Global and local networks in the Solar Energy Industry –
The case of the San Francisco Bay Area

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1. Introduction

In recent years climate change has become a hot topic in the public media. This increased public attention has moved alternative energy sources in the focus of public interest. But not only public concerns, also steadily rising energy costs are a factor for the emergence of alternative energy sources. One element of these new forms of energy supply is solar energy. Even if the importance of this energy source is marginal at the moment, it has established a growing industry in this specific field. Various forms of public subsidies have increased the installed capacity on a global scale and have nurtured a developing industry, due to increased sales. The potential for this industry seems to be enormous, even if the industry today is still dependent on public support. So what is the situation in the country that has the highest energy demand worldwide and where air condition is a basic feature in every household? Is there a rethink in the USA regarding its energy usage?

In the United States renewable energies are on the way. Several states have passed bills to foster the use of alternative energy sources and therefore also solar energy. One of these states is the state of California, which has ideal natural conditions for solar energy. With the two main stimulations, the „California Solar Incentive“ (CSI) in the year 2006 and the „Million Solar Roof“ program (2004) the foundations for rising demand for solar energy products have been created. Interestingly the majority of solar energy companies are located in California. Some of the leading companies worldwide have their headquarters here and numerous smaller companies constantly producing new product improvements and innovations. In particular, this emerging industry has its center in the metropolitan area of the San Francisco Bay Area.

In the academic literature it is generally assumed that spatial proximity is important, especially in immature industries. One factor of success for firms is supposed to lie in the company’s integration into local networks.

At the latest since the article “Clusters and the economics of competition” by Michel Porter local networks of companies are in the focus of political and scientific interest. Since then a vast number of publications have emerged on the topic of clusters and local networks. The underlying argument of this study is that economic relations are bounded to a high degree into social relationships. Companies interact in a complex environment of relations and are dependent on social capital in the shape of networks. Mutual trust plays a role for the existence of network connections.

As a superior question for this project, it has to be analyzed which types of contacts – as well regarding a spatial dimension as an organizational dimension - do exist between companies.
Therefore the concrete questions are: How do the network interactions of companies in the solar energy industry in the region look like? Is there a spatial focus on the region or do interactions pass on a global scale? What are the implications for the exchange of knowledge in such networks?

My main hypotheses for this study are the following ones:

1. **The type of interaction and the geographical orientation of the companies will differ regarding their level in the supply chain.**
   
   The more intense companies are integrated into interactions with their suppliers and customers the more important is spatial proximity for the production process. With increasing orientation towards the requests of costumers and with an increasing degree of competing technologies the number of interaction partners will grow and the degree of interaction will rise.

2. **Smaller companies are dependent on global companies in their region, because of their connections to other companies around the globe and their ability to diffuse external knowledge within the region.**
   
   The establishment and the maintenance of companies’ connections outside of the own region consumes internal resources of a company. Smaller companies are not capable to use their capabilities for building up networks to the same degree as large companies. Therefore global pipelines exist especially between the different global players in distinct regions. These global players act as a kind of “gatekeeper”, which allow or deny smaller companies to share this exclusive knowledge.

3. **Organizations and institutions direct external sources of knowledge inside the cluster.**
   
   Organizations and institutions act as an interface between local buzz and global pipelines. One of their tasks is to create advantages for local companies and to bring different companies together. This brings them in the position being a reference point for smaller companies which do not have direct contact with global companies. Therefore, institutions are at least partly able to diffuse external knowledge also in smaller companies.

4. **In the San Francisco Bay Area processes of specialization towards certain products and technologies in the industry take place. So, the region has specific network functions.**
   
   The company networks in the solar energy industry in the San Francisco Bay Area are embedded in global production networks. Within this global production network
companies in different regions concentrate on specific products and technologies in order to differentiate against competitors in other regions.

The structure of this paper is divided into six parts. First of all, I want to state the main theoretical foundations for this study. These are namely the considerations on the topic of clusters and networks according to Michel Porter and their extension regarding knowledge production by Bathelt et al. (2004). As a second main idea for this paper the concept of Global Production Networks (GPN) will be analyzed. The next chapter will give an overview about the development of the solar energy industry, the special characteristic of this industry and their spatial structure. Then, I want to highlight the organizational structure of the industry and analyze it regarding the theoretical background. The methodology used for this research project is the topic of the fifth chapter. Finally, the results of the empirical study will be applied towards the theoretical concepts. The main findings of this analytical work are the baseline for brief suggestions regarding regional policy.

2. Theory

2.1. Cluster and networks

First of all, it will be discussed what the term network refers to, before going on with the characterization of regional and global networks. Networks are forms of organization, which are situated between market and hierarchy. The network concept, mainly influenced by Granovetter (1985), is offering a middle ground to see economic activity not through the lens of deterministic approaches nor from the view of an atomistic approach. The role of human agency is highlighted but it only happens within structural constraints. Three different benefits can derive from networks. First, “ties can facilitate access to parties that provide information or resources” (Smith-Doerr & Powell 2005: 379). Second, linkages can generate advantages in regard to timeliness over those that lack comparable connections. Third, “referrals offer the opportunity to bypass formal, impersonal channels” (Smith-Doerr & Powell 2005: 379).

The existence of networks can be explained by different theoretical approaches. One is the concept of transaction cost by Williamson. He argues that manifold costs, like search of information, contract agreements, control of quality and governance, come out from the exchange of services of different actors. Companies have either the option to run business activities within the enterprise itself or to purchase services by market exchange. Another option is the establishment of business networks. In contrast to the transaction approach, the
concept of embeddedness argues that economical behavior is an interdependency of the structure of social relations (Bathelt & Glückler 2002: 160). In this concept the existence of networks is explained by the embeddedness of companies in their environment.

The topic of clusters and networks has been brought in the focus of interest since the early 90s und has been a hot topic in social science and economics (Thomi & Sternberg 2008: 75). This concept is used in different academic disciplines regarding various context and different industries in several regions (Bathelt 2005: 204). In particular, this theme got attention within various scientific spheres and in the public by the publications of Porter (1990) “The competitive advantage of nations” and the more local-centered version “Clusters and the economics of competition” (1998). The term cluster is defined by Porter as “geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated organizations (such as universities, standard agencies, trade associations) in a particular field linked by commonalities and complementarities. There is competition as well as cooperation” (Porter 1998). The main idea of his work is that companies within the cluster have specific advantages against other companies outside the cluster. The concept of cluster is based on several theoretical concepts regarding the explanation of specialized industry locations. Even in the early work “Principles of Economics”, Alfred Marshall described the advantages of spatial proximity of companies. One of Porter’s main arguments is that the competiveness of a region accounts out of the following factors: Demand conditions, companies’ strategy, supply conditions and connected and supporting firms within the region. According to Porter there is a vertical as well as a horizontal dimension in a cluster. The vertical dimension describes the interaction networks of a company along the production chain (see chapter 2.2.). On the other hand, the horizontal dimension considers the interaction between the different competitors (Bathelt et al. 2004).

