energikontor sydost

Energy Agency for Southeast Sweden

We support companies and public bodies in their work for energy and climate issues

Solar cells

11 th of May 2017

Ronneby

Agenda May 11

- **09.00-09.30**
  - Introduction, Sarah Nilson and Katrine Svensson Energikontor Sydost
  - The Projects: Sol i Syd, Sol i fys and ENERSELVES,
  - Potential, sol map, regional goals in Blekinge
  - Statistics solar cells in Blekinge
- **09.30-10.10** Technology & trends, Johan Lindahl Svensk Solenergi
- **10.10-10.30** Paus
- **10.30-11.30** Solar energy in buildings**,** Jouri Kanters LU/LTH
- **11.30-12.10** Economy, Johan Lindahl Svensk Solenergi
- **12.10-13.00** Lunch
- **13.00-13.30** Presentation of sun park Olsgården**,** Kristian Olsér Ronnebyhus
- **13.30-15.00** Visit at Olsgården (by bus)

LÄNSSTYRELSEN BLEKINGE LÄN

energikontor sydost

We support companies and public bodies in their work for energy and climate issues

Sol i Syd 2016-2019 april

Stefan Olsson

Sol i Syd

Detta projekt genomförs med stöd av:

EUROPEISKA UNIONEN Europeiska regionala utvecklingsfonden

SOLAR REGION Skåne

SKÅNE

REGION BLEKINGE

kraftringen

Project specific objectives

Sol i Syd

- Compentence development throughout all the branch of industry
- Concept has been produced for small buildings and industry
- Info material on security, procurement, government requirements etc
- Updated regional objectives and action plans
- Inventory of the branch of industry and employment potential
- Annual follow-up of photovoltaic installations
- New network in Blekinge = Sun rays within “Good houses”

godahus ENERGIEFFEKTIVA BYGGNADER I SYDOST

www.godahus.se

energikontor sydost

Contacs Sol i Syd!

Project managers

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www.solisyd.se

Projektet stöds av

EUROPEISKA UNIONEN
Europeiska regionala utvecklingsfonden

ENERSELVES

Overall purpose with Interreg Europe:

- Networking between countries and regions to stimulate economic modernization.
- To realise the initiative from the Commission of the EU about "Regions for Economic Change", regions in close cooperation with the Commission develop and disseminate innovative development ideas.
- Mainly exchange of experience and strategy work in regional interest groups to influence policy and structural funds content.

ENERSELVES

What?

- Facilitate integration of renewable energy into buildings (selfconsumption)
- Bio, (wind), solar, solar thermal and geothermal
- Affect policies so that integration of RES is supported, ERDF most important.

How?

- Exchange of experience with other regions
- Interesting groups receive training, study trips to other regions. Interested? Get in touch!

Study visit in Badajoz, Spain

Project partners

Project partners in addition to Energy Agency for Southeast Sweden:

- Extremadura Energy Agency, Spain
- Marshal Office of Świętokrzyskie Region, Poland
- Malta Intelligent Energy Management Agency (MIEMA), Malta
- Lazio Region, Italy
- Autonomous Region of Sardinia, Italy
- NorthEast Regional Development Agency, Romania

Kontaktperson

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ENERSELVES
Interreg Europe

European Union
European Regional
Development Fund

Thank you!

Solar panels on my house

Questions welcome

Project smedia

energikontor sydost

We support companies and public bodies in their work for energy and climate issues

Sol i FYS

.

Annica Lindh

Integrate solar energy into the physical planning in the County of Blekinge

LÄNSSTYRELSEN BLEKINGE LÄN

Energimyndigheten

Sol i FYS

- Integrate solar energy into the physical planning in the County of Blekinge
- Energy Agency for Southeast Sweden and the County administrative board in Blekinge, run the project
- Financier: Swedish Energy Agency
- Project period: from 2016-06-01 to 2017-12-31

Solar cell flower, charging post. Visby: Foto Elvis Eckerberg

energikontor sydost

Energimyndigheten

LÄNSSTYRELSEN BLEKINGE LÄN

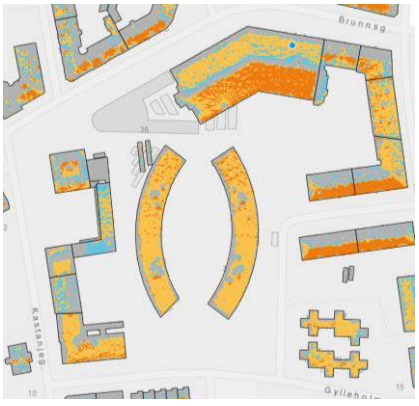
Sol i FYS

Purpose

- Solarmaps drawn up over Blekinge will provide physical planners with increased knowledge to plan for renewable energy
- Stimulate more actors to install solar energy
- Through workshops and education programs, the knowledge of the County Administrative Board and the municipalities increases the way in which physical planning creates long-term and sustainable conditions for solar energy

Sol i FYS

- The sun chart is ordered. It will be finished in May by Thyrens.
- Workshop, for planners, to gather knowledge of what is demanded for the autumn's training opportunities
- Education 1: Beginning of September 2017
- Education 2: Beginning of October 2017
- Occasions for municipalities in the autumn to use the knowledge in a planning process
- The project ends in December



Solkartan.se

Thank you!

Project manager

Kontaktperson

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Projektet stöds av

EUROPEISKA UNIONEN
Europeiska regionala utvecklingsfonden

LÄNSSTYRELSEN BLEKINGE LÄN

Sol i Syd

Solar map and regional objectives

Samuel Karlström
Climate- och energy coordinator

Solar map showing the rooftops in Blekinge

Information about:

- Total roof surface
- Total amount incoming solar energy per year
- Proportion of roof surface with good conditions for solar production
- Estimated electricity production kWh / year

LÄNSSTYRELSEN BLEKINGE LÄN Energimyndigheten energikontor sydost

Regional objective for solar energy - purpose

1. Pay attention to solar energy as a particularly important area in the county's conversion to renewable electricity generation

2. Point out the direction and show what speed the expansion rate should have

3. Cooperate and inspire actors that will make it possible to reach the goals

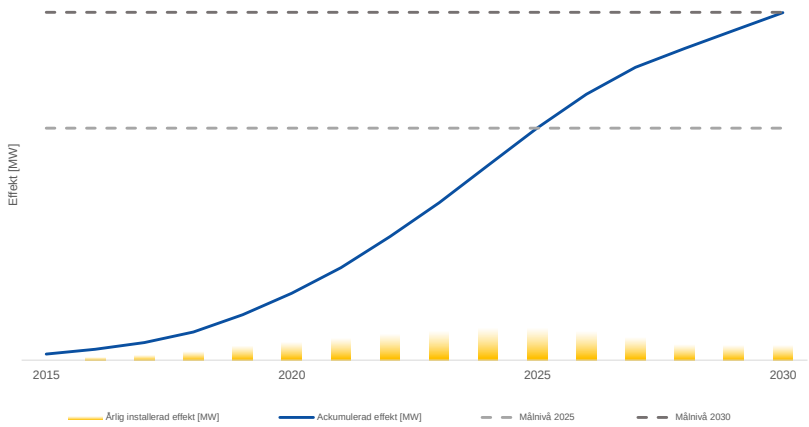
Regional objectives for solar energy in Blekinge

By the year 2025 there is 75 MW installed power
By the year 2030 there is 110 MW installed power

Corresponding to 3.4% of electricity consumption in 2025 and about 5% of electricity consumption in 2030.

The 2016 level is approximately 0.16% of total electricity usage
> It means a great increase

Scenario for market growth for grid connected solar cells



LÄNSSTYRELSEN BLEKINGE LÄN

EUROPEISKA UNIONEN
Europeiska regionala utvecklingsfonden

Sol i Syd

energikontor sydost

VI STÖDJER FÖRETAG & OFFENTLIGA AKTÖRER I ENERGI- & KLIMATARBETET

Solar Panels in Blekinge (and Skåne)

Sol i Syd

11 May 2017
Pierre Ståhl

Purpose

- Number and size of grid connected solar panels
- Increase 2015-2017
- Estimate of quantity produced electricity

Method

- Surveys sent to all electricity grid owners in Blekinge

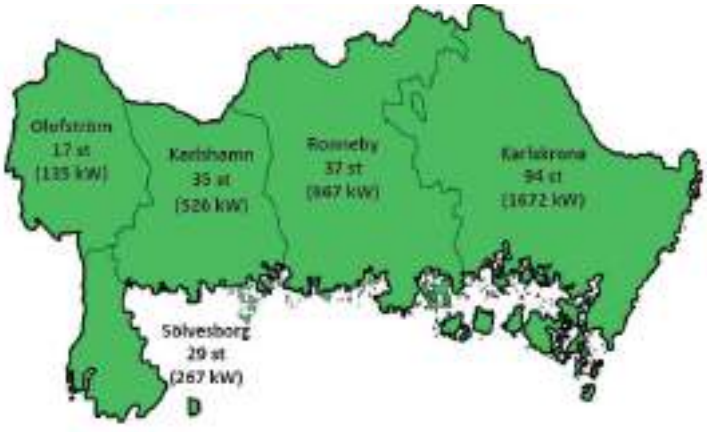
Affärsverken Karlskrona
Ronneby Miljöteknik
Karlshamn Energi
Sölvesborg Energi
Olofströms Kraft Nät AB
Rödeby Elverk
E.On Elnät,
Kraftringen Elnät AB

Results

- Installed power: 3,3 MW
- 212 plants
- Largest: Bostorp 600 kW
- 80% applied for green certificates
- Assuming 1000kWh/kw:

➢ Total production of electricity from solar in Blekinge: 3,3 GWh

74 % more electricity from solar panels in Blekinge - status 31 December 2016



Production/consumption

Plats:	Bostorp
Drifttagning:	Juni 2016
Effekt:	600 kW
Årsproduktion:	ca 600 000kWh

Foto: Solect Power

Blekinge

- Total electricity production 614 GWh*
- Total electricity consumption 2026 GWh*

*SCB 2015

Solar

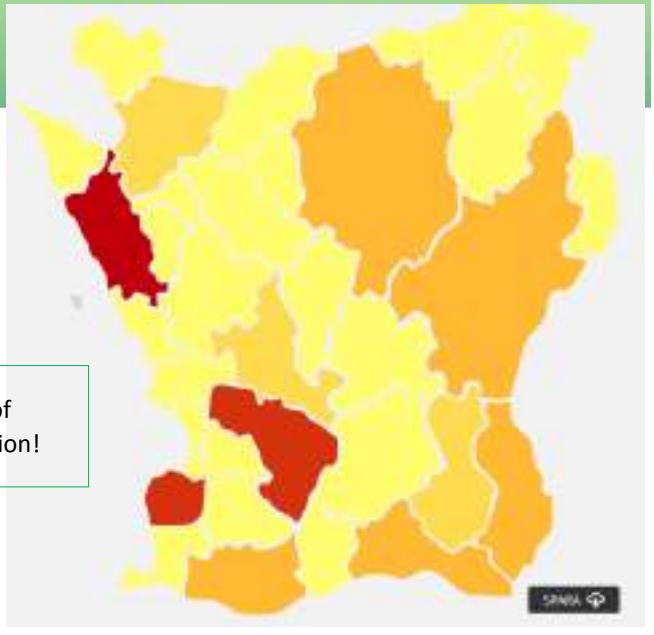
- Blekinge 3,3 GWh:
- 0,5% of production
- 0,16% of consumption

Skåne

- Increase 75% (2016-17)
- Installed power: 23,5 MW
- 1430 plants
- Total electricity production from solar in Skåne: 21 GWh

http://solisyd.se/material/statistik-solceller-i-skane/

- 0,16% of consumption!



Thank you!

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Projektet stöds av

EUROPEISKA UNIONEN
Europeiska regionala utvecklingsfonden

Solar Power: Sweden, The Markets And You

Johan Lindahl
Swedish IEA-PVPS task 1 representative

Introduction

SVENSK SOLENERGI

Svensk Solenergi is a trade association which, with about 170 professional members, represent both the Swedish solar energy industry as well as the research institutions operating in the solar energy field.

Member companies:
- Production companies
- Installers and retailers
- Utilities
- Energy consultant firms
- Property owners
- Universities
- Institutes

Introduction

IEA-PVPS

International Energy Agency
Photovoltaic Power Systems Programme

Energimyndigheten

International Energy Agency – Photovoltaic Power System Program (IEA-PVPS) is one of the collaborative research and development agreements within the IEA. The mission of the programme is to "enhance the international collaboration efforts, which accelerate the development and deployment of photovoltaic solar energy as a significant and sustainable renewable energy option".

IEA-PVPS have 30 members: 25 countries, 5 organizations.

IEA-PVPS are divided into different 'Tasks', which may be research projects or activity areas on technical and non-technical subjects.

Innehåll:

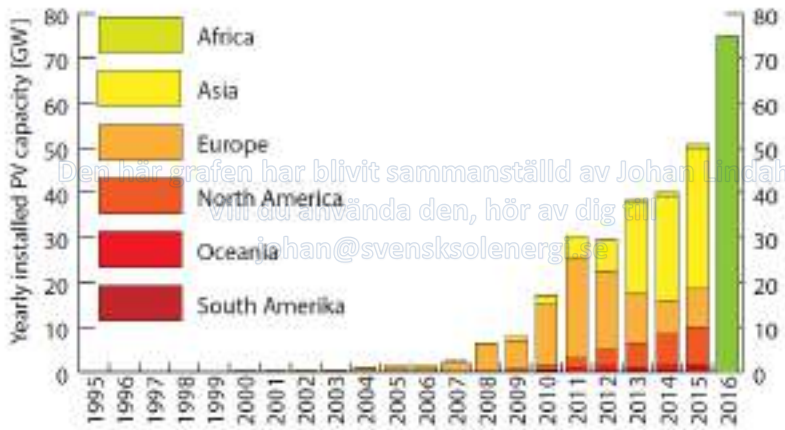
- **Den internationella solcellsmarknaden**
- Industri och teknikutveckling
- Solceller och ekonomi
- Solcellers påverkan på elmarknaden

- Den svenska solcellsbranschen
- Svenska solcellsbranschens framtid
- Solcellers sociala aspekter

The global PV market

Annual installed PV capacity in the world

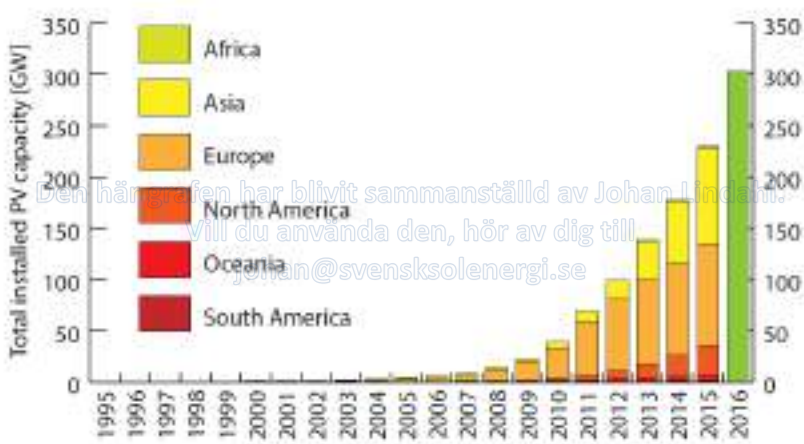
Evolution of annual installed PV capacity from 1993 to 2016 share per region.



The global PV market

Total installed PV capacity in the world

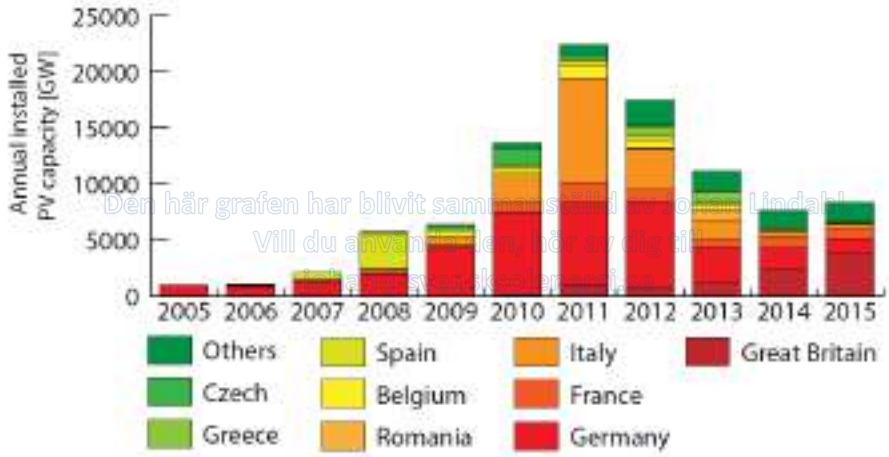
Evolution of total installed PV capacity from 1995 to 2016 share per region.



