, Stockholm, 1998.

18. Knippenberg & De Pater, *De eenwording*, Ch. 3; Johan Schot *et al.*, eds, *Techniek in Nederland in de twintigste eeuw. Vol. V*, Zutphen, 2002.

The Paradigmatic Case of Electricity Supply

The case of electricity supply became paradigmatic for large technical systems in general with Hughes' prize-winning study of the electrification processes in Germany, Great Britain and the United States. This study describes an impressive process of scale increase, focusing on the construction of increasingly large spatial structures for electricity supply: from autoproduction systems in the single factory or home to Edison's 'local systems', which supplied electricity from a 'central station' to external consumers in, for instance, an inner town; from local systems to systems supplying entire urban or rural districts from a single large power station by means of high voltage power transmission; and from such district systems to 'regional systems' using power grids to interconnect several power stations in a pool supplying entire German or US states, or even countries. This process of scale increase roughly occurred between 1880 and 1930.[19]

The Dutch electrification process, described in volume 2 of *Technology in the Netherlands*, appears to have followed a similar pattern of more or less linear growth. Around 1900 the electricity supply landscape was made up primarily of local systems. At the eve of the Second World War, however, electricity supply was completely dominated by some 20 district systems—mostly with a provincial reach. These systems had electrified the country: they connected virtually all municipalities, enabling a national degree of electrification of 218 connections per 1000 inhabitants.[20] Yet only with the first national power grid completed in 1953 would these systems actually be physically interconnected. With the construction of a power grid on the European continent in the 1950s and 1960s, and its interconnection with the Scandinavian grid by the *Konti-Scan* submarine cable between Sweden and Jutland (1965), Dutch households became, so to speak, electrically linked with households from Northern Sweden to Southern Italy through an enormous material network.[21]

Following the 'Western' pattern described by Hughes, the electrification process appears to display an economically determined logic of expansion regardless of specific historical actors and contexts. Indeed, Dutch historians of technology have argued as much.[22] Yet this assumption cannot stand close scrutiny. A second glance at international developments shows that in different countries different social groups monopolised the construction of power systems, causing specific paths of electrification. Variation included the speed, spatial shape, and—most important—also the linearity of the process of scale increase.[23]

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19. Thomas Hughes, *Networks of Power. Electrification of Western Society 1880–1930*, Baltimore, 1983. I call Hughes' 'universal systems' for 'district systems' to emphasise the spatial aspect.

20. Geert Verbong, ed., 'Energie', in Johan Schot *et al.*, eds, *Techniek in Nederland in de twintigste eeuw Vol. II*, Zutphen, 2000, pp. 113–267 on p. 157.

21. Arne Kaijser, 'Trans-border integration of electricity and gas in the Nordic countries, 1915–1992', *Polhem*, 15 (1997), pp. 4–43.

22. P.H.J. van den Boomen & A.N. Hesselmans, 'Van kleinschalige naar grootschalige electriciteitsvoorziening; een analyse van vier electriciteitscentrales 1880–1925', *Jaarboek voor de geschiedenis van bedrijf en techniek*, 3 (1986), pp. 230–51.

23. Theoretically, Hughes' notion of 'technological style' could grasp this phenomenon. However, Hughes applied it to investigate variations in pace of expansion and material shape, taking for granted the linearity of the expansion process. See Hughes, *Networks of Power*, Ch. 1.

In the United States the growth of the electricity supply system followed a consensus between private utilities headed by engineers with a *grow and build ideology*, a strong electrotechnical industry pushing for sales of ever larger-scale equipment, and state governments offering monopolies in return for electrification.[24] In this conglomerate of social interests, electricity supply systems grew to the state level, but the motivation to build a national power grid was lacking. By contrast, in the 1920s the British and French governments founded state-owned companies to enforce the construction of national power grids. Later they would nationalise the entire supply business. Finally, the electrification of Denmark displays an instructive third route. Higher bodies of government did not interfere, while multinational companies hardly gained any foothold. In the absence of such powerful actors able to *enforce* scale increase, hundreds of co-operatively owned local village systems and a substantial number of co-operatively or municipally owned district systems flourished at least until the 1960s. Notably, they did so within the supply areas of a few large regional systems, which had covered most of the country at a fairly early stage. A study of the different system builders, their organisations and their motives confirms that technical and economic arguments did not univocally favour any supply configuration. Instead, small as well as large systems were regarded as feasible in their specific contexts.[25]

To explain the linear process of scale increase in the Netherlands as a technical or economic necessity would thus be short-sighted. Rather this linearity, as well as its pace and material shaping, should be related specifically to Dutch society.[26] In this case, the provincial authorities seized control of the electricity supply business. They replaced local systems with district systems to electrify the countryside and counter the urbanisation process. Meanwhile, other actors failed to develop a grip on the business. Like in England and France, the Dutch national government also proposed a national electrification scheme to be carried out by a state company in the early 1920s, but the bill stranded in Parliament. In addition, the provinces managed to nearly completely frustrate the foundation or expansion of private or municipal local systems using sheer political authority in the form of the Provincial Decree, despite allegations of abuse of public power. Only then did the variation of systems, which peaked in the early 1920s, give way to a supply structure of relatively few, large, and mutually unconnected district systems.

With this dominance the provincial authorities also thwarted later initiatives for national integration. Abroad, one of the most important economic arguments for further scale increase was a further concentration of electricity production. The remarkable concentration of electricity production already achieved in provincial district systems, however, cancelled out this argument in the Nether-

24. Richard Hirsh, *Technology and Transformation in the American Utility Industry*, Cambridge, 1989.

25. With regard to economic performance, for instance, large systems obtained economies of scale, a higher load factor, and a better 'economic mix'. Yet small-scale systems could shut down their engines at night and run on accumulators (local systems); choose between wind, diesel, peat or steam power according to fuel prices; combine heat and power production (municipal district systems); and, simply, did not have to invest in very expensive power grids, making up perhaps half of the total investment costs. Erik van der Vleuten, *Electrifying Denmark. A Symmetrical History of Central and Decentral Electricity Supply until 1970*, Aarhus, 1998.

