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Transparent solar cell techniques

A profitability study

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Abstract

Transparent solar cell techniques: A profitability study

Alexander Cahlenstein

This master thesis is intended to investigate the profitability of transparent solar windows which concentrates parts of the invisible light to a solar cell.
This makes it possible to generate electric energy while the window still is transparent. Other gains apply such as the removal of solar radiation into the building which makes it possible to decrease the amount of energy needed for cooling. The study will investigate profitability of transparent solar windows by simulating energy used for heating and cooling and by investigating profitability of the produced energy. The results show that it is not economically justified to use transparent solar windows for electricity generation with present techniques and with Swedish climate. It is however economically justified to use as a isolating window in buildings.
The master thesis has been completed at Skanska in Stockholm.

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Sammanfattning

Förnybara energikällor utgör idag 52% av Sveriges totala energiproduktion. International energy agency (IEA) rapporterar om en trolig världsomfattande förnybar energiproduktion på runt 26% år 2020.**[1][2]** Ett av de drivande länderna är Kina som idag ser en boom i sin förnybara energiproduktion, något som skulle kunna innebära en kraftig framtida ökning av världens totala förnybara energi.**[3]** Denna högaktuella marknad ställer nya krav på hållbarhet och utmanar olika branscher att innovativt hitta nya sätt att både minska energibehovet och producera förnybar energi. Parallellt med denna utveckling sker en urbaniseringsprocess i Sverige såväl som utomlands. Statistiska centralbyrån (SCB) uppskattade 2015 att 85% av Sveriges befolkning bor i tätorter, vilket i sig är mer effektivt ur ett energiperspektiv. **[4]**

Medan utvecklingen av förnybara energikällor fortskrider i högt tempo behövs innovativa lösningar för energiproduktion som inte bara är anpassad för extern produktion utan även lokal sådan, där förnybara energikällor kan integreras på de platser där energiåtgång är stor. Därutöver kan total energiåtgång minskas om man på de platser med stor energiförbrukning effektiviserar själva användandet av energin. Detta kan göras mer effektivt ju mer koncentrerade platserna med hög energiförbrukning är och går alltså hand i hand med såväl utvecklingen av förnybar energi som den pågående urbaniseringen. Resultatet av att energieffektivisera platser med högt energibehov skulle vara en lägre energiproduktion från fossila energikällor vilket i sin tur ger större plats åt förnybara alternativ i den totala produktionen. Trenden går mot boende i urbana miljöer där man bygger tätt snarare än glest. Ur arkitektonisk synvinkel är ett lyckat koncept att använda stora glasytor i fasaden till större byggnadskomplex för att få en luftig och ljus inomhusmiljö. Därav följer tekniker som försöker integrera solceller i fönster för att generera el men bibehålla transparensen som ett vanligt fönsterglas. Detta kan även innebära en termisk energivinst då en viss del av den energi som värmer upp byggnader då utesluts. Nuvarande tekniker innefattar i huvudsak sådana som innehar en matrismönstrad solpanel som i sin tur är placerad ovanpå eller inuti ett fönster för att sänka transparensen men uppfattas som genomskinligt från avstånd. Andra transparenta solcellstekniker utnyttjar färgsensitering för att skapa en semitransparent yta eller luminiscens för att koncentrera en del av ljusspektrumet till en viss plats där en ordinär solcell sedan placeras. Existerande tekniker är i nuläget relativt outforskade sett till användningsområde och förbättringspotential, delvis som en produkt av deras nuvarande låga verkningsgrad men också då teknikerna är i ett tidigt skede.

Denna rapport kommer analysera och undersöka de affärsmässiga fördelar och nackdelar med transparenta solcellstekniker som kan integreras i byggnader innehar. Rapporten görs som en del av två i ett arbete tillsammans med Andreas Nilsson. Specifikt kommer denna rapport fokusera på en

undersökning av de termisk energivinster eller förluster som uppstår vid användande av potentiella tekniker för elgenerering i fönster tillsammans med smarta reglertekniker. Resultatet tolkas ur ett affärsmässigt perspektiv med hjälp av lönsamhetsberäkningar och en jämförelse görs mellan den utredda tekniken och nuvarande tekniker så som fasadmonterade paneler, takmonterade paneler och semi-transparenta fönster. Denna lönsamhetsundersökning skall ge läsaren en överblick över tekniker som troligen kommer bli kommersiella inom en snar framtid och vilka av dessa som, ur ett affärsmässigt perspektiv, kommer vara användbara i ett framtida byggande.

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1 Introduction

1.1 Skanska

With 10 200 employees in Sweden and 42 900 employees in the group, Skanska is one of the largest construction corporations in Sweden. The company was founded in 1887 and today it has activities in 10 European countries and the USA. More than two thirds of Skanska's projects measures against Skanska Color PaletteTM **[5]**, a strategic framework and communication tool for Green Business, that has been developed to measure and guide the company's performance on the journey with destination Deep Green. The Color Palette is a concretisation of the green vision of Skanska. It is divided in 3 colors that span from beige, green to dark green. The darker the green, the less environmental impact the project has. To further concretise the green map, 4 focus areas are applied: energy, climate, material and water **[6]**.

One of the biggest challenges for the construction industry is to develop solutions for effective energy usage. One solution could be to use buildings as local electric energy production plants or by making them more effective in its energy usage. Since Skanska has long experience of working on large projects such as Öresundsbron, Nya karolinska hospital, 30 St Mary Axe and Heron tower in London; as well as Oculus at new World Trade Center in New York, it is a market actor striving for being in the forefront in the development of new energy effective techniques for buildings **[7] [8] [9] [10] [11]**.

1.2 Motive

As renewable energy alternatives are a growing factor of the total energy production worldwide, **[12]** new products could potentially expand the market to generating energy locally where it is needed, which relieves the large scale power plants. Solar cells on roof tops started as more of a green investment than means for a profitability increase. With the correct implementation of new technologies green investments could also become a proper mean for higher profitability. This, in turn, would force the development of local energy production technologies. However, because of the Yes-In-My-Backyard-effect (YIMBY) such a local energy production unit would undoubtedly be renewable. The YIMBY-effect is the opposite of Not-In-My-Backyard (NIMBY), namely to tolerate something if it is not in sight of the owner.

The topic is of a contemporary relevance as new legislation will also provide better conditions for further development of local energy production, as can be seen in San Francisco city's legislation for constructing all new buildings with solar panels mounted on the roofs; or Dubais mandatory regulation to have every rooftop mounted with solar panels until 2030 **[13]**.

For a construction company, such as Skanska, techniques suitable for energy generation in buildings are interesting. The most suitable techniques include solar cells, as they easily can be integrated in facades and roofs as a small scale energy production unit. However, one big source of both thermal losses and facade area on buildings is the windows. If solar cells could be developed to support an acceptable transparency while generating electricity, both the profitability and sustainability of the building could increase.

As one of Swedens leading construction companies, Skanska is interested in keeping track on contemporary subjects and market change; which could strengthen the position as an innovator on the construction market. As urbanisation is ongoing, sustainability is important during construction as well as after completion of construction. A sustainable building should minimise the need for energy and also use as much renewable energy as possible.

1.3 Objective

This work strives to analyse the market on transparent solar window technologies and draw conclusions on whether they could have a role on a future market. This is done by investigating electricity generation capabilities, economical profitability and thermal energy gains or losses due to removal of electromagnetic radiation. The report also aims to give Skanska an understanding of the current market situation of transparent solar window techniques as well as investigating auspicious techniques. The report can be used as a basis for further investigations on the subject.

1.4 Limitation

The report will not focus on investigating differences between transparent solar window techniques. The simulations and life cycle costs/gains calculations are solely dependant on efficiency, costs and capability of removing certain areas of the electromagnetic spectrum.

The thermal energy study will also focus on techniques that are, or can be manipulated into being transparent. The common ground for the study will be techniques that do not have an effect on visual ergonomics. As visual ergonomics in windows have a large impact on human perception, it is assumed that semi-transparent techniques can't be used in windows, but rather as a semi-transparent facade that can add light inside buildings as a complement to transparent windows **[14]** **[15]**. This report will be limited to treating transparent solar cells and transparent solar concentrators equally from a energy savings perspective and a profitability perspective. The common name for techniques in this report that harvest energy from the sun while being transparent will be transparent solar windows.

This report will be limited to not investigating environmental impact by using certain techniques and materials.

2 Method

2.1 Studies

2.1.1 Foundation

The pre-studies are mainly conducted by telephone interviews and internet studies with the aim of getting insight into corporation technologies and commercialisation processes. Also having a close contact with Skanska employees creates a fundamental understanding of how products are chosen and how products gain Skanskas interest. Literature studies further anchor the understanding of why a certain product has a commercialisation potential and will be presented in this report by briefly explaining the necessary solar cell physics and techniques for transparent solar windows.

2.1.2 Thermal energy study

This report will investigate the thermal energy profile and profitability tendencies for transparent solar window techniques. For investigating the thermal energy profile, simulations for a typical building in Stockholm are completed in 3D-modelling program IDA ICE. Support for IDA ICE and thermal investigations is available from Skanska Technical Support Unit. In IDA ICE an alternative thermal isolating technique with electrochromic mirrors is simulated and uniformly processed and compared to the transparent solar window technique. For each type of thermal isolating window technique a parallel simulation will be done in Upington, South Africa; as Upington has some of the highest solar radiation levels in the world. The simulation cases will thereby consist of a building with ordinary 3-pane windows with the same parameters in Upington and Stockholm, a building with a transparent solar window concentrator built into the windows and a building with a control system turning a transparent window into a mirror during non-working hours. These simulations will be compared and analysed.

2.1.3 Profitability study

The report will continue by calculating the profitability potential of different technologies. The profits will cover tendencies for 4 different products. Roof mounted panels, facade mounted panels, semi-transparent solar cell facades and transparent solar windows. As transparent solar windows hardly are commercial, the profitability study will focus on studying and analysing if the product will have a potential to become profitable. This analysis doesn't require a precise investment cost, but rather need a precise yearly income which can be studied with precision. The profitability study will use energy savings from the thermal energy study to calculate yearly income.

2.1.4 Support and contact

During the studies, interviews by phone and mail has been done to representatives for different companies: SolTech, Solkompaniet and Norden Solar. These companies are some of the largest in Sweden with SolTech probably being the largest of its kind. These companies has given understanding of costs and the market situation.

2.2 Project of interest

To compare differences in the thermodynamic behaviour related to windows, we have chosen a building, Sergelhuset, in the central part of Stockholm as a study subject. Sergelhuset is a suitable object for investigating thermodynamic losses, as it is large and therefore thermodynamical differences will have a greater impact on economic gains. Sergelhuset is situated in the city center and is soon undergoing a large renovation process. The building consist of two parts where the eastern part mostly is a hotel and the western part houses stores and companies. As the eastern part of Sergelhuset mostly is covered in shadows by the surrounding buildings, this report will only analyse the western part. Skanska has been in charge of the planning phase of the renovation. This report will completely rely on the schematics made by Skanska and act as if the building is being renovated by Skanska. The results are general and can be applied to any building in a city center.

3 Current market situation

The market today mainly consist of technologies for using the area of facades to generate energy with matrix-shaped solar cells made of a highly effective material. The matrix-shape creates the illusion of transparency from a distance, therefore being a semi-transparent solar cell. This technique is commercial and companies such as SolTech use this technique in buildings built by large scale construction companies, such as Vallasskolan in Linköping which has been built by Skanska **[figure 1] [16]**. From a distance the matrix-shape is almost invisible making it semi-transparent. As it uses the same technique and materials as ordinary solar cells the efficiency is directly related to the solar cell area fraction. This makes the technique somehow limited and it is arguably a gateway-technique that raises awareness of the possibilities to integrate solar cell technologies into windows.

Figure 1: SolTech windows built into the facade of Vallaskolan by Skanska

At Université de Lausanne, Switzerland, the technical faculty building is equipped with windows made of dye-sensitised solar cells which generates electrical energy **[figure 2]**. The technology is nicknamed Grätzel cell after Lausanne scientist Michael Grätzel whom published an article on the solar cell in 1991 **[17]**. This technology is used as an architectural detail that also generates electricity. It is not to be seen as commercial yet because of its limits due to the colouring effect of the dye in the solar cell. The technique could however have a potential market role as a architectural effect in combination with other energy generating techniques. The low complexity and bendable attributes of the dye-sensitized solar cells gives it another potential market role as a small scale energy generator used indoors to reduce maintenance costs for changing batteries in i.e. door handles with card readers in hotels. The largest dye-sensitised solar cell factory is currently owned by Exeger in Stockholm, Sweden. Exeger is working on bendable dye-sensitised solar cells that could be used in facades outside or inside buildings. The commercialisation phase has just begun and in the coming years Exeger plans to increase its sales. A dye-sensitised solar cell can thus be summarised as a low effective, semi-transparent technique in its early commercialisation phase **[18] [19]**. While Exegers main focus at the moment is techniques in a context of internet of things, Thessaloniki based corporation Brite Solar uses DSSCs to design transparent solar cells for windows.

Figure 2: School of technology in Lausanne with dye-sensitized solar cells as semi-transparent windows

Michigan based startup company Ubiquitous released a concept product of a transparent concentrator with solar cells at the edges and salt-crystals integrated in the concentrator material. The salt-crystals work as integrated micro-prisms which concentrates light to the edges of a window where solar cells convert light into electric energy. Further more the salt-crystals can be integrated in such a way that it only uses parts of the light in the invisible spectrum. Ubiquitous recently launched this new technology on the market which could take market share from corporations selling matrix based techniques and dye-sensitised techniques. The company received publicity since it is the first product to be released with a fully transparent solar cell **[20]**.

To summarise the market of transparent solar windows or semi-transparent solar cells today consist of matrix shaped solar cells, dye-sensitised solar cells and luminescent solar concentrators. These can be ranked in the written order starting from most commercialised to least commercialised. On the market as a whole the dye-sensitised solar cells and luminescent solar concentrators may find new applications such as a technique for internet of things. Using LSC-techniques as a tool for the internet of things is further strengthened by one report from a Japanese study which investigates using integrated LSC in displays for powering the backlight of the screen **[21]**.

4 Technical background

In this technical background a number of techniques are described which are proposed to having a role when developing a smart transparent electricity generating solar cell. The background strives to give the reader an understanding of the different techniques, as they will be used in further contexts later in the report. The technical background also strives to clearly explain the limitations for semi-transparent and transparent solar windows.

4.1 Solar cell physics

4.1.1 Photovoltaic cells

The basic idea of photovoltaic energy conversion relies on quantum theory. Packets of energy, photons, excite electrons in a solid and make them free to move. In a photovoltaic energy conversion device some sort of asymmetry within the material pulls the electrons before they are relaxed. The energy of the excited electrons generates an electromotive force. The energy within the photons depend solely on the frequency of the light. Differing frequencies of light create different colours and different light absorbing materials cause different colours to be reflected from or absorbed in the solid material **[22]**.

$$J_{sc} = q\int b_s(E)QE(E)dE$$

Equation 1: The generated photocurrent J_{sc} by a solar cell as a function of the quantum efficiency QE.

The photocurrent generated by a solar cell at short circuit can be explained according to equation 1. The cells quantum efficiency QE(E) is here the probability that an incident photon of energy E delivers one electron to the external circuit and $b_s(E)$ is the incident spectral photon flux density **[23]**.

The energy E in this context depends on Planck's constant, the speed in vacuum c and the wavelength, or frequency of light. The relationship is shown in equation 2. A typical QE curve is shown in figure 3 **[24]**.

$$E = \frac{hc}{\lambda}$$

Equation 2: The energy in relation to Planck's constant, the speed in vacuum and wavelength.

As seen in figure 3 the possibility for a photon to deliver an electron is dependent on which compound is used **[figure 3]**. A multi-junction solar cell could here be used to efficiently convert light to energy. Ge is a suitable element for a high QE at wavelengths higher than the maximum visible wavelength. GaN and CdTe would be more useful compounds for a high QE efficiency at wavelengths lower than the lowest visible wavelength **[25] [26]**.

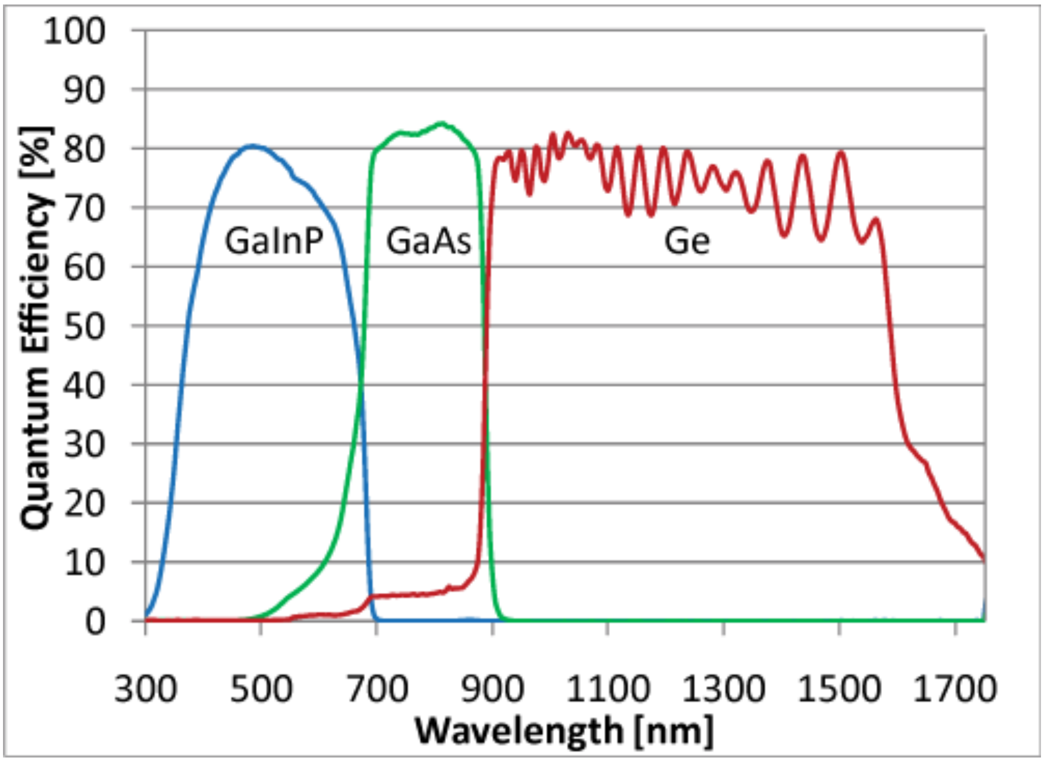

Figure 3: The spectrum of three different compounds with different QE efficiencies ***[24]***

A multi-junction solar cell is basically different layers of p/n junctions which has a corresponding different QE spectrum. Figure 3 shows a triple junction solar cell constructed with different materials **[figure 3]**.

