Potentials and Challenges for Integrating PV in Roof Renovation of Multi-residential Houses—A Questionnaire Survey

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Liane Thuvander, Paula Femenías, Johan Gren and Peter Kovacs

Abstract A questionnaire survey investigates the conditions for future roof renovations, driving forces and incentives as well as barriers to install roof mounted or roof integrated photovoltaics (PV) among Swedish owners and managers of multi-residential buildings. Respondents were identified through a database hosted by the Swedish Energy Agency holding information about all projects that received subsidies for installation of PV between 2009 and 2016. The final sample comprised 77 organizations and the response rate was 36%. The questionnaire covers general information about the responding companies' property portfolios; roof renovations in general; routines, motives, and driving forces for installation of roof PV; and planned roof renovations. Results show that the main cause for conducting roof renovations is end of life-time and improvement of energy efficiency. The initiative to install PV is mostly taken by the board of a Housing Association, the management team, or the board of a company. Standard PV modules mounted onto the roof is the predominant choice. Better profitability is needed to encourage more PV installations, for example, through higher subsidy levels and long-term security of the value of produced electricity. None of respondents asks for more appealing design of PV products, better internal organization, or improved knowledge about operation and management of the PV plant.

Keywords Photovoltaics · PV · Questionnaire survey · Roof · Renovation

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1 Introduction

There is a need for cost efficient renovation solutions resulting in energy efficiency and climate benefits and which are applicable to a larger part of the existing housing stock. Installation of photovoltaic systems (PV) is one way forward. Large parts of the existing housing stock constructed during the 1960s and 1970s have flat roofs or roofs with small inclinations in need of renovation which are also favorable for installation of PV systems. The price of PV has fallen dramatically over the past decade [1] and for less advanced roof installations of PV there are well functioning systems and experienced suppliers. However, little is known about the actual extent of roof renovations in the existing multi-residential building stock. The same goes for Housing Companies' decisions about potentials and limitations related to roof renovations in general and the integration of PV in particular.

Previous Swedish studies have investigated experiences from installing PV among broader stakeholder groups [2], for example suppliers, installers and property managers in general and including different types of buildings (medium-sized facilities) such as multi-residential buildings, schools, offices, and sports arenas [2] or explored more narrow stakeholder groups [3], such Housing Associations that manages residents' owned condominiums in multi-residential buildings. Also, the focus varied from process description for installing PV including procurement and operation [3, 4] to mapping mounting systems for PV with regards to maintenance and moisture damages of building components [2].

This paper presents an overview of larger roof renovations with focus on the integration of PV. Based on 28 responses from a questionnaire survey, the driving forces, incentives and barriers to install roof mounted or roof integrated PV in multi-residential buildings are investigated as perceived by managers and owners of multi-residential buildings.

2 Method

A questionnaire survey was carried out studying Swedish housing owners and managers of rental and resident-owned condominiums in multi-residential buildings that have installed PV with subsidies from the Swedish Energy Agency. The questionnaire focused on PV installations in connection to roof renovations.

A database with information about all projects in Sweden that have received subsidies was used to identify relevant respondents (extract from 18 January 2017). Out of 6222 approved projects, 195 were related to multi-residential buildings and 133 individual stakeholders could be identified. After removing non-housing companies such as construction companies or energy providers 101 organizations remained. Thereafter, contact details such as e-mail or phone numbers were gathered manually through searches on the Internet. The final sample consisted of 77 potential respondents.

In a first step, a request to participate in the questionnaire survey was sent by e-mail to the managers of the property development divisions at the Housing Companies, to chair members of the board in the Housing Associations, or other relevant persons in the Housing Companies or the Housing Associations. After a positive response, the questionnaire was sent out with the choice to either fill in an interactive pdf-file or a web-based version of the questionnaire. Two subsequent reminders were sent out. Four respondents declined to participate. Data has been stored using the web-based survey tool SurveyMonkey®. The study was carried out May–July 2017.

The questionnaire was divided into six sections with in total 26 questions (q) covering general information about the companies' property portfolio, size and type of tenancy; implemented roof renovations (6 q); implemented installation of PV roofs—routines, motives, and driving forces (6 q); planned roof renovations (5 q); as well as general reflections and background information (1 q each).

3 Results

3.1 Responses and Respondents

In total, 28 respondents filled in the questionnaire which corresponds to a response rate of 36%, see Table 1. There are equal number of responses from housing companies (public and private) that offers rental housing (RH) and resident owned housing (ROH) Associations. The response rate for public owned rental apartments is much lower than the total response rate and, in contrary, the response for resident own housing is much higher, almost 50%.