26. For the following see Erik van der Vleuten, 'Constructing centralized electricity supply in Denmark and the Netherlands: an actor group perspective', *Centaurus*, 41 (1999), pp. 3–36.

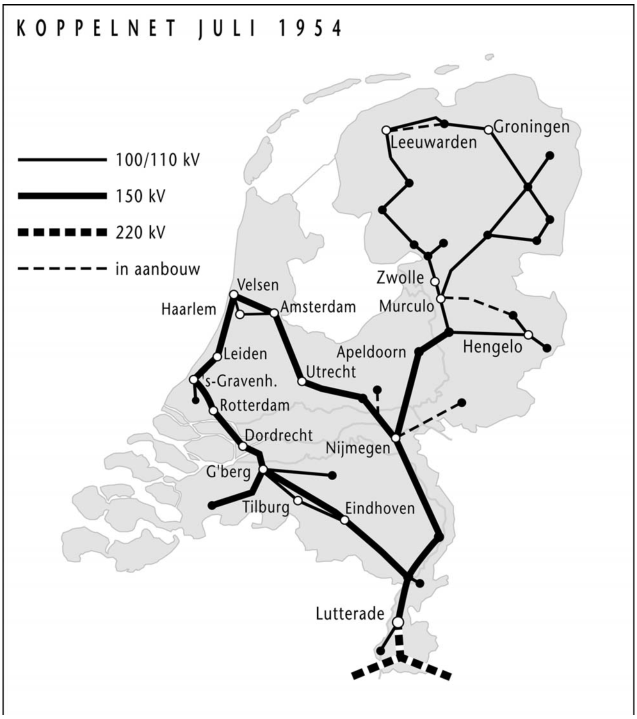

FIGURE 1. The first Dutch national power grid (1953) consisted of two mutually connected rings. The main transformer stations could thus be supplied from two sides, increasing the security of supply.
Source: Johan Schot *et al*., eds, *Techniek in Nederland in de twintigste eeuw* Vol. 2, Zutphen, 2000, p. 222.

lands. The main actors in the supply business only reached consensus upon the construction of a national power grid after a redefinition of the purpose of this grid: instead of achieving economic benefits, the motive to build the grid became an increased security of supply—if one power plant failed, it would be able to draw electricity from the grid. Notably, it was explicitly argued that the economic *losses* of building a national grid were acceptable. This Dutch motive for a secure national system was materially embedded in the geographical shape of the grid: it was building from the beginning as two mutually connected rings, so each junction could be supplied from two sides (see Figure 1).

The New Geography of Infrastructural Technologies

The dominance and motives of the provincial authorities thus shaped a specifically Dutch electrification process—its linear scale increase, pace and material shaping. In a similar fashion the construction of other nationally integrated infrastructural technologies followed the (inter)actions of specific system builders. Their respective histories told in *Technology in the Netherlands* suggest two important observations.

First, many infrastructural technologies developed from local to nationally integrated systems. For instance, gas supply emerged in the nineteenth century as local ('city gas') systems run by private companies and municipalities. From the Inter Bellum, the Dutch State Mines and the partly state-owned steel company *Hoogovens* developed interurban gas networks ('long distance gas') that grew to cover large parts of the country. Finally, after the discovery of a huge natural gas reservoir in 1959 the national government, with two large oil companies and the Dutch State Mines, forged the limited company *Gasunie* to establish a nationally integrated system of gas pipes with a total length comparable to the road system (it is the densest in the world). Notably, the succession of different dominant system builders that made this process possible was subject to severe struggle and conflict.[27]

Contrary to this pattern of expansion, however, the construction of railroad and canal networks originally—in the first half of the nineteenth century—served to connect the Amsterdam and Rotterdam harbours with German industrial markets. Only in a second phase did the national government give priority to national integration through the construction of a dense network of local lines (which, incidentally, would yield to the road transport system from the 1930s and 1950s respectively).[28] The telegraph system followed a similar pattern (as opposed to the telephone system, which expanded from local via interlocal and national to a transnational system). In these cases, the creation of nationally integrated networks had the character of a 'branching process' rather than an expansion process.

Second, it is worthwhile to observe that the Netherlands were not only spatially restructured by such 'dry' networks, but also by the 'wet networks' in the domain of water management. These wet networks are noteworthy not only because of their great density, but also because the same physical infrastructure hosted a variety of functions. For instance, normalised rivers and canals not only served inland navigation, but also constituted the main grid for a drainage system connecting local canal- and pipe systems in agricultural fields, polders, factories and cities. In addition, in the post-war era the national civil service institution *Rijkswaterstaat* developed a nationally integrated and controlled fresh water supply system to distribute the incoming Rhine and Meuse river water to different types of consumers throughout the country.[29]

In sum, Dutch society was literally covered by a variety of material networks. Lines of steel, stone, wires, pipes, water, electromagnetic waves and air corridors embody a veritable material integration of the Netherlands. Often such networks were locally branched as well as internationally connected. Thus they enabled a circulation of humans, artefacts, energy and information from the local to a transnational level. Also for the Netherlands one can speak, with the French sociologist Alain Gras, of a new, human-made geography of large technical systems.[30]

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27. Arne Kaijser, 'Striking bonanza: the establishment of a natural gas regime in the Netherlands', in Olivier Coutard, ed., *The Governance of Large Technical Systems*, London/New York, 1999, pp. 38–57.

28. J. van de Meene, '1890–1917: concentratie en concurrentie', in *150 jaar op de rails*, Leiden, 1989, pp. 8–22.

29. C.N. Disco, ed., 'Waterstaat', in Johan Schot *et al.*, eds, *Techniek in Nederland in de twintigste eeuw Vol. I*, Zutphen, 1998, pp. 53–207. Nil Disco & Erik van der Vleuten, 'The politics of design: balancing interests in water-based large technical systems in the Netherlands in the twentieth century', *Proceedings of the 5th International Conference on Technology, Policy and Innovation*, The Hague, 2002.

