SOLAR REPORT

RECOMMENDED ACTIONS FOR SWEDEN AND HALLAND

BASED ON BEST PRACTICE OF SOLAR ENERGY

SolReg
HALLAND

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The European Institute for Innovation – Technology

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1. Introduction

The European Parliament states that 20% of energy use within member states should be generated by renewable energy by 2020. This requires significant expansion of the renewable energy generation networks throughout the continent. Solar energy, the focus of this report, is increasing worldwide but currently only contributes a minor proportion of the total generation mix in Sweden. This is largely based on historical investment in hydro power schemes, wind and bio energy (see Figure 1 below). A trends assessment from Widén in 2011 indicated that there was likely to be a future expansion of solar energy generation with increasing grid-connected photovoltaics and decreasing system costs. There has been evidence of this trend with solar energy accounting for roughly 0.1% of Sweden's total electricity consumption in 2016 and up to 0.2% by 2017 (International Energy Agency, 2018).

Solar is an intermittent power source which follows annual and diurnal insolation patterns, caused by the earth's movement around the sun and can be disturbed by cloud movement. This intermittent nature of power generation has a number of impacts on both generation and transmission to the power network. While solar can be somewhat predicted, it can still be described as unpredictable. Unpredictable generation is best handled via system reserves, often in the form of storage or reliable base load sources.

This report will investigate the viability of solar implementations in Sweden, with particular focus on the County of Halland. Halland is located in the south west of Sweden and is described further in section 2 below. Solar energy generation in Sweden was recorded as sitting around 190GWh/yr in 2016 (Lindahl, 2017) compared to the total electricity generation of 151.7TWh (Lindahl, 2017).

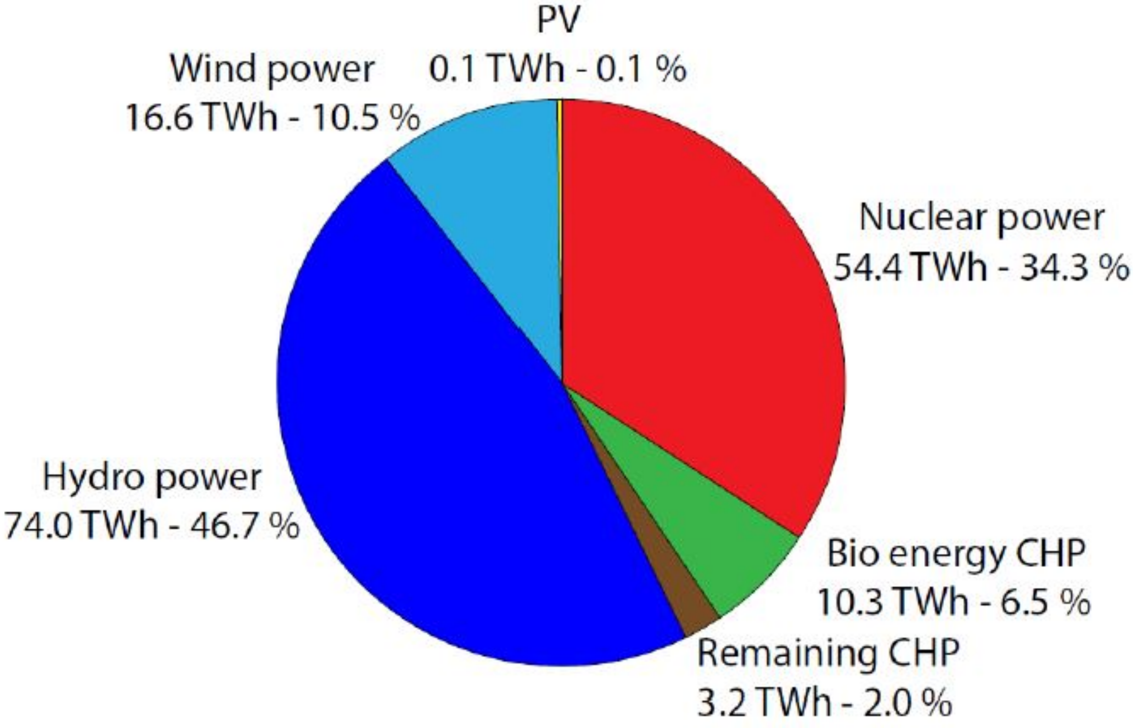

Figure 1: Total electricity production in Sweden in 2016 (Lindahl, 2017)

In considering the low solar production in Sweden in comparison to other sources, it is important to look at the overall potential of solar energy in this country. Sweden's electrical expansion has seen significant progress in the past 150 years with a move from dependency on wood for fuel to coal and now, in recent years, the search for renewable sources. This history can be found in appendix I.

1.1 SOLAR ENERGY IN SWEDEN

In line with the European Union's 2009 Renewables Directive, Sweden has been working towards reaching a 49% share of renewable energy in gross final consumption of energy - electricity, heating/cooling, and transportation - by 2020 (Grantham Institute, 2015). Eurostat reported that Sweden had already exceeded the Directive's 2020 target in 2014 reaching 52.6% of total final energy consumption provided by renewables, up from 38.7% in 2004 (Eurostat, 2014). However, solar energy has only ever provided a minimal contribution to this figure.

