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(Why) did Desertec fail? An interim analysis of a large-scale renewable energy infrastructure project from a Social Studies of Technology perspective

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ABSTRACT

In 2009 the Desertec Industrial Initiative (DII) was founded by several, predominant German enterprises. The objective of DII was to organise the conditions for the realisation of the Desertec idea, which aimed to both (a) supply Europe, in a large-scale manner, with electricity produced in solar power plants in North Africa and the Arabic peninsula and (b) contribute to the self-supply of the Middle East North Africa region (MENA). Protagonists of the desert energy idea saw this megatechnic project as a starting point for a new trans-Mediterranean EU-MENA union, critics in contrast as a neo-colonial project. Disputes over the adequate interpretation and implementation of the Desertec idea broke out from the beginning. In 2014/2015, the media talked of the failure of DII and of the Desertec concept. The majority of the members left DII at the end of 2014. On the other hand, in some MENA countries renewables are playing a crucial role in securing the future of the energy sector. This paper analyses the development of DII and the Desertec idea by using concepts from Social Studies in Technology, and especially by the multi-level perspective approach in Transition Studies. It shows how the interplay of different factors, such as technological developments, entrepreneurial performances and political processes, lead to internal conflicts and the non-realisation – up to now – of related large-scale energy projects. As an important aspect of the paper, different understandings of the future of our energy supply and of North–South relations are presented in detail.

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1. Introduction: a transcontinental infrastructure project for renewable energy as a potential topic for STS

In July 2009, at a press conference held on the premises of Munich Re, a German reinsurance company, several companies, some of them with an international reputation, including Siemens, the Deutsche Bank and the two big energy providers RWE and EON, presented plans for a spectacular large-scale infrastructure project: under the name of a new consortium, Desertec Industrial Initiative (DII), they wanted to start preparing the erection of large-scale concentrated solar power plants (CSP) in the desert areas of North Africa and the Middle East, which would supply power not only to the countries in the MENA region (Middle East – North Africa), but also to Europe. The plans included new transmission lines from North Africa and the Middle East to Europe, using high-voltage co-current technology (Figure 1). At the press conference, there was talk of a possible investment volume of 400 billion euros by the year 2050.¹ In addition to companies involved in the power

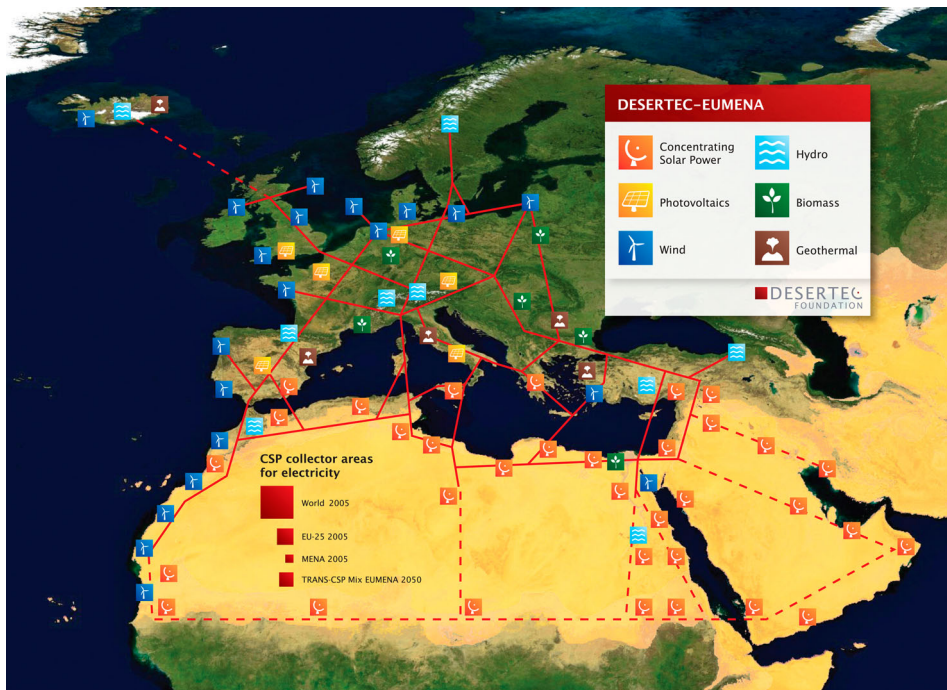


Figure 1. Illustration of the Deserotec concept by the NGO Deserotec Foundation (Deserotec Foundation 2009b).

plant technology and supply industry, electric utilities and the financial sector, the consortium included the Deserotec Foundation, an NGO which, like its predecessor TREC,² had in the past called for such an infrastructure project on the basis of renewable energies, especially CSP. The Deserotec Foundation described the project as a means of combating climate change, but also as a way of establishing a new partnership between the countries north and south of the Mediterranean; this would help to stabilise the southern Mediterranean countries economically and socially by providing jobs and income. At the press conference, the commercial enterprises involved in the DII also adopted the Foundation's rhetoric of responsibility. Deserotec appeared not only as a blueprint for a huge industrial project, but also as a comprehensive vision of transcontinental sustainable development through the building of a large-scale infrastructure: "This initiative is an impressive example of how business interests, a sustainable economy and social responsibility can be harmonized", were the words of the CEO of Munich Re, one of the biggest reinsurance companies in the world.³

It is not surprising that such a project aroused interest in the social sciences, including human geography (Schmitt 2012). From a genuine perspective of human geography, it is interesting to see how the Deserotec Foundation and the DII constructed and spread a new spatial concept, namely "EUMENA", to refer to the economic and political integration of Europe and the MENA region on the basis of a large-scale transcontinental infrastructure project. Furthermore, the project is directly linked to issues like regional and sustainable development and interregional justice. Is the project a remake of colonial exploitation schemes between Europe and North Africa or the Middle East, or, on the contrary a fair contribution to the economic development of the southern Mediterranean countries, or perhaps a specific mixture of idealistic and profane, profit-oriented or even exploitative, motivations?

In the German media, but also in international media, including those in the MENA region, this idea was greeted with enthusiasm in 2009/2010. Due to the superficial media reception, many readers probably gained the impression that corresponding investments in power plants and

transmission lines were on the brink of realisation. However, in later discussions and publications, the DII and its press spokesman made clear that the new consortium first needed to explore the regulatory conditions for such investments, and wanted to contribute to improving them in the political space. In the first two years, the number of DII's shareholders and cooperation partners constantly increased (see Figure 2 for an overview of the social actors, organisations and institutions involved in Desertec/DII). However, by 2013 at the latest, the tone of the reports changed. The hype over Desertec seemed to have come to an end, and instead media reports now talked of fierce "conflicts" (Balsler 2013c) – the conflict lines, including those of intended North–South relations and questions of spatial justice, will be discussed in Section 6 – and of a "shadow" (Balsler 2013a) over the solar energy project; the renowned daily newspaper *Süddeutsche Zeitung* commented melodramatically that "the future was being destroyed" (Balsler 2013c). In the autumn of 2014, the media finally announced the end of Desertec; the dreams of energy from the desert had not come true. Indeed, most of the shareholders backed out of DII at the end of 2014. Since 2015, at first with only three shareholders (but a number of other cooperation partners), the DII has been based in Dubai instead of in Munich and has continued to operate under new conditions. It would thus appear that the project consortium which attracted so much media attention, and was started by leading, financially powerful companies, apparently with strong political support, has been reduced to a small project company with a handful of employees.

The initial Desertec concept, however, intended to implement a large-scale infrastructure project. Large-scale energy infrastructures, like nuclear power plants or nuclear deposits, and the corresponding organisational units, have been contested time and again by social and ecological movements, not only due to their risks for the environment and human health, but also due to their centralistic and antidemocratic character (Mumford 1964), often concentrating their environmental risks in peripheral or socioeconomically disadvantaged regions. When the Desertec project came into public focus, the question arose whether such a large-scale infrastructure project based on renewable,

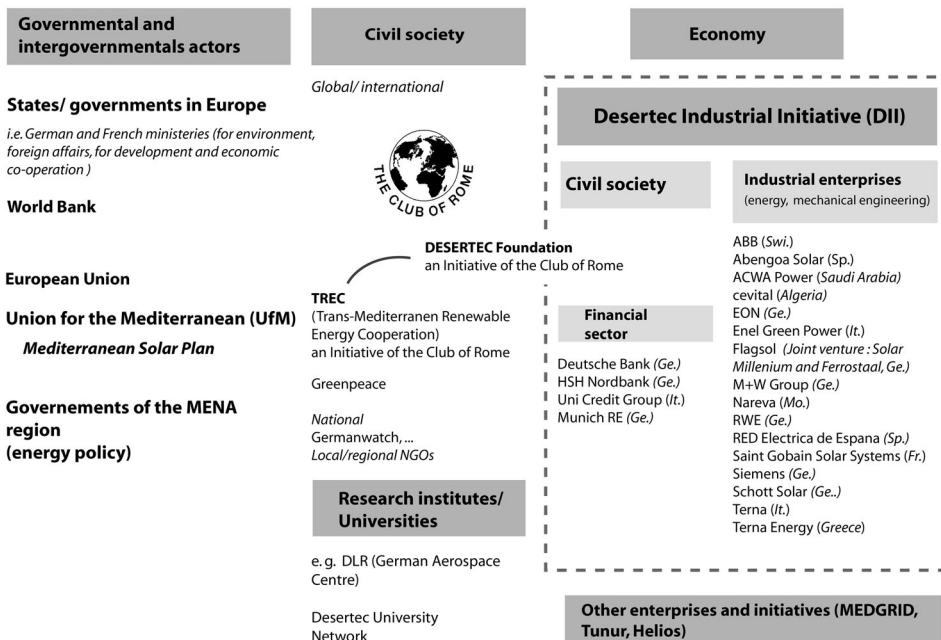


Figure 2. Stakeholders and organisations involved in the development and relevant for implementation of the Desertec concept (situation 2012). Source: by the author (Schmitt 2012, adapted).

rather than on fossil or nuclear energies would have similar or different effects on issues like power relations, equity and social and environmental justice.

As a large-scale infrastructure project based on renewable energies, the Desertec project and its history to date – including its initial failure – is potentially a very interesting case study for the discipline known as Social Studies of Technology (SST) which can be conceptualised as a branch of Science and Technology Studies (STS). One of the main activities in SST is reconstructing the reasons (as a rule multiple reasons) why certain technologies become socially accepted and established, while other, often competing, technologies do not (see Section 2). Why did a consortium of big, financially strong and politically well-networked companies not succeed in launching the Desertec project? Conversely, we might ask: How did it come about in the beginning that these companies let themselves be guided by the concept of an NGO? When the Desertec idea was made the object of a Memorandum of Understanding by a consortium of world-renowned companies, one might have assumed – to use the vocabulary of SST – that this idea had left the area of technological niches and had every chance of becoming an established part of the sociotechnical system of energy supply. But this has not happened, at least not until now; rather, it seems that Desertec became a part of this sociotechnical system only virtually, in concepts, and then sank back into a technological niche. The main aim of this paper is to analyse the “rise” and “fall” of the Desertec idea with the aid of categories developed in SST, especially the multi-level perspective (MLP). How can the fate of the Desertec idea over the past few years be explained in terms of the interplay between technological, economic and cultural developments and processes, and in terms of decisions made by companies, NGOs, scientists, authorities and politicians? The author believes that a reconstruction of this case can also make a contribution to the wider debate in the SST on the establishment of large-scale infrastructure projects, and to the discussion of competing forms of sustainable energy supply structures in Transition Studies. Transition Studies, and especially the Multi-Level-perspective approach (see Section 2), are sometimes accused of reproducing functionalistic or schematic views of societal development and the implementation of new technologies (see Geels and Schot 2007, 402; Truffer and Coenen 2012, 4), ignoring the social effects of technologies beyond the question of sustainability (Shove and Walker 2007). For this paper, not only the *new mainstream* publications in Transition Studies, but also a broad range of approaches to the social study of technology have been considered, including early insights of Max Weber (1864–1920), reconstructions of the history of large-scale technical systems (i.e. Mayntz and Hughes 1988), and sociologically informed critiques of dominant technological systems, for instance with a background in ecological movements (i.e. Mumford 1964; Scheer 2012).

