A HISTORICAL REVIEW OF ENERGY TOPICS IN GERMAN GEOGRAPHICAL LITERATURE FROM 1950 TO 2008

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With 5 figures and 4 tables
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Summary: The article quantitatively and qualitatively evaluates German textbooks and articles in popular German geography journals, discussing patterns of local and thematic tendencies. The analysis shows a growing number of articles on renewable energy, while fossil and nuclear fuels are continuously discussed. Energy plays a minor role in German textbooks, while it is a persisting issue in journals. Nonetheless, a structured energy discussion is hardly visible in geographical journals; instead a large variety of single, unconnected papers has been published. A common theoretical framework does not exist in geographical energy research. As a result, current energy questions are not connected with geography, although geography can massively contribute to the challenges of climate change and decreasing fossil resources.

Zusammenfassung: In einer qualitativen und quantitativen Analyse werden deutsche Geographie-Lehrbücher und Fachzeitschriften in einem Zeitraum von 1950 bis 2008 auf die Behandlung des Themas „Energie" ausgewertet. Räumliche und inhaltliche Strukturen sowie Prozesse werden dargestellt. Während in Geographie-Fachzeitschriften das Thema Energie durchaus präsent ist, findet sich in Fachbüchern kaum ein Hinweis darauf. Dies ist auf die isolierte Behandlung verschiedenster energierelevanter Themen zurückzuführen, bei der keine strukturierte Diskussion aufkommen kann. Somit ist das Thema zwar präsent, kann aber durch die Fragmentierung der einzelnen Beiträge deutscher Geographen nicht systematisch in Lehrbuchform wiedergegeben werden. Darüber hinaus ist keine gemeinsame theoretische Basis der Autoren vorhanden, so dass in den einzelnen Artikeln, oft unzusammenhängend, moderne oder ins Konzept passende Ansätze verwendet werden. Somit ist in der öffentlichen Diskussion um die dringliche Lösung der Energiefrage vor dem Hintergrund von Klimawandel und Ressourcenverknappung die Geographie – als für dieses Thema geradezu prädestinierte Wissenschaft – nicht hinreichend präsent.

Keywords: Geographical energy research, German geography, geography textbooks, geography journals

1 Introduction

In recent years, there has been an increasing interest in energy topics among German geographers. Nonetheless, energy seems to be a less prominent and long-neglected topic which is not included in German geography textbooks, journals, and academic circles. Brücher mentions that energy should be one of the most important issues of geography due to the obvious interactions between energy and space (Brücher 2009, 31). He also points out that the lack of geographical energy research is caused by the many different energy sources, diverse patterns of consumption, and manifold energy subsystems (Brücher 2009, 15).

It is likely to state that in the recent past two processes shifted the energy topic towards one of the most discussed and critically reviewed subjects in public media as well as in geographical papers: the first process may be the peak oil discussion, the post-seventies oil crisis fear of decreasing oil supply, and thus rising prices for fossil energy carriers. The second process may be the climate warming debate, impelled for example by the latest IPCC Assessment Report (IPCC 2007).

This article intends to sketch the major tendencies in the way German, Austrian, and Swiss geographers dealt with the topic of energy from 1950 to 2008. The study reviews German textbooks and the 22 most popular German language geographical journals. The textbooks used in this study have been analyzed in order to describe how energy was integrated into mainstream geography. Articles from journals have been tagged by content and region. This leads to a nearly semi-quantitative analysis of topics and regions within geographical energy research context.

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Similar to this article, SOLOMON et al. (2003) analysed energy geography in the United States and Canada. A comparison between German and American topics is not always possible due to different analysis approaches and time scales. However, at some points, major similarities or differences are worth mentioning.

2 Analysis of textbooks

Before analysing more than 120 post-war German language geographical textbooks, it is necessary to consider whether such textbooks may be seen as mirrors of common geographical knowledge. BLOTEVOGEL and HEINEBERG (1995, 135) expect textbooks to be of high scientific standard, demanding, and well-suited for geographical education in universities. In this article, mostly textbooks from prominent publishing companies (WESTERMANN, TEUBNER, UTB, SPEKTRUM, KLETT) were analysed, which serve as guides in geographic education at university level. Limitations regarding textbooks can persist in the author's personal view on his specific topic, which is a result of own scientific work, main interest, and educational bias. Textbooks usually are remote from the "research frontier" and avant-garde, new approaches, theories or topics. Nonetheless, analysing textbooks can provide a qualitative overview of how energy has been adapted to mainstream geography in Germany.

First, we take a look on some general geography text books. It is evident that energy did not appear in most "complete geography" text books. For example, in LESER's widespread textbook labelled "Geography" (German: "Geographie"), no word is mentioned about energy (LESER 1980). This continues even in later issues, like LESER and SCHNEIDER-SLIWA (1999).

The first larger appearance of the subject in "whole geography textbooks" did not take place until the 21st century. The comprehensive textbook on physical and human geography, edited by GEBHARDT et al. includes a chapter by KREUTZMANN, dealing with political conflicts caused by oil resources (KREUTZMANN 2007). He points out that, by reason of limited oil resources and even the stage of "peak oil," a large number of conflicts for these critical key supply factors are anticipated.