30. Gras, *Les macro-systèmes techniques*.

3. The Material Structure of Social Institutions

Second Order Large Technical Systems

The rapid expansion of the infrastructural technologies is, however, not the only event of importance to a study of material networks and flows. Such a study should also observe a pattern in the development of several important social institutions (I shall use this term in a broad meaning). Of course the importance of infrastructural technologies for the development of such institutions is well known. The German sociologist Renate Mayntz even integrated infrastructural technologies in the sociological systems theory, which analyses societies as consisting of functional subsystems like politics, education, health care, production, defence etc. She first argued that the realm of infrastructures itself became such a subsystem during the twentieth century, developing many features of institutional differentiation.[31] In addition, while basing their development increasingly on infrastructural technologies, other subsystems became increasingly and asymmetrically dependent upon the new infrastructural system.[32]

Manuel Castells went one step further. He noted, for the current Information Age, that social institutions (production, the financial sector) used network technologies to organise themselves in a network shape. While Castells focused on the *why*, the German sociologist Ingo Braun has conceptualised *how* this reproduction of network features took place for a case within the health care sector. From the 1960s the *Eurotransplant* organisation developed the new domain of organ transplantation in the shape of a materially integrated, spatially extended network designed to create and control flows of organs throughout Europe (or at least the participating countries).[33] Junctions belonging to the health care sector, such as hospitals and medical apparatus, were physically interconnected by a variety of infrastructural technologies. Taxies and ambulances were used to mobilise the road system in order to facilitate local circulation of patients and medical personnel. The air transportation system (mobilised by line carriers, charter flights or helicopters) was used to transport organs. Telephones and beepers were used to mobilise telecommunication networks for coordinating transport, obtaining permission from next of kin, and mobilising personnel. Finally, data communication systems allowed the rapid comparison of medical data of donor and recipient over large distances. Underlining the kinship of this medical network with the familiar large technical systems, Braun speaks of 'second order large technical systems'. They are literally constructed 'on top of' the former. Of course, these two types of LTS also differ: first order LTS builders construct and control rather 'homogeneous' networks, while second order system builders like *Eurotransplant* create heterogeneous networks juxtaposing parts they normally do not control. This causes the asymmetrical dependence observed by Mayntz.

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31. Including a separate knowledge base, norms and values, and profession structure; large managing organisations; high internal integration; and society-wide reach and high social inclusion.

32. Renate Mayntz, 'Zur entwicklung technischer Infrastruktursysteme', in Renate Mayntz *et al.*, eds, *Differenzierung und Verselbständigung. Zur Entwicklung gesellschaftlicher Teilsysteme*, Frankfurt am Main, 1988, pp. 233–60; Renate Mayntz, 'Grosse technische Systeme und ihre gesellschaftstheoretische Bedeutung', *Kölner Zeitschrift für Sociologie und Socialpsychologie*, 45 (1993), pp. 97–108.

33. Ingo Braun, 'Geflügelte Saurier. Zur intersystemische Vernetzung grosser technische Netze', in Ingo Braun and Bernward Joerges, eds, *Technik ohne Grenzen*, Frankfurt am Main, 1994, pp. 446–500.

The development of nationally integrated societal institutions in the Netherlands could be studied from a similar perspective. In the following I shall attempt this for the sociotechnical domain of food supply.

The Contested Integration of Food Supply Networks

Volume III of *Technology in the Netherlands* is entirely devoted to the development of food supply.[34] It interprets its topic with a concept in kin with networks or large technical systems. The 'food chain' is defined as 'a structure of phases and links accommodating the flow of foodstuffs'.[35] Phases include actions as primary production, secondary production, distribution, preparation and consumption. Links include locations such as the farm, the factory, the market place, the supermarket or the kitchen. In LTS terminology, these 'links' constitute the nodes in the second order large technical system of food supply, interconnected by lines in the shape of roads, rail-, water- and airways, telephone lines, electricity wires, drainage channels etc.

As in the case of electricity supply network, the spatial expansion of food supply structures during the twentieth century is astonishing. It developed from predominantly local to a predominantly national and transnational scope. The adjective 'predominant' is crucial here. In fact the co-existence of circulation on different spatial levels was already visible in the Middle Ages, when Frisian countries used maritime and inland navigation networks to import grain and wine in the tenth century A.D., and has been so ever since. Likewise, local circulation was certainly not abolished in the twentieth century—it even revived in the 1970s. Therefore the notion of an expansion of the food chain does not refer to all, but to a majority of products and of persons affected by these.[36]

Technology in the Netherlands carefully seeks to explain this expansion process by reference to historical actors. Unlike in electricity supply, the food sector was—except in the Second World War—not controlled by a dominant system builder or small group of system builders. Its development was shaped by a large number of interacting actors with diverging motives, without any overall conception of a food network. The 'food-chain' concept would only become a popular actor concept during the 1990s.

Three actor groups played a pivotal role and must briefly be mentioned.[37] First, in particular from the 1890s a rapidly emerging food industry inserted a multitude of factories as new nodes in the flow of foodstuffs between farm and market. These factories might also supply (half-) products to each-other. Particularly illustrative is the emergence of a specialised ingredients-industry, producing enzymes, vitamins, preservatives, aromatics, flavours, and colours for many food industries.[38] In addition to this multiplication of nodes of industrial processing, individual companies strove for scale increases as a competitive

34. Jan Bieleman, ed., 'Landbouw', in Johan Schot *et al*., eds, *Techniek in Nederland in de twintigste eeuw. Volume III*, Zutphen, 2000, pp. 11–233; A.H. van Otterloo, ed., 'Voeding', pp. 235–373.

35. A.H. van Otterloo, 'Voeding in verandering', in Van Otterloo, ed., 'Voeding', pp. 237–47 on p. 239.

36. A.H. van Otterloo, 'Ingrediënten, toevoegingen en transformatie: hiel en onheil', in Van Otterloo, ed., 'Voeding', pp. 297–309 on pp. 297–98. Van Otterloo, 'Voeding in verandering'.

37. A.H. van Otterloo, 'Nieuwe producten, schakels en regimes 1890–1920', in Van Otterloo, ed., 'Voeding', pp. 249–61; 'Prelude op de consumptiemaatschappij in voor- en tegenspoed 1920–1960', *Ibid*., 263–79; and A.H. van Otterloo & B. Sluyter, 'Naar variatie en gemak 1960–1990', *Ibid*., pp. 281–95.