Empirically, this case study is based on qualitative research carried out over several years, including analyses of interviews with actors and observers. Some basic concepts from SST and Transition Studies are introduced in Section 2, and a short note on methodology in Section 3 is then followed by an analysis of the development of the Desertec idea based on these concepts.

2. Conceptual background: the Transition Studies perspective and social research on ideas and technology

The following analysis reflects approaches within the SST in a broad sense (see, for example, Degele 2002), and from Transition Studies and its MLP, and refers to research in the social sciences on the link between ideas and technology. Since these approaches and concepts, especially MLP, have been discussed in detail in recent years, including discussions of their possible deficits (i.e. Geels 2005a; Geels and Schot 2007; Truffer and Coenen 2012), I will offer only a brief account of them here, in order to explain the terminology used in the following analysis.

Transition Studies is here seen as a part of the more general research field known as SST. It is mainly concerned with showing how social, cultural, economic and political factors, decisions made by groups of actors in negotiation processes, and institutional settings such as laws, subsidies, governance settings, etc. can influence the development and application of technologies. A

generally accepted core insight of STS is that it is not automatically the “best” technology – however this may be defined – that becomes established, but that in the competition between different technological systems, the factors referred to above can play a decisive role in the establishment or non-establishment of a particular system (i.e. Bijker, Hughes, and Pinch 1987; Degele 2002; Geels 2005a; Dolata 2011). This basic insight, which is fundamental to SST, was already formulated by Max Weber (a fact which is hardly ever mentioned in the international literature, especially within Transition Studies). With reference to the defenders of technological determinism, Weber argued that:

as long as they do not recognize that it was and is certain *historically* given and historically alterable *social* conditions, i.e. constellations of *interests* of specific kinds, which made first possible and will make possible (or even impossible) the utilization of *technical* “discoveries” in general, and that consequently the way in which the future of technological development takes shape is also dependent upon the development of these constellations of interests and in no way upon purely technical “possibilities” alone, – no fruitful discussion between us is possible (Weber 1984, orig. 1909, 51, emphasis in original).

However, despite the groundbreaking nature of Weber’s insight for SST, it focuses purely on interests and makes no reference, at least at this point, to cultural factors (or, to use more modern terms, hegemonies, visions and umbrella concepts), which elsewhere play an important role in his work, and which were also prominently discussed in later research on the genesis of technologies. For instance, Degele (2002, 47; in reference to Dierkes, Hoffmann, and Marz 1992) points out that,

The paradigmatic method of research on the genesis of technologies is research on visions/umbrella concepts [*Leitbildforschung* in the German original] (...). It asks which projective formations (umbrella concepts [*Leitbilder*]) social actors refer to in their agency, especially during the early stages of development of a new technology, and how these formations become effective.

In accordance with the at least potentially important role of umbrella concepts for the genesis of a technological system, I will discuss conflicts on competing understandings of the Desertec idea in chapters 5 and 6.

In contemporary SST, the co-evolutionary development of technological systems, economic structures, and the social, cultural and regulatory environment is taken for granted. Research on technology in the social sciences and by historians has generally taken this co-evolution into account (see for instance the classic study by Pinch and Bijker (1987), which considers how today’s iconic forms of the bicycle grew out of the penny-farthing; or the study by Geels (2005a), which has also become a classic, with its discussion of how sailing ships were replaced by steamships). But the majority of authors today understand the term Transition Studies as referring especially to the environmentally sustainable transformation of societies (i.e. Lawhon and Murphy 2012; Schulz 2012), in other words, the establishment of renewable energies and types of production and consumption which preserve resources and at least reduce emissions of pollutants. From a methodological point of view, there is no fundamental difference between research which investigates the genesis and transformation of sociotechnical systems in general terms, and research which also evaluates the development of these technological systems in respect of their sustainability. However, there is an additional need to analyse the extent to which sustainability has actually increased following a change of technology or a sociotechnical transformation. Moreover, it is often expected, at least implicitly, that Transition Studies should not only reconstruct the conditions of system transformations in the past – which is the core activity of the social sciences – but also identify the conditions for effective sustainable transitions and their management in the future (for a critical overview, referring, for example, to the importance of the contested and not consensual meanings of sustainability for such steering efforts, see Shove and Walker 2007). That the possibilities of a scientifically based transition management under complex societal conditions, are very limited, is, in contrast to such ambitions, an insight of any reflective SST: for the SST shows “that, and why, phases of development, involved social actors, socio-economic, technical and cultural conditions interact in a non-trivial manner, i.e. a manner that cannot easily be causally reconstructed” (Degele 2002, 55).

The contemporary MLP approach, which has been developed mainly by Frank Geels (2005b), in essential reference to Rip and Kemp (1998), tries to classify heuristically the various processes that influence the introduction and transformation of sociotechnical systems. This approach works with three important levels, the *landscape*, the *sociotechnical regime* or *system* and the *niche*. The sociotechnical landscape (in the metaphorical sense) “forms an exogenous environment beyond the direct influence of niche and regime actors (macro-economics, deep cultural patterns, macro-political developments). Changes at the landscape level usually take place slowly (decades)” (Geels and Schot 2007, 400). The term sociotechnical regime refers to “shared cognitive routines in an engineering community”, it explains “patterned development along ‘technological trajectories’”; “scientists, policymakers, users and special-interest groups also contribute to the patterning of technological development”. “Sociotechnical regimes stabilise existing trajectories in many ways: cognitive routines that blind engineers to developments outside their focus (...), regulations and standards (...), adaptation of lifestyles to technical systems, sunk investments in machines, infrastructures and competencies” (Geels and Schot 2007, 400). In accordance with a broader literature in the SST, it is assumed that the sociotechnical regime and the material infrastructure, for instance of an energy supply system, are matched, at least to a certain extent, and that they can be conceptualised as a sociotechnical system (see Schmitt 2012, 251). The third term is that of the technological niche:

Technological niches form the micro-level where radical novelties emerge. These novelties are initially unstable sociotechnical configurations with low performance. Hence, niches act as “incubation rooms” protecting novelties against mainstream market selection (...). Niche-innovations are carried and developed by small networks of dedicated actors, often outsiders or fringe actors (Geels and Schot 2007, 400).

Whether technological niches are strong enough to replace, or at least to transform, existing sociotechnical regimes, depends, besides the inherent influential factors on the two lower levels, on the extent to which influences within the landscape, i.e. within the sociocultural, political and economic environment, are conducive to, or even exercise “pressure” in favour of such a change. In the long term, all sociotechnical regimes must adapt themselves to keep up with developments in the surrounding sociotechnical landscape. The basic conception of the MLP approach and of SST in general, is that system transformations, for instance in respect of a sustainable energy supply, only happen when several related developments take place at the same time (Freeman 1988, 11; also Dolata 2011, 38f.). In the following analysis, I will not use the various forms of the MLP approach in an overdetermined way; the analysis of a concrete sociotechnical development cannot be carried out deductively using the MLP approach, but must be adapted to the concrete case and be grounded in the empirical material. I will therefore give a prominent place in my analysis to statements made in interviews by key actors and observers with an interest in Desertec/DII. The criticism that Transition Studies reproduces functionalistic views of society and does not consider individual agency, for instance, does not apply to the following analysis of Desertec. The mid-range MLP approach is based here on a societal theory oriented towards Giddens (1984) *theory of structuration* with its complementary relation of agency (understood here as the agency of subjects) and social structures, such as institutions. In the specific adaption used here, this complementary relation between agency (of subjects) and structures is supplemented by a special emphasis on discourses, ideas and concepts, for “[i]deas and concepts guide and influence the agency, practices and, perceptions of social actors (or subjects) perceptions of social actors (or subjects)”, and vice versa “institutions are shaped by ideas and concepts, while, on the other hand, ideas and concepts are spread, adapted, or modified by institutions” (Schmitt 2015, 9–10). Thus, the dual relation in Giddens (1984) is here transformed into a triadic structure (for details, see Schmitt 2015, 9–10). In the following analysis, this basic theory is mirrored in the detailed interpretation of different concepts, and the elaboration of the contributions of individual social actors to the development of the Desertec idea.

3. Methodological note

This paper is based on my own empirical research on the Desertec project, carried out in 2009 and in the period 2012–2015. In addition to analysing a large number of documents and press reports relating to the project, from September 2009 – just a few weeks after the press conference on the occasion of the founding of DII – I carried out first talks and interviews, for example, with representatives of companies belonging to DII, members of the DII team, and other actors and observers.⁴ Between 2012 and 2015 I conducted extensive expert interviews, mainly in Hamburg (the seat of the Desertec Foundation), Munich (at that time the seat of DII) and Stuttgart in Germany, and Rabat in Morocco; in 2013 I attended a DII conference in Rabat, and held informal but thematically focused interviews with social actors and observers. In addition to these face-to-face interviews, retrospective interviews were held, for instance, an exhaustive interview with the CEO of DII, Paul van Son (by then already in Dubai) that was conducted by phone in 2015. This gathering of empirical data by means of expert interviews over a period of several years has brought me close to the object of research and has proved a great advantage for the analysis presented in this paper, as compared to purely literature-based studies (see for instance van de Graaf and Sovacool 2014). It is astonishing that some studies in economic geography and Transition Studies lack this qualitative closeness to documents, actors and processes in their research fields. This is something that should be taken for granted, for instance by historians of technology. During the research process, I was able to witness both the euphoric beginnings of the DII, and its decline, including some revealing retrospective interviews and discussions in 2015.

4. The development of the Desertec idea – a short historical sketch

In this section, I will reconstruct the historical development of the Desertec idea: how was this very special technological concept born, with what intentions, and how did it find its way from the world of science and NGOs to that of financially strong companies? These background facts are of fundamental importance for an evaluation of the concept (cf. Figure 3).

The basic idea of the Desertec concept – that the intense solar radiation in desert regions could be used to supply energy, not only in the countries where it is produced, but also for instance in Europe – can be traced back to the turn of the nineteenth and twentieth centuries, when scientists tried to estimate the energy content of the solar radiation in the tropical desert regions; at that time it was only possible to speculate on possible ways to transform solar radiation efficiently into usable energy and transport it to Europe. In his book *Woman and Socialism* (1910) which continued to be influential for a long time and saw many reprints, August Bebel, one of the founding figures of German social democracy, quoted the opinions of two physicists concerning the possibility of using energy from desert regions:

A wealth of energy that by far exceeds all demands is furnished by those parts of the surface of the earth that are so regularly subjected to the heat of the sun that it might be applied to regular technical operations. Perhaps it would not be an exaggerated precaution if a nation would even now secure a share in such places. The required areas need not even be very large; a few square miles in Northern Africa would suffice for the requirements of a country like the German Empire (Kohlrausch 1900 cited Bebel 1910; even as a socialist at that time, Bebel obviously had no objection to Kohlrausch's colonial attitude).