The property portfolios differ considerably between the respondents, up to a factor 100 distinguishes the largest from the smallest (Fig. 1). Most of the smaller organizations are ROH, but some smaller privately-owned RH are also represented. The average size of the 124,629 apartments represented through the respondents' organizations is around 77 m^2. Around two-thirds of the responding organizations have a policy regarding PV installation and/or using renewable energy sources.

Table 1 Response rate and type of tenure

Type of tenure	Number of organizations	Number of responses	Response rate (%)
Rental apartments—public owned	33	10	30
Rental apartments—privately owned	11	3	27
Resident owned housing	27	13	48
Other	6	2	33
Total	77	28	36

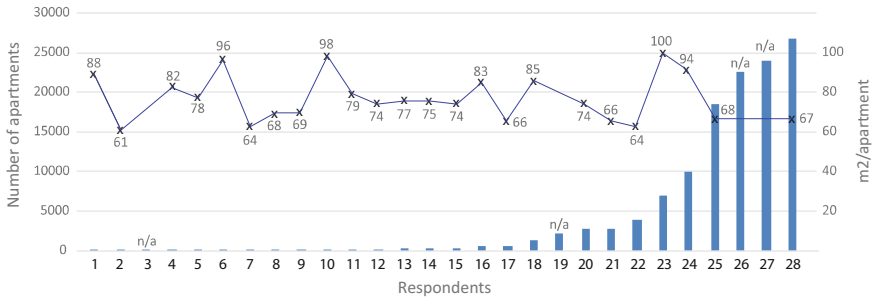

Fig. 1 Number of apartment per responding organization and average apartment size [N = 28]

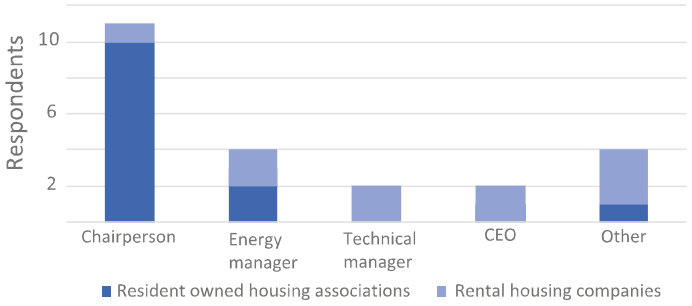

Fig. 2 Position of the respondents [N = 23]

The positions of the respondents in their respective companies/associations are diverse: chairman, energy manager, technical manager, CEO, and other, Fig. 2. In the group called others, the following positions are included: assistant project manager, suppleant of the board, owner, technical consultant, or property manager.

3.2 Roof Renovations in General

The main reason for carrying out a roof renovation, i.e. replacing the roof or conducting a major roof renovation is, not surprisingly, end of technical life-time of the roof. To some extent, also improvement of energy efficiency is a driver (Fig. 3).

Roofs renovated the past five years are mostly in the categories pitched roofs and stock constructed between 1961 and 1980. The number of roof renovations in stocks from the period 1941–60 is much higher than what would be expected considering the relative size of the stock in our study. Flat roofs and tarred roofs and especially the combination of these two categories are perceived as in need of renovation more often than other roof types. When asking for a roof type or

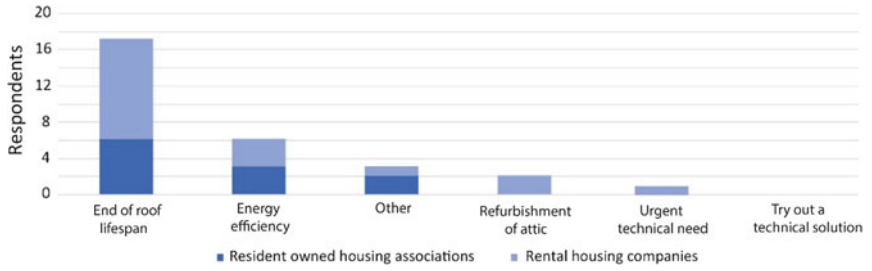

Fig. 3 Causes for roof renovations [N = 23]

