Technology Collaboration Programme
by iea

International Energy Agency
Photovoltaic Power Systems Programme

Task 1 Strategic PV Analysis and Outreach

PVPS

National Survey Report of PV Power Applications in Sweden
2022

Swedish Energy Agency

What is IEA PVPS TCP?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organisation for Economic Cooperation and Development (OECD). The Technology Collaboration Programme (TCP) was created with a belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of 6 000 experts across government, academia, and industry dedicated to advancing common research and the application of specific energy technologies.

The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the TCP's within the IEA and was established in 1993. The mission of the programme is to "enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems." In order to achieve this, the Programme's participants have undertaken a variety of joint research projects in PV power systems applications. The overall programme is headed by an Executive Committee, comprised of one delegate from each country or organisation member, which designates distinct 'Tasks,' that may be research projects or activity areas.

The IEA PVPS participating countries are Australia, Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, and the United States of America. The European Commission, Solar Power Europe, the Smart Electric Power Alliance (SEPA), the Solar Energy Industries Association and the Copper Alliance are also members.

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What is IEA PVPS Task 1?

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. An important deliverable of Task 1 is the annual "Trends in photovoltaic applications" report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the country National Survey Report for the year 2022. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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COVER PICTURE: Alight and Martin & Serveras solpark in Skurup.

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1 INSTALLATION DATA

The photovoltaic (PV) power systems market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters, and batteries. Other applications such as small mobile devices are not considered in this report. PV installations are included in the 2022 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2022, although commissioning may have taken place at a later date.

1.1 Applications for Photovoltaics

The installation of grid-connected PV systems in Sweden can be said to have taken off in 2006, with approximately 300 kW installed that year. Prior to that, only a few grid-connected systems were installed annually, and the Swedish PV market primarily consisted of a small but stable off-grid sector, catering mainly to holiday cottages, marine applications, and caravans. This domestic off-grid market has remained relatively stable over the years.

However, since 2007, the annual installation of grid-connected capacity has surpassed that of off-grid capacity. The grid-connected market is predominantly comprised of distributed roof-mounted systems installed by individual homeowners, companies, municipalities, farmers, and other entities. Right from the beginning, the Swedish distributed market has been driven by the self-consumption business model due to the absence of feed-in-tariffs. To support this business model, capital subsidies and a feed-in premium scheme, which adds value to excess electricity, have been vital. However, as of 2022, no subsidies exist except for the private domestic PV market segment.

In contrast, the centralised PV sector is relatively small compared to global standards. Nevertheless, recent years have witnessed a noticeable surge in interest and activity in the centralised PV park market segment. While the capacity additions from PV parks are still modest, the activity is expected to persist, leading to an expansion in the number and scale of centralised PV parks in the foreseeable future.

1.2 Annual installed PV capacity

The installation rate of PV continues to increase rapidly in Sweden. In 2022, a total of 796.6 MW of grid-connected capacity was added, as illustrated in Figure 1 and Table 1. This translates to a notable 59% market growth compared to the 499.7 MW installed in 2021.

Among the grid-connected PV capacity added in 2022, approximately 37.2 MW is estimated to be centralised ground-mounted PV parks, while 759.4 MW comprises distributed PV systems primarily installed for self-consumption. Consequently, the annual centralised PV market in Sweden experienced a decline of about 29%, whereas the distributed market expanded by 70% compared with 2021, when approximately 52.3 MW of centralised and 445.5 MW of distributed PV was installed.

As mentioned in the past section, Sweden has a small but steady off-grid PV market. Between 2017 and 2019, approximately 2 MW per year were sold for off-grid applications. In 2020, the annual off-grid market slightly decreased to 1.6 MW but rebounded in 2021 to 1.9 MW. Although collection of off-grid capacity through sales statistics is not in the scope of this year’s National Survey Report for Sweden, it's reasonable to estimate that it remains consistent with the figures from recent years in Sweden and 1.5 MW_p of new off-grid capacity therefore estimated for 2022.

Worth noting is that, with the discontinuation of the capital subsidy program (See previous Swedish National Survey Reports) and the gradual phasing-out of the electricity certificate system (See Section 3.2.1), replicating the past market segmentation — which was based on the databases of these two subsidy programmes — of the Swedish installed capacity is no longer viable. This shift is clearly reflected in the data portraying the yearly installed capacity, as shown in Figure 1 and Table 2.

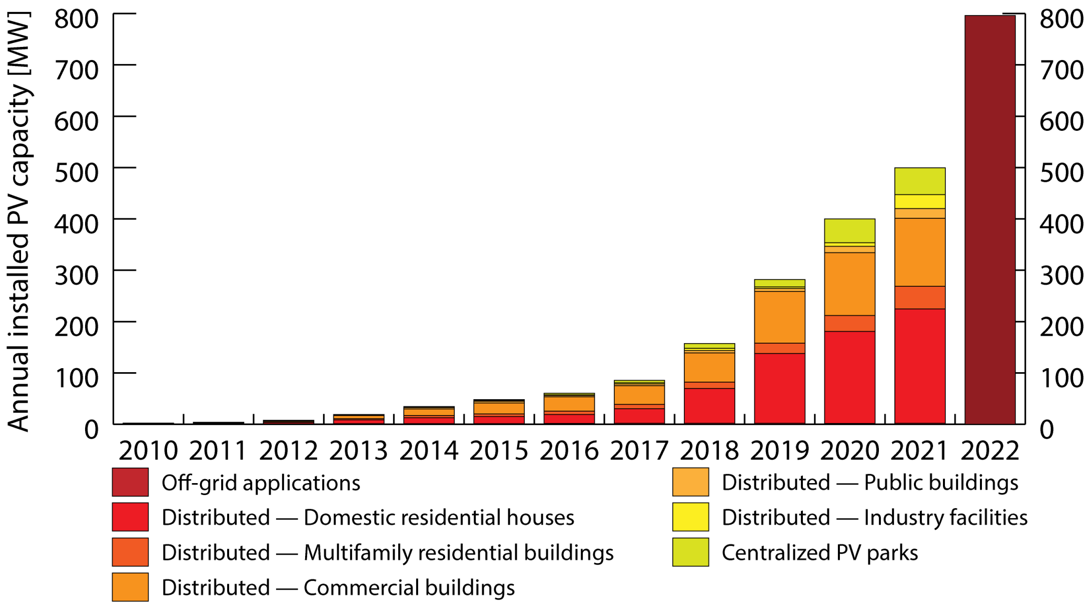

Figure 1: Annual installed PV capacity in Sweden

Table 1: Annual PV power installed during calendar year 2022.

		Installed PV capacity in 2022 [MW]	AC or DC
PV capacity	Off-grid	1.50	DC
	Decentralised	759.41	AC
	Centralised	37.21	AC
	Total	798.12	AC

Table 2: PV power installed during calendar year 2022.

			Installed PV capacity [MW]	Installed PV capacity [MW]	AC or DC
Grid-connected	BAPV	Residential	759.41	-	AC
		Commercial		-	AC
		Public		-	AC
		Industrial		-	AC
	BIPV	Unknown (Included in BAPV)			
	Utility-scale	Ground-mounted	37.21	37.21	AC
		Floating		0	AC
		Agricultural		0	AC
Off-grid		Residential	1.50	-	DC
		Commercial		-	DC
		Mobile applications		-	DC
Total			798.12		AC

Table 3: Data collection process

Is the data reported in AC or DC?	The reported data is in AC
Is the collection process done by an official body or a private company/Association?	Public body, the Swedish Energy Agency (grid connected data) Company, Becquerel Sweden (off-grid data before 2022)
Link to official statistics	http://www.energimyndigheten.se/statistik/den-officiella-statistiken/statistikprodukter/natanslutna-solcellsanlaggningar/
The different data sources used for this report are all described and discussed in APPENDIX I - Data sources and their limitations	

1.3 Total installed PV capacity

The total grid-connected capacity at the end of 2022 was 2 374.6 MW according to the grid operators. Out of this capacity, about 171.1 MW is estimated to be centralised PV and 2 203.6 MW to be distributed. In addition, a total of 23.3 MW of off-grid PV applications was sold in Sweden between 1993 and 2021, of which 19.8 MW is estimated to still be in operation. For 2022, no off-grid capacity has been collected.

By adding the off-grid and the grid-connected PV capacities together, a total of 2 394.4 MW of PV capacity is estimated to up and running in Sweden by the end of 2022, illustrated in Figure 2 and summarised in Table 4. The total installed PV capacity grew by 49 % in 2022, which is in line with the development over the five previous years, where the total market grew by 45 % (2021), 57 % (2020), 66 % (2019), 59 % (2018) and 47 % (2017).

The strong overall growth in the last decade started with the introduction of the direct capital subsidy system (see previous National Survey Reports) in 2006, and has since then been fuelled by the declining system prices (see section 2.2), high popularity among the public (see section 1.6), a growing interest from utilities (see 7.2) and the tax credit for micro-producers (see section 3.3.5).

Just as for Figure 1, the discontinuation of the capital subsidy program (See previous Swedish National Survey Reports) and the gradual phasing-out of the electricity certificate system (See Section 3.2.1), does not allow for the same market segmentation for 2022 as for the years before in Figure 2.

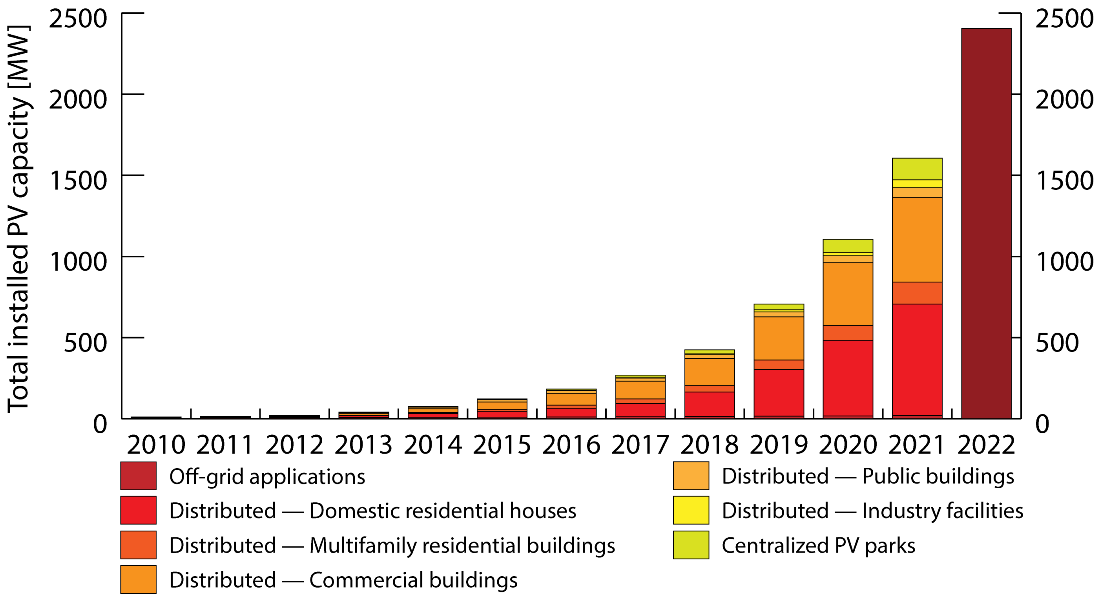

Figure 2: Total installed PV capacity in Sweden.

In total, there were 147 690 grid-connected PV systems in Sweden by the end of 2022. The number of off-grid systems is unknown. A majority of the grid-connected PV systems, 131 298, are small systems below 20 kW. 16 329 are in between 20 kW – 1000 kW and 63 systems are above 1 MW according to the official statistics (summarised in

Table 5). However, the official statistics count everything behind one single connection point to the grid as one system. Several of the centralised PV parks built in Sweden have several connection points to the low-voltage distribution grid. These PV parks are divided into several systems in the statistics, and often in sizes below 1 MW. So, the actual number of PV systems above 1 MW in Sweden is larger than 63 systems the way most people would see it.

With regards to the number of installed PV systems in Sweden, statistics are available for grid-connected system for the years 2016 to 2022. The number of systems at the end of each year, and the corresponding average system size are presented in Table 6. As can be seen at the end of 2022, Sweden had 147 690 grid-connected PV system, and the corresponding average system size was about 16.1 kW. That is a relatively small system size, which clearly illustrates that the Swedish PV market mainly consists of small, distributed PV systems. For 2023, there is a clear break in the trend of continuous growth in average system size on the Swedish PV market, especially notable in the annual average in Table 6. This indicates a faster expansion of the small distributed PV market in Sweden compared to the segment of larger decentralised and centralised PV in 2022. Some developers working on centralised projects have reported experiencing delays, suggesting a potential time lag before these projects that previously were announced for 2022 will be connected to the grid. It's likely that in the next couple of years, there will be a return of the upward trend driven by commissioned centralised PV parks. Another explanation could be that the spike in interest due to high energy prices under the European energy crisis in 2022 was more quickly addressed by private individuals and other actors in smaller PV market segments, as these projects can be developed faster.

Table 4: The cumulative installed PV power in 3 sub-markets. Note that no new sales statistics on off-grid capacity was collected for 2022.

Year	Off-grid [MW]	Grid-connected distributed [MW]	Grid-connected centralised [MW]	Total [MW]
1992	0.80	0.01	0.00	0.81
1993	1.03	0.02	0.00	1.05
1994	1.31	0.02	0.00	1.33
1995	1.59	0.03	0.00	1.62
1996	1.82	0.03	0.00	1.85
1997	2.03	0.09	0.00	2.12
1998	2.26	0.11	0.00	2.37
1999	2.46	0.12	0.00	2.58
2000	2.68	0.12	0.00	2.80
2001	2.88	0.15	0.00	3.03
2002	3.14	0.16	0.00	3.30
2003	3.39	0.19	0.00	3.58
2004	3.67	0.19	0.00	3.86
2005	3.98	0.25	0.00	4.23
2006	4.30	0.56	0.00	4.86
2007	4.57	1.68	0.00	6.25
2008	4.83	3.08	0.00	7.91
2009	4.97	3.54	0.06	8.57
2010	5.34	5.12	0.25	10.71
2011	5.78	8.47	0.28	14.53
2012	6.38	14.92	0.89	22.19

2013	7.31	32.14	1.37	40.82
2014	8.20	63.81	2.95	74.95
2015	9.16	109.19	4.30	122.64
2016	10.43	165.17	7.12	182.73
2017	12.27	244.18	11.64	268.10
2018	14.09	390.15	20.09	425.14
2019	15.82	655.86	35.07	706.75
2020	17.20	1 007.82	81.58	1 106.60
2021	18.89	1 453.33	133.84	1 606.06
2022	19.78	2 203.59	171.05	2 394.42

Table 5: Other PV market information.

			2022
Number of PV systems in operation in Sweden	Grid connected PV	Under 20 kW	131 298
		20 kW – 1000 kW	16 329
		Above 1000 kW	63
		Total	**147 690**
	Off-grid PV		Unknown
Decommissioned PV systems during the year [MW]		202 kW of off-grid system is estimated to have been decommissioned	
Repowered PV systems during the year [MW]		Unknown	

Table 6: Number and average sizes of grid connected PV systems in Sweden at the end of each year.

	2016	2017	2018	2019	2020	2021	2022
Number of systems	10 006	15 298	25 486	43 944	65 819	92 358	147 690
Average size per system for the total number of systems at the end of each year [kW]	14.0	15.1	16.1	15.9	16.6	17.1	16.1
Average size per system for the annual market [kW]	17.3	17.3	17.6	15.7	17.7	18.7	14.4

1.4 PV market segments

The official statistics provided by grid operators and collected by the Swedish Energy Agency only classify PV system sizes (power) into three ranges: 0–20 kW, 20–1000 kW, and >1000 kW. Table 7 summarises the total installations at the end of 2022 based on this data source.

Table 7: Total installations of grid-connected PV capacity and number of systems at the end of 2022, according to the grid operators[1].

	0–20 kW	20–1000 kW	>1000 kW
Total grid-connected PV capacity according to the grid operators collected by the Swedish Energy Agency [MW]	1 347.35	892.93	134.36
Total number of grid-connected PV systems according to the grid operators collected by the Swedish Energy Agency [#]	131 298	16 329	63

Prior to 2022, it was possible to assess more detailed market segmentation based on the former Swedish subsidy programme databases, that were available for 2009–2021. The Swedish direct capital subsidy maintained a comprehensive database of all PV systems that have received support since the subsidy program's inception in 2009 until its termination in 2020/2021. By cross-referencing this database with Sweden's national business directory, each system owner could be assigned a specific business sector, allowing for the division of the database into centralised, industry, commercial, or residential systems (as explained in section 9.1.4). By analysing the annual installed PV capacity for each market segment and comparing it to the total installed PV capacity, an estimate of the market share of each segment in annual installations could be made. The historical development of these shares is presented in Figure 3.

No similar breakdown can be made for 2022 as this subsidy programme have been terminated, and the year is therefore missing in the table below.

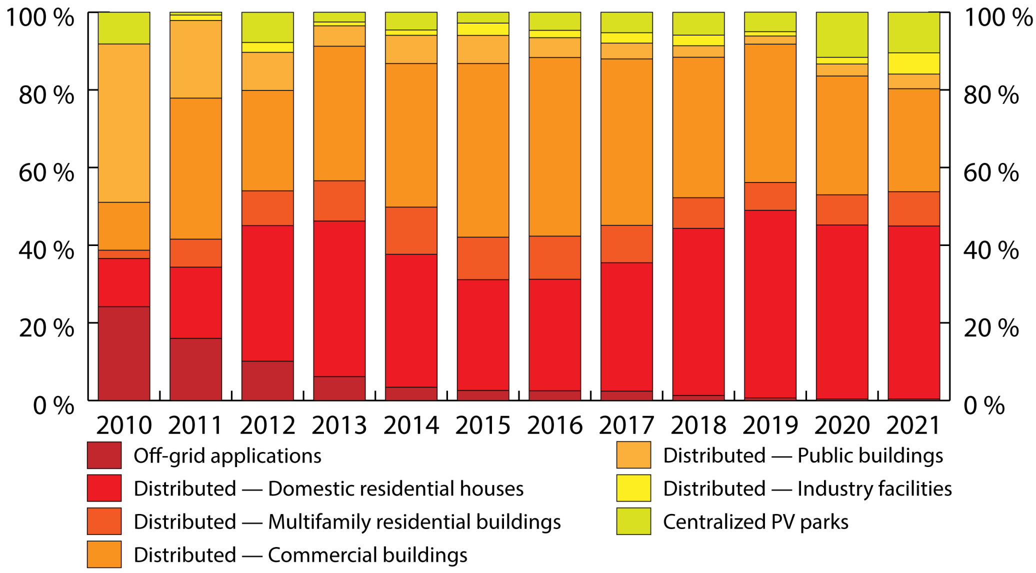

Figure 3: Various market segments share of the annual installed PV capacity in Sweden between 2010–2021 based on statistics from the capital subsidy database.

It is evident that residential domestic single-family houses and commercial facilities have consistently been the largest market segments in Sweden. Although there has been some variation over the years, these two segments have steadily dominated the market. This is primarily due to the ease of implementing the self-consumption business model in these building types. In the same way, the low market shares of other segments such as centralised PV parks, industry, and residential multi-family houses can be attributed to historical policy structures in Sweden.