Immediately after this passage, Bebel goes on to quote a speech made in 1909 by the English physicist Sir S. Thompson, in which the latter argued that solar energy would play a central role in meeting the future energy needs of mankind:

Although our engineers have not yet found the way to apply this gigantic source of power, I do not doubt that they will ultimately succeed in finding it. When the supply of coal in the bowels of the earth has been exhausted, when the water-powers will no longer suffice to meet our requirements, then we will obtain from this source all the energy needed to complete the work of the world. Then the centers of industry will be removed to the



Figure 3. A timeline of events related to the Desertec project. Source: by the author.

glowing deserts of Sahara, and the value of the land will be measured by how well it is suited to the erection of the great "sunbeam traps".⁵

In the context of this paper, it is neither possible nor necessary to reconstruct the complex history of the development of concentrated solar power or photovoltaics up to the present. It is not unimportant to know that the concrete Desertec idea can be linked to the visions of people who lived one hundred years ago. But more helpful with regard to understanding the Desertec concept is a knowledge of the circumstances of its birth, in which certain persons played decisive roles, such as the founder of the Desertec Foundation, Gerhard Knies, the German research organisation DLR

(German Aerospace Centre; in German: *Deutsches Zentrum für Luft- und Raumfahrt*), or the Munich Re reinsurance company as an entrepreneurial actor. At the end of the 1980s and beginning of the 1990s, a first study concerning the erection of CSP in North Africa, including a system for transmitting power to Europe, was carried out by an institute of the DLR and the ZSW (Centre for Solar Energy and Hydrogen Research Baden-Württemberg; German: *Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg*) under the direction of Jürgen Nitsch (ZSW and DLR 1991). These activities were known to Gerhard Knies, a physicist employed by DESY (*Deutsche Elektronen-Synchrotron*), a research centre in Hamburg, who was also active in a scientists' initiative for peace and nature in Hamburg during the time of the peace movement. In a retrospective interview he described the context in which he thought about a transcontinental solar power network for the first time:

At that time [the city of] Hamburg had begun to support arms exports. Specifically (...) the Senate [of the city of Hamburg] wanted to give money for an order for frigates, warships by Libya (...) And we often asked ourselves there [in the initiative] (...): Wouldn't it be much better if Hamburg invested this money in building solar systems in these [North African] countries. That would help to solve the energy problem, it would lead to cooperation between Hamburg and these countries, and it would improve the security problem. (interview G. Knies, March 2014)

This passage shows clearly that the Desertec concept was embedded genealogically in a holistic approach which sought ways of achieving a sustainable energy supply after Chernobyl and before the horizon of climate change. From the beginning, its original protagonists had in view a positive notion of North–South cooperation, based on fair and just relations, as a contribution to regional peace-keeping – in contrast to the colonial context in which Kohlrausch had proposed the exploitation of deserts as a source of energy a hundred years previously. Originally, like the staff of the DLR, Gerhard Knies was inspired by a concept proposed by the aircraft engineer Ludwig Bölkow,⁶ who in the early 1980s spread the idea of using photovoltaic cells to produce electricity in the Sahara, and making it transportable by storing it in the form of hydrogen. A technological system of this kind would have solved the storage and transmission problems of PV, but it would have involved considerable transformation losses. In 1997, in the light of these ideas, Gerhard Knies organised a workshop at the Technical University in Hamburg to discuss the possibility of a “North-African-European electricity network”. At this workshop, he met people from the DLR, in particular, Joachim Nitsch and Franz Trieb, who were working on CSP (interview G. Knies, March 2014; Desertec Foundation 2011). Due to its comparatively economical storage capabilities, in contrast to a PV-based system, CSP became the key technology for the Desertec idea; in 1998, during a sabbatical, G. Knies spent several months in the DLR Institute in Stuttgart, “together with Dr. Franz Trieb in order to examine more closely the DESERTEC idea which was already growing in him” (Desertec Foundation 2011). At a conference in 2002, Gerhard Knies met Uwe Möller, who at that time was the chairman of the German Association for the Club of Rome. Gerhard Knies suggested organising a brainstorming workshop to discuss the possibility of a solar-based cooperation between Europe and North Africa. Consequently, two workshops were held at the Club of Rome's Rissen House in 2003; the second workshop was attended by scientists from North Africa. At this time, under the leadership of Gerhard Knies, and in loose cooperation with the Club of Rome, the TREC network (Trans-Mediterranean Renewable Energy Cooperation) was initiated, with the intention of spreading the Desertec idea; this network included scientists and politicians from the MENA region. At the beginning of the 2000s, the German Federal Ministry of the Environment, headed by Jürgen Trittin (of Die Grünen, the German Green Party), took notice of the activities of the TREC network; the minister and some of the ministry staff obviously found the idea potentially interesting, and the DLR was instructed to make feasibility studies. The MED-CSP study (DLR 2005) looked at the potentials of CSP for supplying energy to the Mediterranean region, and the subsequent TRANS-CSP study (DLR 2006) investigated the possibility of a transcontinental electricity network, i.e. a means of exporting CSP from the MENA region to Europe; the third study, Aqua-CSP, examined the possibility of using CSP technology to desalinate seawater and thus produce drinking water (DLR 2007). In the beginning,

according to his retrospective statements, the leading engineer at DLR, Franz Trieb, was not convinced of the feasibility of exporting electricity; on the contrary, he was very sceptical about it: “I tried to kill the thing [Desertec] with my calculations, but I didn’t succeed” (interview F. Trieb, December 2009). The fact that his initial scepticism was proved wrong by his own calculations may be a reason why Franz Trieb became committed as a scientist to the Desertec idea. The studies directed by him showed the technical feasibility and economic viability of the idea of such an electricity network, and they became the major reference for protagonists of the Desertec idea, as can be seen in the publications of the Desertec Foundation (e.g. Desertec Foundation 2009a, 2009b).

Both TREC and the Desertec Foundation which grew out of it in spring 2009 were connected with the Club of Rome, that exclusive NGO in world civil society, made up of ethically oriented entrepreneurs and intellectuals, which has been associated with the global protection of resources ever since the famous “Limits to Growth” report (Meadows et al. 1972). The connection between TREC/Desertec Foundation and the Club came about as a result of the “Hamburg” connection between Gerhard Knies and the chairman of the German Association for the Club of Rome, and contributed to the reputation of, and the global media attention paid to, the Desertec idea. Prince Hassan bin Talal of Jordan, who was president of the Club of Rome from 1999 to 2009 and a prominent voice in the global dialogue of cultures, took up the Desertec idea and promoted it in the brochures of the Foundation. Its connection to the Club of Rome clearly helped the Desertec idea to find its way out of the conceptual niche of the world of NGOs and onto the agenda of established, internationally known business enterprises, and this applies not only to the way its reputation was raised, but also to the contingent microsociology of the way it spread. The productive counterpart in this process of diffusion was the Munich Re as a globally acting reinsurance company. For economic geographers, it may be useful to know that even in this digital age face-to-face contacts can still be important for the diffusion of ideas. Ernst Rauch, director of the Corporate Climate Centre at Munich Re, explained this in an interview as follows:

Munich Re first started thinking about this idea (...) at the Hanover Fair 2008 (...) Our firm [even as an insurance company] employs about a hundred engineers whose job includes investigating new technological developments, and for them the Hanover Fair is a source of information. At the Hanover Fair 2008, one of our engineers came (...) into contact (...) with (...) Max Schön, who at that time was (...) the president of the German Association for the Club of Rome (...) And then this engineer, who was initially full of enthusiasm for the idea, brought it to Munich. And [the idea] was well received here (...). Sometimes coincidences also play a role: (...) You must know how to handle ideas. You need a department that can investigate the idea, and possibly realize it. And we had exactly this in our firm. It was a coincidence that in 2008 (...) [the] Corporate Climate Centre was founded, due to the fact that Munich Re had recognized the relevance of the issue of climate change for its business strategy. (...) This business development concept is not limited to natural hazards and risks, but also [covers] the field of technology. And so we can say that it was a timely coincidence that the idea resulting from a contact at the Hanover Fair was brought here to Munich, and that someone was available who could take up this idea, not just as a good idea, but as part of a business plan. (...) Then first investigations began. We conducted talks with manufacturers of technological equipment, but also with NGOs and scientific institutions, in order to find out whether this was a viable idea for an insurance company and for industry in a broader sense (interview E. Rauch, April 2015, translated from German).

Members of the Corporate Climate Centre at Munich Re then contacted other companies with a potential interest in realising the Desertec concept as a business model. Different sectors were taken into account, especially power plant manufacturers and suppliers, the financial sector, and power supply companies (see Figure 2). Although Munich Re is a globally acting company, it was obviously easier in the beginning to contact companies that were based in Germany; this factor, plausible in terms of action theory (but not neo-colonial ambitions, see Section 6) explains the high number of German or European companies involved in the founding of DII. Munich Re certainly saw a prospective business field for itself in the insurance of large-scale plants such as those to be produced by the Desertec project, but at the formation of DII it was able to appear as a kind of “honest broker” (Thorsten Jerrowek, Member of the Board, Munich Re)⁷ and moderator, since the economic interests of the industrial companies, for example, were considered to be much greater.

This section shows how an idea for restructuring the energy supply system on a transcontinental basis found its way out of the niche of NGOs and ecologically engaged scientists and into those of international companies. The Club of Rome played an important role here. The Desertec idea was taken up by the companies because it was an answer to current calls for global climate protection (in the terminology of the MLP approach: there were favourable developments within the sociocultural landscape), and it offered at least a potential business model for the companies. So it came about that the Desertec idea had a broad circle of supporters, including organisations which otherwise were opposed to each other: for instance Greenpeace, a non-member of DII which explicitly welcomed the idea (Greenpeace e.V. 2009; Greenpeace International 2009), and RWE, a member of DII, once a powerful German power supply company, which was notorious among ecologists because of its nuclear and lignite-fired power stations.

5. The original “orthodox” reading of the Desertec concept

By the end of the 2000s, a relatively coherent and homogeneous reading of the Desertec concept had apparently developed which was shared by the important actors: the Desertec Foundation, a civil-society organisation founded in 2009, and its predecessor network TREC, both connected to the Club of Rome, the DII, also founded in 2009, and the research institute of the DLR (see Figure 2). The key points of the concept, as published by the Desertec Foundation and at first also by the DII, were based on three feasibility studies which were commissioned by the German Federal Ministry of the Environment in the mid-2000s, and carried out by the DLR under the direction of Franz Trieb (see Section 4). The figure of 400 billion euros as the estimated cost of constructing the proposed new transcontinental energy infrastructure to be completed by the year 2050, as published widely in the media and mentioned at the press conference on the occasion of the founding of the DII, also came from the DLR studies (DLR 2009).

