

Dato: 14/12/2025

Notat:

Opsummering af udendørs belysningsforhold.

I forbindelse med etablering af sektorkoblet anlæg ved Krageris

Sagsnavn : Sektorkoblet anlæg ved Krageris
Notat nr. : V_05_Notat, Udendørs lysforhold fra drivhuslys
Modtager : C7 Consulting

1 Indledning

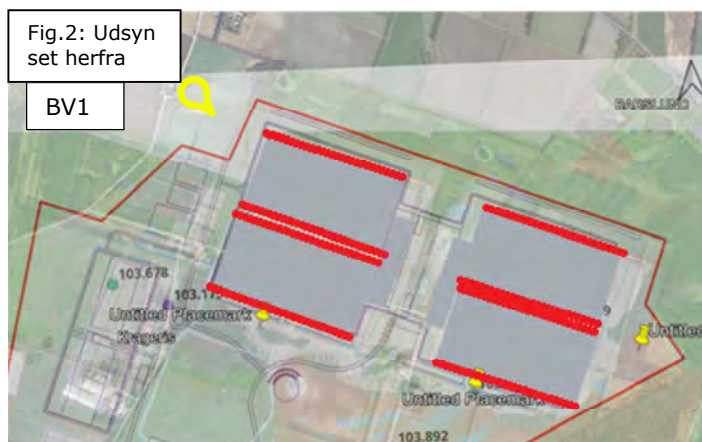
Dette notat omhandler aktuelle belysningsforhold i forbindelse med etablering af et stort drivhusanlæg, som en del af et større sektorkoblet anlæg i Krageris, i Varde kommune.

Notatet opsummerer viden og data på grundlag af bl.a. tekniske rapporter og dokumenter (se liste med appendix og referencer).

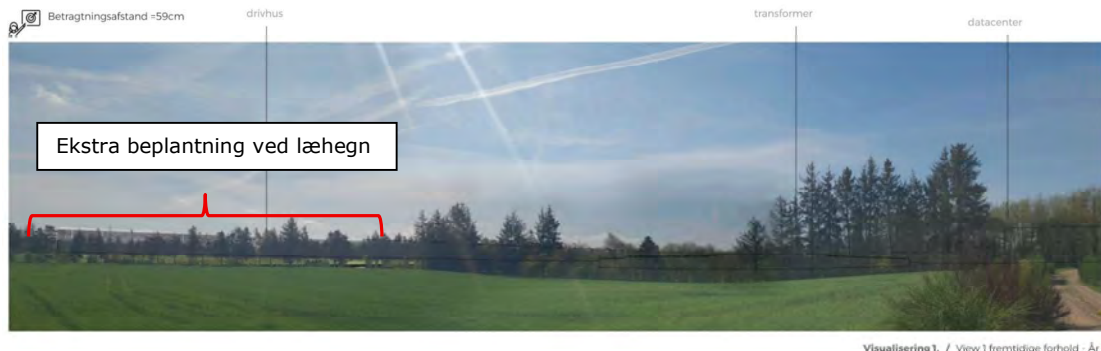
De visuelle og synlige forhold for naboer i området efter mørkets frembrud er ligeledes søgt belyst i dette notat.

I forbindelse med de visuelle forhold, spiller særligt brugen af, og udformningen af "belysningsafdækningen" Obscura 9950 FRW (2), en vigtig rolle, da kvaliteten og styringen heraf, i høj grad vil kunne sikre den visuelle og biologiske lyspåvirkning af omgivelserne i området, så det ikke påvirkes unødigt om aftenen/natten.

Nedenfor er vist et udklip af det aktuelle areal, hvor de grå felter udgør drivhuse. Den gule markering viser den nærmeste nabo, som vil have delvist udsyn til drivhusene (se fig. 2). Denne nabo har ikke umiddelbart udsyn til den vinkel af drivhusene, hvor der kan forekomme lysstriber (linjer markeret med rødt). Mere info følger.



Figur 1: Oversigt over drivhusenes placering i terræn (røde linjer viser retning af gardin/lameller under glastaget)



Figur 2: Billede med udsigt fra BV1, til drivhuse, år 1 efter etablering. Markering viser hvor det anbefales at etablere ekstra beplantning. (SEKTORKOBLINGSPROJEKT VED KRAGERIS VISUALISERINGER. Udarbejdet af GPP Arkitekter A/S)

2 Bygnings forhold:

2.1 Synligt lys fra området:

2.1.1 Datacenteret

Det er oplyst, at der kun er meget begrænset lys fra datacenterbygningerne, da der kun vil være vinduer i servicebygningerne, og ikke i datahallerne. Da datacenteret vil blive omkranset af afskærmende træbevoksning, vil der være minimalt synligt lys inde fra datacenterets bygning. Derfor behandles dette ikke videre i notatet.

2.1.2 Udendørs færdsles- og parkerings arealer

På de udendørs arealer etableres belysning jf. Den danske standard for udvendige arbejdspladser DS/EN 12 464 del 2, samt krav til vejbelysning.

Det anbefales ikke at der etableres facadebelysning, men der kan evt. etableres nedadrettet belysning på facader ved indgange og ifm. adgang og evt. udvendige arbejdsopgaver. Belysningen udføres med godkendte belysningsarmaturer med lav synlig luminans, og med korrekt Cut-off vinkel (den vinkel, hvor den blotte lyskilde ikke længere er synlig for betragter). Det vil ligeledes være en fordel at etablere sensorer som kun tænder lyset, når der er relevant aktivitet i området. Dette for at undgå unødigt lys, særligt om natten.

2.1.3 Drivhuse

I drivhusene er væksten afhængig af tilstrækkeligt lys i de forskellige vækstcykler. Derfor vil der i perioder være behov for ekstra belysning i drivhusene. Både om dagen og efter solnedgang/før solopgang, særligt i vintermånederne. Dog vil den daglige styring slukke lyset i minimum 5 timer i aften/natperioden.