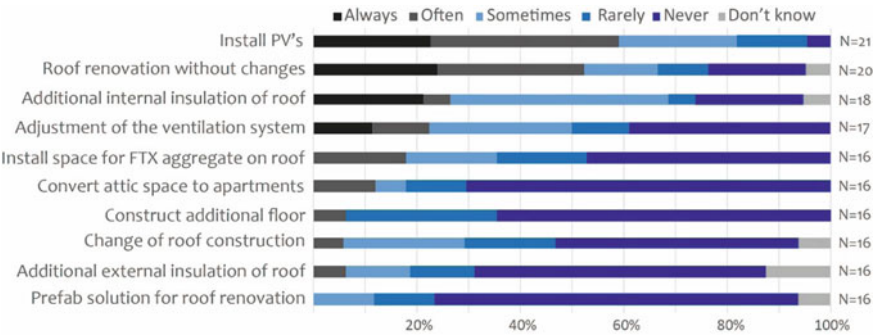

Fig. 4 Measures carried out in conjunction with roof renovations [N = 24]

construction period which has been renovated more often than others flat roofs are mentioned several times.

The most common measures carried out in conjunction with a roof renovation are: replacing the roof without alterations or to install solar panels, Fig. 4. More than half of the respondents 'always' or 'often' install PV or carry out roof renovations without changes.

Among the responding organizations, it is uncommon to renovate roofs and install PV in the same go, most do either or. Reasons for renovating roofs without installing PV are mostly due to the roofs facing an unfavorable direction, having an inappropriate shape, and low profitability/high investment costs of PV, Fig. 5. Other reasons are unclear tax regulations and uncertainties around the future value of the produced electricity. The question about motives for not installing PV has a low response rate, notably for ROHs. Probably this is a consequence of our population (projects with subsidies for PV installation) and that the ROHs are small and only have renovated one roof, i.e. with PV.

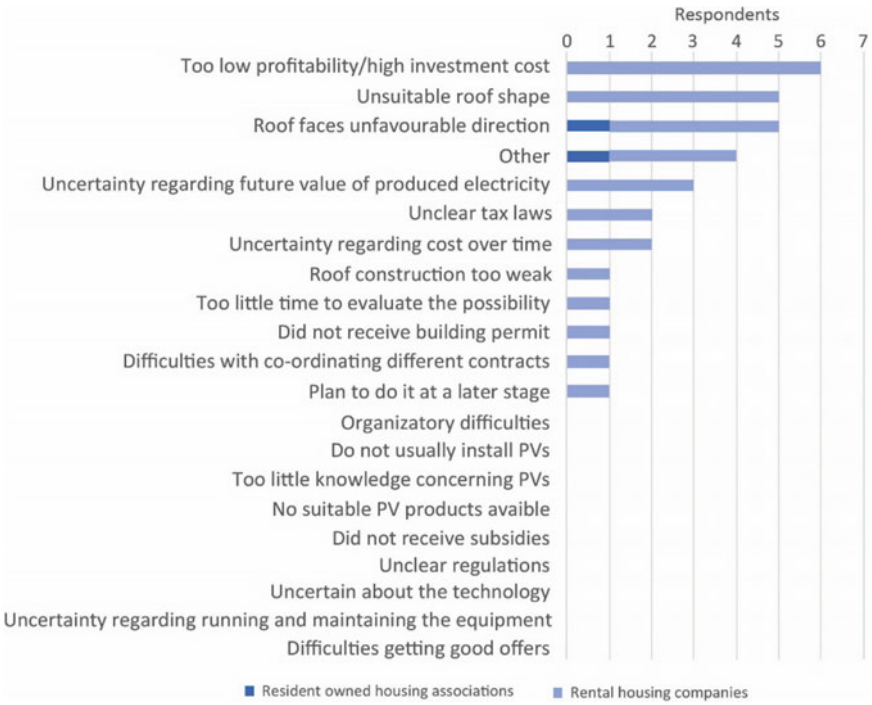

Fig. 5 Reasons for not installing PV in a roof renovation. Up to 5 options could be selected by the respondents (N = 11)

3.3 Implemented PV Installations on Roofs: Routines, Motives and Driving Forces

Standard PV modules mounted onto the roof is the predominant choice, selected by 10 respondents. Another 3 respondents state that they installed roof-integrated standard PV-modules and one states that pre-fabricated roof modules with integrated PV were selected. None of the responding organizations mounted specially designed solutions. The initiative to install PV is most often taken by the Board of the Housing Association of the ROH or in the case of RH organizations, the management team of the business board of the company/association, Fig. 6.