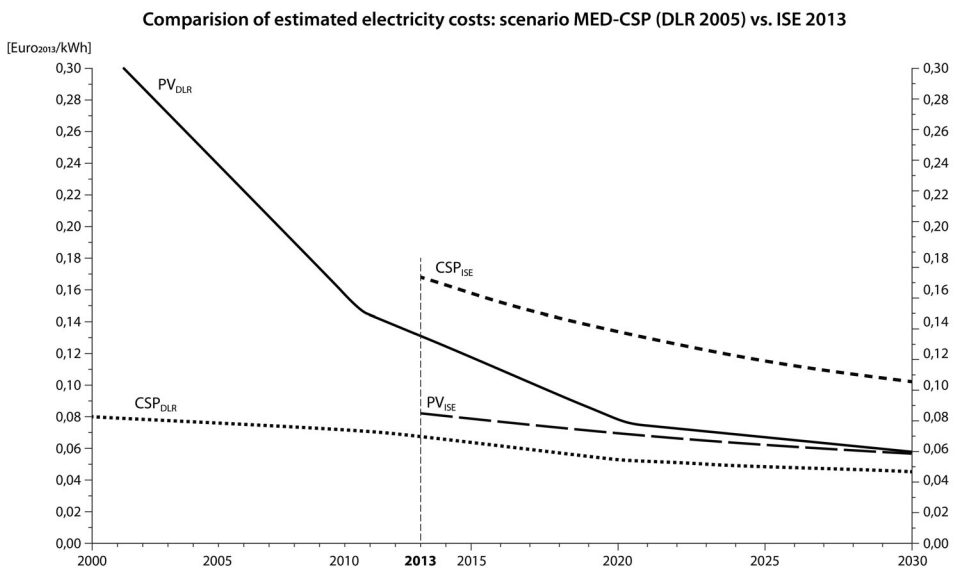
The “classic” Desertec concept is essentially a combination of two technological elements: the use of CSP power stations and high-voltage co-current power lines to transport electricity over long distances with minimum losses. It is well known that, in contrast to PV, CSP plants do not transform light directly into electricity, but use solar energy to heat a liquid. In a second step, as in thermal power plants based on fossil fuels, this thermal power is used to drive a turbine and generate electric power. In order to make effective use of the solar energy, large mirrors are used to heat the medium; parabolic trough power plants represent the currently most widespread technology. For instance, the Andasol I plant, which was put into operation in 2009 in southern Spain, has a turbine capacity of just under 50 MW; its collector field has an area of 1300×1500 m, or 195 ha (Solar Millennium 2008, 8). An important advantage of CSP technology as against other regenerative forms of energy, such as PV or wind, is the fact that, up to a certain degree, the power generated in CSP plants can be controlled and made available when needed, even when the sun is not shining. This is made possible by big storage units, usually filled with liquid salts, which absorb a part of the heat produced in the collector field and can store it for several hours or even weeks. In the early evening hours after sunset, for instance, the stored heat can be delivered to the steam turbine and used to generate electricity. According to Solar Millennium (2008), a full salt storage tank in Andasol I can serve to operate the steam turbine for 7.5 h. The fact that it is possible to control power production in CSP plants by means of a heat storage system gives CSP technology an essential advantage over PV and wind systems, which are volatile and unpredictable. However, in contrast to PV, CSP plants require direct radiation in order to produce heat and thus electricity; if the sun is covered by clouds, no heat is produced. The best places to construct CSP plants are dry deserts and semi-deserts because of the comparatively high solar irradiance there; a CSP plant in central Europe would not be technically or economically viable. Of course, the sun can be obscured by clouds even in the Sahara;⁸ in this case, CSP plants can only go on producing electricity until the stored heat is used up. Thus, if they are to contribute to a really reliable power supply, CSP plants must be part of a large-scale network based on a combination of different technologies.

The scenarios developed by the DLR included the construction of intercontinental high-voltage direct-current transmission lines which would transport the electricity over long distances with comparatively low losses, not only within the MENA region but also to central Europe. In the case of a transmission line from Morocco to the German border at Aachen, the losses are estimated at only about 10–15% including conversion losses from DC to AC and vice versa.⁹

In the reference scenario that was taken up by the Desertec Foundation, the DLR assumed that by the year 2050 approximately 15–17% of the European power requirement and a similar quantity of electricity for the MENA region would be supplied by the Desertec project (DLR 2006, 4). In the Desertec concept, the selection of sites is based on the higher and more reliable solar radiation in deserts and semi-deserts. The new high-voltage co-current lines cannot be optimally planned and laid until the sites of the power plants and the location of the customers have been defined. In other words, Desertec requires close coordination between the definition of power plant sites, the planning of transcontinental transmission lines, and the identification and securing of sales markets.

However, as a large-scale transcontinental infrastructure project, Desertec had the added value of being a comprehensive vision, besides the forecast technical data, which would have beneficial effects in other economic, social and political fields. A number of aspects can be identified which came together in the Desertec idea, and which were skilfully visualised in the brochures published by the Desertec Foundation and the DII (Schmitt 2012, 247f.):

- *Fascination of the desert*: The Desertec idea was fascinating because of its reference to the desert, a concept that has been present at least discursively for centuries in central Europe not as a real landscape, but as a topos and a heterotopia – in Bible stories, as a place of solitude, testing, adventure and danger, a place for discovering oneself, nature or God.
- *Fascination of renewable, alternative energies*: Societies have always been fascinated by technologies. Today, renewable energies have a special fascination, because they appear so different from the traditional energy technologies which were accompanied by noise, fire, steam and smoke. Sun and wind are not just physical objects, but cultural symbols; they were once worshipped as deities. In the ecology movement, and in marketing for renewable energies, this



Draft: T. Schmitt; design: S. Adler, T. Schmitt; source: DLR 2005, ISE 2013

Figure 4. A comparison of two different scenarios for electricity generation costs (see Section 7.1). Source, by author, based on DLR (2005, 15) and ISE 2013.

symbolism has been exploited in attempts to transfer the mythical properties of the sun to technologies which promise to harness its power in the service of humanity (e.g. Claus 1997).

- *Fascination of a large-scale vision*: While people are fascinated by technology in general, they are even more fascinated by large-scale visions and projects. A good example is the Apollo programme for landing the first humans on the moon, which required strenuous efforts by the US government and scientists. It is no coincidence that protagonists of the Desertec project, such as Prince Hassan bin Talal of Jordan, former president of the Club of Rome, regularly compared Desertec to the Apollo programme: "More than 40 years ago the Apollo Space Program was launched to fulfill the old dream of taking man into outer space. Today, we have a bigger dream, to restore balance between man and his home planet, Earth. With the political will, EUMENA countries could now launch an Apollo-like 'EUMENA-DESERTEC' Program, to bring humankind back into balance with its environment", said Hassan bin Talal (Desertec Foundation 2009a, 6). Desertec represented the rare case of a synthesis between a technology that was once considered as an alternative with a large-scale vision. For critics of the Desertec concept, this large-scale visionary character was a reason to be sceptical: big technical projects involve big risks and may lead to big failures (Scheer 2012, 146); they have often been experienced and consequently anticipated as icons of an erroneous, disembedded rationality and modernity.
- *Fascination of (at least partially) overcoming the North–South division*: The idea of overcoming the North–South division in the Mediterranean area also contributed to the fascination of Desertec. Desertec not only wanted to supply Europe with electric power, but also to help desalinate seawater for the arid areas of the earth – the "green desert" is also a fascinating idea. Thus, Desertec communicated a vision of a win-win situation (DII 2013, 56) in which both the North, or Europe, and the South, or North Africa and the Middle East, would profit. The North would gain long-term energy security, and its industries would profit from the investments. The MENA region would gain jobs and thus social stability, which would make it less of a breeding ground for Islamic extremism. Prince Hassan bin Talal saw Desertec as a bridge between North and South. He argued that just as the founding of the European Coal and Steel Community once brought peace and prosperity to Europe, the solar-based industrial project Desertec could be the heart of a trans-Mediterranean community for energy, water and climate security, and could help to create a prosperous and peaceful future (Desertec Foundation 2009a, 6). Desertec appeared to be a solution for many different problems and a projection surface for all kinds of positive utopias.

6. Heterodox and competing readings of Desertec – cause of failure or necessary adaptations?

Up to this point, I have presented a holistic but also an "orthodox" variant of the Desertec concept, based on the relevant DLR studies. It is the variant that was outlined and developed for the public in publications such as the *White Book* and the *Red Paper* of the Desertec Foundation (2009a, 2009b), and on which press reports were usually based. Put simply, one might say that the DLR provided technical backing with its studies, while Gerhard Knies and Prince Hassan bin Talal, together with the other members of the TREC network, provided the holistic embedding of the concept. However, in opposition to this construction of apparent clarity, different readings and interpretations of the concept existed or grew out of it, which correspond to realistic expectations in the reflexive social sciences, and concretely in SST: "When new technologies emerge, there is 'interpretative flexibility' (Bijker 1995): social groups have different problem definitions and interpretations" (Geels and Schot 2007, 405). In some cases, the different, mostly competing, interpretations of Desertec existed emically, i.e. within the main groups of actors (Desertec Foundation, TREC, DII and DLR). But other groups of actors, and especially critics, also had different readings. On the one hand, the co-existence of different interpretations of a basic idea can be fruitful and advantageous for developing realistic plans, but it may also lead to serious tensions, conflicts and disagreement over the

right interpretation or correct exegesis of the concept, or the proper way to implement it in the future. At least at first sight, depending on the particular time, the Desertec case differs here from generalising descriptions of other technological development paths, which end in a “closure”, i.e. a state in which “one interpretation eventually becomes dominant in a community and others cease to exist” (Geels and Schot 2007, 405). The present, provisional, “closure” in the sense of a provisional failure of the whole Desertec project, preceded a phase of disputes over its interpretation, after an apparently coherent and complete plan had been presented to the public.

These conflicts over interpretation, which had perhaps latently existed from the beginning, became manifest over time among the DII shareholders and the staff of DII GmbH, including the two equal CEOs, Paul van Son and Aglaia Wieland, and escalated in 2013. As a result, Aglaia Wieland was forced by the shareholders to resign from her post at DII. In the same year, in the course of these disputes over the right interpretation of the concept, the Desertec Foundation left the DII consortium; since this NGO owned the trademark rights to the name Desertec, the DII had to give up its established name, and changed it to Desert Industrial Initiative. This step was perceived by many external observers, and retrospectively in interviews with key actors, as a serious weakening of DII, but it also meant that the Desertec Foundation lost an important source of its reputation.¹⁰ It seemed to be the end of the dream of conciliating global civil-society interests and commercial interests (See Table 1).

The Desertec idea also brought a number of critics into the arena, including, surprisingly, actors from the ecology and environment movement. The most prominent, and probably the most powerful, critic was Hermann Scheer, the champion and visionary of renewable energies (e.g. Scheer 1993, 1999), often referred to as the “solar pope”, who was given the *Right Livelihood Award* in 1999. He was president of the NGO Eurosolar and a Member of the German Parliament (Bundestag) for the Social Democrats (SPD) for many years.¹¹ These different internal and external readings of Desertec (see Table 1) were concerned with:

Table 1. Different readings of the Desertec concept – an overview.

Desertec	Internal reading	Alternative internal readings	External readings by critics
Main character	Holistic vision (including energy security, mitigation of climate change, regional development) (<i>Desertec Foundation</i>)	Business model	Technocratic concept without sociological reflexivity (<i>Hermann Scheer, parts of ecological movement</i>)
Motivation	Idealism (ecology, peace movement, North–South conciliation and justice) and energy security (<i>TREC, Desertec Foundation: G. Knies, F. Trieb, ...</i>)	Ethically correct business model (<i>DII members</i>)	Trojan horse: obviation of extension of RE in Europe through focusing on improbable future RE imports (<i>H. Scheer; parts of ecological movement</i>)
Target structure of energy supply in Europe	Central and decentral elements (<i>Desertec Foundation; DII</i>)		Only decentral elements (<i>H. Scheer</i>)
Technology	only CSP (<i>German Centre for Aerospace – DLR; F. Trieb</i>)	(mainly) CSP, but also PV and wind (<i>G. Knies, Desertec Foundation; DII</i>)	
Consumer region	MENA + Europe , in equal shares (<i>Desertec Foundation, DLR; DII 1: CEO Wieland and bigger part of staff members</i>)	Only MENA region, export to Europe not realistic (<i>DII 2: CEO P. van Son</i>)	1) only Europe. (<i>partial representation in German media</i>) 2) only MENA region (<i>alternative concept “desert economy”, H. Scheer 2012</i>)
North–South relations/ interregional justice	Partnership , win-win, fair share, justice, co-development (<i>Desertec Foundation, Club of Rome, DLR</i>)		Neo-colonialism , paternalism (<i>numerous external critics, also in forum postings</i>)

In brackets: Stakeholders sharing this reading. Source: By the author.