Energioptimering samt udnyttelse af hvilke bølgelængder af lys planterne har behov for, på bestemte tidspunkter i vækstperioden, bevirker at der i store dele af tiden, vil forekomme lys i lyserøde/pink nuancer. Der kan dog også anvendes lys med andre farver afhængigt af afgrøderne.

De seneste år har der været større fokus på lysforurening og dette emne er i dag indarbejdet i flere standarder, med krav til belysnings kvalitet og lysniveauer, så unødigt lysforurening undgås.

Derfor har LS Svensson udviklet en lysafskærmnings løsning, som placeres under glastaget i drivhusene, Obscura 9950 FRW (2). Denne afdækning styres automatisk i løbet af døgnet i vækstperioderne, og sikrer således, at der ikke slipper lys ud i naturen, når det er mørkt udenfor. Denne lysafdækning sikrer, at næsten alt lyset forbliver i bygningen (ca. 99%), så andelen af lys i området minimeres maksimalt. Afdækningen under taget, kombineres med kraftige gardiner langs væggene som afskærmer ca. 100%, samt et energi/varme-besparende gardin LUXOUS 1147 FR (3), der sikrer mod unødigt varmetab gennem glasset. Som et grundlag for den automatiske løsning, er der desuden foretaget beregninger af samtidighed mellem belysning, afdækning, indendørs klimaforhold og vejrforhold, som viser, at afskærmningen kan holdes fuldt lukket i hele perioden mellem solnedgang og solopgang (6). Afdækningsløsningen sikrer ligeledes, at det er muligt at åbne vinduer, uden afdækningen af lyset mindskes.

Brugen af afskærmningsløsningen er tidligere afprøvet, og det er undersøgt, hvor meget den samlede afskærmning af lys til naturen er minimeret. Der kan derfor henvises til følgende studie EXPERIMENTAL MEASUREMENTS OF LIGHT EMISSIONS FROM ONTARIO GREENHOUSES USING SUPPLEMENTAL LIGHTING AT NIGHT (4).

Her har man undersøgt og målt på 8 forskellige drivhuse med forskellig kombination af tre afskærmningsløsninger.

Det kan oplyses, at de nærmest sammenlignelige drivhustyper i artiklen, med det aktuelle er: drivhus type E og F, som er med klart glas, lysafskærmningsløsninger og LED lys.

Her viser målinger fra foto taget med drone (i en afstand 50 m) at lysafskærmningsløsningen (2) har en effektivitet med et spildlys på under 1% til omgivelserne. Hvorimod afskærmningen ved løsningen med energigardiner i drivhus H) ligger på 36%.

For at kunne illustrere funktionaliteten visuelt, kan man på næste side (fig. 3), se billeder fra et anlæg i Holland, hvor der er anvendt samme afskærmningsløsning, som vil blive anvendt i Krageris.

Fra dette projekt er der optaget en lille video, hvor man kan se lysafskærmningen i funktion:

<https://www.youtube.com/watch?v=PLzYoY6CV0k>

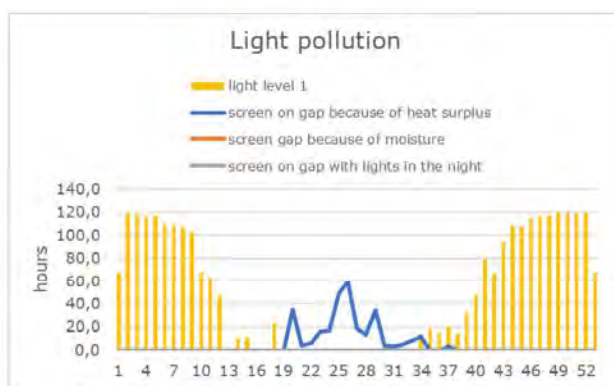


Figur 3: 3 billeder fra YouTube video. Billeder af lysafskærmning: åben, delvist lukket og lukket

Som beskrevet i "Report Light pollution" udført af DLVge (5), (Rapport om Lysforurening), er vækstperioder, temperaturer, dagslys, kunst-lys og fugt mm. inkluderet i en fuld automatisk styring af indeklimaet for opnåelse af optimal plantevækst.

Af denne rapport fremgår det, at styringen af klimakontrol med fugt, temperatur og lysforbrug kan overvåges, så det sikres at bl.a. lysafdækningen, fungerer optimalt. Data herfor er ligeledes bekræftet af Wa3rm og dennes leverandør.

Nedenfor er vist en kurve, hvor det fremgår at "Screen" (lysafdækningen) ikke åbnes på u hensigtsmæssige tidspunkter.



Screen hours closed with an opening for heat or moisture surplus.

Figur 4: Kurve viser tider for: tændt lys, åben for udluftning, udluftning fugt, åben lysafdækning. (DLVge Report Light pollution)

Af billederne på næste side (fig. 5 og 6), fra samme rapport (5). Kan man på fig. 5, se hvor meget lys der vil være om natten, hvis glastaget ikke bliver afdækket. På fig. 6, ses samme anlæg hvor glastaget er afdækket med Obscura 9950 FRW.

Lysstriben på fig. 6, skyldes at afdækningen ikke er hermetisk lukket, og derfor vil der fremstå en linje med svagt lys i de enkelte samlinger.

Øverst i notatet på fig.1 kan man se røde streger, på tværs af bygningerne. De markerer hvor disse lysstriber kan forekomme.

Striberne vil dog ikke være synlige for naboen i position (BV1) (placering er markeret med gult på fig. 1.), da de forekommer langs de nordøst og sydvest vendte gavle.

Lysniveauet fra disse linjer vil visuelt i praksis, svare til en lang juletræskæde med mindre lyskilder, eller lyset fra et meget smalt vindue med tændt lys indendørs, f.eks. i et nabohus.

