FROM ROOFTOP TO FAÇADE PV: INVESTOR INSIGHTS ON INVESTMENT COSTS, PROFITABILITY, AND RISK DRIVERS IN SOLAR PV TECHNOLOGIES

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Overview

Solar PV will likely become the largest source of electricity production globally[1–3]. While ground-mounted PV contributes to the largest share of this growth, multiple countries lack sufficient land areas for utility-scale installations and have competition with agriculture due to scarce fertile land. In such conditions, integrating PV into the existing built environment in cities and buildings will be one of the main sources of solar power in the future. Unlike rooftop PV, which has experienced large growth rates, façade PV or Building Integrated PV (BIPV) remains mostly stagnant because of its higher costs, lower production potential, and more complex planning[4,5]. This is despite building facades having larger surface areas than rooftops and bigger solar irradiation potential in many cities worldwide, such as New York and Paris[6].

Clean energy technologies that scale up quicker typically have lower design complexity and are composed of standardized components such as solar panels versus wind turbines[7]. However, besides technical characteristics, financing and investor's willingness to allocate capital are equally important for technology scale-up[8,9]. The existing literature on solar facades mainly discusses their barriers and drivers[4,5]; however, it fails to breakdown the reasons for lack of investment from an investors perspective. Moreover, it omits accounting for the fact that solar facades are relatively similar from a technical perspective to other PV technology types, and yet investments into PV facades remain much lower. Therefore, in this study we comparatively analyze solar facades with rooftop PV, a widely adopted PV technology in the built environment. We address the following main research question: How does façade PV differ from rooftop PV from an investors perspective?

Methods

We conduct the study via 30 structured interviews with investors and project developers, while focusing on Switzerland - a pioneer country in developing both rooftop and façade PV installations and technology[10], and with plans to become carbon neutral until 2050, mainly using PV in the built environment[11], due to its legal restrictions to install PV on the ground and nuclear phase out. Our method consists of three steps. We first conducted a literature review to identify existing research on differences between rooftop PV and façade PV, from an investors and project developers perspective. Following this, we develop several loose arguments on the reasons for the investment disparity between the two PV technology types. Finally, we conduct structured interviews with 30 Swiss project planners and architects to discuss in depth the financing and investment differences between façade PV and rooftop PV.

Our focus is on non-integrated façade PV – installed usually on windowless walls of storage buildings – integrated façade PV applied to multi-family houses and commercial high-rises and rooftop PV installed on flat roofs. We divide the projects into two size categories: small or below 100 kW and large or above 100 kW, according to the Swiss definition of project sizes for awarding investment subsidy support[12]. We guide the interviewees through an online questionnaire consisting of structured questions on project-specific investment costs and their breakdown into subcomponents, operational expenditures and their drivers, expected production, payback periods and development timelines. Further we ask the interviewees to rank profitability and risk drivers by their importance in regard to the projects financial success. Through conducting the interviews face-to-face, we also collect rich answers that provide context to the rooftop and façade PV differences.

Results

To our knowledge, our results are the first to empirically quantify the investment cost differences and component breakdown between solar facades and rooftop PV. Preliminary findings suggest integrated solar facades having a mean investment cost of between 4800 EUR/kWp and 6400 EUR/kWp for large and small projects, respectively.

In contrast, the costs for rooftop PV range between 900 and 1520 EUR/kWp, depending on the size, while the costs of non-integrated PV ranges between 1580 and 2600 EUR/kWp. The main cost driver for façade PV installations are the individualized modules, which unlike for regular rooftop PV are not mass produced. Consequently, such modules comprise about 43% of overall investment costs for small integrated façade PV, and only 23% in large rooftop PV. Panels for integrated facades are typically custom made. Individual buildings can have more than 50 panel sizes, because of the requirement to integrate the PV façade into the building design. Besides customized sizes, adjusting the modules to ensure they are fire-safe (for instance, glass-glass modules with steal fire brakers) drives the costs. The customization requirements are much lower for non-integrated facades on industrial buildings. Further, our interviewees estimate façade PV production to be about 60% lower than that of rooftop PV. While rooftop PV plants are typically in areas without shadows and have angles of between 10 to 40 degrees to the sun, facades are vertical and as such not optimized for summer production when the solar irradiation is the highest. Combined with higher operational expenditures, the larger investment costs and lower production leads to much lower façade PV profitability, with payback periods reaching 35 years in some cases, while rooftops installations are typically paid back in between 9 to 14 years on average and depending on the size. Another challenge of scaling up façade PV is the lack of technical know how to integrate facades with electrical components into building facades, and much longer project development timelines. Our interviewees estimate for instance up to four times longer conceptualization and permitting project development stages for façade PV than rooftop PV plants, or 8.2 and 7.5 months versus 2.2 and 2.1 month on average.

Conclusions

In summary, our interviewees highlight that façade PV installations, and especially those integrated into building design, are not subject to the same techno-economic considerations as rooftop PV plants. To date, profitability has a subordinate role in integrated façade PV, and instead the main investment drivers are sustainability and an attractive building design. Still, supporting façade PV plants could be of value for governments that aim to increase the production from PV during wintertime, and which have limited land area availability. In such cases, policies to support façade PV could include easing project development, and supporting winter electricity more than summer production, when the vertical façade PV generates more than standard rooftop PV installations. Besides better understanding the investment differences between façade and rooftop PV, our results also provide fine-grained cost data that can aide in modeling carbon-neutral energy scenarios in cities.

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