4.1.2 Illumination

The American society for testing and materials (ASTM) has compiled measured values for three different cases of solar irradiance. These cases depend on whether the radiation levels measured are terrestrial or interstellar. ASTMs compilation is commonly used to compare solar cell panels on a common basis. The interstellar graph, AM0, is measured with air mass coefficient of 0. The terrestrial graph, AM1.5, measured with air mass coefficient of 1.5 **[27] [28]**. The AM1.5 reference spectrum is used and shown plotted in MatLab in figure 4. The last graph is designed for concentrators and is calculated as the sum of direct light and the circumsolar light component in a disk 2.5° around the sun. The integrated energy of AM0 is 1366.1 W/m^2, 1000 W/m^2 for AM1,5 and 900 W/m^2 for the AM1.5 direct plus circumsolar. For solar cells in this report AM1.5 will be used.

The solar irradiance spectrum is dependent on location and time of day and is usually used with a reference spectrum to compare solar cells with ease. The average annual global radiation in Stockholm is around 115 W/m^2 **[29]** compared to approximately 231 W/m^2 in Upington, South Africa, which is known for its high solar radiation **[30]**.

4.2 Transparent solar windows

Transparent solar windows techniques use parts of the invisible solar spectrum to generate electricity. This is made possible by concentrating certain wavelengths to an area where a ordinary solar cell are mounted. As the invisible spectrum doesn't contain as much energy as the sum of the full energy spectrum the techniques always suffer from lower efficiency than solar cells using the entire electromagnetic spectrum for electric energy generation.

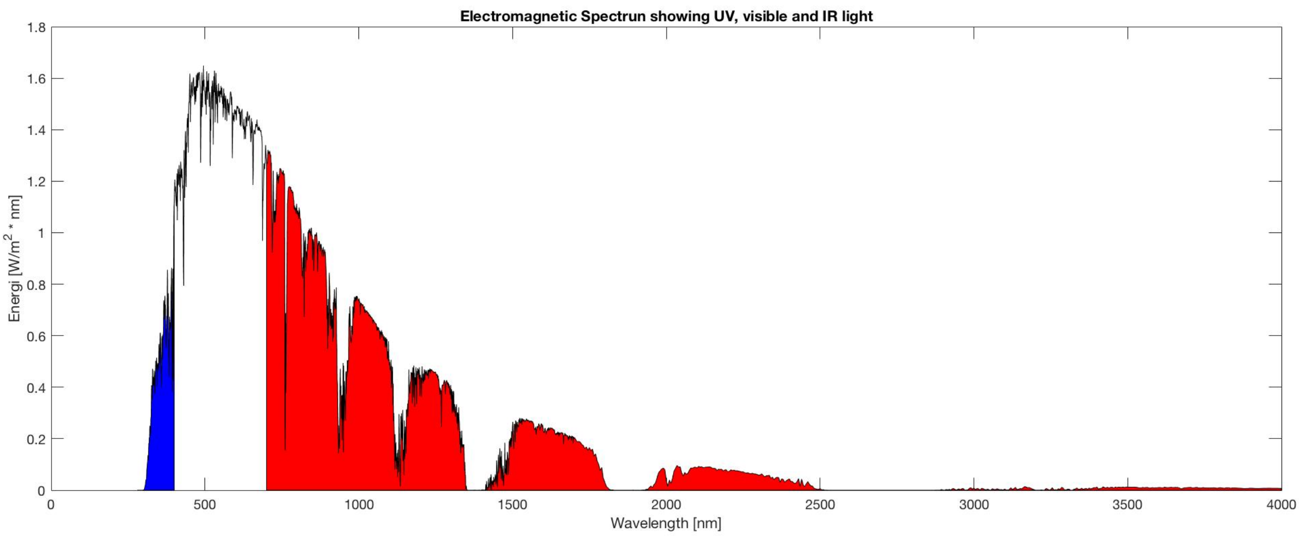

Figure 4: The electromagnetic spectrum showing UV light in blue and IR light in red

4.2.1 Luminescent solar concentrators (LSC)

A luminescent solar concentrator is constructed either by mixing quantum dots or luminescent dye molecules with a transparent material, preferably acrylic, or painting it directly on to the surface of an acrylic material. The quantum dots, or luminescent dye molecules, work as micro-prisms that absorb a fraction of energy derived from a specific interval of wavelengths. As this fraction of energy is lost during the process, the wavelengths are altered proportional to the dissipated energy. The wavelength-alteration filter makes it possible to control the energy spectrum of light. Wavelengths above the energy levels of the visible spectrum can be absorbed by the molecules and then re-emitted with a longer wavelength; this luminescent process is called fluorescence. By using this concept together with acrylic materials that contain refractive indexes chosen to specifically bend wavelength at a certain dispersion level, the concentrator can be constructed to control which wavelengths have a larger outcome angle than the critical angle, all according to Snell's law.

When the angle between the output light beam and the material surface is larger than the critical angle of the material, total reflection is achieved **[30]**. In this way intervals of wavelength are filtered so that they are directed to the edges of the acrylic material and others pass through the material. In those edges, solar cells are mounted that convert the light into an electric current. The electromagnetic spectrum with AM1.5 is shown in figure **[figure 4]**. The light fraction of the invisible to the full light spectrum is calculated from the plot to 57%. The MatLab code used for the plot and the light fraction calculation can be found in the appendix **[Appendix A]**. The efficiency for a typical fluorescent material (the concentrator) of 1 mm is 15%. This can be calculated from the values in table 2 in the Japanese article "Transparent solar concentrator for flat panel display" **[21]**. It should be noted that according to figure 5 in the same article, the internal efficiency would be doubled for a material of 2 mm. This would lead to a higher total concentrator efficiency. The solar cell in the article is compared with and without a light guide plate which concentrates the light to the surface of a regular solar cell. By normalising the measured power to area, the two cases are divided to find the efficiency between direct sunlight to the solar cell and the concentrated case, as can be seen in equation 3.

$$\frac{(I_1 \times U_1)/A_1}{(I_2 \times U_2)/A_2} = Efficiency$$

Equation 3: Relation between power divided by area with and without an acrylic light guide plate

The efficiency for a regular solar cell is 15% which, according to equation 4, results in a total efficiency of approximately 2.3%.

$$Eff_1 \times Eff_2 = 0.15 \times 0.1508 = 0.02262$$

Equation 4: The product of efficiencies, showing the total efficiency

The theoretical maximum efficiency of a multi-junction solar cell is 86% **[32]**. With this multi-junction solar cell a total efficiency of 13% could be reached. The theoretical maximum limit of efficiency for a multi-junction solar cell module, perfectly using the light outside the visible spectrum and ignoring internal losses result, is approximately 49%, as calculated by summarising the energy in the invisible light spectrum and multiplying with the ideal multi-junction efficieny. This efficiency is however not possible to reach with the present technique of wavelength control as it is based on luminescence and therefore a power dissipation is required to make it possible. The transparency of the acrylic glass is up to 92% for a 6mm thick sheet of glass **[33]**. With a thicker glass, the transparency is lowered and the efficiency is higher. Worthy of mention is that according to Skanska Technical Department a transparency of around 75-80% or even less is used in normal windows. This would make it suitable to lower the transparency of the whole spectrum to even further heighten the efficiency. This could possibly be done by adding another type of micro-crystal coating to the surface of the glass.

4.3 Semi-Transparent solar cells

Semi-transparent solar cell techniques have an impact on visual ergonomics, while reaching a higher efficiency compared to transparent solar windows. The techniques have different effects on visual ergonomics. The most common are coloured panels or low-transparency panels. These effects makes the semi-transparent solar cells most usable as facade mounted BIPVs.

4.3.1 Dye-sensitised solar cells (DSSCs)

Dye sensitised solar cells work as batteries in their simplest form. Two transparent and conducting materials encapsulate the active materials. The transparent material that will act as negative pole is coated with a thin layer of titanium-oxide. Titanium-oxide is transparent and doesn't react to lighting as a coloured material does. Consequently it is painted with a dye. The positive pole is coated with a layer of carbon or platina. The negative and positive poles are now assembled and an electrolyte is formed between the conducting materials. This creates a flow of electrons when the dyed material is illuminated **[34]**. As the dye is required for the electrochemical reaction a distinct colouring in a wide array of different colours make the DSSC a distinct solar cell.

The dye-sensitised solar cells was first presented by Michael Grätzel in 1991 with a efficiency of 7.5%. The choice of dyes has a great effect on efficiency and with organic dyes such as photo-sensitiser even higher efficiencies are achieved **[35]**. The efficiency record was found by using Zn-porphyrin based dye with an efficiency of 13% **[36]**.

One basic concept being studied is the possibility to sensitise IR dye. This is possible and has been studied with 12% efficiency combining dyes using the IR-part and visible part of the spectrum **[37]**. By only using the IR part of the wavelengths it could potentially generate electric energy with high efficiency.

4.3.2 Semi-transparent thin film

Semi-transparent thin film solar cells are essentially an ordinary solar cell made thinner with materials suitable for high efficiencies while being cheap and easy to mass produce. The thin films are easily cut and bent into a suitable application **[38]**.

Typical materials used for thin-film solar cells is compounds of Copper, Indium, Gallium and Selenide (CIGS) which use an efficiency of 10 - 13%. Cadmium Telluride (CdTe) is also used with efficiencies of 9 - 12%. Silicon is being used both amorphously and micromorphously with lab measured efficiencies of 26% for mono-crystaline silicon and 21% for multi-crystaline silicon **[39]** **[40]**. The highest efficiency in lab environment for CdTe is 21%. For CIGS the highest efficiency found is 23% **[40]**.

By creating a matrix-shape of thin-film on a transparent material a semi-transparent solar cell is created. This could be completed more sophistically by drilling small holes in a thin-film with a material sturdy enough to handle the geometric shape. This technology using amorphous silicon has a laboratory measured efficiency of 5.9%. However, the technology suffers from sever degradation issues due to its geometry **[41]**. The light transmittance with theses technology is linearly decreasing with a higher production, as the only proper way to increasing the production is by increasing the area of the thin-film and thus removing the transparent spacing. Usual semi-transparent CdTe thin-film such as SolTech ST has an efficiency of 4.2% with a transmittance of 40%. The transmittance is variable between 0.0% to 40% with a corresponding higher or lower efficiency **[42]**.

4.4 Electrochromic mirrors

Similarly to the DSSC an electrochromic filter in its simplest form is built like a battery with 5 layers. Unlike the battery and DSSC, the EC-filter does not create a flow of charges as soon as energy is supplied or removed, it rather forces a reaction which stays permanent although being reversible.
On one end there is a transparent conductor; connected to the conductor is a material reactant to another material. Then an electrolytic substance is added to separate the two reactant materials when $V = 0$. Next layer is the second reactant material which is chosen to react with the first material **[43]**. Lastly there is another transparent conducting layer. The two conductors work as electrodes which can be connected to a voltage source to introduce a redox-reaction between the materials. By continuously managing the voltage, the level of the reaction is controlled. If the materials are chosen to switch from an optically transparent material to a dimmed material, the amount of dimming is controlled by switching the voltage across the electrodes.

The process is reversible, meaning that the voltage between the electrodes is not necessary to sustain the amount of dimming or transparency as there is an oxidation at one of the reactants and a reduction at the other. When the redox-reduction is complete it is fixed until the polarity is switched between the conductors and a new redox-reduction is introduced, forcing the reactants to return to its original state. With the correct materials chosen a smart mirror can be produced which has a reactive material with one transparent state and one reflective state depending on if it is the subject of oxidation or reduction.

One report claims a fully operational electrochromic Bragg mirror is created by using NiO and WO3 nanoparticle layers as reactive materials **[44]**. This could potentially be used to enhance the efficiency of a solar cell window. With a reflective surface the output light beam angle to the surface can be reflected back into the acrylic material to be further added into the total reflection. Also the electrochromic mirror could be used to reflect all light during summer, to decrease the amount of cooling required for the building. This could reduce the energy needed for cooling significantly. By using a control system together with nano-Bragg mirrors, the potential product could regulate itself to reflect light when it would be beneficial for the thermal characteristics. The result would be an increase in efficiency and also a decrease in cooling energy needed.

5 IDA indoor climate energy (ICE) simulation

IDA ICE is a tool used by numerous corporations such as ÅF, Skanska, WSP and ABB to simulate daylight and isolation properties of buildings. The company behind the program, Equa Software, is based in Stockholm and IDA ICE has become a useful tool for complex thermodynamical analysis tasks during construction planning **[45]**.

5.1 Summary

IDA ICE is used to simulate how much energy is required for heating and cooling during a year for the project of interest. Three case simulations are completed and analysed. Case one with ordinary windows using IDA ICE default values, case two with a transparent solar window and case three containing a electrochromic mirror surface together with a control system which forces the window to use a fully transparent surface during working hours and a reflective mirror surface during weekends and time of the day outside working hours. The study will solely focus on transparent solar concentrators, electrochromic mirrors and ordinary windows in comparison. As visual performance is of major importance as when choosing windows in buildings, semi-transparent alternatives is not studied. The common basis for the study is chosen as windows that can maintain a similar transparency of the visual spectrum of light, meaning that it does not intrude on visual performance. The study will also focus on the ideal-case. Meaning that all light outside the visual wavelength interval is removed for the case with transparent solar windows. For the case with electrochromic mirrors all light is removed when the EC-mirror is turned to shade.

From the simulation the results are imported into MatLab where the necessary parameters is summarised and plotted to show graphs containing visual information on how much energy is used throughout the year for each of the three simulations. Also the energy is calculated in kWh to easily multiply with the current electricity price. IDA ICE is used regularly by Skanska Technical department.

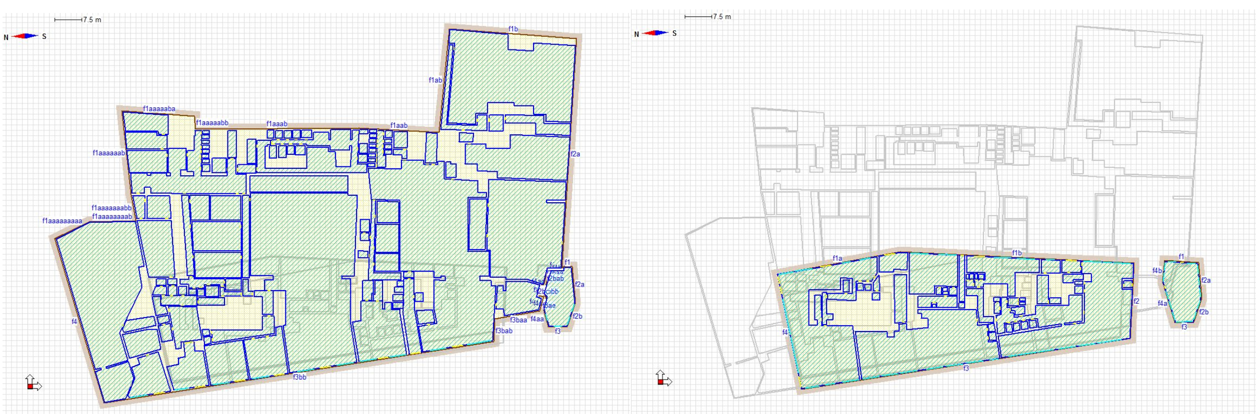

Figure 5: Schematics of Sergelhuset showing the street-floor to the left and the second floor to the right

5.2 Simulation

IDA ICE supports CAD model import as well as 3d-modelling construction in the IDA ICE interface. For these simulations Sergelhuset is modelled directly in IDA ICE. It is made possible with room and facade schematics for the building supplied by Skanska. By using a schematic as template for every floor and at the same time measuring floor and roof height, every room is correctly modeled. The schematics also show doors, windows and different kind of equipment rooms. Some of the equipment rooms are not modeled as they usually are very small in comparison to other rooms. Due to time constraints certain priority as to what level of detail and which rooms are modeled has been made. The rooms and floors are modeled with windows and doors as can be seen in figures **[figure 4,5,6,7]**.

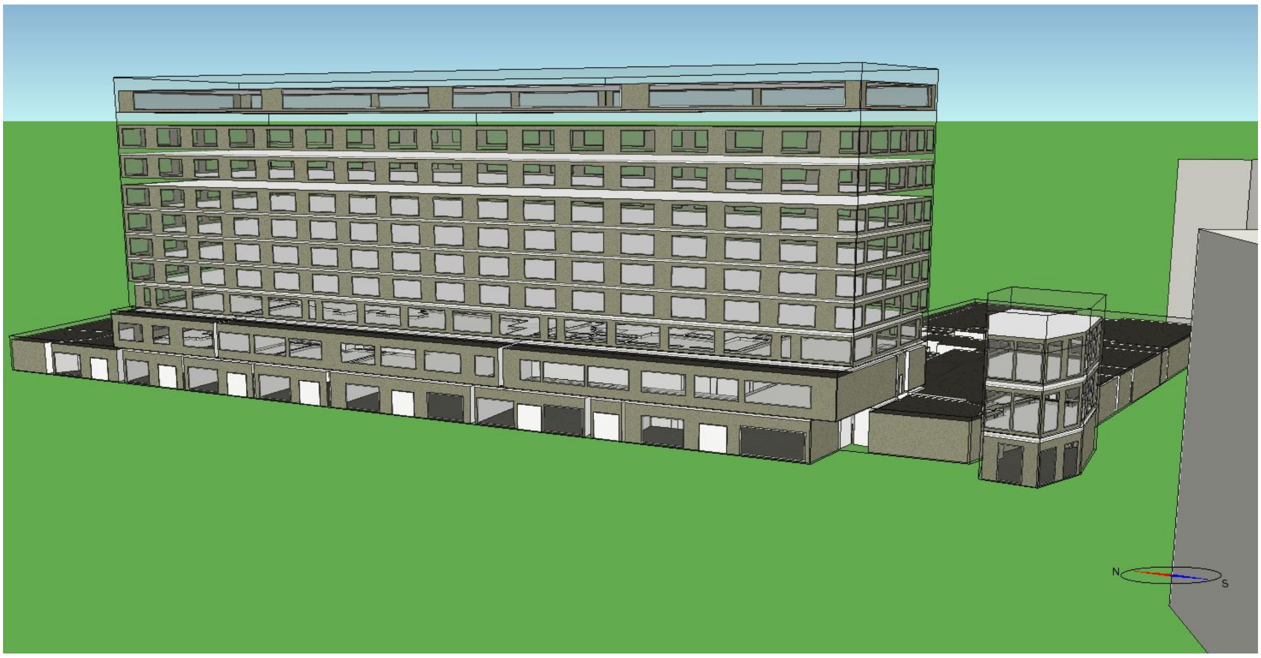

Figure 6: The complete 3d-modeled view of Sergelhuset. The outer walls are transparent and the floors are visible on the inside of the windows

The location is chosen to Stockholm city Sergels torg by GPS coordinates supplied by Google Maps. Climate profile is chosen as Bromma airport climate from the IDA ICE database since it is the closest database profile to Stockholm city. The database profile is edited to use sunlight and height above water level data to Sergels torg instead of Bromma airport. The wind profile is chosen to typical city center wind climate. As the western part of Sergelhuset, which this report is focusing on ,mostly consist of offices and stores a typical holiday profile is chosen to specify public holidays in Sweden. Working hours are chosen to between 07:30 and 18:30. Usually a working day is shorter but as Sergelhuset is a large office complex and the main reason for specifying the working hours is to account for energy and water usage it can be approximated that the same energy is used if less people is working later in the afternoon compared to mid-day. To further explain this approximation it is assumed that the only time the office lights and utilities are completely shut of is when most of the people has left the office.