- the *fundamental character* of the Desertec idea and its *motivation*. While its critics saw it as a technocratic concept and business model, its civil-society protagonists, as shown above, saw it as a holistic vision which brought together very different elements such as a climate- and resource-friendly energy supply, but also a fair and just partnership between North and South. The main civil-society actors, especially Gerhard Knies, who played such an important role in setting up the Desertec Foundation, were physicists or engineers, but biographically they were rooted in the peace, environment and one-world movements (see Section 5). For them, Desertec was a way of achieving idealistic goals. The member companies of DII obviously saw in Desertec an ethically correct business model, if such generalised statements can be made about such a big and heterogeneous group of companies. At least some of the people I interviewed from DII member companies associated Desertec with idealistic and not only economic motives. Critics from the ecology camp, in particular, Hermann Scheer, thought that the reason why the big German energy supply companies RWE and EON joined DII was that they hoped to block the development of renewable energies in Germany by propagating vague visions of energy from the desert in some far future (Eurosolar 2009a): he argued that Desertec was a kind of Trojan horse among the big power supply companies, which because of their reliance on nuclear power and coal had prevented rather than encouraged the development of renewable energies in Germany. Supporters of Desertec among the protagonists of renewable energies argued that a project like Desertec could only be realised with the financial strength of such companies; at the same time, one should be pleased if they wanted to open up business fields in the area of renewable energies.
- The question whether the power stations to be built in the MENA region should be based only on CSP, or also on PV or wind, went right through the camp of the Desertec protagonists. The DLR studies were based entirely on CSP (in addition to some pumped-storage power plants in Norway); the Desertec Foundation, and later the DII, put CSP in the foreground in their publications and charts, while at the same time claiming to be “technologically open” (interview G. Knies, March 2014). The supporters of a “technologically open” strategy argued that the generation costs for electricity from PV or wind were lower, while the price for CSP power continued to be high. But for other protagonists, such as Franz Trieb from the DLR, this technological opening was such a thing as the “original sin” of the Desertec Foundation: for CSP (or alternatively hydropower, for instance from Norway) is the only form of renewable energy capable of providing a reliable and controllable supply of electricity on a large scale. In the medium term, this reliable and controllable power supply can fill the gaps which will inevitably occur in Europe, even if PV and wind are developed on a large scale, because of the fluctuating and volatile character of these energy forms. According to this argument, a decentralised energy supply in Europe using renewable energies, and a “centralized” supply from CSP plants in North Africa are not competing alternatives but are complementary to each other, for without the latter it would be impossible to plan and calculate the development of the former. The currently increasing public uncertainty about the right way to realise the energy turn in Germany might justify the idea of importing CSP electricity. And with all due respect: even the intellectual matadors among the Desertec critics, such as Hermann Scheer, had no masterplan to solve the problem of storage in respect of renewable energies; even Scheer (2012) remained vague in this respect.
- Within the circle of Desertec protagonists, a violent dispute broke out over the question of which *region* the electricity produced in the desert was intended for. In the “orthodox” version, it was not only intended for consumption in the countries of the MENA region, but also for export to Europe. Media reports, especially in Germany, concentrated on the second aspect, and tended to ignore the first one. Yet one of the two equal CEOs of DII, Paul van Son, publicly announced that he thought the idea of exporting electricity from North Africa to Europe was unrealistic in the foreseeable future (see Section 7 for more details). However, most of the staff of the DII, including Aglaia Wieland, the co-CEO, as well as the Desertec Foundation, argued that the export idea was constitutive. Staff members leaked the internal conflict to the press, which published details of it (Balsler

2013b). Paul van Son was able to gain the support of the DII shareholders, and it was Aglaia Wieland who had to leave the DII at the end of 2013. Thus, to the surprise of many observers at that time, Paul van Son drew closer to the position of Hermann Scheer, the Desertec critic, who used the term *desert economy* – “a name similar to that of the Desertec project but different in meaning” (Scheer 2012, 149) – to oppose the idea of exporting electricity to Europe, but to support plans to use CSP plants to supply energy to growing cities in the MENA region, such as Algiers, Casablanca or Cairo.

- Another aspect of divergent perceptions of the Desertec project concerned the question of its implications in respect of *North–South relations*. The metaphor and judgement that the Desertec project was a (*neo*-)colonial project became widespread in internet forums and in parts of the critical public (see Wachtel 2011). Even EU Commissioner G. Oettinger, who thought that in the long term Desertec was a good idea, spoke of Desertec’s “colonial style” before a committee of the German parliament (Bundestag) in 2010; he said that it “had not been presented to the Africans”.¹² I presume that these critics were unaware of the colonial genealogy of the idea of obtaining electricity from the desert (see Section 5 above). Rather, they criticised the fact that European, mainly German, companies were planning a project to use the resources of the South. The cartographic illustrations used by the Desertec Foundation to promote the project (Figure 1) were indeed reminiscent of colonial land-grabbing practices, with straight lines representing the new high-voltage direct current transmission system drawn across North Africa, apparently ignoring physical features or (colonial) national borders. A co-founder of the TREC network and the Desertec Foundation said retrospectively in the interview: “Wherever we went [to make presentations], people said that we were collaborating with big companies and doing business with them, on the backs of the [local] people [in the countries of the South]. And that was just the opposite of what we wanted to do”.¹³ What the critics of Desertec could not know, or refused to see, is that there can be no doubt that the idea was born in the spirit of a true North–South partnership (Section 5). Scientists from the MENA region were involved in the TREC network from the beginning of the 2000s. That the majority of the founding members of the DII had a German or European background can be considered as a strategic error; but this error was admitted at the founding conference of the DII, and the DII made efforts to open membership to companies in potential producer countries. The strong German focus of the founding formation of DII can be explained by the fact that the people at Munich Re who were responsible for preparing the DII network found it easier to contact German companies – so that the accusation of colonialism can be rebutted by network theory arguments. The DII sought the advice of NGOs like *Germanwatch* in respect of investigating or invalidating public accusations according to which big CSP projects, like that in Ouarzazate in Morocco, allegedly threaten the interests of the local people, such as the interests of nomads, for instance (Klawitter and Schinke 2011; see also Wuppertal Institute and Germanwatch 2015).

7. The (provisional) failure of Desertec – an analysis within the MLP framework of Transition Studies

The MLP approach in Transition Studies has been used in the past mainly to analyse technologies that can be inserted in different suitable sociotechnical systems, such as photovoltaic or biogas systems, or electromobility. The Desertec concept is a special case to the extent that it is a proposal for a large-scale international and transcontinental infrastructure system, for which a kind of masterplan exists in the form of the DLR feasibility studies referred to above. Large-scale infrastructure systems (and the failure of such systems) are, however, a classic research field in the discipline known as SST (i.e. Mayntz and Hughes 1988), so that potential aids for an analysis of the Desertec concept may also be found here. In the final phase of my research, I asked my interviewees about the reasons for the “failure” of the DII in the formation which existed from 2009 to 2014. Ernst Rauch, at that time

head of the Corporate Climate Centre at Munich Re, was involved in the formation of the DII in 2009, and he gave me the following answer:

If we had been able to foresee the future in 2009, when the DII was founded, of course we would have acted differently. But the important thing is that in the years following 2009, after the founding of DII, several (...) things, boundary conditions, changed substantially (interview E. Rauch, April 2015).

Ernst Rauch followed this up in the interview by mentioning two important points:

- (1) Political changes, the political instability in North Africa and the Middle East after the winter of 2010/2011.
- (2) Technological developments, in particular, the “rapid development of renewable energies” in Europe as the “demand region”, “driven by the lower cost of photovoltaics”, which led to excess electricity in Europe.

When I asked him to rank the significance of these two points, Rauch stressed the second point. These two points were also mentioned by other interviewees as significant for the “failure” of DII, and in the following analysis, the author of this article also adopts these emically formulated arguments. But they must not be seen in isolation. In the following analysis, they will be not only embedded in the MLP framework of Transition Studies, but also placed in another argumentative context. For the possible failure of the DII was neither unforeseeable, as suggested by these arguments, nor inevitable or without any alternative, as will be shown below. In accordance with the heuristic of the MLP approach, we will begin the analysis with the sociocultural, economic and technical “landscape”.

7.1. Landscape developments and their impacts on the realisation of the Desertec idea

Let us consider the broad international cultural, economic and political environment (or landscape, to use the MLP term) of the Desertec idea or of the DII. After 2009, there were certain trends and developments which appeared to favour realisation of the “dogmatic” DII concept, and others which undermined its implementation – at least according to a retrospective analysis. These trends will be identified below, and their significance in respect of the Desertec idea will be discussed (Figure 5).

7.1.1. Global discussions on climate change and the finite nature of fossil resources

The on-going global discussion in respect of climate change and the finiteness of fossil resources (“peak oil”) was not only the chief motivation for the TREC network to begin developing the Desertec concept (Section 4), but these were also important issues at the *Club of Rome*, under whose umbrella TREC and Desertec found shelter, and for which the Club had been known to a global public ever since the famous report “The Limits to Growth” (Meadows et al. 1972).¹⁴ These global debates occupy a prominent position in the publications of the Desertec Foundation (2009a, 2009b). Regardless of the fact that to this day, when it comes to concrete political decisions, governments in industrial and threshold countries give priority to (short-term, or supposed) economic and employment interests over a forward-looking climate protection policy, at the time of the founding of DII governments, administrations and political parties did not doubt the reality of anthropogenic global warming, with its potentially dramatic consequences for human society – and exceptions may be seen as proving the rule. Thus, the public discourse in world society appeared to favour an initiative involving a large-scale renewable energy project; such ideas had left the discursive and intellectual niches of green activists, politicians and scientists, and become part of the global political mainstream. The fact that big companies that were listed on the stock exchange and had an international reputation used these ideas to justify a business project can be regarded as evidence of this development. The reception of social debates on climate change in the business world, but of course also in politics, was thus an important condition for the founding of DII and the initial euphoria that

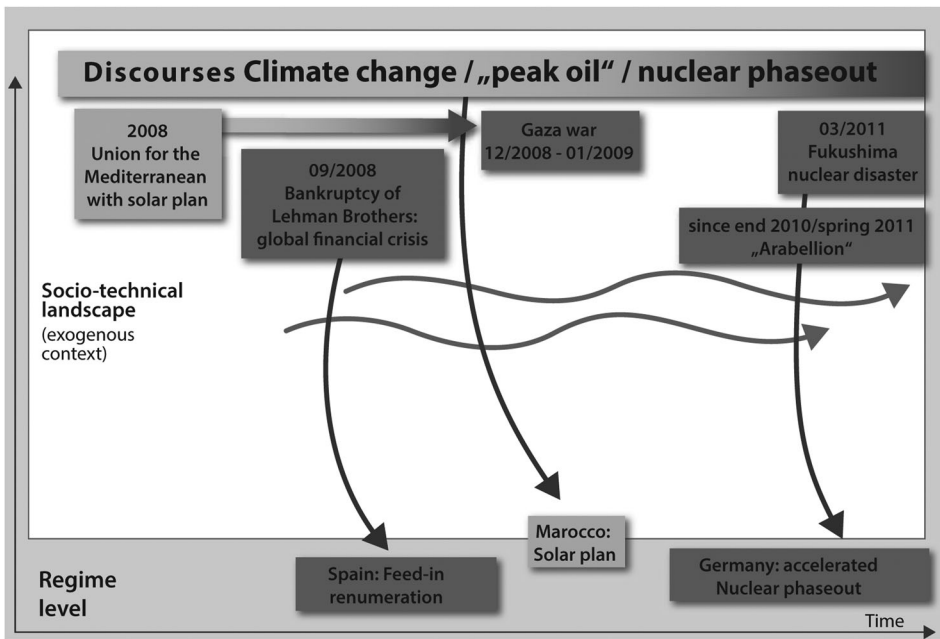


Figure 5. Desertec in the interpretational context of the MLP approach: the sociocultural, political and economic landscape. Source: by the author, referring to the general MLP-scheme in Geels and Schot (2007, 401)

surrounded the project. However, which technological solutions, centralised or decentralised, would finally be selected was not yet clear.