The latitude in southern Sweden is similar to Glasgow, St Petersburg and Riga and as such has a lower solar radiation than in many countries farther to the south. Sunlight hours represent long summer days with 18-19 hours of daylight and relatively short winter days with 6-7 hours of daylight. In northern Sweden this changes considerably with as little as 2 hours daylight at the shortest day in the northern Swedish town of Lulea and 23 hours on the longest day. Clearly this has a significant impact on the viability of solar produced energy.

During the winter much of Sweden would expect extensive snow cover for long periods which is likely to reduce irradiation levels and, and as such, Solar energy generation.

Over the long term in Sweden, there has been an increase in global radiation of 0.3%/year with average solar radiation increasing from 900kWh/m^2 to 1000kWh/m^2 in the past 30 years (SMHI, 2018). Figure 2 shows the Global radiation in Sweden on an annual basis, highlighting the high radiation values in Halland on the South- West Coast. It has been suggested that social conditions may help increase the potential for Solar energy adoption, partially because there are remote areas where the electricity grid is not available. There is also a recognised history in Sweden of city dwellers returning to remote rural areas during summer time, such that off grid living for a period of the year is considered relatively normal.

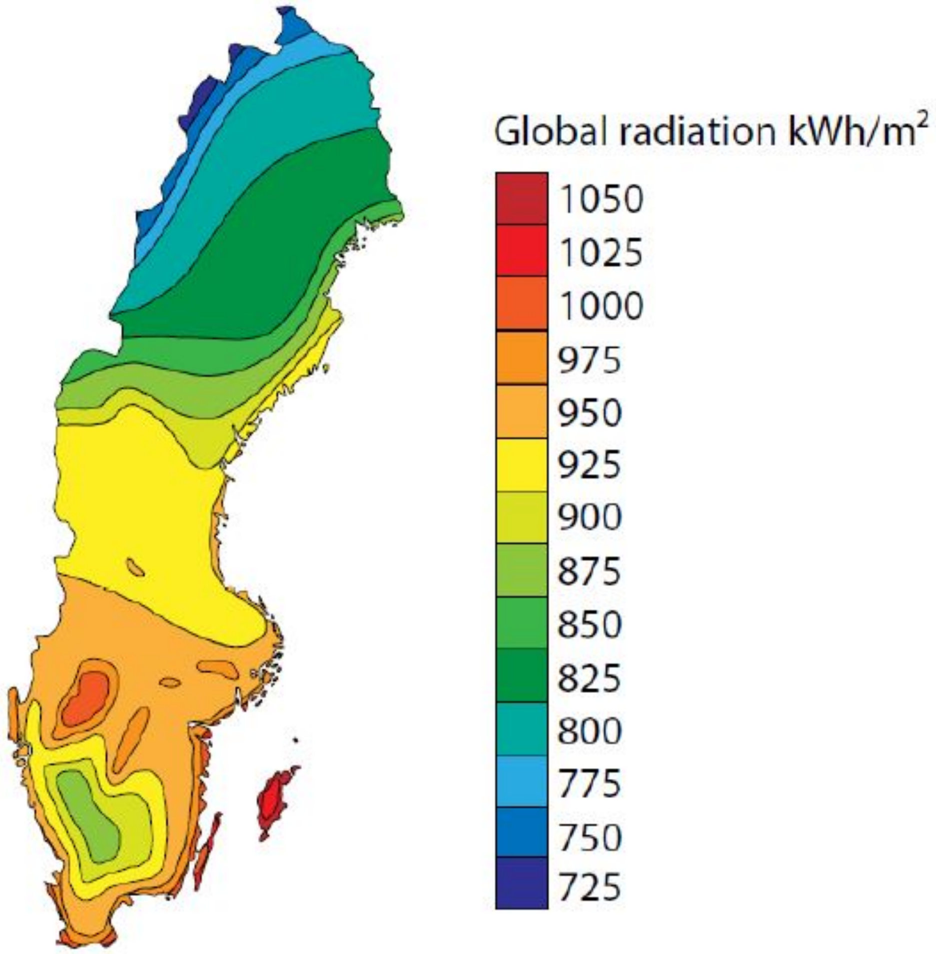

Figure 2: Global solar radiation in Sweden over one year (SMHI, 2018)

2. Introduction to Halland

The aim of this report is to understand the socio economic, policy and environmental context of an area of Sweden. Due to the high global radiation described by SMHI (2018), above, the Province of Halland County was chosen for analysis in this report. The report will then help develop and test scalable business models for solar energy deployments in the Province.

Halland is a Province of Sweden, located in the southwest of the country, with a population of around 325,000 (Statistics Sweden, 2017) making it the seventh largest county in Sweden in terms of population size, with a steadily growing number of inhabitants. It covers a land area of 4,796km^2 and has five towns with a population of over 25,000, the largest being Halmstad with just under 100,000 residents.

Halland is on the West Coast of Sweden which means it has a transitional oceanic climate with moderate continental influences. Windspeeds average around 6m/s in winter and 5m/s in summer. Winters are cold with snow lying most years, while summers are relatively warm with long sunny days.

The province of Halland joined the Greater Copenhagen co-operation initiative in December 2018 to help create a larger entity for marketing and political purposes. For legal purposes the area is subject to Swedish law which includes incentives and policies for renewable energy, this is further detailed in section 4.

2.1 SOCIO-ECONOMIC BACKGROUND TO HALLAND

The Swedish Public Employment Service's forecast survey shows that the Halland economy is much stronger than it has been for some time (Eures 2018). Unemployment is lower than the national average while the construction sector is currently buoyant. Halland household purchasing power is high, and overall this is proving beneficial to the county's ever larger and expanding private services sector.