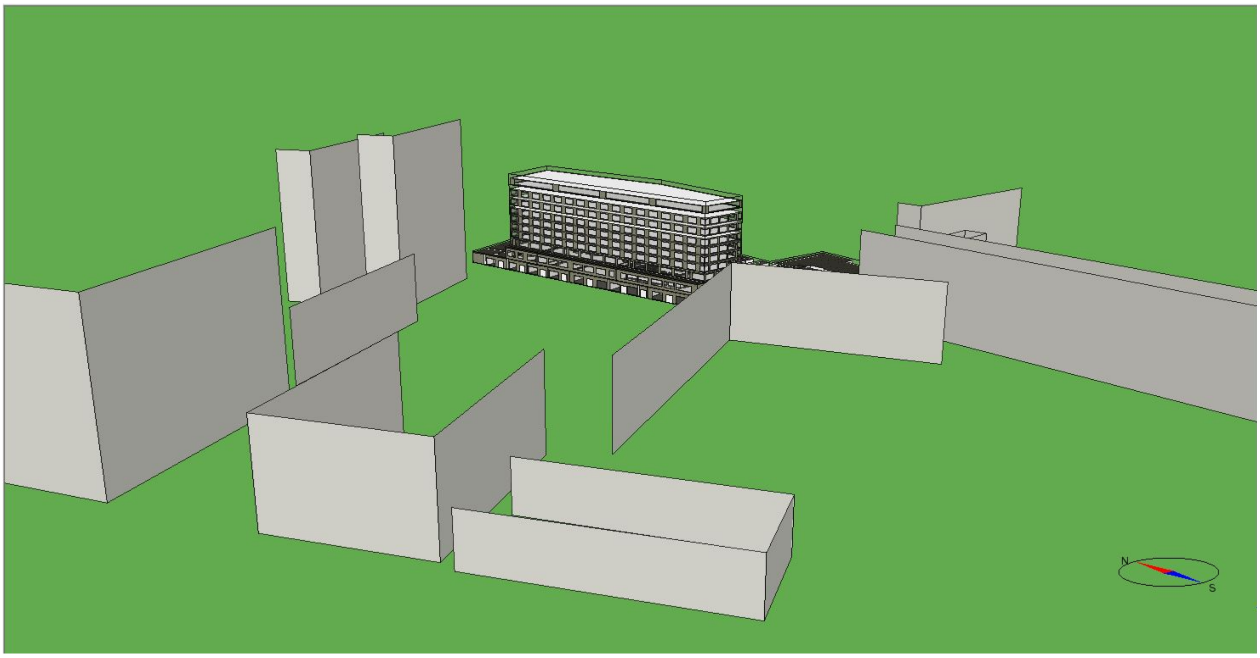

Figure 7: The 3d-modeled view of Sergelhuset with corresponding houses contributing to the shading of the site

The building parameters are chosen with typical values for external walls, internal walls, floors and roof. The window glazing is left in default with a 3 pane glazing window for the first simulation. The second simulation will use glazing with a solar heat gain coefficient of 0.010, a solar transmittance coefficient of 0.005 and a visible light transmittance of 0.001. This is to make sure that minimal light is transmitted inside when using an electrochromic coating. For the third simulation a transparent solar window will be simulated with a Solar heat coefficient of 0.4321, a transmitted light coefficient of 0.4220 and a transmitted visible light coefficient of 0.7400. The solar heat coefficient is calculated in

MatLab by using reference values from a clear window without coating sold by U.S. company Guardian Sunguard **[46]**. The solar heat coefficient is calculated as a sum of the direct gain and the indirect gain. The indirect gain is here assumed to follow a linear pattern in relation to the transmitted solar radiation. The visible light transmission is the default value of a 3 pane window in

IDA ICE. The Transmitted light coefficient is calculated as the product of the total light transmitted, being only the visible light, and the visible light transmission. The MatLab program used to calculate the values and display the electromagnetic light spectrum can be found in appendix A. For the MatLab program the ASTMG173 database is used. The building Sergelhuset is orientated correctly according to Google maps and its height over water level is taken into account for. The rest of Sergels torg is modeled as boxes to account for shading **[figure 8]**. The height of the rest of the buildings around Sergelhuset has an impact on heating and cooling performance as Sergelhuset is one of the lowest buildings around the square, despite being a large building. By contacting the swedish land surveying unit, 3d-maps importable into a CAD-program was received. In these maps exact heights of the buildings around Sergels torg could be achieved.

All other parameters in IDA ICE such as thermal conductivity, thermal bridges and materials are set to default values.

Simulations are completed with energy analysis focus. After simulation, cases 1, 2 and 3 reports are received in IDA ICE containing information about heating and cooling energy. These reports can be found in the appendix **[Appendix C,D,E]**. The finished simulation contains information such as facility lighting, heating, cooling, ventilation, air conditioning (HVAC) as well as domestic hot water.

A problem was found when analysing case 3 containing the EC coating. An EC coating would be used with a control system turning the transparent window into a mirror when the area around the window has been empty for a specified time. Approximately this would be outside of working hours. When simulating in IDA ICE one report is received for the EC mirror situation and one for the ordinary window situation. The data from these two reports need to be manipulated to remove data for hours 07:30 to 18:30 from case 3 report which thereafter replaces the data between hours 07:30 and 18:30 in case 1 report. This is done in MatLab by exporting the IDA ICE data into a .csv file and in turn importing the necessary columns of data into the MatLab interface where a for-loop fills and array with data from the file between 07:30 and 18:30. The first for-loop is further looped again in another for-loop that fills an array with data between the hours outside the interval 07:30 to 18:30. As case 1 array is null when case 3 has a value there is no need to summarise the arrays which would be a difficult task due to the data file elements differing in numbers. The case 1 and 3 arrays are plotted in the same figure resulting in a plot successfully showing the required energy for Sergelhuset for every hour over one year **[Appendix I]**. To further analyse the simulation the mean energy in kWh is calculated in MatLab for each case. Note that due to the data manipulation the array will contain some elements 0 while the other plots are null. This results in the graph reaching the abscissa while graphs in figure 8 and 9 is not. To maintain uniformity and remove unnecessary parameters during import case 1 and 2 are shown in MatLab figures as well **[figure 9,10]**. The MatLab code used to process the IDA ICE data can be found in the appendix **[Appendix B]**.

A parallell simulation for each case is completed for the same building with the same parameters in Upington, South Africa with Upington climate data. This is to investigate if a higher solar radiation, with other azimuth angles affects the thermal profile differently when comparing to Stockholm, Sweden. Upington is most suitable for comparison as it, together with parts of Australia and west South America, has the highest yearly solar radiation. Also Upingtons geographical location is similar to Stockholms apart from the latitude. Stockholms latitude is 59 degrees north and longitude 18 degrees east compared to Upingtons latitude 30 degrees south and 21 degrees east.

5.3 Results

Figures show the ordinary window, transparent solar window and EC-mirror for Stockholm and Upington next to each other **[figure 8,9,10]**. Table 1 show the energy in kWh for ordinary windows, windows with an integrated transparent solar window and a window with an EC mirror used during non-working hours **[table 1]**. The IDA ICE reports for Stockholm is shown in appendix C, D and E and the IDA ICE reports for Upington is shown in appendix F, G and H.

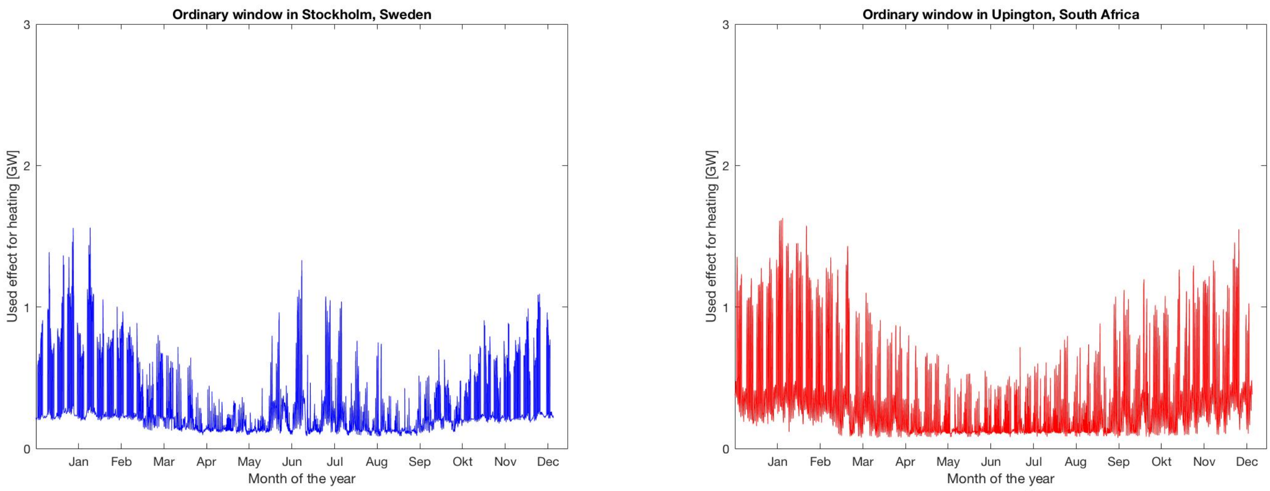

Figure 8: Heating and cooling energy during a year in Stockholm and Upington with ordinary windows

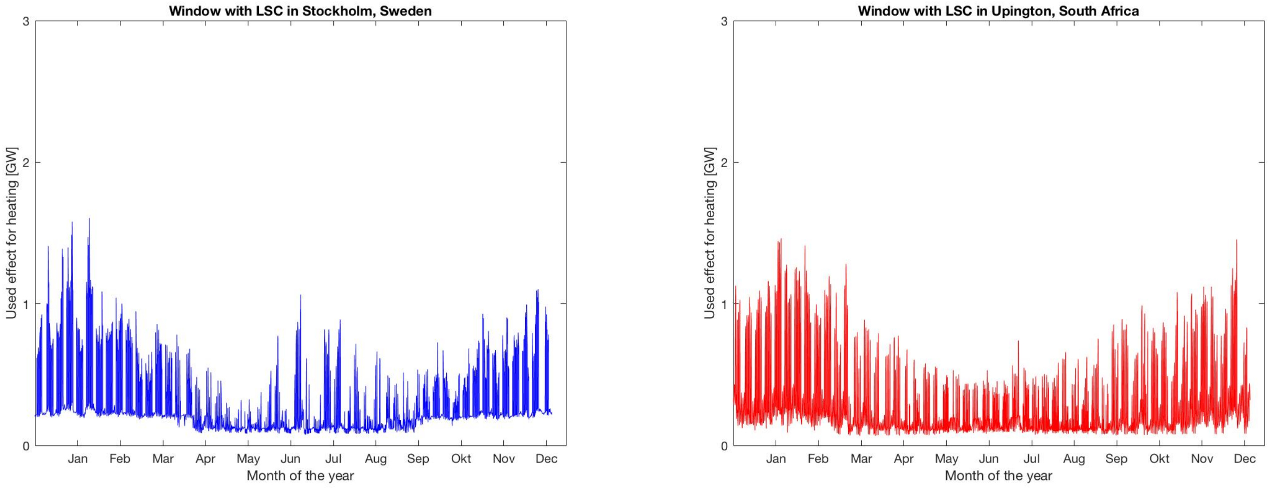

Figure 9: Heating and cooling energy during a year in Stockholm and Upington with LSC windows.

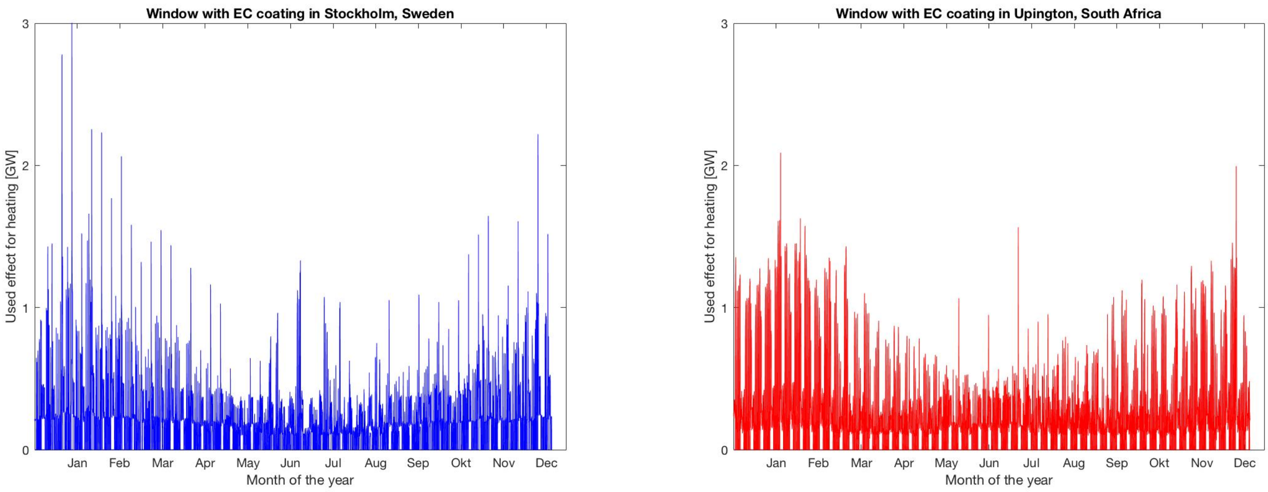

Figure 10: Heating and cooling energy during a year in Stockholm and Upington with ordinary windows during working hours and EC-windows during non-working hours.

During the first months of the year in Stockholm, most energy is used for heating. In Upington the energy is used for cooling. The curve stabilises and is low in energy during April to May while rising as energy needed for cooling, or heating, is higher during the summer months depending on the geographical location. The integrated LSC/DSSC removes some of the peaks during summer in Stockholm, as can be seen in figure 9 compared to figure 8 **[figure 9]**. In Upington the curve is much more linear as the outdoor temperature is more similar to the inside temperature throughout the year. This helps reduce the needed energy mean so that it is slightly lower than that of an ordinary window **[table 1]**. For the EC window the required energy mean is higher than that of an ordinary window. This is because the the EC mirror is used off working hours when the temperature is cooler and even the slightest heating would be beneficial to the energy requirements of the building. The result is a much more stagnated, linear, curve which is observed in figure 10 **[figure 10]**. The same results follow for Upington. In Upington however the difference between ordinary windows and windows with integrated LSC/DSSCs is more obvious.

	Stockholm [GWh]	Upington [GWh]
Ordinary windows	2.4644	2.6899
Luminescent solar concentrator	2.4104	2.2329
Electrochromic mirror during non-working hours	2.8560	2.7074
Difference between ordinary windows and LSC integrated windows	0,054	−0,457
Difference between ordinary windows and EC integrated windows	0,3916	−0,0175

Table 1: Energy difference between ordinary windows, transparent solar windows and EC in Stockholm and Upington

5.4 Simulation conclusion

It is concluded that using a LSC or transparent solar cell techniques for solar generation is further also beneficial for the buildings thermal characteristics. This applies both in Stockholm and Upington. The benefits is much larger in Upington due to higher solar radiation climate which benefits more from removing a fraction of the solar radiation while still having a moderate solar heat exchange.

It is further concluded that using an EC mirror built into the window is not beneficial for the thermal characteristics. The difference between an EC mirror and an ordinary window is larger in Stockholm compared to Upington as the heat difference in Stockholm is much larger. The second rule of thermodynamics states that in any cyclic process the entropy will either increase or remain the same **[47]**. This can be rephrased as that heat always flows from hot to cold objects, never cold to hot, **[48]** which mean that the energy provided to heat the building will flow towards the outside if the outside medium is lower in temperature. This can further be rephrased as temperature will adapt to its surroundings. In Stockholm during months April to May and August to September the building benefit of having a heat flow between inside and outside through the windows. This can be seen in figure 8 compared to figure 10 when looking at the energy mean for the mentioned months. With a proper heat flow through the windows the ambient temperature would cool down the building as the mean temperature in Stockholm is 5-10°C during the mentioned months. The windows which isolates the buildings is pointed towards the sun which further lowers the temperature difference between inside and outside temperature. The effect is that the building is approaching an equilibrium point during these months. When applying an EC filter the building is isolated from the outside and the inside temperature is lowered leading to more needed energy for heating. This lead to the linear curve which is observed in figure 10 **[figure 10]**. In Upington the energy required is used for cooling which is less efficient than heating due to the second law of thermodynamics. By isolating the building the default inside temperature is lowered and therefore less energy is needed for cooling and more is needed for heating which is more energy efficient. This lead to the much lower difference between ordinary windows and EC windows **[table 1]**. It is not efficient in Upington or Stockholm which could be seen as extreme cases when it comes to temperatures and the technique is accordingly not suitable for energy efficiency purposes.

The EC mirror used during non working hours is assumed to be connected to a control system that can switch its chemical attributes whenever it is needed. The simulation and analysis in this report state that the EC mirror coating will not be used between 07:30 and 18:30 Mondays to Friday. The results could be misleading due to the fact that such a control system also easily could be optimised to only use the EC coating when there is a benefit of using it i.e. during weekends when the sun shines on the windows. This could instead lower the needed energy instead of raising it. This regulating system could be used with a sensory system which measures solar illuminations, only using the EC-mirror when there is a gain of using it. This would plausibly lead to a positive effect on a buildings thermal characteristics. To prove such a positive effect much deeper studies are needed as well as practical tests.

6 Life Cycle Costs

The aim for this LCC is to further investigate which techniques has a probable commercialisation chance in the future. To investigate profitability of techniques for solar generation in windows a life cycle costs analysis is completed. The life cycle cost (LCC) is a tool to summarise costs and revenues during the lifetime of products to finally make a good investment decision. A Stanford guideline for building LCCs summarises an LCC as a process of evaluating the economic performance of a building over its entire life **[49]**.

6.1 Summary

The results from the IDA ICE simulations is added to the LCC results to provide an equitable view on the profitability of the proposed products. The LCC is somewhat approximate as it contain products that has not been released and therefore it is proven difficult to take recycle costs into account. The gains for recycling, such as sustainability benefits and environment friendly work is abstract and hardly quantified which makes it attractive if it also is low in costs, making the approximation plausible. An LCC for a company such as Skanska would most suitably contain information about corporation benefits when installing green energy generating technologies. Many LCCs exist such as Jernkontoret's template or Mälardalen's college lecturer Bengt Stridh's investment calculation template **[50]** **[51]**. Information about how Skanska uses LCC analysis is gathered by taking part of the LCC education material supplied by the Swedish Energy Agency in association with the Swedish Technical Research Institute. In this material, basic work is found that is used for the investment calculation **[52]**.

6.2 LCC analysis

The investment calculations is most effectively completed in Excel. The foundation work for the investment calculations is taken from the LCC education material, **[52]** and the foundation work for the Excel program structure is taken from the Energimyndighetens template for indoor armature and Bengt Stridh's template **[51]** **[53]**. Similarly to Bengt Stridh's material a cash flow is calculated and similar posts are used for calculations. The main screen of the Excel-program is shown in figure **[Appendix I]**. The excel program is written in Swedish to simplify comprehension.

