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Exploring regulatory and standards strategies to support the development of advanced photovoltaics

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Abstract

Regulation and standards are determinant factors when it comes to shaping a supportive environment for new technologies. By adopting a proactive and long term stance to address the environmental, health and safety (EHS) issues related both to its manufacturing and to the use and disposal of its products, the crystalline silicon and thin film photovoltaic (PV) industry in Europe has designed interesting regulatory and standards strategies to support its development.

As PV technology is evolving into a new generation of advanced products, some of the initiatives the established PV industry has embarked upon to get involved in the regulatory decision-making process and to have its concerns taken into account may offer interesting examples to inform the emergence of this new generation.

This paper analyses some of the regulatory and standards strategies which supported the emergence of the first wave of the PV industry (part 1) then explores how relevant they are with regard to advanced photovoltaics (part 2).

Contents

I. Introduction

The photovoltaic technology which made possible the development of crystalline silicon then thin film PV cells and modules is evolving into a new generation of products. They include organic (like polymers, small weight organic molecules, nanotubes), hybrid (like inorganic nanoparticles incorporated in polymer films and organic molecules and polymers incorporated in inorganic matrices) and photochemical cells (like dye-sensitised solar cells). As these new products are emerging, it is of interest to investigate if their development could be fostered by some of the regulatory processes which supported the emergence of the crystalline silicon and thin film PV industry in the first place.

Due to the numerous similarities between the respective manufacturing process of the semiconductor industry and the PV industry, many regulatory requirements proved to be transferable from one sector to the other. An environmental health and safety performance guideline like SEMI S2-0706e represents an example of such a regulatory transfer [1]. The PV industry was therefore "jump-started" by the experience gained in the semiconductor industry, notably regarding standards about common issues like chemical exposures, groundwater and air contamination and electronic waste [2]. Their implementation in the PV industry was rendered all the easier and quicker by the move many semiconductor equipment and materials manufacturing companies made into the solar arena.

If the advanced PV industry cannot benefit as much from the regulatory expertise taken from the semiconductor industry as its manufacturing processes do not involve similar issues and hazards, it can still learn from other regulatory initiatives adopted by the crystalline silicon and thin film PV industry.

II. Regulatory experience gained by the crystalline silicon and thin film photovoltaic industry

1. Representative trade association

A significant feature of the PV industry in Europe is that companies involved in the sector formed a trade association relatively early. Created in 1984, the European Photovoltaic Industry Association (EPIA) currently comprises more than 200 members based in 20 countries in Europe and represents about 95% of the European photovoltaic industry. It is the world's largest photovoltaic industry association. In addition to being numerous, and equally important a characteristic, EPIA's members are representative of the various stakeholders involved in the whole PV chain of production, with companies dealing with silicon feedstock, wafers and ingots, cells and modules but also systems and inverters [3]. Being representative of the overall PV sector has allowed the trade association to acquire legitimacy and credibility and to speak with a dominant voice in the field.

From a regulatory perspective, EPIA fulfils two important missions. It represents the European PV industry's principal point of contact with political institutions at the European and International levels, advising regulators but also informing its members on regulatory requirements in preparation. It also acts as a horizon scanning structure and tries to anticipate regulations which might affect the sector. In parallel with these traditional roles, EPIA has established a number of strategic alliances with such key stakeholders in the field as the European Renewable Energy Council (EREC), the Alliance for Rural Electrification (ARE) and the European Association for the Recovery of Photovoltaic Modules (PV Cycle). Since its creation, EPIA has embarked upon a series of actions to ensure that the concerns of the PV industry were heard and taken into account by EU regulators.

2. Influencing EU legislation

RoHS and WEEE Directives

As a part of its advisory role, EPIA intervened in the review both of the Restriction of certain Hazardous Substances (RoHS) Directive, which bans the placing on the EU market of new electrical and electronic equipment containing certain prescribed levels of heavy metals, and of the Waste Electrical and Electronic Equipment (WEEE) Directive on the collection and recycling of electrical and electronic equipment. Initially excluded from their scope, the PV sector could have been included under the RoHS and WEEE regulatory regimes after the review [4]. There was a real possibility that PV modules would be deemed as electronic waste by the EU Commission [5]. This inclusion was challenged by the industry which feared it would imply their compliance with insufficiently tailored as well as costly requirements.

In order to make its point, EPIA adopted a proactive stance. In the case of the RoHS Directive, while replying to an open stakeholder consultation launched by the EU Commission, the trade association also voluntarily provided data to the EU Commission's Directorate General responsible for environment as well as to the consultants hired by the EU Commission to assist in the preparation of the potential impact assessment of the recast Directive. EPIA eventually obtained an exemption for photovoltaics from the RoHS scope.