In physical geography, energy issues are hardly visible. RATHJENS (1979, 50) is a physical geographer and the author of a textbook on the shaping of earth's surface under the influence of mankind (German: "Die Formung der Erdoberfläche unter dem Einfluß des Menschen"). He briefly records the effect of oil and gas extraction on surfaces and concludes that surface lowerings take place in various parts of the world, like the USA, Italy, and Mexico. Twenty years later, BLÜMEL (1999, 117) writes in his textbook on the physical geography of Polar Regions (German: "Physische Geographie der Polargebiete") about ecological problems caused by the exploitation of oil and coal in Alaska, Northern Europe, and Asia. He labels the Arctic areas as rich in energy resources, but not yet opened up due to high development costs.

The literature review yielded the first basic outcome that energy issues are more prominent in human geography, which is not a surprise. The textbook on human geography (German: "Allgemeine Anthropogeographie") by SCHENK and SCHLIEPHAKE (2005) includes various chapters by different authors which deal with the subject of energy. In his chapter on historical geography, SCHENK describes spatial attributes of the pre-industrial and industrial energy systems (SCHENK 2005, 230–235). He differentiates between an unstructured solar energy system of hunters and collectors, after the Neolithic Revolution a structured solar system based on agriculture and after the Industrial Revolution an energy system based on fossil energy carriers. The energy system approach is based on SIEFERLE (1982), a German historian, who defined an energy system as containing stable historical phases, dominated by a particular way of energy supply and demand. Each energy system is also characterised by a distinctive land use structure as a result of energy usage processes. In the same book, HAAS and SCHARRER focus on energy economy and its spatial impacts. The authors define energy as a basic necessity for improving living conditions and material prosperity (HAAS and SCHARRER 2005, 427). The following descriptive-oriented sub-chapters deal with global energy supply and demand sides, nuclear power in Germany, and renewables. These are followed by an outlook towards the global energy supply in the year 2060. SCHLIEPHAKE (2005) concludes that the inequity of the spatial energy resources distribution will persist or even increase. In a forthcoming energy system, energy will shape location and space more than before (SCHLIEPHAKE 2005, 444).

In his introductory textbook on human geography (German: "Anthropogeographie/Humangeographie"), HEINEBERG (2007, 17) notes that the topic of energy consumption is a part of physical human geography (German: "Physischer Anthropogeographie"). He sees the energy question as part of the debate regarding

the limits of growth; with the main statement that mankind consumes the earth's energy resources faster than they recover (Heineberg 2007, 69). Later in this book, energy is merely seen as production factor, location factor, or as part of the cost function of companies, as well as in economic geography and transportation geography. In the field of rural geography, he identifies the reduction of energy consumption and the promotion of renewables as part of development goals for rural municipalities (Heineberg 2007, 292).

Originally published in English language, the textbook on human geography by Knox and Marston (2008) was translated to German and was widely recognized in German speaking countries. In the chapter on interdependencies of nature, society, and technology, a subchapter deals with the effects of energy consumption on the environment. After a short historical review, the present energy structure worldwide is analysed with a special focus on environmental consequences (Knox and Marston 2008, 216-226). Another section deals with alternative solutions, mostly hydro, solar, wind, geothermal, and tide power and their spatial distribution in a worldwide perspective. Later, Knox and Marston describe energy as an important factor for economic development (Knox and Marston 2008, 447–448). Finally, the authors mention the growing dependence of industrialized countries on oil exporting countries outside the core economic regions (Knox and Marston 2008, 730).

Energy made its way into textbooks primarily in connection with economic and industrial geography. One of the leading energy experts in German geography, W. Brücher (1982), discusses selected energy topics in his 1982 published textbook about industrial geography. He limits his remarks almost explicitly to energy production, refining, and finishing. He defines energy as an industrial branch on the one hand and as a location factor on the other hand. Due to this dual function and the fact that 80 percent of all energy usage comes from refined, processed energy; the finishing of energy receives a special spatial importance (Brücher 1982, 88). He analyses the spatial distribution and its underlying dynamics of energy processes using two examples: the German refining and electricity industries. Brücher explains the German petrochemical industries' configuration by means of historical and economical developments which lead to present spatial patterns. The most interesting aspect regarding the electricity industry is, according to Brücher, its ability to immediately respond to an alternating power demand (base, medium, and peak load) using an assortment of types of power plants (he describes water, coal, oil, gas, and nuclear plants), which all have their specific location factors (Brücher 1982, 100). To summarize, Brücher excludes all questions on basic exploitation, trade, social questions or ecological consequences. The view of energy as part of industrial geography persisted in German geographers' minds for more than 20 years. At least it was hardly corrected in textbooks until Brücher himself addressed the energy question, publishing the first German geographical textbook on energy in 2009.