Regarding the centralised PV park market segment, as of the end of 2022, the authors are aware of 41 commissioned PV parks in Sweden with a capacity exceeding 0.5 MW. The underdevelopment of centralised PV parks in Sweden until today, in comparison to many other countries, can be attributed to insufficient support schemes until 2020. The two available support schemes were the renewable electricity certificate system (as described in section 3.2.1) and a maximum subsidy of 1.2 million SEK per system from the direct capital subsidy program (see earlier National Survey Reports). However, it is expected that this market sector will experience significant growth in the coming years, as business models, electricity market development, and technology development are making these systems profitable in Sweden without any state subsidies, for example thanks to innovative business models such as power purchase agreements (PPAs) and PV cooperative models (see section 2.4).

The recent increase in the industry segment can be attributed to two factors. Firstly, the energy tax threshold was raised from 255 kW to 500 kW on July 1st, 2021 (see section 3.3.2), which made it more economically feasible to install larger systems. This change encouraged industries to invest in PV installations to meet their energy needs. Additionally, a few ground-mounted PV parks have been commissioned near industrial facilities. Although these parks are considered industry systems, they are not classified as centralised PV parks (even if they are ground-mounted) since the electricity generated primarily serves self-consumption on-site.

Residential multi-family houses face a general obstacle due to current tax laws, making it complex to self-consume PV electricity within individual apartments. Typically, each apartment has its own meter and contract with the grid operators, while the entire multi-family house has a separate meter and contract for electricity consumed in common areas such as elevators, laundry rooms, and lighting. Under this arrangement, the PV electricity generated by a system on the building can only be utilised for common area consumption.

If the owner of the multi-family house wishes to sell PV electricity to the apartments, they become a retailer of electricity and must adhere to the associated regulations, including the Swedish energy tax, which is applied to the electricity even if it remains within the building. Consequently, achieving a high degree of self-consumption in multi-family houses with this arrangement becomes challenging. Moreover, the value of excess electricity exported to the grid diminishes if the fuse capacity exceeds 100 amperes (see section 3.3.5), making it difficult to achieve profitability for such installations.

However, it is possible to achieve tax-free self-consumption of PV electricity within the apartments if the entire multi-family building, including the individual apartments, shares a single meter and contract with the grid operator. This arrangement requires that the electricity consumption within the apartments is included in the general rent. The owner of the multi-family house can decide whether the residents should pay a fixed price for the electricity regardless of their consumption or handle the metering of electricity consumption themselves and adjust the monthly rent based on individual electricity consumption. The latter solution is becoming increasingly common in Sweden, but the overall complexity and cost of switching meters involved in transitioning to this arrangement is one of the reasons for the low installation numbers for multi-family houses.

As of January 1, 2022, it has become allowed to establish low voltage ground cables (microgrids) between buildings for energy sharing. This allows for self-consumption of energy within multiple neighbouring buildings. However, it should be noted that self-consumption within individual apartments still necessitates the aforementioned solutions. Despite the need for some time to accumulate the necessary knowledge and understanding of this exception to the grid regulation, it is anticipated that this policy shift will stimulate the multi-apartment market segment.

1.5 The geographical distribution of PV in Sweden

The data from the grid operators' statistics about the installed PV power in Sweden has a geographical resolution down to municipality-level. The expansion of PV takes place at different speeds in Sweden's municipalities. When it comes to most installed PV capacity, Gothenburg, followed by Uppsala and Linköping were in the top at the end of 2022 with 83.0, 53.5 and 52.1 MW, respectively.

Similar to last year, the top 3 municipalities in terms of watts of PV capacity installed per capita are Skurup, Sjöbo, and Borgholm, with 1366.3 W/capita (total 22.9 MW), 1158.8 W/capita (total 22.7 MW), and 943.2 W/capita (total 10.2 MW), respectively. This is not a coincidence, as these three municipalities are located in the southern parts of Sweden, where most PV capacity is installed. Additionally, two of them are home to Sweden's largest centralised PV parks, such as Martin & Serveras Solpark in Skurup with 18 MW (as of 2022) and Sparbanken Skånes Solcellspark in Sjöbo with 17.8 MW (expanded in 2021). While, to the best of our knowledge, Borgholm doesn't have any PV parks, it is a municipality with a high density of vacation homes and therefore a substantial summer population which makes residential and commercial PV an interesting investment.

The Swedish electricity market is from the first of November 2011 divided into four bidding areas by decision of the Swedish National Grid (Svenska Kraftnät). The reason is that northern Sweden has an excess of electricity production, since that is where a lot of the wind power and a majority of the hydropower is situated, while the demand is larger than the production in southern Sweden. This has resulted in transmission bottlenecks, and the borders between the bidding areas have been drawn where there are congestions in the national grid. The idea of the four bidding areas is to make it clear where the national grid needs to be expanded and where an increased electricity production is required to better meet the consumption. From this perspective, it is positive that a majority of the PV capacity is being installed in southern Sweden and mainly in the densely populated municipalities.

1.6 Key enablers of PV development

The public opinion about PV

The overall public sentiment towards the PV technology in Sweden is highly positive. According to a recent annual survey [2] conducted by the SOM Institute, where respondents were randomly selected and asked about their preferences for energy source investments over the next 5–10 years, a large majority of 81% expressed a desire for increased investments in PV technology in Sweden. This places the PV technology at the forefront as the most preferred electricity production technology or source among the surveyed population, as well as the least disliked.

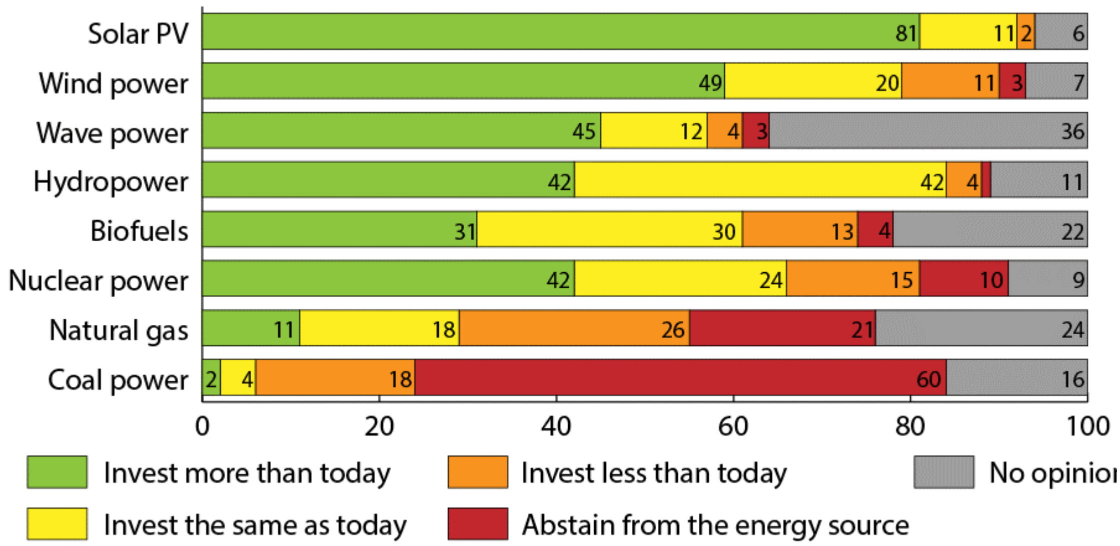

Figure 4: The public opinion in Sweden about different electricity production technologies in 2022.

1.7 PV in the broader Swedish power system

As mentioned in Section 1.5, the Swedish power system has been organised into four bidding areas (SE1–SE4) by the Swedish National Transmission System Operator (Svenska Kraftnät) since November 1st, 2011. This decision was made to address an electricity supply-demand imbalance: northern Sweden has an excess of electricity production, while southern Sweden faces higher demand than production. This disparity led to transmission capacity issues, prompting the delineation of bidding area boundaries at grid congestion points. The purpose of these four bidding areas is to pinpoint regions in Sweden where grid expansion is necessary and where increased electricity production can alleviate consumption demands, thus reducing the need for long-distance electricity transport.

In recent years, significant changes in Swedish power production include the expansion of wind power, the shutdown of two nuclear reactors (Ringhals 2 in December 2019 and Ringhals 1 in December 2020), and the closure of the last coal power plant in 2020.

Regarding electricity consumption, a decrease was observed in almost all months of the year of 2022 as compared to 2021. However, the most notable drop occurred in September, October, and November, which can be attributed to high electricity prices and households adopting cost-saving measures during the autumn as countermeasures to the European energy crisis.

In Figure 5, the Swedish electricity production in 2022 is presented. The electricity production data used in Figure 5 and Figure 6, along with Table 8, were retrieved from Svenska Kraftnät [12], but with complementary data from SCB [13] with regards to the fuels used in the Swedish CHP power plants. The total power generation in Sweden was 170.0 TWh in 2022, while the electricity consumption was 136.8 TWh. In total, Sweden imported 6.1 TWh and exported 39.4 TWh.

As can be seen in Figure 6, the Swedish electricity has historically been produced by technologies that have a low CO2-footprint. This along with the comparably low electricity prices (see section 2.6) counts as the two main reasons why the Swedish PV deployment started late compared to other European markets and still is rather small.

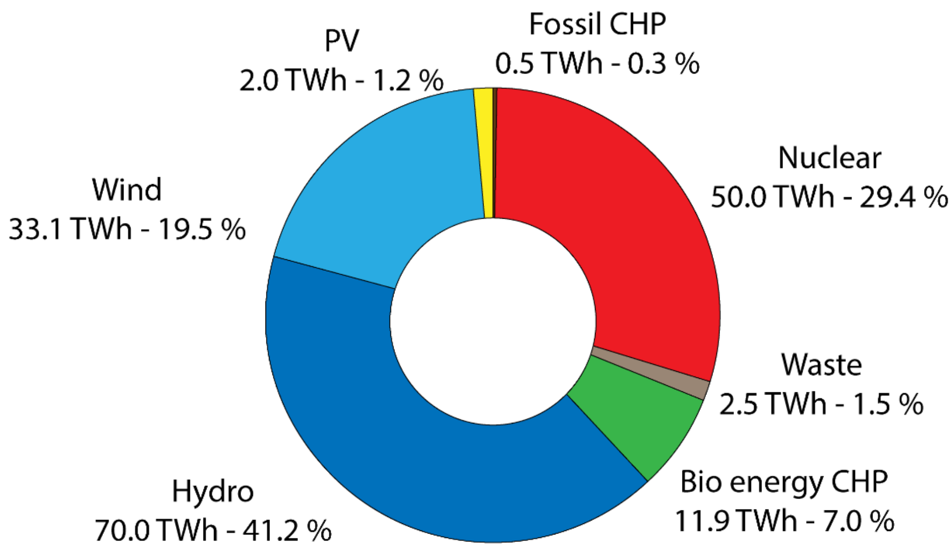

Figure 5. Total electricity production in Sweden in 2022.

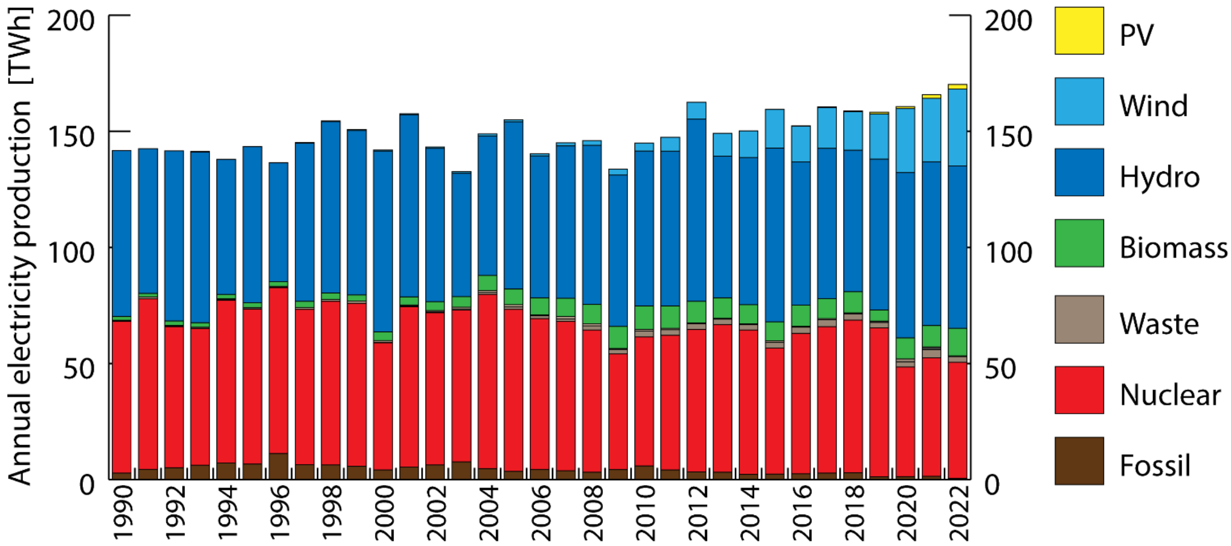

Figure 6. Total annual electricity production in Sweden between 1990 to 2022.

Table 8. PV power and the broader national energy market.

	Data	Year
Total power generation capacities [MW]	47 747	2022
Total renewable power generation capacities (including hydropower) [MW]	33 044	2022
Total electricity demand [TWh]	136.8	2022
New power generation capacities installed [MW]	3 013	2022
New renewable power generation capacities (including hydropower) [MW]	2 934	2022
Estimated total PV electricity production (including self-consumed PV electricity) in [GWh]	1 968	2022
Total PV electricity production as a % of total electricity consumption	1 %	2022
Average yield of PV installations [kWh/kW$_p$]	950	2022

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Module prices in Sweden are closely tied to the global module market. In the period from 2008 to 2013, there was a significant drop in PV module prices in Sweden due to the growing domestic market, which enabled retailers to import larger quantities, and due to the general global price decline closely tied to the advancements in mass-production of PV modules and technology development which led to the use of less material and energy per kW_p of PV capacity. However, between 2013 and 2016, the decline in prices was more gradual. This stability in module prices was primarily attributed to the introduction of import duties on Chinese PV modules and cells by the European Commission in 2013 [14]. These measures included the establishment of a minimum import price (MIP), which meant that silicon modules could not be imported into the European Union at a price lower than 0.56 €/W_p, approximately equivalent to 5.2 SEK/W_p.

Following the removal of these duties, many Swedish retailers reduced module prices for Swedish installation companies by 20–30%. As a result, the average typical module price for end consumers decreased by 14% in 2018, followed by a 4% decline in 2019 and a further 7% drop in 2020 (see Table 9).

Starting 2021, the price survey indicated a notable increase in prices, marking the first such increase since data collection began. These price hikes were observed across various sources, primarily attributed to supply chain constraints, as reported in the IEA PVPS Task 1 Global Trends report [3]. Throughout 2022, global prices for polysilicon, wafers, and cells remained consistently high or continued to rise for most of the year. There was a dip in the final weeks of the year, influenced by factors such as production expansions and the observance of the global and Chinese New Year. The elevated prices experienced in 2021 extended into 2022 in Sweden, resulting in even higher prices during this period.

Table 9: The historical development of typical module prices. The prices are reported by Swedish installers and retailers. The prices are the prices to the end costumer, not the import price for the retailers.

Year	Lowest price of a standard module crystalline silicon [SEK/W_p]	Highest price of a standard module crystalline silicon [SEK/W_p]	Typical price of a standard module crystalline silicon [SEK/W_p]
2004	-	-	70
2005	-	-	70
2006	-	-	65
2007	-	-	63
2008	-	-	61
2009	-	-	50
2010	20	68	27
2011	12	50	19
2012	9.5	40	14
2013	6.0	16	8.9
2014	6.0	12	8.2
2015	5.1	10	7.6
2016	4.5	9.3	7.1
2017	4.0	6.6	5.3
2018	3.2	6.6	4.5
2019	2.9	5.4	4.3
2020	2.5	6.6	4.0
2021	3.5	7.0	4.6
2022	2.6	7.8	5.6

2.2 System prices

Just as for PV modules, Sweden has witnessed a substantial reduction in PV system prices since 2010, particularly before 2013, as demonstrated in Figure 7. This decline can be attributed to two primary factors. Firstly, the prices of modules and balance of system (BoS) equipment have decreased in the global market. Secondly, the expansion of the Swedish market has provided installation firms with a more consistent flow of orders and an opportunity to optimise the installation process, thereby reducing both labour and overhead costs.

Table 23 illustrates a historical trend of decreasing full-time labour positions per installed MW, likely contributing to the overall decline in PV prices in Sweden. Companies have grown and become more efficient in their marketing and installation processes, which holds true for all years except 2021 and partly 2022. The unique circumstances of 2021 and 2022 can be linked to major events stemming from the COVID-19 pandemic and subsequent supply constraints, as detailed in sections 2.2.3 and 6.1.

The maturation of the Swedish PV market and increasing competition are factors that likely exert downward pressure on the prices of Swedish PV systems, which are expected to be lower for 2023 and onwards.

2.2.1 Estimated PV system prices by the sales statistics

The price information from the sales surveys is presented in Figure 7 and Table 10. The methodology for collecting the price statistic is explained in section 9.1.5 and the price development is discussed in section 2.2.3 below.

In comparison to the early years of collecting sales statistics, installation and sales companies have found it challenging to provide generalised price trends on an annual basis for 2021 and 2022. This difficulty arises from the increased hardware price volatility experienced in recent years, leading to fluctuations in end-customer system prices.

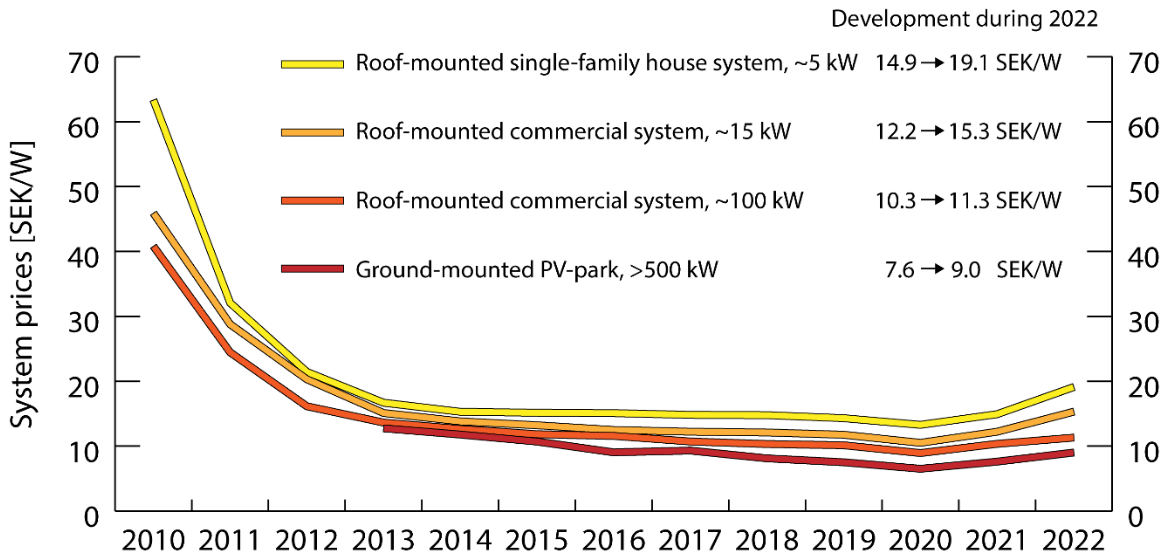

Figure 7: Historic development of the weighted average typical prices for turnkey photovoltaic systems (excluding VAT), reported by Swedish installation companies.

