An organized population of actors in the messy decentralized, downstream photovoltaic industry

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Line (III): Firms: innovation management in transition

1. Introduction

A wide consensus among policy makers is that the energy industry must respond adequately and rapidly to rising power demand, uncertainty in commodity pricing, and tougher environmental requirements. To tackle these urging needs, the world community must shift away from hydrocarbons towards energy alternatives. Such transitions may refer to what Geels (2004) described as '*socio-technical transitions*', largely because a shift of the dominant '*rules of the game*' seems inevitable.

This study deals with one specific technology whose commercial age started in 1954: solar photovoltaic cells. In a nutshell, this radical technology converts solar energy into electricity. As photovoltaic technology matures, it has the potential of providing an increasing, significant share of the international community's electricity demand. Yet, concerns have been expressed about its potential to evolve from niche (the locus for radical innovations) to socio-technical regime (the locus of established practices and associated rules stabilizing existing systems) (e.g. Rip and Kemp, 1998; Geels, 2002). Among the reasons for this doubt are the instability of the industry due to political turmoil (on-again off-again renewable energy policies), especially in the downstream segment, and the significant changes required to the decentralized production, the larger part of the photovoltaic industry.

We argue that what is new and of interest in the photovoltaic case is that, despite the niche's vulnerability, the industry nonetheless encompasses a large number of actors, mainly new entrants, in the downstream, decentralized generation chain. Indeed, unlike traditional electricity production, small players (i.e. small and medium enterprises and local communities) occupy center stage in this segment. In this event, not only are firms evolving in a changing market environment, but also large and small firms alike exist side-by-side.

At first glance, the global value chains literature only addresses the upstream situation and the centralized production of energy in the downstream segment. As a result, it lets the rest of the downstream segment with no explanation of a market characterized by modularity (internal workings of a value chain segment are highly independent with the internal workings of the other segments), instability, and business-models diversity in the downstream segment. It follows that little is known about the role of smaller firms in the emergence of a new market, mainly because prior global value chains research focused essentially on unipolar chains governance, that is, investigated the power exercised by lead firms (i.e., a handful of companies determining the division of labor) in typically, mature industries (e.g., automobile, apparel, and vegetables). In other words, this literature paid scant attention to both multipolar, niche markets and markets under construction. Hence, it is legitimate to ask whether the lessons drawn from the global value chains literature could be applied to unstable markets in general, and the photovoltaic industry in particular.

This paper will address the following research question: how is this deployment in the downstream segment organized? How actors organized themselves? To answer this, we will combine elements from the global value chains (e.g. Gereffi, 1999; Gereffi, Humphrey and Sturgeon, 2005) and business-model literatures (e.g. Teece, 2010; Casadesus-Masanell and Ricart, 2010), with a specific focus on SMEs in order to understand the observed abundance in the downstream segment. An emphasis is placed on the French situation in the downstream segment of the photovoltaic value chain in order to understand this proliferation. Our study results in a taxonomy of four business-models.

For this purpose, in the following section, we will explore the photovoltaic situation, with a special focus on the French situation. The third section is dedicated to the methodology used to construct the typology. And finally we present in the last four sections the three business-models composing our typology.

2. From a general situation in the photovoltaic industry …

The electricity production has historically been carried out by centralized energy generating plants, managed by oligopolistic actors, overwhelmingly large vertically integrated utilities companies. But tradition no longer counts for much in an industry that has seen disrupted by the growing part of alternative energy sources. Broadly speaking, there is no more national oligopoly or monopoly. Indeed, for instance, the photovoltaic value chain is composing of a multitude of actors. However the situation is a great deal more complex than it may appear. Indeed, a great disparity exists between the upstream and the downstream segments.

In line with OECD (2013)'s division of labor, activities can be grouped into two big categories, that of upstream and downstream. In opposition to the upstream analysis that describes the cost structure of the module, the downstream segment is focused on non-module costs.