In contrast to Brücher (1982), Voppel names processes of energy transformation (as results of industrialization) as having major impacts on the natural ecosystem. Voppel inquires into the need for financial investments in order to minimize the negative effects of the energy industry and to challenge massive ecological problems (Voppel 1990, 23). He gives an introduction into the history of industrialization, which is closely connected to the growing need for the usage of energy. He stresses the influence of energy related issues on the spatial pattern of industries. Later, Voppel describes coal, oil, gas, and "other" energy sources and their influence on spatial configurations of industry locations. He judges renewable energy as hardly capable for providing larger shares of energy supply.

Schätzl published a series of books on economic geography in three parts. In part two, focussing on empirical issues, he refers to global energy resources and problems due to population growth and rising standards of living (Schätzl 2000, 179). He closes his few remarks on energy, concluding that developing countries hardly achieve economic progress, even if they have access to national energy resources (Schätzl 2000, 181).

The textbook on economic geography by Voppel (1999) contains a chapter on fossil and renewable resources. It is dominated by an outline of historical developments and present structures of energy demand and supply (Voppel 1999, 135–145). A short subchapter on energy as a location factor for different energy sources follows before the supply side is analysed (Voppel 1999, 141–145, 216–218). The key statement is that each energy resource has a special potential scope. According to Voppel, solar, wind, and hydro energy are not mobile and can only be used near the local plants, while coal, oil, gas, and uranium are movable and can be transported to major supply centres (Voppel 1999, 216). This causes a specific pattern of the energy supply structure (Voppel 1999, 141).

In the rather theoretical textbook on economic geography of Bathelt and Glückler (2002), energy is merely seen as scarce production factor which is characterised by an increasing demand of space. This may lead to conflicts and, in the worst case, to severe confrontations and even wars (Bathelt and Glückler 2002, 53).

In his concise dictionary on terms in agrarian geography, Spielmann (1989, 23, 114) sees energy as a production factor for agro companies. He focuses on the increased energy efficiency as response to rising energy prices.

In transportation geography, energy has become a serious topic since the 1990s. For example, Maier's and Atzkern's textbook on transportation geography (German: "Verkehrsgeographie") contains a short chapter on energy and transportation (Maier and Atzkern 1992, 219–221). The authors point out that the energy consumption in the field of transportation as well as the share of this sector compared with total energy consumption in Germany steadily increases (Maier and Atzkern 1992, 221). In their textbook about transportation geography, Nuhn and Hesse (2006, 334) briefly discuss energy issues as part of the changing mobility framework. They describe how the growing demand for energy causes rising oil prices, which leads towards a new importance of transport costs. This initiates a different economical calculation of traffic-intensive life and business models (Nuhn and Hesse 2006, 335). The textbook about transportation geography (German: "Geographische Mobilitäts- und Verkehrsforschung") from Gather et al. (2008) only mentions energy in connection with the concern over the ecological impact of traffic. The authors predict that the increase of freight traffic and the connected increase of CO_2 emissions will balance out the decrease of emissions caused by more efficient individual cars.

In textbooks on developing countries, energy is often seen as critical for economic development. The textbook on developing countries (German: "Entwicklungsländer") by Scholz contains a short excursus about countries that are rich of resources. He states that countries from the southern hemisphere play an important role as suppliers of resources in general and energy sources specifically, but these countries' position is very unstable, due to dependencies on industrialized countries and competition between poor supplier countries (Scholz 2006, 186).

In his textbook on political geography (German: "Politische Geographie"), Boesler (1983, 153) considers energy resources as a starting point for political decisions. He distinguishes between four aspects of resources accessibility: ease of production factors access; geographical locations of extractions and their distances to consumption; basic social, cultural, and ecological conditions; resilience of natural surroundings. Boesler describes the energy dependencies of industrialised countries, which have to import the majority of their resources. Moreover, he points out that the industrialized countries' risks increase with rising import dependency, lower diversification of supply structures, higher market power of individual suppliers, higher chances of substitution, and lower possibilities of recycling (Boesler 1983, 167). He concludes that energy politics is most important among all resource related affairs of state. However, except from criticism of developing countries' inefficiency, he does not feature the risks of the present trade structure for developing countries, which is – even at that time – a narrow-minded true European-centric perspective.

Regarding the geography of rural or urban areas, energy is also less prominent. Henkel (1999) gives a short note on historical changes in agricultural techniques caused by innovations in energy supply in his textbook on rural areas (German: "Der Ländliche Raum"). He describes mechanization as driving force for efficiency in agriculture (Henkel 1999, 121). Also, the electrification of rural areas caused the driving out of manufactured goods by handcrafters, who were replaced by centralized, larger production units. The latter initiated an increased number of trade activities (Henkel 1999, 186). Heineberg's (2006) textbook on urban geography (German: "Stadtgeographie") relates to energy in a few points. He describes concepts of a "functional mix" in cities, which – among others – may reduce the consumption of space and energy (Heineberg 2006, 53).