38. Van Otterloo, 'Ingrediënten', p. 373.

strategy, concentrating production in still larger factories with larger markets for products and raw materials. This happened in particular after the First World War, when an increasing purchasing power inspired companies to prioritise the market of households.

Retail companies constitute a second group of importance. Initially the central urban market squares of the nineteenth century were replaced by specialised markets and a dense network of shops in the rapidly expanding urban quarters. In addition, for individual retail companies also upscaling was a much-used competitive strategy, as the success of cooperative wholesale societies, chain store businesses, and particularly supermarket chains suggest. The chain stores Albert Hein (currently a leading retailer worldwide known as Ahold) and De Gruyter opened their first self-service shops in 1952. Albert Hein opened its first supermarket (that is, a self-service shop also selling fresh foodstuffs such as vegetables and fruits) in 1955. Many small local shops closed their doors due to competition from supermarkets; by 1980 the total number of food stores had more than halved.

Finally, a third group of 'intermediaries' coordinated between the still more distant nodes of production and consumption and thus facilitated the upscaling process. This group was very diverse. It included advertising agencies, governmental bodies, scientific research institutes and public information officials (including home economics teachers). Motives ranged from profit concerns to improving national health by shaping foods and eating habits.

By 1960, all this had resulted in a national integration of food chains. A standardised assortment of foodstuffs had become available everywhere in the country for all social groups. In conjunction with the homogenising effect of intermediaries on consumer choices, this national food supply system produced what Dutch food-historians call the 'unification of the Dutch meal', succeeding regional and social variety in food- and meal patterns.[39] Food and meal patterns have again become fragmented since, but this does not signify a shortening of food flows. On the contrary, the same fragmentation is visible in Paris, Amsterdam and Copenhagen. Different social groups choose differently from one and the same assortment of foodstuffs, now standardised throughout most of Western Europe.[40]

Technology in the Netherlands does not investigate systematically *how* all these actors created or mobilised material networks to realise extended food flows, but its many examples inspire a first impression. In the food business, the construction of new network-lines seems to have occurred only at the local level. Examples include the massive construction of local pipe systems for the drainage of agricultural fields (by 1990 these drained some 600 000 hectares of agricultural soil) and so-called *full dress* land re-allocation projects, which from the mid-1950s entailed the creation of new local paved roads, electricity supply connections, water supply systems and drainage canals.[41] Finally, there were a few attempts to construct milk transportation pipes. In the 1960s a co-operatively

39. Jozien Jobse-van Putten, *Eenvoudig maar voedzaam. Cultuurgeschiedenis van de dagelijkse maaltijd in Nederland,* Nijmegen, 1996 (first edition 1995), pp. 499–506.

40. Marlou Schrover, 'Smaakegalisatie, Bosche bollen en koekjesgiganten. De voedings- en genotmiddelenindustrie 1850-heden', in *Voedings- en genotmiddelenindustrie. Een geschiedenis en bronnenoverzicht. Historische bedrijfsarchieven 5*, Amsterdam, 1993, pp. 13–57 on pp. 48–49.

41. J. Bieleman, 'Bodemverbetering en waterbeheersing', in Bieleman, ed., 'Landbouw', pp. 27–45 on 44; 'Van ruilverkavelen naar landinrichten', *Ibid.*, pp. 47–63.

owned dairy in Heino (near Zwolle in the North-East) connected six farms to an underground pipeline network, through which milk was supplied and skimmed milk returned. Yet the system was dismantled due to technical imperfections, and this technology remained marginal—despite the demonstration of its feasibility by a 15 kilometres milk-pipeline through the Wadden Sea, which has connected Nes on the small island of Ameland to the mainland since 1978.[42]

Instead of building new networks, food companies preferred to create flows of foodstuffs by mobilising existing network lines. Trucks, barges and train wagons were adapted to transport foodstuffs on road, inland navigation and railroad networks. For instance, when the above-mentioned Albert Hein company introduced the system of branch stores following the British example in the early twentieth century, it built its own fleet of trucks, maintained by company mechanics, to supply branch stores throughout the country from a central warehouse in Zaandam (near Amsterdam).[43] Later, the parking place would prove an essential precondition for the success of the supermarket: it allowed the material coupling to households via the road network.

A final example from the production phase shows how the mobilisation of networks could be subject to severe social conflict. To facilitate the transfer of dairy production from the farm to local dairy factories in the 1880s, the latter had organised the daily collection of milk jugs by road or canal transport: boats and trucks belonged to the factory equipment as did steam engines and centrifugal separators. A second wave of concentration started in the 1960s, leaving only a few very large factories processing raw milk from substantially larger areas. Also this development was intimately tied to the mobilisation of transport networks. It depended upon a cluster of three innovations. Dairy companies developed refrigerated transport trucks to enable long distance transportation of milk. A related innovation was the installation of refrigerated tanks at single farms. These allowed dairy companies to save on transport costs by collecting milk only a couple of times per week. This was crucial for making the further concentration of production economically feasible. Finally, automatic milking machines and pipe systems at the farm would even transport the milk from the single cow to the refrigerated tank (milk pipelines in Dutch farms increased in length from 4500 kilometres in 1971 to 43 000 in 1980).

Unlike large farmers, smaller and medium-sized farmers were reluctant to purchase an expensive milk tank and adapt to the new system. The national government, politically committed to a rationalisation of agriculture, therefore decided to support the introduction of refrigerated tanks with subsidies. These were awarded through the dairy companies, however, which incorporated them in their strategies to force smaller farmers to innovate. Indeed, dairy companies regularly gave farmers the choice between innovation and quitting business. The conflict escalated into what was called the 'tank war', reaching a climax in 1978 when farmers in Hoogeveen (in the North-East) took hostage the board members of their cooperative dairy factory in the factory canteen. The taking hostages lasted for several days, and in this particular case a compromise was negotiated, in which the farmers could join another dairy and maintain their jug system. Such actions remained incidental, however, and would not turn the tide.