Table 10: National trends in system prices for different applications.

Year	**Residential BAPV** Grid-connected, roof-mounted, distributed PV system ~5 kW [SEK/W_p]	**Small commercial BAPV** Grid-connected, roof-mounted, distributed PV systems ~15 kW [SEK/W_p]	**Large commercial BAPV** Grid-connected, roof-mounted, distributed PV systems ~100 [SEK/W_p]	**Small centralised PV** Grid-connected, ground-mounted, centralised PV systems >0.5 MW [SEK/W_p]
2007				
2008		96.00	67.00	
2009		76.00	47.00	
2010	63.33	45.89	40.79	
2011	32.07	28.77	24.44	
2012	21.43	20.29	16.13	
2013	16.68	15.09	13.62	12.73
2014	15.28	13.81	12.63	11.77
2015	15.13	13.20	11.82	10.69
2016	15.07	12.48	11.56	9.03
2017	14.81	12.22	10.70	9.30
2018	14.76	12.09	10.31	8.18
2019	14.40	11.74	10.28	7.50
2020	13.27	10.50	8.92	6.50
2021	14.91	12.21	10.34	7.60
2022	19.12	15.34	11.32	9.01

2.2.2 Cost breakdown of residential PV systems

In addition to the PV system prices extracted from the sales statistics, a study on Swedish grid-connected roof-mounted residential PV systems was conducted in 2020 [4]. This will translate to the category "Domestic residential houses" in Figure 3.

The inherent cost structure of Swedish villa systems has not before been explored, except for results from a small survey conducted in 2015 and 2017 inside the scope of IEA PVPS [5]. The cost structures presented in Table 11, and Figure 8 are based on 115 PV system projects that were carried out in 2020, and display the supplier cost structure without VAT or profit margin. Eight supplier companies that focus on the private residential market reported a detailed cost breakdown on 10–15 projects each and participated in both individual semi-structured interviews and group discussions amongst each other. Comparing the result of this study and the average cost for grid-connected roof-mounted PV systems on single-family houses from the statistics is the database of the Swedish direct capital subsidy the profit margin seems to be about 10 %. In addition, the end customer also pays 25 % in VAT for the system.

Apart from the cost structure, the results showed that the average villa system size was 9 kW_p, which seemed to correspond well do the average system size recorded in the Svanen database for Swedish single-family house systems installed in 2019–2020. Monocrystalline cells are dominating in terms of cell technology, followed by half-cut monocrystalline cells, and the string inverter was the most common inverter type amongst the studied projects.

The results, presented in Figure 9, show that the single largest cost for all suppliers was that for installation work which include both the mounting of the system and the electrical installation. In the category of hardware costs, module costs are the most extensive. In a supplier cost structure for costs per kW_p, hardware costs make up 60.5%, labor costs 32.9 % and other costs 6.6%. In actual costs, this corresponds to 7 082, 3 849 and 770 SEK/kW_p, respectively.

A standardised supplier cost structure for a 10 kW_p system, presented in Figure 9, shows that the total cost amounts to 10 9840 SEK. Noticeable in that cost structure is that the module costs surpass the cost for installation work and becomes the largest single cost. The reason for the slight variation in shares per cost for the standardized system is that there is a slight economy of scale even inside the residential segment, since some costs don't vary for each kW_p, being fixed costs (such as permits) or semi-variable (such as shipping, travel time, and travel costs). Except for the modules, the individual costs vary by less than or equal to one (1) percentage point between the two setups.

Table 11: Cost breakdown for a grid-connected roof-mounted residential PV system 2020 in SEK/W_p. The table presents a supplier cost structure excluding VAT and profit margins.

Cost category	Average [SEK/W_p]	Low [SEK/W_p]	High [SEK/W_p]
Hardware			
Modules	3.17	2.53	3.93
Inverter	2.04	1.21	2.40
Mounting materials	0.38	0.60	3.02
Other electronics	1.49	0.13	0.73
Subtotal hardware	**7.08**	-	
Soft costs			
Installation work	3.50	1.41	5.01
Permits and reporting	0.13	0.01	0.49
Working travel time	0.23	0.02	0.74
Planning and sales	0.48	0.11	1.33
Shipping to customer	0.16	0.02	0.27
Travel costs	0.09	0	0.32
Other	0.04	0	0.25
Supplier margin	1.17	-	
VAT	3.22	-	
Subtotal soft costs	**9.01**	-	
Total	**16.09**	-	

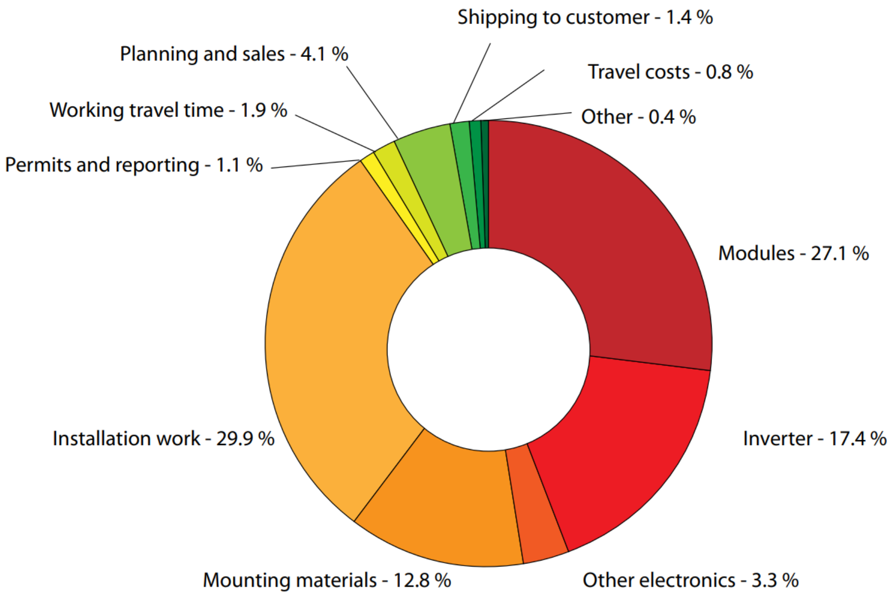

Figure 8: The supplier cost structure for a typical Swedish grid-connected roof-mounted residential PV system in 2020. The total price was 11.70 SEK/W$_p$.

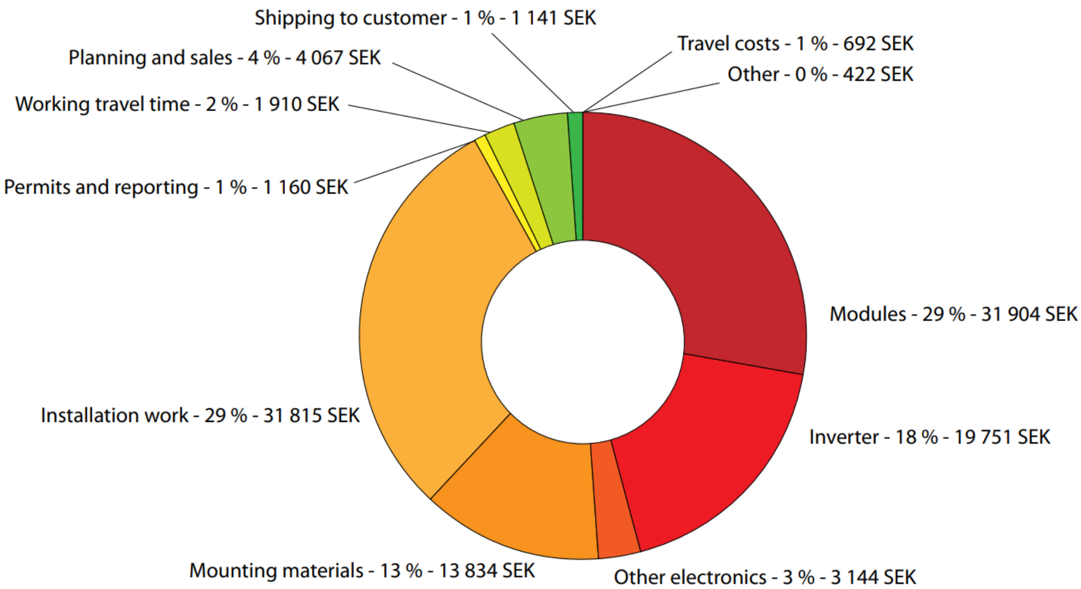

Figure 9: The supplier cost structure for a typical Swedish grid-connected roof-mounted residential PV system (10 kW$_p$) in 2020. The total price was 109 840 SEK.

2.2.3 PV system price discussion

As mentioned in the introduction to this section, prices in all market segments have significantly decreased over the past decade. Prior to 2021, prices had started to stabilise, with reductions ranging from 1% to 15% in 2020, depending on the segment. However, this trend was disrupted in 2021 and 2022, as indicated by the sales survey, which reported price increases across all segments.

Before 2022, the capital subsidy program database provided a valuable resource for analysing system prices, but it is no longer available as the program has been terminated. Consequently, the price survey now stands as the sole source for Swedish PV system prices. Historically, installation companies tended to estimate typical system prices lower than the average in the direct capital subsidy program database during periods of declining prices. Conversely, their estimates were higher than the prices recorded in the subsidy database for 2021. This disparity could be attributed to a few possible factors. It may reflect that the survey respondents are more attuned to price changes and tend to overestimate yearly average trends. Alternatively, the presence of outlier systems in the subsidy database for all categories could influence average prices in different directions. Lastly, it's worth noting that capital subsidy program statistics are based on commissioning dates, whereas sales statistics are based on the date of the sale. While there is no data available for 2022 other than the sales survey, these trends can be relevant to keep in mind when valuing the price development trends.

In numerical terms, the survey results revealed that small residential systems experienced the highest price increase in 2022, rising from 14.9 SEK/W to 19.1 SEK/W, marking a 28% increase. Small commercial systems increased by 25%, from 12.2 SEK/W to 15.3 SEK/W, larger commercial systems increased by 10%, from 10.3 SEK/W to 11.3 SEK/W, and ground-mounted parks increased from 7.6 SEK/W to 9.0 SEK/W, corresponding to an 18% increase.

The price increases were attributed by retailers and installers to several factors, including high shipping costs, a global trend of elevated prices, the Russian invasion of Ukraine with subsequent difficulties in sourcing European BoS technology, and inflation. They also noted that price volatility made it challenging to determine a typical yearly price, particularly in 2022, when module prices dropped significantly towards the end of the year after remaining high for most of the year.

These higher prices were most noticeable in smaller market segments where hardware costs constitute a larger proportion of the total price. This shows that hardware prices had a significant impact on overall cost development. However, the maturation of the market has positively influenced the cost-effectiveness of installers and the overall downstream value chain.

Another note is that the market segment sizes presented in the survey may no longer represent the overall Swedish market. Residential systems are now typically larger than 5 kW, commercial systems often exceed 15 kW and are closer to 100 kW, and ground-mounted parks are often larger than 500 kW. While the price values are presented normalised to SEK/W, it's essential to consider the impact of scale on the economics of a PV systems, as discussed in the cost structure breakdown. To be able to compare the prices and keep the consistency, however, it is considered necessary to keep the size ranges as is for the PV system price survey.

Table 12 summarises the PV system prices in 2022. The price ranges presented are appraisals made by the authors and are based on data from the installer and retailers' surveys.

Table 12: Estimated turnkey PV system prices of different typical PV systems in 2022 based on sales statistics.

Category/Size	Typical applications and brief details	Current prices [SEK/W_p]
Off-grid 2 kW	A stand-alone PV system is a system that is installed to generate electricity to a device or a household that is not connected to the public grid. The price is for a small off-grid system on a cottage for seasonal use (summer) that is not connected to main grid.	27–35
Residential BAPV 5-10 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected households. Typically roof-mounted systems on villas and single-family homes.	17–23
Small commercial BAPV 10-100 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	9–16
Large commercial BAPV 100-250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected large commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	7–13
Industrial BAPV >250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected industrial buildings, warehouses, etc.	7–12
Small centralised PV 1-20 MW	Grid-connected, ground-mounted, centralised PV systems that work as central power stations. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	7–10
Large centralised PV >20 MW	Grid-connected, ground-mounted, centralised PV systems that work as central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	not applicable

2.3 Financial parameters and specific financing programs

The interest rate (styrräntan) set by the central bank of Sweden (Riksbanken) remained at 0.00% until May 2022, marking the first shift from zero or negative rates since February 2015, when it increased to a positive interest rate of 0.25%. Subsequently, it was gradually raised throughout the year, reaching 2.5% by the end of 2022 [6]. These central bank interest rate changes directly influenced market rates, resulting in a notable increase in the cost of capital in Sweden during 2022.

In Table 13, the average nominal mortgage rate for residential installations in 2022 has been used. For commercial installations in Sweden, a realistic nominal loan rate is reported to be the STIBOR rate plus 450 basis points (dps). However, it's important to note that since interest rates have been on the rise since 2022, and higher values are reasonable to assume beyond, readers should consider the loan rates as estimates and for the values to be higher in 2023 and that it has not been stable throughout 2022.

Table 13: PV financing information in 2022.

Different market segments	Loan rate [%]
Average rate of loans – residential installations [7]	3.5 %
Average rate of loans – commercial installations [8]	6.5 %
Average nominal cost of capital – industrial and ground-mounted installations	6.5 %

Several commercial banks have introduced specialised "solar loans" aimed at individual homeowners with single-family houses. As far as the authors are aware, the first loan explicitly designed for PV installations in Sweden was launched by Sparbanken Syd in 2019. Currently, individuals looking to invest in PV systems can secure a loan of 250,000 SEK at a variable interest rate of 5.99% (as of 2023) with a repayment period of up to 10 years [23]. Other examples include Swedbank and SEB, both offering "solar loans" of up to 350,000 SEK at a variable interest rate of 6.10% in 2023 and a repayment period of up to 10 years [24][25]. Another option is Vattenfall, which, in partnership with Handelsbanken, provides a solar loan at an interest rate of 5.40% [26].

2.4 Specific investments programs

As early as 2009, Sweden's PV cooperative, Solel i Sala & Heby ekonomisk förening, was formed. This cooperative entered into a FiT agreement with the local utility company Sala-Heby Energi, purchasing the electricity generated by the cooperative's PV systems. Since its inception in 2009, this cooperative has successfully built six systems with a combined capacity of 599 kW_p. Other notable PV cooperatives with co-owned PV systems include Solel i Bergslagen ekonomisk förening, operating three systems totalling 156 kW_p, and Solcell 1:1 ekonomisk förening, which manages two systems with a total capacity of 27 kW_p.

The PV cooperative business model has evolved over the years and has also been adopted by utility companies involved in the construction of large PV parks or systems. This model allows private individuals or companies to purchase shares in the cooperative, where each share represents a certain yearly production or compensation. The cooperative then deducts this from the share owners' electricity bills or provides it as monetary compensation. Examples of this model include the 1 MW_p park with solar tracking located outside Västerås, jointly managed by utility company Mälarenergi and KP (formerly Kraftpojkarna). Another example is the Törneby driftförening Ek. Förening cooperative initiated by Kalmar Energi, which installed a crowdfunded 600 kW_p system on the roof of a local farm called Nöbble Gård. Following the success of Nöbble Gård, Kalmar Energi embarked on building a PV park near Kalmar Airport on behalf of the cooperative, developed in stages of 750 kW_p each, with the first completed in September 2017, the second in June 2018, and the third in May 2019. In 2017, Öresundskraft initiated the cooperative Solar Park Ek. Förening, which, in two phases, constructed a PV park with a total capacity of 530 kW_p on a former landfill near Helsingborg. Another PV park cooperative, Karlskrona Solpark drift Ek. Förening, was initiated by utility Affärsverken. Their initial stage of a 0.6 MW_p crowd-funded PV park was completed in April 2019, followed by a second stage of another 0.6 MW_p completed in October 2019. Jämtkraft, a utility company, also established Östersunds Solpark Drift Ek. Förening, which owns a 3 MW_p PV park located outside Östersund, commenced in late 2019. Additionally, local utilities Tranås Energi and C4 Energi have initiated similar cooperatives: Bredstorp Sol Ek. Förening and Solpunkten Kristianstad Ek. Förening, respectively. As of 2022, these two cooperatives operate PV parks with capacities of 1.2 MW_p and 4 MW_p outside Tranås and Kristianstad, respectively.

Table 14: Summary of existing investment schemes.

Investment Schemes	Introduced in Sweden
Third party ownership (no investment)	Yes
Renting	Yes
Leasing	Yes
Financing through utilities	Yes
Investment in PV plants against free electricity	Yes
Crowd funding (investment in PV plants)	Yes
Community solar	Yes
International organisation financing	No

2.5 Additional Country information

Sweden is a country in northern Europe. With a land area of 407 284 km² [9]. Sweden is the fifth largest country in Europe. With a population of 10 521 556 people at the end of 2022, the population density of Sweden is quite low with about 25.7 inhabitants per km², but with a much higher density in the southern part of the country [10]. About 88% of the population live in urban areas [11].

Table 15: Country information in 2022.

Retail Electricity Prices for a household (range)	2.5–6.9 SEK/kWh (including grid charges and taxes)
Retail Electricity Prices for a commercial company (range)	1.9–5.3 SEK/ kWh (including grid charges and taxes)
Retail Electricity Prices for an industrial company (range)	1.2–3.1 SEK/kWh (including grid charges and taxes)
Liberalisation of the electricity sector	Sweden currently has one of the most liberalised and top ranked electricity systems in the world [12], due to its (1) *high operational reliability* - the delivery security was 99.985 % in 2021 [13], (2) *high electrification level* – 100 % of total population have access to electricity [14], and (3) *low greenhouse gas emissions* – emissions from fossil fuels associated with the domestic electricity production, in 2021 was 1.4 TWh, which corresponds to 0.9 % of the total Swedish electricity production of 165.8 TWh [15].

2.6 Electricity prices

In 2022, the Nordic electricity market saw its highest-ever average electricity prices. Several factors contributed to this, including the Ukraine conflict, which led to Russian gas export restrictions and raised electricity prices across Europe. Additionally, lower wind power production, a hydrological deficit, and reduced nuclear power availability pushed up electricity prices in the Nordic region, including Sweden, making them more in line with European rates.

Monthly system prices ranged from 0.81 SEK/kWh in October to 2.44 SEK/kWh in December. Average prices in the four Swedish electricity areas – SE1, Luleå, SE2, Sundsvall, SE3, Stockholm, and SE4, Malmö – varied from 0.63 to 1.62 SEK/kWh. They were identical in all Swedish areas for 41% of the year. On average, Malmö's electricity price was 0.24 SEK/kWh higher than in Stockholm, 0.96 SEK/kWh higher than in Sundsvall, and 0.99 SEK/kWh higher than in Luleå.

The highest hourly prices reached 8.51 SEK/kWh in Stockholm and Malmö on August 30th from 19:00 to 20:00. In Luleå and Sundsvall, the peak hourly price in 2022 was 6.43 SEK/kWh on December 14th from 17:00 to 18:00. The lowest hourly price across all Swedish areas was recorded on November 12th from 03:00 to 05:00, plummeting to -0.023 SEK/kWh. In the overall Nordic region however, the system price never turned negative.