The upstream part of the photovoltaic value chain deals with the solar panel manufacturing process. Not only do we include here the conversion of metallurgical-grade silicon to the mono- or polysilicon that can be used for solar cells, but also all the process required to the module manufacturing. That is to say it encompasses the silicon casting into ingots, the wafer slicing from the ingot block, the transformation of the wafer into a cell and the cell soldering to form a module. The upstream segment (generating module costs) is highly hierarchical and concentrated. It is worthwhile noting that crystalline silicon, based on sand, is the feedstock for photovoltaic panels, its price has a great influence over the entire silicon photovoltaic upstream value chain. Indeed, one can observe the impact of cost variations on the photovoltaic module cost as polysilicon count for about 20%-25% of the total module cost in 2013 (Bazilian et al., 2013:331; Platzer, 2015:3).

Turning to the downstream part of the photovoltaic value chain, it deals with activities related to non-modules costs. Non-module costs encompass two categories: non-module hardware (e.g. fixed supports or tracking systems, cables, inverters) and soft costs (e.g. marketing and customer acquisition, connection, financing, system design, installation labor, permitting and inspection costs) (IEA Technology Roadmap, 2014:30-31; Barbose and

Darghouth, 2015:2;16). In the light of the nature of the job in the downstream segment, EPIA (The Value Chain, 2012:1) reckons that "a large part of the value of photovoltaic systems in created locally, regardless of where the cells have been made and modules have been assembled". Indeed, main of the downstream activities are situated close to the end market (PWC, 2009:35).

What is of interest is that the downstream segment experiments a split into two power generation processes: centralized and decentralized generations. Centralized production is generated on a large-scale and is mainly managed by highly integrated corporations (through hierarchical governance), mainly large utilities and organizations. Here, marginal modifications are required to the market infrastructure. DESERTEC, one of the world's largest generation programs, is a perfect exemplification of centralized generation. It was based on the idea of large-scale utilization of renewable energy in deserts and arid regions, where solar energy is abundant and constantly available. As for decentralized production (up to 60% of the global market), energy is generated in a multitude of small places, including the following types of applications: residential, commercial facilities (and farms) and also off-grid.

As it is produced on a local scale for small communities of people, it is unsurprising that this part of the value chain is much more modular. This disruption opens a window of opportunity to new, smaller entrants, including small and medium enterprises (SMEs) and local authorities, to get on the first rung of the ladder. This situation is true in numerous countries, including France, Germany, the U.K. and the U.S.

3. … To the specific French photovoltaic situation

Let us observe in detail the French case. Here we are not used to face to an oligopoly but rather to a monopoly. Indeed, traditionally in the French power sector, a single actor, that is EDF, manages all the value chain from the production to the distribution, through the transmission (Esnault, 2002:8).

To foster the energy transition, in France, as in many other Western countries, government authorities have set up in 2006 supportive policies and measures (e.g. feed-in tariff)

to incite consumers to adopt solar panels despite the high acquisition cost. At the top, the feed-in tariff has reached 60 cents per kWc leading to very good returns on their investment[1]. Thus, this state assistance enabled a rapid development of the market.

Yet, following years of robust growth, the French Government has setting up a moratorium in December 2010, running for three months. Specifically, the French ministry of ecology issued a decree (n°2010-1510) on 10th December 2010 with the purpose of temporarily suspending the EDF's obligation of purchase electricity generated from solar sources[2]. In specific terms, no more new photovoltaic projects superior to 3kWc could be permitted during this period. Further, state subsidies have fallen to 30 cent per kWc.

It seems that the reason the moratorium was put in place in the first instance was to avoid the imminent catastrophe that could happen when firms are engaged in a price war. Indeed, numerous businesses felt obliged to sell at a loss in order to avoid losing market share in a fast growing market. Furthermore, needless to say that these heavy appealing practices actually resulted in shifting the photovoltaic market from the energy market to the financial market. In other words, it is seen as a financial product. Thus, this financial windfall has attracted lot of companies, but not only qualified ones. Moreover, firms in the downstream segment were more prone to buy low-cost and proven panels. Unfortunately these products were manufactured in foreign countries, mainly in China. Thus according to Didier Landaud of Emix, state support benefited greatly to China-based manufacturing firms.