The global PV market

Annual installed PV capacity in Europe

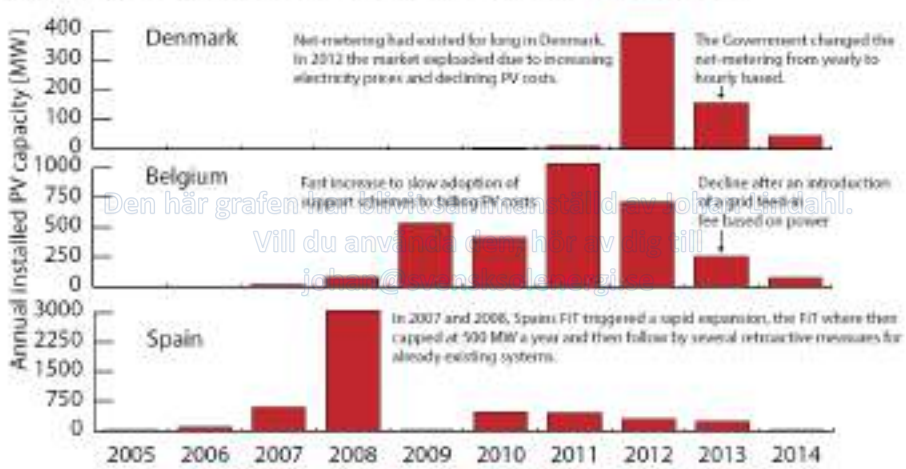
The development of the annual PV market in Europe 2005-2015.



The global PV market

Boom and bust PV markets

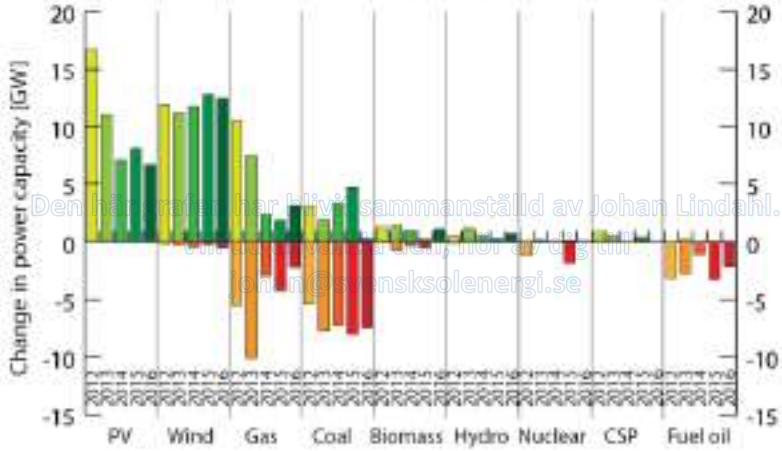
Examples of boom markets that collapsed as a result of regulatory changes.



The global PV market

Changes in the EU power production

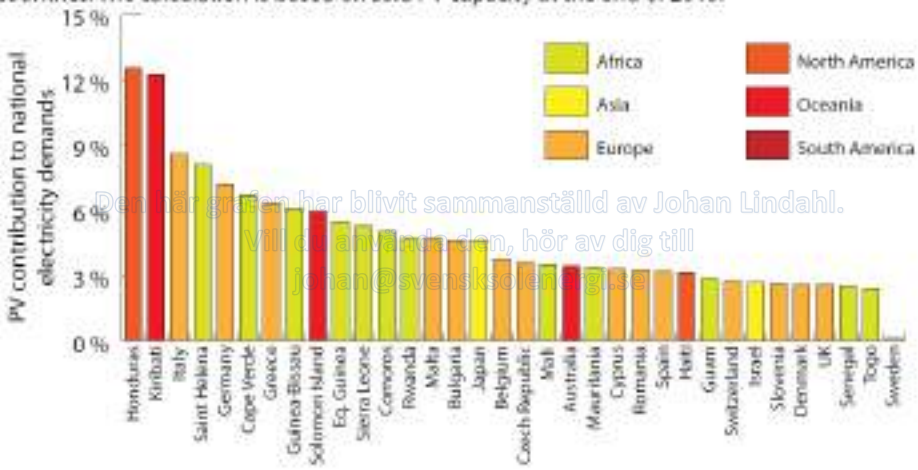
New installed and decommissioned power capacity in EU in the five last years.



The global PV market

PV share of electricity production

Theoretically PV electricity contribution to the total electricity demand in some countries. The calculation is based on sold PV capacity at the end of 2015.



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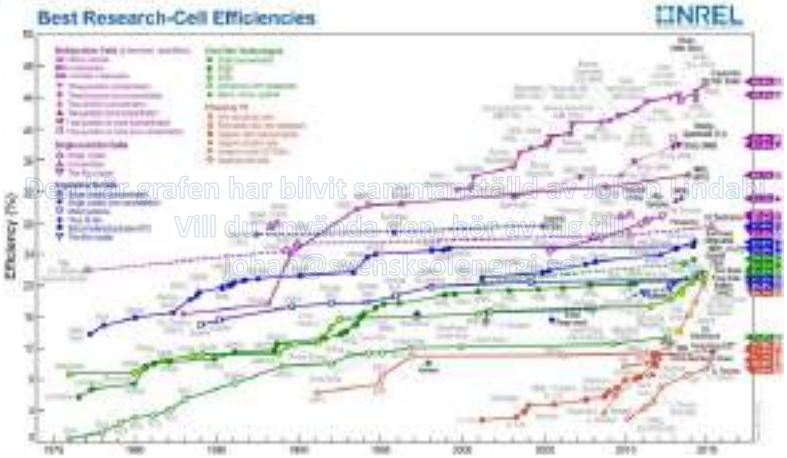
Industry and technology development

Development of the efficiency of solar cells

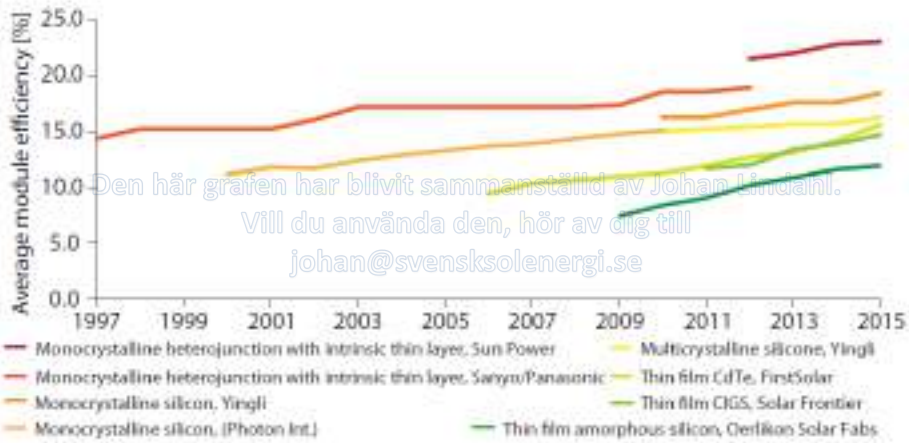
The highest confirmed conversion efficiencies for research cells, from 1976 to the present, for a range of photovoltaic technologies.



Industry and technology development

Module efficiency development

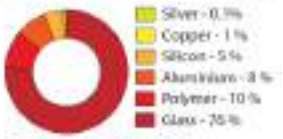
Commercial 1-sun module efficiencies development under the last years.



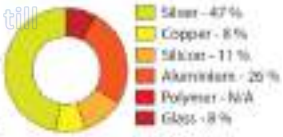
Industry and technology development

Material and energy reductions in PV

The weight-to-power ration has continuously been going down for PV modules due to material savings and improved solar cell efficiency.



Relative material weight of a silicon module [%]



Relative material value of a silicon module [%]

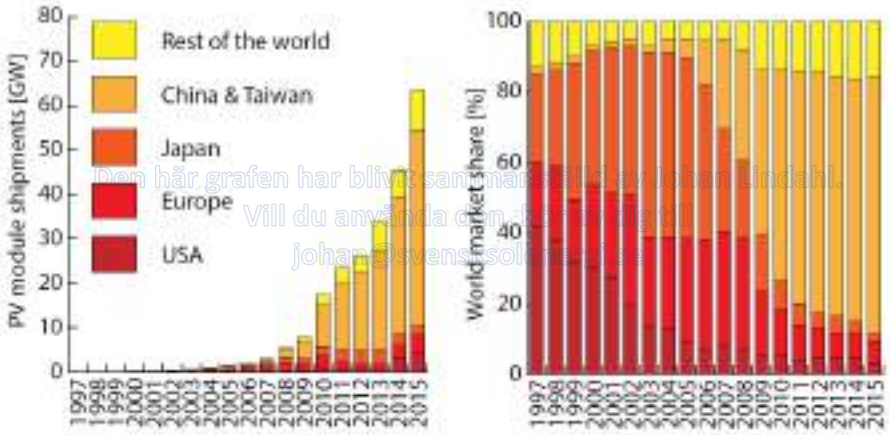
Energy:
Production efficiency has improved the energy usage in polysilicon production. It has gone down with **31 % in 5 years**, from 80 kWh/kg in 2010 to 55 kWh/kg in 2015.

Specific materials:
Silicon and silver usage has been reduced significantly during the last **10 years**. Down **75 % for silicon**, from 16 g/W to less than 4 g/W, and **87 % for silver**, from 0.15 g/W to 0.02 g/W.

Industry and technology development

PV module shipments

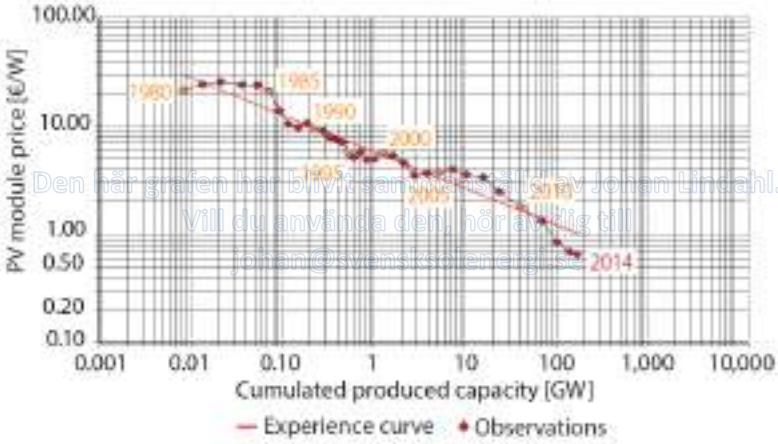
China and Taiwan entered the mass production market in 2004 and ramped up a PV industry with strong growth rates. Now they dominate the market.



Industry and technology development

PV module price experience curve

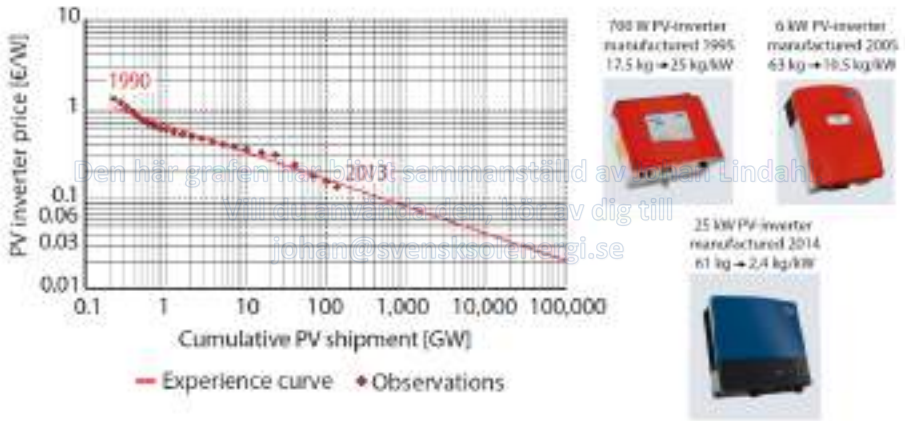
Past PV module prices as compared to cumulated produced PV module capacity. The price reduction has been about 21 % for each doubling of produced volume.



Industry and technology development

Inverter price experience curve

Past PV inverter prices as compared to cumulated PV shipment.
The price reduction has been about 19 % for each doubling of PV shipments.



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The economics of PV

Low Module Cost

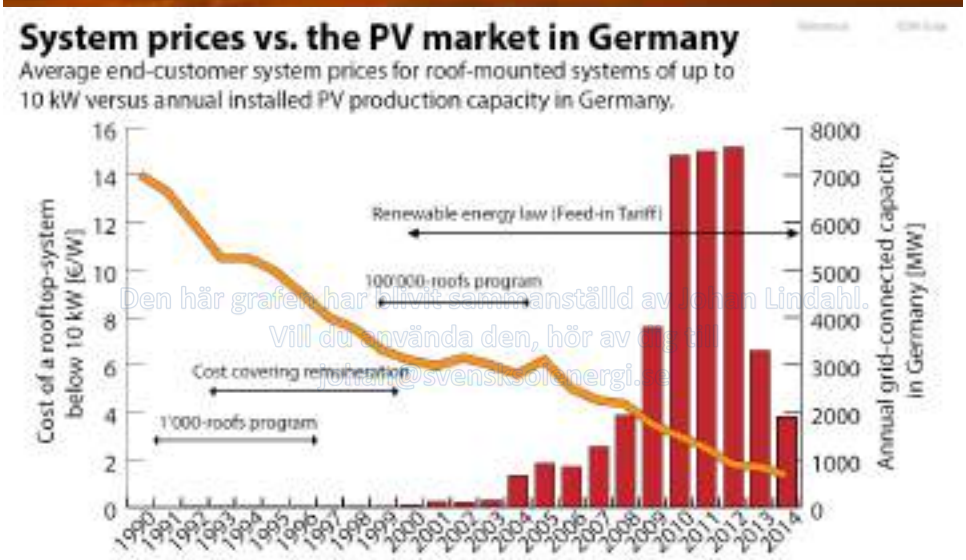
Reability

$/kWh

Reduced Balance of System Costs

High Module Efficiency

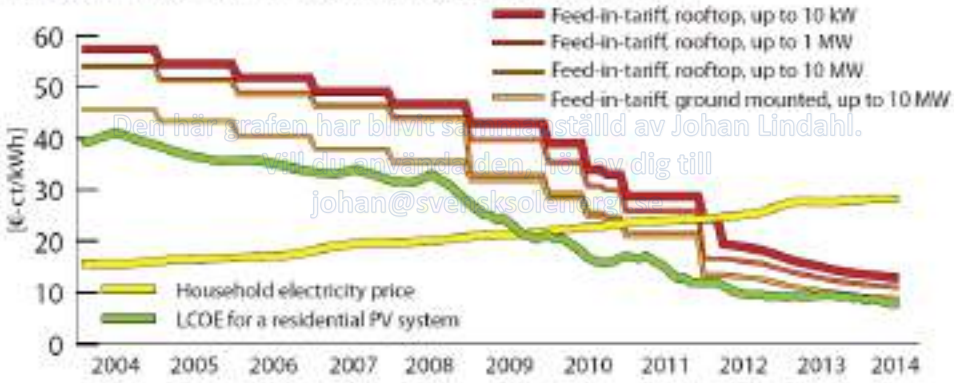
The economics of PV



The economics of PV

The feed-in-tariff system in Germany

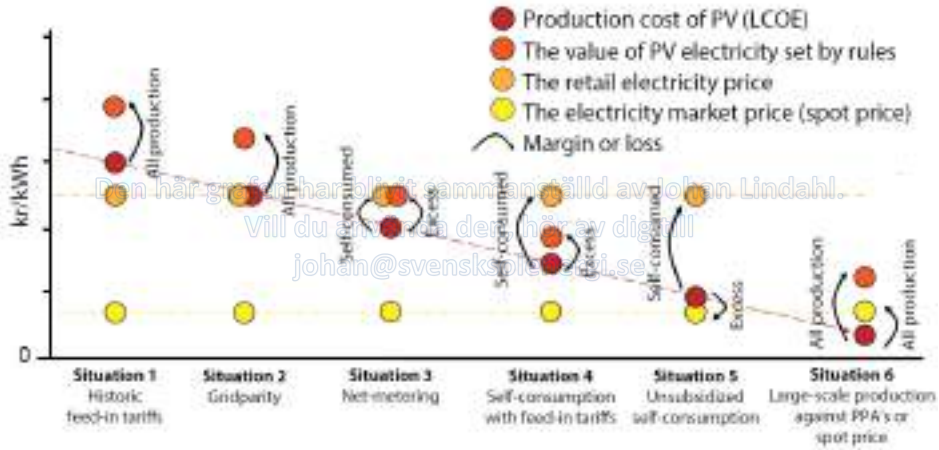
The German feed-in tariff (FIT) system guarantees owners of PV installations a fixed for 20 years. This has driven down system prices and grid parity was achieved in Germany in 2010. Today the FIT for a rooftop project is already below the level of domestic household electricty prices, which encourage directly on-site self-consumption.