Hvis der er tåge eller meget fugt i luften, kan der opstå situationer hvor lyset fra disse linjer kan skimtes, særligt hvis man placerer sig i en position, hvor man kigger ind mod drivhusenes gavle.



Gable sidewall screen (Obscura 10070 FR W) closed, roof screen open

Figur 5: Eksempel hvor der ikke er afdækning af lyset fra taget



Gable sidewall screen (Obscura 10070 FR W) closed, roof light abatement screen (Obscura 9950 FR W) closed

Figur 6: Eksempel hvor både tag og sider er lukkede

3 Konklusion og anbefalinger

Ved opførelse af drivhuse i disse landlige omgivelser i den vestjyske natur i Danmark, er det vigtigt at sikre at bygningerne ikke fremstår for dominant lysende i landskabet om natten, og at problemer ved lysforurening mindskes så meget som det overhovedet er muligt.

- Af de nærmeste naboer er det primært en nabo, som vil have et delvist udsyn til drivhusene. Derfor bør der fokuseres på, at dette udsyn minimeres, ved som det er foreslået at øge beplantningen og evt. forhøje den afskærmende effekt ved at beplante en ny jordvold langs skel (se. Fig. 2)
- Af vedlagte studier/rapporter kan man se, at det er muligt at afskærme lyset fra drivhusene næsten helt, og det kan ske uden, at det har indvirkning på klimastyring og vækstbetingelserne for dyrkning af afgrøder.
- Det anbefales, at der ved projekt-udførelse, sikres en dokumenteret funktionsafprøvning. Både af funktions sikkerhed og sikring af korrekt placeret afdækningen. Hvilket bekræftes af Wa3rm.
- Der bør ligeledes udarbejdes en tydelig drifts- og vedligeholdelsesplan for både det fysiske anlæg og styringen heraf, så det sikres at anlægget fungerer optimalt i hverdagen, uden unødige driftsforstyrrelser. Ved nedbrud sikres en procedure for hurtig levering og reparationer/udbedring af lysafskærmningen. Dette er ligeledes bekræftet af Wa3rm.

I forbindelse med etablering af et sektorkoblet anlæg i Krageris, kan det ud fra det oplyste materiale konkluderes, at der med de fremlagte dokumenter og undersøgelser, er søgt en grundig kortlægning af hvilke tiltag, der kan gøres for at undgå unødige lyspåvirkninger (spildlys/lysforurening) i mørke. Hvis anbefalingerne efterkommes og anlægget udarbejdes efter de anbefalede anvisninger og erfaringer, vurderes det, at det samlede anlæg ikke vil bidrage med unødigt lys fra bygninger og anlæg fra det sektorkoblede anlæg i Krageris.

Det fremgår ud fra placeringer, funktion og praktiske afskærmninger, at der er gjort de nødvendige tiltag for at undgå unødigt spildlys, som ville kunne afstedkomme lysgener for naboer og andre i området.

Hvad er lysforurening?

Lysforurening er som udgangspunkt alt lys, der er menneskeskabt, som ikke kommer fra solen, månen eller stjernerne.

Der findes dog også en anden definition, som tilgodeser de menneskelige behov i lidt større grad. Den lyder: Lysforurening er alt lys, som er spildlys.

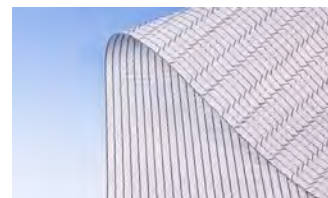
Med spildlys menes overskydende lys, som ikke tjener et nødvendigt formål for mennesker i mørket. Eks. julebelysning, reklamebelysning og facadebelysning på bygninger mm.

Referenceliste:

- 1) Ref.: SEKTORKOBLINGSPROJEKT VED KRAGERIS VISUALISERINGER. Udarbejdet af GPP Arkitekter A/S, 15. september 2025.
- 2) Appendix 1: Datablad Belysningsafdekning, Obscura 9950 FR W, LS Svensson.
- 3) Appendix 2: Energi-afdekning, LUXOUS 1147 FR, LS Svensson.
- 4) Ref.: EXPERIMENTAL MEASUREMENTS OF LIGHT EMISSIONS FROM ONTARIO GREENHOUSES USING SUPPLEMENTAL LIGHTING AT NIGHT BENJAMIN SNOW¹, WILLIAM LUBITZ², SYEDA TASNIM³, THOMAS GRAHAM⁴, DAVID LLEWELLYN⁴, FADI AL-DAOUD⁵ 1 University of Guelph, School of Engineering, Guelph, ON, Canada. 2 University of Guelph, School of Engineering, Guelph, ON, Canada. 3 University of Guelph, School of Engineering, Guelph, ON, Canada. 4 University of Guelph, School of Environmental Sciences, Guelph, ON, Canada. 5 Ontario Ministry of Agriculture, Food and Rural Affairs. Harrow, ON, Canada. Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB) Virtually from Québec City, Canada - May 11-14, 2021.
- 5) Appendix 3: DLVge Report Light pollution, Rapport om Lysforurening. V1.1 21-08 2025
- 6) Appendix 4: Light Pollution, WA3RM, December 14, 2025

Notat er udført af:

Inger V. Erhardtsen, IVE Rådgivning



OBSCURA 9950 FR W

Product information

Application	Inside
System	Hanging, Sliding
Feature	Supplemental lighting
Flame retardant	Yes
Material	Polyester 100%
Pattern	Full plastic
Warranty	Warranty five (5) years under all types of greenhouse covering. See Svensson's limited warranty for all terms, conditions and exclusions in writing.