It results that this stop-and-go policy makes impossible the energy transition, as the stability of the niche is a prerequisite to make the evolution towards regime becomes true. More than that, it has undoubtedly inflicted a hard blow on the market development, and more specifically it has a damaging impact both on the morale and health of the market. It is not unheard of and it is not an unknown fact that this caused waves of bankruptcies, layoffs and takeover. The firms experiencing the most negative effects of such a moratorium are SMEs. Specifically, the number of companies involved has drastically fallen leading to an industry consolidation. In the same vein the number of people working in the industry has dropped

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[1] http://www.photovoltaique.info/Chiffres-cles.html

[2] http://legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000023212761&categorieLien=id

from 32,500 in 2010 to 10 130 in 2013 (28 700 in 2011 and 16 800 in 2012) (ADEME, 2014[3] and 2013).

Besides, the French authority recognizes an increased polarization of firm size. Indeed, it is not a homogeneous group, and we must be very careful in this issue. Specifically, the photovoltaic industry suffers from the small size of firms and the lack of medium size companies (SER, 2014:8).

Let us consider the single largest segment in the downstream segment, that is solar installer, which is occupied by a broad and heterogeneous group of companies (Durand, 2014: 21). Specifically, most independent France-based professional installers set up very few solar panel systems; in fact, about 80% of them get to set up only one or two solar installations per year.

We acknowledge that the deployment in the downstream segment is partially led by some rarer (but still relevant) cases of local conservation and renewable energy initiatives. These local communities, which allow more than one clean energy to be placed on their territory, play the crucial role of facilitator, i.e. they play a crucial role in the deployment of renewable energy sources in general, and of photovoltaic energy in particular. A case in point is Perpignan Méditerranée. In addition to photovoltaic, the city generates power from wind, biogas and thermal solar plants for its population of 257 000. Not only has it achieved energy independence since 2015 but it also generates revenues by selling the excess back to the national grid. Smaller communities may also have their place in this category. As for example, the *Communauté des Communes du Thouarsais*, a group of municipalities of 36 000 inhabitants, is involved in solar, wind and biomass power production. However, in this paper we only focus on the strategies and business-models adopted by the firms.

[3] ADEME, Le photovoltaïque en France en 2013 (Juin 2014).

4. Constructing the business-model typology

Business-model is a relatively recent term, traced back to 1954 with the work of Peter Drucker in 'The Practice of Management'. Even though there has been an increasing interest of business-model construct by academics and practitioners, there is not yet a widely accepted definition (Zott et al., 2011). While we do not intend to contribute to the clarification of this term, for the purpose of our work, we opt for the definition provided by Teece (2010): a BM has to depict the mechanisms that help companies to link two dimensions of firm activity - value creation and value capture – in order to create and sustain a competitive advantage.

Acknowledging that a business-model is a reflection of the realized strategy of one's firm, one can say that, with different strategies come different business-models (Casadesus-Masanell and Ricart, 2010). Based on the interviews with representatives (CEOs, founders, directors, etc.) of SMEs and local communities operating in the French decentralized production system, we propose a typology of business-models. Rather than constituting prescriptive criteria, this typology describes "ideal-types" of firms, and consequently constitutes a tool for our research to put the seeming chaos of social reality in order. These firms are 'ideal types' in that they are based on certain elements and characteristics common to most cases of each category. By no means, it corresponds to all of the characteristics of any one particular case. To distinguish these business-models, we combine two criteria:

1. Energy diversification: we are interested to know whether the firm operates in photovoltaic market only or in energy market in general.
2. Industrial diversification: we are interested to know whether the company operates in energy market solely or not.

Having discussed the two criteria, it is now possible to present our matrix that focuses on the firm's activity scope. In line with other popular strategy models such as the product-market growth matrix (Ansoff, 1957), the BCG Growth-Share matrix and the regimes of appropriability matrix (Teece, 1986), we propose to build our taxonomy around a two by two matrix. Specifically, four 'ideal' business-models present in the decentralized production derive from the intersection of these two criteria: the photovoltaic specialized-based business-model (BM1); the energy-based business-model (BM2); the complementary function-based business-model (BM3); and the general-purpose technologies business-model (BM4). The matrix chart below

presents these four ideal types of business-models observed in the photovoltaic downstream and decentralized industry. We acknowledge that this is by no means the only way to classify business-models.

Energy diversification		Industrial diversification: Mono-industry	Industrial diversification: Multi-industry
	Mono-market	**BM1** The photovoltaic specialized-based business-model	**BM3** The complementary function-based business-model
	Multi-market	BM2 The energy-based business-model	**BM4** The general-purpose technologies business-model

Figure 1: What is your business-model?