The economics of PV

The development of business models for PV

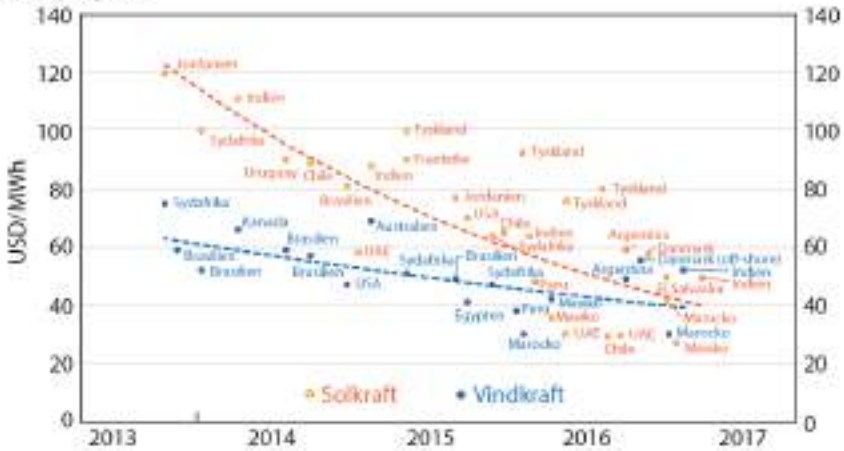
Various business models for PV owners under different market conditions and regulations.



Solceller och ekonomi

Låga produktionskostnader i anbudsprogam

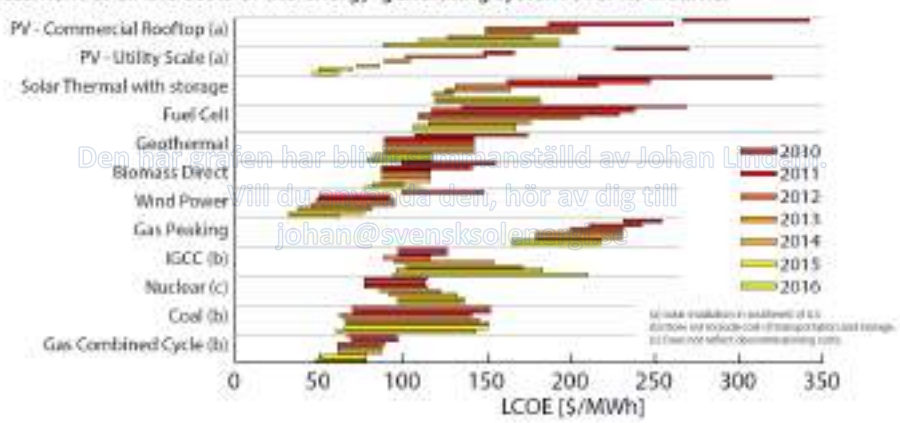
Rapporterade lägsta bud för stora sol- och vindkraftsprojekt i olika nationella anbudsprogram.



The economics of PV

Levelized Cost of Energy in the U.S.

Levelised Cost of Energy "LCOE" is the price at which electricity must be generated from a specific source to break even over the lifetime of the project. It is an economic assessment of all the costs of the energy-generating system over its lifetime.



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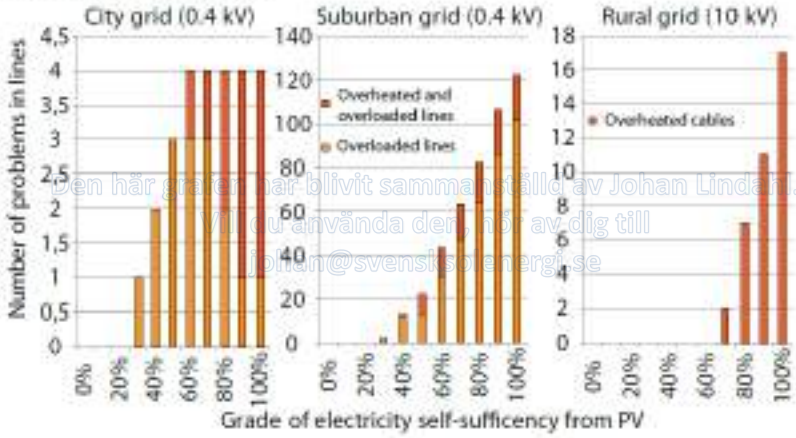
The effect off PV on the electricity market

PV hosting capacity in Swedish grids

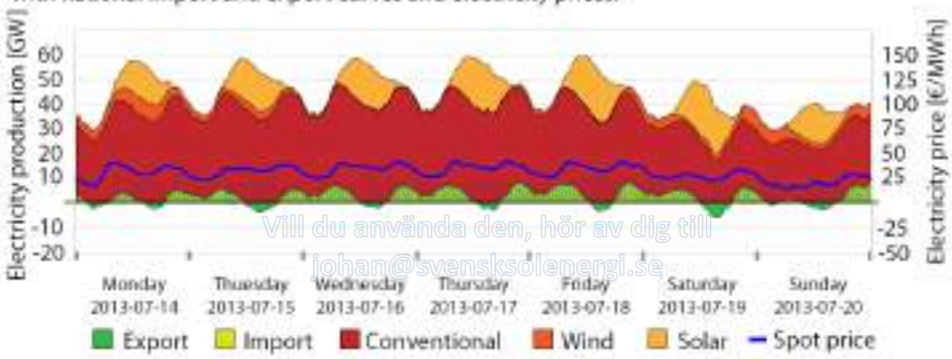
Overloading / overheating as performance index in some of Fortums typical electricity grids.



The effect off PV on the electricity market

Electricity production in Germany 2014

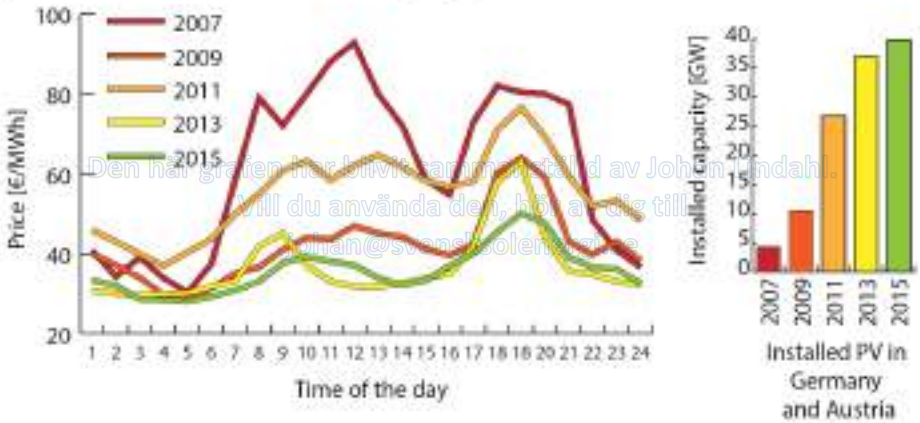
Power curves for week 29 for conventional, wind and solar power production with national import and export curves and electricity prices.



The effect off PV on the electricity market

Lower midday prices due to PV

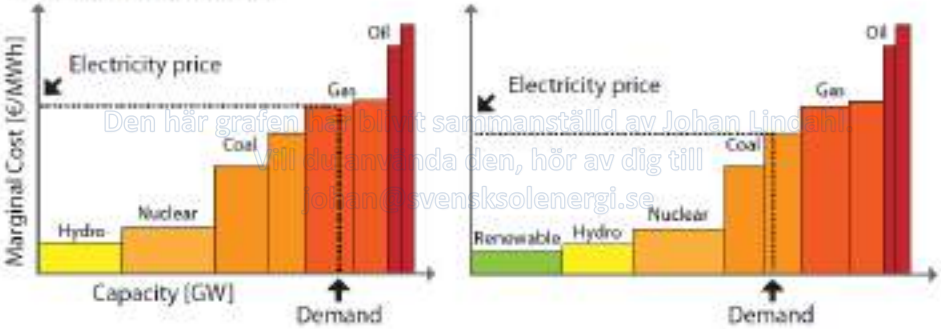
Average day-ahead spot price between 15/4 and 31/10 on the German/Austrian spot market Phelix and the installed PV capacity in these two countries.



The effect off PV on the electricity market

The merit of order effect

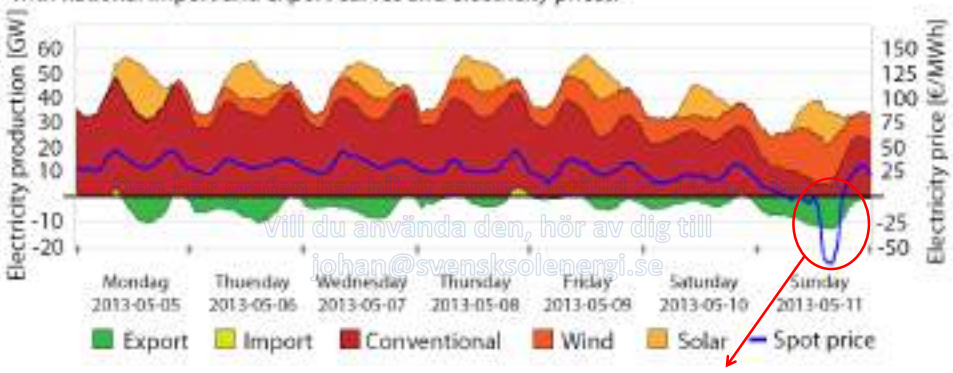
When they are generating, renewables enter the Merit Order at the very bottom, due to the low marginal costs. This has the effect of pushing conventional sources of generation to the right on a dispatch model, thus lowering the highest marginal cost and therefore the overall price paid to all generators.



The effect off PV on the electricity market

Electricity production in Germany 2014

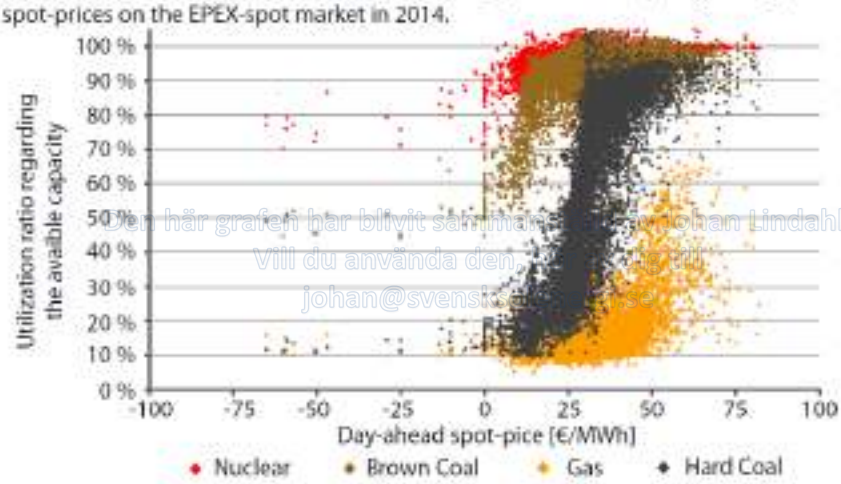
Power curves for week 19 for conventional, wind and solar power production with national import and export curves and electricity prices.



The effect off PV on the electricity market

Plant utilization over day-ahead prices

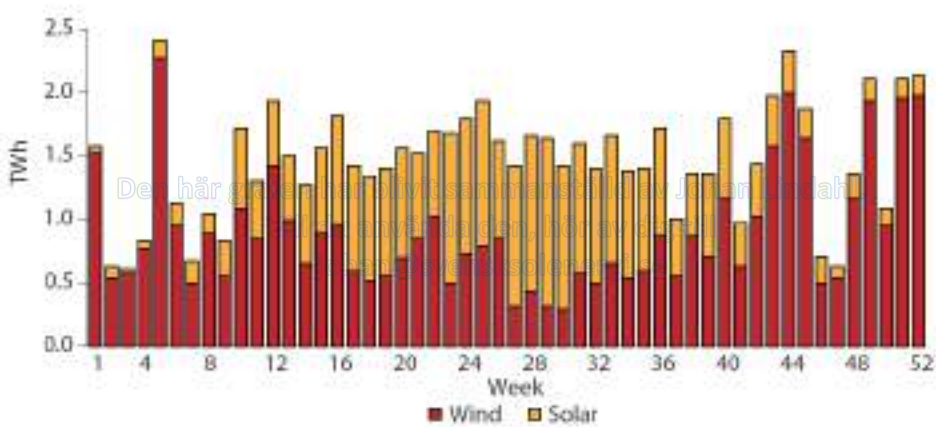
The dependece of plant utilization ratio, regarding the avaible capacity, on day-ahead spot-prices on the EPEX-spot market in 2014.



The effect off PV on the electricity market

Correlation between PV and Wind

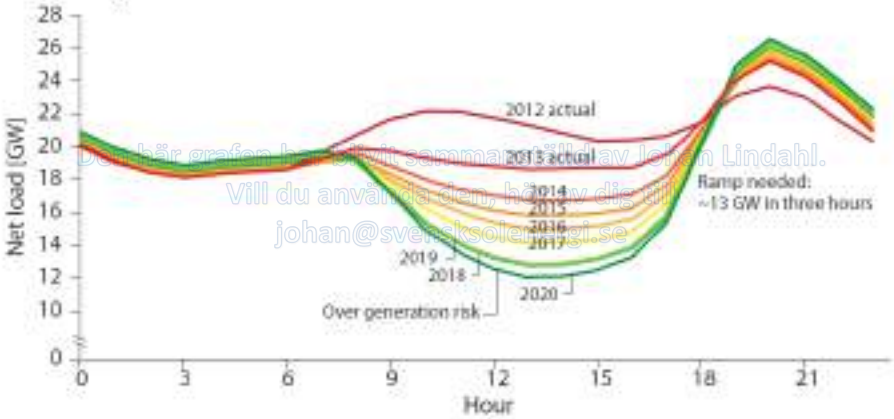
Weekly production of solar and winde in Germany in 2013.



The effect off PV on the electricity market

The duck chart

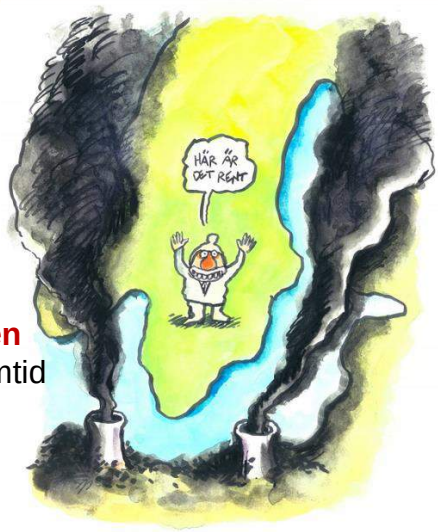
Expected evolution of the net load of a typical spring day in California.
The "duck chart" illustrates how large PV generation requires flexibility from the rest of the power system.