In order to convince EU regulators that there was also no need to have the PV industry covered by the WEEE Directive, EPIA commissioned a study on the feasibility of a take-back and recovery system for PV products. The conclusions of the study were adopted by PV Cycle, a European association founded in Brussels in 2007 and with which EPIA was partnering, to address the specific issues related to the disposal of PV products. PV Cycle put together a Europe wide voluntary take-back system for waste with the objective of enabling the recovery of up to 90% of PV products by 2015. In addition to avoiding inappropriate and expensive waste regulations, the motivation of PV Cycle was also to address potential public acceptance issues and to secure a positive image of solar cells by promoting the sustainable use of PV technology.

REACH Regulation

EPIA's action during the development of the EU Regulation on the Registration, Evaluation and Authorisation of Chemicals (REACH) was of a different nature. Explicitly aiming to improve the protection of human health and the environment, through better and earlier identification of the properties of chemical substances, the Regulation impacts the chemical industry but also affects all downstream users, including all developers and manufacturers of electronics products. For instance, passing information up and down the supply chain is rendered compulsory under the REACH regime. Suppliers have therefore to inform users about the risks associated with particular substances and how to manage them and users have to tell their suppliers what they are planning to do with substances.

As it was obvious that given the broad scope of the REACH Regulation, the solar cell industry would fall under its regime, EPIA's actions focussed not on developing arguments to exclude the PV sector from REACH but on finding ways to support a successful implementation of the newly introduced requirements. Highlighting the risk that REACH could lead to a "detrimental disruption" of the photovoltaic sector if manufacturers of solar cells did not engage in a continuous dialogue with their suppliers, EPIA arranged an expert meeting to inform its members about REACH and to get an overview of the state of preparation of PV companies [6]. It also hired a specialist consultancy to assist in developing a guidance document with a number of practical recommendations, such as the need to anticipate volume changes in the demand for chemicals to tackle registration requirements in advance. This document, issued in June 2008, facilitated companies' understanding of the REACH requirements and their impact on the PV sector.

3. Development of pre-standards and interim standards

The most significant programmes for the development of standards on PV applications take place within two organisations: the International Electrotechnical Commission (IEC) and the European standardisation body for electrical standards (CENELEC) [7]. The IEC established a technical committee on solar photovoltaic energy systems in 1981 which is known as TC82 and is the "main worldwide promoter for PV standardisation" [8]. On the European level, CENELEC creates voluntary electrotechnical standards in support of European legislation and was mandated in 1995 by the European Commission to set up a technical committee to develop European standards for PV. However, achieving standards through the traditional standardisation processes can take from 3 to 6 years and some alternative methodologies were explored with a view to supporting the development of the PV industry.

In order to seek to address the industry's needs to quickly achieve technical agreements, CENELEC has initiated the creation of "pre-standards" through Workshop Agreements (CWA). Developed in a workshop widely advertised in advance and largely open, they represent a fast and flexible way to set standards. Even though they encompass important limitations as they cannot support legislative requirements nor address significant health and safety issues and as their content cannot conflict with existing or forthcoming European standards, they nonetheless offer a useful solution to bridge standards gaps in technical domains. Furthermore, they can subsequently be confirmed as European standards by going through the traditional CENELEC process. PV cells have already been discussed in some of the Workshop Agreements and are taken into account in, for example, the CWA for domestic cogeneration.

Another category of standards, known as interim standards, are being developed by the Global Approval Programme for PV (PV GAP) which is a not-for-profit organisation based in Geneva. The need for interim standards was identified in the mid 1990's by the PV industry itself which had a growing concern about the lack of standards for PV quality. This was leading to inconsistencies in the quality of PV modules and installations commercially available and was potentially damaging for the whole sector. The programme, officially set up in 1997, was initiated by the PV industry and was intended to encourage the acceptance of IEC standards, creating some interim standards while IEC standards were in development and until they were issued. This initiative therefore helped fill standards gaps in areas like quality management processes and PV systems' design and installations. It provided developers and manufacturers with certification standards with which to comply as well as a PV quality mark and seal to label their products to certify their approval under the PV GAP Programme.

4. Maintaining a green reputation

A distinct feature of PV technologies is their environmentally friendly image which is explained by the cleaner way PV electricity generators operate compared to other conventional electricity generators [9]. However, this "green" image would not have made much sense if the manufacturing process and the disposal of PV products had not been also designed in an environmentally responsible manner. Typically, the end-of-life phase of PV products had to be included in the life cycle assessment (LCA) in order to evaluate their overall environmental impacts from initial design to final disposal [10]. This was an issue at which the PV industry was all too aware and it embarked upon both a proactive and long-term strategy to design safety into the manufacturing process and to take into account recycling issues [11]. Technology options were carefully assessed, some technologies presenting mostly occupational risks (e.g. amorphous silicon based PV) while others were mostly associated with disposal issues (e.g. Cadmium Telluride based PV) [12].