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42. P.R. Priester, 'Het melkveehouderijbedrijf', in Bieleman, ed., 'Landbouw', pp. 99–125 on 113.
43. Van Otterloo, 'Prelude op de consumptiemaatschappij', p. 264.

In the early 1980s the introduction of the new system had practically been completed.[44]

Some Other Examples

Among other institutions that may profitably be studied in this way, the Dutch petrochemical industry is of particular interest. First, it illustrates a process of 'branching' as observed above for the railroad and telegraphy networks, for the industry had already created transnational flows of chemicals, with international markets for raw materials and products, when so-called chemical complexes emerged. In such complexes, products and by-products from one factory are locally supplied as raw material for the next factory, thus creating complex local flows of chemicals.[45] Well known examples from the history of chemical technology include the sulphuric acid complex in eighteenth century England and the synthetic dye industry in late nineteenth century Germany. In the Netherlands such complexes only emerged around the nitrogen fixation plant of the Dutch State Mines from the 1930s and the oil refinery of the Royal Dutch/Shell near Rotterdam from the 1950s. This latter complex would expand to one of the world's largest; many foreign companies built their own factories here, and by the 1970s it stretched from Europort in the Rotterdam harbour to Antwerp, Belgium.[46]

A second feature of interest is that the petrochemical industry not only mobilised existing roads, railroad tracks and waterways, but also built entirely new network lines. Factories were often tied physically together with pipelines conveying e.g. crude oil, naphta, ethene, chlorine and oxygen. In the Europoort-Antwerp area more than 70 factories were mutually interconnected by pipelines or railroad tracks; the complex resembles one large chemical machine (see Figure 2), connected by crude oil, ethene and naphta pipelines to other factories in the Netherlands and Germany.

It should be noted that such second order large technical systems also emerged in service sectors. The example of the European organ transplant system in health care has already been mentioned. In a similar fashion, the Dutch medical system can be described as a second order LTS including family doctors, clinics, hospitals, and laboratories for nodes and using various types of network lines to circulate specialists, patients, tissue samples, blood and information.[47] The emergence of a fine meshed network of family doctors, replacing the hotchpotch of official and less official health care services of the nineteenth century, is noteworthy because family doctors constituted the first social group to use bicycles, telephones, and later motorcycles and automobiles for professional use. As in Germany and the US, this group even founded an Association for Doctors and Automobiles (*Vereniging Voor Arts en Auto)* in the 1920s.[48]

44. Priester, 'Het melkveehouderijbedrijf', pp. 112–14.

45. Ernst Homburg, ed., 'Chemie', in Schot *et al*., eds, *Techniek in Nederland in de twintigste eeuw Vol. II*, pp. 271–407.

46. Ernst Homburg, Aat van Schelm & Piet Vincken, 'Industrialisatie en industriecomplexen', in Homburg, ed., 'Chemie', pp. 377–401.

47. E.S. Houwaart, *Medische techniek in Nederland in de twintigste eeuw. Beschrijving van het onderzoeksprogramma 'medische techniek' in het kader van het onderzoeksproject 'Geschiedenis van de techniek in Nederland in de twintigste eeuw'*, Eindhoven, 1996, p. 4.

48. See current research of Peter Staal at the Foundation for the History of Technology/Eindhoven University of Technology.

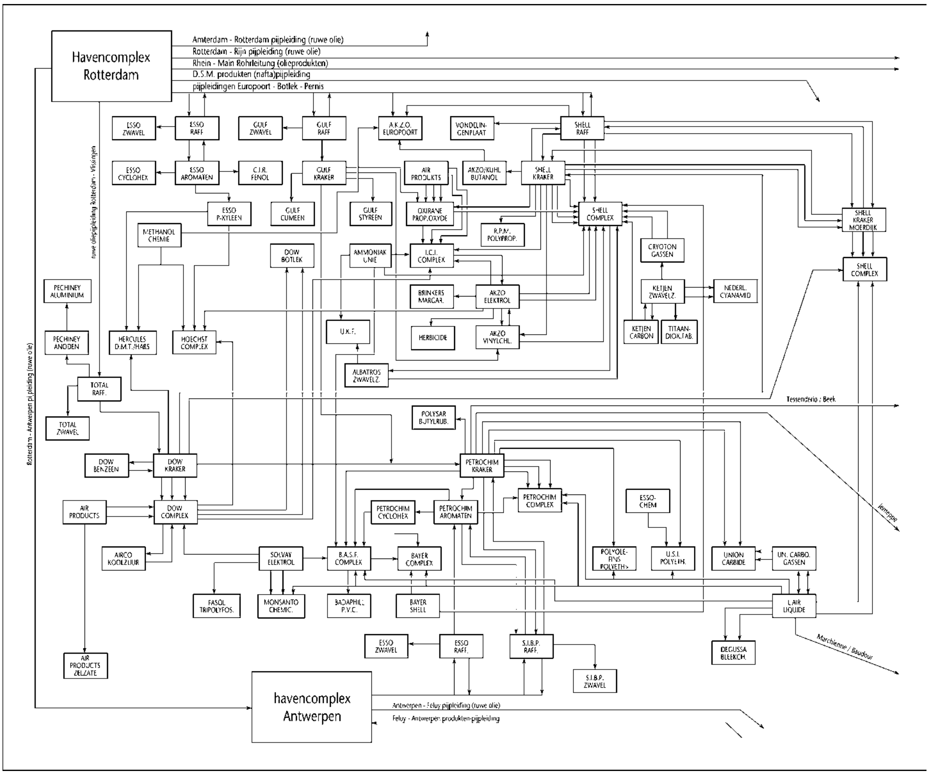

FIGURE 2. The petrochemical complex between Rotterdam and Antwerp around 1970 included more than 70 chemical plants, mutually connected by pipelines and railway tracks, forming one giant chemical machine. Non-chemical factories and chemical factories processing natural gas or imported raw materials are not included.
Source: Johan Schot *et al.*, eds, *Techniek in Nederland in de twintigste eeuw* Vol. 2, Zutphen, 2000, p. 399. Redrawn from E. Wever, *Olieraffinaderij en petrochemische industrie. Ontstaan, samenstelling, voorkomen van petrochemische complexen*, 1974, p. 131.