7.1.2. Founding of the Union for the Mediterranean

Another exogenous event in the international political environment of the Desertec idea, which could have been favourable to it, was the founding in 2008 of the *Union for the Mediterranean (UfM)* between the European Union and the countries of the Mediterranean South. This Union was mainly due to an initiative of the then French president, Nicholas Sarkozy. It was intended to deepen regional cooperation between the two groups of countries, despite, or because of, all the crises, problems and conflicts (security, migration, Israel–Palestine conflict ...). In the final document recording the founding of the UfM, a study of “the feasibility, development and creation of a Mediterranean Solar Plan” (UfM 2008, 18f.) was named as one of the “key initiatives” for realising the goals of the organisation. In the media, the Desertec idea was sometimes described as a project for implementing this Solar Plan. And indeed, the relatively prominent place given to the Mediterranean Solar Plan in the joint declaration on the founding of the UfM was due to the ideas of TREC, the predecessor of Desertec – at least according to what Gerhard Knies, first chairman of the Desertec Foundation, said in his interview (March 2014). According to Knies, workers in French Ministries had seen TREC’s website and found it a good idea for the Mediterranean Union. In addition – since TREC was mainly a German initiative – it was hoped that this might attract the support of the German government (which at first was sceptical of the French proposals) for the Union:

In January 2007 we from TREC had a very long discussion with members of staff of various French ministries and the Embassy. They were very interested and asked us what the German government thought about the project. (...) They had working papers with copies of pages from our TREC website. The French (...) really embraced the proposal. In the summer of 2008 they presented Desertec as the flagship project of the Union for the Mediterranean (interview G. Knies, March 2014).

Thus, the Union for the Mediterranean could have provided important political support for a trans-continental Desertec project linking countries north and south of the Mediterranean. And supporters of Desertec like Prince Hassan bin Talal of Jordan, the former president of the Club of Rome, also saw Desertec as the nucleus of a comprehensive project that would not be restricted to building technological infrastructure but would also be conducive to peaceful cooperation:

[Desertec] is an opportunity for the Mediterranean riparian regions of Europe, the Middle East and North Africa (EUMENA) to form a community for energy, water and climate security – with some similarities to the Community of Coal and Steel established in Europe some 60 years ago – for a prosperous and peaceful future (Prince Hassan bin Talal cited Desertec Foundation 2009a, 6).

Just as regulation of the production of coal, a fossil fuel, was at the beginning of European cooperation on a practical level, a cooperation which later led to the EU, Renewable Energies would be at the beginning of a comprehensive Mediterranean Union – that was the vision. But after Israel's attacks on the Gaza Strip at the end of 2008 and beginning of 2009, the establishment of the UfM was postponed, and enthusiasm for this big political project was damped, perhaps irreversibly: after the attacks, Arab countries refused to cooperate with Israel, even in the multilateral context of the Mediterranean Union, and this obstructed the set-up of the new structures. The so-called Arab Spring also led de facto to a further delay in the establishment of the "Union". In the end, the potential tailwind created by the UfM in the exogenous political landscape became a calm for the niche concept Desertec.

7.1.3. The global financial crisis and Desertec

The outbreak of the global financial crisis, marked by the collapse of Lehman Brothers in September 2009, also affected the Desertec project. As a result of the crisis, the realisation of large-scale business projects, or investments generally, came under pressure. Some national economies were very badly hit by the financial crisis. Particularly significant for the Desertec context was Spain, which suffered a recession and a serious drop in government revenue after the national real estate bubble burst. In the "orthodox" Desertec concept, Spain would play an important role as a transit country for transporting electricity, and possibly also as a customer. In addition, in the 2000s Spain had developed into an important location for the large-scale application of CSP technology. In 2007 feed-in tariffs for RE installations were introduced in Spain which guaranteed payment of 27 euro cents/kWh up to 49 MW installed capacity for 25 years (Greenpeace International 2009, 74). On this basis, the CSP plants Andasol I to III were designed for an installed capacity of 49 MW. However, as a result of the financial crisis, Spain stopped paying this feed-in remuneration, which cut down investment opportunities in respect of CSP both nationally and internationally. In addition, Spain had built up an excess supply of energy through the development of RE, which became even bigger as a result of the economic recession following the financial crisis because there was a lower demand for electric power. Thus, Spain had no interest in importing electricity for itself from countries south of the Mediterranean. And, at least in the medium term, the idea of constructing big transit lines through Spain was unrealistic; it seemed doubtful whether, in the complex approval procedures, the Spanish government and administrative organs would give their support to the construction of transmission lines, without any tangible benefit for the Spanish economy and society.

7.1.4. The Fukushima nuclear disaster and its consequences

Besides the dramatic consequences for those directly affected, the nuclear disaster at Fukushima in March 2011, as a discursive event, also influenced political decisions made around 9000 km away in Europe, and gave a new impetus to debates concerning a nuclear power phase-out which had been going on since the 1970s. In Germany, the federal government incorporated this directly in the national energy policy by deciding to speed up the nuclear phase-out, with direct consequences for the energy industry. It would be plausible to think that Fukushima might have also given a new impetus to the Desertec project, assuming for instance that the advantage of being able to

regulate the energy supply from CSP plants would find social and political approval. Instead, after Fukushima, there was an impressive increase in the construction of decentralised renewable energy installations in Germany, but without any consensual vision of how to meet the full demand using renewable energies in the long term. Considered superficially (and for the protagonists: only superficially), this increase, which German companies argued was too high because of the EEG surcharge, seemed to make the production of electricity in the desert superfluous. The accelerated restructuring of the German electric power industry after Fukushima was thus a disadvantage for Desertec supporters. Yet to this day there is no politically accepted long-term concept for how renewable energies can meet the complete power demand in Germany using only decentralised installations, although decentral storage and the implementation of power-to-gas systems might possibly allow the building up of a full supply of domestic renewables in Central Europe in the long term.

7.1.5. The “Arab Spring” and its consequences for the Desertec project

With regard to the so-called Arab Spring, which gave rise to so many political hopes, one might plausibly argue that, at least at the beginning, it could have given ideological support to a regenerative infrastructure project like Desertec. But the opposite happened, at least in respect of the MENA countries Tunisia, Egypt or Libya, which were affected in deep, if different, ways by the revolutionary processes. Ernst Rauch (Munich Re) said in the interview:

The political situation in North Africa and the Middle East has become unstable – just think of the Arab Spring. This means that discussions on the political level with these countries were much slower. Suddenly there were no more contact people [for instance due to staff changes in the ministries]. That was not foreseeable (interview E. Rauch, April 2015).

Conversely, it is no coincidence that Desertec-compatible projects were successful in Morocco. The monarchy, under which plural social discourse was possible before the *Arabellion* – within limits that were controlled by the state – made some concessions to the revolutionary forces at the beginning of the *Arabellion* and subsequently remained politically stable (for a further discussion of Morocco, see Section 7.2.3).

7.2. On-going regime restructurations and Desertec

In the terminology of the MLP approach, the Desertec idea coincided with a reasonably favourable environment in the sociotechnical and cultural landscape. But less favourable to the work of the DII, which was founded in 2009, were the on-going restructurations within the energy supply system.

7.2.1 Two competitive niche technologies: photovoltaics and CSP

In the publications of the Desertec Foundation, the emphasis was laid as a rule on the construction of big solar thermal power plants (CSP) in the desert regions and not on big photovoltaic installations. The priority accorded to CSP technology was based on the fact that – unlike PV and wind systems – solar thermal heat can be stored, which makes it possible to regulate a supply of electricity from renewable energies (Sections 5 and 6). This was considered as the decisive advantage of CSP technology. At the beginning of the 2000s, when the Desertec idea was developed in the TREC network, and the first feasibility study was prepared by the DLR (DLR 2005), both CSP and PV were still niche technologies. In respect of electricity generation costs, these two technologies could be regarded as equal, both at that time and in future forecasts. The first basic DLR study MED-CSP gave a cost of approximately 8 euro cents/kWh for CSP technology at sites in the MENA region in the early 2000s, and 25–30 euro cents/kWh for PV (see Figure 4 and DLR 2005, 15). According to the assumed learning curves, the price for PV could be expected to fall in subsequent years, but the assumed generation costs for PV would remain above those of other relevant sources of energy until far into the 2030s (see Figure 3). A more recent forecast by the Fraunhofer Institute for Solar Energy Systems (ISE) published in 2014 (the last year of the

Munich-based DII) shows that these assumptions in the DLR study were not right (ISE 2014): the average cost of generating electricity with PV plants at comparable sites (with high solar radiation) was given as only about 8 euro cents/kWh in 2013, and this was expected to fall moderately to about 6 euro cents by 2030; the generating costs with CSP technology were higher than with photovoltaics both in 2013 (with an assumed cost of 14–19 euro cents/kWh) and in the figure forecast for 2030 (9–11 euro cents/kWh) (ISE 2014, 14). The high demand for PV modules, for instance in Germany due to feed-in remuneration, and then China's entry into solar cell production, led to a reduction in the costs of PV which exceeded optimistic forecasts and took many actors in the energy market by surprise. Thus, in comparison to PV or wind, CSP became unattractive, since the returns were too low under the given market and subsidy conditions – as long as there was no remuneration for its decisive advantages, storage and regulation; to this day, the markets and the government with its possibility of regulatory interventions have remained largely blind to this situation. While countries like Germany were willing to pay for greater installed capacity and a global reduction in the cost of renewable energies by granting high subsidies, they have yet to honour the provision of controllable renewable energy. There is a good reason to speak of a market, or failed market modelling, which prevents the expansion of CSP.

7.2.2 The restructuring of the German electricity regime

In addition to the above changes in the international political "landscape", there were also some remarkable changes after 2009 in the energy industry in Germany as the "anchor country" for the Desertec project; these changes directly affected the chances of realising the project. The energy transition in Germany, at first understood as a nuclear power phase-out (and in the meantime as a long-term phase-out of fossil energies), did not begin as a reaction to the Fukushima nuclear disaster, but goes back to the so-called nuclear consensus which was negotiated in 2000 between the Social Democrat and Green government and the big power supply companies. In 2010, despite protests by the anti-nuclear movement, the Christian Democrat and Liberal government extended the approved lives of the existing nuclear power stations. Nevertheless, it must have been clear to the power supply companies that the phase-out would be completed in a more distant but still foreseeable future, and that they would have to develop alternatives both in respect of the generation of electricity and in respect of their business models. In this context, implementation of the Desertec idea could be conceived as a practicable long-term strategy which would enable financially strong power supply companies to continue to perform well in the electricity market with regenerative, but centralised, installation structures. In this light, it is not surprising that RWE and EON, two big German energy suppliers, joined the DII, both of which had scarcely invested in renewable energies up to this point, and both of which had been key opponents of the environment movement for a long time. On the other hand, for Hermann Scheer, one of the global pioneers of renewable energies, an SPD politician and president of Euro-solar, who died in 2010, the Desertec project was instrumentalised as a kind of Trojan horse by the established supply companies, "in order to put a stop to the dynamic development of Renewable Energies in this country [i.e. in Germany]" (Eurosolar 2009b). The reconstruction of the genesis of Desertec/DII in Section 4 does not exclude the possibility that RWE and EON joined the DII consortium with such an idea in mind; but any claim that Desertec and DII as a whole were founded for the purpose of preventing a decentralised development of renewable energies is not tenable and is refuted by my reconstruction of what happened. Mumford (1964), in his dichotomous comparison of two kinds of technologies, with decentralised or centralised organisation, has shown that the apparently technical question of the organisation of supply structures involves a great number of sociopolitical conditions and implications (Table 2).

He argues that centralised technologies encourage centrally controlled and undemocratic social formations: a press release by Eurosolar in June 2009, probably written by Hermann Scheer, applies this argumentation as follows:

Table 2. The dichotomy of authoritarian and democratic technics according to Mumford (1964).