Innehåll:

- Den internationella solcellsmarknaden
- Industri och teknikutveckling
- Solceller och ekonomi
- Solcellers påverkan på elmarknaden

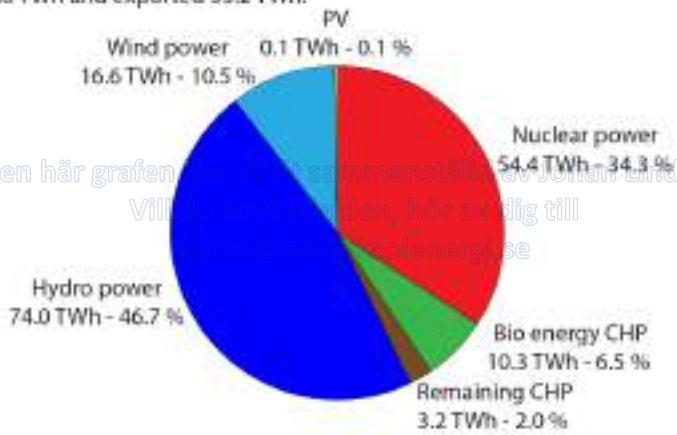
- **Den svenska solcellsbranschen**
- Svenska solcellsbranschens framtid
- Solcellers sociala aspekter



The Swedish PV market

Total electricity production in Sweden in 2015

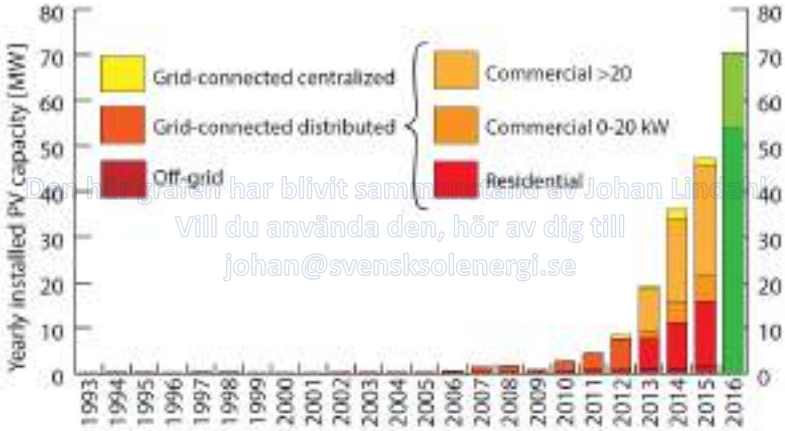
The total electricity generation in Sweden was 158.6 TWh in 2015. The electricity consumption was 135.9 TWh and another 9.4 TWh was lost in the grid. In total Sweden imported 12.6 TWh and exported 35.2 TWh.



The Swedish PV market

Yearly installed PV capacity in Sweden

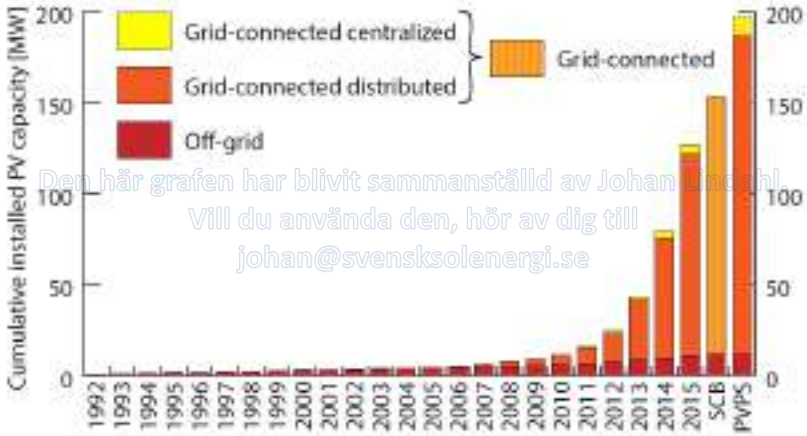
In 2016 preliminary 70 MW of PV was installed in Sweden.



The Swedish PV market

Cumulative installed PV capacity in Sweden

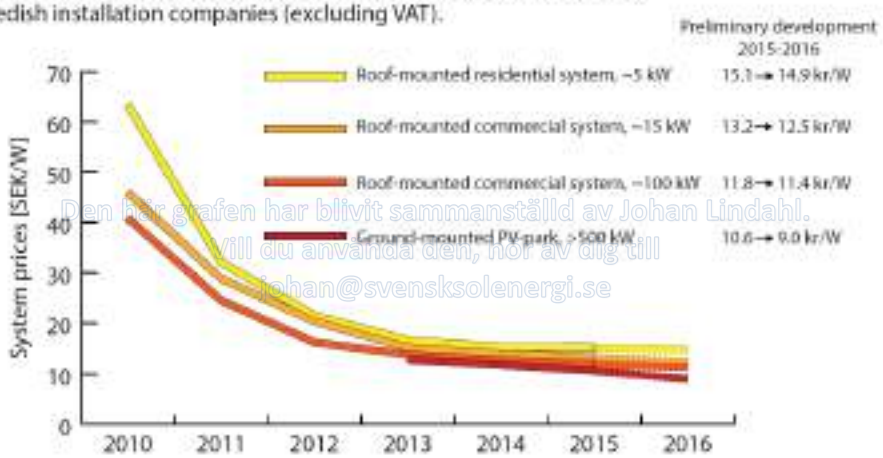
The cumulative PV capacity in Sweden was between estimated 155-200 MW by the end of 2016.



The Swedish PV market

PV system price development in Sweden

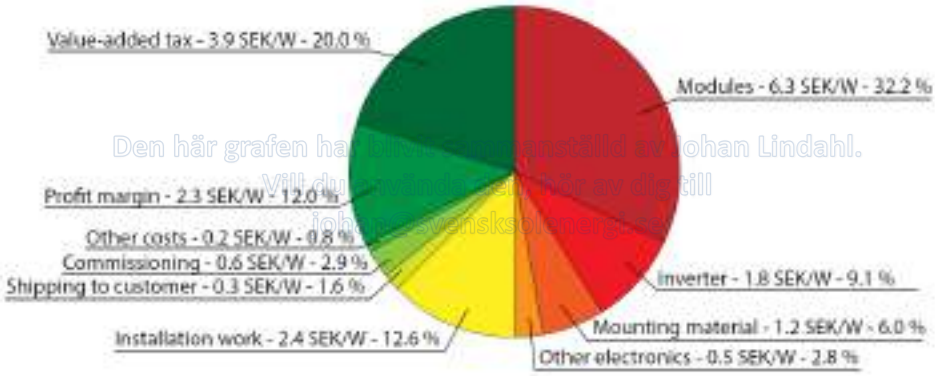
Avergare typical prices for turnkey photovoltaic systems reported by Swedish installation companies (excluding VAT).



The Swedish PV market

Residential PV system cost structure

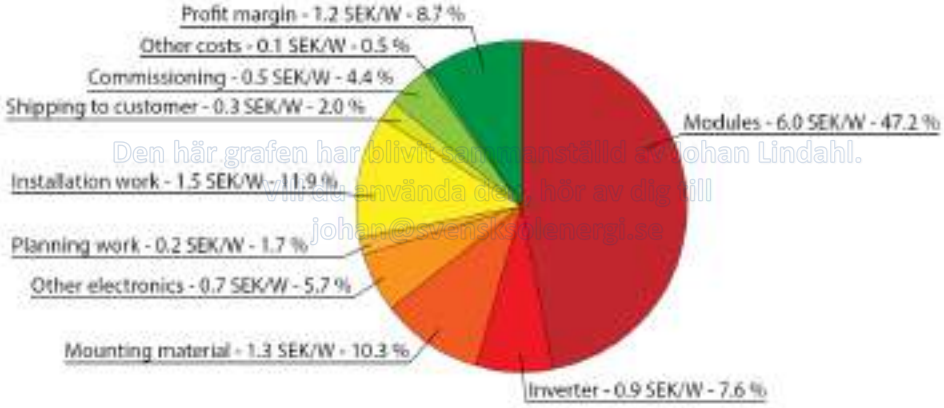
Average of 15 Swedish companies cost structures for a typical turnkey grid-connected roof-mounted residential PV system (4-6 kW) in the end of 2015.
In total 19.5 SEK/W = 2.08 €/W.



The Swedish PV market

Commercial PV system cost structure

Average of 5 Swedish companies cost structures for a typical turnkey grid-connected roof-mounted commercial PV system (40-60 kW) in the end of 2015.
In total 12.7 SEK/W = 1.35 €/W.

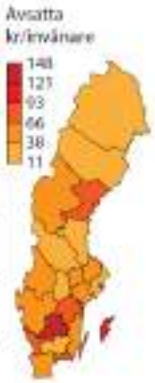


Den svenska solcellsbranschen

Statligt stöd för installation av solceller

Sedan 2009 finns ett statligt stöd för installation av solceller. Stödet riktas till alla typer av aktörer, såväl företag och offentliga organisationer som privatpersoner.

	2009-2011 förordning	2012 förordning	2013-2014 förordning	2015 förordning
Maximal täckning av investeringskostnaden	60 %	45 %	35 %	30 % företag 20 % övriga
Taket för stöd per solcellssystem	2 miljoner Kr	1,5 miljoner Kr	1,3 miljoner Kr	1,2 miljoner Kr
Maximal systemkostnad per W (Exkl. moms)	75 Kr/W	40 Kr/W	37 Kr/W	37 Kr/W
Total budget	212 miljoner Kr	60 miljoner Kr	210 miljoner Kr	50 miljoner Kr



Intresset för stödet är stort och vid slutet av 2015 hade det kommit in 10 693 ansökningar till Länsstyrelserna. Av dessa hade 3 772 beviljats stöd.

The Swedish PV market

Installation vs. the direct capital subsidy

The Swedish PV market has double itself four years in a row with the same amount of allocated money from the direct capital subsidy. The Swedish government has now announced a large increase in the budget for the next years.

Den svenska solcellsbranschen

Sänkt skatt på egenproducerad förnybar el

Den 1:a januari 2015 började skattereduktionen för mikroproducenter förnybar el att gälla, som är en ändring i inkomstskattelagen (1999:1229).

Skattereduktionen är 60 öre/kWh för all el som matas in till elnätet.

Vem har rätt att få skattereduktion?
- Mikroproduktionsanläggning ska ha samma anslutningspunkt som uttagsabonnemanget för microproducenten.
- Mikroproducenten får ha en säkring om högst 100 ampere i anslutningspunkten.
- Mikroproducenten måste ha anmält till nätkoncessionshavaren att förnybar el framställs och matas in i anslutningspunkten.
- Rätten gäller fysiska och juridiska personer, dödsbon samt svenska handelsbolag. Om flera personer har anmält till nätkoncessionshavaren att de framställer och matar in förnybar el i en och samma anslutningspunkt, ska underlaget fördelas lika.

Hur mycket skattereduktion kan man få?
Underlaget för skattereduktionen är antalet kilowattimmar du matat in i anslutningspunkten under ett kalenderår, dock högst så många kilowattimmar som du tagit ut i anslutningspunkten under samma kalenderår och dessutom högst 30 000 kilowattimmar per år.

När får man skattereduktionen?
Elnätsföretagen kommer lämna kontrolluppgifter om hur mycket el som matats in och ut i anslutningspunkten i januari 2016. I din inkomstdeklaration 1 som ska lämnas i maj 2016 kommer uppgifter om skattereduktionen finnas med.

The Swedish PV market

Reduced tax on self-generated electricity

A tax credit for micro-producers of renewable electricity, an amendment to the Income Tax Act (1999:1229), was introduced the 1 of January, 2015.

The tax credit is 0.60 SEK / kWh for renewable electricity fed into the grid.

Who is entitled to receive the tax credit?
- The electricity should be fed into the grid at the same connection point as where the elcetricty is received.
- The micro-producer fuse may not exceed 100 amps at the connection point.
- The micro-producer must notify the grid owner that renewable electricity is produced at the connection point and fed into the grid.
- The right applies to both physical and legal persons.

How much tax credit can one get?
The basis for the tax reduction is the number of kWh that is fed into the grid at the connection point under a calendar year. However, the maximum number of kWh one can receive the tax credit for may not exceed the number of kWh bought at the connection point within the same year. In addition one is only obliged to a maximum of 30,000 kWh per year.

When is the tax credit received?
The grid owner utility company will file statements about how much electricity that has been fed into and out of the connection point under 2015 in January 2016. Data on the tax reduction will then be included in the income tax return information, which should be submitted to the Tax Agency in May 2016.

Den svenska solcellsbranschen

Energiskatt på egenkonsumtion - del 2

Regeringen har tagit fram en lagrådsremiss som innebär en sänkning från normalskattenivån, i dag 29,2 öre/kWh, till 0,5 öre/kWh för egenanvändning från solcellsanläggningar på mindre än 255 kW genom avdrag i punktskattedeklaration.

Sammantaget leder de föreslagna ändringarna till en situation där:

- Om en juridisk person äger en eller flera anläggningar vars **sammanlagda effekt understiger 255 kW** betalar denna **0 öre/kWh** i energiskatt för den egenkonsumerade elen.
  Det är samma förutsättning som gäller i dag.

- Om en juridisk person äger flera anläggningar vars **sammanlagda effekt överstiger 255 kW**, men där varje **enskild** anläggnings effekt **understiger 255 kW**, ska denne betala **0,5 öre/kWh** i energiskatt för den egenkonsumerade elen.
  I dag gäller en energiskattesats på 30 öre/kWh.

- Om en juridisk person äger **en** anläggning var **effekt överstiger 255 kW** ska denne betala 30 öre/kWh i energiskatt för den egenkonsumerade elen som producerats i den anläggningen, men **0,5 öre/kWh** i energiskatt för den egenkonsumerade elen hos övriga anläggningar **om de är mindre än 255 kW**.
  I dag gäller en energiskattesats på 30 öre/kWh för alla anläggningarna.

Lagändringen är förslagen att börja gälla den **1 juli 2017.**

The Swedish PV market

VAT registration of microproducers

As of the first of January 2017 private microproducers no longer need to register for VAT if they want to sell their surplus PV electricty.

The requirments are:

- Sales must not exceed SEK 30 000, excluding VAT, during the current tax year.
- And sales did not exceed this limit the previous two years.

At a high reimbursement from a retail of 0.6/kWh, 50 000 kWh can be sold before reaching the limit. This corresponds to the annual output from a PV system of about 50 kW.

Den svenska solcellsbranschen

Nätuppkoppling och nätnyttan

Inmatningsabonnemang

Enligt ellagen 4 kap. 10§ får ett elnätsbolag **inte ta betalt** för ett inmatningsabonnemang eller för att byta elmätaren om solcellsägaren är en nettokonsument på årsbasis och effekten på solcellsanläggningen och säkringsabonnemanget inte överstiger **43,5 kW** respektive **63 ampere**.

Ersättning för nätnyttan

Enligt ellagen 3 kap. 15§ är ett elnätsbolag **skyldig att betala en ersättning för "nätnyttan"** (kallas också för "energiersättning") för den överskottsel en solcellsägare matar in till nätet. Ersättningen skall motsvara värdet av den minskning av energiförluster som inmatning av el från anläggningen medför.

Denna ersättning betalas ut per automatik oavsett om solcellsägaren har en köpare av sin överskottsel eller inte. Någon koncensus om hur stor nätnyttan är i lokalnät finns inte i dagsläget. Ersättningen varierar ofta mellan 2-5 öre per kWh.

The Swedish PV market

Storage subsidy

In 2016 the Swedish government allocated **25 million SEK** to support investment in storage. The aid is an investment support that can cover up to **60 percent** of the storage system costs and with a limit of **50 000 SEK per person**.

The requirement is that the energy storage should be connected to a renewable electricity production system built to primarily produce electricity for **local self-consumption**. Furthermore, the system need to be connected to the grid and **only private persons** are eligible for the support.

The budget for 2016 is 25 million SEK, while the budget for 2017-2019 is 50 million SEK per year.

Den här grafen har blivit sammanställd av Johan Lindahl.
Vill du använda den, hör av dig till
johan@svensksolenergi.se

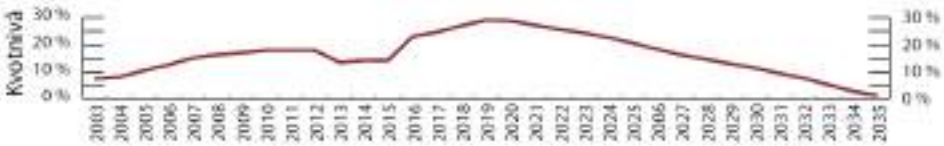
Den svenska solcellsbranschen

Elcertifikatsystemet

Elcertifikat är ett ekonomiskt stöd för producenter av förnybar el och har funnits i Sverige sedan år 2003.