Its journal *Arts en Auto* is still published and can be found in any waiting room. Among its many current topics is the Internet and its opportunities and implications for family doctors.[49]

4. Networking Nature

The Industrialisation of Nature

The proliferation of human-built material networks is visible in still a third domain. Castells observed how in the sociological tradition, that interprets social action from the changing relationships between Nature and Culture, the network society constitutes a new era. Culture was long dominated by Nature, and social organisation inspired by the struggle for survival. The eras of enlighten-

49. Wouter Keijser, 'E-mailen. Zorg loopt achter', *Arts & Auto*, 6 (2001), pp. 34–35.

ment and industrialisation, by contrast, saw the submission of Nature by Culture. Social organisation was now aimed at the exploitation of natural resources. The network society displays a third pattern: Culture has suppressed Nature to a degree, where the latter is maintained only as a cultural form. The environment that remains is purely cultural. In Castells' theory, this allowed flows of information to become the basic thread of social structure.[50]

Again we can take this observation one step further. Humans not only affected and appropriated Nature, but did so by manipulating it as physical networks and flows. An important example resonating with Castells' second pattern has already been mentioned: humans attributed different functions to wet nature, reshaped its properties accordingly, and transformed it into human-controlled large technical systems for water control, navigation, drainage and fresh water supply.[51] Others refer to this increasing human control of wet nature as the 'industrialisation of rivers'.[52] In the Netherlands, this occurred as early as the ninth and tenth century A.D. A veritable delta area (bordered by sea in the West and North, and hosting three large European rivers the Rhine, Meuse and Scheld), the landscape had traditionally been shaped primarily by natural processes as peat formation, erosion and sedimentation by sea and rivers. Since the extensive peat bog reclamations, however, humans rapidly became the primary factor shaping the landscape. The reclamations caused a descending ground level, making sea and river floods endemic, and changing the shape of the country. Humans reacted by developing a variety of water management techniques, building dams, weirs, thousands of kilometres of dikes, pumping systems, etc, gradually extending their scope of control from local drainage systems to, during the nineteenth and twentieth centuries, the nation-wide flow of the large rivers and the entire coast line.[53]

The Construction of Ecological Networks

Still more surprising, perhaps, is that the human recreation of 'nature' as a cultural form (Castells' third pattern) also seems to occur in the shape of building material networks.[54] Dutch nature conservation had originally been concerned with the purchase and preservation of local nature reserves. The Nature Monuments Association, founded in 1905, considered these not as 'real nature', but sought to preserve pre-industrial landscapes that were partly shaped by older, pre-industrial agricultural practices. Correspondingly, conservation entailed the continuation of such practices: nature management including fishing and hunting, grazing by sheep, tree cultivation, mowing and peat cutting, and using water mills. By the 1960s nature reserves formed small, but generally unconnected islands of protected area.

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50. Castells, *The Rise of the Network Society*, p. 477.

51. Kaijser, 'Technological systems in the natural world'.

52. Eva Jakobsson, 'Industrialized rivers. The development of Swedish hydropower', in Arne Kaijser and Marika Hedin, eds, *Nordic Energy Systems. Historical Perspectives and Current Issues*, Canton, MA, 1995, pp. 55–74.

53. van de Ven, ed., *Man-made Lowlands*.

54. The following draws on Henk van den Belt, 'Nature management in the systemic society: the case of the Netherlands', Paper for the workshop: *The Rise of the Systemic Society. Large Technical Systems and their Societal Effects in the Netherlands in the 20th Century*, Eindhoven, 16 June 2000.

Yet the 1970s witnessed a veritable change of paradigm in nature management, ignited by a small group of biologists propagating an increase in nature area by creating 'new nature'. They defined nature by *ecological reference*: nature as it 'would have looked' without human interference. The new *systems ecology* developed in the United States inspired their view of nature as ecosystems fed by solar energy, which was fixed in green plants and subsequently run through diverse food chains. A rich variety of feedback mechanisms directed the system to equilibrium. Accordingly, earlier nature conservation techniques were rejected. After the creation of initial conditions, nature was to maintain itself and human interference limited to a minimum.

The techniques of the new 'nature building' (a *contradictio in terminis* that was soon renamed 'nature development') included, firstly, the creation of a complete food chain. In the case of its first showpiece, the *Oostvaardersplassen* area on a newly reclaimed polder, the re-introduction of large herbivores is illustrative. According to one theory, such large herbivores helped create the prehistorical Dutch landscape consisting of open grasslands alternating with dense woods (the scientific debate on this shape of the prehistorical Dutch landscape still unresolved). With aurochs and tarpans (European wild horses) being extinct, replacements were found in Heck oxes (the result of retro breeding in the direction of aurochs), conics and red deer.

A second action was to increase the size of nature reserves, which strongly affects the capacity of the various species to preserve themselves. One option was to create larger reserves. However, it was perceived that the size of nature conservation areas could also be increased by interconnecting smaller, isolated reserves by means of so-called wet- or green corridors. The 1985 *Ooievaar Plan* (a prize-winning contribution to an official competition on regional land-use planning) illustrates the emerging notion of regional ecological networks. Aiming to improve the river area crossing the country from East to West, it proposed the creation of two large and environmentally diverse 'nodes' to generate biodiversity, a number of smaller reserves to serve as 'stepping stones', and improved rivers and river forelands as corridors facilitating the migration of plant and animal species. Another example of regional network building takes place in the Veluwe area, a (for Dutch standards) large area of nature fragmented by roads, railways, fences and cattle grids. The 'de-fragmentation' of this area involves the construction of 'ecoducts', eco-culverts and badger tunnels.

This strategy of increasing the nature conservation area by ecological network building became national policy with the national government decision *Nature Policy Plan* of 1990. Alarmed by the reduction in biodiversity in part due to the declining size of natural habitats and their fragmentation, it promised the creation of a nationwide physical infrastructure facilitating the national circulation of animals and plants.[55] Dutch nature is currently viewed as a 'fragmented ecological network … [that will gradually] be transformed to an ecologically robust functioning network'.[56] This network, the *National Ecological Network*, should consist of core areas and nature development areas intercon-

55. Ministry of Agriculture, Nature Management and Fisheries, *Nature Policy Plan of the Netherlands*, The Hague, 1990.

56. Ministry of Agriculture, Nature Management and Fisheries, *Natuur voor mensen. Mensen voor natuur. Nota natuur, bos en landschap in de 21e eeuw*, The Hague, 2000, p. 22.