In December, all of Sweden, including the northern parts of the country, experienced high price levels due to factors like low temperatures, increased demand, nuclear power limitations, freezing rivers, low wind power production, and ice accumulation on wind turbines.

Despite reduced access to hydro power production and the beforementioned factors, electricity prices in the Nordic region remained lower than in Germany, where the average price was 2.51 SEK/kWh (compared to 1.45 SEK/kWh in the Nordic region).

The surge in electricity prices in Sweden has sparked significant interest, particularly in residential solar PV. Installers and sellers are experiencing a surge in clients who want more control over their electricity costs. The shorter payback times and volatile prices have been driving interest in 2022, to the extent that installers have been struggling to meet the high demand.

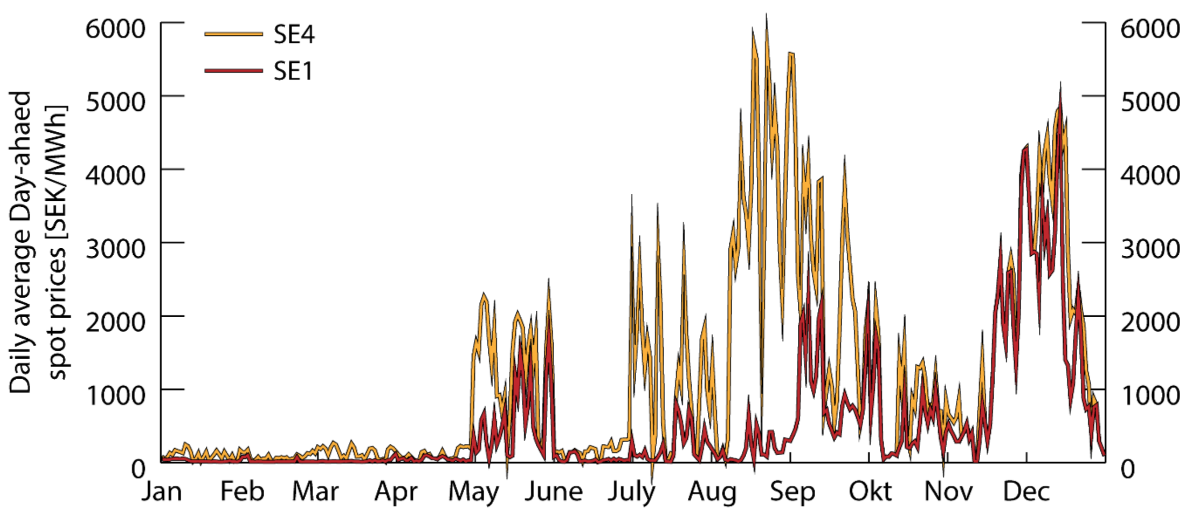

Figure 10: Daily average day-ahead spot prices in area 1 (Luleå) and area 4 (Malmö) in 2022.

2.7 Global solar radiation

The total amount of solar radiation that hits a horizontal surface is called the global radiation. The global solar radiation thus consists of the direct radiation from the sun and the diffuse radiation from the rest of the sky and the ground. The solar radiation therefore depends on the weather, on the position on the globe and the season of the year. The distribution of annual average global radiation over Sweden is presented in Figure 11 [16].

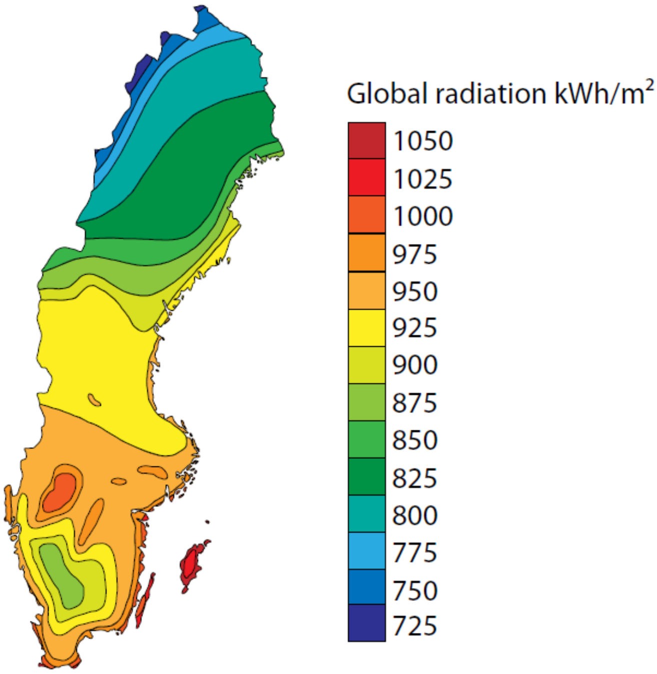

Figure 41: Average global solar radiation in Sweden in one year.

In the long-term variation of global radiation in Sweden a slight upward trend has been noted and the average solar radiation has increased by about 8 % from the mid-1980s until 2005–2006, from about 900 kWh/m^2 in 1985 to the current level of the recent years, which has varied between 900–1 000 kWh/m². Recent years have seen some further increase, and a similar trend is seen in large parts of Europe. In 2022, annual average accumulated global radiation reached 1 006.5 kWh/m² [16]. This is quite a normal value and is well below the historic record of 1 050.6 kWh/m^2 in 2018, as illustrated in Figure 52, when long periods of anticyclone weather (where barometric pressure is high) over Scandinavia gave very sunny weather during May and July.

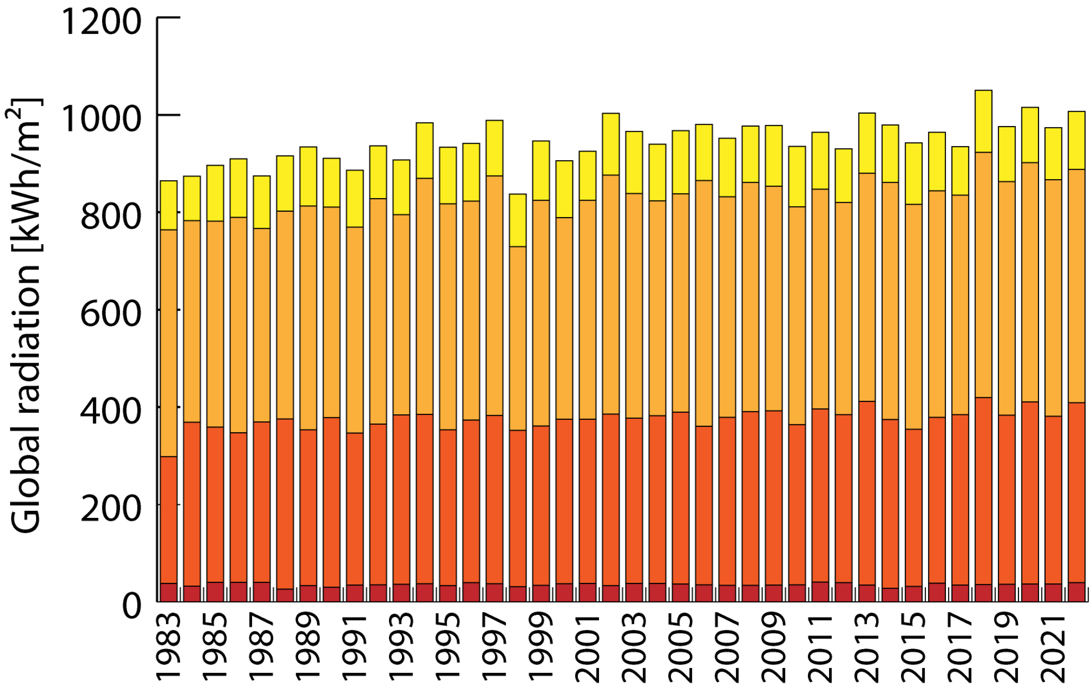

Figure 52: The annual average accumulated global solar radiation in Sweden between 1983 and 2022.

3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of PV. Direct support policies have a direct influence on PV development by incentivising, simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

Table 16: Summary of PV support measures.

Category	Residential		Commercial + Industrial		Centralised	
Measures in 2022	On-going	New	On-going	New	On-going	New
Feed-in tariffs	-	-	-	-	-	-
Feed-in premium (above market price)	Yes	-	(Yes)[1]	-	-	-
Capital subsidies	-	-	-	-	-	-
Green certificates	Yes[2]	-	Yes[2]	-	Yes[2]	-
Renewable portfolio standards with/without PV requirements	-	-	-	-	-	-
Income tax credits	Yes[3]	-	(Yes)[3]	-	-	-
Self-consumption	Yes	-	Yes	-	-	-
Net-metering	-	-	-	-	-	-
Net-billing	-	-	-	-	-	-
Collective self-consumption and virtual net-metering	Yes	Yes[4]	-	Yes[4]	-	-
Commercial bank activities e.g., green mortgages promoting PV	Yes	Yes	-	-	-	-
Activities of electricity utility businesses	Yes	-	Yes	-	Yes	-
Sustainable building requirements	Yes	-	Yes	-	-	-
BIPV incentives	-	-	-	-	-	-
Guarantees of origin	Yes	-	Yes	-	Yes	-

[1] Only small commercial system can benefit from the tax credit system.
[2] Eligible for systems completed before December 31st, 2021.
[3] Feed in premium is compensated as income tax credits. It is the same system.
[4] Micrograds for sharing and storage of electricity are allowed since January 1st 2022.

3.1 National targets for PV

Sweden does not have an official target for PV installations.

3.2 Direct support policies for PV installations

3.2.1 The renewable electricity certificate system

The renewable electricity certificate system operates on the principle that producers of renewable electricity receive government-issued certificates for each MWh they generate. Meanwhile, certain electricity players have a quota obligation, meaning they must purchase certificates corresponding to a set portion of the electricity they sell or consume. These certificates provide extra income to producers alongside their electricity sales revenue. Ultimately, the cost of these certificates is passed on to electricity consumers, affecting their electricity prices.

Eligible energy sources for certificates include wind, small hydropower, some biofuels, solar PV, geothermal energy, wave, and peat in power generation. Each production facility can earn certificates for up to 15 years, with a cutoff in 2045.

The quota-bound stakeholders are:

1. Electricity suppliers
2. Electricity consumers using more than 60 MWh annually from a plant with over 50 kW_p capacity
3. Electricity consumers using imported or Nordic power exchange-purchased electricity
4. Producers commercially annually supplying more than 60 MWh of electricity to a grid without grid concession (nätkoncession), if it's used by consumers on the same grid
5. Electricity-intensive industries registered by the Swedish Energy Agency.

The system began in Sweden in 2003 to boost renewable electricity use. Initially, the goal was to increase annual renewable energy production by 17 TWh by 2016 compared to 2002 levels. In 2012, Sweden and Norway established a joint certificate market with a target of increasing renewable electricity production by 26.4 TWh between 2012 and 2020. This common market allows the trading of both Swedish and Norwegian certificates to meet quotas [51]. In March 2015, Sweden and Norway increased their combined goal to 28.4 TWh by 2020, funded primarily by Swedish consumers [52]. Additionally, in 2017, the system was extended until 2030 with an additional 18 TWh of renewable electricity, gradually increasing by 2 TWh each year from 2022 to 2030 [53]. Due to rapid wind power expansion, this goal was reached in March 2021 [54].

To prevent certificate prices from plummeting and adversely affecting early investors, the Swedish government made changes in November 2020. It was decided that power production constructed after 2021 would no longer be eligible for certificates, and the system's termination was advanced to 2035 from the previous 2045 end date [55]. This transition means that some PV systems in Sweden still benefit from the certificate system, but it is gradually being phased out.

In 2022, the average certificate price took another significant drop for the second year in a row, falling to 9.10 SEK/MWh from 2021's value of 18.9 SEK/MWh, which in turn fell from the previous year's average of 69.6 SEK/MWh, and even more so from 2019's 120.7 SEK/MWh [56]. The quota obligation was increased to 26.2% in 2022, breaking downward trends of 25.5% in 2021, 26.3% in 2020 and 30.5% in 2019 [57].

Until 2005, there were no PV systems included in the electricity certificate system [58]. However, as indicated in Table 17, the number of approved PV installations has grown steadily over the years, with a majority of the approved plants in the certificate system now being PV systems. Nevertheless, these PV systems account for only a small fraction of the total installed power and generated certificates.

After the amendment stipulating that no power production constructed after 2021 would qualify for certificates, the Swedish Parliament introduced an annual administrative fee of 200 SEK for owners of certificate trading accounts, effective from July 1st, 2021 [59]. This change rendered participation in the renewable electricity certificate system unprofitable for owners of smaller PV systems, including many villa owners. To avoid the account fee, PV system owners had to close their electricity certificate accounts before May 31st, 2021, resulting in the revocation of the approval of their systems for electricity certificates. This explains the significant drop in systems approved for electricity certificates at the end of 2021, along with the reduced number of certificates issued to PV systems, as seen in Table 17. It's evident in Table 17 that only larger PV systems continue to benefit from the electricity certificate system, as the average system size more than doubled when 67% of the PV systems withdrew their participation in the program between 2020 and 2021.

248 072 certificates were issued to PV in 2022 [50]. This is only about 12 % of the theoretical production of 2 375 MW × 900 kWh/kW ≈ 2 137.5 GWh from all grid-connected PV systems in Sweden. The reader should note that the calculation above is very simplified, especially since the whole cumulative grid-connected PV power at the end of 2022 was not up and running throughout the whole year. 338.0 MW of PV power was accepted in the certificate system at the end of 2022 [17], making it 14 % of the total installed PV grid connected capacity.

Table 17: Statistics about PV in the electricity certificate system [56][17]**.**

	Number of approved PV systems in the certificate system at the end of each year	Total approved solar power in the certificate system at the end of each year	Average size of PV systems in the certificate system at the end of each year	Number of issued certificates from solar cells per year	Number of produced certificates eligible in kWh per installed power and year
2006	3	103 kW	34.3 kW	20 MWh	194 kWh/kW
2007	6	184 kW	30.6 kW	19 MWh	103 kWh/kW
2008	16	508 kW	31.7 kW	129 MWh	254 kWh/kW
2009	27	1 059 kW	39.2 kW	212 MWh	200 kWh/kW
2010	62	3 227 kW	52.1 kW	278 MWh	86 kWh/kW
2011	138	4 196 kW	30.4 kW	556 MWh	133 kWh/kW
2012	395	8 104 kW	20.5 kW	1 029 MWh	127 kWh/kW
2013	972	18 419 kW	19.0 kW	3 705 MWh	201 kWh/kW
2014	1 866	36 437 kW	19.5 kW	10 771 MWh	296 kWh/kW
2015	3 270	63 934 kW	19.6 kW	24 544 MWh	384 kWh/kW
2016	5 107	104 070 kW	20.4 kW	45 535 MWh	438 kWh/kW
2017	7 428	159 050 kW	21.4 kW	74 148 MWh	466 kWh/kW
2018	11 282	250 912 kW	22.2 kW	120 919 MWh	482 kWh/kW
2019	16 683	380 227 kW	22.8 kW	181 908 MWh	478 kWh/kW
2020	19 903	492 759 kW	24.8 kW	290 152 MWh	589 kWh/kW
2021	6 615	333 954 kW	50.5 kW	255 206 MWh	764 kWh/kW
2022	6 279	338 442 kW	53.9 kW	248 072 MWh	733 kWh/kW

In summary, the current form of the renewable electricity certificate system has primarily benefited larger PV systems and parks constructed before the close of 2021. Neither currently nor historically has it offered substantial support to smaller PV systems Sweden.

3.2.2 Tax reduction for green technology

The tax reduction program for green technology gained legal effect January 1st 2021 and replaced three existing support systems, namely the direct capital subsidy for PV installations (2009:689) [18] for private persons, the subsidy for storage of self-produced electricity (2016:899) [19] and the subsidy for private installations of charging points for electric vehicles (2017:1318) [20]. It is often referred to as the *green deduction*.

The support system is managed and administered by the system suppliers and ultimately by the Swedish Tax Agency (Skatteverket). It is designed much like the ROT tax deduction, see 3.9.4. This means that instead of the system owner applying for the economic support and handling the process, as was the case with the capital subsidy program it replaced, the tax deduction reduce the price for the house owner already on the invoice, and the system suppliers will report the deducted amounts to the tax authorities [4].

This system provides a percentual tax deduction for the hardware and installations costs of the three energy efficiency measures for private house owners. PV installations are offered a 20 % deduction, while batteries and charging points for electric vehicles get a 50 % tax deduction. This deduction can be made by private individuals and can be used once per year and person. There is a maximum annual accepted amount of 50 000 SEK. In the case of all three measures being installed at once, which has both cost and installation benefits, there is a possibility that the maximum amount will be reached. Since PV have the lowest deduction level, the regular ROT-tax deduction might be applied to the PV installation while the charging point and the battery installation is included in the green deduction.

To facilitate the administration for both companies and the Swedish Tax Agency, a level of 97 percent of the total investment cost has been approved as deductible costs for the green deduction [21]. The support can logically only be given if the system owners have paid enough tax to deduct the share from.

As shown in Table 18, most private house owners have been using the system to invest in EV chargers over the past two years. However, in 2022, more funds were deducted as parts of PV installations, which can be explained by it generally being a more capital-intensive investment than EV chargers. Additionally, the deductions for PV systems within this program saw a substantial 166% increase from 2021 to 2022. In terms of funds spent, there was a corresponding 174% increase during the same period. When looking at relative growth, the most significant increase was in the number of storage systems within the program, with a remarkable 557% rise from 2 166 systems in 2021 to 14 231 systems in 2022. This likely corresponds to the total amount of storage systems installed by private individuals in Sweden.

Table 18: Statistics about the tax reduction for green technology [22].

	Number of buyers of PV systems that received the green deduction				Total amount deducted inside the green deduction system [SEK, thousands]				Average amount of tax deduction per buyer of green technology [SEK, thousands]			
	Solar PV	**EV Chargers**	**Storage systems**	**Total**	**Solar PV**	**EV Chargers**	**Storage systems**	**Total**	**Solar PV**	**EV Chargers**	**Storage systems**	**Total**
2021	22 171	53 953	2 166	72 297[1]	473 315	577 739	66 027	1 117 081	21.3	10.7	30.5	15.5
2022	59 041	94 366	14 231	142 845[1]	1 296 491	1 009 628	452 633	2 758 752	22.0	10.7	31.8	19.3

[1] Since the same buyer can use the green deduction for several green technologies, the total number of buyers is lower than the sum of the buyers having used the green deduction for each green technology.

Considering that the green deduction accounted for 14.6% (97% of 15%) of the total investment for a residential PV system in 2021 and 19.4% (97% of 20%) in 2022, we can estimate that approximately 3.3 billion SEK was invested in the private residential PV sector in 2021, and 6.7 billion SEK was invested in 2022. It is however important to note that there are simplifications to this estimate. Firstly, for the deduction to apply, the PV system owner must have paid sufficient taxes to cover the full deduction. Therefore, the actual deducted amount may be less than the full 14.6% or 19.4% of the total investment. While most private individuals are likely eligible for the full deduction, there could be exceptions. Secondly, since there is a maximum deduction limit of 50 000 SEK within the program, it's possible that the ROT-deduction is used instead of the green deduction when installing multiple green technologies, especially since PV has a lower deductible share than EV chargers and storage systems. Lastly, there might be special cases where the total cost of the PV installation alone exceeds the total deductible amount. This would apply to systems with a total cost of 257 732 SEK, which is higher than a typical system cost but could be reached with larger systems, building-integrated PV, installations in remote areas, or a combination of these factors.