Halland County has a diverse business sector with a large services and public sector, and the county also benefits from being close to, and within commutable distance of, not only Gothenburg but also the Malmö-Copenhagen region (Eures 2018).

Halland is a county of small businesses, with more than half the employees in the private sector working in companies with fewer than 50 staff. Around 12% of those who are gainfully employed in the county are self-employed, compared with around 10% in Sweden as a whole, with almost 70% working in the private sector. It may be relevant to a project considering energy, that the largest employer in Halland County is the Ringhals AB nuclear power plant with more than a thousand employees. The timber and building products industry traditionally play a strong role in the manufacturing sector in Halland County, as do the food, paper and pulp and engineering industries. Commerce followed by business services are the biggest industries in the private services sector.

In 2018 and 2019 the number of people employed is expected to rise above all in the private services sector, for example in construction, the hotel and catering trade, commerce and business services. Employment in public-sector organisations is also expected to increase, but to a lesser extent (Eures 2018).

Cross boundary commuting levels are high with over 30,000 commuters, working outside the region, primarily commuting to Gothenburg. In-commuting levels are, in contrast, low.

In 2018 and 2019, employment is expected to rise by 4,000 people, whilst the unemployment rate will be broadly unchanged as a result of the large influx of manpower.

The county's unemployment has been dropping since spring 2017. At the end of 2018, the proportion of unemployed people in Halland County is estimated to be 5.9% of the labour force. The county therefore has one of the lowest unemployment rates in Sweden.

Many companies in industry are experiencing major shortages of, among others, tooling machine operators, engineers and technicians. There is demand in the construction sector for many different kinds of experienced tradesmen with Swedish professional qualifications, for example construction plate workers, plumbing and central heating fitters and electrical installation engineers. In the construction industry there is also a big shortage of engineers of all types and supervisors. The catering trade is seeing a large shortage of experienced cooks. The transport sector has a major shortage of experienced lorry drivers, bus drivers and lorry mechanics. Doctors are still in short supply, as are nurses with specialist skills. There is also a big shortage of assistant nurses with advanced training in, for example, emergency care, psychiatric care and geriatric care. In the municipalities there is also a shortage of pre-school teachers and certified teachers (Eures, 2018).

2.2 SOLAR POTENTIAL OF HALLAND

As shown in figure 2, the south western areas of Sweden have significant levels of global radiation in contrast to the northern regions. This poses great potential for County Halland to have considerable solar uptake. Halland has excellent potential for solar energy with a horizontal solar radiation of 1000kWh/m^2.

Halland, on average has more solar installations per capita than the average for Sweden as a whole (5.3W/capita in Halland compared to 4.2W/capita in Sweden) (Andersson & Åhlund, 2014). The County Administrative Board of Halland stated in 2011 that the solar production is estimated to be 0.5GWh with the potential estimated for rooftops to be 640GWh. Given that the current uptake of solar in the whole of Sweden is 190GWh/yr, this gives Halland an exceptional opportunity for solar photovoltaic implementation.

According to Energimyndeighetera (2018) in their data results for solar energy installation support, they state that Halland has received 124,496,040SEK[1] since 2009. This is the fourth highest amount granted from the support which gives grants to grid-connected PV systems that do not exceed 12MillionSEKs per system and do not exceed a peak power of 37,000kWpeak. This solar cell support grant provides evidence of the support to develop solar generation projects in this region.

3. Areas of Good Practise in Halland

This section of the report considers the municipalities of Halland that have utilised solar energy.

3.1 HALMSTAD MUNICIPALITY

Halmstad is located on Sweden's west coast, 130km south of Göteborg and is Sweden's 19th most populated municipality according to Statistics Sweden (2017). Of relevance to solar energy, the line of latitude of Halmstad is 56° North, approximately the same as Glasgow, Aalborg and Riga. The latitude will impact on the seasonal variation of daylight hours and it is worth noting that even on the shortest day of the year, December 21st, 2018, the main town of Halmstad received over 6 and a half hours of daylight.

Halmstad has seen electricity increases in four separate time periods to date. The first in 1890 when streetlights were installed; the second happened nearly 50 years later between 1939 and 1950 with an increase in the number of hydropower plants being installed; 2000-2008 saw a second phase expansion to hydropower plants and implementation of combined heat and power (CHP) and wind power; and then in 2013 Halmstad saw an expansion of wind and solar into the electric generation mix.

In 2006, a municipality-owned company, HEM (Halmstad Energy and Environment) was formed which deals with all waste handling and energy procurement in the municipality. The 2000-2008 electrical expansion highlighted some issues in renewable energy expansion in this area. While investment in renewable energy was encouraged, it wasn't always straightforward.

One factor which has assisted the growth of solar energy is the major presence of military installations in the Halmstad area; this means that wind power has been deemed inappropriate for this area due to the potential obstruction, and this has effectively increased the investments in alternative renewable energy options such as solar.

A pilot project initiated at Kattegattgymnasiet to link the school with car mechanic and electrician education and solar energy generation. This project was to offer hands-on experience with grid-connected solar cells and electric cars (Johanesson, 2016). This cooperation never happened as planned but the solar photovoltaic (PV) panels were installed on the school as agreed.