	Area [m^2]	Efficiency [%]	Energy exchange [$kWh/Kw, yr$]
Roof mounted	482	16,3 %	935
Facade mounted	1152	12,1 %	505
Semi-transparent facade	894	4,2 %	401

Table 2: Area, efficiency and energy exchange for different solar cell techniques

The Excel-program contain 3 pages where the first page contain input data, assumptions and output data. It should be mentioned that some of the input data in this report is also assumed and the cost analysis is very approximate. The approximation will however be plausible as a comparison basis and the main reason for the LCC is to clarify which parameters will need to improve if the technique is going to be profitable in the future.

The area and efficiency is firstly input in the program. In this example values simulated in PVSyst by Andreas Nilsson in Transparent solar cell techniques: From a solar irradiance- and environmental perspective **[46]**. The results from Andreas Nilssons investigations and simulations are found in table **[table 2]**. All the values are related to Sergelhuset and simulated in PVSyst. The values for energy exchange are somewhat low due to the shading profile of Sergelhuset and the geographical position of the building. The area for the semi-transparent solar cells are the same same as the facade area and its efficiency are found in data-sheets from SolTech ST panels who are a common semi-transparent facade system **[46]**. The efficiency of a facade mounted solar cell system could be higher than the efficiency specified in table 2 **[Table 2]**. As the energy exchange has been simulated with the specified efficiencies for the same geographical location as the thermal energy study the efficiencies in table 2 will be used when investigating profitability.

The efficiency is calculated for the case with present solar cell efficiency, concentrator efficiency and removable by the non-visible electromagnetic spectrum. This efficiency is calculated as 1.3% in chapter 2.3. It is assumed that the connection fuse exceeds 100 A which enables tax reduction **[55] [56]**. The economical life span is chosen as 50 years to present a large span for the investigation. The discount rate is chosen as 5.0% which is the commonly used discount rate without doing a risk-calculation. The investment cost is chosen as 9 060 kr/kW for the roof mounted systems. This price is chosen on a basis on mail contact from NordenSolar who is a typical supplier of such systems.**[57]**

For the facade mounted systems the investment cost is chosen as 30 000 kr/kW. This price is chosen on a basis on mail contact with Solkompaniet who is a supplier of such systems **[58]**. 11 800 kr/kW was the mean cost for larger instalments in Sweden 2015, **[59]** which further implies that the values from NordenSolar and Solkompaniet are plausible. The semi transparent solar cell facade and the transparent solar window investment values are estimated. The investment cost is estimated on a basis on the price per kilowatt being doubled the facade mounted system investment cost. This lead to a semi transparent solar cell facade price of 60 000 kr/kW and a transparent solar window price of 200 000 kr/kW. It is not necessary for this report to be precise as this report will cover tendencies e.g. if the product has tendencies to be profitable and if the maintenance costs is low enough. These values result in a roof mounted panel cost of 707 094 kr, a facade mounted system cost of 4 181 760 kr, a semi transparent solar cell facade price of 2 903 040 kr and a transparent solar window price of 1 430 400 kr which can be seen in the cash flow page of the excel program **[Appendix J]**. The investment supports is chosen to 30% which is the maximum support companies can enjoy **[59]**. Further, 95% produced electricity is used in the building and the sold and bought electricity is given plausible values. The calculated installed power is 78.560 kW for the roof mounted system, 139.392 kW for the facade mounted system, 48.384 kW for the semi transparent solar cell facade and 11.622 kW for the transparent solar window system. The number of changed inverters every 15 year is chosen according to installed effect. The other parameters are used according to Bengt Stridh's LCC default values.

6.3 Profitability results

In the Excel-program page Results, present-value and payback time are found for every product with or without investment funds. The roof mounted panels has a payback time of 8 years with funds and 13 years without funds while having a high present value. The facade mounted panels does not pay back either with funds or without funds. This is because the investment cost is high compared to the efficiency. Both the semi transparent solar cell facade and the transparent solar windows has a negative present value and does not payback within the life span. It is however noted that the semi transparent solar cell facade is closer to profitable than the transparent solar windows **[Appendix N]**.

Profitability

	Without investment support, with possible tax reduction		With investment support and with possible tax reduction
Roof mounted			
Present value	555 769,99 kr	Present value	767 898,19 kr
Discounted payback time	14,00	Discounted payback time	9,00
Facade mounted			
Present value	-2 090 876,45 kr	Present value	-890 876,45 kr
Discounted payback time	>Life length (50 years)	Discounted payback time	>Life length (50 years)
Semi transparent solar cell facade			
Present value	-1 798 167,66 kr	Present value	-927 255,66 kr
Discounted payback time	>Life length (50 years)	Discounted payback time	>Life length (50 years)
Transparent solar cell			
Present value	-1 504 584,87 kr	Present value	-807 264,87 kr
Discounted payback time	>Life length (50 years)	Discounted payback time	>Life length (50 years)

Figure 11: Results window of the life cycle cost analysis

When looking at the cash flow it is noted that the transparent solar windows result has a lower accumulated present value each year. The other panels result in a continuous increasing accumulated present value **[figure 11]**.

The cash flow of the roof mounted panel, the facade mounted panel, semi transparent solar cell facade and transparent solar windows is shown in figures **[Appendix J, Appendix K, Appendix L, Appendix M]**.

6.4 Profitability conclusion

It is concluded that the roof and facade panels are profitable if correctly configured. The semi transparent solar cell facade is generating money with the assumed values, but it does not reach a positive present value within the life span. The transparent solar windows suffer from produced power because of the much lower efficiency which raises the cost per kilowatt to a level where it cannot become profitable. This is seen in Appendix M, where the costs exceed the incomes **[Appendix M]**. As the investment cost is very low already it can be assumed that the plausible factors of improvement is the efficiency of the technique and the geographical location of the product. Using a transparent solar windows in a country with a high solar radiation would increase the energy exchange and make the product closer to profitable.

In table 1 it is found that 0.054 GWh is saved annually by using a transparent solar windows compared to an ordinary window. With an energy price of 1 kr/kW, as is used in the LCC, the savings on energy is accordingly 54 000 kr annually. If the lower required energy for heating and cooling is assumed constant each year and this is added as an annual income, and the price for a 3-pane window (approximately 1000 kr/m^2) is removed from the investment cost, we receive a new cash flow model **[Appendix N]**.

This concludes that a transparent solar window with the possibility of completely removing the part of the electromagnetic spectrum invisible to the human eye will, even with early commercialised techniques, become profitable during its life span. Further it should once again be mentioned that the investment costs is highly speculative. The yearly income from each of the 4 techniques are however a very plausible comparison and it shows that the transparent solar window has a potential of generating a very high income annually. A comparison of the first 5 years is shown in table **[table 3]**.

Year	Roof mounted panel income [kr]	Facade mounted panel income [kr]	Semi-transparent solar cell facade income [kr]	Transparent solar window income [kr]
1	75 995	72 130	13 672	57 229
2	72 368	68 688	13 019	57 075
3	68 914	65 409	12 397	56 929
4	65 625	62 288	11 804	56 790
5	62 493	59 315	11 241	56 658

Table 3: Income for roof mounted panels, facade mounted panels, semi-transparent facade solar cells and transparent solar windows with added annual profit for heating and cooling savings

The energy price chosen for the LCC and heating & cooling energy is 1 kr/kWh. This is a correct value for Swedish conditions. As Sweden has a low energy price compared to many other countries the income for a solar cell installation would be higher in Upington, or most other countries in Europe, compared to Sweden. The energy price in South Africa was a factor 1.58 higher than the Swedish price in 2015. In Italy that same value was 2.94 times higher the Swedish energy price. For consistency the Upington energy price is used and the resulting cash flow for the first 5 years is shown in table 4 **[table 4] [61]**.

Year	Roof mounted panel income [kr]	Facade mounted panel income [kr]	Semi-transparent solar cell facade income [kr]	Transparent solar window income [kr]
1	109 543	104 277	22 532	84 220
2	104 315	99 301	21 457	84 272
3	99 337	94 562	19 456	84 321
4	94 596	90 050	18 527	84 368
5	90 082	85 752	17 643	84 412

Table 4: Income for roof mounted panels, facade mounted panels, semi-transparent facade solar cells and transparent solar windows with added annual profit for heating and cooling savings and with South African energy price

It is shown that a transparent solar window would have the potential of generating almost as much as a roof mounted panel. The transparent solar window would then payback after 15 years with funds and 28 years without funds.

7 Discussion and conclusion

This part of the report will conclude and discuss the results from the IDA ICE simulation and life cycle cost analysis. As both the simulation and the LCC has a common ground for investigating the profitability, they complement each other and a common conclusion and discussion is therefore needed.

7.1 Discussion

Comparing transparent solar window technologies with solar cells mounted on the facade or roof is problematic and could possibly be misinterpreted because of it's different potential as a product. This report concludes that transparent solar window techniques could become a profitable product either by increasing the price for sold energy, improving its efficiency or, for the LSC case, finding another place on the market than that as an energy producer. Possibly as an isolating window which concentrates light to a point outside the window. This would then have to be compared to an ordinary window, instead of a solar panel, to properly analyse its profitability.

The investment cost used for the transparent solar window in the LCC is misleading due to the fact that in practice only approximately half of the windows would be used with a transparent solar window technique. This is due to the fact that half of the building will be shaded throughout the year and will therefore not be the exposed to direct heating from the sun. It could plausibly be corrected by bisecting the investment cost while using the same gains for heating and cooling. Further studies must be made to prove this thesis.

7.2 Conclusion

The LSC has a interesting potential for being a tool to enhance sustainability capabilities in buildings. It has an apparent positive effect on the thermal capabilities of a building and it generates electric energy which both lowers the costs for cooling and the costs for electricity. It should however be understood that current technology offers to low efficiencies to justify investments economically. It is not economically justified to use transparent solar window techniques for energy generation but it is however justified to use it for energy saving purposes and this is possibly where the technique should be used most effectively. The potential efficiencies are however on the verge of being profitable. For the life cycle cost analysis in this report an efficiency of 1.3% efficiency is used as a current realistic efficiency for transparent solar concentrators. This doesn't generate enough electric energy to be economically justified. If raised to 4% it reaches the same efficiency as semi-transparent facade mounted solar cells which could make it economically justified, even though it is not efficient compared to roof mounted or ordinary facade mounted systems. Current DSSCs reach 13% which would make it almost as efficient as an ordinary facade mounted system, but more versatile and semi-transparent, making it possible to use it in facades for electricity generation **[35]**.

As shown in table 1 the energy savings for a transparent solar windows in Stockholm, Sweden is 0.054 GWh which roughly represent 54 000 SEK annually with a energy price of 1 kr/kWh. In Upington, South Africa, the transparent solar window represent energy savings of 0.457 GWh. This is roughly 457 000 SEK annually with a energy price of 1 kr/kWh. This would represent an energy price of 17% less each year. Because of a higher energy exchange the produced energy would be higher in Upington compared to Stockholm and it is plausible to say that both the transparent solar window, semi-transparent solar cell and ordinary solar cell would be profitable solely for energy generation purposes in an area with extreme solar radiation. Together with the thermal energy savings it would be economically justified even with current technology. Possibly transparent solar window technology could be invested in for projects in areas with high solar radiation, raising attention to the product and products. When efficiencies rise with more desirable engineered technology, it could be economically justified to use in construction projects in Scandinavia.

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9 Appendix

Appendix A

```
clear all
load('ASTMG173.mat');

A = table2array(AM1);
B = -(table2array(AM2));
Wavelengths = table2array(AM);
Irradiance = A.*(10.^(B));
startingIndex = find(Wavelengths==400);
endingIndex = find(Wavelengths==700);
T_visible_value = 0.74;

desiredX = Wavelengths(startingIndex:endingIndex);
desiredY = Irradiance(startingIndex:endingIndex);
Area = trapz(desiredX,desiredY);
TotalArea = trapz(Wavelengths,Irradiance);

LightFractionVisibleLight = Area ./ TotalArea
T_value = LightFractionVisibleLight * T_visible_value
g_value = T_value + (0.02 * (T_value / 0.84))
% Approximerad från värden gällande ett klar-genomskinligt glas utan beläggningar.
% Det antas att den indirekta delen av g-värdet linjärt ökar med den genomträngande so
lenergin.
% G-värdet motsvaras av det direkt transmitterade ljuset (T-värdet) + det
% indirekt transmitterade ljuset

UV_wavelengths = Wavelengths(1:startingIndex);
UV_irradiance = Irradiance(1:startingIndex);
IR_wavelengths = Wavelengths(endingIndex:2002);
IR_irradiance = Irradiance(endingIndex:2002);


figure
plot(Wavelengths,Irradiance, 'black')
hold on
A1 = area(UV_wavelengths, UV_irradiance);
A2 = area(IR_wavelengths, IR_irradiance);
A1.FaceColor = ['blue'];
A2.FaceColor = ['red'];
xlabel('Wavelength [nm]')
ylabel('Energi [W/m^2 * nm]')
title(['Electromagnetic Spectrun showing UV, visible and IR light'])
```

Appendix B

```
clear all

load('EC.mat')
load('utanEC_SC.mat')
load('LSC.mat')
load('EC_up.mat')
load('utanEC_SC_up.mat')
load('LSC_up.mat')

%% Deklarerar variabler

%%%%%%%%%%%% Stockholm
noEC_energy = table2array(noEC);
time_noEC = table2array(utanEC_SC_time);

EC_energy = table2array(EC);
time_EC = table2array(MedEC_time);

LSC_energy = table2array(LSC);
time_LSC = table2array(LSC_time);

Plot_noEC = sum(noEC_energy, 2);
Plot_LSC = sum(LSC_energy, 2);
Plot_EC = sum(EC_energy, 2);

Array_NOEC = zeros(59628,1);
Array_EC = zeros(58067,1);
i_day = 1;
i_week = 0;
i_day_2 = 1;
i_week_2 = 0;

%%%%%%%%%%% Upington
noEC_energy_up = table2array(noEC_up);
time_noEC_up = table2array(utanEC_SC_time_up);

EC_energy_up = table2array(EC_up);
time_EC_up = table2array(MedEC_time_up);

LSC_energy_up = table2array(LSC_up);
time_LSC_up = table2array(LSC_time_up);

Plot_noEC_up = sum(noEC_energy_up, 2);
Plot_LSC_up = sum(LSC_energy_up, 2);
Plot_EC_up = sum(EC_energy_up, 2);

Array_NOEC_up = zeros(70931,1);
Array_EC_up = zeros(67931,1);
i_day_up = 1;
i_week_up = 0;
i_day_2_up = 1;
```

```
i_week_2_up = 0;

%% Icke-EC delen av vektorn
%%%%%%%%%%Stockholm
for n = 1:length(time_noEC)

    time = time_noEC_up(n);
    hours_day = time - i_day*24;
    week_days = time - i_week*24*7;
    I = Plot_noEC(n);

    if hours_day >= 24

        i_day = i_day + 1;

    end

        if week_days >= 7*24

            i_week = i_week + 1;

        end

norm_time = time - i_day*24;

            if (norm_time > 7.5 &&  norm_time < 18.5)

                Array_NOEC(n,:) = Array_NOEC(n) + I;

            end

norm_week = time - i_week*7*24;

                if (norm_week >= 120 && norm_week <= 168)

                    Array_NOEC(n,:) = 0;

                end
end


%% EC delen av vektorn
%%%%%%%%%%%%% Stockholm
for i = 1:length(time_EC)

    time_2 = time_EC(i);
    hours_day_2 = time_2 - i_day_2*24;
    week_days_2 = time_2 - i_week_2*24*7;
    I = Plot_EC(i);

    if hours_day_2 >= 24

        i_day_2 = i_day_2 + 1;
```

```
    end

        if week_days_2 >= 7*24

            i_week_2 = i_week_2 + 1;

        end

norm_time_2 = time_2 - i_day_2*24;


            if (norm_time_2 < 7.5 || norm_time_2 > 18.5)

                Array_EC(i,:) = Array_EC(i) + I;

            else

                Array_EC(i,:) = 0;

            end

norm_week_2 = time_2 - i_week_2*7*24;

                if (norm_week_2 >= 120 && norm_week_2 <= 168)

                    Array_EC(i,:) = Array_EC(i) + I;

                end

 end

%% Icke-EC delen av vektorn
%%%%%%%%%%%% Upington
for n_up = 1:length(time_noEC_up)

    time_up = time_noEC_up(n_up);
    hours_day_up = time_up - i_day_up*24;
    week_days_up = time_up - i_week_up*24*7;
    I_up = Plot_noEC_up(n_up);

    if hours_day_up >= 24

        i_day_up = i_day_up + 1;

    end

        if week_days_up >= 7*24

            i_week_up = i_week_up + 1;

        end
```

```
norm_time_up = time_up - i_day_up*24;

            if  (norm_time_up > 7.5 &&  norm_time_up < 18.5)

                Array_NOEC_up(n_up,:) = Array_NOEC_up(n_up) + I_up;

            end

norm_week_up = time_up - i_week_up*7*24;

                if  (norm_week_up >= 120 && norm_week_up <= 168)

                    Array_NOEC_up(n_up,:) = 0;

                end
end


% EC delen av vektorn
%%%%%%%%%%%% Upington
for i_up = 1:length(time_EC_up)

    time_2_up = time_EC_up(i_up);
    hours_day_2_up = time_2_up - i_day_2_up*24;
    week_days_2_up = time_2_up - i_week_2_up*24*7;
    I_up = Plot_EC_up(i_up);

    if  hours_day_2_up >= 24

        i_day_2_up = i_day_2_up + 1;

    end

        if  week_days_2_up >= 7*24

            i_week_2_up = i_week_2_up + 1;

        end

norm_time_2_up = time_2_up - i_day_2_up*24;


            if  (norm_time_2_up < 7.5 || norm_time_2_up > 18.5)

                Array_EC_up(i_up,:) = Array_EC_up(i_up) + I_up;

            else

                Array_EC_up(i_up,:) = 0;

            end

norm_week_2_up = time_2_up - i_week_2_up*7*24;
```

```
        if (norm_week_2_up >= 120 && norm_week_2_up <= 168)

            Array_EC_up(i_up,:) = Array_EC_up(i_up) + I_up;

        end

end

%% Beräkningar

Energi_window_kWh_Stockholm = mean(Plot_noEC)*8670/1000
Energi_window_kWh_Upington = mean(Plot_noEC_up)*8670/1000
Energi_medEC_kWh_Stockholm = mean(mean(Array_EC) +
mean(Array_NOEC))*8670/1000
Energi_medEC_kWh_Upington = mean(mean(Array_EC_up) +
mean(Array_NOEC_up))*8670/1000
Energi_medLSC_kWh_Stockholm = mean(Plot_LSC)*8670/1000
Energi_medLSC_kWh_Upington = mean(Plot_LSC_up)*8670/1000

%% Plottar

%%%%%%%%%%%Ordinary Windows
figure
subplot(1,2,1)
plot(time_noEC, Plot_noEC,'b')
ylim([0 3e6])
xticks([722.5 1445 2167.5 2890 3612.5 4335 5057.5 5780 6502.5 7225 7947.5 8670])
xticklabels({'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Okt','Nov','Dec'})
yticks([0 1e6 2e6 3e6])
yticklabels({'0','1','2','3'})
xlabel('Month of the year')
ylabel('Used effect for heating [GW]')
title(['Ordinary window in Stockholm, Sweden'])

subplot(1,2,2)
plot(time_noEC_up, Plot_noEC_up,'r')
ylim([0 3e6])
xticks([722.5 1445 2167.5 2890 3612.5 4335 5057.5 5780 6502.5 7225 7947.5 8670])
xticklabels({'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Okt','Nov','Dec'})
yticks([0 1e6 2e6 3e6])
yticklabels({'0','1','2','3'})
xlabel('Month of the year')
ylabel('Used effect for heating [GW]')
title(['Ordinary window in Upington, South Africa'])

%%%%%%%%%%%%LSC Windows
figure
subplot(1,2,1)
plot(time_LSC, Plot_LSC,'b')
ylim([0 3e6])
xticks([722.5 1445 2167.5 2890 3612.5 4335 5057.5 5780 6502.5 7225 7947.5 8670])
xticklabels({'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Okt','Nov','Dec'})
```

```
yticks([0 1e6 2e6 3e6])
yticklabels({'0','1','2','3'})
xlabel('Month of the year')
ylabel('Used effect for heating [GW]')

title(['Window with LSC in Stockholm, Sweden'])

subplot(1,2,2)
plot(time_LSC_up, Plot_LSC_up,'r')
ylim([0 3e6])
xticks([722.5 1445 2167.5 2890 3612.5 4335 5057.5 5780 6502.5 7225 7947.5 8670])
xticklabels({'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Okt','Nov','Dec'})
yticks([0 1e6 2e6 3e6])
yticklabels({'0','1','2','3'})
xlabel('Month of the year')
ylabel('Used effect for heating [GW]')
title(['Window with LSC in Upington, South Africa'])

%%%%%%%%%%%%%%EC Windows
figure
subplot(1,2,1)
plot(time_noEC, Array_NOEC,'b')
xticks([722.5 1445 2167.5 2890 3612.5 4335 5057.5 5780 6502.5 7225 7947.5 8670])
xticklabels({'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Okt','Nov','Dec'})
yticks([0 1e6 2e6 3e6])
yticklabels({'0','1','2','3'})
ylim([0 3e6])
hold on
plot(time_EC, Array_EC,'b')
xlabel('Month of the year')
ylabel('Used effect for heating [GW]')
title(['Window with EC coating in Stockholm, Sweden'])

subplot(1,2,2)
plot(time_noEC_up, Array_NOEC_up,'r')
xticks([722.5 1445 2167.5 2890 3612.5 4335 5057.5 5780 6502.5 7225 7947.5 8670])
xticklabels({'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Okt','Nov','Dec'})
yticks([0 1e6 2e6 3e6])
yticklabels({'0','1','2','3'})
ylim([0 3e6])
hold on
plot(time_EC_up, Array_EC_up,'r')
xlabel('Month of the year')
ylabel('Used effect for heating [GW]')
title(['Window with EC coating in Upington, South Africa'])
```