In regional geography, according to Hettner's scheme, energy is seen as space-shaping feature or critical development factor. In his textbook on centralism in France (German: "Zentralismus und Raum. Das Beispiel Frankreich"), Brücher describes centralized and centralizing economic decision structures in France after 1946, which led to the nationalization of the whole energy industry (Brücher 1992, 53). Brücher then describes the location of French nuclear power plants. They were located near rivers due to required water cooling, but also near large settlement and business agglomerations like Paris (Brücher 1992, 65). The focus on hydro power in rural parts like Limousin, where existing small hydro plants were driven out of business by larger units managed by the national firm Electricité de France

(Brücher 1992, 74). Brücher closes with an explanation of the French way towards nuclear power, which is more or less the result of the centralized government's wish to reduce import dependencies (Brücher 1992, 198). In Wiese's textbook on the regional geography of Africa, the topic of energy plays a minor role in different sections. He names two major problems. Firstly, 90 percent of the population in tropical Africa uses firewood as primary energy source. Secondly, oil is the major source of national income in many African countries (Wiese 1997, 16). Later, he mentions large dam projects, which on the one side provide energy for economic uses, on the other side cause ecological and social problems (Wiese 1997, 54). A historical review on energy resources and the energy branch is presented in a subchapter. Wiese explains the spatial heterogeneity of energy resources, differentiating "rich" countries in Northern and Western Africa (oil), South Africa and Zimbabwe (coal), Namibia and Niger (uranium), as well as many other countries without any access to fossil energy (Wiese 1997, 192). In tropical Africa, firewood still is an important source of energy, causing ecological problems like deforestation (Wiese 1997, 195).

The main finding of the review of German geographical textbooks is that topics of energy play a minor role in the broad palette of geographical work in textbooks. The reasons for this are discussed in the results chapter of this paper.

3 Analysis of articles

3.1 Methodology and publication output

For the following analysis, German geographical journals were examined. According to a preliminary definition of geographical energy research as a multi-approach and cross-subdiscipline research area, the only selection criteria consisted in linkages to energy related topics. Energy should play a dominant role in the publication. It is evident that most of the authors did not mainly consider themselves or their papers as part of geographical energy research. Nonetheless, the review of articles may help to understand which energy related topics and which regions are of particular geographical interest.

Table 1 lists the 22 respective journals containing 375 relevant articles. Articles were categorized as relevant if their major focus was on energy topics. It shows that the "Geographische Rundschau" includes nearly one third of all applicable papers (120 articles). Rank 3, 4 and 5 are held by school and teaching oriented journals ("Zeitschrift für den Erdkundeunterricht", "Praxis Geographie" and "Geographie und Schule"), resulting in a total of 76 articles.

The first aspect to consider is the absolute frequency of published articles, in order to see the academic output activity over time. The absolute frequency of published energy relevant articles in German geographical journals between 1950 and 2008 is shown in figure 1. Although a steady increase cannot be indicated, an increase of total numbers can be seen from 1979 on. At first glance, it seems that there are peaks in publication output in the 1980s and from 2004 on. However, compared to the absolute frequency of all published articles – whether energy related or not – in the reviewed journals (Tab. 2), only one significant peak in the 1980es can be identified. While the share of energy related articles increases slowly from 1.45% in the 1950s to 1.68% in the 1970s, the share is doubled in the 1980s with 2.45% of all articles related to energy. A decrease to 1.88% in the 1990s is followed by a leap to 2.81% in the not yet completed first decade in the 21st century. This matches with the research of Brücher, who indicates that 2.5% of geographical articles between 1974 and 1995 had a major focus on energy, while 1.3% had an indirect relation to energy (Brücher 2009, 31). It is likely to expect that this decade will be the first to cover more than 3% energy related articles, which is due to an increasing number of geographers working specifically on energy issues.

3.2 Contents and regional foci of publication output

Absolute and relative frequency

Each relevant article was integrated in a relational database system and was manually tagged with additional information. The first item consisted of a linkage between time and the described energy carriers (Tab. 3). Thus, it should be possible to distinguish between each fossil and renewable segment over time. We see that coal and oil dominated the publication output until the 1980s, when renewables quickly caught up, especially hydro power (1980), later wind (1990) and biomass (since 2000). Table 3 and figure 2 show the relation between publication years and described energy topic. They indicate that renewables supersede fossils in the 1980s. While the number of articles dealing with coal, oil or nuclear subjects decreases,

Table 1: Analysed German geographical journals

Rank	Journal	Energy related articles
1	Geographische Rundschau	120
2	Informationen zur Raumentwicklung	35
3	Zeitschrift für den Erdkundeunterricht	27
4	Praxis Geographie	25
5	Geographie und Schule	24
6	Geographie heute	23
7	Naturschutz und Landschaftsplanung	22
8	Natur und Landschaft	14
9	Raumforschung und Raumordnung	13
10	Zeitschrift für Wirtschaftsgeographie	12
11	Die Erde	12
12	Erdkunde – Archive for Scientific Geography	10
13	Petermanns Geographische Mitteilungen	8
14	GeoBit	7
15	Berichte zur deutschen Landeskunde	6
16	GIS Business	4
17	Zeitschrift für Geomorphologie / Supplement	4
18	Informationen/Institut für Raumforschung	3
19	Geographische Berichte	2
20	Geographische Rundschau / International Edition	2
21	Zeitschrift für Geomorphologie	2
22	Geographische Zeitschrift	1

simultaneously especially the topics wind (44 articles), biomass (42), and hydro (28) gain attention of German language geographers.