[1] Current conversion rate 100 SEK = €9.63

In 2014, a 500MWh/yr solar PV park was built on Skedalahed, a former landfill site. The plan for the solar park was for the electricity generated to be used for electric vehicles (EVs) through a programme called *"Solen i tanken".* EV users would report distance travelled and HEM would guarantee production from solar energy to match the electricity consumed by EVs. However, in 2014, there were not enough EVs in Halmstad to demand 500MWh/yr of electricity (Johanesson, 2016).

In association with the Department of Real Estate (DRE), the Halmstad Municipality installed number of solar energy systems on municipal buildings between 2010-2016 as shown in table 1. The DRE granted 2Million SEKs annually for solar energy solutions, which increased to 2.5Million SEKs in 2016.

Table 1: Solar Installations on Municipal buildings in Halmstad, 2010-2016

Installation	Completed	Cost (thousand SEK)	Subsidy (%)	Area (m^2)	Peak power output (kW)	Calc. Energy production (MWh/yr)	Cost per peak prod (SEK/W)	Cost of energy produced (SEK/kWh)	Utilisation factor
Sannarpsygymnasiet	2010	3079	55	460	56.7	56	54	3.16	0.11
Stenstorpshallen	2011	858	45	245	33.2	29	26	1.71	0.1
Frosakullsskollan	2012	685	0	218	33	26	21	1.52	0.06
Getingeskolan	2012	899	45	415	50.8	48	18	1.08	0.11
Kattegattgymnasiet	2012	407	45	136	17.6	18	23	1.29	0.12
Vallas Hogstadieskola	2012	898	0	383	50	48	18	1	0.11
Sondrumsskolan	2013	1003	35	451	61.7	58	16	0.99	0.11
Garden On	2013	159	35	51	7.3	7	22	1.3	0.11
Mjellby Konstmuseum	2013	177	35	59	8.3	8	22	1.28	0.1
Halmstad Arena	2014	1767	35	902	131.1	123	13	0.82	0.11
Andersbergs Idrottshall	2014	720	0	251	35.2	43	20	0.97	0.14
Vastra stranden LBVA	2014	974	0	40	53.5	26	18	0.91	0.13
Eldsberghallen	2014	349	0	98	15.3	12	23	1.61	0.09
Skedalahed	2014	11000	0	3240	500	500	22		0.11
Gathenheilmsvagen 19	2014	29	0	128	15.6	17	19	0.96	0.13
Lundsgards fsk	2014	171	0	115	15.6	16	11	0.63	0.11
Hoppets vag 26	2014	180	0	113	17.6	17	10	0.61	0.11
Nymansgaten 23	2015	550	0	191	25	32	22	0.98	0.15
Ringenas Strandtoalett	2015	70	0	3					

3.2 VARBERG MUNICIPALY

Varberg is a coastal municipally located in the northern part of Halland County.

The main investment has been the Coop Forum's installation of 360m^2 solar cells expected to produce 50,000kWh/yr. The cost is understood to have been SEK 1 Million, with an expected 7-year repayment period.

With Soldisan, Varberg Energi has built by far the largest solar cell park in Sweden. 9300 solar modules with a line of 3GWh have been installed. The investment costs amounted to SEK 23 million. Through this Varberg Energi is making a significant contribution to reducing greenhouse gas emissions in Sweden, as the park supplies around 2% of Sweden's solar energy.

The plant, was built on an area of six hectares, next to the highway E6, which is the main north-south road through Norway, and the west coast of Sweden. The space of the power plant is equivalent to about ten football pitches, and can serve the electricity needs of 250 houses or 1500 apartments at the same time.

Mats Eriksson, the regional chairman of the board, explained during the construction phase. "The current construction of a solar cell park fits well with our growth strategy and it was natural for us to make such an undertaking possible. We are looking forward to further investments in various alternatives to energy supply and it will be exciting to follow the Solsidan and see how such a large facility works."

Johan Öhnell, CEO of Solkompaniet, who supplied the solar cells, is also very satisfied and states. "Varberg Energi's investment shows that it is possible to build solar parks at significantly lower costs when large plants are built. The cost of the plant is 20% lower than the cost compared to the IEA statistics for Sweden." Varberg Energi is at the forefront of large-scale solar plant construction. In addition, Varberg is on its way to becoming one of the most liquid communities in Sweden.

The location of the solar cell plant was chosen for various reasons. On the one hand, there is an existing Infrastructure, thanks to an existing wind power plant on site, on the other hand, the installation is highly Visibility in order to arise curiosity among passers-by and turn them into ideas about the possibility of installing Solar collectors on their own house roofs.

"There needs to be a broader movement in society when it comes to environmental awareness. We believe that the visibility of the photovoltaic system can help people to start thinking about investing in solar cells on their own homes. comments Björn Sjöström. CEO of Varberg Energi.

Due to the location of the solar cell plant in combination with the wind turbines, the wind turbine produces the most energy in winter and the solar collectors in summer.

3.3 FALKENBERG

The Sloinge Tennis Club has installed a 140m^2, 20MWh/yr sysem. The overproduction from this system is purchased by Falkenbergs Energi. The system was part financed by the Swedish Society for Nature Conservation (Greenmatch 2018).

3.4 KUNGSBACKA

The Kungsbacka area has been highlighted as being within the top ten municipalities in Sweden for investing in solar energy. Among the highlights are a public sector led investment at Kolla Parkstad, Kollaskolan school: the scale of this is 500m^2, producing 73kW solar energy per year.
An array of 3500m^2 solar cells have been installed on municipal buildings around Kungsbacka while, the Valda Heberg neighbourhood is now recognised as using 100% renewable energy.