Properties	Value	Unit	Test Methods
Shading level in diffused light PAR**	99	%	Svensson method
Shading level in direct light PAR**	99	%	Svensson method
Energy saving	50	%	Svensson method
Width of strips	4	mm	
Weight	67	g/m ²	

* Width 50 mm

** PAR = 400 - 700 nm, accuracy +/- 1%

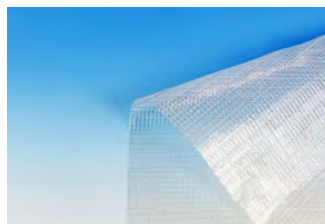
*** UV-light = 300 - 400 nm

This product image is for illustrative purposes only and may vary in appearance and design from the delivered product. Although the information in this data sheet has been composed with care, Svensson does not accept any liability in respect of its accuracy.

Further information concerning the product and its installation may be obtained from Svensson and its authorized distributors. Svensson's products and names are protected by patent and other intellectual property rights.

Products marked FR are flame retardant. No other products delivered by Svensson are flame retardant.

AB Ludvig Svensson is an ISO 14001/90001 certified company.



LUXOUS 1147 FR

Product information

Application	Inside
System	Hanging, Sliding
Feature	Energy saving
Flame retardant	Yes
Material	Polyester 100%
Pattern	Full transparent
Warranty	Warranty five (5) years under all types of greenhouse covering. See Svensson's limited warranty for all terms, conditions and exclusions in writing.

Properties	Value	Unit	Test Methods
Shading level in diffused light PAR**	25	%	Protocol NEN 2675
	19	%	Svensson method
Shading level in direct light PAR**	15	%	Protocol NEN 2675
	11	%	Svensson method
UV light transmission ***	12	%	Svensson method
Energy saving	47	%	Svensson method
Width of strips	4	mm	
Weight	57	g/m ²	

* Width 50 mm

** PAR = 400 - 700 nm, accuracy +/- 1%

*** UV-light = 300 - 400 nm

This product image is for illustrative purposes only and may vary in appearance and design from the delivered product. Although the information in this data sheet has been composed with care, Svensson does not accept any liability in respect of its accuracy.

Further information concerning the product and its installation may be obtained from Svensson and its authorized distributors. Svensson's products and names are protected by patent and other intellectual property rights.

Products marked FR are flame retardant. No other products delivered by Svensson are flame retardant.

AB Ludvig Svensson is an ISO 14001/90001 certified company.



Report

Light pollution

Brief description

Study if it's possible to grow tomatoes under lights without disturbing the environment with light pollution.

Version

V1.1

Date

21-8-2025

Contractor

WA3RM
Malmö
Sweden
Contact Ruud Brouwer
Phone
Cell +46 735 26 02 21
E-mail ruud.brouwer@wa3rm.se
Internet www.wa3rm.se

WA3RM

Consultant

DLVge
Violierenweg 3
2665 MV Bleiswijk
Contact Ruud Brouwer
Phone 010 462 3030
Cell +31 653427212
E-mail r.brouwer@dlvge.nl
Internet www.dlvge.eu

Project 25-0061



Content

1	Introduction	3
1.1	Your compagny.....	3
1.2	Query	3
1.3	Starting points.....	3
2	Results	5
2.1	Approach	5
2.2	Calculation and results.....	7
2.2.1	<i>Climate at the location</i>	7
2.2.2	<i>Sun and lights on plants</i>	8
2.2.3	<i>Energy need</i>	8
2.2.4	<i>Screens</i>	9
2.2.5	<i>Screen position with lights</i>	9
2.3	Conclusion	9
	Appendix: Table light and screen hours	10

1 Introduction

1.1 Your company

From the WA3RM website:

Where others see waste, we find opportunity.

By connecting industries with companies that can make use of their waste streams we enable more local production capacity and new jobs. We see a future without take-make-waste where resources are used efficiently and all industries are engineered for circularity. Current industrial design is outdated and the world needs to quickly cut down on emissions and use resources far more efficiently. We help the future greats seize this moment by rethinking business models, securing investments and, developing circular operations.

1.2 Query

Your email 10th of March 2025.

We are developing a large greenhouse project in Denmark, and are currently in the process of determining the environmental impacts of this project, together with the municipality. As part of that, we are investigating the light pollution effects of this project, and were wondering if you are able to help us with that. We want to get some numbers on the expected extent of the light pollution, is that something you are able to calculate?

1.3 Starting points

The environmental impacts regarding light pollution are a result of the light levels in the greenhouse, type of moveable screens to avoid light pollution and the way the climate in the greenhouse is managed. Light pollution will particularly effect a big area at cloudy nights, between sunset and sunrise.

To make growing tomatoes in greenhouses more profitable supplementary lights are fitted. These lights will bring spring light levels on the tomatoes even in dark winter days. The tomatoes will use these lights converting it to kg production. For the entrepreneur it's very important all light is directed to the plants. Light which is leaving the glasshouse is a waste of energy. That's why greenhouses are fitted with moveable screens to prevent light escaping to the environment. (light pollution screens)



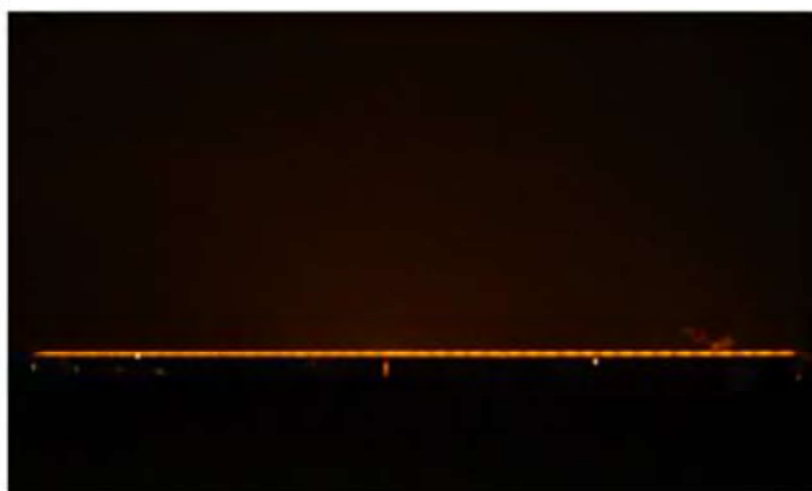
Lighted vegetable crop (LED) with closed overhead screen

The light pollution screens blocks light for 99%. This screen is used during night time. Even when the screen blocks nearly all the light it can transport moisture to a certain level and also air can pass the screen up to $40\text{m}^3/\text{m}^2\cdot\text{h}$.