Authoritarian technics	Democratic technics
System-centred	Man-centred
Unjust distribution of goods and bads, in Favour of central elites	Socially and regionally fairer distribution of goods and bads
Powerful	(Relatively) weak
Centralised	Decentral
Inherently unstable	Durable

Source: By the author, based on Mumford (1964).

It was the early environment movement which shook the faith of people in such promises of salvation and turned against centralized and undemocratic structures. Actors like Greenpeace, who in a current study welcome the Desertec model, thus reveal that they do not understand the character and the functional mechanism of the energy turn (...) It means more than just protecting the climate, it means bringing about a complete change of paradigm in energy supply, industry and society. Individuals, civic enterprises and medium-sized businesses will democratize our energy supply and replace less dominant companies (Eurosolar 2009a).

However, the question arises whether Mumford's pioneering insight concerning the connection between the structure of technology and the form of society, which was taken up by the alternative movement, is reduced here to a kind of coagulated, unquestioned ideology, and whether the positive effects for global society of a transcontinental energy network based on renewable energies would not outweigh the possible disadvantages. One could argue, in opposition to Scheer, that the Desertec model is a large-scale, but not a centralised system, since although it must be coordinated, it can be realised only in cooperation with many actors in Europe and the MENA region. Mumford's dichotomy would thus be relativised in favour of hybrid, mixed forms.

When the German government revoked the reactor lifespan extension after the Fukushima disaster in 2011, and ordered an accelerated nuclear phase-out, the big energy companies in Germany were caught off guard. At the same time, the government continued to subsidise decentralised renewable energy installations. Thus, between 2009 and 2011 the installed capacity of PV in Germany rose by a factor of 2.3 from 10.6 to 23.49 GW (Bundesnetzagentur 2013, 20). While the DII was still in the design phase, a decentralised restructuring of the German energy system was taking place, which affected the sources of energy, the sites of power stations and company structures. Although surveys show that the majority of people in Germany support the decision to speed up the nuclear phase-out, the public debate on the increasing amount of money spent on subsidies for renewable energies intensified after 2011; there were growing demands to limit this spending, and these demands were met with legislative amendments. Although the German public, or *published opinion*, had enthusiastically welcomed the Desertec project, there now seemed to be no chance in the political discussion to justify extending such subsidies to RE electricity generated *abroad*. But under the present conditions, such subsidies, or alternatively purchasing guarantees, would have been a *conditio sine qua non* for realising the Desertec concept with its high, internationally coordinated investments; in 2009, when DII was officially launched, all the protagonists from Desertec or DII whom I interviewed were agreed on this point. One of the self-appointed tasks of the DII was

to create a favourable regulatory environment in order to enable local off-take as well as export of desert power to Europe. The desired regulatory framework aims to mitigate the existing regulatory risks, to create the right conditions for a prompt implementation of renewable energy projects and to ensure a generation of revenues, sufficient to close the "financial gap" currently inherent to most renewable energy technologies (DII 2013).

By 2013/2014 at the latest, it became obvious that, despite verbal support from the German government and the EU, no one would be prepared in the medium term to pay subsidies for electricity from abroad or to give purchasing guarantees.

Thus, DII did not fail because of a general competition between decentralised and centralised renewable energy systems, but, at least partially, because the decentralised systems were developed

more rapidly and had already used up the government subsidies which the political class thought it could justify in the face of the German public. While decentralised PV and wind systems left their technological niches and became part of the established energy supply system, imported CSP electricity, despite support by international companies, stayed in a technological niche.

7.2.3. Take-off: the beginning of a CSP/RE success story in the MENA region?

While the idea of exporting electricity from the MENA region to Europe seems to be a very distant prospect, the use of renewable energies to generate electricity for national consumption has increased in recent years in some countries in the region. The much-discussed reference case is Morocco, which, under conditions of political stability, encouraged the development of renewable energies at the behest of the national decision-making powers – in other words King Mohammed VI and his advisers. In November 2009, the Moroccan Solar Plan was presented to the public in the presence of the king (and the US Foreign Secretary Hillary Clinton), in the pre-Saharan regional centre of Ouarzazate. According to the plan, solar thermal plants with a total capacity of 2000 MW were to be built at five different sites by 2020; the investment costs were estimated at 9 billion US \$ (Masen 2010). This investment in renewable energies was explained by the need to reduce the country's dependence on imported sources of energy, the increasing demand for electric power within the country, and climate protection goals. In addition, Morocco wanted to establish itself as the “first North African developer of large-scale solar power plants” and to “integrate itself in the regional and international energy markets” (Masen 2012). This last is an indication that Morocco was also considering the energy export option in the sense of the Desertec concept, although this was probably seen “as a strategically very interesting option” in the “medium term” rather than in the short term.¹⁵

In 2016, after a construction period of four years, the first of a planned group of solar thermal power stations was completed near the pre-Saharan regional centre of Ouarzazate. It was called Noor I, *noor* being a French transcription of the Arabic noun meaning “light”. This CSP plant uses parabolic trough technology and has an installed capacity of 160 MW; it covers an area of around 4.5 sq km; it can store enough heat to generate electricity for 3 h. By 2018 the whole complex near Ouarzazate will have an installed capacity of 580 MW and cover an area of 30 sq km (Masen 2015). Noor I was commissioned by the state Moroccan Agency for Solar Energy that was founded in 2009 (Masen 2015). Probably to the surprise of many European observers, the contract was awarded to an international consortium under the leadership of the Saudi Arabian company Aqwa Power. This company was not a founding member of the DII, but it holds a large interest in the present-day DII with its headquarters in Dubai, and occupies a strong market position in the area of CSP, while Siemens, for example, decided in 2012 to stop building CSP plants.

In this context, Siemens had made an investment which, according to observers, was a strategic mistake (and helped to open up business opportunities for the competing Saudi Arabian Aqwa Power): in 2009 Siemens bought the Israeli company Solel, which was a leading company in the area of solar thermal trough technology for CSP plants, and had built CSP plants in California in the 1980s. However, the political tensions between Israel and most of the Arab countries were exacerbated by the Gaza War in 2008/2009, and this seriously affected the economic policies of the Arab countries, with the result that Siemens now had no chance in these countries in respect of acquiring public contracts in the CSP area; it may also have had negative effects on other business fields of Siemens. Practically at the same time that it left the DII consortium, Siemens announced in October 2012 that it intended to stop building CSP plants and to sell its subsidiary Solel.¹⁶ After the insolvency in 2011 of *Solar Millenium*, a German project developer for CSP plants, the withdrawal of Siemens from the CSP business could be interpreted as a turning point in the history of Desertec, which thus lost an important anchor company. But the *de facto* boycott of Israeli enterprises by Arab states should not be short-sightedly equated with human-rights driven, ethical business behaviour, in view of fundamental human rights violations in authoritarian, or even totalitarian, Arab countries like Saudi Arabia.

However, awarding the contract for Noor I to an Arab company dissipated accusations of European neo-colonialism in connection with such solar projects. In the German media, reports on the Moroccan solar power station frequently made reference to Desertec, and sometimes even gave the impression that this power station was a part of the Desertec project or an activity of the DII. In formal terms, this is not true, for the decision to build these power plants was made by Moroccan institutions, and was initiated originally by the king. But in a broader, discursive sense, it can be regarded as an achievement of the TREC network, Desertec's predecessor, which had involved Moroccan scientists. The building of this complex and the founding of DII were visible expressions of an overarching discourse, and it is plausible to think that the Moroccan members of TREC were instrumental in the Moroccan Solar Plan.¹⁷ Moreover, the KfW, a German public investment bank, mandated by the German Ministry for Economic Cooperation and Development and the Ministry of the Environment, co-financed the construction of Noor I with a loan (100 million euros) and a donation (15 million euros), together with other foreign and international sponsors (World Bank, l'Agence Française de Développement, Banque Africaine de Développement, European Commission) (Masen 2015).

In the region of North Africa, the Noor power plant complex and the Moroccan Solar Plan stand out as a uniquely consistent renewable energy project. The Moroccans decided in favour of CSP technology, despite its higher electricity generation costs in comparison for instance with PV and wind (perhaps as a result of its promotion by the TREC network); with its salt storage system, Noor I can generate electricity for 3 h without direct radiation from the sun, while the CSP plant Noor II (200 MW, initial operation scheduled for 2018) has a storage capacity of seven to 8 h and uses the water efficient dry cooling technology. Noor III (under construction) with a solar power tower of 247 m high has a capacity of 150 MW; Noor IV (75 MW) relies, despite of the original planning, on photovoltaic, due to the cost advantages of this established technology.

The Moroccan strategy of building big renewable energy plants to help meet the national power demand rather than for export, does not correspond to the Desertec model so much as to the *desert economy* proposed by Hermann Scheer. In the terms of the DLR studies, we can say: MED-CSP (CSP as a source of power for the MENA countries) is currently a realistic option, while TRANS-CSP (exporting electricity to Europe) is not (Figure 6).

The Moroccan power plant complex shows that finding suitable sites in the desert is not an easy matter: around 2000 workers and their families need adequate infrastructures, which they find in the regional centre of Ouarzazate. Another point is that the Noor I power plant requires water, which is obtained from the nearby reservoir El Mansour Eddahbi – an important consideration in a desert region.¹⁸ A look at the climatic conditions at concrete sites shows that even in pre-Saharan or Saharan regions CSP technology does not guarantee an uninterrupted supply of electricity: even in the Sahara, as at Ouarzazate, the sky can cloud over, especially in the winter months when demand is higher, which can result in shutdown of the power plant when the stored heat runs out.

8. Conclusion: Desertec as a “technology without sociology” or as a long-term option?

Hermann Scheer used a catchy wording for the Desertec concept which scholars of SST might find interesting: he referred to Desertec as “technology without sociology” (Scheer 2012, 144) and as the expression of a “new gigantomania” (Scheer 2012, 137). He concluded that “technical feasibility” – and Scheer had no doubt that this applied to Desertec – is “not social feasibility” (Scheer 2012, 150). The following passage makes his argument clear:

Realization of the desert power project at the promised cost and within the planned time schedule is practically impossible for obvious political, economic and sociological reasons. By this I do not mean that the authors of the studies did a bad job. But such studies can only calculate what would happen if everyone involved spent several decades carrying out the project exactly as planned. But this is totally unrealistic, if only because of the number of institutions that would be involved: over forty national governments, each country with its own national grid

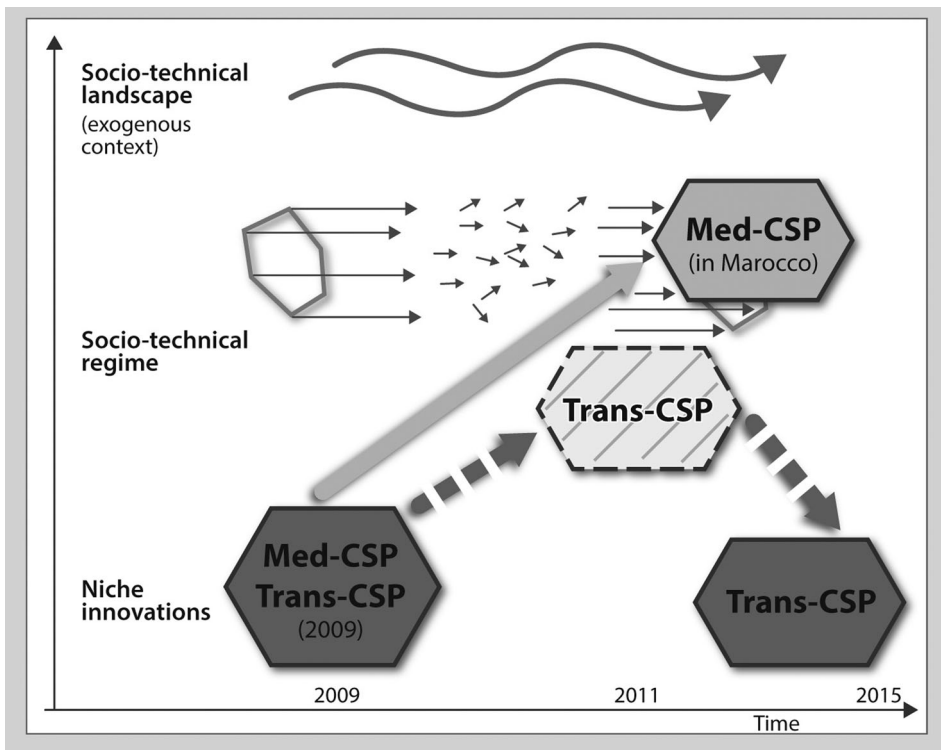


Figure 6. Desertec in the interpretational context of the MLP approach: the niche technology CSP between virtual and real “take-off”. MED-CSP: CSP for Mediterranean countries; TRANS-CSP: CSP plants for electricity export to Europe. Source: by the author, referring to the general MLP-scheme in Geels and Schot (2007, 401)

system, and, not least, many regional governments through whose territory the power transmission lines would have to pass (Scheer 2012, 145f.).