4. Swedish Incentives

The low population density in parts of the country, and the willingness, until very recently, for many Swedes to spend 4-10 weeks of summer time living in summer cottages without electricity, has possibly had as much influence on energy take up as the limited coal and oil reserves.

In February 2013, new laws for solar support were introduced which provided 35% of total investment cost, up to 1.2 Million SEK with maximum installation capacity of 37,000kW. The law also states that all owners with grid connected PV systems are entitled to seek support. The government planned to disburse 210 Million SEK in solar support between 2013 and 2016. By the end of 2013, 107.5Million of this had already been granted with 220 Million SEK worth of applications received. The Energy Agency released a further 45 Million SEK to the support scheme.

In September 2015, the Swedish government announced a plan to cut reliance on fossil fuels by 2020. This included the aim of powering Stockholm by 100% renewable resources by 2050. A further goal is to run the entire country with 100% renewable energy by the year 2040.

In late 2016, the Swedish Government announced a government subsidy that will cover 60% of the cost of installing a residential energy storage system up to a maximum of 50,000 SEK. The credit applies to the battery, wiring, control systems, smart energy hub, and installation work for homes with rooftop solar systems. It has been described as a complementary support system to the existing scheme supporting solar PV generation in Sweden. Initially it is expected to run until December 2019.

In summary, Sweden's current policy climate for renewable energy is appealing, with financial incentives for investment in solar energy and other renewable sources.

The new incentive scheme for domestic storage should enable households to install a combined solar energy and battery storage scheme with an effective financial subsidy. Within Halland, this clearly offers an opportunity for households to invest; the situation in Halland to date is that investment in solar energy has been driven by the public sector rather than households and the subsidised installation costs is one way to help the domestic sector catch up with the public sector.

5. **Opportunities**

5.1 INCREASING COMPETENCE FOR SOLAR ENERGY

It would appear that in Halland, and especially in the main town of Halmstad, the public sector has taken the lead and installed solar energy systems on public buildings. There is less evidence of domestic or household systems. Given the decreasing installation costs of solar energy, the difficulties associated with installing wind turbines in an area of military activity and the Government targets of 100% renewable energy by 2040, it would appear that the drive for increased solar energy across all sectors is positive.

However, the limited domestic take-up to date could suggest that there may be a need for capacity growth in the area, both for potential domestic adopters, but also for the public sector that may be providing insufficient encouragement for domestic update. While financial incentives are helpful, there appears to be lack of research into the ability to overcome other factors including fear of long-term investments, uncertainty over non-traditional technology and lack of peer examples.

It is also noted that in Sweden as a whole 58% of houses are owner occupied (Eurostat, 2018), with the remainder living in rented or social rented properties. Just under 50% live in flats with just over 50% living in detached or semi-detached houses. Traditionally it has been easier to install domestic solar energy systems on the rooftops of detached or semi- detached properties and on owner occupied properties. This has largely been due to ease of decision making where one owner or family can make the decision to install. It is inevitable that flatted dwellings with multiple occupants and rented properties where the owner and tenant may have different opinions, may be more difficult. However, with the type of dwelling and tenure status both over 50% conditions should be favourable for finding sufficient numbers of households to consider installing solar energy and storage systems.

What is less clear is the willingness to install solar or the propensity to innovate. The statistics do not clearly show whether Swedish households aspire to solar energy or how much encouragement they need to make the installation decision. Qualitative research into attitudes towards renewable energy and solar in particular could be beneficial to understanding what barriers, if any, remain to the widespread adoption of solar energy systems in Halland. The findings of such research could determine whether there is a need for a social or partnership programme to help increase decision making capacity or propensity to innovate and install solar energy systems.

5.2 SOLAR ENERGY OPPORTUNITIES

As Sweden's electricity grid is interconnected within each region individually, the potential arises for the different voltages in each region to make national implementation of renewables a challenging task. Further specialist research is therefore required however evidence suggests that local systems work best as opposed to developing national or multi region networks.

The current policy position clearly encourages the take up of solar energy systems but also the combination with a storage system. The storage element may form an important part of the total solar energy picture. The perception that solar produces insufficient energy in winter, when the demand for heating and lighting is at its highest, is potentially both a real and perceived drawback. Storage systems that can enable a solar energy operator to utilise the energy generated during the winter hours of daylight (as noted above, around 6.5 hours at the shortest day) for their evening demands of heat and light could be very valuable. This is especially so for domestic installations where peak demand can often be evening – and in many domestic cases, where house occupants are out at work, daytime demand when the solar system is generating, may be negligible. For this reason, storage provides a ready answer to the mismatch in time of supply and time of demand.

Incentives subsidise installation costs rather than Feed in Tariffs. This illustrates a difference to the system in some other EU countries such as Germany.

The high global radiation (SMHI, 2018) in Halland indicates the region offers positive conditions for effective generation of solar energy. Therefore, the potential for increasing the installation of solar and battery combined systems at domestic and municipal level would appear to be high.

The process of installing solar energy on municipal buildings has already started and could be considered an opportunity with vast potential as further municipal buildings aim to install solar energy systems over the next 20 years, helping Sweden strive to reach its ambitious renewable energy targets. The opportunity for storage is even greater as it could be combined with new solar energy systems or retro fitted onto the existing systems that do not currently have storage. The financial incentives for municipal buildings do not appear to be as strong as for domestic buildings but the benefits and the policy fit should encourage implementation.