The main idea is that spatial proximity correlates with an intensive competition with other companies. In recent years this concept has been extended by further components. Thus, according to Sternberg & Thomi (2008: 74) the “diagonal dimension” of clusters in addition to the vertical and horizontal dimension has come into focus of interest. Additional actors like research institutes, service provider or other organizations and institutions are included in the analysis (Bathelt et al. 2004; Kiese & Schätzl 2008). Furthermore, clusters are discussed under the topic as integrated “knots” in global production chains.
A central element in the analysis of network structures is the importance of company’s integration inside an actor network. The consideration of Bourdieu’s concept (1983) of social capital can be a good starting point of explanation. He differentiates between economic capital, social capital and cultural capital. Social capital describes the possibilities for an individual to gain advantages out of the integration into interpersonal relations. With the integration into a social network the individual gains information and the possibility to acquire further contacts. Applied for companies Maskell (2000: 111) mentions, “[…] social capital ‘enables firms to improve their innovative capability and conduct business transactions without much fuss and has, therefore, substantial implications for economic performance”.

![Figure 1: Local Buzz and global pipelines. In: Bathelt et al. (2004: 46)](image)

As Bathelt et al. (2004) state, it does not only depend on interactions within the cluster, also the transaction and interaction flows outside the cluster to external actors are relevant. Functional company’s relations are not limited to narrowly defined local milieus. Knowledge and information play a great role in the process of interaction of companies. To demonstrate the different possibilities to gain knowledge Bathelt et al. (2004: 39-40) differentiate between “buzz” and “global pipelines”. Thereby, the term “buzz” relates to “information and communication ecology created by face-to-face contacts, co-presece and co-location of people and firms within the same industry and place or region” (Bathelt et al. 2004: 38). The exchange of news is fulfilled rather randomly between persons of a local network. In contrast to this, access to global pipelines is costly and ties internal capacities of a company for the establishment of such interactions (Malmberg 2003: 158). Figure 1 shows that actors within a region can have access to buzz on the basis of shared values and attitudes. Global pipelines add distinct information from places outside of the region to the knowledge base of only certain actors. However, access to external knowledge is of substantial relevance for
companies within a local network. The reason for this is that it prevents a technological lock-in and that it diffuses new information inside the regional cluster. “Thus clusters can be seen as nested within, and impacted by, other spatial scales of analysis, including regional and national innovation systems, as well as the kind of global relationships and forces implied by [...] ‘pipelines’ [...], each of which adds an important dimension to the process of knowledge creation and diffusion that occurs within the cluster” (Wolfe & Gertler 2004: 1079).

Larger companies have more capabilities than smaller companies; therefore they are more capable of building up global connections. Like Graf (2008) argues this leads to asymmetric power relations within the regional production system. Especially those companies, which have external knowledge sources and diffuse this knowledge into the local milieu are of great importance for the regional firms. These companies fulfill the role as a gatekeeper to certain knowledge flows and have a special position of power against other actors in the local network. Like Graf (2008: 2-4) argues, “in terms of network relations this means that a gatekeeper has to interact frequently with partners external to the system and at the same time be integrated within the local system via a sufficient number of internal relations.” Wrobel (2009: 96) describes “gatekeepers” as key persons within networks because of their ability to have a command in several “languages” (codified settings), which enables them to absorb new knowledge. Their abilities are the requirements for the conversion of valuable, but previously entirely incomprehensible information into influential business processes.

2.2. Global production networks

A second theoretical approach used in this study, is the global production network. This explains interaction relations with the mutual interconnectivity of companies within the global production system. Besides the functional process of exchange between companies, also external actors are included in this concept and play a great role in the production process. Furthermore the GPN approach is not limited to material flows between actors, but it also recognizes immaterial flows between the different actors.

The starting point of this theoretical concept is the deliberation regarding the “commodity chain approach”. Here, functional relations of companies along the supply chain are the focus of the analysis. The definition of this supply chain is “a network of labor and production processes whose end result is a finished product” (Hopkins & Wallerstein 1986: 159). The substantial elements of a supply chain are based on input-output relations as a sequence of value-adding production steps. In addition, in reality uneven power relations emerge between
different actors in the market. The access to information flows is important for the degree of power asymmetry between the market participants (Kulke 2007: 118). In recent years the supply chain approach has been extended towards the global commodity approach and the global value chain approach. Thereby the work of Gereffi (1996; 1999) was very influential. The process of globalization is highlighted in the analysis of value chains and has an impact on the structure of the chain. In this seminal work the internationalization of labor division is integrated in the analysis of organizational aspects in certain industries. The main questions arise from topics of power relations within the global value chain and the governance structure within this chain (Blair 2009: 9). One fundamental idea is the distinction between buyer- and producer- driven chains which influence the power of certain actors within the chain.

But in reality, production and distribution is integrated into much more complex interconnected chains. Like Kulke (2007: 122) notes, it is not sufficient only to draw attention on the supply side of products. Also actors, like planners, politicians and consumers have an essential influence on the organization of the supply chain. So, supply chains and the behavior of actors are embedded in political and institutional frameworks and are influenced by any change within this framework (Kulke 2007: 123). The new, upcoming literature on global production networks focuses on the social-institutional embeddedness of an interconnected production system. Therefore external actors are included in this approach (see. Hess & Yeung 2006). Coe et al. (2004: 471) define a „global production networks as the globally organized nexus of interconnected functions and operations by firms and non-firm institutions through which goods and services are produced and distributed.”

One central difference of the GPN approach with regard to the other conceptions is that interconnections in the production systems are not seen as linear relations. Rather flows within the production process pass in both directions and are influenced by the specific socio-institutional environment of each part of the network. This approach takes a relational perspective and builds upon the assumption that “flows” and “places” are in mutual interconnectedness to each other (Henderson et al. 2002: 438). In figure 2 the complex interrelations of companies with different actors is illustrated. The exchange of material and non-material flows is not only between suppliers, producers and consumers, it also includes state organizations and other network members. National and regional regulations also influence the character of production networks.

National boundaries are despite progressing globalization still important in order to explain the differences in the economic environment, factors of economic development, cultural
norms and mechanisms of regulation, which are based on nation states. Therefore the location plays a great role for the organization of production (Andersen & Christensen 2005: 1264).