The motives for installing PV vary widely. The most common motives are energy saving, the idea that it is an effective environmental measure, reaching self-sufficiency/contributing to being self-sufficient with electricity; to access subsidies; and marketing of an environmental profile, Fig. 7.

Regarding lessons learnt from carrying out a roof renovation with PV, out of nineteen respondents, twelve state that their organizations are satisfied with how the PV project turned out and would not change anything in a new project. A potential bias related to this is that the respondents want to illustrate how successful their

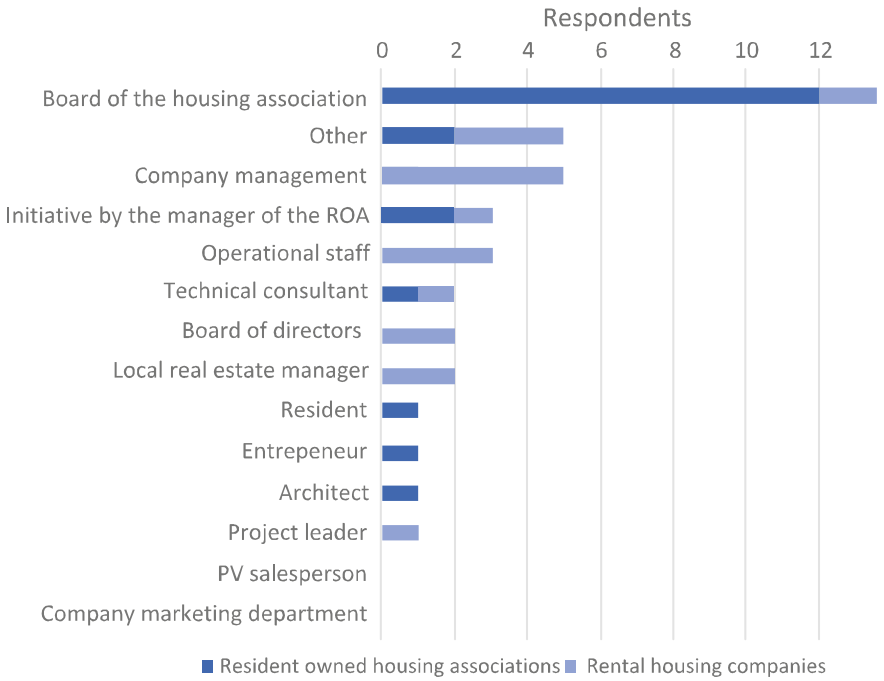

Fig. 6 Stakeholders that initiated roof renovation with PV. Others are, for example: politicians, technical manager, researcher, owner of construction company with experience of installing PV. Up to 5 options could be selected by the respondents (N = 24)

organization was and, in case of the ROH, possibly the main workload was delegated to an external project leader and, thus, the respondent is not acquainted with all the details of the project. Among the comments from those who suggested changes they would like to make slight changes to the procurement process and clarify roles; have a turnkey contract instead of contracts with two separate contractors; or add details in the procurement process, contract, follow-up; renovate the roof at the same time and not install hybrid PV; mount a net between the PV modules and the roof to avoid birds to build nests; and install larger PV plants.

3.4 Future Roof Renovations

Regarding plans for roof renovations the up-coming five years, many respondents plan either to install PV without renovating the roofs or to install PV and renovate the roof at the same time (8 respondents for each option, out of 20). Eleven respondents identified the following types of roofs to be renovated: both pitched roofs (4) and flat roofs (3); mostly in buildings constructed 1961–80 (6 responses), and buildings constructed 1941–60 (3 responses) and 1981–2000.