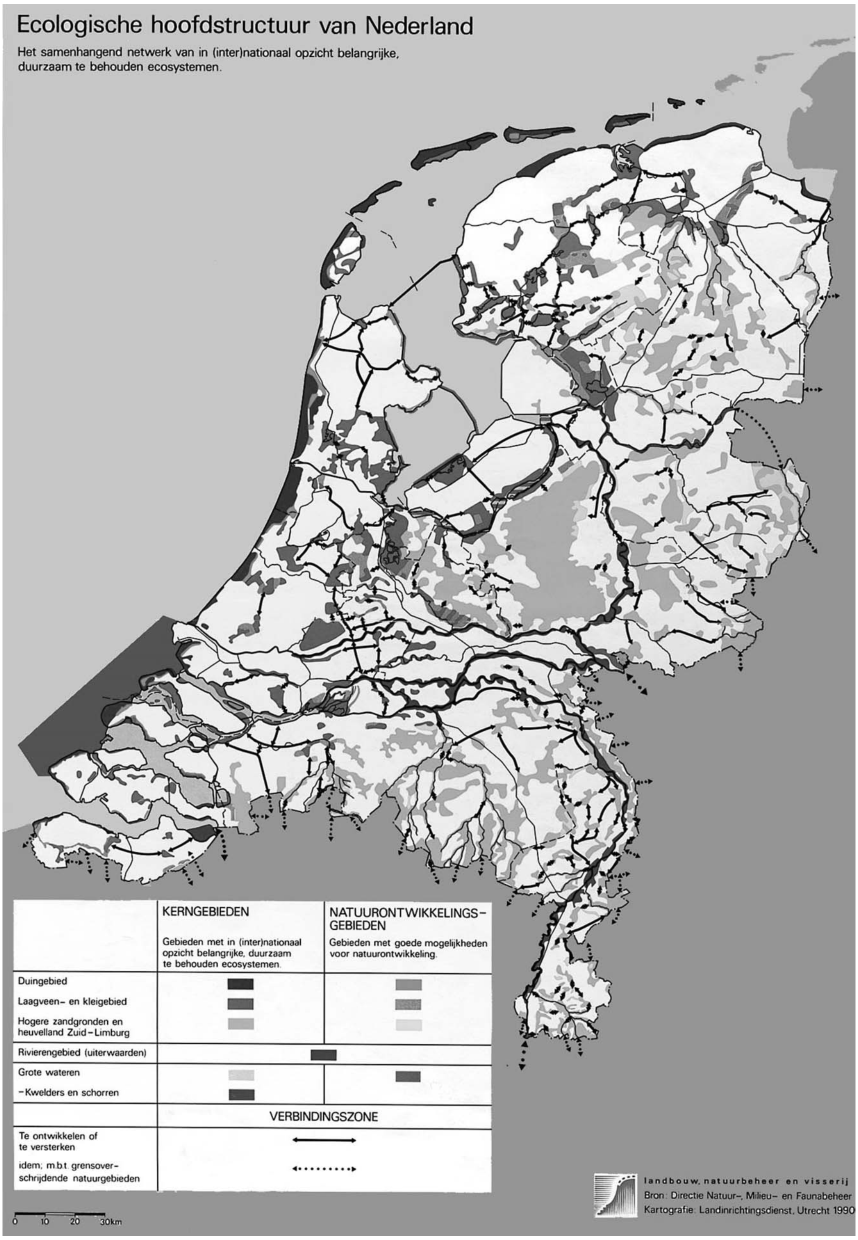

FIGURE 3. The National Ecological Network as proposed in 1990.
Source: Ministry of Agriculture, Nature Management and Fisheries, *Nature Policy Plan*, The Hague, 1990, Appendix.

nected by green or wet ecological corridors.[57] The construction of nature development areas and green corridors implies the purchase and transformation of farm lands for this purpose. The network should be embedded in provincial and local zoning schemes by 2005; the 'ecological backbone' of the Netherlands should be fully operational in 2018 (see Figure 3).

57. *Ibid.*, p. 25.

The Dutch ecological network should in turn be interconnected into a so-called pan-European ecological network. Its planning involved several trans-national system builders. In 1989, the Standing Committee of the Bern Convention, served by the Council of Europe, called for the preservation of areas of specific conservation interests. In 1992 the implementation of this resolution by the European Union led to *Natura 2000*, devising 'a network of protected areas' on a European scale. In response, the Standing Committee of the Bern Convention formulated the *Emerald Network* extending this envisioned network of reserves to the whole of Europe and parts of Africa. Besides protecting reserves, the Convention had already recommended the construction of corridors as an important technique (Recommendation No. 25, 1991).[58] Finally, in 1995 a Conference of Ministers approved the *Pan-European Biological and Landscape Diversity Strategy*, served by the Council of Europe and endorsed originally by 49 countries. By coordinating between regional, national and trans-national network building initiatives it aims to design a pan-European ecological network, understood as a 'physical network of core areas, corridors, restoration areas and buffer zones'.[59] In this international context the Dutch national government obliged itself to build a number of trans-national ecological connections (included in Figure 3). According to the Dutch government, the Pan-European network should be operational by 2020.