Nevertheless, according to Ernst & Kim (2002: 1418) three different but interconnected transformations in the organization of the global economy have taken place as a response to the enhanced requirements in global competition. First, global production networks (GPN) have proliferated as a major organizational innovation in global operations (e.g. Borrus et al., 2000 in Ernst & Kim 2002). Second, these networks have accelerated the international knowledge diffusion, providing new opportunities for local capability formation in lower-cost locations outside the industrial heartlands of North America, Western Europe and Japan. Third, a long-term process of “digital convergence” (e.g. Chandler & Cortada 2000 in Ernst & Kim 2002), enabling the same infrastructure to accommodate manipulation and transmission of voice, video, and data, has created new opportunities for organizational learning and knowledge exchange across organizational and national boundaries. Therefore, there is a fundamental trend towards an increased mobility of knowledge (Ernst & Kim 2002: 1418).

2.3. Networks of networks

Combining both theoretical concepts, the cluster approach and the global production network approach, lead us towards the idea of local networks within global networks. Like Dicken (2007: 24) argues, companies are integrated in global networks as well as in local network relations. The global production system is interconnected with local networks, which can have the form of a localized cluster. Therefore, every part of the global network is somehow connected with the regional context and interacts directly or indirectly with organizations and businesses within a distinct region. In reference to Castells’ publication “Network society” (2000), Dicken (2007: 18) points out that global production landscapes are “spaces of places”
as well as “spaces of flows”. In figure 3 the “global” system consists of individual manufacturing and service sectors bounded in different territorial systems like local communities or regions.

Global production networks not only integrate companies, they also integrate national and local economies in their structure. So, organizational structures diminish (Dicken 2007: 24). However, on the other side national and regional characteristics and policies have also an influence on the production system on a regional and global scale. Local knots in global networks can be identified, if institutions and companies are bounded to their “local community” through certain values and norm systems.

In this project one spatial section out of this entire system, the San Francisco Bay Area, will be analyzed regarding the theoretical considerations about global production networks. Thus, the reflections about knowledge creation will be grabbed and analyzed with reference to the selected companies. In the sense of the relational understanding of economic geographical questions this paper tries to explain the functions of the region within the global production system.

3. The emergence of the solar industry

3.1. The political move for solar

The market for photovoltaic is one of the fastest growing markets in the world with a huge potential for the future. Calzonetti (2008: 150) expects a rise for this technology-based industry of 35% annually until the year 2020. This strong growth is due to massive public subsidies throughout the world. Starting from the renewable energy incentive in Germany in the year 2000, many other countries have set up different incentive packages in order to
increase their installation capacities in solar energy. In the USA, California was one of the first states setting up incentives for the solar energy industry. As Taylor (2008: 2842) describes there were also policies and attempts to foster solar energy in the 1980s and 90s, but no big impacts have occurred before the year 2000. First, on the federal level tax credits were given for installing solar energy on rooftops and on commercial buildings. And then California has adopted the successful feed-in-tariff system. In January 2006 the California Solar Incentive (CSI) was approved by the California Public Utilities Commission. Over the next ten years $2.9 billion will be granted to homeowners, businesses, farmers and government to install 3,000 MW of new solar capacities on 1 million rooftops in California (Burtis 2006: 46; Colatat et al. 2009: 7). According to Taylor (2008: 2839) this incentive has created a market for solar. Furthermore, the very ambitious politic of California’ government has the goal that state's investor-owned utilities buy or produce a certain amount of their power from renewable sources. So the California Renewable Portfolio Standard (RPS) mandates that 20% of the all electricity generated must come from renewable sources by 2010 (Colatat et al. 2009: 8). By 2020 both investor-owned utilities and municipal utilities must achieve 33 percent renewables. Therefore the demand for solar energy will strongly increase. In addition to that, numerous municipalities have created own inducements to support solar. All these political decisions leading towards the creation of a demand for solar have effects on the global production network (see chapter 6).

3.2. The spatial development of the solar energy industry

California can be seen as the state of origin for the solar energy industry. In contrast to latter location of this industry in East Germany or other locations in Asia, the activities in solar energy in the state of California have a long history. This can be traced back to the time of competition between the US and the Soviet Union in airspace technology (Colatat et al. 2009: 3). First in the region of Los Angeles, one of the centers for aerospace industry, several activities in the area of photovoltaic have established. Shortly after the invention of the first photovoltaic cell in the year 1957 by Bell Laboratories the first application developed in airspace technology (Colzonetti 2008: 150; Colatat et al. 2009: 4). Solar energy technology was able to function as the standard in energy supply of airspace satellites. The location of Los Angeles evolved as the center of research and development for photovoltaic cells. “In the 1970s, amidst growing interest in using photovoltaics to supply terrestrial “bulk” electricity, Los Angeles remained an important, though not the only, center of photovoltaic activity” (Colatat et al. 2003: 3).
But since 2001, it comes to a resurgence of PV industry activity unmatched since the late 1970s. This resurgence of the solar industry also was connected with a shift of the photovoltaic center from Los Angeles towards the San Francisco Area. There are two main factors for the timing and new location of photovoltaic production. On the demand side, Germany passed the Renewable Sources Act in 2000, which established a cost-based feed-in tariff for photovoltaic systems. This has created a large market demand for solar products. On the supply side, companies were looking for new opportunities after the burst of the IT bubble. San Francisco was the clear leader in developing a wide variety of new technologies and, with a new market in a technology-based industry, more attention was being paid to photovoltaics and other “clean” technologies” (Colatat et al. 2009: 6). Because of the concentration of semiconductor companies in part of this region, especially around San Jose, the San Francisco Bay region had advantages in regard to other locations in becoming the new center for solar companies.