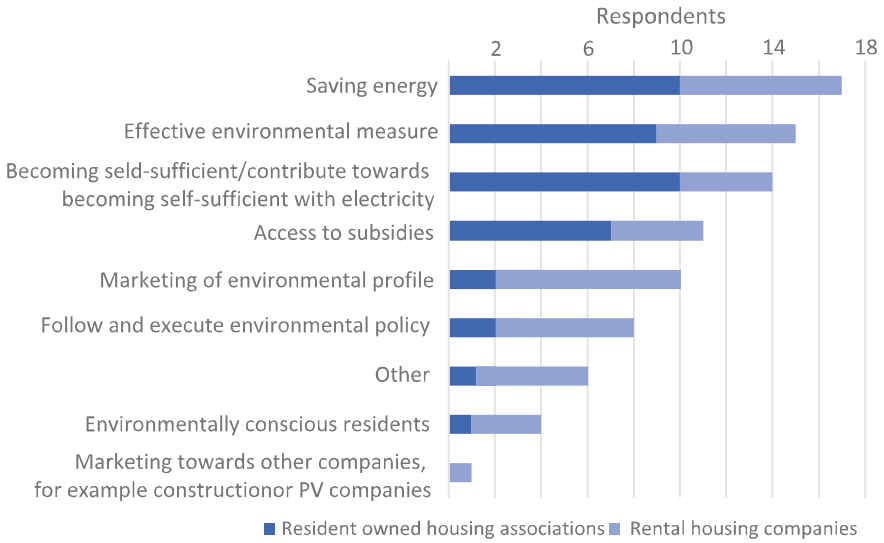

Fig. 7 Motives for installation of roof PV. Others are: owner directive, synergies, supplement to existing heating system, feels good to take a step towards a cleaner world, economy in general, and hundred percent renewable energy. Up to 5 options could be selected by the respondents [N = 24]

On the question of what is needed to encourage more PV installations, better profitability was mentioned most often, Fig. 8. Other important factors relate to economy, such as higher subsidy rates and more security regarding the future value of produced electricity. None of respondents see a need for more appealing/more beautiful design of PV products, better organization within the own company, or better knowledge about operation and maintenance of the PV plant.

Pre-fabricated roof elements with integrated PV are of no interest to 13 of the respondents (10 ROH, 3 RH). At the same time 8 respondents are positive to this kind of solution as a renovation and energy measure and 3 respondents stated other reasons. The mentioned reasons for selecting "other" indicated that the respondents did not understand the questions properly/do not know what is meant by a pre-fabricated roof element with integrated PV.

The respondents were also asked to rank different methods to handle surplus electricity generated from the PV in order to counteract a negative economic result. The two most favorably ways are to introduce a common subscription for electricity for the whole building so that the solar electricity can be used in the apartments and to introduce batteries to store surplus electricity generated during day-time to enable using it in the evening and night.

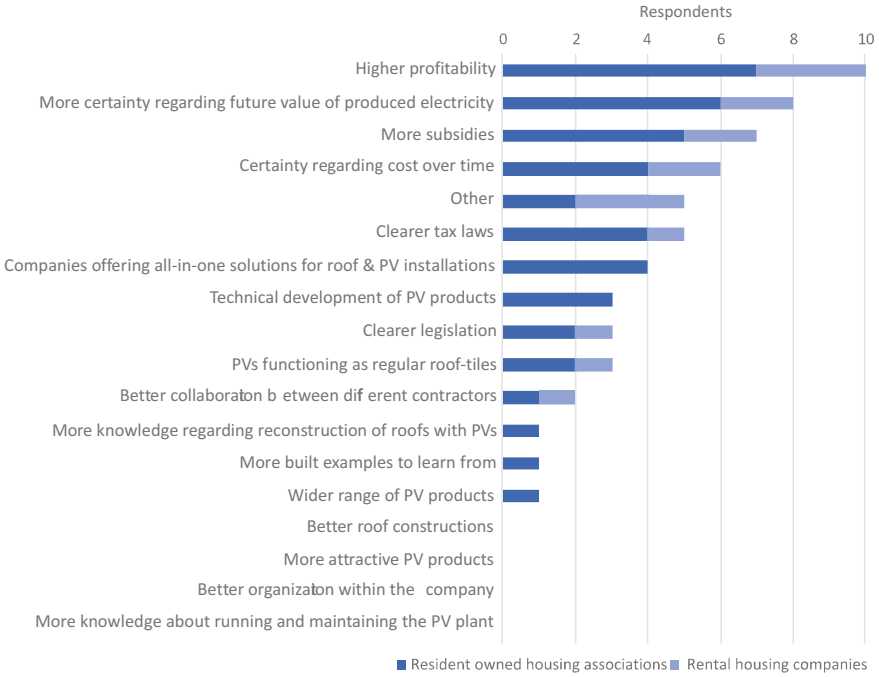

Fig. 8 Motivations to increase PV installations. Up to 5 options could be selected by the respondents [N = 20]

4 Discussion and Conclusion

Regarding roof renovations in general, it is interesting to mention that only a few of the responding organizations conduct a roof renovation with installation of PVs. Instead they do either a renovation or install PV. At the same time, the main reason for conducting a roof renovation is the technical end-of-life time of the roof (Fig. 3). This could be a good opportunity to integrate PV when carrying out a roof renovation but the challenge is to stimulate the PV thinking among mainstream housing managers. Our results differ from the study of Sommerfeldt et al. [3] in which motives for installing PV are among others the combination of roof renovations with installation of PV in order to utilize scaffolding efficiently and by that decrease the installation costs for PV. Other motives for installing PV according to Sommerfeldt et al. [3] are the decrease of operations costs by self-produced electricity, energy efficiency, contribution to sustainability, and marketing of environmental profile. All those are also important motives in the study of Olsson et al. [2] and in our survey.