För varje producerad megawattimme (MWh) förnybar el kan producenterna få ett elcertifikat av staten. Elproducenterna kan sedan sälja elcertifikaten på en öppen marknad där priset bestäms mellan säljare och köpare. Elcertifikaten ger på så sätt en extra intäkt till den förnybara elproduktionen, utöver den vanliga elförsäljningen. Köpare är aktörer med så kallad kvotplikt, främst elleverantörer.

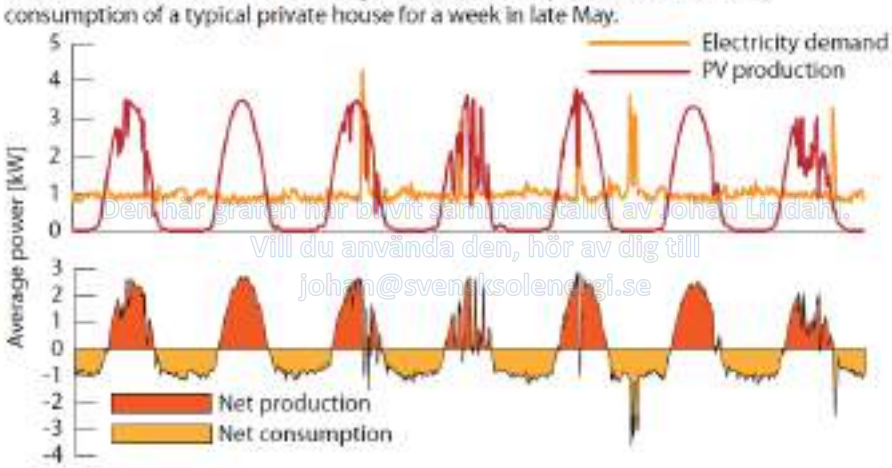
Nya anläggningar som tagits i drift efter elcertifikatsystemets införande har rätt till elcertifikat i 15 år, dock längst till utgången av år 2035.



The PV development in Sweden

Private PV production vs. demand

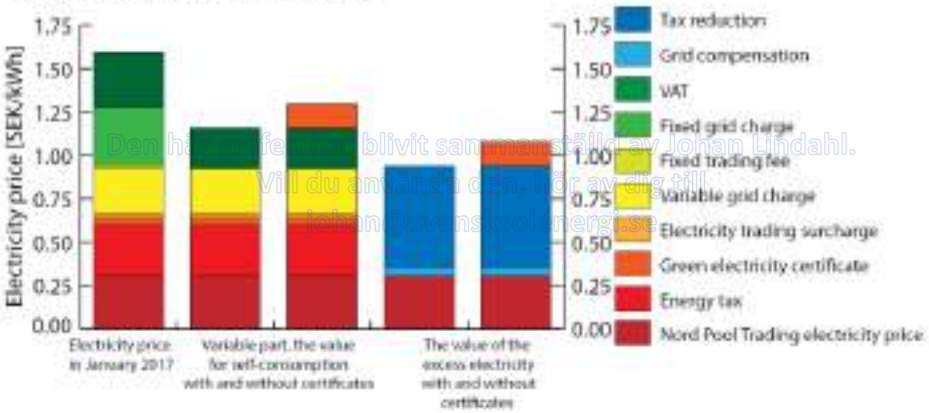
Produced electricity from a 4 kW large PV systems compared to the electricity consumption of a typical private house for a week in late May.



The Swedish PV market

Value of PV electricity

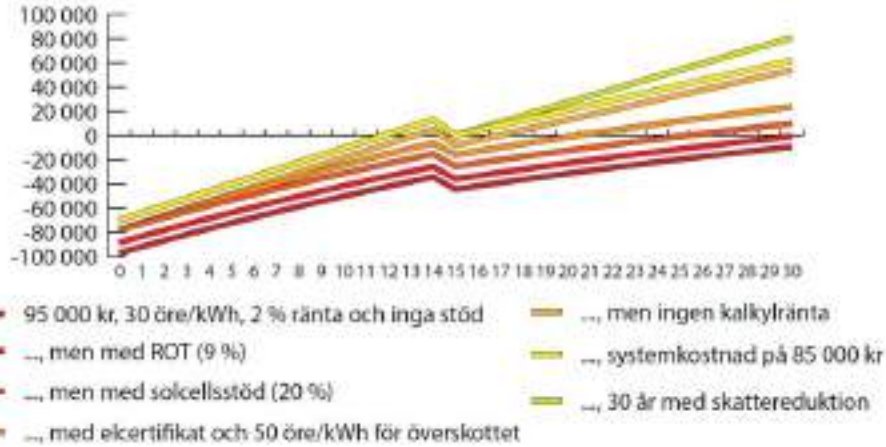
The lowest variable electricity price offers for a typical house with district heating in Stockholm with an annual electricity consumption of about 10 000 kWh/year, a 16 ampere fuse and Vattenfall as the grid owner.



Den svenska solcellsbranschen

Återbetalningstid för ett villasystem

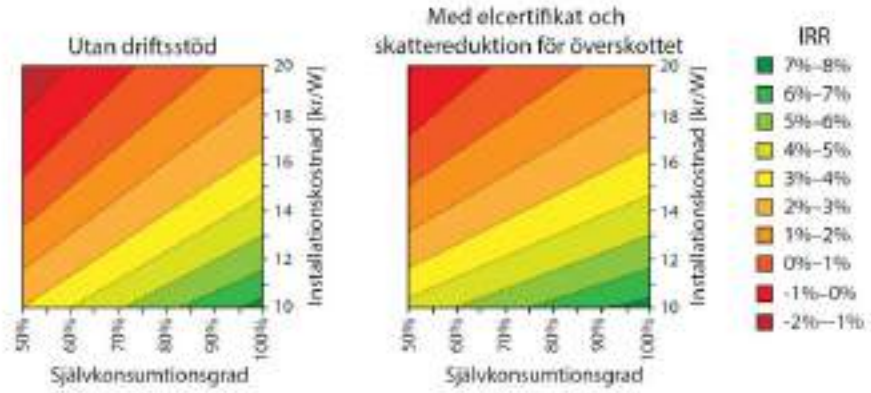
Beräkningar för ett villasystem på 5 kW, 50 % självkonsumtion och övriga standardvärden.



Solceller och ekonomi

Lönsamheten för en fastighetsägare

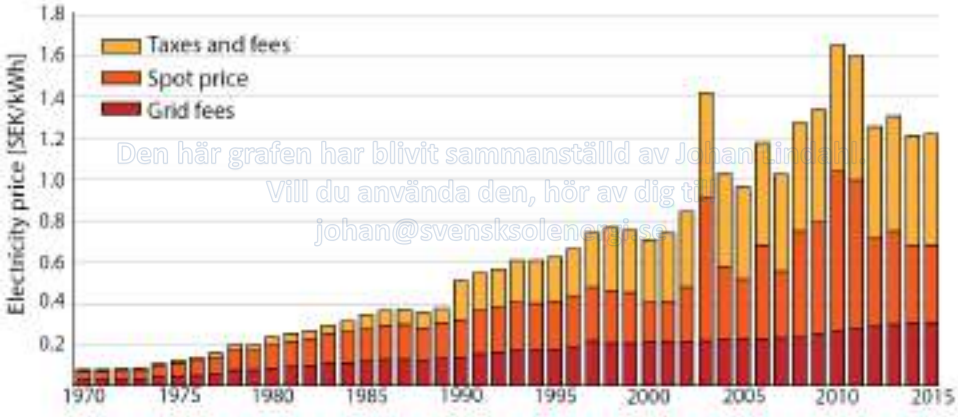
I beräkningarna har en årsproduktion på 950 kWh/kW och livslängd på 30 år använts.
IRR står för "Internal rate of return".



The Swedish PV market

Historic electricity prices for end consumers

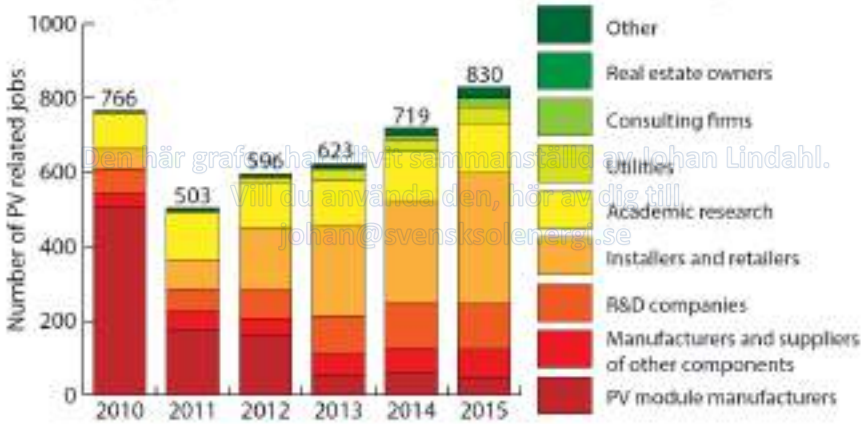
The development of the electricity price (in january) for a private end consumer with a single family house with electric heating.



The Swedish PV market

PV related jobs in Sweden

The number of jobs in the Swedish PV module production industry has dropped due to the bankruptcy of several companies. However, the numbers of people involved in selling and installation of PV systems increases as the market grows.



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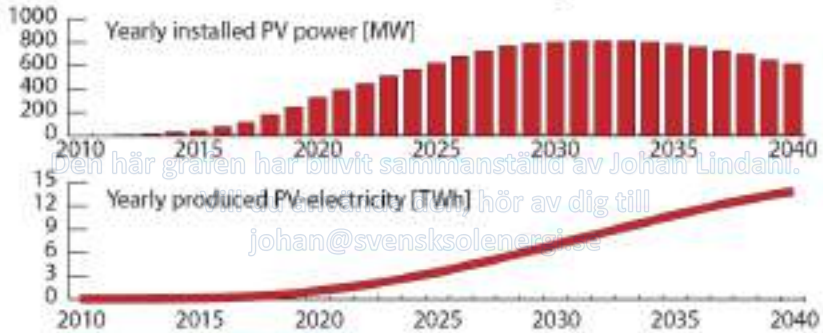
The future Swedish PV market

PV strategy of the Swedish Energy Agency

The Swedish Energy Agency has developed a draft strategy and vision for PV based on the target of 100% renewable electricity production by 2040 set by the Swedish politicians.

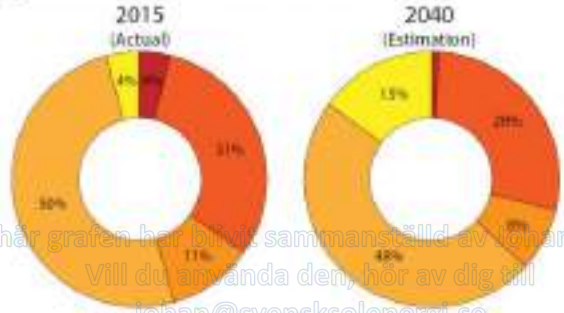
The future Swedish PV market

Construction rate to reach 14 TWh by 2040



The future Swedish PV market

Market segment shares in 2040?



The future Swedish PV market

The number of PV systems?

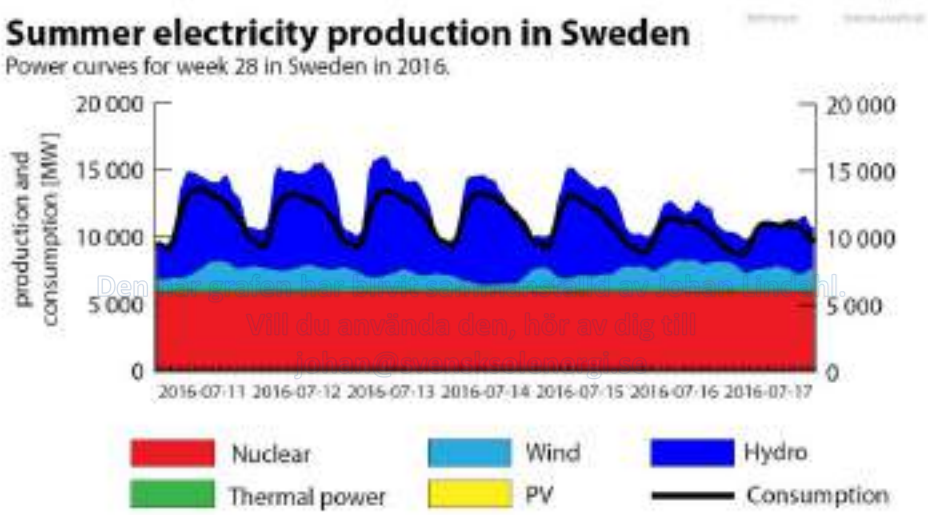
To produce 14 TWh of solar electricity in Sweden approximately 14.5 GW is needed.
With the estimated market shares, the number of systems will approximately be:

	2016		2040
Residential systems à 5 kW	~10 000	→	~800 000
Agriculture and commercial systems à 15 kW	~1 500	→	~77 000
Large commercial systems à 100 kW	~1 000	→	~70 000
PV parks à 5 MW	~3	→	~450

The future Swedish PV market

At the end of 2015 Australia had installed **1 475 000** house systems (<10kW), and **25 000** commercial systems (10-100kW). In some areas, **40%** of the houses have PV systems.

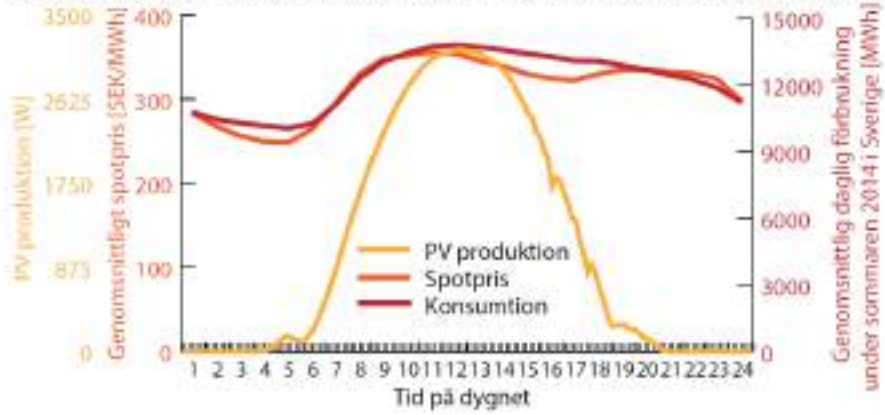
The future Swedish PV market



Solcellers påverkan på elmarknaden

Elförbrukning under sommaren i Sverige

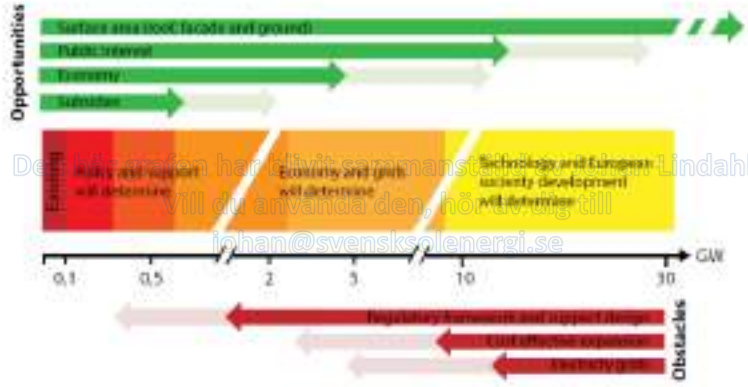
Genomsnittligt dagligt spotpris mellan den 1/6 och 31/8 under 2014 på Nord Pools spotmarknad SE3, genomsnittligt daglig elförbrukningen i Sverige mellan den 1/6 och 31/8 under 2014, och verklig produktion från ett 4 kW solcellssystem en solig dag i juni.



The future Swedish PV market

Driving forces and limits for PV expansion

Synthesis of the prerequisites, including opportunities and obstacles, for a significant PV expansion in Sweden.