Aggregated to fossil and renewable energy, the picture is getting sharper: the fast rise of renewables since the 1980s did not substantially decrease the publication output referring to fossil energy issues.

Regional classification

The second tag of each article consisted in a spatial localization by continent (Tab. 4). The regional focus of articles is directed to Germany and the other European countries with more than 200 publications. Global topics with relation to energy are analysed in 41 cases. Concerning other continents, Asia (53) is dominant, while Africa (23), the Americas (North America: 18, South America: 17), and Australia (2) are left behind. 19 articles were not focused on special regions.

Worldwide distribution

Figure 3 presents a time-spatial pattern of post-war geographical energy research publications. Besides the growing number of publications on Germany's and Europe's energy issues, it is remarkable that Asia marks a steadily increasing number of articles, mostly caused by Central Asia's oil and gas industry transformations and later by China's growing energy needs. Starting with numerous articles on economic issues like oil in Iran, Arabian countries, and the Soviet Union (Weigt 1957; Fellmann 1965; Gerloff 1967; Nötzold 1969), social and development topics emerge in the 1980s (Scholz 1980; Gerlach 1982; Manshard 1982 among others). Transformation struggles due to the Post-Soviet era ascend from the mid-1990s (Wein 1996; Wagner 1997; Scholz 2002).

For Africa and South America, two peaks of article output are visible in the 1980s and the first decade of the 21st century. The reasons for this rise in Africa

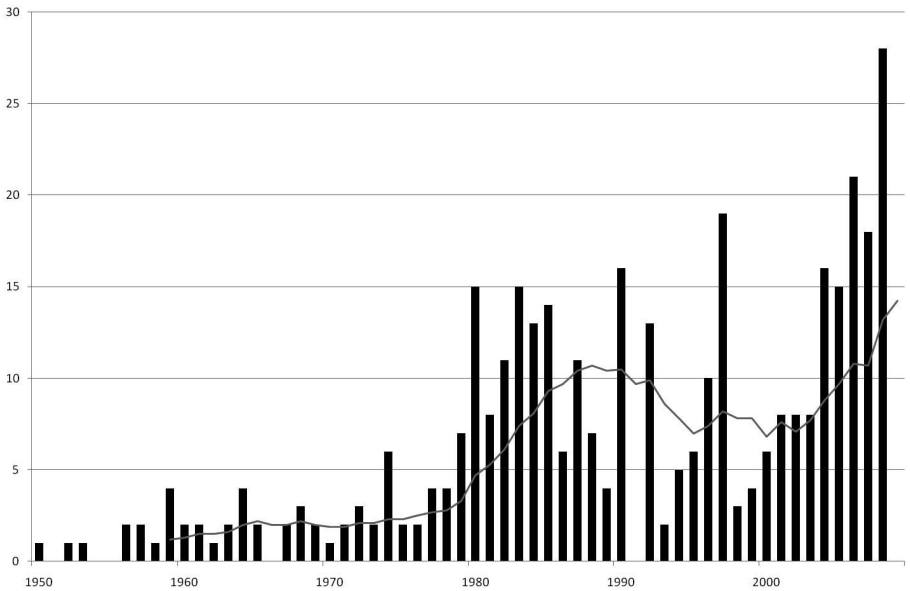

Fig. 1: Absolute frequency of published energy relevant articles in German geographical journals between 1950 and 2008. The grey line indicates the moving average based on a ten year interval.

consist in scores of economic geography related publications on primarily oil and gas resources and its exploitation (Gabriel 1979; Gellert 1980; Sanusi 1983 among others). Later, issues on energy scarcity as a development barrier were widely discussed (Krings 2000; Lado 2002; Bahr 2007 and Schüssler 2008a). For South America, a more diversified publication structure is visible. Articles concentrate on oil and gas, but also on hydropower and coal, mostly in Brazil and Venezuela. North America has a peak in the 1990s with no evident subject concentration.

Articles on energy with regional focus on Germany

The situation in Germany is visualised in figure 5. In Germany, the progress in geographical energy research began with works on coal in the mid 1950s (Köhler 1957; Knübel 1958; Wohlrab 1959; Uhlig 1959; later Melz 1961; Barthel 1963). The first articles on the exploitation of oil in Germany were published by Ebel (1960), Walter (1963, 1964) and Graeber (1964). Works on refinery locations followed by Bürger 1967, Hausmann 1968, Riffel 1972, 1973 and – with a focus on the Wilhelmshaven harbour – by Degener (1974). In the 1970s, the main focus shifted towards a considerable problem oriented view on energy locations and resulting problems, regarding coal, energy efficiency, and general problems caused by energy industries.