Economic aspects have been mentioned as an important factor for not installing PV (Fig. 5) or to expand future installation of PV (Fig. 8). The availability of subsidies is possibly a crucial barrier and subsidies will still have a major importance in the near future in order to create a mass market for PV installations. With respect to the small amount of installations, there are possibly too few examples to learn from and there is a lack of well-documented knowledge. For the ROH associations, their national organisation could play an important role to convince, collect, share, and communicate knowledge about roof PV.

The managers of ROH associations are usually non-professionals in construction and their decisions often based on inspirations from other ROH associations or the city scape. The social impact between individual is important and every new PV installation increases the probability for further PV installations in the neighborhood [5]. Also, according to Palm [5], the contact between relatives and friends is more important rather than neighbors and the contact between the individuals can act as a complement to professional consulting.

The addition of an extra floor/attic on top of the building with new apartments is not considered as an option among most of the respondents. The most common measure is to replace the roof without alterations of the existing form and size. Prefabricated roof elements (see Fig. 4) still seem to be rare in roof renovations. Possibly because there are too few available (more less none?) solutions, a lack of knowledge, i.e. this solution is not known among the housing owners and managers, or that the existing are not applicable because of the nature of the planned roof renovations. A conclusion could be that future development of prefabricated roof elements with integrated PV, thus, should focus on roof constructions without addition of an additional floor. These should provide joints adaptable to the different existing roof constructions. Even if the interest in prefabricated solutions is low today, there is a certain curiosity and willingness to apply it in future roof renovations.

Interesting to mention is that none of respondents see a need for more appealing design of PV products, better organization within the own company, or better knowledge about operation and management of the PV plant. These results contradict findings from a process-simulation workshop, where the participants identified the those aspects as important for a more extensive implementation of roof PV in renovations [4].

Our questionnaire was directed to all Swedish housing owners and managers of rental housing and resident-owned housing in multi-residential buildings that have installed PV with subsidies. This gives a certain bias as the respondents in general have a positive attitude towards PV and the barriers are possibly perceived differently from those who have not installed PV. However, we can take advantage from the knowledge the respondents have from carrying renovations with PVs and identify barriers and potentials in relation to the installation of PV and not only reasons for opting out PV. One can speculate that few housing owners of multi-residential buildings will install PV without subsidies. By that, our study probably covers most of the installed PV in this type of buildings. Furthermore, the responses include several smaller ROH organizations, sometimes only owning one

property and consequently not conducting many other roof renovations. Finally, our research provides first result regarding PV integration in roof renovations, motivations as well as barriers. For a better understanding of the roof renovations and the potentials for integration of PV in multi-residential buildings, future research needs to focus on the renovation process in general and reasoning behind decision-making involving not only housing managers but also other stakeholders.

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References

1. J. Lindahl, *National Survey Report of PV Power Applications in Sweden, in IEA International Energy Agency* (Swedish Energy Agency, Stockholm, 2015)
2. D. Olsson, C. Heincke, P. Wennerhag, *Erfarenheter från medelstora solcellsinstallationer på byggnader. En intervju- och enkätstudie med fokus på montage* (Energiforsk, Stockholm, 2015)
3. N. Sommerfeldt, H. Muyingo, T. af Klintberg, *Solceller ur flera persepktiv. Handbok för beslutsfattare. KTH, skolan för industriell teknik och management* (institutionen för energiteknik, Stockholm, 2016)
4. P. Kovács, L. Thuvander, P. Femenías, O.P. Hemlin, D. Larsson, *Nya utsikter för solceller vid takrenovering* (Bygg and Teknik, Stockholm, 2017), pp. 12–17
5. A. Palm, *Residential Solar Photovoltaics Deployment: Barriers and Drivers in Space* (Lund University, IIIEE, 2017)