When the tomatoes are growing they absorb water and nutrients and they evaporate water to the greenhouse for getting nutrients in the entire plant. The surplus of moisture must be transported to the ambient. If the screen blocks the transport of moisture the screen needs to be opened a bit causing light pollution. The proposed greenhouse is able to manage this issue. Because the greenhouse is fitted with fans on the end gables it can blow fresh dry air into the greenhouse driving out the surplus of moisture. The chapter results in this report shows the effect on light pollution with this type of greenhouse.



*Gable sidewall screen (Obscura 10070 FR W) closed,
roof screen open*



*Gable sidewall screen (Obscura 10070 FR W) closed,
roof light abatment screen (Obscura 9950 FR W) closed*

Light pollution with LED lights (screens open vs closed)

2 Results

2.1 Approach

With the DLVge greenhouse simulation model an energy calculation for each hour a year will be made with local climate data. Output of this model is on top of the energy need, light, screen and screen on gap hours as well. For this calculation the following input is used:

Greenhouse sizes	4 greenhouses, 432mx238.5m each.
vent size	Per greenhouse: 288 windows 1200x1125. 384 windows 1200x3375.
type of glass	Clear Float Glass, tempered 4mm thick.. 91% light transmissions value. AR coating on 1 side. 2373x1125mm for most of the roof.
location	55°50'20.89"N 8°40'23.87"E (55.839136, 8.673297)
orientation	21° rotated clockwise from West-East



Type of screens	Top screen: Svensson Luxous 1147 FR. Bottom: Obscura 9950 FR W (light pollution screen). Mounted on the Trusses. Side: Obscura 10070 R FR W (light pollution screen)
Supplementary light output and efficiency	300 $\mu\text{mol}/\text{m}^2/\text{s}$ efficiency $>3.5 \mu\text{mol}/\text{J}$

Type of heating system. Tube rail, 5 circuits per truss, 2 pipes per circuit.
Number of pipes each circuit a truss.

11. TUBE RAIL SYSTEM

The tube rail system is designed to function primary as a heating system. Simultaneously it will function as a trolley transport rail. Details of the system as per following specifications.

Heating loops

The heating loops are running parallel to the greenhouse gutters

Pipe diameter	: ø51,0 x 2,25 mm
Number of tubes per bay	: 10 pcs.
Center to center distance	: 550 mm, horizontal
End piece	: Pre-bend
Suspension	: Tube rail supports
Connection to distribution lines	: IMAG approved pressure hose - 2,5 m per loop
Completed with	: Set of half tube clamps as end stop

Grow tubes , 5 circuits per truss, 2 pipes per circuit.

13. GROW TUBE SYSTEM

The grow tube system is designed to create heat close to the crop. The pipe temperature is kept on low grade to avoid possible damage to the crop. Details of the system as per following specifications.

Heating loops

The heating loops are running parallel to the greenhouse gutters.

Pipe diameter	: ø51,0 x 2,25 mm
Number of tubes per bay	: 10 pcs.
Center to center distance	: vertical, distance between pipes to be discussed
End piece	: two elbows and a piece of pipe
Suspension	: In gutter suspension system
Connection to distribution lines	: IMAG approved pressure hose - 5,0 m per loop
Completed with	: ¼" air vent at highest point in the heating loops

No snow melting system required

Type of air handling units 480 AHU units per greenhouse.
Max: 18000 m³/h per AHU.
Heating: 30 kW per AHU.
Cooling: pad wall (outside air only).
100% outside air, 100% inside air, or anything in between.

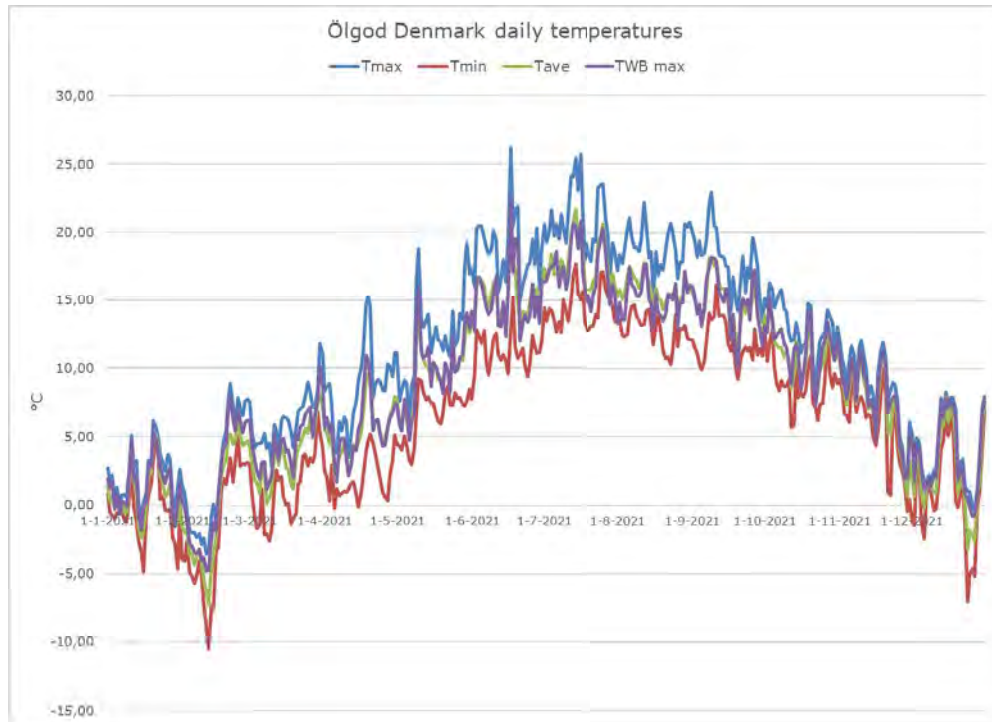
Crop in glasshouse Planting: week 23. Harvest from week 31 to week 19.