The green deduction has generally been well-received by both the installers and the buyers of PV systems in Sweden. However, the Swedish Solar Association has highlighted an issue with regards to that the system is tied to the year-breaks and only validates deductions after the final invoice has been paid. According to the Swedish Solar Association, it's common to request a portion of the payment in advance as a security measure for both completed and future work, ranging from 10 to 80 percent. Not seldom, the final invoice covers only the labor and materials related to the final electrical work. However, the green deduction is only approved by the Swedish Tax Agency once the installation is finished and fully paid, typically on the final invoice. When all partial payments occur in the same year, this does not cause any issues. However, problems arise when partial payments span across two years, with the breaking point on January 31st. In such cases, customers can only claim the green deduction for the partial payments made in the final year. The extent of this issue, however, remains unknown to the authors at the time of writing.

3.2.3 Guarantees of origin

Guarantees of origin (GOs) were introduced in Sweden on December 1st, 2010, as electronic documents that certify the source of electricity. For each MWh of electricity they generate, electricity producers receive a guarantee from the Government. These GOs can then be sold in an open market, typically to utility companies interested in selling a specific type of electricity. Utilities purchase GOs corresponding to the amount of electricity they intend to sell. It's important to note that applying for guarantees of origin is still a voluntary process.

Once the electricity supplier has acquired GOs and sold electricity to a customer, the GOs are "nullified," meaning they are no longer valid. This nullification process ensures that the amount of electricity sold from a particular source matches the amount of electricity produced from that same source.

Table 19: Statistics about solar guarantees of origin [36].

Year	Solar GOs issued in Sweden	Solar GOs transferred within Sweden	Solar GOs imported to Sweden	Solar GOs exported from Sweden	Solar GOs nullified in Sweden	Solar GOs that expired in Sweden
2011	194	96	-	-	0	0
2012	378	173	-	-	104	90
2013	2 337	1 373	-	-	324	294
2014	7 846	4 563	-	-	1 510	972
2015	18 953	11 301	-	-	5 314	2 830
2016	36 702	22 183	-	-	11 966	9 454
2017	58 806	65 936	1 481 437	69 279	96 442	16 146
2018	111 143	1 306 626	568 832	1 467 852	317 189	29 499
2019	166 670	894 568	1 527 014	526 292	976 716	51 935
2020	272 646	943 181	1 383 593	373 746	927 148	68 924
2021	316 475	518 255	969 157	201 969	952 894	111 143
2022	383 928	967 315	2 376 906	120 393	2 881 142	115 057

A utility company looking to sell electricity generated from, for example, solar PV can go about it in two ways. They can either nullify guarantees of origin from their own PV system or purchase guarantees of origin from a PV system owner and nullify them when selling the electricity to their end customers.

On June 1st, 2017, changes were made to the GO act (2010:601) and regulation (2010:853) to empower the Swedish Energy Agency to issue guarantees of origin for electricity that can be transferred to another EU Member State [37]. Consequently, the Swedish GO system has been aligned with the EECS standard.

As a result of the new legislation, and due to the increase of PV system, the trading with solar GOs in Sweden increased dramatically, as can be seen in Table 19, and has remained at that level since then. Except for 2018, the import of GOs has been markedly larger than the exports from Sweden since the introduction of the GO act in 2017, along with a continuous increase in nullifications compared the year before.

The electricity market in 2022 was highly volatile with considerable price hikes across all energy types for GOs, particularly towards the year's end. According to Svensk Kraftmäkling (SKM), the largest brokerage firm in the Nordic electricity market, Solar GOs were at average traded for 3.27 €, but ranging from a low of 1.70 € to a high of 8.50 €. The trading volumes still lag behind other energy types, despite an increase. Worth noting is that some Swedish utilities buy solar GOs issued in Sweden from small-scale PV owners for a much higher price.

From the first of October 2021, GOs can solely be issued for the electricity that reaches the grid supported by the grid concession. Previously it could also be issued for electricity in a grid without support of grid concession.

3.2.4 BIPV development measures

In 2022, Sweden did not have any specific measures in place for BIPV. However, with the inauguration of the new government in October 2022, they included a commitment in their political manifesto (‘Tidöavtalet’) [23] to assess the current necessity of building permits for BIPV. It's important to note that the rules of building permits only apply to a limited number of BIPV installations and does not represent a widespread concern within the BIPV sector in Sweden.

3.3 Self-consumption measures

Self-consumption of PV electricity is permitted in Sweden and is the primary business model that is driving the market. Numerous utilities provide a range of agreements for surplus electricity generated by micro-producers.

Since the spring of 2014, an ongoing discourse has unfolded regarding the applicable tax regulations for micro-producers. Consequently, there have been several amendments to various tax laws during this period. This section outlines some specific tax regulations that have an impact on self-consumption and micro-producers in Sweden.

Table 20: Summary of self-consumption regulations for small private PV systems in 2022.

PV self-consumption	1	Right to self-consume	Yes
	2	Revenues from self-consumed PV	Savings on the electricity bill
	3	Charges to finance Transmission, Distribution grids & Renewable Levies	None
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Various offers from utilities + 0.6 SEK/kWh + Feed in compensation from the grid owner
	5	Maximum timeframe for compensation of fluxes	One year
	6	Geographical compensation (virtual self-consumption or metering)	On site only
Other characteristics	7	Regulatory scheme duration	Subject to annual revision
	8	Third party ownership accepted	Yes
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Grid codes requirements
	10	Regulations on enablers of self-consumption (storage, DSM…)	Tax reduction for green technology
	11	PV system size limitations	1.Below 43.5 kWp and 63 A, and net-consumer on yearly basis, for free feed-in subscription towards the grid owner. 2.Below 100 A and maximum 30 MWh/year for the tax credit. 3.Below 500 kW_p for no energy tax on self-consumed electricity.
	12	Electricity system limitations	None
	13	Additional features	Feed in compensation from the grid owner

3.3.1 General taxes on electricity

In Sweden, taxes and fees are imposed both on the production and consumption of electricity. Taxes related to electricity production include property taxes (refer to section 3.6.1), taxes on fuels, and emissions taxes.

When it comes to electricity consumption, the primary taxes are the energy tax on electricity and the value-added tax (VAT). In 2022, the manufacturing and agriculture industry paid an energy tax of 0.006 SEK/kWh. The energy tax rate for residential customers has been incrementally raised in recent years after the Swedish Energy Commission's decision (as discussed in section 3.1) to eliminate the specific tax on nuclear energy and finance it through a higher energy tax [63].

The most recent increase took effect on January 1, 2022, raising the energy tax from 0.356 SEK/kWh (excluding VAT) to 0.360 SEK/kWh. However, some municipalities in northern Sweden have a lower energy tax rate of 0.264 SEK/kWh (excluding VAT) [64]. Additionally, a 25% VAT is added on top of the energy tax.

3.3.2 Energy tax on self-consumption

There has been an ongoing modernisation of the Swedish tax rules when it comes to taxation on self-consumed electricity. The current rules, which were implemented July 1st 2021, can be summarised as [24]:

- A solar electricity producer that owns one or more PV systems whose total power amounts to less than 500 kW_p does not have to pay any energy tax for the self-consumed electricity consumed within the same premises as where the PV systems are installed.
- A solar producer that owns several PV systems, whose total power amounts to 500 kW_p or more, but where all the individual PV systems are smaller than 500 kW_p, pays an energy tax of 0.005 SEK/kWh on the self-consumed electricity used within the same premises as where the PV systems are installed.
- A solar producer that owns a PV system larger than 500 kW_p pays the normal energy tax of 0.360 SEK/kWh on the self-consumed electricity used within the same premises as where the PV system is installed, but 0.006 SEK/kWh in energy tax for the self-consumed electricity from the other systems if they are less than 500 kW_p.

Under the current legislation, there's a constraint on the construction of self-consumption PV systems exceeding 500 kW_p in Sweden. This is primarily due to the full energy tax applied to self-consumed electricity, which limits the profitability of such systems. Consequently, the untapped technical potential of large industrial properties for PV systems remains.

For systems smaller than 500 kW_p, the main economic hurdle for real estate owners planning to deploy multiple small PV systems has been alleviated by this legislation. However, the administrative burden of measuring and reporting self-consumed electricity still applies if the total power exceeds 500 kW_p.

It's worth noting that it only is since July 1st, 2021, that this limit has been at 500 kW_p. Prior to that, PV system owners had to pay energy tax on self-consumed electricity generated by systems larger than 255 kW_p. The previous limit especially impeded market growth in the industrial and large commercial sectors. The increase in the limit was well-received by the Swedish PV sector, although many advocates for its complete removal, including the Swedish Solar Trade Association [66].

There's a positive development in this regard as the government has expressed its intent to eliminate the 0.006 SEK/kWh energy tax for real estate owners with multiple small systems. They plan to do this by submitting a state aid notification to the EU Commission [67], thus removing the administrative barrier.

3.3.3 Deduction of the VAT for the PV system

Sweden has a non-deductible VAT for permanent residences [25]. However, homeowner's associations or property owners are granted the right of deduction for VAT for roof-mounted PV systems as long as the acquisition is attributable to the association's or company's VAT-liable sales of surplus electricity. This position, published in November 2020 by the Swedish Tax Agency, replaced the former position from 1 March 2018 [26], as it was legally tried in case 6174-18 of the Swedish Supreme Administrative Court [27].

Before that, only if all generated electricity was delivered to an electricity supplier, and the PV system was therefore exclusively used in economic activity, deduction of the VAT for the PV system was allowed. Worth noting is that it was crucial for the case that a roof-mounted PV system is not a part of the permanent residence. Consequently, this does not necessarily apply to building-integrated PV.

To summarise, a homeowner's association or property owner may deduct VAT on the investment, operation, and preparation of a PV system corresponding to the proportion of electricity that will be sold to the electricity grid [28].

3.3.4 VAT on the revenues of the excess electricity

A PV system owner that sells the excess electricity will receive compensation from the electricity trading utility company and from the grid owner (see section 3.11). If the total annual renumeration from the property (including other revenue streams than selling excess electricity) exceeds 80 000 SEK for two consecutive years, excluding VAT, the house owner needs to register for VAT and handle the VAT streams between the utilities that buy the excess electricity and the tax agency (see Figure 13). If the total annual sales do not exceed 80 000 SEK the PV system owner is exempted from VAT [29].

At a reimbursement from a utility company of 0.5 SEK/kWh, 160 000 kWh can be sold per year before reaching the limit. At a self-consumption rate of 50 % it corresponds to a PV system of a size of about 320 kW_p. Hence, as a general rule of thumb, the 80 000 SEK limit corresponds to PV systems of 275–400 kW_p, which would be an exceptionally large PV system size for a regular homeowner.

The limit of 80 000 SEK was implemented the 1st of January 2022 and is an improvement for the Swedish PV market. Before 2022, the limit was 30 000 SEK, as the start of the new system for PV, which was implemented January 1st, 2017. Before that, a private homeowner needed to go through the administration of registering for VAT and reporting the VAT to the Government. The new set of rules makes it much easier for a household to invest in PV in Sweden. Furthermore, it has also reduced the administration for the tax agency as it doesn't need to handle the registration of thousands of private PV owners. As the Government is not losing any tax income, as illustrated in Figure 13, it is a win-win situation for all parties as compared to before the 1st of January 2017.

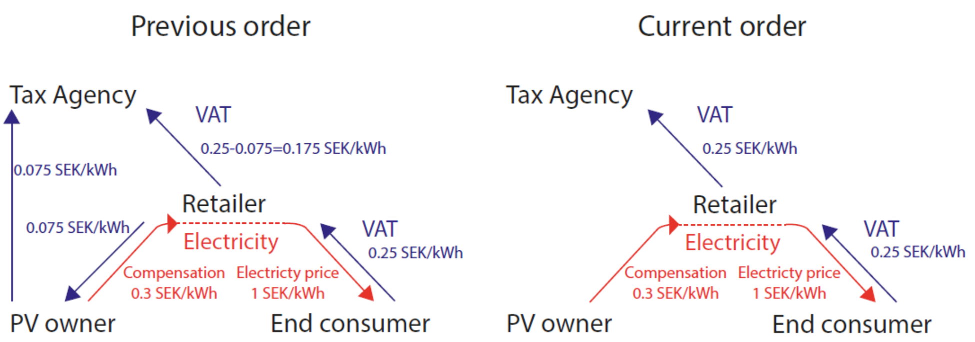

Figure13: Illustration of the revenue and VAT streams for the excess electricity for a private PV owner before and after the 1st of January 2017.

3.3.5 Tax credit for micro-producers of renewable electricity

The 1st of January 2015, an amendment to the Income Tax Act was introduced [30]. The tax credit is 0.60 SEK/kWh for renewable electricity fed into the grid. The right to receive the tax credit applies to both physical and legal persons. To be entitled to receive the tax credit the PV system owner must:

- feed in the excess electricity to the grid at the same connection point as where the electricity is received,
- not have a fuse that exceed 100 amperes at the connection point,
- notify the grid owner that renewable electricity is produced at the connection point.

The tax reduction is determined by the number of kWh that a system feeds into the grid at the connection point during a calendar year. However, there are some limitations: the tax credit cannot exceed the number of kWh purchased in the same year, and it is capped at a maximum of 30,000 kWh annually.

The grid owner is responsible for measuring the electricity fed into and out of the connection point throughout the year, and this data is transmitted to the Swedish Tax Agency (Skatteverket). Subsequently, the tax reduction is incorporated into the income tax return information, which must be submitted to the Swedish Tax Agency in May of the following year.

The tax credit, amounting to 0.60 SEK per kWh, is an additional benefit received on top of other compensations for surplus electricity. These include compensation provided by electricity retailers (refer to section 7.2), grid benefit compensation (refer to section 3.11), and earnings from the sale of renewable electricity certificates and guarantees of origin (refer to sections 3.2.1 and 3.2.3). Think of the tax credit system as a bonus for surplus electricity. However, unlike some other European countries, the Swedish tax credit system does not guarantee a fixed income over a specific period. This means that the additional earnings a micro-producer gains from the tax credit system when feeding electricity to the grid can be subject to political decisions, potentially leading to changes in the amount or even withdrawal of the tax credit.

According to the Swedish Tax Agency, a total of 108 897 micro-producers of renewable electricity collectively received 231 333 857 SEK for the excess electricity they supplied to the grid in 2022. This calculation is based on the 552 593 MWh of excess electricity reported by grid operators to the Swedish Tax Agency. On average, micro-producers with a capacity of less than 100 amperes contributed 5 074 kWh of electricity to the grid in 2022, as summarised in Table 211.

Table 21: Statistics about tax credit for micro-producers of renewable electricity.

Year	Number of micro-producers	Paid funds each year [SEK]	The basis (excess electricity) of the tax reduction [kWh]	Average electricity fed into the grid per micro-producer [kWh/micro-producer]
2015	5 391	11 421 003	19 035 005	3 531
2016	8 161	19 545 400	32 575 667	3 992
2017	12 138	30 068 341	50 113 902	4 129
2018	20 350	57 098 546	95 164 243	4 676
2019	40 442	102 164 634	170 274 390	4 210
2020	56 188	183 883 925	306 473 209	5 454
2021	76 370	231 333 857	385 556 429	5 049
2022	108 897	331 555 731	552 592 885	5 074
Total	**-**	**967 071 437**	**1 611 785 730**	**-**

These numbers encompass all small-scale renewable energy production, not just PV systems. Historically, the share of technologies of systems with a production capacity below 69 kW (which corresponds to the 100-ampere limit of the tax reduction) in the green electricity certificate system has been studied to get an estimation of the share of PV in the tax reduction. This method provided a rough estimate because the total electricity produced annually, and the self-consumption ratio, vary among different renewable energy technologies and individual systems. However, as explained in section 3.2.1, there are few incentives for residential PV system owners to register for green electricity certificates in 2022, rendering this estimation unfeasible.

In both 2020 and 2019, 98% of the capacity for systems below 69 kW in the green electricity certificate system consisted of PV systems, while the corresponding figure for 2018 was 96%. Therefore, it's reasonable to assume that the share of PV would have remained at a similar level in 2022 if not for the system changes. With 98% PV among micro-produced electricity, this would mean that PV system owners received a total of 947 730 008 SEK through the tax credit for micro-production systems by the end of 2022.

3.4 Collective self-consumption, community solar and similar measures

Collective self-consumption from a PV system within an apartment building is permitted in Sweden as long as all the apartments share the same grid subscription. Many housing companies and housing societies are opting for this approach. In this setup, the standard practice is for the entire apartment building to have a single electricity contract with the utility. The electricity costs are typically either included in the rent or the housing company/society measures and bills electricity consumption internally.

To modernise the legislation around electricity grids, an exception to the IKN Ordinance became legally effective on January 1st, 2022 [78][81]. This exception allows for the establishment of microgrids for sharing and storing renewable electricity. However, due to the wording of the exemption, it is not entirely straightforward to predict the scope of its application and how it aligns with the rules concerning the tax on self-consumed electricity for larger systems. For instance, the regulation states that the internal low-voltage grids should serve as a supplement to the public grid and be confined to a limited area. The practical implementation of these criteria can be subject to different interpretations. To obtain clarity, the Energy Markets Inspectorate (Ei) must legally assess the matter through what is known as binding replies *("bindande besked").*

Virtual self-consumption where the electricity is transported through a grid that is covered by a grid concession is currently not allowed [31].

3.5 Tenders, auctions & similar schemes

There were no national or regional tenders or auctions in 2022 in Sweden.

3.6 Utility-scale measures including floating and agricultural PV

There were no specific national or regional subsidies for utility-scale PV in Sweden in 2022. The support and measures accessible for utility-scale PV are the general support schemes of the direct capital subsidy that expired mid-2020 but with a cap of 1.2 million SEK per system which lowers the benefits of utility-scale centralised PV parks, the green electricity certificate system that expired 31st December 2021 (see section 3.2) and the guarantees of origin system (see section 3.2.3). This means that from 2022 onwards, the utility scale segment is developing under unsubsidised market conditions in Sweden. Even if there are no subsidies in Sweden, the centralised market segment is competitive [32].

3.6.1 Property taxes

Power generation facilities in Sweden are charged with a general industrial property tax. Today, PV technology is not defined as a power generation technology in the valuation rules for power production units in the real estate law (Fastighetstaxeringslagen). The tax agency has so far classified the few large PV parks that exist as "other buildings" and taxed them as industrial units. Currently, the property tax of an industrial unit represents 0.5 % of the assessed value of the facility [33].

3.7 Social Policies

There were no social policy measures directed to PV in Sweden in 2022.

3.8 Retrospective measures applied to PV

There are currently no retrospective measures applied to any subsidies for PV in Sweden.

3.9 Indirect policy issues

3.9.1 Rural electrification measures

There were no rural electrification measures in Sweden in 2022.

3.9.2 Exemption for building permits for solar energy systems

As of the first of August 2018, PV and solar thermal system installations on buildings are exempted from building permits in general. Some installations still require building permits, and that is when the one of following situations applies [34]:

- When the PV or solar thermal system does not follow the shape of the current building.
- When the PV or solar thermal system is installed within a residential area that is classified as valuable from either a historical, cultural, environmental, or artistic point of view.
- When the PV or solar thermal system is installed within a residential area where the municipality in the detailed development plan defined that building permits are required for solar systems.
- When the PV or solar thermal system is installed within an area that is of national interest to the military. Maps over these areas are located can be found here.