4. The solar energy industry from the insight

Since one central theoretical foundation of this paper is the global production network approach, this chapter deals with the production chain of the solar energy industry. The term solar energy is kind of confusing, because it has to be differentiated between distinct forms of solar energy. In common parlance, solar energy has become a synonym for power generated by sunlight. But there are three different types of solar energy: solarthermy, centralized solar power (CSP) and photovoltaic. This study only encompasses the situation of photovoltaic. Every solar system consists of the raw material silicon which is followed up in a series of production steps. The production process dissects into the manufacturing of silicon, which is also the basic material of wafers in the form of ingot (Bradford 2006: 107). These wafers are the foundation of solar cell manufacturing companies. Solar cells are the heart of the system, since they generate electricity out of sunlight. It can be distinguished between three different technologies regarding solar cells:

- monocrystalline cells
- polycrystalline cells
- thin-film cells

At the moment polycrystalline cells are the dominant technology with a share of nearly 90% in the market. Even if monocrystalline cells have a higher efficiency, they are more costly to produce (Bradford 2006: 106). So their application is limited to certain areas, where high
efficiency is needed. Parton et al. (2009: 8) points out that the competitive pressure for the more mature c-si technology will increase in the next couple of years. The reasons are constant enhancements of product innovations in the area of thin-film and a reduction of manufacturing costs. The main purpose of the companies engaged in this technology is to lower the demand for silicon in order to drive down production costs. Furthermore a number of small companies have emerged in recent years developing new (3G) technologies. All these applications are only in initial stage and not important for the general market. But due to potentially lower costs in the production regarding other technologies they could lead to a shift of the photovoltaic market (Bradford 2006: 107). In the next step of production the solar cells are positioned and combined with each other in order to manufacture the solar module, known more commonly as the solar panel. Finally, it follows the cut and the placement inside the frame. The finished product is distributed in two different channels. While the distribution for residential usage is small-scale, the distribution for commercial solar power generation is large-scale. The different purposes lead to different business’ orientations. An overview of this production system gives figure 4. The whole manufacturing process is assisted by company-internal research departments, public research institutes, banks and venture capital companies, designers, architects and also engineers (Bradford 2006: 108).

Due to the focus of this study to analyze the process of interaction and innovation it is necessary to describe the model of technological change. The concept of the interactive technological change integrates the interaction with suppliers and costumers as important sources for innovation (Bathelt & Glückler 2003: 243). The constant exchange with actors on all different stages of the production and distribution process is vital for obtaining information about product and process developments. So the analysis of material and immaterial flows between the different companies is important to find out about the innovation process. The
different activities in the production process can be done by different companies, but they can also be internalized by just one company. According to Susman (2008: 2490) the largest companies in the solar energy industry tend to integrate several production steps within the own company instead of specializing on only a certain activity. While “some are completely integrated from polysilicon to distribution of complete solar energy systems, […] others buy from or become partners with suppliers of materials or components along various segments of the supply-chain.” Therefore different company strategies result into a distinct potential for interaction relations on the basis of exchange connections. One important aspect at this is the close connection with the semiconductor industry. Several companies out of the semiconductor industry have found a new business area in the solar energy industry. Furthermore, both industries are dependent on the same basic material silicon (Mason 2008: 281). While the solar energy industry in their first years could still use recycled material of the semiconductor industry, this has changed significantly due to the growth in solar-cell production. “Today the demand for silicon for photovoltaic cells exceeds that for microelectronic products” (Mason 2008: 281). The close connection between both industries results into similar infrastructural requirements of the region (labor pool, R&D facilities).

5. Methodology

The spatial selection of the region encompasses the metropolitan region of San Francisco as well as the center of the Silicon Valley, San Jose. In this surrounding the international airport of San Francisco is located as well as several important trade fair locations. The reason for this selection is the analysis of local linkages in this study. In the literature it is assumed that face-to-face contacts play a great role for these linkages and spatial proximity is necessary for the development of constant face-to-face contacts. Due to the delimitation of the area it is ensured that potential partners for face-to-face contacts as well as potential meeting points and events are accessible within one hour. Another reason for this selection is that six of the most important solar energy manufacturers have their headquarters or national headquarters in the region (Colatat et al. 2009: 6): Miasole (Mountain View), Nanosolar (San Jose), Sunpower (San Jose), Schücco Solar (Union City), Solyndria (Fremont), Suntech (San Francisco). Furthermore, two major research institutes for photovoltaic research, the University of Berkley and the Paolo Alto Research Institute, are located here.

Employment in solar energy related industries has been concentrated in the San Francisco Bay Area in the year 2008 throughout California. Depending on the estimation up to 46 % of all
occupation in the solar industry in the state of California is located in the Bay Area (COE 2008a: 10). This correlates with an estimated employment of up to 8000 people in this region. According to COE (2008b: 1) 257 companies have a location in the Bay Area (figure 5). These are 33% of the total number of approximately 770 businesses in the state California. Colatat et al. (2009: 6) mention, that “there are 46 solar cell manufacturer establishments in California and, of these 46, twenty are located in the Bay Area, greater than the number of establishments in any other state“. Furthermore they have observed several dozen start-up companies and, according to their interviews, at least 100 start-ups that try to get into the market.

This study uses apart from generally accessible secondary statistics and the analysis of the literature, especially qualitative interviews with experts to illuminate the complex and manifold network dependencies in the solar energy sector. As Yeung (2003: 442) mentions questions in the context of the “New Economic Geography” need other methodological approaches than space-related approaches. Purely quantitative analyses are not able to reflect the relational connections of actors within a social network adequately. In order to deal with the underlying theoretical approaches this study encloses a broad range of actor groups and is not only limited to certain companies. Apart from the attempt to map the situation of the different stages in the supply chain by interviewing company representatives from each stage, also actors from industry organizations, venture capital companies and political institutions were interviewed. The size of the companies varies strongly; small start-up companies as well as global players were analyzed in this study. Overall 12 qualitative interviews were conducted with various experts in this industry. Seven out of these interviews were conducted during two field trips in the period of November, 2nd 2009 until November, 4th, 2009 and from November, 30th until December, 3rd, 2009. The rest of these interviews were taken by phone. The interviews were digital recorded after given permission and then transcript. The analysis of these interviews was done through the computer software MAXQDA.

According to the theoretical concepts the following central aspects were analyzed in the conducted expert conversations (table 1):
Theoretical concepts | Empirical questions
--- | ---
Embeddedness within the region | Location of suppliers and customers, contacts to local institutions
Network integration | Number of interconnected companies, possibilities for building up new connections, attending trade fairs
Knowledge production | Access to knowledge/interaction as a source of knowledge generation
Local buzz | Cooperation with other companies, relationship to competitors, trust
Gatekeeper in clusters | Sharing knowledge with companies in the region, power relations

**Table 1: Selection of empirical questions in the interview guide**

**6. Results**

6.1. Networks regarding the geographic dimension

One outcome of this study is that interactions between the different companies within the San Francisco Bay Area are limited. But the connectedness between the companies and local institutions is quite strong. So it can be argued that the local embeddedness in a socio-economic environment is more important for the choice of location of R&D and of control functions more important than the intraregional interlacement of various companies itself.

Another outcome is that the importance of local networks differs regarding to the stage of the company within the supply chain. Most of the interviewees mentioned that the local as well as the global dimension are important for their business. Interviewee [CO 02] stated very clear with regard to the importance of space that “[…] location plays no role for our business”. On the other hand [CO 03], an installation company, explained that the company is only active in adjacent counties. It seems that manufacturers of solar cells have the ability to separate their fields of operation spatially. Companies at the end of the supply chain do not have this possibility because of the necessity of direct communication with consumers.