5. First quadrant: The photovoltaic specialized-based business-model (BM1)

The photovoltaic specialized-based business-model designates business-model implemented by companies that focus solely on photovoltaic (BM1).

A case in point is FranceWatt, founded in 2009 in the department of Seine-Maritime (Barentin near Rouen). Following the moratorium, during 9 months, no revenues were reported and consequently showed a loss. Thus in 2014 the firm was closed down and restarted from new by liquidating all liabilities.

FranceWatts develops modules and systems to meet any application. Conception and manufacturing activities are entirely onshore/in France. It proposes unframed laminated photovoltaic panels. Its photovoltaic solutions are various: among others photovoltaic tile, large roof, railing, cladding, shading, off-grid solutions, carport, roof-terrace and bi-glass.

An important part of its value proposition is the aesthetic value. It offers bespoke solutions. According to Sylvain Robillard, FranceWatts opts for a non-conventional positioning in moving away from pure price competition and towards competition for quality and aesthetics. The firm considers itself a craftsman firm of the photovoltaic market. The Sales Manager of FranceWatts, the question that it has to answer is "are you capable of doing something and how?", as opposed to "how much does it cost?". Hence, besides the cost and the land use factors, FranceWatts focuses on design, that is, on the aesthetic characteristics of the cell. This is not to say that the price has no impact on the buying decision. Along with its strategy of visibility, it complies with some national, European and international certifications promoting the traceability and security of the proposed panels: BIPV, IEC and ISO certifications.

Others install and exploit photovoltaic plants. One of the most telling examples is Gensun. GenSun, created in 2007. It offers two services: the installation and the maintenance of photovoltaic systems. This company builds up solar plant for its clients, i.e. power producers. Yet, the director, Brian Boulanger, considers its core activity as uncertain. As a compensation for this inconvenience, the firm diversifies its revenue sources with maintenance contracts. Maintenance activity enables to recoup part of the investment. In other words it carries out a forward integration in the value creation chain. With about 35 employees, the firm achieved annual sales of €22 million in 2014 but face an uphill battle to produce profits.

The last group of actors provides exclusively services such as technical advices. An illustrative example is KiloWattSol. Set up in 2007, KiloWattSol is a spin-off of ENTPE (Ecole Nationale des Travaux Publics de l'Etat) and of LASH (Laboratoire des Sciences de l'Habitat). This company is the only firm of our panel providing services exclusively. Not only is KiloWattSol a leading European independent provider of yield assessment for photovoltaic projects, but it also has an expanding global portfolio of operations in countries such as Burkina Faso, Turkey, Japan, Thailand, the United States and Italy. With more than 1000 projects, it

works with a cumulated nominal capacity exceeding 1GWp. His reputation attracts important clients (mainly banks) for sizeable projects. The firm is competing with roughly 50 independent technical advisors. What distinguishes it from the other technical advisors is its solid experience in portfolio assessment.

Its business-model has evolved from a razor-and-blades model to a much more high-end work. On the basis of internally developed software, the company offers high-quality expertise and counter-expertise for some companies having its internal technical advisor service. Its yield assessment requires calculations over a 25-year period. In 2014, its 10 employees generated 114 000€ of profit, equivalent to one sixth of its turnover. This conversion rate has been similar over time. Despite this, its operating profit was negative since 2010, indicating its difficulty to make profit thanks to its sole activity.

6. Second quadrant: the energy-based business-model (BM2)

The energy-based business-model is implemented by companies specialized in clean energies, including (but not solely) solar energy (BM2). These firms should be large and solid enough to enter other markets.

As suggested Accenture (2010:10) the energy business moves slowly but surely towards a low-carbon future. For that purpose, for energy firms not having their main economic activity in the clean energy, two other paths can be observed: either remain in the conventional energy space, or move at least partially into clean energy. As for example, Total opted to acquire solar plant, and Eon chose to get rid of its traditional energy production sources to deftly towards a more sustainable source, including solar energy. That is why, instead of limiting this second business-model solely to renewable energy sources, we prefer to enlarge it to include firms operating in the energy industry in general. We can observe two different situations.