6. **How storage can help these opportunities**

Due to the low compensation for selling excess electricity back to the grid, storage systems can act as the median carrier for electricity, in addition to a possible balancer of the grid. Instead of selling back excess and buying in times of low demand, a good storage system would be able to store the electricity generated during peak power times and mitigate the need to buy from the grid during peak usage times.

This is recognised by the Swedish Government with their subsidy programme announced in 2016. This specifically noted the benefit of adding storage to solar energy and targeted the lowering of installation costs rather than the long-term benefit of income-for-generation schemes such as Feed in Tariffs.

Andreas Gustafsson, program manager for the research and innovation department of the Swedish Energy Agency stated that "The scheme represents a complementary support system to the existing scheme supporting solar PV generation in Sweden. It's one step, but an important step towards establishing a smart, distributed grid based around clean, renewable energy. It's expected that in supporting the installation of batteries, we'll enable two outcomes — one to enable better use of solar PV generation systems, and the second is to help establish smarter, more flexible grids that can contribute to stabilize the grid against fluctuations in frequency and voltage. In this context, it's important to have systems for storing energy, rather than simply pumping excess electricity into the grid, only to buy it back at a later date when you have a demand." (Cleantechnica 2016).

The incentive program aims to be attractive to "prosumers" — private persons or companies using rooftop solar for their own energy needs. (Gustaffson, 2016). Johan Lindahl, a spokesperson for Swedish Solar Energy says, "Solar PV is a rapidly expanding market in Sweden. It's in a good position to grow from a small position currently. In general, there is a growing interest for PV in Sweden and the general public is very positive towards the technology. A recent survey found that about 20% Swedish homeowners were considering investing in rooftop solar or a small wind turbine." There is no reference to the survey although having been reported in the Swedish press it may be assumed to be credible. It is reported here to indicate that there is a belief in the concept of investment in solar and storage packages at the domestic scale.

The Swedish Energy Agency further noted that Energy storage on the scale envisaged by the incentive scheme is new for Sweden. "There's very little to no home energy storage at the moment. Hopefully we can look forward to success, and new companies and jobs to come along with introduction of these storage solutions" (Gustaffson, 2016). This is a reference to the possible wider benefits of solar schemes, the potential for job creation with local installers, maintenance and even some manufacture all possible. This potential could be anticipated and enhanced through local training, promotional and partnership schemes to encourage companies and jobs to be created in the sector.

7. Conclusion

Currently the timing is positive to install any renewable energy scheme in Sweden and the financial incentives for solar energy and storage schemes is encouraging. The Swedish national incentive scheme for solar energy and storage is set to continue until December 2019, with the potential to be continued after that date currently unknown. The Swedish Energy Agency have been able to influence the Government and the Finance Ministry to enable financial support to be made available to renewable energy schemes. This ties in with and supports the ambitious target to make Sweden a 100% renewable energy country by 2040.

Halland is a good location in Sweden for both geographical and political reasons to attempt to roll out a solar energy system. The public sector has taken a lead in installing solar energy systems but there are still a considerable number of public sector buildings without renewable energy and which could be suitable for new solar energy schemes before 2040, and to help meet the targets for 2040. Halmstad and Kungsbacka have made some positive progress in installing solar energy systems, but other towns and villages in Halland County have installed only limited amounts to date. As solar energy overall in Sweden still represents less than 1% of the total energy mix, there is clearly scope for growth. The Government supports this growth potential through the incentive schemes and positive policies which would support the installation of solar in the villages, on domestic properties and on further public buildings in the towns.

The policy and financial incentives also highlight the mixed package of energy generation together with storage. This would seem to be the best supported way forward in terms of government finance available, and for the Halland climate with relatively short winter days and potentially peak demand during winter hours of darkness. With housing tenure and type favourable, there is potential for the domestic sector to adopt solar energy and storage systems.

Opportunities overall would probably relate to domestic household properties, municipal buildings, and some off-grid houses. There may be an additional opportunity with the large-scale solar energy EV charging scheme which appears to have stalled.

8. Future Recommendations

EIfI-Tech has gathered some future recommendations and top priorities for the county of Halland to encourage the uptake of solar energy production and usage.

8.1 DEVELOP AND TEST NEW SCALABLE BUSINESS MODELS[2] FOR SOLAR ENERGY IN HALLAND

As stated earlier in this report, there is clearly a value for RES uptake in Halland, yet wind energy is inappropriate in the capital city of Halmstad, as wind turbines obstruct air space in this military zone. HEM (Halmstad Energy & Environment) has already demonstrated interest in establishing a market for solar PV through their incomplete project between electricians and car mechanics to offer hands-on experience with grid connected solar cells. Further, around 20% of Swedish households have expressed interest in installing solar PV equipment, in contrast to a significant proportion of homes that are rented and not owned—therefore stripping many Swedish renters of any sense of ownership and thus the need to invest in RES-technology. Thus, there seems to be a need for an innovative system of ‛'renting" solar panels/energy. Perhaps it is valuable to municipality-owned HEM (Halmstad Energy & Environment) to invest in solar PV equipment and encourage households to lease the equipment or pay some sort of service fee for using them. If it does not make sense for households to invest in solar PV, as they are often renting their properties, then perhaps they can ‛'rent" their solar energy as well.