In these cases, a regular building permit must be submitted to the municipality.

3.9.3 Curtailment policies

There were no rules when it comes to curtailment of renewable electricity in Sweden in 2022.

3.9.4 ROT tax deduction

The ROT-program is an incentive program for private persons that buy services from the construction industry in Sweden in the form of tax credits. ROT is a collective term for measures to renovate and upgrade existing buildings, mainly residential properties. Reparations and maintenance as well as conversions and extensions are counted as ROT work and are therefore tax deductible, provided that such work is carried out in close connection with a residence that the client owns and in which he or she lives, or if it is a second home, like a recreational summerhouse [35].

The ROT-tax deduction in 2022 was 30 % of the labour cost and of maximum 50 000 [35] for the installation of a PV system. The requirements are that the house is older than five years and that the owner has not used the green tax deduction. Installation and replacement of solar panels are entitled ROT, while services of solar panels are not.

According to the Swedish Tax Agency, labour costs are estimated at 30 % of the total cost, including VAT. The total deduction for the whole PV systems was therefore 9 % in 2022. If it can be proved that the labour costs constitute a higher proportion than 30 %, the total deduction then consequently becomes higher.

3.10 Financing and cost of support measures

In the first version of the direct capital subsidy program 142 531 152 SEK were disbursed and in the second version a total of 3 545 404 848 SEK has been disbursed from 2009 to the end of 2021. This system is financed by the Swedish state budget and the money is distributed by the 21 county administrations.

In addition, the direct capital subsidy for renewable energy production in the agriculture industry program granted a total support of 33 542 362 SEK to PV systems has during 2015–2021. This system is financed by the European Agricultural Fund for Agricultural Development (EJFLU), meaning the funding comes from the European Union.

Furthermore, PV systems have benefited from the renewable electricity certificate system and had at the end of 2022 received a total of 1 257 218 certificates over the years (see section 3.2). By taking the monthly average prices for the certificates and multiplying these prices with the number of certificates that has been issued to PV in each month the total support to PV by the end of 2022 becomes 69 773 918 SEK [36]. The renewable electricity certificate system is financed by electricity consumers, except for electricity-intensive industries that have certificate costs only for the electricity that is not used in the manufacturing process.

Finally, a rough estimation is that a total of 947 730 008 SEK (see section 3.3.5) has been paid to small scale PV system owners through the tax credit for micro-producers of renewable electricity subsidy under 2015–2022. And for the tax deduction for green technology, 1 769 806 SEK has been paid. These subsidies are financed by the Swedish state budget.

Adding all the above subsides, the Swedish PV market had received approximately a total of 4 741 million SEK in direct subsidies at the end of 2022.

3.11 Grid integration policies

3.11.1 Grid connection policies

The standard procedure for grid connection involves notifying the grid owner well in advance of installing a PV system. The grid company must then specify the requirements for the installation. After installation, the electrical company must submit a final report to the grid company and conduct a system inspection [38]. The grid company then replaces the electricity meter at no cost to measure surplus electricity fed into the grid. All feed-in is measured hourly and self-consuming customers that want to measure all electricity produced, including self-consumption, need to cover the cost of installing a separate meter.

As explained, in the Swedish PV market, distributed PV systems are the most common. The Swedish Energy Market Inspectorate (Ei) has examined grid connections for small-scale systems in several cases and determined that distributed system operators (DSO) shall connect micro-production PV systems to the grid at no additional cost, even if the grid needs to be reinforced. However, if the PV system requires a larger fuse than the existing one, the grid company has the right to charge a connection fee for the fuse upgrade. This can result in high costs and in some cases, the grid may need to be adjusted to the fuse. The PV system owner has the right to request a review of the connection terms beforehand and in case of disputes regarding the fee, the PV system owner or the grid company can turn to Ei for review.

For centralised PV systems, grid reinforcement may be necessary, which can be costly and complex [39]. No data is available for the cost of grid-connection for centralised PV in Sweden in 2022. However, a comprehensive economic study of six PV parks commissioned in 2019–2020 in Sweden, shows that the grid connection costs varied significantly between projects and across different grid owners, with connection costs ranging from 9 615 €/MW_p to 56 662 €/MW_p, with an average of 29 596 €/MW_p [20].

3.11.2 Grid access policies

3.11.2.1 Grid benefit compensation

A micro-producer is entitled to reimbursement from the grid operator for the electricity that is fed into the grid. The electricity producer is entitled to compensation when supplying electricity based on the production facility's contribution to reduced costs for the electricity grid company. In simplified terms, the compensation should be calculated based on the difference between the electricity grid company's cost when the production facility is connected to the grid compared to the hypothetical equivalent cost if the production facility was not part of the network [40]. The compensation varies between different grid owners and grid.

3.11.2.2 Feed-in subscriptions for micro-producers

In December 2021, the Swedish Government proposed a legislative change aimed at removing the requirement for homeowners to be annual net consumers to qualify for a free feed-in subscription towards the grid owner. The proposal was submitted to the Council on Legislation for review and was subsequently approved, with the change becoming effective on July 1st, 2022 [77].

However, as of March 2023, the Swedish Energy Markets Inspectorate (Ei) released an assessment indicating that reducing the grid fee for smaller production facilities is not in compliance with the EU's electricity market regulation. This regulation specifies that all grid users, including producers, should bear their own costs. Consequently, following this assessment, the exception was immediately revoked. EU law takes precedence over national laws in member states, and as a result, owners of smaller production facilities should not receive a reduced grid fee [41].

3.11.2.3 Aggregated grid subscriptions

Since January 1st, 2021, it has been possible to subscribe for aggregated grid contracts ("*summaabonnemang*") for connection points in areas where Svenska Kraftnät previously refused increased grid connection capacities. The prerequisite is that there are connection agreements for the points and that it is technically possible to connect them. An aggregated subscription means that the grid customer is given the opportunity to transfer power between the different connection points that are included in the aggregated subscription.

These can be used to alleviate the situation in areas where there is a lack of grid capacity. The change is being implemented in the existing tariff structure to be able to facilitate the rapidly emerging markets relatively quickly [42].

4 INDUSTRY

The Swedish PV industry mainly contains of small to medium size installers and retailers of PV modules or systems. In 2021, the author was aware of 308 companies that sold and/or installed PV modules and/or systems in the Swedish market. While no survey has been sent out to the industry in 2022 and therefore the same exercise of collecting companies has not been performed, there is reason to believe that the downstream industry of installers and retailers are growing steadily in Sweden.

With regards to the upstream industry there were 2 active module producers in Sweden in 2022 (see section 4.2), even if the production volumes were small, and 19 companies active in manufacturing of production machines or balance of systems equipment (see section 4.3). Furthermore, the authors were aware of 11 companies that can be classified as R&D companies, or companies that had R&D divisions in Sweden (see section 4.4) in 2022.

Unfortunately, there is a trend of fewer and fewer upstream PV industry companies in Sweden. Several Swedish module manufacturers shut down or went bankrupt around 2010–2012, namely ArticSolar, Eco Supplies, Latitude Solar, PV Enterprise and REC Scanmodule. In recent years several Swedish start-ups, R&D companies and manufacturers of BoS products have been forced to close down, e.g., Optistring Technologies AB (in 2017), Box of Energy AB (in 2018), Sol Voltaics AB (2019), Solibro Research AB (in 2019), Solar Wave (in 2019), and Solarus Sunpower AB (in 2020).

4.1 Production of feedstocks, ingots and wafers

Sweden did not produce any feedstock or wafers in 2022 and there are currently no plans for this kind of production in the future.

4.2 Production of photovoltaic cells and modules

Module manufacturing is defined as the industry where the process of the production of PV modules (encapsulation) is done. A company may also be involved in the production of ingots, wafers, or the processing of cells, in addition to fabricating the modules with frames, junction boxes, etc. The manufacturing of modules may only be counted to a country if the encapsulation takes place in that country.

In the beginning of 2011, there were five module producers in Sweden that assembled modules from imported silicon cells. In the acceleration of PV module price reductions on the world market in 2011 and 2012, the Swedish module manufacturers struggled (along with the rest of the European module production industry) and at the end of 2012 only SweModule AB of the Swedish companies remained in business. In 2015 also SweModule was filed for bankruptcy, and there is no longer any large-scale module production in Sweden. Renewable Sun Energy Sweden AB, who bought the production equipment and the brand SweModule produced 0.6 MW_p of commercial modules as part of their product development in 2022. Furthermore, CIGS thin film equipment manufacturer Midsummer AB set up a BIPV production line in Sweden in October 2019 and produced about 1.5 MWp BIPV modules in 2022. In total 2.1 MW_p of modules were therefore produced in Sweden in 2022. However, both SweModule and Midsummer has announced plans to produce larger quantities in 2023. Total PV cell and module manufacturing together with production capacity information is summarised in Table 22 below.

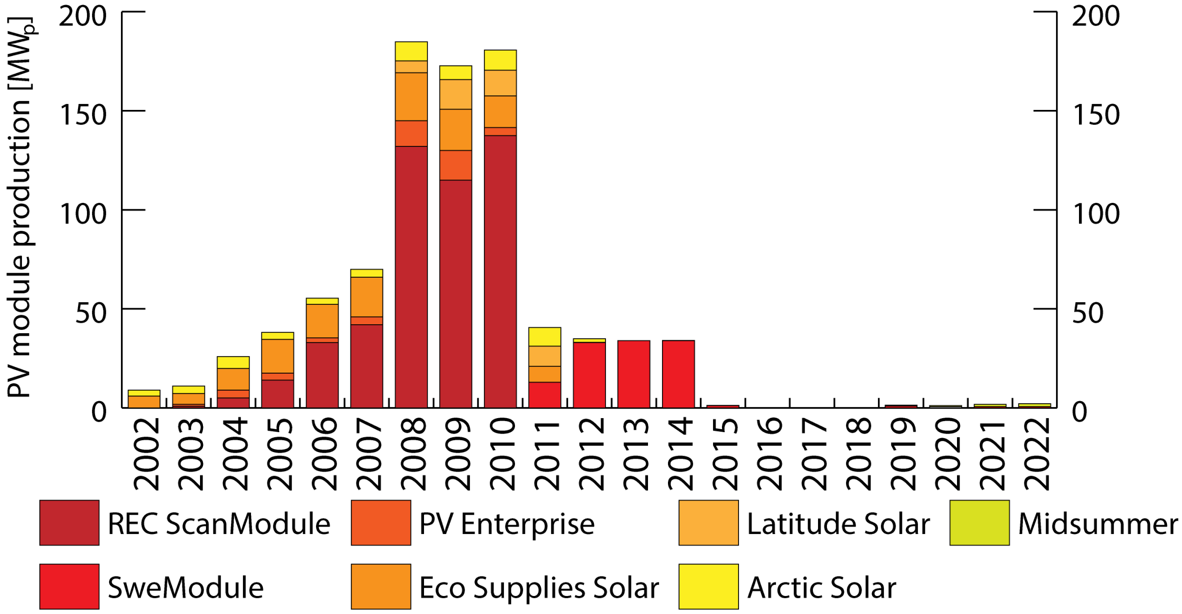

Figure 14: Yearly PV module production in Sweden over the years.

Table 22. PV cell and module production and production capacity information for 2022.

Cell/Module Manufacturer	Technology	Total Production [MW]		Maximum Production Capacity [MW/yr]	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
SweModule	Mono-Si	-	0.60	-	150
Thin film manufacturers					
Midsummer	BIPV CIGS	1.50	1.50	5	5
Cells for concentration					
None	-	-	-	-	-
Totals		**1.50**	**2.10**	**5**	**155**

4.2.1.1 Midsummer AB

Midsummer is a supplier of equipment (further described under the section 4.3.1.7) for the manufacturing of CIGS thin film flexible solar cells as well as a developer, producer, and installer of solar roofs. They sell integrated solar roofs with a focus design and with 90 % lower CO2 emissions compared to conventional panels according to a third-party verified LCA. Today they have three products: Midsummer SLIM — long CIGS modules integrated directly onto regular standing seam metal roofs, Midsummer WAVE — flexible solar panel that follows the wave shape of Sweden's most popular roof tiles and Midsummer BOLD — 60-cell thin film CIGS solar panels for applications on membrane and metal roofs. The main market for SLIM and WAVE is the residential single-family home market. Typically, Midsummer BOLD modules are installed on factories and warehouses which usually can't handle the weight of conventional panels. Another popular market is that for sports halls and arenas.

Midsummer also has a sheet metal production line. The thin film solar panels as well as the production of sheet metal, with or without solar cells, for roof applications take place in Järfälla. They have also received funding from the Italian government to expand their production to Bari, Italy, where a facility with an annual capacity of 50 MW is under development.

4.2.1.2 SweModule

Module production has taken place in Glava, Värmland since 2003 when REC ScanModule AB built a module production facility there. In end of 2010 REC ScanModule AB closed down their production, but the facilities were taken over by SweModule AB that continued to produce modules from imported silicon solar cells. In 2015 SweModule went bankrupt. In total, over 2 500 000 multi crystalline silicon modules, corresponding to 500 MW, have been produced at the site since 2003. However, it seems like these numbers will increase in the coming years as the production facilities in September in 2016 were acquired by the newly formed company Renewable Sun Energy Sweden AB. The company begun with refurbishment and repairing of some of the equipment in 2016 and in 2017 the equipment was upgraded to be able to produce monocrystalline modules with four- and five-busbars. Under 2018 the certification process of their four- and five-busbars modules was finalised, and the factory is now ready to produce larger quantities. Under 2016, 2017 and 2018, small quantities of approximately 100, 250 and 500 modules respectively were produced to test the equipment. In 2019, the company produced about 3 000 modules and in 2020, 2021 and 2022 approximately 2000 modules, which was sold mainly to the Swedish and African PV market. In 2023, with increased interest in European-made technology after COVID, new cells and updated manufacturing equipment will ramp up both production and production capacity notably.

4.2.1.1 Windon AB

Windon was started in 2007 after a year of product development of different PV equipment. In 2011 Windon became an OEM by producing PV modules with its own brand in SweModules production facility in Glava, Sweden. Since the closure of the production facility in Glava in 2015, the company first moved their OEM production of modules to a factory in Poland, but since the beginning of 2017 almost all of Windons modules are produced on two production lines in a facility in northern Italy by Windon's own staff. Windon plans to expand their module production by also producing some quantities in Latvia in addition to the production in Italy. In addition to the module production the company also produces mounting material and inverters.

4.3 Manufacturers and suppliers of other components

4.3.1.1 CC90 Composite AB

CC90 Composite's patented product CC90 UNUM is a mounting system for solar panels. Its rails and brackets are made of composite. To obtain a durable, time-saving, and easy installation, several parts are mounted with a click function. The mounting system can be used on both tile and metal roofs. The company was founded in 2019 and is based in Västerås, Sweden.

4.3.1.2 Checkwatt AB

Checkwatt AB is a R&D intense company providing solutions for a 100% renewable energy system. Data acquisition from sensors and through integration with other systems is a core part of the business. Sensors include but are not limited to electricity meters, irradiance, and temperature sensors. System integration is made with devices and servers of technology providers (inverters, EV chargers, etc) as well as with electricity market stakeholder and grid operators.

Through a high density of accurate data and innovative algorithms, their service called 'virtual irradiance sensor' can provide the benefits of a real physical irradiance sensor without the need of purchasing and installing one. Another relatively new service involves control of distributed flexibility such as battery storage systems, hybrid solar PV inverters and EV chargers. This energy market role is called aggregator or BSP (Balancing Service Provider).

4.3.1.3 Comsys AB

PV modules produce DC current, which in traditional systems is converted via inverters to AC current. The AC current is in most installations later converted back to DC to run different applications such as LED lighting systems, servers, routers etc. Comsys is a company that develops DC-based backup power systems for data centres and tele-/datacom systems. They have developed hardware and a concept with DC-UPS systems with integrated PV regulators to run servers and lighting systems directly on DC current without conversions, thereby reducing the losses significantly.

Comsys has installed the DC power system in data centers and commercial buildings since 2011. In addition, Comsys installs DC microgrids that can go into island mode in the event of a power outage, which is a unique feature. Most PV inverters only do "power injection" to an already available power grid, which means that in a grid black-out situation, the PV system stops producing energy and does not act as a power backup system.

The production of the components occurs at two locations in Sweden, Malmö and Söderhamn.

4.3.1.4 CW Lundberg Industri AB

CW Lundberg Industri have a long experience in roof safety. The company is based in Mora, Dalarna County, and has been on the PV market since 2016. Amongst their products are a variety of components and services in roof construction and safety, like roof ladders and support rails. They also give lessons in roof safety for companies in the industry. Connected to solar energy, they manufacture mounting brackets for PV and solar thermal panels, on which the panels are mounted directly. Thereafter, they can be mounted as they are on sheet metal roofs or on other suppliers' rail systems for other roof types.

4.3.1.5 Ferroamp Elektronik AB

Ferroamp was founded in 2010 and has developed the EnergyHub system. The modular technology offers a new system design that enables a better utilisation of renewable energy in buildings by introducing a local DC nanogrid ecosystem with smart power electronics. PV solar production and energy storage is closely integrated on a DC grid, reducing conversion losses as solar energy is stored directly in the batteries without multiple conversion steps as common in traditional system designs. The EnergyHub offers cost effective backup power functionality for selected DC loads such as servers, LED lights and DC fast charging of electric vehicles. Ferroamp has also developed a platform for energy efficiency measures with a service portal for partners and customers, which extends operation hours to nights and winter months with dynamic power peak management and selective load control. During 2019 the company supplied its DC grid technology for the world's largest DC powered office building in Gothenburg including 180 kW PV, 230 kWh energy storage, 100 kW HVAC system and 1 500 luminaires all powered by 380/760 VDC.

In 2014 Ferroamp reached a milestone as they started the shipment of their EnergyHub ACE system for energy efficiency, hence going from a solely R&D company to a production company. In the end of 2015 Ferroamp released its PV solar and energy storage solutions. The battery cells come from China, but the production and mounting of all the components takes place in Sweden. Shipments of scalable PV solar and Energy Storage solutions started in 2016. 2018 started with a listing on Global Clean Tech top 100 list for game changing technologies and in June 2018, Ferroamp won the Smarter E Award for its PowerShare technology, PowerShare allows buildings to share PV solar, energy storage and EV charge control via a local DC grid. Benefits include increased self-consumption, better utilisation of energy storage and the potential to create Local Energy Communities with controlled energy flows. In 2020 Ferroamp won the Intersolar Award for its generic string optimiser solution that allows solar cells to be integrated directly into various DC systems such as public transport systems, ships or EV charging stations.

4.3.1.6 MAPAB

MAPAB (Mullsjö Aluminiumprodukter AB) manufacture aluminium structures for the assembly of PV modules. The company provides solutions for mounting on roofs, facades or the ground. Previously, most of the production was exported to the European market, but in 2012 MAPAB started to deliver more to the growing Swedish PV market and starting from 2017 approximately 98 % of their mounting products were sold in Sweden.