Firstly, some firms initially operate in the photovoltaic industry and then diversify its offer to other energy markets. A case in point is Montpellier-based Arkolia Energies, founded in 2009 by Laurent Bonhomme and Jean-Sébastien Bessière. With a team of 33 persons, the company has been involved in photovoltaic since inception. It owes its present survival not least

to the fact it was capable in 2011 of diversifying its activity into methanization, biomass, and an ambivalent presence in wind energy. Such a decision was made possible by using the company' core competencies to enter into these markets. Another other valuable step was to become a project owner, that is, acquired an energy plant. According to the type of energy, Arkolia Energies invests various part of the value chain. For example for the photovoltaic market, the firm is not only a project developer (technical adviser and package builder) but also a developer and project owner. They are majority owner at 51% of the four big ground-mounted photovoltaic power plants for a total of €75M and 70MW. Conversely, up to now they do not have any R&D activity in the photovoltaic industry. It has its sole foreign operations in Ghana and Tunisia.

In 2014, this prosperous business achieves an average annual turnover of 31M€ for an average annual profit of 865k€. Its profit is totally reinvested in the company to increase the capital and then reduce its dependence on financial firms. Today its social capital amounts more than €2 million.

Our second case deals with companies starting in energy markets, but not in photovoltaic, and then enter in addition in the photovoltaic market. An example is provided by UNITe holding. In 2007, UNITe holding was born out of a merger between HYDROWATT created in 1985 (hydro-electricity) and ALTECH created in 1999 (wind power). The company diversifies its activities the following year through the creation of SOLUNITe. This latter makes photovoltaic roof framing, namely **Solar K®,** in St Girons. Specifically, in collaboration with Rigidal Systems, it produces photovoltaic system for silicium amorphe modules under the name UNISOLAR. This process has received a favorable opinion from SOCOTEC, a certification provider, in late 2008. In 2012, the turnover raised to €21M and they employed 63 workers. Based in Lyon, the group UNITe nevertheless has local operations in most of the French regions through its 70 production units or through its 5 engineering, technical and maintenance centers.

With more than 30 years of experience behind it, UNITe provide expertise in water, wind and solar energy production. It covers from the potential study to realization to exploitation. To date, the company operates 45 hydraulic power stations, develops over 10% of the wind farms authorized in France and, makes its own photovoltaic panels. All activities included, they are in charge of more than 80MW of renewable installed capacity in France mainland.

7. Third quadrant: the complementary function-based business-model (BM3)

This business-model category is set up by diversified companies whose core competencies come from mature industries and integrate photovoltaic panels into another structure (BM3). Specifically, these firms, building upon the knowledge they gained in other industries, propose new services as a complement to their traditional offer. In other words, the photovoltaic industry is also appealing for companies occupying originally other industries. Indeed some firms from other industries still see a market opportunity despite the moratorium. They share some similarities. Most of these companies benefit from a strong capital base and a (relatively) large number of employees. Indeed, they are either large or medium-sized enterprises. These companies include among others builders of car park shelters with photovoltaic shade panels, roof covering companies that install PV roof tiles and electrical installation firms proposing an electrical installation of solar modules. It is not an exhaustive list. Far from it. We expect to add more industries to the list with the database we will analyze in the near future.

A prime example is GagnePark, created in December 2006. Backed by its research and experience on parking construction, Gagnepark recently enlarged its value proposition. Indeed, the firm opted in 2008 to satisfy its existing customers by extending its offerings to photovoltaic shade structure. It considers design as of particular importance in its value proposition, in addition to its strong expertise in car-parks construction. Yet, it offers non-standardized products, allowing it to reap advantages of economies of scale and to deliver a custom product. The firm had patented its building system under the name of "OMBRAPARK". This patented building system based upon its expertise in parking solutions was been used to over 150 000m2, cumulating 37MW and 38 car parks. Its solar activity is expanding in 2012 through solar-powered shelters. However, since the decreed of 2010, its solar activity has been halved. Indeed in 2009-2010, more than 50% of its activity is dedicated to its solar activity. Nowadays, it was reduced to 20%. However, the company still makes a multi-thousand euro investment each year in R&D focused on building system. In 2014, the firm had €14 million of sales and €1 million of net profit.