In Falkenberg, the Sloinge Tennis Club has installed a 140m^2, 20MWh/yr system, which was partly financed by the Swedish Society for Nature Conservation (Greenmatch 2018). The overproduction from this system is then purchased by Falkenbergs Energi. Selling overproduced solar energy to energy companies, which could in turn resell this energy to consumers in need of energy, could be a good option for other businesses as well as universities throughout Halland.

Finally, according to the Swedish Energy Agency, "There's very little to no home energy storage at the moment. Hopefully we [Sweden] can look forward to success, and new companies and jobs to come along with introduction of these storage solutions". This is a reference to the possible wider benefits of solar schemes, the potential for job creation with local installers, maintenance and even some manufacturers. This potential could be anticipated and enhanced through local training, promotional and partnership schemes to encourage companies and jobs to be created in the sector. The county's universities should be utilised as a natural location for these trainings.

[2] A business model refers to how a business creates, delivers and captures value.

In regard to higher education, there are 14 public universities and 17 public university colleges in Sweden, and also a number of independent institutions of higher education, they do provide state of the art education to train the future specialists for the country's economy. However, at Campus Varberg there is higher vocational education for Solar energy.

As the capacity of solar cells will be greatly expanded in Sweden over the coming years and has doubled every year in recent years, the interest of private individuals, companies and authorities in investing in solar energy is rising accordingly. Sweden is therefore facing an exciting development and it is expected that the demand for competent project planners for solar energy will greatly increase.

Therefore the demand for knowledge and experience in dealing with solar technology is increasing for both buyers and sellers of solar technology components. At present, the vast majority of professionals who work in the planning and installation of solar cell systems are self-taught.

Accordingly, the Varberg campus has established the degree program Solar Projector with specialization in solar cells. As a solar project planner, the graduates with a Polytechnic degree, have a unique holistic view of solar projects and can take responsibility for all aspects of an installation. Graduates know the entire product life cycle and can guide the customer to the best solution. They analyze the deal, evaluate and produce the best concept for the client, implement it, and ensure that the work is done correctly, including the subsequent maintenance of the equipment.

Graduates of the program have the knowledge, skills and competencies to work as solar cell project planners, project managers with an solar cell focus, solar energy company key account managers, climate and energy consultants, and solar energy projectors. The training provides the students with all necessary tools and skills to work with and take responsibility for parts or the entire installation.

8.2 STRENGTHEN CUSTOMER COMPETENCES FOR SOLAR ENERGY IN BOTH THE PUBLIC AND PRIVATE SECTOR

In 2014, a 500MWh/yr solar PV park was built on Skedalahed, a former landfill site in Halmstad. The plan for the solar park was for the electricity generated to be used for electric vehicles (EVs) through a programme called "Solen i tanken". EV users would report distance travelled and HEM would guarantee production from solar energy to match the electricity consumed by EVs. However, in 2014, there were not enough EVs in Halmstad to demand 500MWh/yr of electricity (Johanesson, 2016).

Perhaps this solar PV park and "Solen i tanken" programme should be revisited. Halland county is growing in population. There will likely be more and more commuters, as Halland is commutable to Gothenburg as well as Malmö & Copenhagen. The growing population of Halland, and thus a probable increase in commuters seeking jobs outside of Halland, will lead to an increase in demand for EVs—regardless of the fact that gas prices are most inexpensive on the Swedish west coast (near Gothenburg) due to the location of the refineries. Nevertheless, this PV park would be of interest to revisit for HEM.

In addition, perhaps the solar PV park can supply solar energy to homes or the Halmstad university rather than focusing solely on EVs.

The Kungsbacka area has been highlighted as being within the top ten municipalities in Sweden for investing in solar energy. Among the highlights are a public sector led investment at Kolla Parkstad, Kollaskolan school: the scale of this is 500m^2, producing 73kW solar energy per year. An array of 3500m^2 solar cells have been installed on municipal buildings around Kungsbacka while, the Valda Heberg neighbourhood is now recognised as using 100% renewable energy. Plus, the Swedish government has committed to running the entire country with 100% renewable energy by the year 2040. This is a big step for Sweden. The importance of sustainability and RES take-up is now becoming engrained in the Swedish culture. However, the limited domestic RES take-up to date could suggest that there may be a need for capacity growth in the area, both for potential domestic adopters, as well as for the public sector that may be providing insufficient encouragement for domestic update. While financial incentives are helpful, there appears to be lack of research into the ability to overcome other factors including fear of long-term investments, uncertainty over non-traditional technology and lack of peer examples. Overcoming this knowledge gap and making sure incentives for the uptake of solar PV is known, should be a major action for Halland.

Swedes often spend 4-10 weeks in summer cottages without much need for any electricity at all. When isolated cottages such as these do require electricity use, however, off-grid solar PV seems to be the most practical (i.e. renewable energy, sun shines in summer for long periods of time, local grids/micro-grids are most effective in more rural areas). The problem at hand is that PV technology is expensive. Laws for solar support should be made more known to these households. Zero-interest loans to be paid back over a longer period of time can make the installation of this solar PV technology for these households possible. The option for homes to sell their excess energy back to the grid—especially during summer time when energy is in demand, but not so much in residential homes—should be explored. This could give Swedish households, who often rent their homes, incentive to install solar PV tech and eventually even profit from their decision.

8.3 ESTABLISH A JOINT ACTION FORUM/PLATFORM FOR SOLAR ENERGY IN HALLAND

Another future recommendation for Halland to encourage solar energy uptake is to establish a joint action forum for solar energy in Halland; or in other words, a joint platform for business development and market development in solar energy. This would entail both public sector involvement as well as private sector involvement, in coordination for their mutual benefit. This vehicle could be used as a platform for future business development.