4.3.1.7 Midsummer AB

Midsummer is a supplier of equipment for the manufacturing of CIGS thin film flexible solar cells as well as a developer, producer, and installer of thin film solar panels (further described under the section 4.2.1.1). Midsummer was founded in 2004 by people with a background in the optical disc manufacturing equipment and the photo mask industry. The head office is in Stockholm, Sweden. Midsummer's compact turnkey manufacturing line called DUO produces 6-inch wafer-like CIGS thin film solar cells deposited on stainless steel substrates using a proprietary all-sputtering process. With the rapid price decline of PV products, Midsummer has developed a niche with flexible modules that weigh about 30 % of a corresponding crystalline silicon module. Midsummer's equipment customers are thin film solar cell manufacturers all over the world. Midsummer's other machine product is the UNO, a research tool for universities and institutions focused on sputtering and solar panel research. Midsummer's customers are mainly focusing on the BIPV market and especially the rooftop segment.

4.3.1.8 Nilar AB

Nilar, founded in 2000, is a company within the stationary electrical energy storage sector. They currently have over 100 patents and manufacture high-tech batteries on an industrial scale. The first scalable and fully automated production line was implemented in 2014, during 2018 they commercialized their second-generation battery. Today, they have approximately 250 employees located in Sweden. They produce their solutions locally in the company's factory in Sweden. The target markets for their products are home and small-scale storage, smart grid infrastructure, and commercial and industrial support. Nilar produce fully recyclable batteries both when it comes to chemistry and design, free of cadmium, mercury and lead. The patented Nilar Hydride® battery is based on a bi-polar design, where cells are laid horizontally and stacked on top of one another to gain space efficiency. By placing their flat cells in a layered structure in their building block the battery packs that can be varied in sizes and opens up for easy assemble and as well as disassemble at end of life.

Nilar, together with Ferroamp, has developed a complete solution that integrates energy storage with power electronics which facilitates both installation and utilization of the systems. Nilar also works closely with Enequi. Enequi's technology works by harvesting the energy when it's available either from PV or at a low cost from the grid. The energy is then stored in the built-in Nilar battery packs that can allocate and manage the total energy needs of the property.

Nilar has also launched energy storage solutions to meet the growing demands of the residential market which have been widely distributed throughout Scandinavia and Europe.

4.3.1.9 Northvolt

Northvolt was founded in 2016, and is establishing its position as a leading European supplier of sustainable, high-quality battery cells and systems, by creating a European and American supply system of production facilities:

- Northvolt Labs**,** the demonstration line and research facility outside Västerås, Sweden, started its production in 2019 and ramps up to 350 MWh of battery capacity per year. They also have a pilot plant for recycling.
- Northvolt Battery Systems Jeden, located in Gdansk, Poland, builds battery modules and energy storage solutions. It started production in 2019.
- Northvolt Ett, the company's first Gigafactory is being constructed in Skellefteå, Sweden, and will serve as Northvolt's primary production site, hosting active material preparation, cell assembly, recycling and auxiliaries. Large-scale production began in 2021. Ramping up to full capacity, Northvolt Ett will produce at least 32 GWh of battery capacity per year. An application for an environmental permit has been made that would allow for the expansion to 40 GWh per year.
- Northvolt Dwa: a highly automated factory for battery systems assembly in Gdańsk, set to enter production during 2023. Alongside the factory, an engineering R&D center will be established.

They have their headquarters in Stockholm, Sweden and in addition to the above-listed sites, there are development plans for facilities in Heide (Germany), Gothenburg (Sweden), Borlänge (Sweden), Montreal (Canada), San Leandro (USA), Fredrikstad (Norway) and Setubal (Portugal).

4.3.1.10 Sluta Gräv AB

Sluta gräv AB is a company that specialises in development and manufacture of groundscrews. The screws are designed in Helsingborg, Sweden. Sluta Gräv operate on a global basis via a partner network and have business in 12 market. Groundscrews is a modern ground foundation and has it clear advantage compared to concrete. Faster installation and with a re-usable and recyclable product that has 60% lower CO2 emission than comparable concrete foundation makes the groundscrew a better sustainable alternative. Sluta Gräv Groundscrew can be used for centralised PV systems and Sluta Gräv also offer an own mounting racks system.

4.3.1.11 Weland Stål AB

Weland Stål in Ulricehamn manufactures a range of roof safety products. In the last few years, the company has experienced a growing interest in its products from the Swedish PV market. In the wake of this, Weland Stål developed a new line of attachment parts for mounting solar panels on roofs in 2014. The production is situated in Ulricehamn and the products have so far only been sold in the Swedish market, but since 2017 some products are exported to other parts of Scandinavia as well.

4.3.1.12 Windon AB

Windon AB has developed their own mounting materials which they produce in the Swedish town Tranås. Originally, it was only a ground mounted mounting system suitable for Windon's own module brand. But in 2019, Windon also developed and started to produce roof mounting systems, which are compatible with many different module brands. The aluminum profiles for Windon's mounting systems are produced by an OEM contract with SAPA in Vetlanda, while all the sheet metal and steel details are produced by Windon in Tranås.

In 2014 Windon also started to develop inverters with an individual capacity range of 1–20 kWp. The parts for the inverters come from all over the world but are assembled at an OEM production facility in China. However, Windon plans to move the assembling of the inverters to Tranås when quantities increase enough to justify the cost.

4.4 R&D companies and companies with R&D divisions in Sweden

4.4.1.1 Dyenamo AB

Dyenamo is a highly specialised chemical company providing state-of-the-art materials for research and industrialisation. Since 2011, they have manufacture and sell high-quality specialty chemicals in their facilities in Stockholm. They pave the way for industry and research organisations to access the latest findings in chemistry-based cleantech energy conversion, particularly in the fields of dye-sensitised solar cells, perovskite solar cells and solar fuels.

4.4.1.2 Delta Electronics (Sweden) AB

Delta Electronics is a global developer and manufacturer of switching power supplies, thermal management systems and solutions in the areas of Telecom Energy, Data Centre Infrastructure, Renewable Energy, EV Charging, Industrial Automation, Building Automation and Display and Monitoring Solutions.

It has close to 200 sales offices, R&D centres and manufacturing facilities around the world. Its major brands include Delta, Eltek, Vivotek and Loytec.

4.4.1.3 Epishine

Epishine was founded 2016 with the aim to commercialise organic polymer solar cells. They are a spin-off from Linköping University based on decades of research resulting in process break-throughs that they think is part of the tipping point for printed OPV, where global research simultaneously has proven interesting performance and life-length.

Their first manufacturing site in Linköping focuses on small modules optimised for indoor ambient lighting, targeting the growing number of battery-driven wireless products, specifically the IoT-market where Epishine initially focuses on replacing batteries in low power devices such as sensors and consumer electronics.

The manufacturing process, although on a small scale, is constructed as a roll-to-roll process with a conscious focus on establishing manufacturing methods that can be scaled up to larger formats in the next step that will target the BIPV-market.

4.4.1.4 Evolar AB

Evolar is an Uppsala-based company solar aiming to commercialise the next generation of photovoltaics. Their PV Power Booster technology, based on a perovskite tandem solar cell technology, increases solar cell efficiency by 25 percent over conventional solar cells. The company had about 25 employees in 2022, operating a 2500 sqm facility in Uppsala with R&D labs and a pilot manufacturing plant. The PV Power Booster technology for adding a perovskite solar cell layer can be combined with most primary cell technologies.

In 2023, Evolar AB was acquired by American thin-film manufacturer First Solar. From May 2023, it will remain in Uppsala but operational as a subsidiary of First Solar under the name First Solar European Technology Center AB.

4.4.1.5 Exeger Operations AB

Exeger is a Swedish company with a solar cell that transforms all forms of light into electrical energy. The material, Powerfoyle, is a fully customisable solar cell. With its specific design properties, it can be integrated into several applications/electronic devices, such as consumer electronics or Internet of Things (IoT).

Commercially available products are Urbanista Los Angeles, Urbanista Phoenix, adidas Headphones RPT 02-SOL, D3-Tech ModCom 1 EcoPro, Blue Tiger Solare, POC Omne Eternal and Spåra Hund.

Powerfoyle enhances products it is integrated into with extended or even unlimited battery life.

4.4.1.6 Peafowl Plasmonics AB

Peafowl Plasmonics, former Peafowl Solar Power, is a deep-tech start-up company based in Uppsala, Sweden, empowering the next generation of electronic applications by using plasmonics technology for light harvesting. Initial markets are low-power devices that benefit from being self-powered, for example indoor sensors, e-paper displays and dynamic windows. The completely transparent light harvesting cells of Peafowl bring new sustainable energy solutions.

4.4.1.7 Samster AB

Samster has developed a "Cold PVT" which is a panel that supplies both electrical and thermal energy. The product consists of solar thermal pipes under a regular PV module and is specially made for operating at cold temperatures. Samster is using commercial PV modules, and the thermal parts are produced separately. Samster is responsible for development, assembly, and sales. The Cold PVTs are optimal for boosting and rescuing geothermal heating systems. At the same time as hybrids deliver more electric power due to cooling, they also lower the electricity consumption and prolongs the life span of the geothermal heat pump.

4.4.1.8 SolTech Energy Sweden AB

Stockholm based Soltech Energy Sweden is listed on Nasdaq First North Growth Market and has over 70 000 shareholders. Soltech is a total supplier of energy and solar cell solutions. With oversight over the entire value chain, from development to installation, they can transform all types of properties into more sustainable and self-sufficient energy producers. Another area of business for Soltech Energy is solar as a service. The company's business within this area is in China, where they sell and install through their joint venture company ASRE.

4.4.1.9 Sticky Solar Power AB

Sticky Solar Power (formerly known as JB EcoTech) is a Swedish developer and supplier of innovative solar photovoltaic technology solutions. The company is based in Stockholm and was founded in 2012. Their product is a cell interconnection and string production technology that avoids lead, decreases silver consumption, lowers cost, increases throughput, and minimizes factory footprint. The technology has been developed by Sticky Solar Power since 2012 and is undergoing final industrialization ahead of commercial launch.

4.4.1.10 Swedish Algae Factory AB

Swedish Algae Factory was founded in 2016 around the discovery of the light-manipulating traits of the microalgae group diatoms. The nanostructured silica shells of diatoms can trap light efficiently and manipulate shorter wavelengths of light to longer wavelengths of light. The company has developed an algae cultivation and wastewater treatment system from which they harvest these silica shells from the algae. The organic algae biomass that is left after the extraction of the silica shell, could be utilised in several applications such as for feed production or energy and organic fertilisers. In late 2016 the company started to test the silica shells' ability to enhance the efficiency of solar panels. Initial lab tests showed that the nanostructured silica material could enhance the efficiency of silicon solar panels with over four relative percentages, due to its light trapping and light manipulating properties.

The company has started product testing together with partners to further test this material’s ability to enhance the efficiency of silicon solar panels by being incorporated into coatings in and on silicon solar panels, reaching an enhancement of 5 % in panel efficiency so far. The company has also validated the potential of the material to enhance the efficiency of DSSC (dye-sensitised solar cell). This research was published in 2020. Since 2018 Swedish Algae Factory has operated a pilot facility with a yearly production capacity of 30 kg of this material. In late 2020 the company started to build a commercial production plant with a yearly production capacity of 700 kg, which was finalised in 2022.

The technology is primarily targeting two use cases in the industry. One is to use the material in PV modules during the actual production of the modules. The other is to offer the material for retrofit coatings on top of the glass of already installed modules, as a way of increasing the performance of old modules.

5 HIGHLIGHTS OF R&D

5.1 PV research groups

The Swedish solar cell related research consists largely of fundamental research in new types of solar cells and photovoltaic materials. Several of the research groups in this category are at the forefront and are highly regarded internationally. Furthermore, there are some smaller groups that focus on PV systems and PV in the energy system-oriented research.

5.2 Public budgets for PV research

The majority of the Swedish government's funds to PV research are distributed by the Swedish Energy Agency (Energimyndigheten), which is tasked with leading the energy transition in Sweden, and the Swedish Research Council (Vetenskapsrådet). Other organisations that can dispense Governmental money to PV related research are The Swedish Governmental Agency for Innovation Systems (Vinnova) and The Swedish Foundation for Strategic Research (SSF).

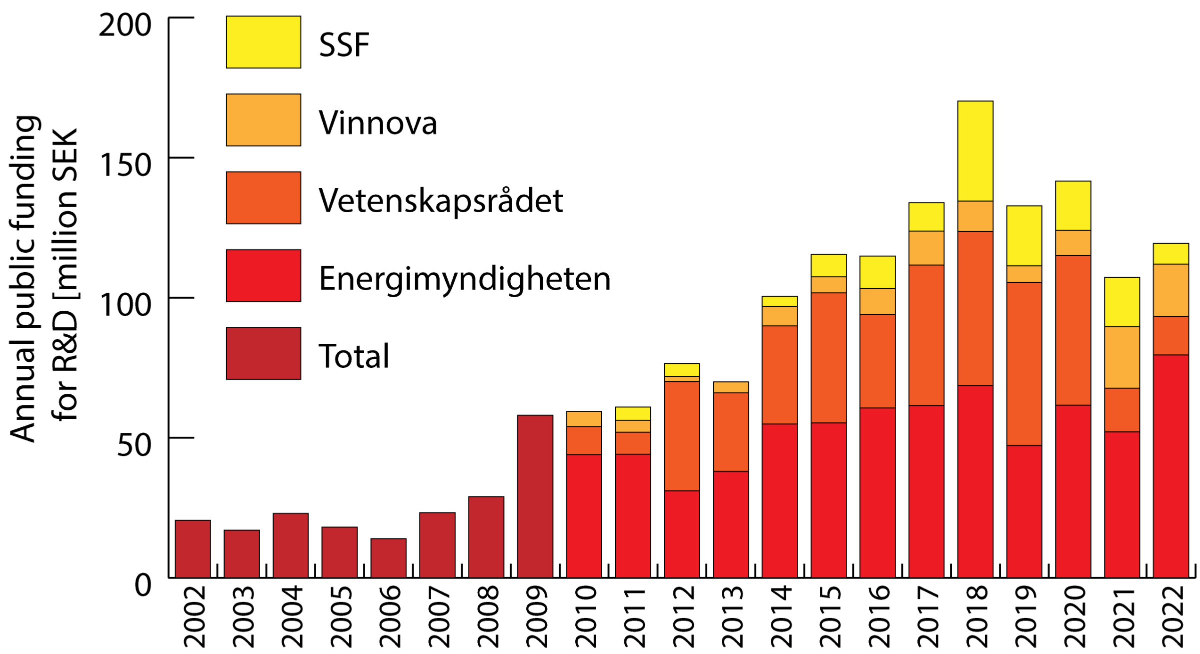

Figure 15. Annual public funding for PV related research in Sweden

Note that the difference in funds dedicated to PV research from Vinnova appears smaller for 2019 compared to the Swedish National Survey Report published in 2020. This is, however, not a trend of declining research funding, but rather a result of a changed methodology when manoeuvring Vinnova's internal database to access the information. The new methodology that has been applied for 2022, 2021, 2020 and retrospectively for 2019.

6 PV IN THE ECONOMY

This chapter aims to provide information on the benefits of PV for the economy.

6.1 Labour places

With the bankruptcy and shutdown of several of the Swedish PV module factories in 2010 and 2011 the number of full-time equivalent (FTE) in the Swedish PV module production industry decreased dramatically. However, the number of people involved in selling and installing PV systems is increasing as the Swedish PV market grows. The growing market in turn leads to an increased involvement from utility companies, consulting firms, and real estate owners. In many companies and research institutes, several people work only partly with PV-related duties. The number of PV-related FTEs summarised in Figure16 and Table 23 is an assembly of all the reporting stakeholders' estimations of how many FTEs the Swedish PV market employs at their company. The figures are therefore just estimations. For 2022, no survey has been performed, and no data has thus been collected on the number and evolution of FTEs that can be allocated to the Swedish PV market.

By summarising the labour places related to the actual Swedish PV market, i.e., PV system installers and retailers, utilities, consulting firms, real estate owners and building companies, and dividing it with the annual installed PV capacity, one can get an estimation of how many labour places that are created per installed PV capacity. As Table 23 shows, the estimated number of created labour places per installed MW was 6.5 in 2020 and 7.6 in 2021.

The years prior to 2021 demonstrated a clear trend of fewer and fewer created labour places per installed MW, which cannot be explained by changes in general system sizes (as Table 6 shows). The reason is probably that the companies are becoming bigger and more effective in their marketing and installation processes. The decreasing created labour places is probably one of the reasons for the declining PV prices in Sweden that is shown for the same period (See section 0). Just as with the PV system price development, the opposite trend can be detected for 2021, with an increase of 1.1 FTE per installed MW. While there can be many explanations for this development, it is likely connected to the turmoil caused by the COVID-19 pandemic, with effects like longer project times and supply chain issues. This could have impeded the market development, pushing the commissioning of PV systems to 2022 instead of 2021, without affecting the companies' staffing.

Given the challenges faced by the Swedish PV market, such as supply shortages and cost-related issues, it's likely that the low number of jobs created per installed capacity hasn't fully recovered to 2020 levels in 2022, which would indicate that the installers are installing to their maximum capacity and in an efficient manner. However, considering the market's growth, we can estimate that there are now approximately 6.5 to 7.6 jobs per installed MW, which falls somewhere between the 2020 and 2021 levels. This suggests there were around 5 002 to 5 849 PV market-related FTEs in 2022. Additionally, FTEs associated with research and development, education, utilities, and other sectors are believed to have increased, following a similar trend as in previous years with annual growth of 20-30 %. This is based on that no decelerating effects or differences can be seen in the budget for PV-related research or in the general development of R&D companies. With non-market-related FTEs at 974 in 2021 and thus an approximate 1200 in 2022, this would bring the total rough estimate to approximately 6 600 FTEs in the Swedish PV sector in 2022, illustrated in Figure 16.

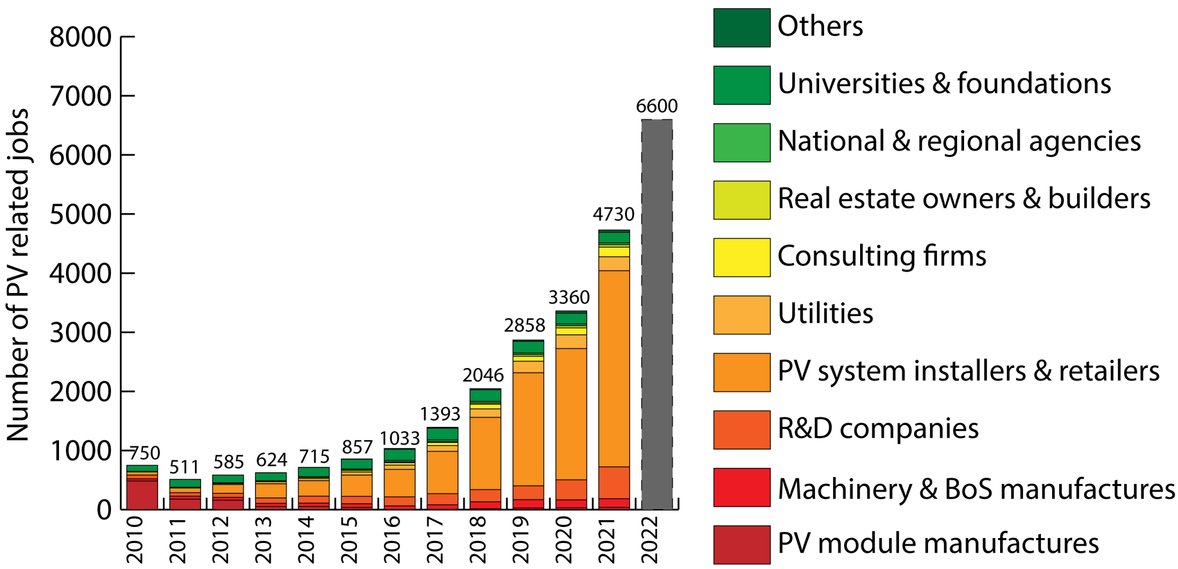

Figure 16. The historic development of PV related full-time equivalents in Sweden. The value for 2022 can be considered a rough estimate.