Scheer’s analysis is interesting for two reasons. First, it offers serious anchor points for a retrospective discussion in the social sciences on the development of the Desertec concept, where it is at least partially shared. Second, it had a performative character, since Scheer was an important German politician with an interest in the environment, whose opinion, even posthumously, influenced the attitude to Desertec of his party, the SPD (which as from 2012 again provided the Minister for Economic Affairs and the Minister of the Environment) and of other social stakeholders. His opinion also affected the core actors in the DII. The retrospective analysis by Paul van Son, DII’s CEO, which is quoted below, concerning the question why the export hopes of the Munich-based DII were not fulfilled, shows a number of similarities to Scheer’s argumentation. In his analysis van Son refers to the fact that a part of the Desertec mission had been fulfilled, namely “to make renewable energies competitive [in the MENA region], so that solar and wind power can successfully compete in the deserts against other sources of energy such as oil, gas, coal and nuclear power” (interview P. van Son, March 2015) – which corresponds to Scheer’s desert economy concept. But, according to van Son, this does not apply to the second part of the Desertec, the idea of exporting electricity from MENA to Europe, which is unrealistic in the foreseeable future, under the given conditions. Paul van Son argues as follows:

And the second issue [the first being supplying the national markets of the MENA countries with power based on renewable energies, T.S.] is connecting the markets [in Europe and the MENA region, T.S.], in the way we are familiar with in Europe, [in the form of] electricity networks (...). As you know, Europe has big excess capacities. Europe will go on supplying electricity to Morocco or North Africa for many years (...). Exporting energy to Europe will only be interesting when producing it is cheaper in North Africa or in the Middle East and big quantities are

available. And then the networks will be built (...) But in primitive versions, mainly in the press but also in scientific institutions, there was the idea that special cables would have to be built in order to transport the electricity [to Europe] from North Africa, or some such nonsense. That's not how the energy sector works (interview P. van Son, March 2015).

In this statement, it is striking that Paul van Son distances himself not only from (unidentified) “scientific institutions” but implicitly also from large parts of the studies and texts published in the name of the DII, in other words from the staff of the company headed by himself.

We could say that for Paul van Son the original Desertec idea was technology without understanding how the market works, while for Scheer it was technology without understanding the sociological aspects involved. However, in contrast to Scheer, Paul van Son does not exclude the possibility that *in the long term* exporting electricity from MENA to Europe could be a reasonable and viable business model. To borrow the language of the French regulation school, before it can be realised the Desertec concept needs a strong “international state” or strong international cooperation in respect of the construction of transcontinental transmission lines, and “strong” nation states that intervene in the business process by giving purchase guarantees for the power generated in the desert. In terms of the MLP approach, Desertec/DII supporters wanted to take a technology that was well-developed but which occupied only a niche in terms of market shares, and make it, from zero to hundred, a significant part of the sociotechnical international energy supply system. But they failed to define intermediate business goals via which the new energy supply structure could evolve. The only intermediate goal they considered was the development of RE for consumption in the MENA countries – and in countries like Morocco efforts are indeed being made to achieve this goal.

The above analysis shows that the implementation of a “complete” Desertec project has not been possible to date, on the one hand because of fundamental, inherent problems (such as the complicated coordination required for transcontinental transmission lines or the problem of obtaining purchasing guarantees for electricity imported from the Sahara), and on the other hand because of contingent, unforeseeable factors (like the outbreak of the *Arab Spring*). From the point of view of STS, it would be possible to argue that there will always be unforeseeable difficulties in connection with large-scale projects and that these must be anticipated when planning the project.

Under the current, otherwise unchanged, market conditions, a transcontinental electricity network *à la* Desertec could only be realised if the decided and coordinated political will of national governments, and, for example, of the EU, enabled a remodelling of the conditions for energy markets in favour of the idea. Protagonists of Desertec can legitimately continue to argue that the lack of such a political will and its implementation is a blatant failure of politics or governance, since additional CSP energy from the Sahara would help to ensure that Europe's power needs can be fully met with RE, and that gradually building up such technical structures makes economic sense in the long term. How meeting all of Europe's energy needs with renewable energies can be achieved in the long term is at present an open question, since, despite the excess capacities of decentralised installations, without efficient storage technologies power cannot be produced when it is dark or when there is no wind. A study by Henning et al. (2015) suggests that meeting central Europe's full demand with *local* renewable energies will not be possible, so that at least a small percentage of RE power, for instance, 15% as proposed by the DLR, must be imported from countries in the South. Without challenging the primary role of decentralised systems in supplying Europe's energy, CSP-based desert power could thus play a “central” role in future which would help to keep down the cost of developing decentralised systems. On the other hand, power-to-gas systems could allow the storage of temporary surpluses for use during periods with no wind and no photovoltaic energy production, thus making electricity imports unnecessary.

8.1. Insights for Transition Studies and the SST?

Recent projects in East Asia, such as the East Asian Supergrid (promoted by Masayoshi Son of Japan) and the Global Energy Interconnection (promoted by the State Grid Corporation of China), show that

the idea of super grids based on renewables is globally still alive, beyond the specific context of the “EUMENA” region.

The focus of this article lies on the reconstruction of the Desertec project by applying concepts and categories from SST and especially Transition Studies. But does this case study also offer general insights for theory development? Acknowledging the limitations of a single case study for drawing theoretical conclusions, this final section offers some ideas for a further theoretical discussion. My analysis has been fruitfully guided by general insights from SST, based on an adaption of Giddens’ theory of structuration, and on the basic MLP approach. I am not sure, however, whether the sophisticated, perhaps overly scholastic, efforts at definition in parts of the Transition Studies literature (Markard and Truffer 2008) can be valorised for the analysis of empirical case studies.

On the one hand, the Desertec case study shows the potential power of visions, or umbrella concepts such as the Desertec idea, for the structuration of economic activities in the sense of the implementation of technological innovations and the establishment of large technical systems. In addition, it shows the importance of individual agency, individual persons, in promoting the implementation of ideas (as in the case of Gerhard Knies, Prince Hassan bin Talal or Franz Trieb), and the importance of contingent micro social and geographical factors for the establishment of innovation networks; recognition of those aspects has a long tradition in SST, but seems to be missing in the newer, more functionalist and formalistic debates of Transition Studies. On the other hand, despite the impressive activities initiated by the medium-range vision of Desertec, the idea was thwarted by hard economic factors (especially the relative electricity generation costs of CSP), institutional factors (the complexity of the environments of a transcontinental large-scale technological system), and contingent factors (the so-called Arab Spring). The protagonists of Desertec were not able, at least in the short term, to influence the wider economic and institutional conditions, in order to make Desertec feasible. In this respect, this case study emphasises the relevance of hard economic and institutional factors for the selection of innovation paths. The extensive growth of renewables in recent decades is the result of shrinking production costs, but also of governmental interventions, such as subsidies. In a few decades from now, a retrospective judgement might be as follows: The market and institutional conditions of a post-growth society did not allow the establishment of a sound renewable energy system based on “decentral” and “central” elements which would be economically viable from a global perspective.

The Desertec case study also encourages reflection on the linkage between different kinds of social justice and transition to a global renewable energy system. It shows how ethically honourable motives for the improvement of North–South relations and the self-interested quest for business models can form specific, perhaps unexpected, amalgams. However, at least in the case of Morocco, the national government has been able to take the driver’s seat and use the available international support for its Solar Plan and its own development objectives.

Notes

1. Statement by Caio Koch-Weser, Deutsche Bank, press conference on the founding of DII, July 2009 (author’s own transcription).
2. TREC: Transmediterranean Energy Cooperation, a network of people founded in 2002, mainly by the Hamburg engineer Gerhard Knies, for the promotion of solar-based energy cooperation between European countries and those of the MENA region.
3. Nikolaus von Bomhard, the then Chief Executive Officer of Munich Re, at the press conference held on 9.7.2009 (author’s own transcription).
4. Due to research restrictions and the geographical dispersion of the people I wanted to talk to, the interviews in this first round, in 2009/2010, were mainly conducted by telephone.
5. Sir S. Thompson, opening speech at the 79th congress of the British Association in Winnipeg (Canada), quoted after Bebel (1910). Bebel’s *Woman and Socialism* was one of the most influential works in the social democratic and socialist literature and was reprinted many times even after his death. It is conceivable that this book first made the idea of using the Sahara as a source of solar energy familiar to a broad public which then continued to discuss it for decades. However, Gerhard Knies, as a central protagonist of the Desertec idea, was not aware

of these quotes in Bebel's book (personal communication Knies, June 2017). For Gerhard Knies the activities of the DLR were mainly inspired by the aircraft engineer Ludwig Bölkow (see below).

6. It is interesting that Ludwig Bölkow (as an industrialist and the initiator of the European Airbus) was influenced in his technological and ecological engagement by the publications of the Club of Rome (Ludwig-Bölkow-Stiftung 2017), under whose auspices the Desertec idea was later developed.
7. Statement at the press conference on the occasion of the founding of DII, July 2009 (author's own transcription).
8. My impression is that this aspect was largely ignored in publications by the Desertec Foundation or the DII – obviously in order to preserve the integrity of their own vision.
9. Estimate by DLR (DLR 2006, 26, personal communication F. Trieb [DLR], December 2009).
10. This view was shared by a number of the people I interviewed, including Gerhard Knies (interview, March 2014).
11. Hermann Scheer died in 2010 and had opposed Desertec both in public and within his party, and in a book that was published posthumously (Scheer 2012).
12. This is how it was expressed (in indirect speech) in a German parliament press release (Deutscher Bundestag 2010).
13. Interview H. El Nokraschy, March 2014.
14. Meadows et al. (1972) focused on the finiteness of fossil resources and global pollution of the environment in a limited space; the potential danger of an anthropogenic climate change due to increasing carbon dioxide emissions is briefly mentioned (Meadows et al. 1972, 73; 81), but is not discussed at length, unlike other kinds of environmental pollution, including increased temperatures in urban heat islands: for the authors it was "not known how much CO₂ or thermal pollution can be released without causing irreversible changes in the earth's climate" (Meadows et al. 1972, 81).
15. According to a representative of the German Ministry for Economic Cooperation and Development (9/2014), placed in Rabat, Morocco, in an interview quoted after Fischer (2015, 140).
16. However, Siemens delivered two turbo generator sets, each one comprising two steam turbines and one generator, for Noor I, and so Siemens was, despite its withdrawal from DII, quite present on this relevant construction site.
17. However, I have not been able to verify this plausible assumption by interviews with the people concerned.
18. Supporters of Desertec had often argued that thermal power plants in the desert could be designed to use air cooling instead of water. It is significant that proximity to a reservoir influenced the choice of site for Noor I.

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