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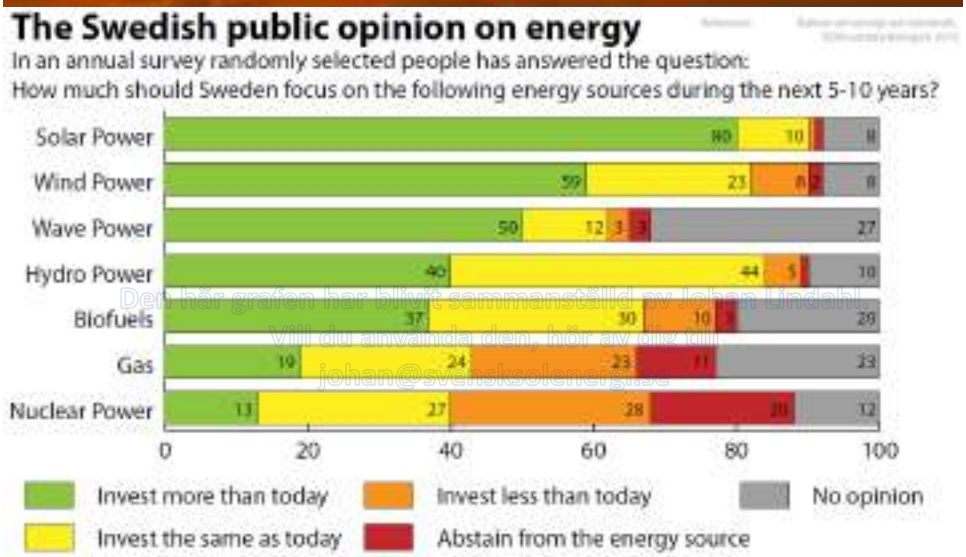
The social aspect of PV



The social aspect of PV

Motives behind private investment in PV

In surveys Swedish citizens have been asked to answer the questions:

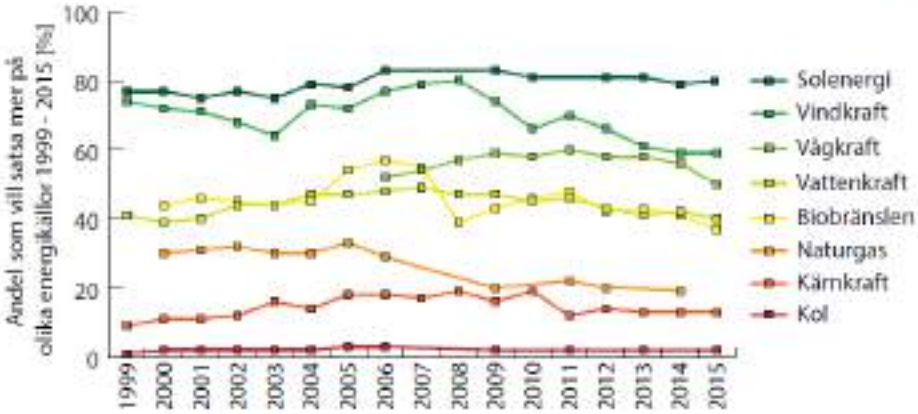
- Would you like to produce your own electricity if you had the possibility?

- Why are you interested in producing your own electricity?
- I want to...

Solcellers sociala aspekter

Historisk opinion om energi

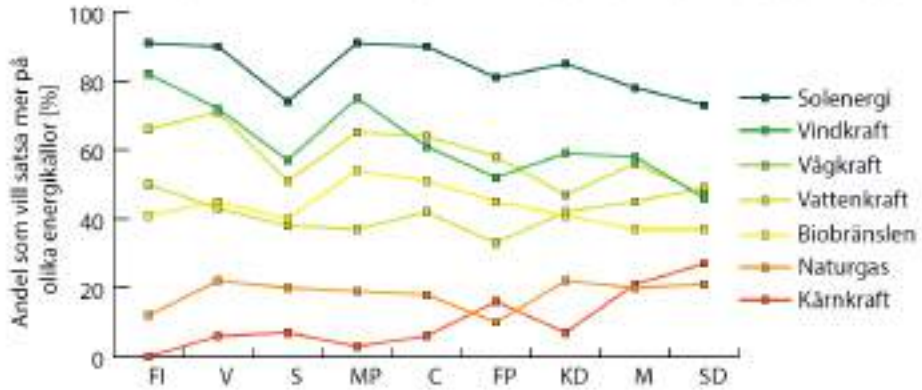
I undersökningar från SOM-institutet har ca 1650 personer genom åren fått svara på frågan:
-Hur mycket bör vi i Sverige satsa på nedanstående energikällor under de närmaste 5-10 åren?



Solcellers sociala aspekter

Politiska skillnader i åsikter om energi

I en undersökning från SOM-institutet fick ca 1650 personer 2014 svara på frågan:
-Hur mycket bör vi i Sverige satsa på nedanstående energikällor under de närmaste 5-10 åren?
Grafen visar andel positiva till att satsa mer på olika energislag efter politisk grupptillhörighet.

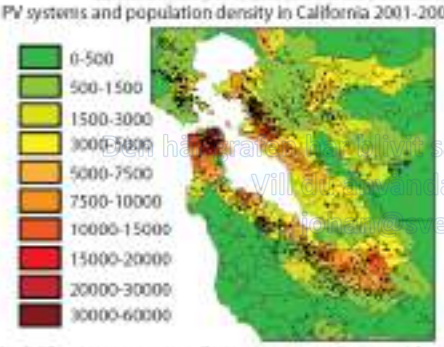


The social aspect of PV

Peer effects in the diffusion of PV systems

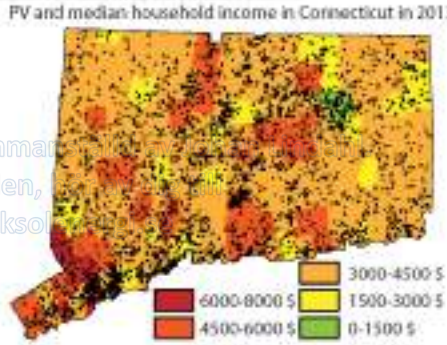
PV system diffusion does not simply follow patterns of housing density or income. Along conditions such as electricity price and incentive programs, PV diffusion show strong peer effects, which appear to increase in magnitude over time, are greater for larger installations and at the more localized street level.

PV systems and population density in California 2001-2003



In California an extra installation in a zip code area with 5000 owner-occupied homes increases the probability of an adoption in the zip code by 0.78 percentage points [1].

PV and median household income in Connecticut in 2013



Adding a PV system in a town in Connecticut one increases PV system adoption by roughly 26.4 additional systems over the next year [2].


Thank you for your attention
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Min bakgrund

- Arkitekt utbildad i Nederländerna. Arbetat som arkitekt i Danmark och Sverige. /Architect exam from the Netherlands. Worked as architect in DK & SE
- Doktorand på LTH i Lund 2010-2015. /PhD student at Lund University 2010-2015
- Nu: bitr. lektor på LTH /Now: assistant professor at Lund University
- Medlem:
  - IEA-SHC Task 41: solenergi & arkitektur
  - IEA-SHC Task 51: solenergi i stadsplanering

  /member of IEA SHC Task 41: solar energy & architecture, Task 51: solar energy in urban planning

Innehåll /content

- Teknik & utformning /technology & design
- Plan-och bygglagen (PBL) /Planning & building act
- Solenergi i stadsplanering /Solar energy in urban planning
- Solenergi i arkitektur /Solar energy in architecture
- Verktyg* /Tools

Solenergi i byggnader? /Solar energy in buildings?

- Passiv: /passive
  - Fönster (+solskydd) /windows (+blinds)
  - Trombe wall
- Aktiv: /active
  - Solceller -> el PV -> electricity
  - Solfångare -> värme /ST -> heat

Teknik: solfångare /Technology: ST (Heat)

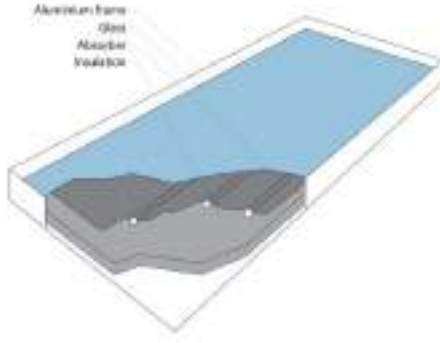
- Subgrouper /Subgroups
  - Plana solfångare /Flat-plate collector
  - Vakuumsolfångare /Vacuum tube collector
  - Oglasade solfångare /Unglazed collector

Vakuumrör
Vacuum tube

Plan glasade solfångare
Flat plate collector

Oglasade solfångare
Unglazed collector

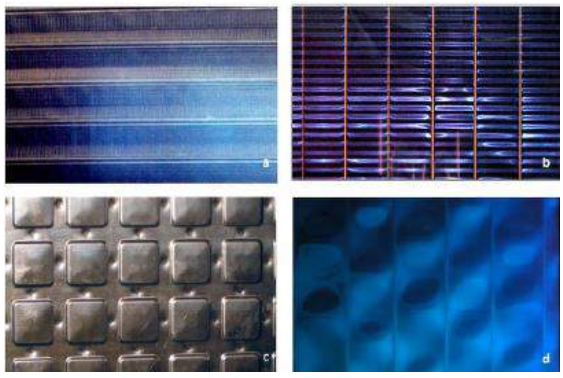
Solfångare; plan /ST: flat plate



Solfångare; plan /ST: flat plate

» Begränsad val av olika storlekar och former.
/Limited choice of dimension and forms

» Absorbatorns färg: behövs vara mörk för att vara effektiv
/absorber's colour: needs to be dark to be efficient



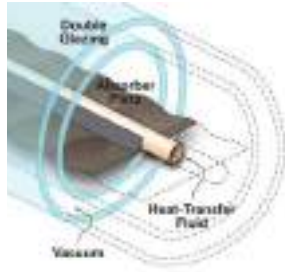
Absorbatorer

Solfån

Solfångar

Solfångare; plan /ST: flat plate

Solfångare: vakuumrör /ST: vacuum tube

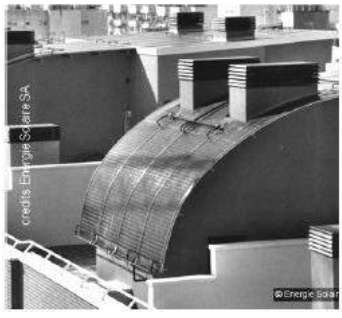


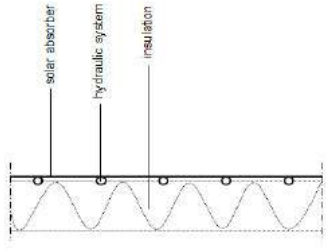
Solfångare: vakuumrör /ST: vacuum tube

> Enkla rör /Single tubes
> Standard arrangemeng: 10-15 rör /standard 10-15 tubes
> Inte mycket flexibilitet /not much flexibility

Solfån n tube

Solfångare: oglasad /ST: unglased





Solfångare: oglasad /ST: unglased

> Inte vanligt i kalla klimat /not common in cold climates

> Få produkter tillgängliga /limited choice

∆ Standardprodukter /standard products

> Absorbators metallplåt den ända synliga lager /absorber's metal sheet visible layer

Solfångare: oglasad /ST: unglased

Solfångare: oglasad /ST: unglased

Teknik: solceller /Technology: Photovoltaics (Electricity)

- Olika sorter solcellstekniker /different subgroups
  - Kristallina celler (~15-20%) /crystalline cells
  - Tunnfilm (~10-15%) /thin-film
  - Organisk / grätzelcell (DSC) (?) /dye-sensitised
  - (Begränsing 'single-junction' cells: 33%) /Physical limit: 33%

- Utseende /Look

Monokristallin

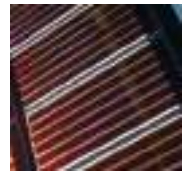
Monocrystalline

Polikristallin

Poly crystalline

Tunnfilm

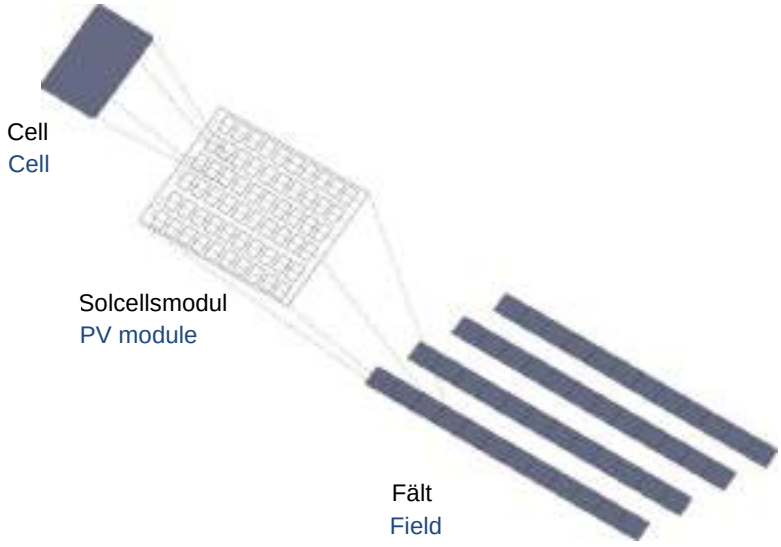
Thin film



Grätzelcell

DSC

Teknik: solceller /Technology: PV



Andra färger? /other colours?

Verkningsgrad /efficiency 15-15.8%

ColoredSolar / polycristalline

Även vitt? /Even white?

Sample	Voc [V]	FF [%]	Jsc [mA/cm²]	Efficiency [%]
Reference	0.727	71.8	36.58	19.1
White	0.714	74.7	21.38	11.4
Δ [%]	-1.8	4.0	-41.5	-40.2

CSEM

Solceller i glas /PV in glass

Onyx Solar (10-20 eller 30% genomskinlighet). Verkningsgrad okänd

Polysolar

genomskinglighet	verkningsgrad
10%	10%
20%	8.8%
30%	7.7%
40%	6.6%
50%	5.5%

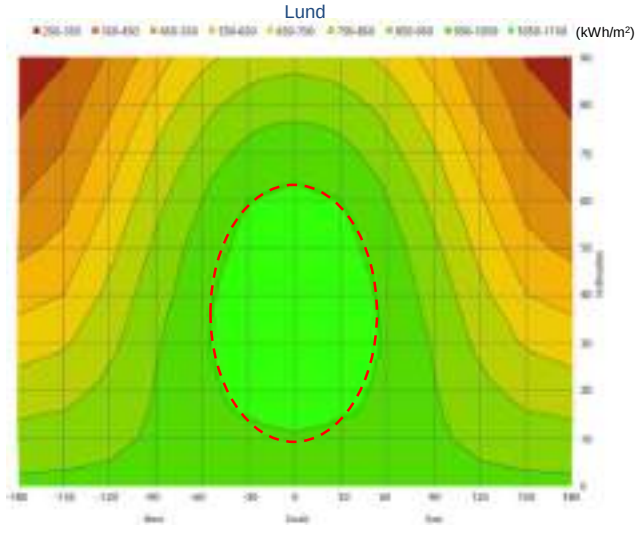
Solinstrålning: Sverige /Solar irradiation in Sweden

- Hur mycket solinstrålning får vi i Södra Sverige (Malmö) per år? (hor. yta) /How much solar irradiation in the South of Sweden?
  - Svar /answer: 1000 kWh/m^2 Optimerad vinkel /optimised angle

Photovoltaic Geographical Information System (http://re.jrc.ec.europa.eu/pvgis/)

Takvinkel /roof inclination

Årlig solinstrålning mot en yta i Lund /annual irr on a surface in Lund



Plan-och bygglagen (PBL)

Planning and Building Act

Solenergi & stadsplanering

Solar energy in urban planning

Stadsplanering /urban planning

- Ingen ’right of light’ i svenska lagar /no ’right of light in Swedish regulations’

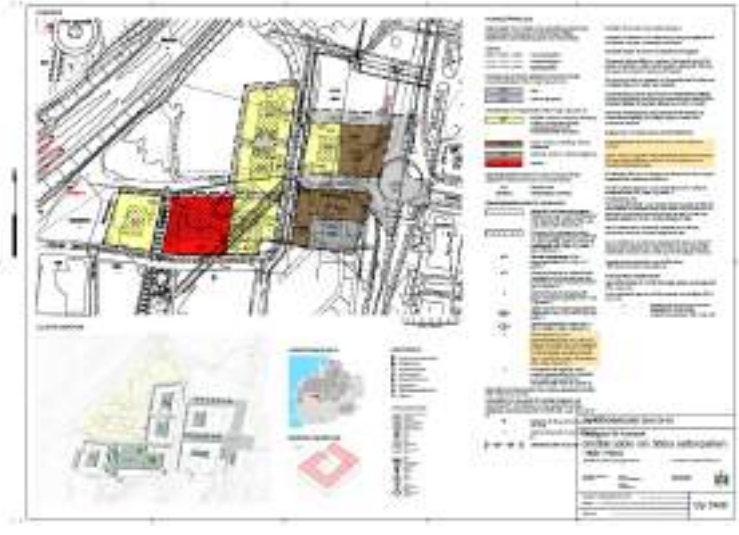
- Dagsljuskrav i BBR (DF: 1%) /Daylight requirements

Stadsplanering

- Städerna kan inte kräva att solenergianläggningar anläggs /cities cannot require that solar energy systems are installed
- I stadsplaneringen spelar byggherrarna nyckelroll! /Real estate developers play key role
- Innan januari 2015: /before January 2015
  - > Särkravsprincipen: kommunerna kunde kräva solenergi (få som gjorde) /special requirement principal: municipalties could put additional requirements
- Särkravet togs bort januari 2015: /was removed January 2015
  - > Få 'verktyg' kvar att ställa krav på byggherrarna /only some tools left to put requirements on real estate developers

-I detaljplanen kan man bara ställa 'icke-tekniska' krav /in the detailed development plan, only non-technical requirements can be set

Detaljplan /Detailed development plan



Detaljplan Hyllie / solkvarter

Taket utformas som ett sammanhängande plan som lutar mot söder så att lutning från horisontalplanet är lägst xx grader och högst xx grader och att lutningens orientering avviker max xx grader från söder. Se illustration. (PBL 4 kap 16 § punkt 1)

The roof should be designed as a continuous plane inclined to the south with a minimum slope of xx degrees and a maximum of xx degrees and slope orientation deviates max xx degrees from the south.