Appendix C - IDA ICE report with ordinary windows in Stockholm

EQUA SIMULATION TECHNOLOGY GROUP		**Delivered Energy Report**	
Project		**Building**	
		Model floor area	29934.7 m2
Customer		Model volume	96959.1 m3
Created by	Alexander Cahlenstein	Model ground area	7774.8 m2
Location	Stockholm Sergels torg	Model envelope area	22040.0 m2
Climate file	Stockholm Sergels torg Climate	Window/Envelope	16.7 %
Case	Sergelhuset	Average U-value	0.4757 W/(m2 K)
Simulated	2017-06-28 19:54:10	Envelope area per Volume	0.2273 m2/m3

Building Comfort Reference

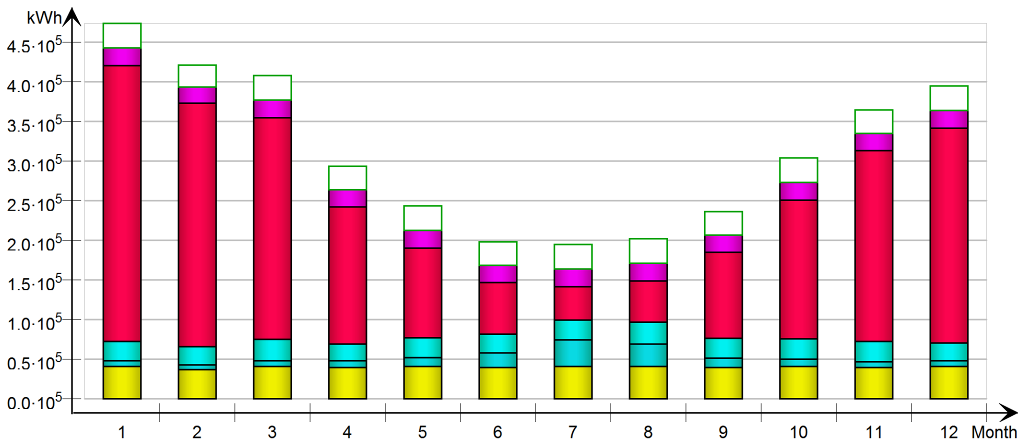
Percentage of hours when operative temperature is above 27°C in worst zone	98 %
Percentage of hours when operative temperature is above 27°C in average zone	0 %
Percentage of total occupant hours with thermal dissatisfaction	14 %

Delivered Energy Overview

		Purchased energy		Peak demand
		kWh	kWh/m^2	kW
■	Lighting, facility	483804	16.2	55.23
■	Electric cooling	155838	5.2	291.2
■	HVAC aux	294830	9.8	102.1
	Total, Facility electric	934472	31.2	
■	Fuel heating	2173775	72.6	1782.0
■	Domestic hot water	265839	8.9	30.35
	Total, Facility fuel*	2439614	81.5	
	Total	3374086	112.7	
□	Equipment, tenant	362857	12.1	41.42
	Total, Tenant electric	362857	12.1	
	Grand total	3736943	124.8	

*heating value

Monthly Purchased/Sold Energy



Appendix D - IDA ICE report with LSC windows in Stockholm

SIMULATION TECHNOLOGY GROUP

Delivered Energy Report

Project		Building	
		Model floor area	29934.7 m2
Customer		Model volume	96959.1 m3
Created by	Alexander Cahlenstein	Model ground area	7774.8 m2
Location	Stockholm Sergels torg	Model envelope area	22040.0 m2
Climate file	Stockholm Sergels torg Climate	Window/Envelope	16.7 %
Case	Sergelhuset	Average U-value	0.4757 W/(m2 K)
Simulated	2017-07-24 23:56:29	Envelope area per Volume	0.2273 m2/m3

Building Comfort Reference

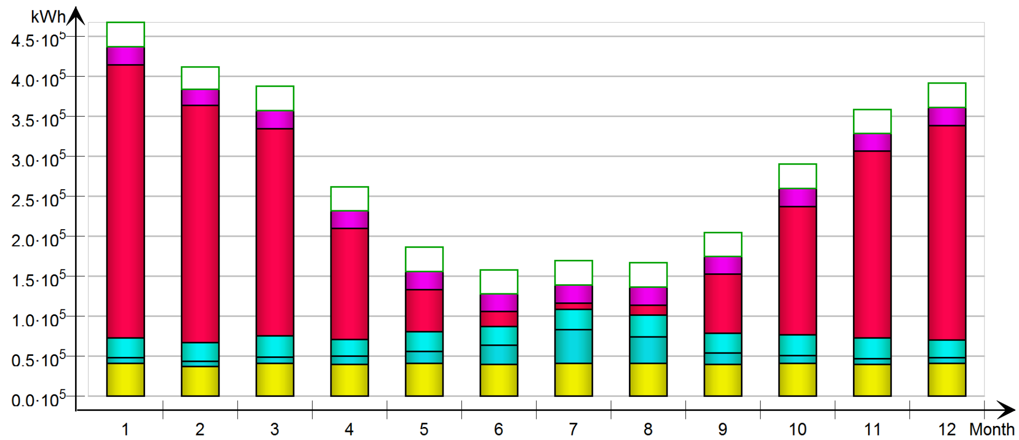
Percentage of hours when operative temperature is above 27°C in worst zone	99 %
Percentage of hours when operative temperature is above 27°C in average zone	0 %
Percentage of total occupant hours with thermal dissatisfaction	13 %

Delivered Energy Overview

	Purchased energy		Peak demand
	kWh	kWh/m²	kW
Lighting, facility	483804	16.2	55.23
Electric cooling	184230	6.2	345.6
HVAC aux	294517	9.8	102.3
Total, Facility electric	962551	32.1	
Fuel heating	1865374	62.3	1723.0
Domestic hot water	265839	8.9	30.35
Total, Facility fuel*	2131213	71.2	
Total	3093764	103.4	
Equipment, tenant	362857	12.1	41.42
Total, Tenant electric	362857	12.1	
Grand total	3456621	115.5	

*heating value

Monthly Purchased/Sold Energy



Appendix E - IDA ICE report with EC mirror during non-working hours in

EQUA SIMULATION TECHNOLOGY GROUP		Delivered Energy Report	
Project		**Building**	
		Model floor area	29934.7 m2
Customer		Model volume	96959.1 m3
Created by	Alexander Cahlenstein	Model ground area	7774.8 m2
Location	Stockholm Sergels torg	Model envelope area	22040.0 m2
Climate file	Stockholm Sergels torg Climate	Window/Envelope	16.7 %
Case	Sergelhuset	Average U-value	0.4757 W/(m2 K)
Simulated	2017-06-26 22:22:43	Envelope area per Volume	0.2273 m2/m3

Building Comfort Reference

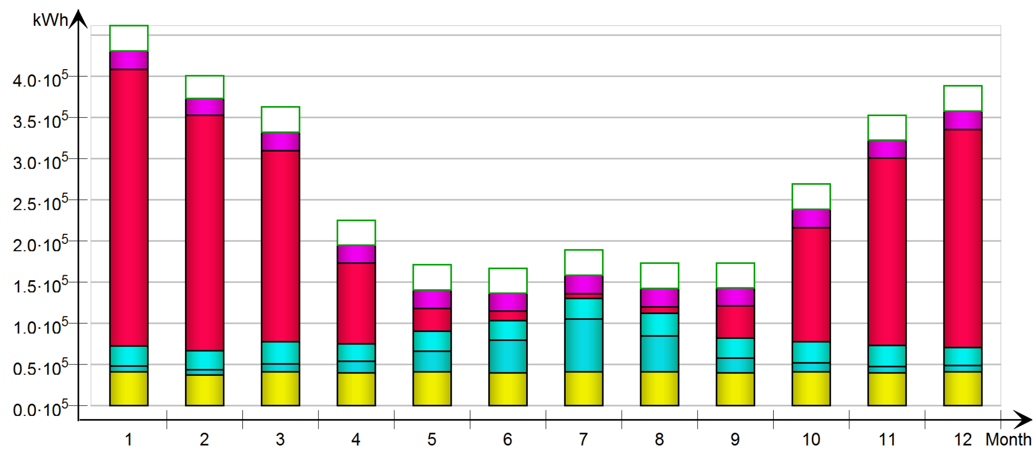
Percentage of hours when operative temperature is above 27°C in worst zone	99 %
Percentage of hours when operative temperature is above 27°C in average zone	1 %
Percentage of total occupant hours with thermal dissatisfaction	12 %

Delivered Energy Overview

	Purchased energy		Peak demand
	kWh	**kWh/m²**	**kW**
Lighting, facility	483804	16.2	55.23
Electric cooling	253954	8.5	433.6
HVAC aux	294246	9.8	102.3
Total, Facility electric	1032004	34.5	
Fuel heating	1675230	56.0	1676.0
Domestic hot water	265839	8.9	30.35
Total, Facility fuel*	1941069	64.8	
Total	2973073	99.3	
Equipment, tenant	362857	12.1	41.42
Total, Tenant electric	362857	12.1	
Grand total	3335930	111.4	

*heating value

Monthly Purchased/Sold Energy



Stockholm

Appendix F - IDA ICE report with ordinary windows in Upington

SIMULATION TECHNOLOGY GROUP		**Delivered Energy Report**	
Project		**Building**	
		Model floor area	29934.7 m2
Customer		Model volume	96959.1 m3
Created by	Alexander Cahlenstein	Model ground area	7774.8 m2
Location	Upington_684240 (ASHRAE 2013)	Model envelope area	22040.0 m2
Climate file	ZAF_UPINGTON_684240(IW2)	Window/Envelope	16.7 %
Case	Sergelhuset	Average U-value	0.4757 W/(m2 K)
Simulated	2017-07-26 16:29:28	Envelope area per Volume	0.2273 m2/m3

Building Comfort Reference

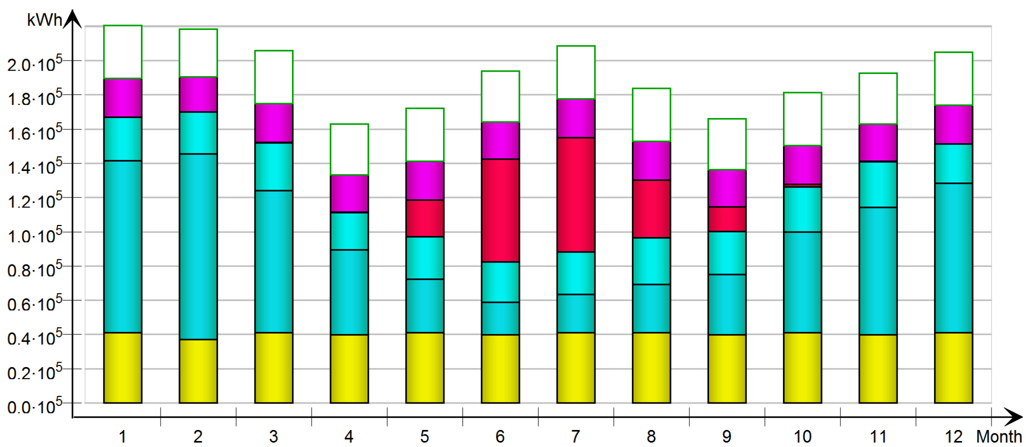
Percentage of hours when operative temperature is above 27°C in worst zone	100 %
Percentage of hours when operative temperature is above 27°C in average zone	0 %
Percentage of total occupant hours with thermal dissatisfaction	7 %

Delivered Energy Overview

	Purchased energy		**Peak demand**
	kWh	**kWh/m²**	**kW**
Lighting, facility	483804	16.2	55.23
Electric cooling	698421	23.3	476.0
HVAC aux	301001	10.1	103.6
Total, Facility electric	1483226	49.6	
Fuel heating	198940	6.6	761.8
Domestic hot water	265839	8.9	30.35
Total, Facility fuel*	464779	15.5	
Total	1948005	65.1	
Equipment, tenant	362857	12.1	41.42
Total, Tenant electric	362857	12.1	
Grand total	2310862	77.2	

*heating value

Monthly Purchased/Sold Energy



Appendix G - IDA ICE report with LSC windows in Upington

EQUA SIMULATION TECHNOLOGY GROUP

Delivered Energy Report

Project		Building	
		Model floor area	29934.7 m2
Customer		Model volume	96959.1 m3
Created by	Alexander Cahlenstein	Model ground area	7774.8 m2
Location	Upington_684240 (ASHRAE 2013)	Model envelope area	22040.0 m2
Climate file	ZAF_UPINGTON_684240(IW2)	Window/Envelope	16.7 %
Case	Sergelhuset	Average U-value	0.4757 W/(m2 K)
Simulated	2017-07-27 04:37:36	Envelope area per Volume	0.2273 m2/m3

Building Comfort Reference

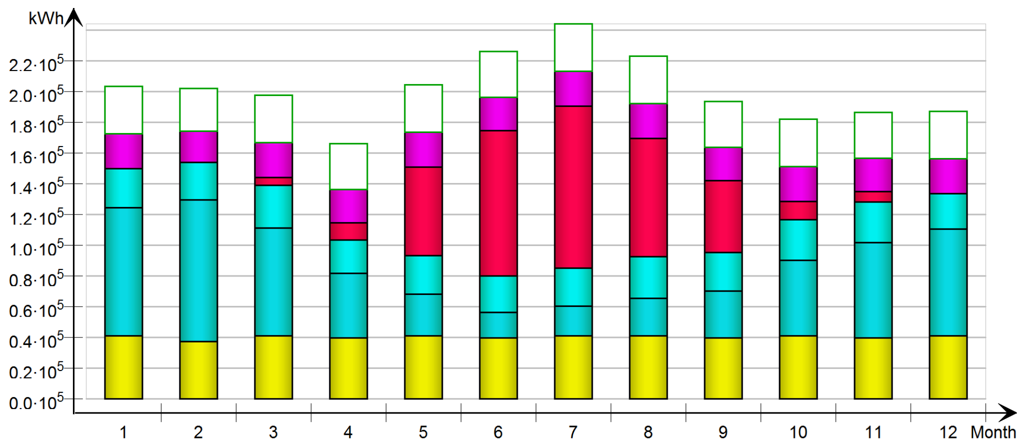
Percentage of hours when operative temperature is above 27°C in worst zone	100 %
Percentage of hours when operative temperature is above 27°C in average zone	0 %
Percentage of total occupant hours with thermal dissatisfaction	7 %

Delivered Energy Overview

	Purchased energy		Peak demand
	kWh	kWh/m2	kW
Lighting, facility	483804	16.2	55.23
Electric cooling	586629	19.6	443.4
HVAC aux	301063	10.1	103.6
Total, Facility electric	1371496	45.8	
Fuel heating	416149	13.9	808.6
Domestic hot water	265839	8.9	30.35
Total, Facility fuel*	681988	22.8	
Total	2053484	68.6	
Equipment, tenant	362857	12.1	41.42
Total, Tenant electric	362857	12.1	
Grand total	2416341	80.7	

*heating value

Monthly Purchased/Sold Energy



Appendix H - IDA ICE report with EC mirror during non-working hours in Upington

EQUA SIMULATION TECHNOLOGY GROUP

Delivered Energy Report

Project		Building	
		Model floor area	29934.7 m2
Customer		Model volume	96959.1 m3
Created by	Alexander Cahlenstein	Model ground area	7774.8 m2
Location	Upington_684240 (ASHRAE 2013)	Model envelope area	22040.0 m2
Climate file	ZAF_UPINGTON_684240(IW2)	Window/Envelope	16.7 %
Case	Sergelhuset	Average U-value	0.4757 W/(m2 K)
Simulated	2017-07-26 22:13:42	Envelope area per Volume	0.2273 m2/m3

Building Comfort Reference

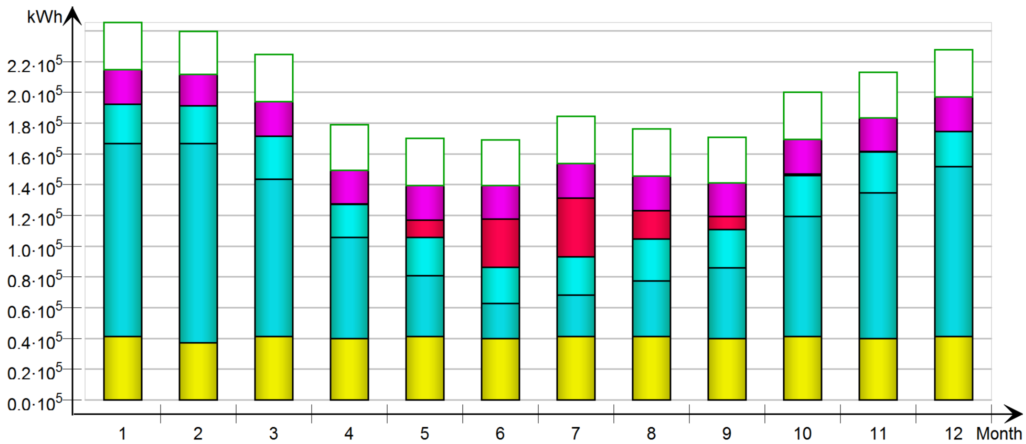
Percentage of hours when operative temperature is above 27°C in worst zone	100 %
Percentage of hours when operative temperature is above 27°C in average zone	3 %
Percentage of total occupant hours with thermal dissatisfaction	7 %