Generally, the interviews have indicated that the degree of interaction to companies within the region is quite limited. This correlates with the argumentation of Thune (2009), who describes that there is relatively little interaction between firms located in the same place, and firms in highly innovative regions source external knowledge primarily from non-local sources. Also Knoben (2009) points out that the literature often focuses on the region and not on the firm. So it is only assumed that co-location of a large number of companies also result into interactions between them. “[But] previous empirical research has shown that this assumption does not necessarily hold and that agglomerations and localized inter-organizational linkages
are, at the firm-level, only weakly related (Arndt and Sternberg 2000; Mota and De Castro 2004; Sohn 2004 in Knoben 2009). As a result, the possibility that firms with localized inter-organizational linkages that are not located in dense concentrations of firms might be just as innovative as their spatially concentrated counterparts, or that agglomeration effects without any localized inter-organizational linkage account for the enhanced innovativeness of firms cannot be excluded” (Appold 1995 in Knoben 2009: 758). Still, it seems that spatial proximity is important for connections with external actors. For instance, a global-oriented consulting company [EA 01] mentions regarding the question where the majority of the clients are located.

“Right here in Silicon Valley. So, most of, I got a number of clients up in Fremont which is on the East Bay east side and then a couple of here in San Jose, and then a couple over in Sunnyvale. So on and of in solar companies, I have, in our office we have locally we have a thin-film solar company or in a thin-film category which is in Fremont. We also have a solar cell company in San Jose, which their production actually is in the Philippines. And then we have ingot-growing companies with furnaces and up-furnaces to the low-end of the food chain in Mountain View.”

Therefore there are some potential advantages for solar energy companies in this region.

”[…] the Silicon Valley is a hub for we have a little, quite a few universities with Stanford, Berkley, San Jose, Santa Clara, San Jose State for example. There are a lot of connections here in Silicon Valley […] there is an advantage in that regard” [EA 01].

Also [CO 04] recognizes a specific benefit for the own company of having a location right in this region:

"I would say it is quite a tight community. And most people here are very open and interested in introducing people around to foster business. It is just kind of the culture here, if you know someone who is doing financing for a business that might be similar you would introduce them to another business. It is just everyone views it as opportunistic to seed contacts in this particular area. I think that is pretty unique compared to a lot of places.”

The production of solar cells tend to shift towards low-cost-destinations. In order to reduce cost a number of companies outsource their own fabrics in other locations [EA 01]. Also [CO 01] points out that the internal connections with their locations around the world are of enormous importance. The extent of outsourcing varies in respect of the position in the manufacturing process. So solar cell companies are much more likely to shift their production sites than pure module manufacturers (Hausmann 2009). In the case of a global, vertically integrated company the interaction of the different transnational locations of the company is done via videoconferences. Regarding the question, if there are regular meetings with staff from company’s locations outside the US, it is formulated:

“Oh yes, we have a meeting everyday. We have a meeting every night. […] Typically, what we have, typically it depends upon the agenda, but then we have telephone calls, we have video conferences, we have web calls. So I think that there are three modes of calls that we have, depends upon the size of the group” [CO 01].

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But still, face-to-face contacts can not be replaced. So, personal encounters provide an efficient way of communication. The depth and the speed of feedback can not be reached by any other form of communication (Storper & Ventables 2004: 354). This is clearly visible in the explanations of [CO 01] where it is argued that the most important team members act as a kind of interface in the interaction process of both company locations.

“The CEO is now travelling to India. So he will be in India to the end of January. So he makes it upon that he is in India for three month and then he is back for sometime. So he splits his time between the two locations, with mostly and same with through the rest of the management team […] except most of the heads of manufacturing and operations are based out of India. So our vice-president of manufacturing is based out of India” [CO 01].

Figure 6: Local and global company linkages. Source: Own illustration

Most of the manufacturing process of solar cells is done in Asian countries, especially in China, Taiwan or Malaysia. Only headquarters, sales offices and some R&D activities stay in the Bay Area. As Heeg (2010) argues the solar cell market has become a mass market in the last couple of years. This has lead to a differentiation regarding the specialization of labor and of the organizational structure of the companies.

6.2. Connections within the production system

Local linkages with suppliers and costumers are the basic idea in the cluster approach. It is assumed that the connections between these actors have a strong influence on the potential of innovation. This leads to two questions. How many suppliers and customers do the companies have? And do they work close together with them or nor?

The connections between suppliers and costumers vary strongly depending on the stage of the production chain of the company. In general, the solar companies in this survey have only a
limited amount of interactions to their suppliers. But particularly the intensity of these interactions is interesting. While [CO 02] explains that interactions mostly happen on a formal basis, [CO 04] highlights the strong relation to the supplier side. These interactions are also important for product development and the evolution of innovative products.

The nature of companies’ linkages can be explained by taking the type of firm into account. The characteristic of regional networks is determined by the reasons for choosing the specific location. The interviews have shown that companies that have personal bonds in their location have another type of network connections than other companies. In this case, these networks have an informal nature and are based on friendship and shared social backgrounds and experiences. These networks provide important news about the market like the suppliers do.

“[Usually our suppliers] will mention that there is a new product available that could usually simplify our work or be more reliable but I do have many friends and contacts who are also solar installers and a lot of my friends which I always ask them, we all have identified a lot of the challenge of our business” [CO 03].

The access to new contacts with customers and suppliers mostly happens on the basis of written information and internet-based search. But still, in some cases informal contacts are important as they provide a way of reputation. This is clearly expressed in the following example:

“Typically market research points the way, but referrals and industry connections are ideal for opening the door although not essential” [CO 05].

The selection process and the importance to have relevant information about potential business partners can be explained by the efforts which are necessary to build up new network linkages. [CO 01] explicitly states that it is of great interest for a company to have stable, long-term relations with network partners.

“I am ok, with doing innovations and invent with customers over time but every time I change a customer or if I change a supplier it is causing a significant amount of work, variations in my production process and I don’t want be doing that”.

A conscious limitation regarding the number of linkages to suppliers can be observed. This is made obvious in the comments of [CO 01]:

“In terms of module customers we have the top five customers would kind of, would take almost 95% of our production from modules that we sell to - just the module.”