The roof material must consist at least xx per cent of solar cells (PV). In addition to the specified construction or total height, technical devices for local energy may be erected. These have to be integrated into the architectural design.

Byggnadsmaterial på tak ska till minst xx procent utgöras av solceller

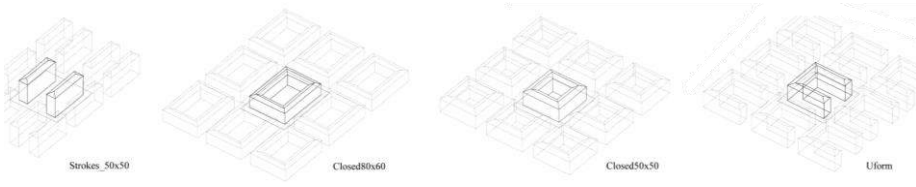
Utöver angiven byggnads- eller totalhöjd får tekniska anordningar för lokal energiproduktion uppföras. De ska integreras i den arkitektoniska gestaltningen

Stadsplanering /Urban planning

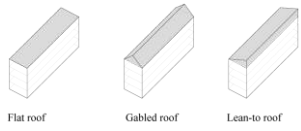
- Stadsbyggnadskontoret skapar förutsättningarna för solenergi i nya byggnader /urban planning dept. Set framework for solar energy in new buildings
  - Täthet /density
  - Orientering /orientation
  - Utformning /design
  - Takform /roof design

- Jämför på /compare at www.solarplanning.org

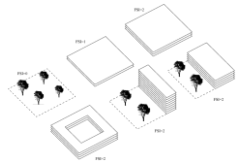
Solarplanning.org



Byggnadsform

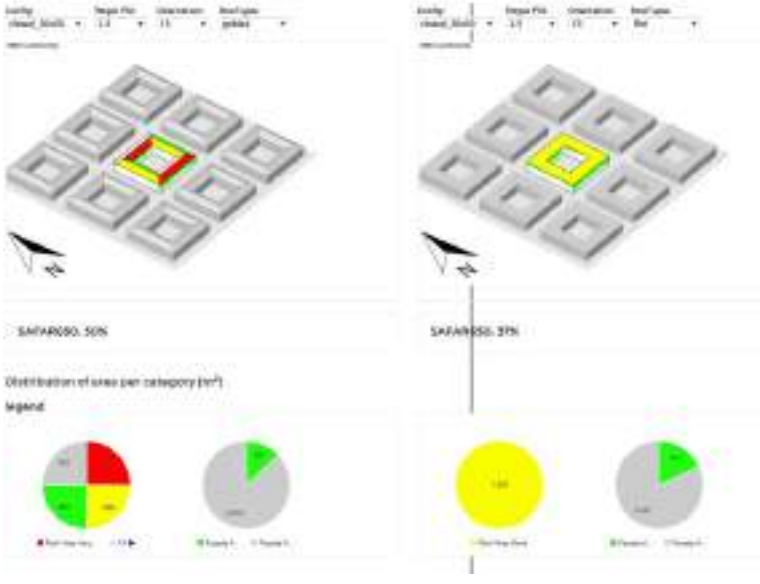


Takform

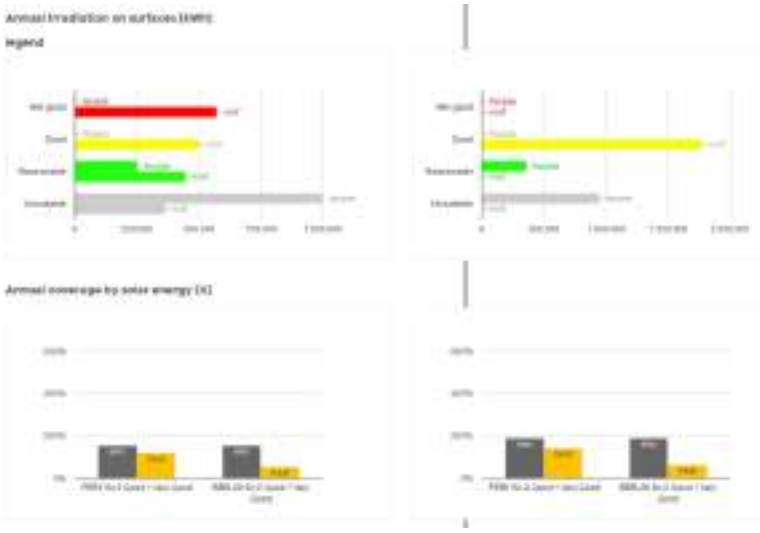


Täthet

Solarplanning.org



Solarplanning.org



Bygglov /building permit

Δ att kunna i

u need to appl

Δ asy? No, no

Rättsfall /legal cases

- Fastighetsägare vs grannar eller kommunen /building owners vs. neighbours or the municipality

Year	Name of case	Owner / external	Municipality	Heritage consultant	Länsstyrelsen	MMD	MMÖD
2013	Bengtsson & Nederman vs. city of Uppsala & Stjerna	external	Uppsala	Upplandsmuseet	Uppsala	Nacka	Svea
2015	BRF Bornholm vs. City of Malmö	owner	Malmö	Malmö Museer	Skåne	Växjö	Svea
2015	Kullberg & city of Linköping vs. Brofeldt	external	Linköping		Östergötland	Växjö	

Bygglov /Building permit

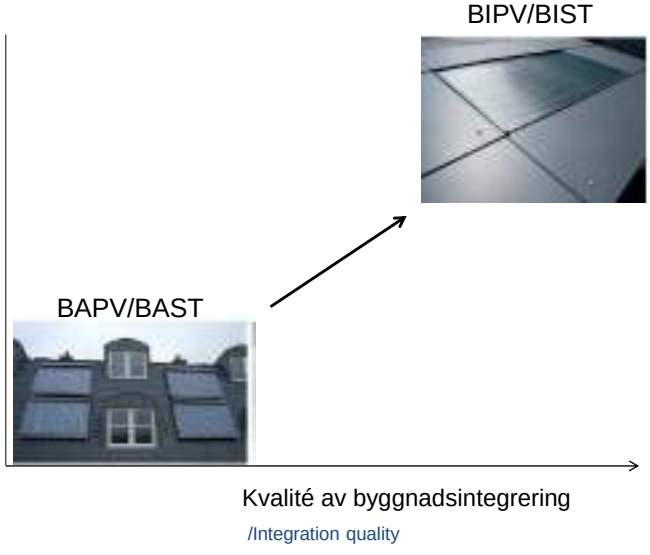
- Framtiden? /The future? (Swedish National board of housing and planning is investigating if in the future, filing a building permit for solar energy systems is not necessary anymore)

- Är det en bra utveckling? /Is this a good development?

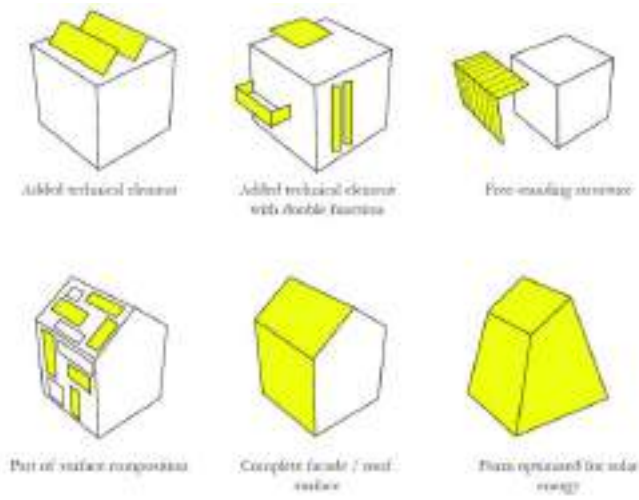
Solenergi i arkitektur?

/Solar energy in architecture

ByggnadsINTEGRERAD /Building integrated



Integreringsstrategier /integration strategies



Source: IEA SHC Task 41: Solar energy and Architecture.

Mervärde byggnadsintegrerade solsystem
/Added value of building integrated solar

- Producerar el, värme på plats /produces electricity, heat on site.
- Byggnaden är bärande konstruktionen /Building is the load bearing construction
- Ersätter konventionella byggmaterial /Replaces conventional building materials
- Arkitektonisk integrerade system kan ge högre marknadsacceptans /Architecturally integrated systems could give higher market acceptance
- Kan skylta att fastighetsägaren bryr sig om miljön /Can show that building cares about the environment

Designing with Solar Power.Prasad & Snow. 2005

Arkitektoniska integrerade system /Architecturally integrated systems

- Målet borde vara att integrera solenergianläggning i byggnaden på hög arkitektonisk nivå. /Goal should be to integrate system at a high architectural level
  - en kontrollerad och sammanhängande integration av solsystem som tar hänsyn till: /A controlled and coherent integration of the system which takes into account
    - Funktion /Function
    - Konstruktion /Structure
    - Form (estetik) /Form, aesthetics

Source: IEA SHC Task 41: Solar energy and Architecture.

Funktionell integrering
/Functional integration

- Vilken teknik (solceller / solfångare) passar bäst? /Which techonolgy fits best?
- Skuggning /Shading
- Brandsäkerhet /Fire safety
- Motstå vindlaster /Resist wind loads
- Risk för stöld /Risk of theft
- Säker kablage (PV) /Safe cabling
- Tryckskillnader (ST) /Pressure difference

Konstruktiv integrering /structural integration

∆ Integrering i klimatskal: /Building envelope integration

- ∑ Belastning på modulen–> konstruktionen /loads from modules to construction
- ∑ Undvika köldbryggor /avoid thermal bridges
- ∑ Undvika kondens /avoid condensation
- ∑ Andra materialen som står i kontakt med solceller / solfångare bör tåla höga temperaturer /Envelope materials in contact with solar products should withstand high temperatures
- ∑ Fogning bör möjliggöra utvidning /Jointing should make expansion possible

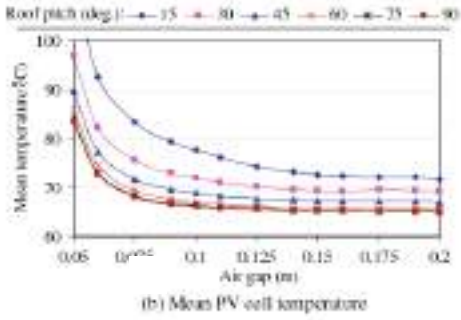
Konstruktiv integrering /structural integration

∆ Blind förankring av solcellsmoduler /Blind attachment

Väla Gård, Skanska

Luftgap /Air gap

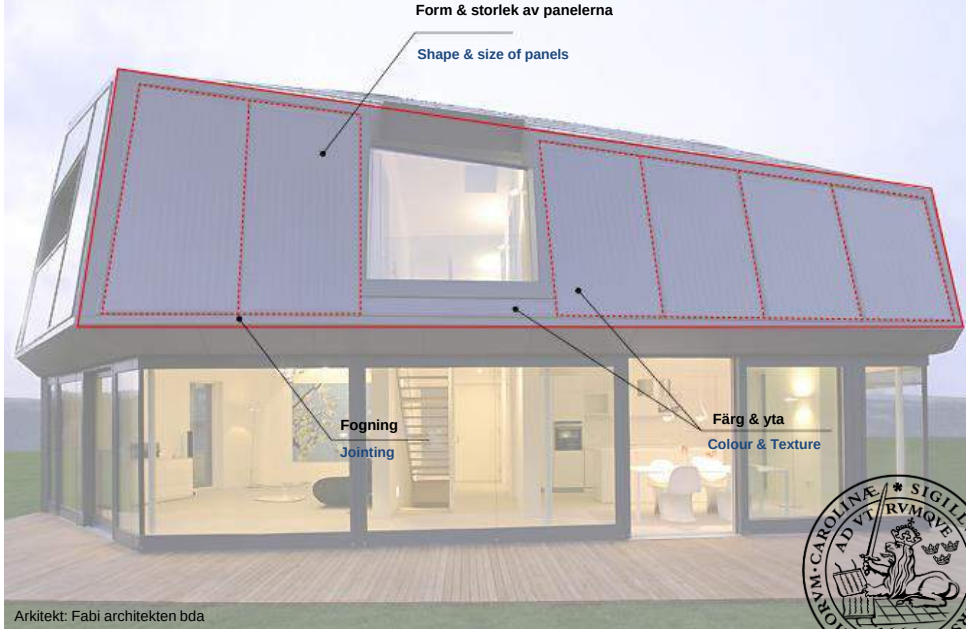
- Integrerade solceller blir varmare än icke-integrerade solceller /Integrated PV panels will get warmer than standalone panels



- Se till att ha luftgap av >0.08 m (80 mm) för att minska påverkan på verkningsgraden /Ensure an air gap of >0.08 m (80 mm) to reduce the impact on the efficiency

NREL, Numerical determination of adequate air gaps for building-integrated photovoltaics (Guohui Gan)

Arkitektonisk integrering /Architectural integration



Arkitekt: Fabi architekten bda

Bedömningskriterier /Assesment criteria

- ∆ När har man lyckats med en arkitektonisk integerering?
  /When do we speak of a good architectural integration?