Delivered Energy Overview

	Purchased energy		Peak demand
	kWh	kWh/m²	kW
Lighting, facility	483804	16.2	55.23
Electric cooling	877846	29.3	530.8
HVAC aux	300911	10.1	103.7
Total, Facility electric	1662561	55.5	
Fuel heating	109082	3.6	734.0
Domestic hot water	265839	8.9	30.35
Total, Facility fuel*	374921	12.5	
Total	2037482	68.1	
Equipment, tenant	362857	12.1	41.42
Total, Tenant electric	362857	12.1	
Grand total	2400339	80.2	

*heating value

Monthly Purchased/Sold Energy



Appendix I: The main interface of the life cycle costs analysis excel program

Indata

Namn/Typ	Enhet	Roof mounted	Facade mounted	Semi transparent solar cell facade	Transparent solar cell window
Yta	m^2	482,00	1152,00	1152,00	894,00
Verkningsgrad	%	16%	12%	4%	1%
Säkringens storlek i anslutningspunkten	A	150	150	150	150
Ekonomisk livslängd	År	50	50	50	50
Kalkylränta	%	5%	5%	5%	5%
Investeringskostnad utan stöd	kr/kW	9000,00	30000,00	60000,00	200000,00
Investeringsstöd	Kr	30%	30%	30%	30%
TIlläggskostnader vid investeringen	Kr	0,00	0,00	0,00	0,00
Energiutbyte år 1	kWh/Kw ,år	935,00	505,00	401,00	401,00
Egenanvänd el	%	100,00%	100,00%	100,00%	100,00%
Pris köpt el	kr/kWh	1,00	1,00	1,00	1,00
Pris såld el	kr/kWh	0,50	0,50	0,50	0,50
Ersättning från nätägare	kr/kWh	0,05	0,05	0,05	0,05
Elcertikatvärde	kr/kWh	0,13	0,13	0,13	0,13
Andel solel som ger elcertifikat	%	100,00%	100,00%	100,00%	100,00%
Kvotplikt medelvärde	%	23,10%	23,10%	23,10%	23,10%
Ursprungsgarantier	kr/kWh	0,01	0,01	0,01	0,01
Antal år med skattereduktion	År	15	15	15	15

Antaganden

	Enhet	Roof mounted	Facade mounted	Semi transparent solar cell facade	Transparent solar cell window
Tak för investeringsstöd	kr	12000000,00	1200000,00	1200000,00	1200000,00
Antal byten av växelriktare	st	2	3	1	1
År till byte av växelriktare	år	15	15	15	15
Kostnad för byte av växelriktare	kr	20000,00	20000,00	20000,00	20000,00
Elcertifikathantering	kr/år	2000	2000	2000	2000
Loggning	kr/år	0	0	0	0
Inmatningsabonemang	kr/år	2000	2000	2000	2000
Resor	kr/år	0	0	0	0
Övrigt	kr/år	0	0	0	0
Summa fasta driftkostnader	kr/år	4000	4000	4000	4000
Försäkring	kr/år	0	0	0	0
Underhåll	kr/år	0	0	0	0
Tillsyn	kr/år	5000	5000	5000	5000
Summa rörliga driftkostnader	kr/år	5000	5000	5000	5000
Årlig degradering av utbyte	%/år	0,01%	0,01%	0,01%	0,01%
Tillgänglighet	%	99,90%	99,90%	99,90%	99,90%
Antal år med elcertifikat	år	15	15	15	15
Skattereduktion	kr/kWh	0,6	0,6	0,6	0,6
Tak för skattereduktion	kr	18000	18000	18000	18000

Utdata

	Enhet	Roof mounted	Facade mounted	Semi transparent solar cell facade	Transparent solar cell window
Installerad effekt	kW	78,566	139,392	48,384	11,622

Appendix J: Cash flow of a roof mounted solar panel as a part of the life cycle costs analysis

Roof mounted

	Energiproduktion [kWh]		Investering nuvärden [kr]				Intäkter nuvärde [kr]					Resultat nuvärde [kr]			
												Utan stöd		Med investeringsstöd	
År	**Energi**	**Energi nuvärde**	**Investering**	**Investering med investeringsstöd**	**Kostnader**	**Egenanvänd el**	**Såld el**	**Ersättning nätägare**	**Elcertifikat**	**Ursprungsgaranti**	**Skattereduktion**	**Summa per år**	**Ackumulerat**	**Summa per år**	**Ackumulerat**
0			-707 094,00 kr	-494 965,80 kr								-707 094,00 kr	-707 094,00 kr	-494 965,80 kr	-494 965,80 kr
1	73385,75	69891,19	0,00 kr	0,00 kr	-8 571,43 kr	69 891,19 kr	0,00 kr	0,00 kr	6 987,02 kr	698,91 kr	0,00 kr	69 005,70 kr	-638 088,30 kr	69 005,70 kr	-425 960,10 kr
2	73378,41	66556,38	0,00 kr	0,00 kr	-8 163,27 kr	66 556,38 kr	0,00 kr	0,00 kr	6 653,64 kr	665,56 kr	0,00 kr	65 712,32 kr	-572 375,98 kr	65 712,32 kr	-360 247,78 kr
3	73371,07	63380,69	0,00 kr	0,00 kr	-7 774,54 kr	63 380,69 kr	0,00 kr	0,00 kr	6 336,17 kr	633,81 kr	0,00 kr	62 576,13 kr	-509 799,85 kr	62 576,13 kr	-297 671,65 kr
4	73363,74	60356,53	0,00 kr	0,00 kr	-7 404,32 kr	60 356,53 kr	0,00 kr	0,00 kr	6 033,84 kr	603,57 kr	0,00 kr	59 589,61 kr	-450 210,24 kr	59 589,61 kr	-238 082,04 kr
5	73356,40	57476,66	0,00 kr	0,00 kr	-7 051,74 kr	57 476,66 kr	0,00 kr	0,00 kr	5 745,94 kr	574,77 kr	0,00 kr	56 745,63 kr	-393 464,61 kr	56 745,63 kr	-181 336,41 kr
6	73349,07	54734,20	0,00 kr	0,00 kr	-6 715,94 kr	54 734,20 kr	0,00 kr	0,00 kr	5 471,78 kr	547,34 kr	0,00 kr	54 037,38 kr	-339 427,22 kr	54 037,38 kr	-127 299,02 kr
7	73341,73	52122,60	0,00 kr	0,00 kr	-6 396,13 kr	52 122,60 kr	0,00 kr	0,00 kr	5 210,70 kr	521,23 kr	0,00 kr	51 458,39 kr	-287 968,83 kr	51 458,39 kr	-75 840,63 kr
8	73334,40	49635,61	0,00 kr	0,00 kr	-6 091,55 kr	49 635,61 kr	0,00 kr	0,00 kr	4 962,07 kr	496,36 kr	0,00 kr	49 002,48 kr	-238 966,35 kr	49 002,48 kr	-26 838,15 kr
9	73327,06	47267,28	0,00 kr	0,00 kr	-5 801,48 kr	47 267,28 kr	0,00 kr	0,00 kr	4 725,31 kr	472,67 kr	0,00 kr	46 663,78 kr	-192 302,57 kr	46 663,78 kr	19 825,63 kr
10	73319,73	45011,95	0,00 kr	0,00 kr	-5 525,22 kr	45 011,95 kr	0,00 kr	0,00 kr	4 499,85 kr	450,12 kr	0,00 kr	44 436,70 kr	-147 865,87 kr	44 436,70 kr	64 262,33 kr
11	73312,40	42864,24	0,00 kr	0,00 kr	-5 262,11 kr	42 864,24 kr	0,00 kr	0,00 kr	4 285,14 kr	428,64 kr	0,00 kr	42 315,91 kr	-105 549,97 kr	42 315,91 kr	106 578,23 kr
12	73305,07	40819,00	0,00 kr	0,00 kr	-5 011,54 kr	40 819,00 kr	0,00 kr	0,00 kr	4 080,68 kr	408,19 kr	0,00 kr	40 296,33 kr	-65 253,63 kr	40 296,33 kr	146 874,57 kr
13	73297,74	38871,35	0,00 kr	0,00 kr	-4 772,89 kr	38 871,35 kr	0,00 kr	0,00 kr	3 885,97 kr	388,71 kr	0,00 kr	38 373,15 kr	-26 880,49 kr	38 373,15 kr	185 247,71 kr
14	73290,41	37016,64	0,00 kr	0,00 kr	-4 545,61 kr	37 016,64 kr	0,00 kr	0,00 kr	3 700,55 kr	370,17 kr	0,00 kr	36 541,74 kr	9 661,26 kr	36 541,74 kr	221 789,46 kr
15	73283,08	35250,41	0,00 kr	0,00 kr	-4 329,15 kr	35 250,41 kr	0,00 kr	0,00 kr	3 523,98 kr	352,50 kr	0,00 kr	34 797,75 kr	44 459,00 kr	34 797,75 kr	256 587,20 kr
16	73275,75	33568,46	0,00 kr	0,00 kr	-4 123,00 kr	33 568,46 kr	0,00 kr	0,00 kr	0,00 kr	335,68 kr	0,00 kr	29 781,15 kr	74 240,15 kr	29 781,15 kr	286 368,35 kr
17	73268,42	31966,77	0,00 kr	0,00 kr	-3 926,67 kr	31 966,77 kr	0,00 kr	0,00 kr	0,00 kr	319,67 kr	0,00 kr	28 359,77 kr	102 599,92 kr	28 359,77 kr	314 728,12 kr
18	73261,09	30441,50	0,00 kr	0,00 kr	-3 739,69 kr	30 441,50 kr	0,00 kr	0,00 kr	0,00 kr	304,41 kr	0,00 kr	27 006,23 kr	129 606,14 kr	27 006,23 kr	341 734,34 kr
19	73253,77	28989,00	0,00 kr	0,00 kr	-3 561,61 kr	28 989,00 kr	0,00 kr	0,00 kr	0,00 kr	289,89 kr	0,00 kr	25 717,29 kr	155 323,43 kr	25 717,29 kr	367 451,63 kr
20	73246,44	27605,81	0,00 kr	0,00 kr	-3 392,01 kr	27 605,81 kr	0,00 kr	0,00 kr	0,00 kr	276,06 kr	0,00 kr	24 489,87 kr	179 813,30 kr	24 489,87 kr	391 941,50 kr
21	73239,12	26288,62	0,00 kr	0,00 kr	-3 230,48 kr	26 288,62 kr	0,00 kr	0,00 kr	0,00 kr	262,89 kr	0,00 kr	23 321,03 kr	203 134,33 kr	23 321,03 kr	415 262,53 kr
22	73231,79	25034,28	0,00 kr	0,00 kr	-3 076,65 kr	25 034,28 kr	0,00 kr	0,00 kr	0,00 kr	250,34 kr	0,00 kr	22 207,97 kr	225 342,30 kr	22 207,97 kr	437 470,50 kr
23	73224,47	23839,79	0,00 kr	0,00 kr	-2 930,14 kr	23 839,79 kr	0,00 kr	0,00 kr	0,00 kr	238,40 kr	0,00 kr	21 148,04 kr	246 490,34 kr	21 148,04 kr	458 618,54 kr
24	73217,15	22702,29	0,00 kr	0,00 kr	-2 790,61 kr	22 702,29 kr	0,00 kr	0,00 kr	0,00 kr	227,02 kr	0,00 kr	20 138,70 kr	266 629,04 kr	20 138,70 kr	478 757,24 kr
25	73209,83	21619,06	0,00 kr	0,00 kr	-2 657,72 kr	21 619,06 kr	0,00 kr	0,00 kr	0,00 kr	216,19 kr	0,00 kr	19 177,53 kr	285 806,57 kr	19 177,53 kr	497 934,77 kr
26	73202,51	20587,53	0,00 kr	0,00 kr	-2 531,17 kr	20 587,53 kr	0,00 kr	0,00 kr	0,00 kr	205,88 kr	0,00 kr	18 262,24 kr	304 068,81 kr	18 262,24 kr	516 197,01 kr
27	73195,19	19605,21	0,00 kr	0,00 kr	-2 410,63 kr	19 605,21 kr	0,00 kr	0,00 kr	0,00 kr	196,05 kr	0,00 kr	17 390,62 kr	321 459,43 kr	17 390,62 kr	533 587,63 kr
28	73187,87	18669,76	0,00 kr	0,00 kr	-2 295,84 kr	18 669,76 kr	0,00 kr	0,00 kr	0,00 kr	186,70 kr	0,00 kr	16 560,61 kr	338 020,05 kr	16 560,61 kr	550 148,25 kr
29	73180,55	17778,94	0,00 kr	0,00 kr	-2 186,52 kr	17 778,94 kr	0,00 kr	0,00 kr	0,00 kr	177,79 kr	0,00 kr	15 770,22 kr	353 790,26 kr	15 770,22 kr	565 918,46 kr
30	73173,23	16930,64	0,00 kr	0,00 kr	-2 082,40 kr	16 930,64 kr	0,00 kr	0,00 kr	0,00 kr	169,31 kr	0,00 kr	15 017,54 kr	368 807,81 kr	15 017,54 kr	580 936,01 kr
31	73165,91	16122,80	0,00 kr	0,00 kr	-1 983,24 kr	16 122,80 kr	0,00 kr	0,00 kr	0,00 kr	161,23 kr	0,00 kr	14 300,79 kr	383 108,60 kr	14 300,79 kr	595 236,80 kr
32	73158,60	15353,51	0,00 kr	0,00 kr	-1 888,80 kr	15 353,51 kr	0,00 kr	0,00 kr	0,00 kr	153,54 kr	0,00 kr	13 618,25 kr	396 726,86 kr	13 618,25 kr	608 855,06 kr
33	73151,28	14620,93	0,00 kr	0,00 kr	-1 798,85 kr	14 620,93 kr	0,00 kr	0,00 kr	0,00 kr	146,21 kr	0,00 kr	12 968,29 kr	409 695,15 kr	12 968,29 kr	621 823,35 kr
34	73143,96	13923,30	0,00 kr	0,00 kr	-1 713,19 kr	13 923,30 kr	0,00 kr	0,00 kr	0,00 kr	139,23 kr	0,00 kr	12 349,34 kr	422 044,49 kr	12 349,34 kr	634 172,69 kr
35	73136,65	13258,96	0,00 kr	0,00 kr	-1 631,61 kr	13 258,96 kr	0,00 kr	0,00 kr	0,00 kr	132,59 kr	0,00 kr	11 759,94 kr	433 804,43 kr	11 759,94 kr	645 932,63 kr
36	73129,34	12626,32	0,00 kr	0,00 kr	-1 553,92 kr	12 626,32 kr	0,00 kr	0,00 kr	0,00 kr	126,26 kr	0,00 kr	11 198,67 kr	445 003,10 kr	11 198,67 kr	657 131,30 kr
37	73122,02	12023,87	0,00 kr	0,00 kr	-1 479,92 kr	12 023,87 kr	0,00 kr	0,00 kr	0,00 kr	120,24 kr	0,00 kr	10 664,18 kr	455 667,29 kr	10 664,18 kr	667 795,49 kr
38	73114,71	11450,16	0,00 kr	0,00 kr	-1 409,45 kr	11 450,16 kr	0,00 kr	0,00 kr	0,00 kr	114,50 kr	0,00 kr	10 155,21 kr	465 822,49 kr	10 155,21 kr	677 950,69 kr
39	73107,40	10903,82	0,00 kr	0,00 kr	-1 342,33 kr	10 903,82 kr	0,00 kr	0,00 kr	0,00 kr	109,04 kr	0,00 kr	9 670,53 kr	475 493,02 kr	9 670,53 kr	687 621,22 kr
40	73100,09	10383,55	0,00 kr	0,00 kr	-1 278,41 kr	10 383,55 kr	0,00 kr	0,00 kr	0,00 kr	103,84 kr	0,00 kr	9 208,98 kr	484 702,00 kr	9 208,98 kr	696 830,20 kr
41	73092,78	9888,11	0,00 kr	0,00 kr	-1 217,53 kr	9 888,11 kr	0,00 kr	0,00 kr	0,00 kr	98,88 kr	0,00 kr	8 769,45 kr	493 471,45 kr	8 769,45 kr	705 599,65 kr
42	73085,47	9416,30	0,00 kr	0,00 kr	-1 159,56 kr	9 416,30 kr	0,00 kr	0,00 kr	0,00 kr	94,16 kr	0,00 kr	8 350,91 kr	501 822,36 kr	8 350,91 kr	713 950,56 kr
43	73078,16	8967,01	0,00 kr	0,00 kr	-1 104,34 kr	8 967,01 kr	0,00 kr	0,00 kr	0,00 kr	89,67 kr	0,00 kr	7 952,34 kr	509 774,71 kr	7 952,34 kr	721 902,91 kr
44	73070,85	8539,16	0,00 kr	0,00 kr	-1 051,75 kr	8 539,16 kr	0,00 kr	0,00 kr	0,00 kr	85,39 kr	0,00 kr	7 572,80 kr	517 347,50 kr	7 572,80 kr	729 475,70 kr
45	73063,55	8131,72	0,00 kr	0,00 kr	-1 001,67 kr	8 131,72 kr	0,00 kr	0,00 kr	0,00 kr	81,32 kr	0,00 kr	7 211,37 kr	524 558,87 kr	7 211,37 kr	736 687,07 kr
46	73056,24	7743,72	0,00 kr	0,00 kr	-953,97 kr	7 743,72 kr	0,00 kr	0,00 kr	0,00 kr	77,44 kr	0,00 kr	6 867,19 kr	531 426,05 kr	6 867,19 kr	743 554,25 kr
47	73048,93	7374,23	0,00 kr	0,00 kr	-908,54 kr	7 374,23 kr	0,00 kr	0,00 kr	0,00 kr	73,74 kr	0,00 kr	6 539,43 kr	537 965,49 kr	6 539,43 kr	750 093,69 kr
48	73041,63	7022,38	0,00 kr	0,00 kr	-865,28 kr	7 022,38 kr	0,00 kr	0,00 kr	0,00 kr	70,22 kr	0,00 kr	6 227,32 kr	544 192,81 kr	6 227,32 kr	756 321,01 kr
49	73034,33	6687,31	0,00 kr	0,00 kr	-824,08 kr	6 687,31 kr	0,00 kr	0,00 kr	0,00 kr	66,87 kr	0,00 kr	5 930,11 kr	550 122,91 kr	5 930,11 kr	762 251,11 kr
50	73027,02	6368,23	0,00 kr	0,00 kr	-784,83 kr	6 368,23 kr	0,00 kr	0,00 kr	0,00 kr	63,68 kr	0,00 kr	5 647,08 kr	555 769,99 kr	5 647,08 kr	767 898,19 kr
Summa	3660312,15	1 337 687,81 kr	-707 094,00 kr	-494 965,80 kr	-164 303,33 kr	1 337 687,81 kr	0,00 kr	0,00 kr	76 102,64 kr	13 376,88 kr	0,00 kr	555 769,99 kr	8 572 523,81 kr	767 898,19 kr	19 391 062,01 kr