Glasshouse temperatures and RH Temp: 24°C (day), 16°C (night).
RH: 75% (day), 85% (night).

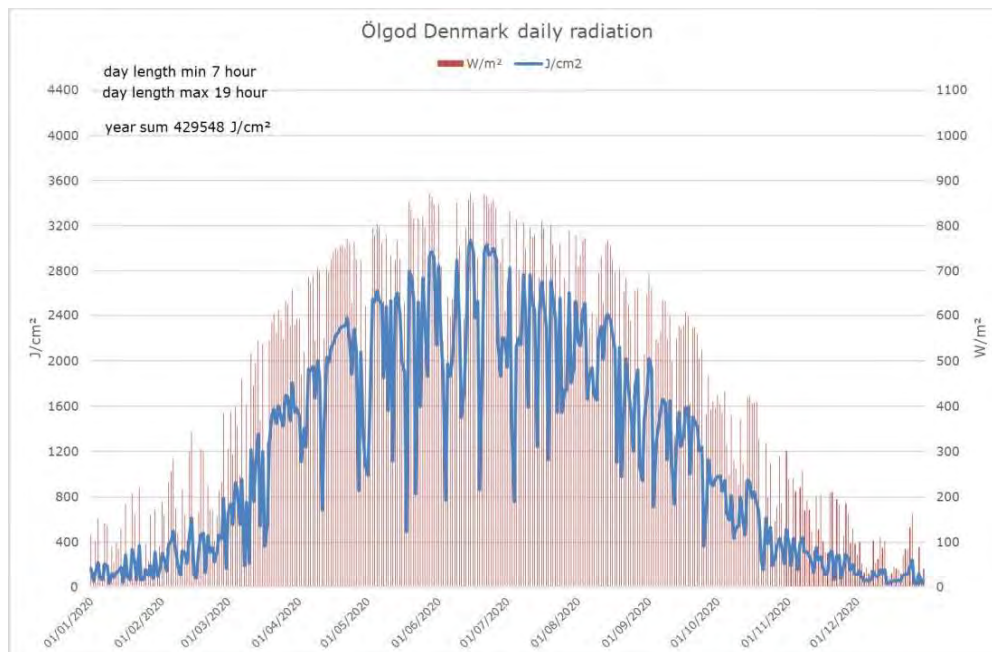
Lighting hours and period and goal for mol/m².day. Goal: 22 Mol/m²/day.
Max 17 hr/day.

2.2 Calculation and results

2.2.1 Climate at the location

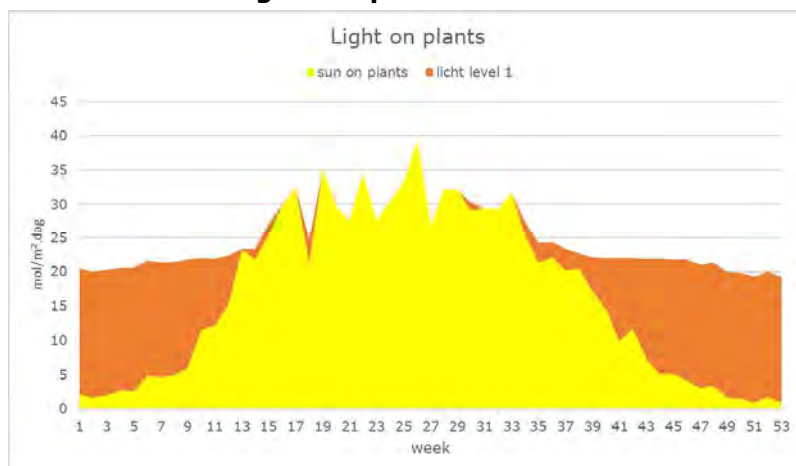


Minimum, maximum, average and wet bulb temperatures a day.



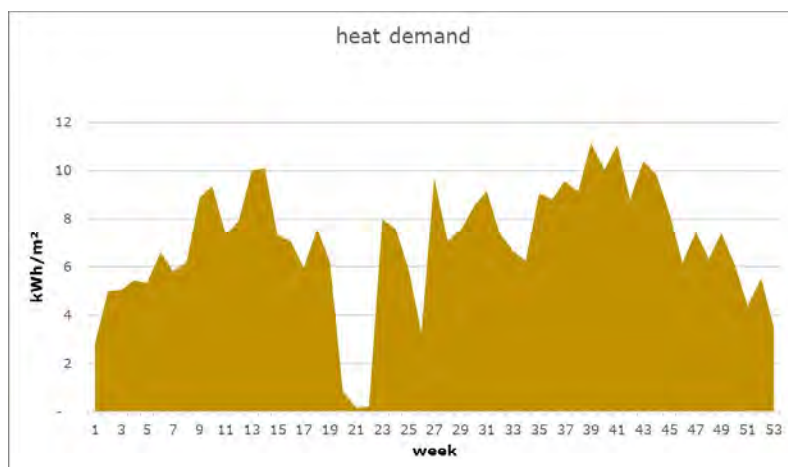
Sun radiation and day sum sun.

2.2.2 Sun and lights on plants



Sun and light on plants day average.

2.2.3 Energy need



Heat demand glasshouse after screens, light and sun.