Like many interview partners [CO 03, CO 04] describe, relationships to competitors do not exist. Therefore it neither comes to a high degree of intense rivalry nor to cooperation between the respective actors in the market in the same segment. As [CO 02] describes contacts to competing companies are very limited. But it is of great importance to know about
the latest information regarding the quality of competitor’s products. This monitoring can either be fulfilled through external actors or by the company itself. It seems as if the size of the company is important, if contacts to external actors exist. As [CO 04] points out, „as a start-up we rely on outside reviews mostly. As we grow we’ll do more in-house testing”. In contrast [CO 02] underlines, that monitoring of products from other companies occurs within the own company. Thereby it is also referred in the same way to the importance to be always up-to-date regarding the performance of competitors. The different aspects of relationships with competitors are expounded in table 2.

<table>
<thead>
<tr>
<th></th>
<th>small companies</th>
<th>large companies</th>
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<tbody>
<tr>
<td>Communication process with</td>
<td>no communication with competitors</td>
<td>limited collaboration with</td>
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<tr>
<td>competitors</td>
<td></td>
<td>competitors in the certification</td>
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<tr>
<td>monitoring of competitors’</td>
<td>relying on outside information</td>
<td>testing, testing agencies</td>
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<tr>
<td>performance</td>
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Table 2: relationship to competitors regarding the company size

Cooperation is not only limited to suppliers and customers, it also includes competitors from time to time (Florida & Kenney, 1988; Kenney & Florida, 2000 in Engel & del-Palacio 2009: 497). Due to the necessity to reach a critical mass in the market, to establish formal and informal standards and to create efficient customer solutions companies are forced to design legal and organizational conventions together. This applies especially towards the solar energy industry. It also can be verified on the basis of the conducted interviews. Like [CO 02] highlights, that – even if the competition in the market is very intense – it comes to a close collaboration with competitors on the topic of formal standards for solar modules.

Like already mentioned above, external actors, which are not directly involved in the production process, tend to be very important for the different companies. As an outcome of the conducted interviews it can be observed that one role of organizations is the communication with public agencies. Some of these organizations take over the function as a representative of the industry and get involved in the decision-making process with public institutions on various political dimensions. This is clearly pointed out in the interview with [OR 02]:

“Government is extremely important, because the solar industry is essentially a policy-driven market right now [...] those policies that help to drive the market right now. So government agencies are extremely critical to the solar industry.”

In this context one can see why such organizations are extremely important for the solar energy industry. “Knowing what they do and what they are planning to do and what they are doing and that is why (the organization) turns to be central in the industry leading this way.”
Although this organization is mainly active on the state regulatory basis, it also has an impact on the regional context.

“California has over 800 local governments and anytime you wanna’ build a project you have to get permission to build from that local government. So, one of the things we have spent a lot of time doing […] is helping to educate the local governments, because if they haven’t seen a solar project before and then they don’t have much familiarity, then they tend to be slower and slower in decision-making [OR 02].”

Another group of actors are venture capital companies or also consulting firms. As [OR 01] describes, is the access to venture capital crucial, especially for young companies, in their business development. Here, geographical proximity between companies and solar energy companies is important [CO 06]. One venture capital firm [EA 02] highlights that it is beneficial to be close to clients. On the hand, control functions and the reduction of transaction costs are important. On the other hand also informal meetings play a big role.

[...] I mean [meeting clients on not-business related activities] is part of a way you establish trust and a working relationship with your clients – not just for the solar industry – you have to have that […] whether it be over lunch, or whether it would be a couple of coffee, or breakfast, or maybe dinner, the occasional hockey game over here […], right down the street here. It’s like any sort of profession when you have to have that ability to connect outside of work” [EA 01].

Venture capital companies contribute to the performance of their clients not only by material flows but rather immaterial flows and the production of information are central. This means for the solar energy industry that a specific group of persons have to be in the region. This is confirmed by Engel & del-Palacio (2009: 496) for this particular region. In the Silicon Valley Region experts and knowledge is essential for entrepreneurs. “In this “incubator region” (Schoonhoven & Eisenhardt, 1989), the supporting infrastructure of professional service providers- including lawyers, bankers, venture capitalists, and a myriad of consultants - is well versed in the needs of startups and small technology companies (Saxenian 2006 in Engel & del-Palacio 2009: 496).”

6.3. knowledge generation and information flows

After reviewing the aspects of organizational and spatial embeddedness of the companies now it comes to the question how this does affect the innovation process of companies. So what are the main sources of knowledge? How is information transferred between different actors and on which scale?

From the comments of the interviewees can be concluded that mainly written information about the general market development as well as about potential costumers and suppliers is
used. Like almost all interviewees mention that journal articles or internet information are central access points to the supply of new knowledge. In this case, it matters how well these information can be absorbed by the company. One important factor for the implementation of knowledge into the firms is the utilization of the employees as a source of knowledge. Like [CO 03] describes, former work experience in other companies is essential. On the other hand primarily own R&D activities accounts for the generation of concrete knowledge regarding process and product innovations. In their study Wolfe und Gertler (2004: 1090) summarize, that - despite the general opinion - the generation of knowledge has little to do with the local dimension, rather the external influx is – if anything - of importance. In the same direction leads the statement of [CO 02]; in this case the local environment is not important for the access to knowledge. So, all R&D activities are performed by the company itself. However, it seems that also companies-external research facilities as well as certification facilities are important. So, the process of knowledge generation on the basis of informal, personal knowledge exchange apparently is of secondary interest. Thus the importance of buzz in this case seems to be based on something else. This suits into the comment of Asheim et al. (2007: 666) where “[…] buzz also exists in such environments as part of the informal interactions in and outside job situations. But in these contexts it is more a mode of information exchange rather than knowledge exchange for learning and innovation. This distinction builds on the recognition that knowledge differs from information because of the cognitive features of the individual as a necessary component for knowledge to exist (Amin and Cohendet: 2004). The importance of such buzz is, however, diminishing as a consequence of the reduced importance of tacit knowledge in industrial districts and cluster because of outsourcing, offshoring, and foreign direct investments.”

But still, one of the interviewees assessed local buzz as an important source of new information. Primarily this buzz is created by the employees of various companies who interact with each other.

“[…] here in Silicon Valley it is interesting, because it is such an entrepreneurial place and we always had – we have a high level of integrity we get exposed to a lot of things, but it is kind of interesting to see some of the engineers are out there and talking and things get carried away” [EA 01].

As Asheim et al. (2007: 661) points out, different kinds of knowledge are of importance for each industry. It can be distinguished between analytic, synthetic and symbolic knowledge (see figure 7). Analytic knowledge is mostly used in business with a scientific knowledge basis. R&D faculties and universities are very important for the innovation process (Coenen et al. 2004).
Therefore connections with universities are common. But knowledge is mostly acquired by using various kinds of codified knowledge. Although both kinds of knowledge are important, mostly formal organized information influences the innovation process. Therefore there are specific requirements regarding the analytical resources of companies’ staff (Asheim et al. 2007: 661). The differences in the importance of face-to-face contacts and buzz of the different industries and knowledge-based activities have important consequences for the spatial distribution of these industries. Like Asheim et al. (2007: 667) argue, are face-to-face contacts and buzz for industries with a focus on an analytical knowledge-base of minor importance. Hence, face-to-face contacts are a mean in the horizontal communication of colleagues in local and global communities. In order to that these industries are more likely to find close to universities and research centers.