A pilot project was initiated at Kattegattgymnasiet school in Halmstad to link the school with car mechanic and electrician education and solar energy generation. This project intended to offer hands-on experience with grid-connected solar cells and electric cars (Johanesson, 2016). This cooperation, however, never happened as planned but the solar photovoltaic (PV) panels were installed on the school as agreed. One obvious question is why did this project never happen? Clearly the municipality of Halmstad (public sector) has expressed interest in expanding the skillset of the future job market (private sector) to improve competences in solar energy. Halmstad is home to a university. More involvement with students entering the job market could be of interest.

HEM (Halmstad Energy & Environment) has already installed a number of solar PV installations on municipal buildings. Another question is who will maintain these buildings? It would be of interest to the municipality to hold trainings—or projects like the car mechanic & electrician education, perhaps in schools/universities—to help expand this market. As mentioned earlier in this report, the Swedish Energy Agency further noted that "there's very little to no home energy storage at the moment" (Gustaffson, 2016). This is a reference to the possible wider benefits of solar schemes, the potential for job creation with local installers, maintenance and even some manufacture all possible. This potential could be anticipated and enhanced through local training, promotional and partnership schemes to encourage companies and jobs to be created in the sector.

Finally, qualitative research into attitudes towards renewable energy and solar in particular could be beneficial to understanding what barriers, if any, remain to the widespread adoption of solar energy systems in Halland. The findings of such research could determine whether there is a need for a social or partnership programme to help increase decision-making capacity or propensity to innovate and install solar energy systems.

8.4 ENCOURAGE THE COOPERATION BETWEEN ACTORS IN DIFFERENT FIELDS TO FIND NEW APPLICATIONS OF SOLAR ENERGY

Halland should encourage the cooperation between actors in different fields aimed at finding new applications of solar energy to strengthen the market position of solar energy.

Halland, Sweden is growing in population and has a diverse business sector with large public and services sector. There is an increase in the demand for workers in the construction (i.e. heating, electrical & mechanical engineers, etc.), hotel & catering (i.e. cooks), commerce & business and public (i.e. pre-school & certified teachers) sectors. Demand for teachers and public sector employees, plus growing population in Halland, also implies more energy efficient schools and public buildings would be of use to Halland. To adapt to the growing need for larger or more school/public spaces and thus higher energy bills, it would be of interest for schools/public buildings to increase their energy efficiency and decrease their energy bills.

The process of installing solar PV on municipal buildings has already started and could be considered an opportunity with vast potential as further municipal buildings aim to install solar energy systems over the next 20 years, helping Sweden strive to reach its ambitious renewable energy targets. The opportunity for storage is even greater as it could be combined with new solar energy systems or retro fitted onto the existing systems that do not currently have storage. The financial incentives for municipal buildings do not appear to be as strong as for domestic buildings but the benefits and the policy fit should encourage implementation. As the demand for electrical & mechanical engineers is increasing, as well as the demand for solar installations on municipal buildings, it would be of interest for municipalities to offer trainings, networking opportunities, classes at the universities, incentives, etc. for young students to not only become electrical/mechanical engineers, but also electrical/mechanical engineers with a special focus in solar energy/RES.

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10. Appendix 1 History of Energy in Sweden

1850 - 1900	
1850	Significant increase in use of energy and the introduction of new energy sources and carriers related to industrial revolution
	Sweden went from being almost self-sufficient to more dependent on energy imports (coal and oil)
	Annual energy use was 11TWh, of which 80-90% came from domestic, mainly wood
1880	Cities grew and new industries subsequently emerged. The countryside became central to developing industries due to access to rivers and streams for growing hydropower.
1890	Electricity production with electro-technical equipment became the forefront in the industrial breakthrough.
	Industrial worker productivity increased by 3.5% and energy used per hour of work increased by 1.5% per year
	Economic instability borne of the financial crisis disrupted the energy industry providing opportunity for energy sources breakthrough.
1900 - 1950	
1900	Energy use increased to 35TWh 50% form domestic wood and coal
	The share of hydropower grew from 18% in 1880 to 60% in 1900
	Policy implemented to reduce dependence on imported energy and produce energy from hydropower. This took 40 years to implement and dominated the energy industry.
1915 (during WW1)	Electrification of countryside began
	Coal imports fell from 4.036Mtonnes in 1916 to 1.5Mtonnes in 1917 and in response to the subsequent shortage, electrification increased substantially.
1920	All easily electrified areas were connected to the grid including railroads and municipal buildings.
1923	Sweden's annual electrcity generation amounted to 2.5TWh with 95% of this generated from hydropower (remaining 5% from thermal power plant)

1950 - 2000	
1950	Utilising large-scale hydropower in northern Sweden meant new technologies for long distance electricity transfer were established
	ASEA became world leaders in High Voltage Technology due to the development of transformers and use of AC
	Improved small electric motors giving more opportunities for electrification in the home
	Ownership of electric stoves, fridges, washing machines and hoovers became widespread
	The number of women employed in industry increased
	Electronics and computers were introduced
1960s/1970s	Nuclear power was introduced to power the grid
1973	The oil crisis affected both international and domestic markets, resulting in the expansion of nuclear power
2000 - 2050	
2016	Energy consumption was 160TWh/yr
2017	Swedish Government announces ambition for the country to be powered 100% from renewable sources by 2040

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