By adopting a proactive cradle-to-grave approach, clearly indicating that current and future recycling requirements have been carefully considered, the PV industry made an unambiguous statement about its willingness to be a sustainable industry on an ongoing basis. It pre-empted public acceptance issues about the use and disposal of hazardous materials involved in PV modules. This was "very much in line with consumers' perception of a clean energy option" [13].

III. Regulatory and standards strategies to support the development of advanced photovoltaics

1. Proactive and long-term approach

Valuable insights can be gained from the proactive and long-term approach the crystalline silicon and thin film PV industry adopted to deal with the EHS hazards associated with the manufacture, use and disposal of PV cells. Taking these hazards into account helped establish the green image of PV technologies and further provided the PV industry with a competitive "market edge" [14]. It therefore contributed to the successful commercialisation of PV technologies. The manufacturing of advanced photovoltaics is expected to be more environmentally friendly than the silicon-based PV industry and therefore unlikely to require a similar handling of hazardous materials. It can nevertheless raise a number of EHS concerns requiring the development of appropriate safety procedures. For example, the production of dye-sensitised titanium dioxide PV cells may result in occupational exposure for which some precautions are needed in the workplace [15]. The advanced photovoltaic sector has therefore to ensure it extends the green and healthy image of PV electricity to each stage of its manufacturing and disposal processes to fully support future consumer confidence.

Advanced photovoltaic developers can learn in particular from the cradle-to-grave strategy adopted by the crystalline silicon and thin film PV industry which incorporated recycling strategies from the outset. This modus operandum not only enhanced consumer confidence in their products and addressed potential public acceptance issues but also engaged with end-of-life issues considered from a regulatory perspective in a proactive way. When it comes to recycling, the proposition of the voluntary take-back system for waste put in place under PV Cycle demonstrates that a well designed private sector initiative can be accepted by regulators in lieu of compulsory regulatory requirements which are deemed inappropriate by the industry concerned.

Likewise, by initiating new categories of standards (i.e. pre-standards and interim standards), the crystalline silicon and thin film based PV industry has supported the commercialisation of its products by providing guidance to manufacturers to produce reliable products and by strengthening consumer confidence in them. Not all advanced photovoltaics are near to market but the example set by the more mature PV industry is worth bearing in mind as it shows that industry driven initiatives can complement the actions of regulators and foster the take up and diffusion of new technologies.

2. Community building

As demonstrated by the European Photovoltaic Industry Association (EPIA), building a community of developers and companies is determinant to the promotion and support of the development of a given sector. Stakeholders involved in advanced photovoltaics need to be represented at national and European levels to acquire appropriate levels of information about legislative and regulatory developments. Being part of a network also facilitates a pooling of expertise which makes the provision of data and advice to decision makers more convincing. Last but not least, it makes it easier to mobilise the sector, through internal meetings and workshops, to define positions on regulatory and technical issues. The advanced photovoltaics sector has therefore to ensure that it belongs to a community, consisting of all participants in the value chain, and that its interests are represented in a credible manner.

3. Forward-looking approach

Another concern for novel technologies that may be faced by advanced photovoltaics lies in the delay which often exists between the emergence of a technology and the regulatory responses. Currently, when it comes to designing new regulations for an emerging field, a pattern can often be observed in the approach adopted by regulators who first establish a regulatory inventory to check potential gaps and then design new regulations to fill them [16]. However, this reactive approach toward regulation may not be the optimum method to support and assist an emerging industry. Setting a representative organisation which could be tasked with developing a vision for the technology and informing regulators about its expected evolution and the regulatory needs or hurdles it is likely to face could prove invaluable. The roadmap developed by PV Net, a collaborative network combining expertise from the crystalline silicon and thin film PV industry and the scientific community represents an interesting first step in this direction [17]. Even though the PV NET roadmap exercise was not undertaken as part of a regulatory decision making process, the results it yielded can still be used to inform regulators about the technological advances and the regulatory gaps which are foreseen. It would therefore be worthwhile for the advanced photovoltaic sector to engage in such a forward-looking approach.

IV. Conclusion

Regulation and standards are determinant factors when it comes to shaping a supportive environment for new technologies but the development of the advanced photovoltaic industry can only partially be informed by the regulatory experience gained by the more mature solar industry. It does not have the similarities the silicon based PV industry shares with the semiconductor industry and which has allowed the adoption of the SEMI regulation by both industries. The manufacturing, use and disposal of its products may also include a number of unique characteristics for which new regulatory requirements and standards have to be designed. Nevertheless, some of the initiatives the crystalline silicon and thin film photovoltaic PV industry has embarked upon from a process perspective offer very interesting examples of self-regulation which advanced photovoltaic developers could use as a basis for future regulatory strategies and which could contribute to a successful commercialisation of their technologies.

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