Appendix K: Cash flow of a facade mounted solar panel as a part of the life cycle costs analysis

Facade mounted

	Energiproduktion [kWh]		Investering nuvärden [kr]		Intäkter nuvärde [kr]							Resultat nuvärde [kr]			
												Utan stöd		Med investeringsstöd	
År	Energi	Energi nuvärde	Investering	Investering med investeringsstöd	Kostnader	Egenanvänd el	Såld el	Ersättning nätägare	Elcertifikat	Ursprungsgaranti	Skattereduktion	Summa per år	Ackumulerat	Summa per år	Ackumulerat
0			-4 181 760,00 kr	-2 981 760,00 kr								-4 181 760,00 kr	-4 181 760,00 kr	-2 981 760,00 kr	-2 981 760,00 kr
1	70322,57	66973,87	0,00	0,00	-8571,43	66973,87	0,00	0,00	6695,38	334,87	0,00	65432,69	-4116327,31	65432,69	-2 916 327,31 kr
2	70315,53	63778,26	0,00	0,00	-8163,27	63778,26	0,00	0,00	6375,91	318,89	0,00	62309,80	-4054017,51	62309,80	-2 854 017,51 kr
3	70308,50	60735,13	0,00	0,00	-7774,54	60735,13	0,00	0,00	6071,69	303,68	0,00	59335,96	-3994681,55	59335,96	-2 794 681,55 kr
4	70301,47	57837,20	0,00	0,00	-7404,32	57837,20	0,00	0,00	5781,98	289,19	0,00	56504,04	-3938177,51	56504,04	-2 738 177,51 kr
5	70294,44	55077,53	0,00	0,00	-7051,74	55077,53	0,00	0,00	5506,10	275,39	0,00	53807,29	-3884370,22	53807,29	-2 684 370,22 kr
6	70287,41	52449,55	0,00	0,00	-6715,94	52449,55	0,00	0,00	5243,38	262,25	0,00	51239,24	-3833130,98	51239,24	-2 633 130,98 kr
7	70280,38	49946,96	0,00	0,00	-6396,13	49946,96	0,00	0,00	4993,20	249,73	0,00	48793,76	-3784337,22	48793,76	-2 584 337,22 kr
8	70273,36	47563,77	0,00	0,00	-6091,55	47563,77	0,00	0,00	4754,95	237,82	0,00	46464,99	-3737872,23	46464,99	-2 537 872,23 kr
9	70266,33	45294,30	0,00	0,00	-5801,48	45294,30	0,00	0,00	4528,07	226,47	0,00	44247,36	-3693624,87	44247,36	-2 493 624,87 kr
10	70259,30	43133,12	0,00	0,00	-5525,22	43133,12	0,00	0,00	4312,02	215,67	0,00	42135,58	-3651489,29	42135,58	-2 451 489,29 kr
11	70252,28	41075,05	0,00	0,00	-5262,11	41075,05	0,00	0,00	4106,27	205,38	0,00	40124,59	-3611364,70	40124,59	-2 411 364,70 kr
12	70245,25	39115,18	0,00	0,00	-5011,54	39115,18	0,00	0,00	3910,34	195,58	0,00	38209,57	-3573155,13	38209,57	-2 373 155,13 kr
13	70238,23	37248,83	0,00	0,00	-4772,89	37248,83	0,00	0,00	3723,77	186,24	0,00	36385,95	-3536769,18	36385,95	-2 336 769,18 kr
14	70231,20	35471,53	0,00	0,00	-4545,61	35471,53	0,00	0,00	3546,09	177,36	0,00	34649,36	-3502119,82	34649,36	-2 302 119,82 kr
15	70224,18	33779,03	0,00	0,00	-4329,15	33779,03	0,00	0,00	3376,89	168,90	0,00	32995,66	-3469124,16	32995,66	-2 269 124,16 kr
16	70217,16	32167,29	0,00	0,00	-4123,00	32167,29	0,00	0,00	0,00	160,84	0,00	28205,12	-3440919,04	28205,12	-2 240 919,04 kr
17	70210,14	30632,45	0,00	0,00	-3926,67	30632,45	0,00	0,00	0,00	153,16	0,00	26858,94	-3414060,09	26858,94	-2 214 060,09 kr
18	70203,11	29170,84	0,00	0,00	-3739,69	29170,84	0,00	0,00	0,00	145,85	0,00	25577,01	-3388483,08	25577,01	-2 188 483,08 kr
19	70196,09	27778,98	0,00	0,00	-3561,61	27778,98	0,00	0,00	0,00	138,89	0,00	24356,27	-3364126,82	24356,27	-2 164 126,82 kr
20	70189,07	26453,52	0,00	0,00	-3392,01	26453,52	0,00	0,00	0,00	132,27	0,00	23193,79	-3340933,03	23193,79	-2 140 933,03 kr
21	70182,06	25191,31	0,00	0,00	-3230,48	25191,31	0,00	0,00	0,00	125,96	0,00	22086,79	-3318846,24	22086,79	-2 118 846,24 kr
22	70175,04	23989,33	0,00	0,00	-3076,65	23989,33	0,00	0,00	0,00	119,95	0,00	21032,63	-3297813,62	21032,63	-2 097 813,62 kr
23	70168,02	22844,69	0,00	0,00	-2930,14	22844,69	0,00	0,00	0,00	114,22	0,00	20028,78	-3277784,84	20028,78	-2 077 784,84 kr
24	70161,00	21754,68	0,00	0,00	-2790,61	21754,68	0,00	0,00	0,00	108,77	0,00	19072,84	-3258712,00	19072,84	-2 058 712,00 kr
25	70153,99	20716,67	0,00	0,00	-2657,72	20716,67	0,00	0,00	0,00	103,58	0,00	18162,53	-3240549,48	18162,53	-2 040 549,48 kr
26	70146,97	19728,19	0,00	0,00	-2531,17	19728,19	0,00	0,00	0,00	98,64	0,00	17295,66	-3223253,82	17295,66	-2 023 253,82 kr
27	70139,96	18786,87	0,00	0,00	-2410,63	18786,87	0,00	0,00	0,00	93,93	0,00	16470,17	-3206783,65	16470,17	-2 006 783,65 kr
28	70132,94	17890,47	0,00	0,00	-2295,84	17890,47	0,00	0,00	0,00	89,45	0,00	15684,08	-3191099,57	15684,08	-1 991 099,57 kr
29	70125,93	17036,84	0,00	0,00	-2186,52	17036,84	0,00	0,00	0,00	85,18	0,00	14935,50	-3176164,07	14935,50	-1 976 164,07 kr
30	70118,92	16223,94	0,00	0,00	-2082,40	16223,94	0,00	0,00	0,00	81,12	0,00	14222,66	-3161941,41	14222,66	-1 961 941,41 kr
31	70111,90	15449,82	0,00	0,00	-1983,24	15449,82	0,00	0,00	0,00	77,25	0,00	13543,84	-3148397,57	13543,84	-1 948 397,57 kr
32	70104,89	14712,65	0,00	0,00	-1888,80	14712,65	0,00	0,00	0,00	73,56	0,00	12897,41	-3135500,16	12897,41	-1 935 500,16 kr
33	70097,88	14010,64	0,00	0,00	-1798,85	14010,64	0,00	0,00	0,00	70,05	0,00	12281,84	-3123218,32	12281,84	-1 923 218,32 kr
34	70090,87	13342,13	0,00	0,00	-1713,19	13342,13	0,00	0,00	0,00	66,71	0,00	11695,65	-3111522,67	11695,65	-1 911 522,67 kr
35	70083,86	12705,52	0,00	0,00	-1631,61	12705,52	0,00	0,00	0,00	63,53	0,00	11137,44	-3100385,23	11137,44	-1 900 385,23 kr
36	70076,86	12099,29	0,00	0,00	-1553,92	12099,29	0,00	0,00	0,00	60,50	0,00	10605,87	-3089779,36	10605,87	-1 889 779,36 kr
37	70069,85	11521,98	0,00	0,00	-1479,92	11521,98	0,00	0,00	0,00	57,61	0,00	10099,67	-3079679,69	10099,67	-1 879 679,69 kr
38	70062,84	10972,22	0,00	0,00	-1409,45	10972,22	0,00	0,00	0,00	54,86	0,00	9617,63	-3070062,06	9617,63	-1 870 062,06 kr
39	70055,84	10448,69	0,00	0,00	-1342,33	10448,69	0,00	0,00	0,00	52,24	0,00	9158,60	-3060903,46	9158,60	-1 860 903,46 kr
40	70048,83	9950,13	0,00	0,00	-1278,41	9950,13	0,00	0,00	0,00	49,75	0,00	8721,47	-3052181,99	8721,47	-1 852 181,99 kr
41	70041,82	9475,37	0,00	0,00	-1217,53	9475,37	0,00	0,00	0,00	47,38	0,00	8305,21	-3043876,78	8305,21	-1 843 876,78 kr
42	70034,82	9023,26	0,00	0,00	-1159,56	9023,26	0,00	0,00	0,00	45,12	0,00	7908,82	-3035967,96	7908,82	-1 835 967,96 kr
43	70027,82	8592,72	0,00	0,00	-1104,34	8592,72	0,00	0,00	0,00	42,96	0,00	7531,35	-3028436,61	7531,35	-1 828 436,61 kr
44	70020,81	8182,73	0,00	0,00	-1051,75	8182,73	0,00	0,00	0,00	40,91	0,00	7171,89	-3021264,72	7171,89	-1 821 264,72 kr
45	70013,81	7792,29	0,00	0,00	-1001,67	7792,29	0,00	0,00	0,00	38,96	0,00	6829,59	-3014435,14	6829,59	-1 814 435,14 kr
46	70006,81	7420,49	0,00	0,00	-953,97	7420,49	0,00	0,00	0,00	37,10	0,00	6503,62	-3007931,52	6503,62	-1 807 931,52 kr
47	69999,81	7066,43	0,00	0,00	-908,54	7066,43	0,00	0,00	0,00	35,33	0,00	6193,22	-3001738,30	6193,22	-1 801 738,30 kr
48	69992,81	6729,26	0,00	0,00	-865,28	6729,26	0,00	0,00	0,00	33,65	0,00	5897,62	-2995840,68	5897,62	-1 795 840,68 kr
49	69985,81	6408,17	0,00	0,00	-824,08	6408,17	0,00	0,00	0,00	32,04	0,00	5616,14	-2990224,54	5616,14	-1 790 224,54 kr
50	69978,81	6102,41	0,00	0,00	-784,83	6102,41	0,00	0,00	0,00	30,51	0,00	5348,09	-2984876,45	5348,09	-1 784 876,45 kr
Summa	3 507 527,60 kr	1281851,58	-4181760,00	-2981760,00	-164303,33	1281851,58	0,00	0,00	72926,05	6409,26	0,00	-2 984 876,45 kr	-170 960 015,59 kr	-1 784 876,45 kr	-109 760 015,59 kr

Appendix L: Cash flow of a semi transparent solar cell facade as a part of the life cycle costs analysis

Semi transparent solar cell facade

	Energiproduktion [kWh]		Investering nuvärden [kr]				Intäkter nuvärde [kr]					Resultat nuvärde [kr]			
												Utan stöd		Med investeringsstöd	
År	**Energi**	**Energi nuvärde**	**Investering**	**Investering med investeringsstöd**	**Kostnader**	**Egenanvänd el**	**Såld el**	**Ersättning nätägare**	**Elcertifikat**	**Ursprungsgaranti**	**Skattereduktion**	**Summa per år**	**Ackumulerat**	**Summa per år**	**Ackumulerat**
0			-2 903 040,00 kr	-2 032 128,00 kr								-2 903 040,00 kr	-2 903 040,00 kr	-2 032 128,00 kr	-2 032 128,00 kr
1	19382,58202	18459,60192	0	0	-8571,428571	18459,60192	0	0	1845,406404	92,2980096	0	11825,87776	-2891214,122	11825,87776	-2 020 302,12 kr
2	19380,64376	17578,8152	0	0	-8163,265306	17578,8152	0	0	1757,354156	87,894076	0	11260,79813	-2879953,324	11260,79813	-2 009 041,32 kr
3	19378,70569	16740,05459	0	0	-7774,538387	16740,05459	0	0	1673,503257	83,70027294	0	10722,71973	-2869230,604	10722,71973	-1 998 318,60 kr
4	19376,76782	15941,31484	0	0	-7404,322273	15941,31484	0	0	1593,653245	79,70657421	0	10210,35239	-2859020,252	10210,35239	-1 988 108,25 kr
5	19374,83015	15180,68639	0	0	-7051,735498	15180,68639	0	0	1517,613218	75,90343195	0	9722,467543	-2849297,784	9722,467543	-1 978 385,78 kr
6	19372,89266	14456,35078	0	0	-6715,93857	14456,35078	0	0	1445,201388	72,28175391	0	9257,895354	-2840039,889	9257,895354	-1 969 127,89 kr
7	19370,95537	13766,57633	0	0	-6396,131971	13766,57633	0	0	1376,244636	68,83288165	0	8815,521877	-2831224,367	8815,521877	-1 960 312,37 kr
8	19369,01828	13109,71397	0	0	-6091,554258	13109,71397	0	0	1310,578106	65,54856987	0	8394,286392	-2822830,081	8394,286392	-1 951 918,08 kr
9	19367,08138	12484,19334	0	0	-5801,480246	12484,19334	0	0	1248,044808	62,42096668	0	7993,178865	-2814836,902	7993,178865	-1 943 924,90 kr
10	19365,14467	11888,51897	0	0	-5525,219282	11888,51897	0	0	1188,495241	59,44259484	0	7611,237523	-2807225,664	7611,237523	-1 936 313,66 kr
11	19363,20815	11321,26678	0	0	-5262,113602	11321,26678	0	0	1131,78704	56,60633389	0	7247,54655	-2799978,118	7247,54655	-1 929 066,12 kr
12	19361,27183	10781,08062	0	0	-5011,536764	10781,08062	0	0	1077,78463	53,9054031	0	6901,233889	-2793076,884	6901,233889	-1 922 164,88 kr
13	19359,33571	10266,66906	0	0	-4772,892156	10266,66906	0	0	1026,358906	51,3333453	0	6571,469154	-2786505,415	6571,469154	-1 915 593,41 kr
14	19357,39977	9776,802278	0	0	-4545,611577	9776,802278	0	0	977,3869238	48,88401139	0	6257,461636	-2780247,953	6257,461636	-1 909 335,95 kr
15	19355,46403	9310,309141	0	0	-4329,153883	9310,309141	0	0	930,7516048	46,55154571	0	5958,458409	-2774289,495	5958,458409	-1 903 377,49 kr
16	19353,52849	8866,074391	0	0	-4123,003698	8866,074391	0	0	0	44,33037195	0	4787,401065	-2769502,094	4787,401065	-1 898 590,09 kr
17	19351,59313	8443,035984	0	0	-3926,670188	8443,035984	0	0	0	42,21517992	0	4558,580975	-2764943,513	4558,580975	-1 894 031,51 kr
18	19349,65797	8040,182553	0	0	-3739,685894	8040,182553	0	0	0	40,20091276	0	4340,697572	-2760602,815	4340,697572	-1 889 690,82 kr
19	19347,72301	7656,550985	0	0	-3561,605613	7656,550985	0	0	0	38,28275493	0	4133,228127	-2756469,587	4133,228127	-1 885 557,59 kr
20	19345,78824	7291,224124	0	0	-3392,005346	7291,224124	0	0	0	36,45612062	0	3935,674899	-2752533,912	3935,674899	-1 881 621,91 kr
21	19343,85366	6943,328573	0	0	-3230,481282	6943,328573	0	0	0	34,71664286	0	3747,563934	-2748786,348	3747,563934	-1 877 874,35 kr
22	19341,91927	6612,03261	0	0	-3076,64884	6612,03261	0	0	0	33,06016305	0	3568,443933	-2745217,904	3568,443933	-1 874 305,90 kr
23	19339,98508	6296,544196	0	0	-2930,141752	6296,544196	0	0	0	31,48272098	0	3397,885165	-2741820,019	3397,885165	-1 870 908,02 kr
24	19338,05108	5996,109088	0	0	-2790,611193	5996,109088	0	0	0	29,98054544	0	3235,478441	-2738584,541	3235,478441	-1 867 672,54 kr
25	19336,11728	5710,009025	0	0	-2657,724945	5710,009025	0	0	0	28,55004513	0	3080,834125	-2735503,707	3080,834125	-1 864 591,71 kr
26	19334,18366	5437,560023	0	0	-2531,166615	5437,560023	0	0	0	27,18780012	0	2933,581209	-2732570,125	2933,581209	-1 861 658,13 kr
27	19332,25025	5178,110731	0	0	-2410,634871	5178,110731	0	0	0	25,89055365	0	2793,366413	-2729776,759	2793,366413	-1 858 864,76 kr
28	19330,31702	4931,040876	0	0	-2295,842734	4931,040876	0	0	0	24,65520438	0	2659,853346	-2727116,906	2659,853346	-1 856 204,91 kr
29	19328,38399	4695,759783	0	0	-2186,51689	4695,759783	0	0	0	23,47879891	0	2532,721692	-2724584,184	2532,721692	-1 853 672,18 kr
30	19326,45115	4471,704959	0	0	-2082,397038	4471,704959	0	0	0	22,35852479	0	2411,666446	-2722172,517	2411,666446	-1 851 260,52 kr
31	19324,51851	4258,340751	0	0	-1983,235274	4258,340751	0	0	0	21,29170375	0	2296,39718	-2719876,12	2296,39718	-1 848 964,12 kr
32	19322,58605	4055,157064	0	0	-1888,795499	4055,157064	0	0	0	20,27578532	0	2186,63735	-2717689,483	2186,63735	-1 846 777,48 kr
33	19320,6538	3861,668141	0	0	-1798,852856	3861,668141	0	0	0	19,3083407	0	2082,123625	-2715607,359	2082,123625	-1 844 695,36 kr
34	19318,72173	3677,411404	0	0	-1713,193197	3677,411404	0	0	0	18,38705702	0	1982,605264	-2713624,754	1982,605264	-1 842 712,75 kr
35	19316,78986	3501,946345	0	0	-1631,612568	3501,946345	0	0	0	17,50973173	0	1887,843509	-2711736,911	1887,843509	-1 840 824,91 kr
36	19314,85818	3334,853477	0	0	-1553,916732	3334,853477	0	0	0	16,67426738	0	1797,611013	-2709939,3	1797,611013	-1 839 027,30 kr
37	19312,92669	3175,733325	0	0	-1479,920697	3175,733325	0	0	0	15,87866663	0	1711,691295	-2708227,608	1711,691295	-1 837 315,61 kr
38	19310,9954	3024,205478	0	0	-1409,448283	3024,205478	0	0	0	15,12102739	0	1629,878223	-2706597,73	1629,878223	-1 835 685,73 kr
39	19309,0643	2879,907674	0	0	-1342,331698	2879,907674	0	0	0	14,39953837	0	1551,975514	-2705045,754	1551,975514	-1 834 133,75 kr
40	19307,13339	2742,494936	0	0	-1278,411141	2742,494936	0	0	0	13,71247468	0	1477,79627	-2703567,958	1477,79627	-1 832 655,96 kr
41	19305,20268	2611,638749	0	0	-1217,53442	2611,638749	0	0	0	13,05819375	0	1407,162523	-2702160,796	1407,162523	-1 831 248,80 kr
42	19303,27216	2487,026272	0	0	-1159,55659	2487,026272	0	0	0	12,43513136	0	1339,904813	-2700820,891	1339,904813	-1 829 908,89 kr
43	19301,34183	2368,35959	0	0	-1104,33961	2368,35959	0	0	0	11,84179795	0	1275,861778	-2699545,029	1275,861778	-1 828 633,03 kr
44	19299,4117	2255,355004	0	0	-1051,752009	2255,355004	0	0	0	11,27677502	0	1214,879769	-2698330,149	1214,879769	-1 827 418,15 kr
45	19297,48176	2147,742351	0	0	-1001,66858	2147,742351	0	0	0	10,73871175	0	1156,812482	-2697173,337	1156,812482	-1 826 261,34 kr
46	19295,55201	2045,264358	0	0	-953,9700764	2045,264358	0	0	0	10,22632179	0	1101,520604	-2696071,816	1101,520604	-1 825 159,82 kr
47	19293,62245	1947,67603	0	0	-908,5429299	1947,67603	0	0	0	9,738380152	0	1048,871481	-2695022,945	1048,871481	-1 824 110,94 kr
48	19291,69309	1854,74406	0	0	-865,2789809	1854,74406	0	0	0	9,273720299	0	998,7387992	-2694024,206	998,7387992	-1 823 112,21 kr
49	19289,76392	1766,246272	0	0	-824,0752199	1766,246272	0	0	0	8,831231359	0	951,0022833	-2693073,204	951,0022833	-1 822 161,20 kr
50	19287,83495	1681,971093	0	0	-784,8335428	1681,971093	0	0	0	8,409855463	0	905,5474053	-2692167,656	905,5474053	-1 821 255,66 kr
Summa	966 758,53 kr	353 308,96 kr	-2 903 040,00 kr	-2 032 128,00 kr	-164303,3291	353308,9645	0	0	20100,16356	1766,544822	0	-2 692 167,66 kr	-140 532 498,79 kr	-1 821 255,66 kr	-96 115 986,79 kr