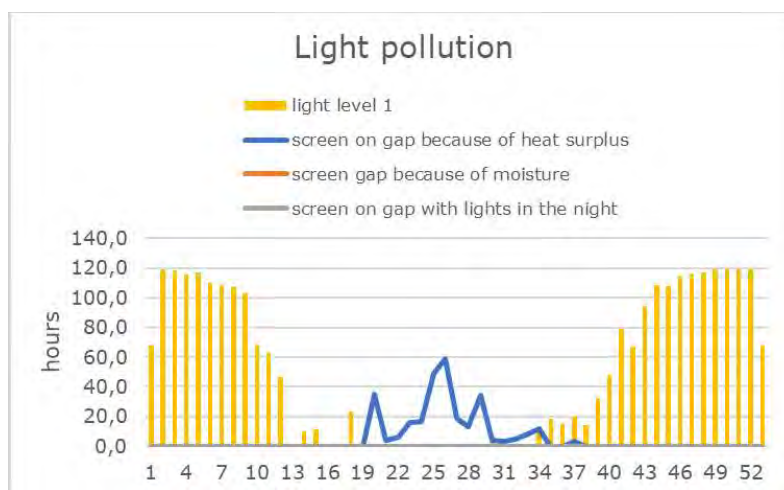
In this graph the heat demand each week is shown. This demand is dependent on outside climate conditions, setpoint greenhouse conditions, screen position, heat from LED lights, heat from sun and evaporation by the plants. From week 20 until week 22 the greenhouse is empty and is not heated. At this moment the old plants go out the greenhouse and new fresh plants will be put in to start again in week 23.

2.2.4 Screens



Close time screens.

2.2.5 Screen position with lights



Screen hours closed with an opening for heat or moisture surplus.

With the proposed greenhouse it's possible to dehumidify and cool the glasshouse without opening the light pollution screen during lighting at night. There is a wide range to control this issue. The weather information of the last 4 years doesn't show situation where it should be necessary to open the screen during lighting at night.

In the appendix a table with hours of the parameters in the graph is shown.

2.3 Conclusion

The type of proposed greenhouse to be built for tomato project in Ölgod Denmark is very well prepared for climate control under a closed screen environment. Because the greenhouse can dehumidify with closed light pollution screen, the change of light pollution is minor.

The elaborated study on this project shows that during the major of outside conditions no screen opening is necessary to vent off the moisture. Under the climate situation of last years at the greenhouse location our calculations shows no need for screen gaps during lights on at night. Night is defined as the hours between sunset and sunrise.

Appendix: Table light and screen hours

week	light hours	Screen on gap because of heat surplus	Screen on gap because of moisture	screen on gap with light on in the night
1	68	0	0	0
2	119	0	0	0
3	118	0	0	0
4	116	0	0	0
5	117	0	0	0
6	110	0	0	0
7	108	0	0	0
8	107	0	0	0
9	103	0	0	0
10	68	0	0	0
11	63	0	0	0
12	46	0	0	0
13	1	0	0	0
14	10	0	0	0
15	11	0	0	0
16	0	0	0	0
17	0	0	0	0
18	24	0	0	0
19	0	0	0	0
20	0	35	0	0
21	0	4	0	0
22	0	6	0	0
23	0	16	0	0
24	0	17	0	0
25	0	49	0	0
26	0	59	0	0
27	0	19	0	0
28	0	13	0	0
29	0	34	0	0
30	7	4	0	0
31	0	3	0	0
32	0	5	0	0
33	0	8	0	0
34	13	12	0	0
35	19	0	0	0
36	15	0	0	0
37	20	3	0	0
38	14	0	0	0
39	33	0	0	0
40	48	0	0	0
41	79	0	0	0
42	67	0	0	0
43	94	0	0	0
44	108	0	0	0
45	108	0	0	0
46	115	0	0	0
47	117	0	0	0
48	117	0	0	0
49	119	0	0	0
50	119	0	0	0
51	119	0	0	0
52	119	0	0	0
total	2639	287	0	0

December 17, 2025
Malmö, Sweden

WA3RM

Light Pollution

This document summarizes the investigation on the light pollution caused by the greenhouse project in Varde. The greenhouse will make use of LED growlights, to increase the yield of the crop. Especially during the winter months, when the day is shorter, this is essential.

When the sun is down, light pollution can become an issue. The effect on wildlife can be significant. For that reason, screens in the greenhouse are used to keep light from escaping, greatly reducing light pollution. The greenhouse will use 3 different screens. The sidewalls have a heavy screen that blocks 100% of all light, this screen is closed all night. The top of the greenhouses uses 2 screens simultaneously, a blackout screen that blocks 99% of the light, and an energy screen that is used to keep heat from escaping, but also blocks some light (25%).

The company DLVge did a study showing that the climate conditions allow the screens to be closed whenever the lights are on, so there will be no moments when the screens are not blocking the light from escaping.

The greenhouse will probably install $300 \mu\text{mol}/\text{m}^2/\text{s}$ of growlights. This is a measure of the number of photons that will hit the crop per second. The majority of the light will be a mix of red and blue light. The exact spectrum of the lights will depend on the crop choice and growing strategy, but in general the light will be about 70-90% red (600-700nm), 5-10% blue (400-500nm), with the remainder of the light coming from the middle of the range (500-600nm) and the far red spectrum (above 700nm).

This light will hit the crop, and about 85-90% will be absorbed, the rest will be reflected up to the screens. Of the $300 \mu\text{mol}/\text{m}^2/\text{s}$ that are emitted, 15% reaches the screen, of that only 1% passes the blackout screen, and then the energy screen blocks a further 25%. So the light escaping the greenhouse is

$$300 \mu\text{mol}/\text{m}^2 \cdot \text{s} \cdot 0.15 \cdot 0.01 \cdot 0.75 = 0.3375 \mu\text{mol}/\text{m}^2 \cdot \text{s}$$

So the whole system blocks 99.9% of the light from escaping. The amount of light escaping is around 4 Lux. The same system, with the same lights and screens, has been used for a greenhouse in Frövi, Sweden. This greenhouse is operational since may 2024, and there have been no complaints about light pollution from the neighbours.