Regarding the argumentation of Bathelt et al. (2004) one have to analyze, if companies purposeful try to search situation where buzz is exchanged in order to gain new knowledge channels. Furthermore, also the importance of this knowledge source has to be explored. In respect of the occurrence of informal meetings with business partners is expressed:

“So even, you know, when you are playing golf, you are still talking business. When you are having a beer, when you are having cocktails you are still talking business. When you go to a ball game you are still talking business. But yes we do a lot of that. Around here it is exactly where else in the world that golf is a big part of the business. And going to a ball game is a big part of the social part of the business” [EA 02].

So, it seems that mainly the enhancement of social relations is the focus of such meetings. This is crucial for the creation of a common social background which is the foundation of trust building. Innovations are viewed as a result of social processes which depend on close interaction and network linkages in localized production contexts (Bathelt 2003: 769-770).

As Bathelt (2005: 206) point out, co-location serves as a powerful means to participate in the process of creating institutions and stimulates knowledge transfer. By the term institutions is referred to norms, accepted rules, habits, conventions but also formalized institutions like organizations and other actors. “The process of institution building can be mediated through or strongly supported by communities of practice (Brown and Duguid, 1991; Wenger, 1998).

<table>
<thead>
<tr>
<th>Analytical</th>
<th>Synthetic</th>
<th>Symbolic</th>
</tr>
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<tbody>
<tr>
<td>Innovation by creation of new knowledge.</td>
<td>Innovation by application or novel combination of existing knowledge</td>
<td>Innovation by recombination of existing knowledge in new ways.</td>
</tr>
<tr>
<td>Importance of scientific knowledge often based on deductive processes and formal models.</td>
<td>Importance of applied, problem-related, knowledge (engineering), often through inductive processes.</td>
<td>Importance of reusing or challenging existing conventions.</td>
</tr>
<tr>
<td>Research collaboration between firms (R&amp;D department) and research organizations.</td>
<td>Interactive learning with clients and suppliers.</td>
<td>Learning through interaction in the professional community, learning from youth/street culture or ‘fine’ culture, and interaction with ‘border’ professional communities.</td>
</tr>
<tr>
<td>Dominance of codified knowledge due to documentation in patents and publications.</td>
<td>Dominance of tacit knowledge due to more concrete know-how, craft, and practical skill.</td>
<td>Reliance on tacit knowledge, craft, and practical skills and search skills.</td>
</tr>
</tbody>
</table>

Figure 7: Typology of knowledge bases. Source: Asheim et al. (2007: 661)
These communities are virtually self-organized and are bound together through day-to-day interaction and regular meetings. Community members tell stories about their work to bridge the gap between theoretical and practical knowledge (Brown and Duguid, 2000). This helps in the exchange of existing knowledge, the generation of new knowledge and development of competencies” (Bathelt 2005: 206). Especially the notes of Schamp et al. (2009: 41) are interesting on this subject. He argues on the basis of the empirical work of Capello (1999) that only a minority of the smallest companies within a cluster use local, collective learning. On the other hand, learning processes by the majority of companies take place on the basis of non-local relations. In this manner multinational companies have difficulties to contribute to local knowledge relations. This is the case because they have to integrate knowledge of the region efficiently in their own global, intra-organizational system of knowledge. Contrary to that, Blanc & Sierra (1999: 201) argue, that “multinational firms increasingly tend to develop international intra-firm networks to exploit the ‘locationally differentiated potential’ of foreign centers of excellence. […] we would add that these networks are internal to the multinational firm in order to extend its intrinsic capabilities through an internally coordinated learning process based on relations of internal proximity, but they are complementary to external inter-firm or inter-individual networks whose role is to harness external capabilities through proximity relations.” Apart from information flows within the firm also the supplier-costumer relation is a source of information regardless of spatial proximity. As Coccia (2008: 108) describes is feedback between the different companies an effective way for technological diffusion. This process is exemplified in figure 8.

![Figure 8: Technology-knowledge transfer and diffusion process. Source: Coccia (2008: 108)](image)

This flow of information within the production network can be very well observed in the interaction between the companies. [CO 05] mentions that an outcome of interaction with other companies is that this keeps the company abreast what is competitive. In the same way lead the explanations of [CO 03]:

“I really hope things move forward. Sometimes I feel I give [the suppliers] a pretty valuable feedback because I have been in the industry for ten years at this point which is a long time in our industry. And I will point out that a product for example that they sell, they really shouldn’t sell because it is going to cause problems on the line.
Knowledge circulates not only within rigid networks, it is also exchanged during temporary meetings. Therefore trade shows and industry meetings play a great role. Many of the companies which are located in the San Francisco Bay Area have already joined trade fairs or industry meeting either as participants or visitors. One of the biggest trade fairs in the United States, the “Solar Power International”, took place in Anaheim, Orange County, during October 25th to October 29th. Especially workshops with respect to various topics regarding the solar energy industry were on the agenda of this trade fair. Because of the great amount of participants from countries around the globe there is a high potential to build up global information and knowledge circuits. The interviews have illustrated that trade fairs have an important function in the interconnection of businesses. Furthermore participants exchange the latest news about products and technologies. Still, not all interviewed companies take the chance to join these trade fairs and industry meeting. Smaller companies, like [CO 03], mentions that mainly financial and temporally restrictions are reasons for not being there.

“We don’t go to trade shows. We always think we should go to trade shows or to conferences but my view is that it is a waste of money. I have heard that even the larger players (don’t go) and if it is a waste of money for them, the companies that employ 50 people, it is definitely a waste of money for me to pay for both or exhibition stands at a conference.”

The importance of trade shows and conferences regarding the possibility to gain information and knowledge is described by Asheim et al. (2007: 667): “The typical buzz situation can be found at an informal meeting place [bar, pub, hotel lobby in connection with conferences and fairs, etc (Maskell et al, 2004)], where networking activities are ongoing and exchange of (normally) information not knowledge takes place. We have argued that the only group that may exchange knowledge in buzz situations (and not only information), are people employed in creative industries which draw on a symbolic knowledge base. In such occupations, as with jobs in research, knowledge is highly individualized and, thus, social capital and collective learning is of less importance.” In addition, it is noted that there are also other ways to get access to the latest information.