Table 23: Estimated number of yearly full-time labour places created per installed PV capacity.

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
PV market related labour places	89	174	286	323	450	598	897	1494	2281	2596	3756	5 426[1]
Annual installed capacity [MW]	4.0	7.9	18.9	34.4	48.0	60.3	85.7	157.2	281.8	400.1	499.7	798.1
Labour places created per MW	**22.1**	**22.2**	**15.2**	**9.4**	**9.4**	**9.9**	**10.5**	**9.5**	**8.1**	**6.5**	**7.6**	**6.8**

[1]Rough estimate, no survey was sent out to explore PV-related FTEs in Sweden in 2022.

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

In Sweden electricity is transported from the major power stations to the regional electricity grids (40–130 kV) via the national grid (220 kV and 400 kV). From the regional grids, electricity is transported via local, low voltage grids (40 kV or less) to the electricity consumers. The voltage in the wall sockets in Sweden is 230 V.

The backbone of the electrical grid, the national grid, is owned by the Swedish state and managed by the Swedish National Grid (Svenska Kraftnät), whereas power utility companies own the regional and local grids. The Energy Markets Inspectorate (Ei) is the regulatory authority over the electricity market. Since the grid is a monopoly, there is only one network owner in each area that is licensed.

The base price of the electricity is daily set by the Nordic electricity retailing market, Nord Pool. Electricity trading companies then use this price as basis for their pricing in the competition for customers. The Swedish electricity market was deregulated in 1996, which resulted in that the customers could change their electricity supplier more easily.

There are more than 150 grid owners in Sweden. However, the Swedish grid market is dominated by Vattenfall, E.ON and Ellevio that covers about 50 % of all customers. The retail market is dominated by three companies; Vattenfall, Fortum and E.ON.

7.2 Interest from electricity utility businesses

Several utility companies started marketing small turnkey PV systems suited for roofs of residential houses in 2012. The utility companies that the author is aware of that offered these kinds of turnkey PV systems in 2022 were:

Affärsverken Karlskrona, Arvika Kraft, Axpo Sverige, Bixia, Borlänge Energi, Borås Elhandel, C4 Elnät, Dalakraft, E.ON Energilösningar, Ellevio, Energi Försäljning Sverige, Enkla Elbolaget i Sverige, Eskilstuna Strängnäs Energi & Miljö, ETC El, Falkenberg Energi, Falun Energi & Vatten, Fortum Markets, Fyrfasen Energi, Gislaved Energi, GodEl i Sverige, Gotlands Elförsäljning, Gävle Energi, Göteborg Energi, Halmstads Energi och Miljö, Herrljunga Elektriska, Jönköping Energi, Kalmar Energi Försäljning, Karlstads Energi, Kraftringen Energi, Kungälv Energi, LEVA i Lysekil, Luleå Energi, MälarEnergi, Mölndal Energi, Nossebro Energi Försäljnings, Nybro Energi, PiteEnergi, Sala-Heby Energi, Sandhult-Standareds Elektrisk Ekonomiska förening, SEV Strängnäs Energi, Skellefteå Kraft, Skånska Energi, Sollentuna Energi & Miljö, Statkraft Financial Energy, Stockholm Exergi, Storuman Energi, Södra Hallands Kraft Ekonomiska Förening, Sölvesborg Energi, Telge Energi, Tekniska Verken i Linköping, Trollhättan Energi, Tranås Energi, Uddevalla Energi, Umeå Energi, Upplands Energi Produkt & Miljö, Varberg Energi, Vattenfall, Vimmerby Energi & Miljö, Växjö Energi and Öresundskraft Marknad .

At least one utility company, Umeå Energi, also offer leasing of PV system to private individuals.

Furthermore, in 2011, several utility companies started introducing compensation schemes for buying the excess electricity produced by micro-producers. This trend continues, as more and more utility companies now have various offers for the micro-producer's excess electricity, their green electricity certificates and guarantees of origin. The offers and compensation vary between the utilities. Most of them have in common that the demand that the micro-producer is a net consumer of electricity during a year and that they buy their electricity from the utility company. Some buy the GO's and the green electricity certificates, while some don't.

Since 2014 a few utilities have started to work with centralised PV parks. The proactive utility companies that have started to work with PV parks have had to test different financial arrangements and business models such as share-owned PV parks, power purchase agreements and PV electricity offers to end consumers. The utility companies that have built PV parks over 1 MW_p by 2022 are to the authors' knowledge Affärsverken, Arvika Kraft, Bixia, C4 energy, EON, ETC El, Göteborgs Energi, Jämtkraft, Jönköping Energi, Kalmar Energi, Luleå Energi, Mälarenergi, Vallebygdens Energi and Vattenfall.

7.3 Interest from municipalities and local governments

As stated in section 1.5, there are some municipalities in Sweden that stand out in installed PV in total and by capita. Important factors for the high local PV diffusion rates are in general peer effects [43] and local organisations that promote PV. Research has shown that the influence of local initiatives from different stakeholders has played a major role in the deployment of PV in many of the municipalities with the highest PV penetration in Sweden [44]. In several cases local electric utilities, often owned by the municipality, have successfully taken an active role in supporting PV with action such as purchasing the excess electricity of PV adopters, selling PV systems and dissemination of information. Other local initiatives that have influenced the adoption of PV are seminars and information meetings arranged by local actors. One example to highlight is the Swedish Energy Agency financed information campaign for residential PV adoption that occurred in Sweden in 2017, in which 41 % of Sweden's municipalities participated and led to a positive effect on PV adoption rates [45]

Some Swedish municipalities and local government have introduced ambitious goal for PV. Examples are:

- In Örebro County, the goal is to produce 150 GWh of PV electricity by 2030, which would correspond to about 4 percent of the county's electricity use [46].
- The municipality of Uppsala that has set a goal to have approximately 30 MWp of PV by 2020 and about 100 MWp by 2030 [47].
- In the municipality of Linköping, the City Council formulated a goal in 2018 that PV electricity should have reached a penetration level of 5 % in 2025 and at least 20 % in 2040.
- The municipality of Helsingborg has set an ambition that local production of solar power corresponds to 10 percent of electricity demand in 2035 [48].
- Kristianstad's goal is for the municipal group to produce 2 GWh of solar energy per year in 2020, and 40 GWh per year in the municipality by 2030 [49].

Another activity several municipalities have implemented is the fabrication of so called "sun maps" to help potential stakeholders in PV to easier assess the potential for their roof. These "sun maps" illustrate in colour scale the incoming solar radiation on all the roofs in the city, sometimes considering the tilt of the roof and shadowing effects of nearby buildings or building elements. At the time of writing the sun maps that the author is aware of are; Ale, Alingsås, Borlänge, Borås, Botkyrka, Danderyd, Ekerö, Eskilstuna, Eslöv, Falkenberg, Falun, Forshaga, Gävle, Göteborg, Haninge, Helsingborg, Huddinge, Håbo, Härnösand, Härryda, Höganäs, Hörby, Höör, Järfälla, Kalmar, Karlshamn, Karlskrona, Karlstad, Katrineholm, Kramfors, Kristianstad, Kumla, Köping, Landskrona, Lidingö, Lidköping, Linköping, Ljungby, Lomma, Ludvika, Luleå, Lund, Malmö, Motala, Munkfors, Mölndal, Nacka, Norrköping, Norrtälje, Nykvarn, Nynäshamn, Olofström, Ronneby, Salem, Sigtuna, Skövde, Smedjebacken, Sollefteå, Sollentuna, Solna, Stockholm, Strängnäs, Strömstad, Sundbyberg, Sundsvall, Södertälje, Sölvesborg, Timrå, Trosa, Tyresö, Täby, Umeå, Upplands Väsby, Upplands-bro, Uppsala, Vallentuna, Varberg, Vaxholm, Vellinge, Värmdö, Värnamo, Västerås, Ånge, Ängelholm, Örebro, Örnsköldsvik, Östersund and Österåker.

There are 15 regional energy agencies (Energikontoren) in Sweden whose purpose is to promote energy efficiency and the use of renewable energy at local and regional level. With support from the Swedish Energy Agency (Energimyndigheten) they coordinate national initiative project with the municipality's energy and climate advisers.

The largest local PV promoting project is probably the association Solar Region Skåne, which started in 2007 as a collaboration between the municipality of Malmö, the regional energy agency of Skåne (Energikontoret Skåne) and Lund University. Solar Region Skåne is a network and knowledge centre for solar energy activities in the Skåne province.

8 HIGHLIGHTS AND PROSPECTS

8.1 Highlights

Despite price increases and general economic hardship with increased inflation and interest rates, the positive PV market development in Sweden continued in 2022, with 798.1 MW installed. This corresponds to a market growth of 59 %, compared to the 499.7 MW that was installed in 2021. While the centralised PV market shrunk with 29 %, there is a general appetite for PV parks in Sweden and the project pipeline remains high. The Swedish PV market is still dominated by residential roof-mounted systems for single-family houses and roof-mounted systems on commercial buildings.

However, turmoil on the market continued to impact the Swedish PV market, with prices being particularly affected. In numerical terms, the price survey results revealed that small residential systems experienced the highest price increase in 2022, rising from 14.9 SEK/W to 19.1 SEK/W, marking a 28% increase. Small commercial systems increased by 25%, from 12.2 SEK/W to 15.3 SEK/W, larger commercial systems increased by 10%, from 10.3 SEK/W to 11.3 SEK/W, and ground-mounted parks increased from 7.6 SEK/W to 9.0 SEK/W, corresponding to an 18 % increase. The price increases were attributed by retailers and installers to several factors, including high shipping costs, a global trend of elevated prices, the Russian invasion of Ukraine with subsequent difficulties in sourcing European BoS technology, and inflation. They also noted that price volatility made it challenging to determine a typical yearly price, particularly in 2022, when module prices dropped significantly towards the end of the year after remaining high for most of the year.

The termination of support policies makes it difficult to assess market segmentation development in Sweden past 2021, since the capital subsidy database has been a valuable resource for that purpose. In policy terms, the system for green electricity certificates closed for new systems commissioned after 2021, and the capital subsidy program was closed for new applications already in mid-2020. This leaves the centralised, commercial, public and industry segments relying on market incentives such as utilities buying PV electricity above spot-market price and guarantees of origin as possibilities for extra revenues. Generally, self-consumption business models and corporate PPAs are driving the PV market development in Sweden. For private individuals, the tax reduction for green technology, starting 2021, has become the most impactful support system, adding to the tax credit for micro-producers for electricity fed into the grid by PV systems under 69 kW_p of size. An exemption from the general grid-rules allowed for renewable energy sharing between buildings starting 2022, the extent to which these have been established is not known, but it is expected to stimulate the multi-family house PV segment, as it allows for collective self-consumption.

On the industry side, there was barely any module production in Sweden. Some Swedish companies focusing on new PV technologies or balance of system components continued to develop in a healthy way. Furthermore, the Swedish PV industry is becoming increasingly diversified every year, with more and more actors with other core businesses, such as utilities and real estate owners, taking interest in the PV technology.

8.2 Prospects

In the short term, the economic crisis and geopolitical events are causing uncertainty on the Swedish PV market. On the other hand, lower hardware prices and high availability of PV modules are expected to accelerate market growth. Swedish installation companies are reported to struggle to keep up with demand, and while the GW-mark was not reached for annual additions in 2022, it is expected to surpass 1 GW with good margin in 2023.

In the medium term, it is expected that the Swedish PV market continues to grow. The introduction of the tax credit for micro-producers in 2015, the launch of an information platform by the Swedish Energy Agency and the increase of activity from utilities have made the situation quite good for homeowners and small companies to invest in PV. The introduction of internal low-voltage grids for energy sharing is well awaited by the industry and a first step in allowing collective self-consumption. Future steps to align with EU-regulation awaits and should enable more possibilities for jointly acting self-consumers or even energy communities.

Large centralised PV parks have been a marginal occurrence in Sweden until now. This market segment is, however, expected to grow a lot in the coming years, as PV parks now seem economically viable without any subsidies. Developers are currently struggling with extensive permitting processes, which creates a barrier for rapid growth in this segment. Whether this is a short-term problem caused by inexperience of such processes in the deciding institutions or whether it is a long-term problem for the industry remains to be seen.

In the long term, the Swedish PV market is in a good position to grow. In general, there is a growing interest for PV in Sweden and the public is very positive towards the technology.

9 APPENDIX I - DATA SOURCES AND THEIR LIMITATIONS

Several data sources are used in the collection of the statistics presented in this report, all of which have their respective advantages and disadvantages. In the following section, these are discussed to provide an overview of the statistical situation on the Swedish photovoltaic market.

9.1.1 Surveys to grid operators regarding grid-connected PV capacity

All the grid-connected PV capacity is collected through surveys sent out by Statistics Sweden, SCB, (Statistiska Centralbyrån) on behalf of the Swedish Energy Agency (Energimyndigheten) to all the Swedish grid operators [1]. As it is mandatory to notify the grid operator when a PV system is connected to the grid, the grid operators should have all the grid-connected PV systems within their grid area registered, and they are obliged to share this information with the Swedish Energy Agency. The accuracy of the grid connected capacity is therefore judged to be high. That methodology has, however, only been carried out for the years of 2016 and thereafter. The historic numbers for the installed grid-connected PV capacity (and off-grid PV capacity) in Sweden until the end of 2015 are exclusively based on the yearly collection of the sales statistics by the Swedish representatives in IEA PVPS task 1. The official statistics of the grid operators, collected by the Swedish Energy Agency, only include segmentation in PV system sizes (power) in the ranges 0–20 kW, 20–1000 kW and >1000 kW.

For 2016 and 2017 weighted average number between the sales statistics and the statistics from the grid operators has been used due to uncertainties about the quality of the grid operators' statistics these years. For a more detailed description see the 2018 version of National Survey Report of PV Application in Sweden [2].

Additionally, the grid operators are not always notified if a PV system's capacity is increased after the original grid connection. This is, however, presumed to only cause a small possible deviation, but cannot be quantified at present.

9.1.2 Off grid sales statistics

Data for off-grid PV systems are by definition impossible to get from the grid operators. The information about installed off-grid PV capacity is therefore based on cumulative sales statistics that have been collected directly from company representatives throughout the years by the Swedish representatives in IEA PVPS task 1. Off-grid systems older than 20 years are assumed to have been decommissioned by now and are therefore withdrawn from the cumulative sales statistics to obtain the total off-grid capacity in Sweden. The companies that have contributed off-grid data are listed in the older Swedish National Survey Reports for the sales statistics for their respective year. The accuracy of the off-grid capacity is judged to be much lower than for the grid connected capacity.

No collection of off-grid statistics has been collected for 2022 and the number for 2022 is therefore an estimate made by the authors of the report.

9.1.3 Labour places

As in the case of off-grid installations, the data collection of labour places is based on cumulative sales statistics that have been collected directly from company representatives throughout the years by the Swedish representatives in IEA PVPS task 1. This methodology provides no exact measure on the amount of labour places, nor does aim to do so. It is rather an effort to provide a representational picture on the development and the direction in which the market is heading. If the company representative is not contactable, the information is retrieved from open-source registers of companies' key figures of annual reports and company information.

The data collection is thereby limited to the IEA APVPS Task 1 representative's insight of the market and ability to detect new market actors.

No collection of labour places statistics has been collected for 2022 and the number for 2022 is therefore an estimate made by the authors of the report, as is explained in Section 6.1.

9.1.4 Database of the Swedish direct capital subsidy

To obtain market segmentation, there is another data source in addition to the surveys sent to grid operators regarding grid-connected PV capacity, discussed in 9.1.1. In the database of the Swedish direct capital subsidy (see older Swedish National Survey Reports) all PV systems that have been granted support from the start of the subsidy programme in 2009 until now are recorded. By cross-referencing between this database and Sweden's national business directory, a business sector can be assigned to each system owner. By doing this, the database can be divided into centralised, industry, commercial or residential systems. It is also possible to sort the PV systems based on if they were installed on "ground (mark)", "single-family houses/small buildings (småhus)", "multi-family houses (flerbostadshus)", "facilities (lokaler)" or "other (annat)". The Swedish standard classification names for the different type of buildings are added within the parenthesis to make it easier for the Swedish readers as there in some cases are no straightforward translations into English for these building types. The "other (annat)" classification includes all installations that do not fit into the other building types. This could be decentralised ground mounted systems, systems on churches or other cultural buildings and systems on schools just to mention a few.

A problem with the database of the Swedish direct capital subsidy is however that a lot of systems have been recorded in an incorrect way, for example with the wrong power rating, granted subsidy, or organisation. When it is obvious that the information has been recorded incorrectly, these systems have manually been removed for the analysis within this report.

Furthermore, the direct capital subsidy has now been closed, and a lot of in capacity is missing in this database, especially for the year 2021. Hence, the segmentation results should be viewed as estimates calculated by the authors. The fact that no new systems were added for 2022, given the termination of the program, makes it impossible to use the database of the Swedish direct capital subsidy as a source for segmentation after 2021, resulting in the inability to create a market segmentation for 2022.

9.1.5 PV system prices

When it comes to PV system prices, the yearly survey that goes out to the Swedish installers and retailers is the source used for this and previous Swedish National Survey Reports. These surveys have been conducted the same way since 2010, and they collect statistics about prices that the installer and retailer companies regard as typical for some standard PV systems for their company. The reported prices have for the years 2010–2017 been weighted with regards to the number of kW_p each company installed in that market segment. For the 2018–2022 numbers, the reported prices have not been weighted (as the collection of installation data from the installation companies ended after 2017) and the reported prices are a regular average.

9.1.6 Cesar

Cesar is Sweden's accounting system for electricity certificates and guarantees of origin. In Cesar, plant owners are given their respective electricity certificates based on the registered plants' reported electricity production. In Cesar, the account holders electronically transfer their electricity certificates and guarantees of origin to the person they have agreed to sell the certificates to. Also, it is in Cesar that electricity certificates are annulled for fulfilment of quota obligations.

The Swedish Energy Agency is responsible for managing and developing the electricity certificate system in Sweden and since January 1st, 2015, they have also been responsible for Cesar.

9.1.7 Tax credit for micro-producers & Tax deduction for green technology

Statistikportalen, the data base managed by the Swedish Tax Agency (Skatteverket) is used for examining the tax credit for micro-producers of renewable electricity and the tax deduction for green technology. They provide the number of control entities that have eligible for the tax credit, as well as the amount that has been paid. Since the intention is to obtain the total amount that has been disbursed in tax credits and between what amount of system owners, the methodology for data collection is considered satisfactory and without major challenges.

However, some simplifying assumptions are made when the share of systems that receive the tax credit is calculated. This is explained in section 3.3.5.

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