Appendix M: Cash flow of a transparent solar window as a part of the life cycle costs analysis

Transparent solar cell window															
	Energiproduktion [kWh]		Investering nuvärden [kr]		Intäkter nuvärde [kr]							Resultat nuvärde [kr]			
												Utan stöd		Med investeringsstöd	
År	Energi	Energi nuvärde	Investering	Investering med investeringsstöd	Kostnader	Egenanvänd el	Såld el	Ersättning nätägare	Elcertifikat	Ursprungsgaranti	Skattereduktion	Summa per år	Ackumulerat	Summa per år	Ackumulerat
0			-1 430 400,00 kr	-733 080,00 kr								-1 430 400,00 kr	-1 430 400,00 kr	-733 080,00 kr	-733 080,00 kr
1	4 655,76 kr	4 434,06 kr	0,00 kr	0,00 kr	-8 571,43 kr	4 434,06 kr	0,00 kr	0,00 kr	443,27 kr	22,17 kr	0,00 kr	-3 671,93 kr	-1 434 071,93 kr	-3 671,93 kr	-736 751,93 kr
2	4 655,30 kr	4 222,49 kr	0,00 kr	0,00 kr	-8 163,27 kr	4 222,49 kr	0,00 kr	0,00 kr	422,12 kr	21,11 kr	0,00 kr	-3 497,54 kr	-1 437 569,47 kr	-3 497,54 kr	-740 249,47 kr
3	4 654,83 kr	4 021,02 kr	0,00 kr	0,00 kr	-7 774,54 kr	4 021,02 kr	0,00 kr	0,00 kr	401,98 kr	20,11 kr	0,00 kr	-3 331,43 kr	-1 440 900,90 kr	-3 331,43 kr	-743 580,90 kr
4	4 654,36 kr	3 829,16 kr	0,00 kr	0,00 kr	-7 404,32 kr	3 829,16 kr	0,00 kr	0,00 kr	382,80 kr	19,15 kr	0,00 kr	-3 173,22 kr	-1 444 074,12 kr	-3 173,22 kr	-746 754,12 kr
5	4 653,90 kr	3 646,45 kr	0,00 kr	0,00 kr	-7 051,74 kr	3 646,45 kr	0,00 kr	0,00 kr	364,54 kr	18,23 kr	0,00 kr	-3 022,52 kr	-1 447 096,63 kr	-3 022,52 kr	-749 776,63 kr
6	4 653,43 kr	3 472,46 kr	0,00 kr	0,00 kr	-6 715,94 kr	3 472,46 kr	0,00 kr	0,00 kr	347,14 kr	17,36 kr	0,00 kr	-2 878,97 kr	-1 449 975,60 kr	-2 878,97 kr	-752 655,60 kr
7	4 652,97 kr	3 306,78 kr	0,00 kr	0,00 kr	-6 396,13 kr	3 306,78 kr	0,00 kr	0,00 kr	330,58 kr	16,53 kr	0,00 kr	-2 742,24 kr	-1 452 717,85 kr	-2 742,24 kr	-755 397,85 kr
8	4 652,50 kr	3 149,00 kr	0,00 kr	0,00 kr	-6 091,55 kr	3 149,00 kr	0,00 kr	0,00 kr	314,81 kr	15,74 kr	0,00 kr	-2 612,01 kr	-1 455 329,85 kr	-2 612,01 kr	-758 009,85 kr
9	4 652,04 kr	2 998,75 kr	0,00 kr	0,00 kr	-5 801,48 kr	2 998,75 kr	0,00 kr	0,00 kr	299,78 kr	14,99 kr	0,00 kr	-2 487,96 kr	-1 457 817,81 kr	-2 487,96 kr	-760 497,81 kr
10	4 651,57 kr	2 855,66 kr	0,00 kr	0,00 kr	-5 525,22 kr	2 855,66 kr	0,00 kr	0,00 kr	285,48 kr	14,28 kr	0,00 kr	-2 369,80 kr	-1 460 187,61 kr	-2 369,80 kr	-762 867,61 kr
11	4 651,11 kr	2 719,41 kr	0,00 kr	0,00 kr	-5 262,11 kr	2 719,41 kr	0,00 kr	0,00 kr	271,86 kr	13,60 kr	0,00 kr	-2 257,25 kr	-1 462 444,86 kr	-2 257,25 kr	-765 124,86 kr
12	4 650,64 kr	2 589,65 kr	0,00 kr	0,00 kr	-5 011,54 kr	2 589,65 kr	0,00 kr	0,00 kr	258,89 kr	12,95 kr	0,00 kr	-2 150,05 kr	-1 464 594,91 kr	-2 150,05 kr	-767 274,91 kr
13	4 650,18 kr	2 466,09 kr	0,00 kr	0,00 kr	-4 772,89 kr	2 466,09 kr	0,00 kr	0,00 kr	246,53 kr	12,33 kr	0,00 kr	-2 047,94 kr	-1 466 642,85 kr	-2 047,94 kr	-769 322,85 kr
14	4 649,71 kr	2 348,42 kr	0,00 kr	0,00 kr	-4 545,61 kr	2 348,42 kr	0,00 kr	0,00 kr	234,77 kr	11,74 kr	0,00 kr	-1 950,68 kr	-1 468 593,52 kr	-1 950,68 kr	-771 273,52 kr
15	4 649,25 kr	2 236,37 kr	0,00 kr	0,00 kr	-4 329,15 kr	2 236,37 kr	0,00 kr	0,00 kr	223,57 kr	11,18 kr	0,00 kr	-1 858,03 kr	-1 470 451,56 kr	-1 858,03 kr	-773 131,56 kr
16	4 648,78 kr	2 129,66 kr	0,00 kr	0,00 kr	-4 123,00 kr	2 129,66 kr	0,00 kr	0,00 kr	0,00 kr	10,65 kr	0,00 kr	-1 982,69 kr	-1 472 434,25 kr	-1 982,69 kr	-775 114,25 kr
17	4 648,32 kr	2 028,05 kr	0,00 kr	0,00 kr	-3 926,67 kr	2 028,05 kr	0,00 kr	0,00 kr	0,00 kr	10,14 kr	0,00 kr	-1 888,48 kr	-1 474 322,74 kr	-1 888,48 kr	-777 002,74 kr
18	4 647,85 kr	1 931,28 kr	0,00 kr	0,00 kr	-3 739,69 kr	1 931,28 kr	0,00 kr	0,00 kr	0,00 kr	9,66 kr	0,00 kr	-1 798,75 kr	-1 476 121,49 kr	-1 798,75 kr	-778 801,49 kr
19	4 647,39 kr	1 839,13 kr	0,00 kr	0,00 kr	-3 561,61 kr	1 839,13 kr	0,00 kr	0,00 kr	0,00 kr	9,20 kr	0,00 kr	-1 713,28 kr	-1 477 834,77 kr	-1 713,28 kr	-780 514,77 kr
20	4 646,92 kr	1 751,38 kr	0,00 kr	0,00 kr	-3 392,01 kr	1 751,38 kr	0,00 kr	0,00 kr	0,00 kr	8,76 kr	0,00 kr	-1 631,87 kr	-1 479 466,64 kr	-1 631,87 kr	-782 146,64 kr
21	4 646,46 kr	1 667,81 kr	0,00 kr	0,00 kr	-3 230,48 kr	1 667,81 kr	0,00 kr	0,00 kr	0,00 kr	8,34 kr	0,00 kr	-1 554,33 kr	-1 481 020,97 kr	-1 554,33 kr	-783 700,97 kr
22	4 645,99 kr	1 588,23 kr	0,00 kr	0,00 kr	-3 076,65 kr	1 588,23 kr	0,00 kr	0,00 kr	0,00 kr	7,94 kr	0,00 kr	-1 480,48 kr	-1 482 501,44 kr	-1 480,48 kr	-785 181,44 kr
23	4 645,53 kr	1 512,45 kr	0,00 kr	0,00 kr	-2 930,14 kr	1 512,45 kr	0,00 kr	0,00 kr	0,00 kr	7,56 kr	0,00 kr	-1 410,13 kr	-1 483 911,57 kr	-1 410,13 kr	-786 591,57 kr
24	4 645,07 kr	1 440,29 kr	0,00 kr	0,00 kr	-2 790,61 kr	1 440,29 kr	0,00 kr	0,00 kr	0,00 kr	7,20 kr	0,00 kr	-1 343,12 kr	-1 485 254,70 kr	-1 343,12 kr	-787 934,70 kr
25	4 644,60 kr	1 371,56 kr	0,00 kr	0,00 kr	-2 657,72 kr	1 371,56 kr	0,00 kr	0,00 kr	0,00 kr	6,86 kr	0,00 kr	-1 279,30 kr	-1 486 534,00 kr	-1 279,30 kr	-789 214,00 kr
26	4 644,14 kr	1 306,12 kr	0,00 kr	0,00 kr	-2 531,17 kr	1 306,12 kr	0,00 kr	0,00 kr	0,00 kr	6,53 kr	0,00 kr	-1 218,52 kr	-1 487 752,52 kr	-1 218,52 kr	-790 432,52 kr
27	4 643,67 kr	1 243,80 kr	0,00 kr	0,00 kr	-2 410,63 kr	1 243,80 kr	0,00 kr	0,00 kr	0,00 kr	6,22 kr	0,00 kr	-1 160,62 kr	-1 488 913,13 kr	-1 160,62 kr	-791 593,13 kr
28	4 643,21 kr	1 184,45 kr	0,00 kr	0,00 kr	-2 295,84 kr	1 184,45 kr	0,00 kr	0,00 kr	0,00 kr	5,92 kr	0,00 kr	-1 105,47 kr	-1 490 018,60 kr	-1 105,47 kr	-792 698,60 kr
29	4 642,74 kr	1 127,94 kr	0,00 kr	0,00 kr	-2 186,52 kr	1 127,94 kr	0,00 kr	0,00 kr	0,00 kr	5,64 kr	0,00 kr	-1 052,94 kr	-1 491 071,54 kr	-1 052,94 kr	-793 751,54 kr
30	4 642,28 kr	1 074,12 kr	0,00 kr	0,00 kr	-2 082,40 kr	1 074,12 kr	0,00 kr	0,00 kr	0,00 kr	5,37 kr	0,00 kr	-1 002,91 kr	-1 492 074,45 kr	-1 002,91 kr	-794 754,45 kr
31	4 641,81 kr	1 022,87 kr	0,00 kr	0,00 kr	-1 983,24 kr	1 022,87 kr	0,00 kr	0,00 kr	0,00 kr	5,11 kr	0,00 kr	-955,25 kr	-1 493 029,70 kr	-955,25 kr	-795 709,70 kr
32	4 641,35 kr	974,06 kr	0,00 kr	0,00 kr	-1 888,80 kr	974,06 kr	0,00 kr	0,00 kr	0,00 kr	4,87 kr	0,00 kr	-909,86 kr	-1 493 939,56 kr	-909,86 kr	-796 619,56 kr
33	4 640,89 kr	927,59 kr	0,00 kr	0,00 kr	-1 798,85 kr	927,59 kr	0,00 kr	0,00 kr	0,00 kr	4,64 kr	0,00 kr	-866,63 kr	-1 494 806,19 kr	-866,63 kr	-797 486,19 kr
34	4 640,42 kr	883,33 kr	0,00 kr	0,00 kr	-1 713,19 kr	883,33 kr	0,00 kr	0,00 kr	0,00 kr	4,42 kr	0,00 kr	-825,45 kr	-1 495 631,64 kr	-825,45 kr	-798 311,64 kr
35	4 639,96 kr	841,18 kr	0,00 kr	0,00 kr	-1 631,61 kr	841,18 kr	0,00 kr	0,00 kr	0,00 kr	4,21 kr	0,00 kr	-786,23 kr	-1 496 417,87 kr	-786,23 kr	-799 097,87 kr
36	4 639,49 kr	801,04 kr	0,00 kr	0,00 kr	-1 553,92 kr	801,04 kr	0,00 kr	0,00 kr	0,00 kr	4,01 kr	0,00 kr	-748,87 kr	-1 497 166,74 kr	-748,87 kr	-799 846,74 kr
37	4 639,03 kr	762,82 kr	0,00 kr	0,00 kr	-1 479,92 kr	762,82 kr	0,00 kr	0,00 kr	0,00 kr	3,81 kr	0,00 kr	-713,28 kr	-1 497 880,02 kr	-713,28 kr	-800 560,02 kr
38	4 638,57 kr	726,42 kr	0,00 kr	0,00 kr	-1 409,45 kr	726,42 kr	0,00 kr	0,00 kr	0,00 kr	3,63 kr	0,00 kr	-679,39 kr	-1 498 559,42 kr	-679,39 kr	-801 239,42 kr
39	4 638,10 kr	691,76 kr	0,00 kr	0,00 kr	-1 342,33 kr	691,76 kr	0,00 kr	0,00 kr	0,00 kr	3,46 kr	0,00 kr	-647,11 kr	-1 499 206,53 kr	-647,11 kr	-801 886,53 kr
40	4 637,64 kr	658,76 kr	0,00 kr	0,00 kr	-1 278,41 kr	658,76 kr	0,00 kr	0,00 kr	0,00 kr	3,29 kr	0,00 kr	-616,36 kr	-1 499 822,89 kr	-616,36 kr	-802 502,89 kr
41	4 637,17 kr	627,32 kr	0,00 kr	0,00 kr	-1 217,53 kr	627,32 kr	0,00 kr	0,00 kr	0,00 kr	3,14 kr	0,00 kr	-587,07 kr	-1 500 409,96 kr	-587,07 kr	-803 089,96 kr
42	4 636,71 kr	597,39 kr	0,00 kr	0,00 kr	-1 159,56 kr	597,39 kr	0,00 kr	0,00 kr	0,00 kr	2,99 kr	0,00 kr	-559,18 kr	-1 500 969,14 kr	-559,18 kr	-803 649,14 kr
43	4 636,25 kr	568,89 kr	0,00 kr	0,00 kr	-1 104,34 kr	568,89 kr	0,00 kr	0,00 kr	0,00 kr	2,84 kr	0,00 kr	-532,61 kr	-1 501 501,74 kr	-532,61 kr	-804 181,74 kr
44	4 635,78 kr	541,74 kr	0,00 kr	0,00 kr	-1 051,75 kr	541,74 kr	0,00 kr	0,00 kr	0,00 kr	2,71 kr	0,00 kr	-507,30 kr	-1 502 009,04 kr	-507,30 kr	-804 689,04 kr
45	4 635,32 kr	515,89 kr	0,00 kr	0,00 kr	-1 001,67 kr	515,89 kr	0,00 kr	0,00 kr	0,00 kr	2,58 kr	0,00 kr	-483,19 kr	-1 502 492,24 kr	-483,19 kr	-805 172,24 kr
46	4 634,86 kr	491,28 kr	0,00 kr	0,00 kr	-953,97 kr	491,28 kr	0,00 kr	0,00 kr	0,00 kr	2,46 kr	0,00 kr	-460,23 kr	-1 502 952,47 kr	-460,23 kr	-805 632,47 kr
47	4 634,39 kr	467,84 kr	0,00 kr	0,00 kr	-908,54 kr	467,84 kr	0,00 kr	0,00 kr	0,00 kr	2,34 kr	0,00 kr	-438,37 kr	-1 503 390,84 kr	-438,37 kr	-806 070,84 kr
48	4 633,93 kr	445,52 kr	0,00 kr	0,00 kr	-865,28 kr	445,52 kr	0,00 kr	0,00 kr	0,00 kr	2,23 kr	0,00 kr	-417,54 kr	-1 503 808,37 kr	-417,54 kr	-806 488,37 kr
49	4 633,47 kr	424,26 kr	0,00 kr	0,00 kr	-824,08 kr	424,26 kr	0,00 kr	0,00 kr	0,00 kr	2,12 kr	0,00 kr	-397,70 kr	-1 504 206,07 kr	-397,70 kr	-806 886,07 kr
50	4 633,00 kr	404,02 kr	0,00 kr	0,00 kr	-784,83 kr	404,02 kr	0,00 kr	0,00 kr	0,00 kr	2,02 kr	0,00 kr	-378,80 kr	-1 504 584,87 kr	-378,80 kr	-807 264,87 kr
Summa	232 218,66 kr	84 866,00 kr	-1 430 400,00 kr	-733 080,00 kr	-164 303,33 kr	84 866,00 kr	0,00 kr	0,00 kr	4 828,13 kr	424,33 kr	0,00 kr	-1 504 584,87 kr	-75 484 887,57 kr	-807 264,87 kr	-39 921 567,57 kr