However, this bold contemporary network-building project does not escape the crucial role of continuous negotiations between different social groups and interests, which was observed above for other networks. For instance, the delegation of the construction of the National Ecological Network to provincial and municipal authorities, which have extensive procedures for public participation, implies that national plans can be affected and even thwarted at provincial and local levels. Opposition mainly stems from farmer organisations, disputing that fertile agricultural lands must be 'given back to nature' to create green corridors and nature development areas. In the municipality of Gaasterland in the Northern province of Friesland, as in many other places, resistance by local farmers to provincial planning led to a complete stop of the planning process and ultimately a change of procedures. A recent report concludes that a national discussion on environmental values locally often degenerates into sheer battles of interests, which are particularly problematic as democratic control on this level usually is rather poor. From the point of view of nature conservation, such events generally result in a smaller increase of nature area than originally planned.[60] In fact, at the current pace the completion of the National Ecological Network is not expected before 2030.[61]

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58. Graham Bennett, 'Maastricht II + 5', *The Pan-European Ecological Network. Special Issue of European Nature*, 1 (1998), pp. 9–11. Council of Europe, *The EMERALD Network–a Network of Areas of Special Conservation Interest for Europe*, Strasbourg, 1997; European Commission, *Natura 2000. Managing our Heritage*, Luxembourg.

59. Council of Europe, 'Information document on the Pan-European Ecological Network', www.nature.coe.int/english/main/econets/peen/docpeen.htm.

60. Lex Linsen, 'Meer open overleg kan uitkomst natuurbeleid verbeteren', *Ethiek & Beleid*, 0012 (2000), pp. 6–15.

61. The Netherlands Ministry on Housing, Spatial Planning, and the Environment, *Ruimte maken, ruimte delen. Vijfde nota ruimtelijke ordening*, The Hague, 2001, Ch. 3, p. 87.

Moreover, trade-offs at the national level are also changing the project. The nature conservation policy plan for 2000–2010 constitutes a remarkable break with the vision of pure nature, separated from human society, of the nature developers, which also had primacy in the 1990 Nature Policy Plan. The current designation for the *National Ecological Network*, while shaped by humans, is also 'to cater for human desires' and be 'easily accessible and usable'.[62] This means, for instance, that the green and wet arteries will be shaped so as to convey not only red deer and otters, but also 'sporty city dwellers from the urbanized West exploring the area by canoe or bike'.[63] Finally, the foot and mouth disease epidemic in spring 2001 showed that agricultural export interests outweighed the importance of freely migrating animals, as the national government hurried to close ecoducts and other passages to prevent the spreading of the virus.

The European network building initiatives face even bigger challenges. In addition to the previous complications comes the fact that the Emerald network and the Pan-European Biological and Landscape Diversity Strategy are non-binding international legal instruments, with 'extremely limited' financial resources.[64] Only the European Union's *Natura 2000* has a binding status of a EU directive (the so-called Habitats directive). Still, this obligation is limited to the protection of valuable areas. The designation of these areas as well as the choice of conservation methods are delegated to the individual member states.

5. By Way of Conclusion

As others observed for urban and global societies, the single country can also be studied as a network society. In the Netherlands of the twentieth century, the construction of nationally integrated physical networks played a prominent role in a variety of rarely compared realms as technological change, social institutions and nature management. Together, these networks helped shape the perhaps most prominent example of the technological society, the so-called *man-made lowlands*. As important constitutive features of all modern nations, the development of this type of societal structures deserves historical attention in its own right.

The selected cases presented above allow for several observations about the development of such structures. First, one may observe two different patterns of national integration. The electricity supply system, the ecological networks and—typically—the food supply system display a process of scale increase. Networks on lower geographical scale levels were increasingly interconnected on national and transnational levels. The development of railway networks and chemical industrial complexes, by contrast, illustrate a process of branching, in which transnational material networks were branched at national, regional or local levels.

Second, a consideration of historical actors responsible for the development of networks suggests a remarkable variety in actor motives and the processes of system building. Concerning the process of system building, some system builders were able to consciously shape networks without much opposition (electricity supply and chemical industry networks until the 1970s). Yet other

62. Ministry of Agriculture, Nature Management and Fisheries, *Natuur voor mensen*, p. 9.
63. *Ibid*., p. 22.
64. Bennett, 'Maastricht II + 5', p. 11.

system builders faced strained negotiations between many parties (ecological networks), and sometimes the process was shaped by interactions of many actors, none of them providing central coordination (food supply). The motives to construct nationally integrated networks varied from economic advantages for certain companies, social groups or the nation to slowing down the process of urbanisation, propagating healthier eating habits, and the stimulation of biodiversity. In summary, the national material integration on so many and diverse fields is an empirical observation that cannot be directly attributed to the dominance of certain actors or motives. Its explanation would demand further inquiry.

RÉSUMÉ *Dans les Pays Bas, la construction simultanée de la société et des réseaux technologiques à une longue histoire. Cependant ce n'est que dans le vingtième siècle que les Pays Bas devinrent une société en réseaux. Puisant dans le langage technique des travaux dans le domaine des 'grands systèmes techniques' et sur l'histoire empirique des programmes technologiques hollandais cet article montre que durant ce siècle les paysages techniques, sociaux et écologiques furent modifiés par des processus concrets de mise en réseaux. L'étude de cas précis (la production électrique, la chaîne alimentaire, l'industrie pétrochimique et l'écologie) montre une diversité de causes, de motivations, de conflits et de négociations derrière cette obsession universelle pour la création de réseaux de circulation.*

ZUSAMMENFASSUNG *Schon seit langem geht in den Niederlanden die Entwicklung von Netzwerk-Technologien Hand in Hand mit der Umwandlung der Gesellschaft. Aber erst im 20. Jahrhundert wurden die Niederlanden eine wirkliche "Network Society". In diesem Artikel wird gezeigt, wie im letzten Jahrhundert Infrastrukturmaßnahmen technologische, soziale und sogar natürliche Umwelten neu erschufen. Dabei wird auf das Vokabular aus dem Forschungsgebiet "large technical systems" (große technische Systeme) und auf Ergebnisse des Niederländischen Forschungsprogramms für nationale Technikgeschichte zurückgegriffen. Ausgesuchte Fallstudien über die Entwicklung der Stromversorgung, der Nahrungsmittelketten, der petrochemischen Industrie und der Naturschutzgebiete zeigen, wie vielfältig die Entwicklungspfade bei der Netzwerkentwicklung sind-ebenso wie die Motive, Interessen, Konflikte und Verhandlungsverläufe, die hinter der scheinbar universell menschlichen Leidenschaft für Zirkulation und Netzwerkbau stehen.*

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