In 1980, Julius published his article about renewables as a potential solution for German energy supply, which can be regarded as milestone in German geographical discussion of renewable energy supply. Afterwards, one part of the discussion shifted towards rural areas and potential for biomass production (Bahr 1982; Lücke 1983; Peters 1983). Nonetheless, the 1980s were still dominated by the topic of coal. In the 1990s, a diversified palette of topics were published, mostly articles on coal (Lotzmann 1990; Ebert and Zlonicky 1990; Täubert 1992 among others) and wind power (Jarass 1990; Kleinschmidt et al. 1994; Breuer 1996; Mielke 1996; Wolpert 1996 among others). Oil, nuclear energy, and renewables played only a minor role in this decade.

The relations changed in the first eight years in the 21st century. Works on coal decreased in num-

Table 2: Absolute and relative frequency of energy related articles in German geographical journals between 1950 and 2008

Articles in German Geographical Journals			
	Absolute	Total	Relative
1950-1959	12	829	1.45 %
1960-1969	20	1458	1.37 %
1970-1979	33	1967	1.68 %
1980-1989	104	3531	2.95 %
1990-1999	78	4143	1.88 %
2000-2008	128	4555	2.81 %

Table 3: Absolute and relative frequency of energy related articles in German geographical journals

	1950–1959		1960–1969		1970–1979		1980–1989		1990–1999		2000–2008	
	Sum	%	Sum	%	Sum	%	Sum	%	Sum	%	Sum	%
Coal	7	54	9	41	5	16	13	14	18	22	7	6
Oil	5	38	11	50	21	68	23	27	17	20	19	17
Gas	1	1	2	9	4	13	2	2	7	8	5	4
Nuclear	0	0	0	0	1	3	9	11	3	4	3	3
Biomass	0	0	0	0	0	0	7	8	6	7	29	25
Hydro	0	0	0	0	0	0	12	14	6	7	10	9
Solar	0	0	0	0	0	0	6	7	5	6	7	6
Wind	0	0	0	0	0	0	6	7	14	17	24	21
Geothermal	0	0	0	0	0	0	7	8	6	7	4	4
Hydrogen	0	0	0	0	0		0	0	1	1	6	5

bers, while especially wind and biomass were intensively discussed. Wind power installations were examined under the planning aspects (Schwahn 2000; Breuer 2001; Egert and Jedicke 2001; Nohl 2001 and many more) as well as ecology impacts (Ketzenberg et al. 2002; Kriedemann et al. 2003). Biomass was seen through the perspective of agriculture and rural land use (Karpenstein-Machen 2004; Reinhard and Gärtner 2005; Hillebrecht et al. 2005; Wichtmann and Schäfer 2005; Mette 2005; Breuer and Holm-Müller 2006; Schüssler 2008b and others). (Fig. 5)

Table 4: Regional classification of energy related articles between 1950 and 2008 in German geographical journals

Region	Articles
Germany	138
Europe	64
Asia	53
Global	41
Africa	23
North America	18
South America	17
Australia	2

4 Results

The main findings of this literature review can be summarized in four basic theses, which interact according to the same underlying context.

1. As identified above, energy is hardly visible in German geographical textbooks. The publication of Brücher (2009) is the first single textbook that deals with energy geography. What are the reasons for this evident gap? Brücher (2009, 32) names four explanations: due to ubiquitous availability of energy from oil, gas, and coal, energy is not a critical location factor and hence loses spatial relevance. Second, energy became more related to ecological impacts, which distracted from truly spatial aspects (Brücher 2009, 33). Third, energy is dominated by political developments, which also decreases geographical interest in this issue (Brücher 2009, 33). Last but not least, energy in German textbooks was more or less concentrated on industrial geography (Brücher 2009, 33). All four reasons by Brücher can be seen very critically and may be just scratching the surface: Brücher's first point is incongruous, since renewables quickly rose in the 1980s as a new topic and are strongly related to spatial aspects, such as optimal location search for wind, biomass or solar energy and new energy systems. Regarding his second thesis, ecological impacts of (energy-related) economic activities were present as major foci in geography, particularly in human ecology approaches. Third, political topics are the core field of studies in political geography, and can be found in many articles, but hardly in textbooks. Brücher's fourth thesis is true as long as it is applied to textbooks, but the thesis is false if applied to single articles, which cover a wider range of geographical topics. The first reason for the absence of energy in textbooks is the scattered range of energy topics in geographical journals, which made it impossible for textbook authors to identify research foci and structured discussions within geographical