Imerys is another illustrative example of a firm that initially operated in a mature industry but subsequently decided to enter the photovoltaic market. Originally specialized in roof covering, Imerys later diversified its offer in proceeding to an intra-chain upgrading. Since 2001, its team has undertaken R&D with the intent to developing photovoltaic roof tiles, thereby becoming one of the rare makers in France. The company proposes this alternative to its traditional photovoltaic panels installed on top of a roof. The photovoltaic roof tiles installation process is very similar to the process of installing convention clay roof tiles, even though the photovoltaic roof tiles are a bit bigger. Thus, by taking the place of clay tiles, photovoltaic roof tiles intend to ensure the tightness of the roof. Furthermore, it is also argued that it preserves integrity and aesthetics: the installation process used and the colors (i.e. slate-grey and silver) enable the tiles to disappear in the roof.

Our last example deals with Marchegay. Founded in 1948 in Vendée, Marchegay bears the name of its founder, Roland Marchegay. After NNN years of belonging to Richel, in 2011, it bought backs its independence to become SAS Marchegay Technologies. Initially, it was focused on the construction of frames and metal structures. Its diversification to the solar industry started in 2007. The following year, a fourth activity rounds out the range of its offer by promoting the building of quality greenhouses, facades and sustainable buildings.

Focusing on its solar activity, the company designs, builds and installs roof integrated photovoltaic panels for the residential, agricultural, tertiary and industrial industries. Its photovoltaic solutions encompass custom built photovoltaic roofs, photovoltaic shade structures, photovoltaic hangars, and photovoltaic kits. Far from being the only one, Marchegay proposes shade structures with a power input of 33kWc, either for 7 or 13 parking spaces. The modules could be crystalline, laminated, or double glass, depending on the client's wish. What differentiates Marchegay from its competitors is that it proposes greenhouses with photovoltaic roof and photovoltaic hangars. The latters are used exclusively for agricultural storage, with a capacity either of 36kWc or 100 kWc. What is even less common is that its Helios RP+ system is compatible for integration on a greenhouse. As far as we know Marchegay is the only company to offer this solution in our panel.

8. Fourth quadrant: the general-purpose technologies business-model (BM4)

Conversely to the other business-models that focus solely or at least mainly on a dedicated technology, the fourth business-model of our categorization is built up on technologies that are deployed in different downstream markets. Indeed, the general-purpose technologies business-model designs companies that propose products not specific to one market or industry.

IEA (Good practice policy framework for energy technology research, development and demonstration (RD&D), 2011:35) acknowledges the important role of generic and general purpose technologies in the development of renewable energy research, development and demonstration. As such governments are encouraged to allocate public funding on these technologies, including energy storage and grid management (Johnstone et al., 2010). "One general consequence of the rise in these intermediate technology markets has been an increase in downstream product-market competition" (Gambardella and McGahan, 2010:264).

AEG Power Solutions, to cite an example, is a transnational corporation specialized in energy conversion, belonging to 3W Power Holdings S.A. Not only does it aim at industrial and telecommunications markets but also the photovoltaic market in isolated sites. It deals with all activities connected to energy management, such as power inverter and energy storage. The firm extended its solar activity in, for example, Africa, Ukraine and Italy. Until recently, production, installation and maintenance of BOS was operated was located in Germany, France, Spain and Malaysia. Located near Tours, the French offices' activity is now only limited to look after all R&D activity connected to direct current.

In 2013, turnover reached 28 millions of euro and an operating result of -7 millions of euros. The turnover has been cut by one-third compared to the previous years, resulting to a worst operating result.

9. Conclusions and further developments

We can observe a proliferation of actors in the photovoltaic industry, especially in the decentralized, downstream part of the value chain. At first sight this population appears to be messy. Yet, based on two criteria – energy and industrial diversification -, it is possible to classify firms into four 'ideal' business-models: the photovoltaic specialized-based business-model (BM1); the energy-based business-model (BM2); the complementary function-based business-model (BM3); and the general-purpose technologies business-model (BM4).

A further step will be to test the typology quantitatively. We will examine business-model of 283 firms, derived from a listing provided by two significant French professional associations, *Syndicat des Energies Renouvelables* and *Enerplan*.

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