- ∆ Behöver en gemensam vokabulär /need of common vocabulary

Integreringskvalité? /Integration quality

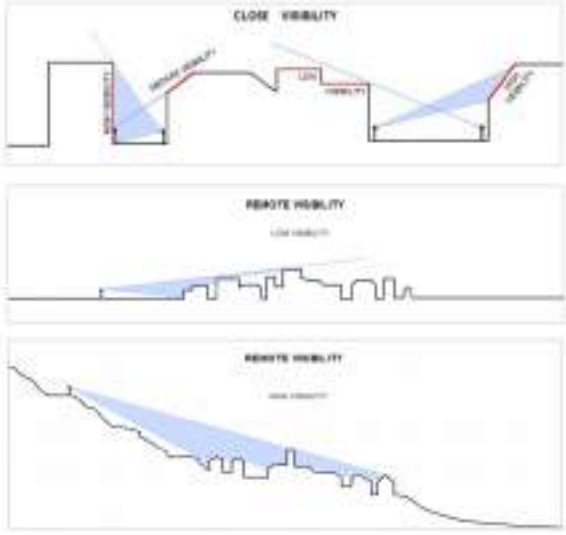
Results of a European survey conducted in 2004 on the appreciation of solar systems' architectural integration by different building professionals

Ref: Towards an improved architectural quality of building integrated solar thermal systems (BIST). MariaCristina Munari Probst , Christian

Integreringskvalité / LESO-QSV method

/integration quality

Synlighet /visibility



Munari Probst, MC., Roecker, C., Solar Energy promotion and Urban Context protection: LESO-QSV (Quality - Site - Visibility) method, in proceedings PLEA 2015, Bologna, Italy 201

Integreringskvalité / LESO-QSV method

/integration quality

Känslighet /sensitivity

High sensitivity

Medium sensitivity

Low sensitivity

Munari Probst, MC., Roecker, C., Solar Energy promotion and Urban Context protection: LESO-QSV (Quality - Site - Visibility) method, in proceedings PLEA 2015, Bologna, Italy 201

Integreringskvalité / LESO-QSV method

/integration quality

Politiksk beslutsfattande

/politicial decision

ACCEPTABILITY GRID		ZONE SENSITIVITY		
		LOW	MEDIUM	HIGH
FIELD VISIBILITY	LOW			
	MEDIUM			
	HIGH			

Fig.13: Proposed acceptability grid resulting from the crossing of zone sensitivity and system visibility

ACCEPTABILITY GRID		ZONE SENSITIVITY		
		LOW	MEDIUM	HIGH
FIELD VISIBILITY	LOW	0	1.5	3.0
	MEDIUM	1.5	3.0	6
	HIGH	3.0	6	9

Fig.14a: Example of permissive integration quality acceptance values

ACCEPTABILITY GRID		ZONE SENSITIVITY		
		LOW	MEDIUM	HIGH
FIELD VISIBILITY	LOW	2.5	5	7.5
	MEDIUM	5	7.5	9
	HIGH	7.5	9	10

Fig.14b: Example of very restrictive integration quality acceptance values

Goda exempel

/Good examples


Integrering? /integration?


uglybelgianhouses


Franziskanerkloster Graz

DETAILS | solar design

VISIBLE MATERIALS

The visible materials are natural stone and red brick pattern masonry and the crystalline PV cells as part of the window frame system. The architect chose to increase the distance between the PV cells from 5 to 40 mm to make the cells more transparent and to give the cells appearance from both outside and inside.

COLOURS AND REFLECTIVITY

The colour of the PV cells is the characteristic PV blue.

COLORS SYSTEMS/CONDITIONS

The integrated electricity cables are not visible, as they are hidden by the ceiling. The PV cells are integrated into the glass and are part of the glazing system.

IEA SHC TASK 41 **SOLAR ENERGY AND ARCHITECTURE** COLLECTION OF CASE STUDIES

DWELLING HOUSES SPINNEREISTRAßE | Austria

Photovoltaic

IEA SHC TASK 41 **SOLAR ENERGY AND ARCHITECTURE** COLLECTION OF CASE STUDIES

DETAILS | solar design

VISIBLE MATERIALS

SOLARWATT MSX 125-180 SCT (A - (sector mono)

COLOURS AND REFLECTIVITY

The PV panels are blue

FIXING SYSTEMS/JOINTING

PV glued on the aluminium sliding elements

ARCHITECTURAL EVALUATION | solar architecture

THE OVERALL GLOBAL COMPOSITION

[illegible]

DETAILED COMPOSITION OF SURFACE AND MATERIALS

The PV panels are blue, the same colour as the sun shades on the north side, which do not produce solar energy. The sliding shutters complement the bright wooden exterior of the building.

ADDED VALUES AND FUNCTION

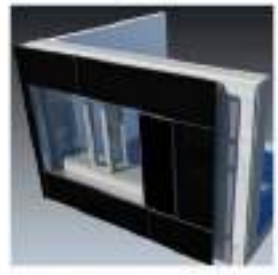
The interior environment is controllable with the moving solar shades. The building is an example of high quality residential architecture aimed at low-income families. The skeleton structure with wooden wall panels and a partially stacked ventilated block are unusual for this kind of building.

SHC

COPENHAGEN TOWERS HOTEL | Denmark

Photovoltaic

ARCHITECTURAL EVALUATION | solar architecture



THE OVERALL GLOBAL COMPOSITION

Copenhagen Towers are two tall buildings containing a hotel, conference center and offices. The building complex has a sustainability strategy, and the overall plan was orientated for optimal daylight. One of the towers has PV integrated on three of the facades.

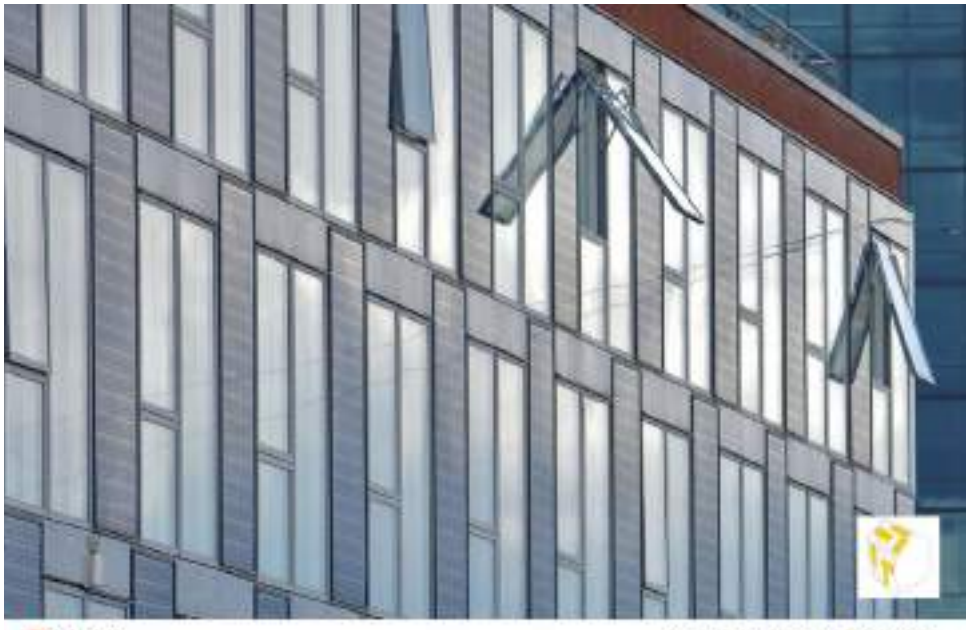
DETAILED COMPOSITION OF SURFACE AND MATERIALS

The photovoltaic facade is an example of a building integrated solution that replaces the entire facade cladding. The intention was that solar panels should be an integrated part of the design. When the photovoltaic modules were installed, the facade concept was redesigned and in order to minimize difference in appearance, black glass without photovoltaics was installed on the remaining facades.

ADDED VALUES AND FUNCTION

The integrated photovoltaic facade provides the hotel with a green image, and as a result many conferences with a sustainability agenda are located in the hotel. The facade integrated photovoltaics have a double function as facade cladding.

POWER TOWER | Austria
Photovoltaic



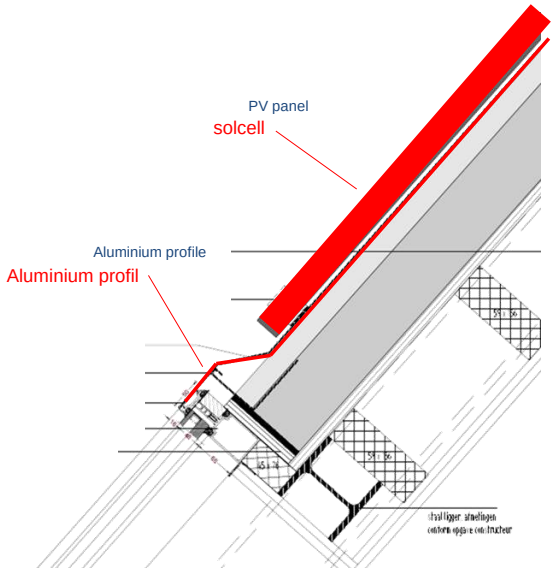
STUDENT HOUSING | Denmark
Photovoltaic

Bureau SLA

ColoredSolar

GAIA Solar

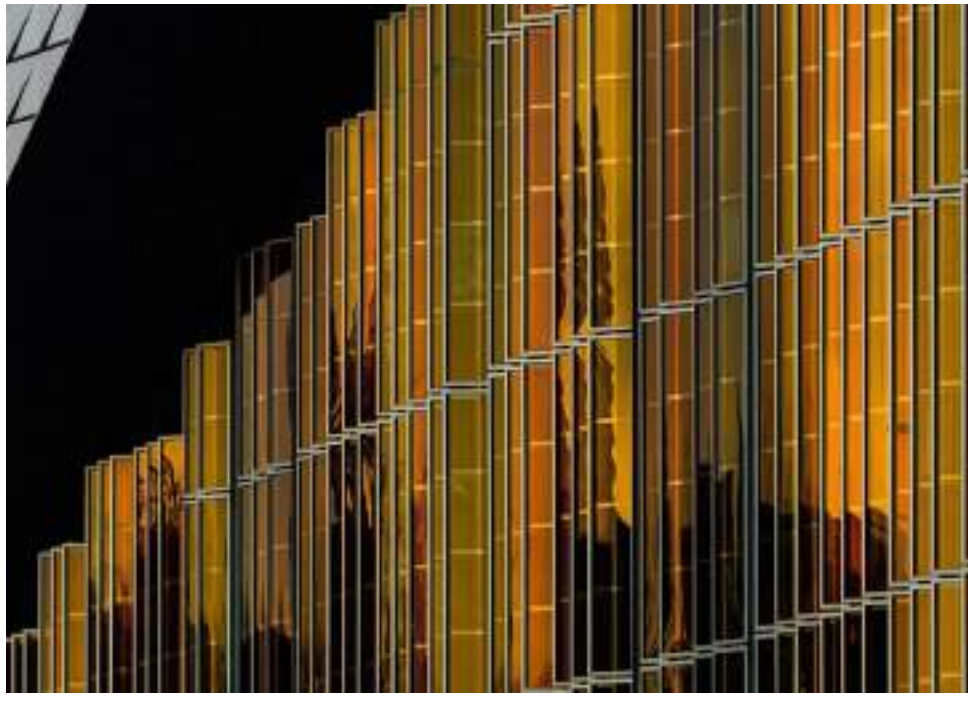
Pier Luigi



Liten luftgap!

Very small air gap!

Swiss convention centre, Richter Dahl Roca



Swiss convention centre, Richter Dahl Roca

Swiss convention centre, Richter Dahl Roca

Väla Gård, Skanska

***Verktyg** **/Tools**

Att bedöma solpotentialen / Assessing the solar potential

- Mål: att kvantifiera solpotentialen visar hur byggnadens design och byggnader omkring påverkar möjligheterna / Goal: to quantify the solar potential will show how the design of a building **AND** the surrounding affect solar possibilities

- Vad är viktigt när man studerar solpotentialen? / What is important when you want to study the solar potential?

  - Plats av (icke) lämpliga ytor /Location of (un)suitable areas
  - Hur mycket energi kan produceras? /How much energy can be produced?

Några exempel /Example of solar assessments

- Cambridge, USA

Några exempel /Example of solar assessments

∆ Cambridge, USA

Nybyggnation /New buildings

Lund Brunnshög

Malmö Hyllie


Frågor? /Questions?

Sunpark Olsgården

RONNEBYHUS

Business Concept

AB Ronnebyhus will own and manage properties with **housing** and related facilities in a **safe environment**. The operations will be characterized by the **spirit of service**, **development and a** variety of attractive housing for accommodation in Ronneby Municipality

Vision

With **pride** we offer **attractive** and **secure** accommodation to **all** our tenants.

1947 foundation

1996 AB

2600 Apt (300 agreements with Ronneby Municipality)

100 lok. 19000 m2

50 employment

15 year avg. employment

47 year average age

16 % solidity

22% Removals

3,2 % avg. vacancy

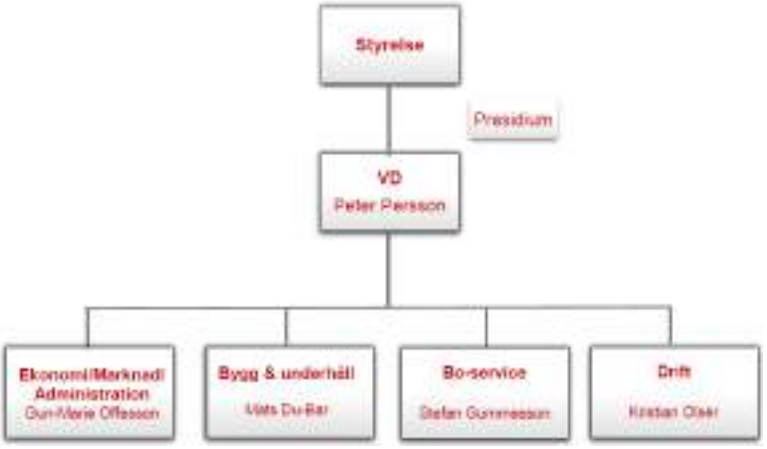
735 msek Property value

860 msek rateable

955sek / sqm average rent

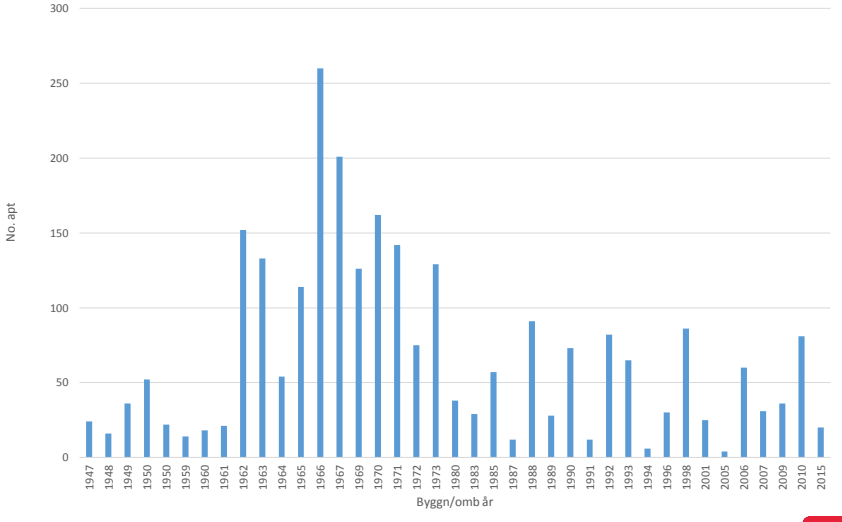
192sek Maintenance / sqm

AB Ronnebyhus Org. chart



Here we are

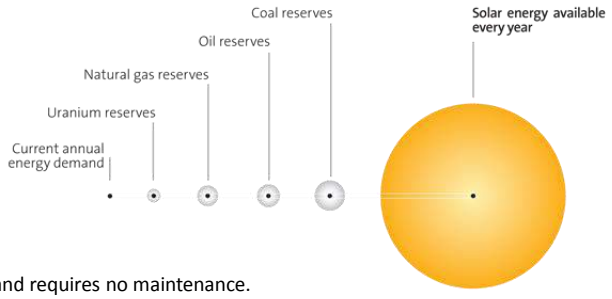
Age structure of buildings



2015 Operation

Security housing Espedalen

Why solar electricity?



Simple: to install and requires no maintenance.

Renewable: Good supply of silicon, aluminum and iron. Recycling. Energy payback <3 years.

Environmentally friendly: Silent, no moving parts and no emissions. Maintains landscape.

Small-scale and locally: Often on the existing roof, the existing electrical installation. Low transmission losses, 6-10% of the electricity produced in Sweden is lost in transmission losses.

Sunpark Olsgården

Prod. cost	3,5 msek (2,3 msek)
Contribution	1,2 msek
Calc Capacity	175 000 kwh/year

Installation

Installation

Facts of installation

- 13 pc roofs with solar cells glass / glass 30years warranty
- 1316 sq.m.
- 785pc panels of 255W / pc
- 1850 pc roof hooks.
- Approx 3850 meters aluminum profiles.
- 200,2kW peak power, among the 10 largest in Sweden.
- 175 000kWh / year, equivalent to the household electricity from 70 apartments
- Consumption in 2009, 542MWh; 2010 534MWh; 2011 521MWh; 2012 527MWh; 2013 513,3MWh
- Display on Olsgården and viewing on the website
- 5 weeks of installation time
- The entire facility was commissioned on 2014-04-28
- We got 35% of the contribution from the provincial government
- The electricity certificates for 15 years (yields about 400 thousand)

Result Sunny portal (SMA)

Year 2015; 198 MWh
Year 2016; 203 MWh

Newspaper articles

Checklist

- Hourly metering of peak effect
- Evaluating the roof pitch
- Max 35% of the total building electricity
- New production of apartments
- Possible to break the solar insolation
- Climate sensible investment
- Display for goodwill

Thank you for shown interest

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