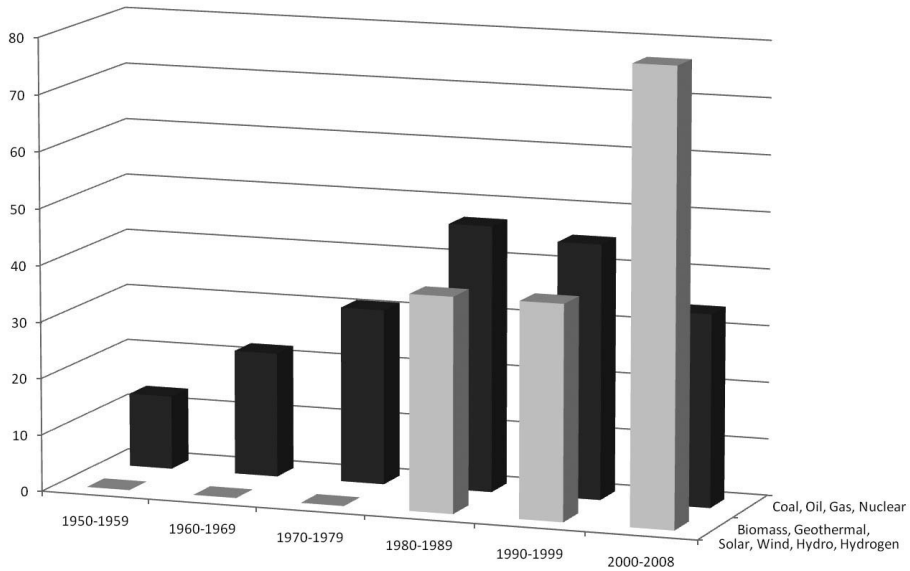

Fig. 2: Absolute frequency of articles on fossil/nuclear fuels and renewables in German geographical journals

research. The second reason can be explained by the fact that there is no common theoretical basis for geographical energy research. For their studies, authors search for suitable theories and try to use them as theoretical framework. Especially different historical energy systems, process chains, the sustainability concept or regulation theory are often used. Due to the missing common energy approach, no consistent debates have developed, which could be integrated into mainstream geography. This leads to the following point.

2. A variety of energy topics is visible in German geographical journals, including content on fossil and renewable energy, physical and human geography, and local to global scale. Like SOLOMON et al. (2003, 309) figuratively describe, "many rich veins wind through the energy landscape". This is simultaneously promising as well as threatening for geographical energy research. The analysis of articles illustrates that a common theoretical framework, mutual approaches and even related discussions are missing in German geography. There are hardly any references between the articles and no connected progressions, which indicates that work is almost entirely based on single scientists' effort as "loners". If energy should play a larger role in German geography, the need for networking among energy geographers is obvious. One noteworthy effect consists in the foundation of an academic circle within the GERMAN GEOGRAPHICAL SOCIETY dealing with geographical energy research (German "ARBEITSKREIS GEOGRAPHISCHE ENERGIEFORSCHUNG in the "DEUTSCHE GESELLSCHAFT FÜR GEOGRAPHIE") in the year 2006. As SOLOMON et al. (2003, 309) point out in their article on energy in American geography, at least some core emerging challenges have to be detected and have to be outlined as major fields of study, due to the fact that the number of energy geographers is insufficient to the task of working on all the "bright and attractive research topics".

3. As mentioned above, in the 1980s renewables caught up in publication numbers. The fast rise of renewables since the 1980s did not substantially decrease the publication output referring to fossil energy issues. However, in the first nine years of the 21st century, the number of publications referring to renewables doubled that of those referring to fossil fuels. In order to have a balanced mix, research must continue on fossil fuels as well as renewables, because both determine spatial energy systems and regulations.

4. In public discussion, energy issues are not linked to geography. Political, economical, and ecological questions dominate, while the contribution of geographers for solving energy-related questions is not present in public media. Together with the integration of energy as topic for geography lessons in schools, these might be important tasks for the future in order to establish geographical energy research as essential field of work.

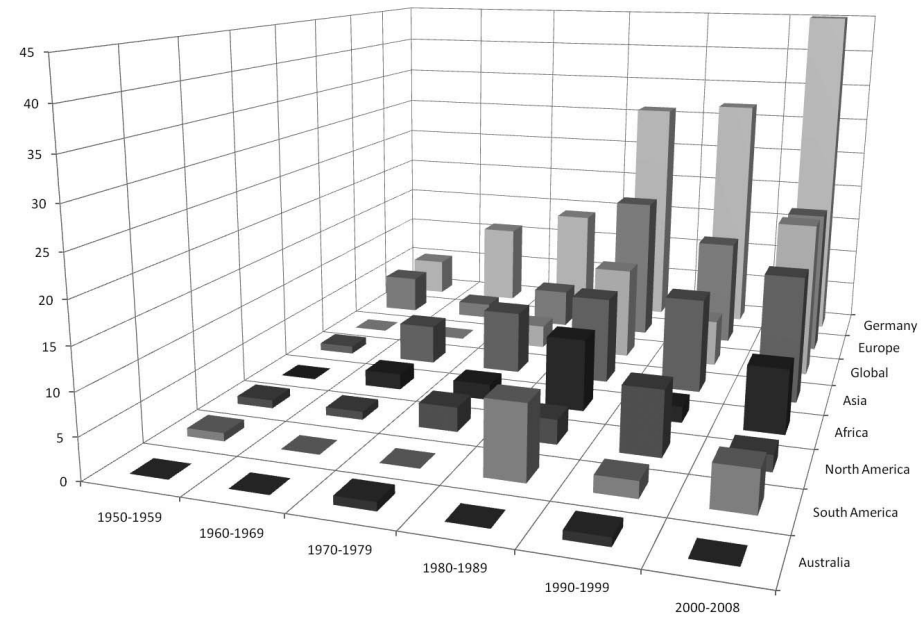

Fig. 3: Time-spatial patterns of geographical energy publications between 1950 and 2009 in German geographical journals.