Finally, one aspect regarding the diffusion of knowledge and the flow of information lies in the actors which limit diffusion processes. The qualitative survey has shown that the interviewed companies limit the exchange of information flows only to certain companies. Therefore knowledge is a kind of an exclusive good, which not all firms have to the same degree. Lazaric et al. (2008: 840) argue regarding the importance of these gatekeepers of
knowledge that, they are at the heart of the network and could either create ‘network externalities’ or restrict knowledge access intentionally or unintentionally. Therefore they have three different roles:

- knowledge searching function for capturing external sources of information
- transcoding function for translating the meaning of such an information

In this sense, some companies can be labeled as ‘gatekeepers’, which knowledge only diffuse within the own company or only transmit it to their strategic partners. For instance, [CO 02] notes that they will even help companies which have a good quality. But it is made clear that this company function as a gatekeeper. So it is mentioned that “[new business contacts] come to us, because we are the leading company. We meet on different occasions. We have the leading technology and upcoming technologies are not so efficient than our own products.”

So, power relations are essential in the process of acquiring information. This relates to the apparently minor importance of local buzz as a source of knowledge. Therefore it is more likely that suppliers can get access to a shared knowledge-base. This is made clear in the case of [CO 01]:

“Typically what we do is, we work with a lot of companies. We identify like seven or ten top companies in the different components like we have in the supplier. So we identify who are long-term partners. And then we typically share this kind of information with them. So this is something we are looking at. So, if I have a costumer and if I come across a new innovation technology which I think is significant to improve the quality of my product or components of my product I would take that to a costumer and say ‘would you be willing to take something and develop it there?’ […] that is how we share the development, they kind of look at it and we look at it and then we do a collaborated development”.

7. Conclusion

Conclusively, the empirical findings do not support the theory that vertically connected firms work closely together within their own region and that this also leads to knowledge spillovers. So, the agglomeration of solar energy companies does not correlate with the idea of a cluster. But what did the qualitative interviews reveal about the research questions outlined in the introduction?

How do the network interactions of companies in the solar energy industry in the region look like? By and large, business networks are important for the solar companies. One outcome of this study is that it has to be distinguished between large and small companies. Smaller
companies seem to have more informal network relations than larger companies. The network interactions can be differentiated between contacts to suppliers and costumers, competitors and other institutional actors. The general assumption, that the interaction between actors connected through the supply chain is intense, can not be verified on the basis of the interviews. Rather, connections to other supportive actors are more likely to be stronger. Especially the larger companies have connections to competitors. In the field of setting standards for the industry they also tend to work together. Institutional actors definitely have a function for solar companies. They provide information regarding the regulatory environment and provide a pool of potential contacts. But regarding hypothesis 3 “Organizations and institutions direct external sources of knowledge inside the cluster” there are no clear evidences to verify or deny this hypothesis. The reason for this is that larger companies only work in particular fields together with organizations.

Is there a spatial focus on the region or do interactions pass on a global scale? Despite the underlying argumentation by many scholars, who state that the local context leads to intense cooperation with other companies or to intense rivalry with competitors, this study shows that regional linkages are of minor importance. This particularly applies for multinational companies. Spatial distance can be bridged better and better due to modern telecommunications. Since the first cluster approaches, numerous innovations in the area of telecommunication have happened. Here, it has to be mentioned the possibility to exchange information with increasing speed around the globe. This is not only true for high-tech regions in industrial countries; it also applies for the emerging high-tech regions in Asia. Furthermore, it comes to an enhanced possibility of communication between various location due to web 2.0 technologies and video conferences. Companies use all of these possibilities and can reduce their dependence on direct interaction. Even face-to-face contacts can partly be simulated via video conferences, like [CO 01] has impressively pointed out. Once again, institutional actors seem to be the only local connections for companies in the San Francisco Bay Area. Therefore hypotheses number 1 “The type of interaction and the geographical orientation of the companies will differ regarding their level in the supply chain” can be verified. But this is only due to the specific characteristics of for example cell manufacturers and installation companies. Like stated in the interviews, considerations about costs regarding the production process of solar cells and modules are extremely important. The qualitative interviews confirm that a shift of production locations towards some Asian countries takes place, despite of the regional induced demand in California. However, the R&D facilities of the companies are likely to stay in the Bay Area.
What are the implications for the exchange of knowledge in such networks? There are some implications regarding the exchange of knowledge for companies in the region deriving from the type of interaction. Larger companies are more likely to use various localized capabilities from their location in other regions. Therefore they possess a broader knowledge base than local companies. But generally, it seems that the concept of buzz is not particularly important for this industry. Codified information is often accessible by publications in the internet or in industry magazines. Most research and development processes happen within the company. This partly disproves hypotheses number 2: “Smaller companies are dependent on global companies in their region, because of their connections to other companies around the globe and their ability to diffuse external knowledge within the region”.

Companies use the institutional environment of the region for their business relations. Out of this derives that the region has the function of a hub for solar energy companies. Like the study has demonstrated, spatial proximity to actors outside of the production system is of great importance for the solar companies. So, hypotheses number 4 “In the San Francisco Bay Area processes of specialization towards certain products and technologies in the industry take place. So, the region has specific network functions” can be proved. This is not so much because of specific products and technologies, but because of their organizational infrastructure. The San Francisco Bay Area performs specific functions within a global production network of the solar energy industry. These functions are the access to venture capital and the strategic location in one of the markets with very high potential. In addition, cooperation with legal and regulatory agencies in the region and the integration in the political decision-making process is important for the global production network as a whole.

The discussion about the importance of local and global knowledge channels is not only limited to academic considerations. Rather, insights about access to global and local network have implications on political decision-making. The primary goal for regional policy is to create an innovation climate which provides local companies advantages in competition. Deriving from the outcomes of this study it has questionable, if a strong focus on creating local networks is possible. In this region local network seem to have minor importance for the solar industry, especially regarding innovation processes. So, in my opinion innovation processes are more likely to happen via gateways and through research facilities. Therefore a highly-skilled labor force is central. Constant innovation processes are necessary for the solar energy companies in this region in order to compete with other companies around the globe.
8. References


COE (=Centers of Excellence) (2008a): Environmental Scan – Solar Industry – San Francisco Bay and Greater Silicon Valley Regions. Source:


X. Appendices

Characteristics of the interviewed companies:

CO 01 global, vertically integrated module manufacturer
CO 02 global cell manufacturer
CO 03 local installation company
CO 04 module manufacturer
CO 05 cell manufacturer
CO 06 ingot producer
CO 07 local installation company
OR 01 global-oriented industry association
OR 02 regional industry association
EA 01 global consulting company
EA 02 venture capital company