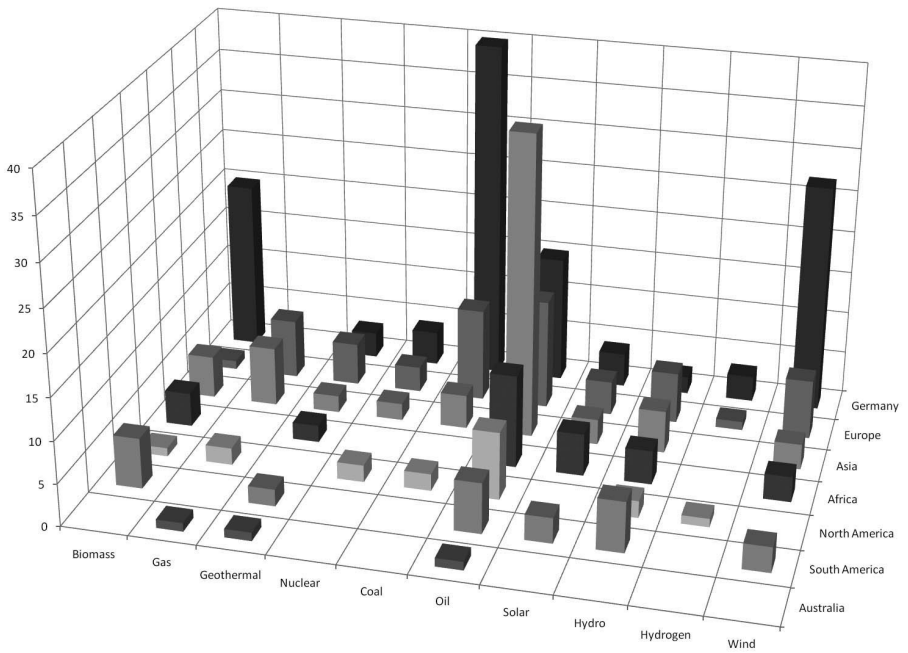

Fig. 4: Spatial-content pattern of articles on energy in German geographical journals

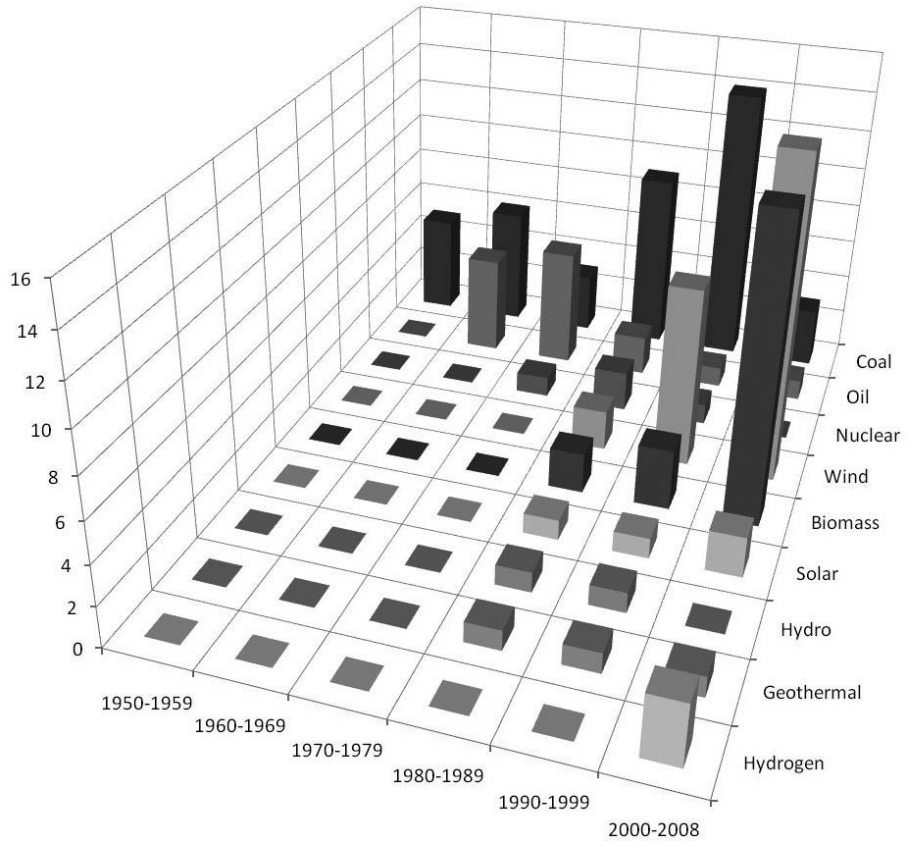

Fig. 5: Energy-related publications in German geographical journals with the regional focus on Germany between 1950 and 2008.

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