December 17, 2025
Malmö, Sweden

WARIM

Screens

The screens used in the roof are the Ludvig Svensson “Obsura 9950 FR W” and “Luxous 1147 H2no FR” screens. The Obscura screen is the blackout screen, the Luxous screen is an energy and shading screen. To show the effect of the blackout screen, Ludvig Svensson shared a video, available in the link below:

<https://www.youtube.com/watch?v=PLzYoY6CV0k>

Below are 3 screenshots of the video, showing the difference in light when the screens are open and closed:

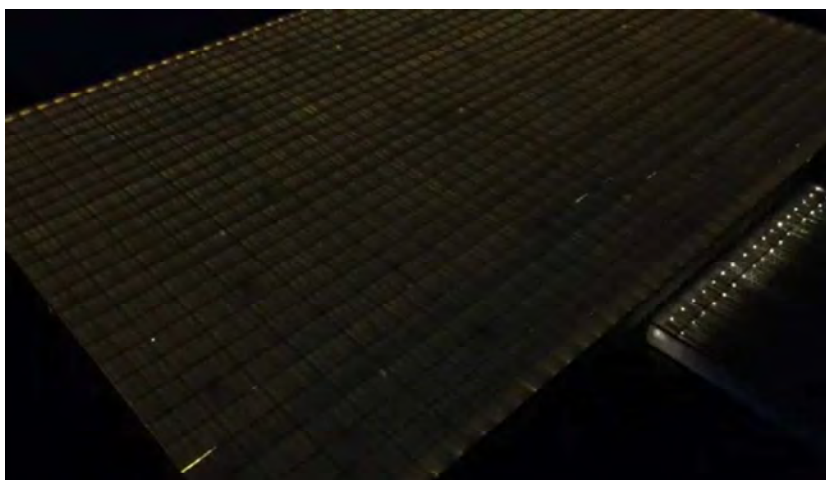


Figure 1: Screens closed

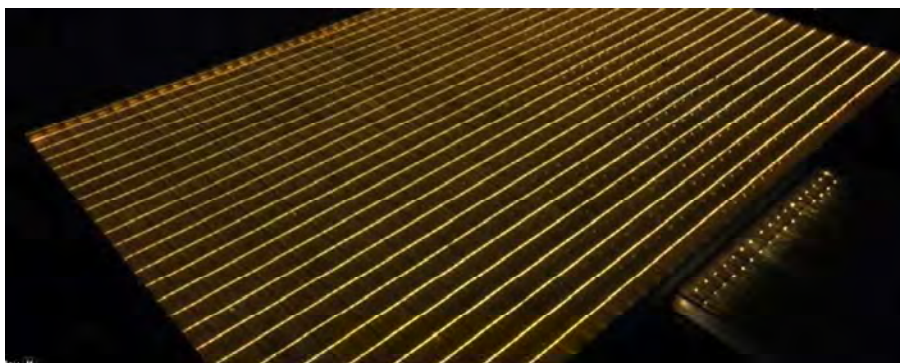


Figure 2: Screens opening

December 17, 2025
Malmö, Sweden

WARMM

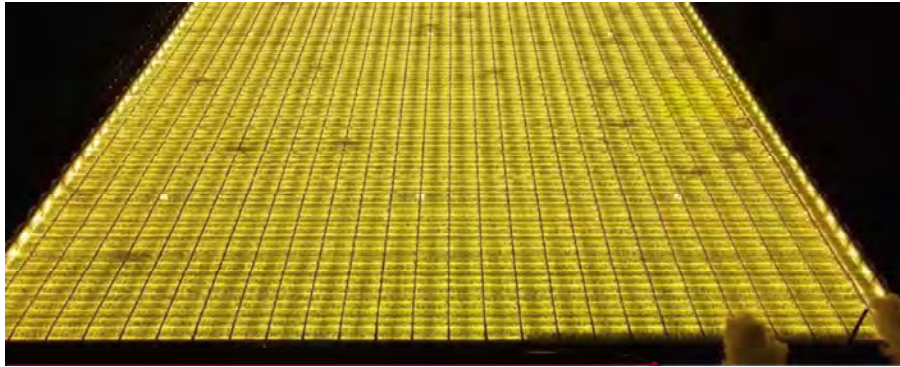


Figure 3: Screens open

December 17, 2025
Malmö, Sweden

WARMM

Canadian research

Research from Canada, published in 2021, looked at the effectiveness of screens on the intensity of light pollution.

https://library.csbe-scgab.ca/docs/meetings/2021/CSBE21805.pdf?utm_source=chatgpt.com

Table 1. Characteristics of test greenhouses (LA: Light Abatement).

Greenhouse	Roof Glazing	Curtain Type	Lighting	Crop
A	Triple Poly	LA	HPS	Propagation (empty)
B	Clear Glass	LA	HPS	Cucumbers
C	Clear Glass	Energy	HPS	Tomatoes
D	Clear Glass	Energy	LED (49% red, 38% green, 10% blue)	Peppers
E	Clear Glass	LA	LED (full spectrum)	Tomatoes
F	Clear Glass	LA	½ HPS ½ LED	Tomatoes
G	Triple Poly	LA	LED intercrop (95% red 5% blue)	Cucumbers
H (Bovey)	Clear Glass	Energy	HPS	Mostly Empty

Table 1: Greenhouse categories

In this investigation, the lighting and screens in greenhouse E and F were closest to the greenhouse in Varde, since they refer to a greenhouse with clear glass, a blackout screen (Light abatement), and LED lights. The research showed that 99.7-99.8% of light was blocked by the screens.

Table 3. Relative light intensity as a fraction of 100% (open) case for greenhouses with light abatement curtains, for both measurement methods.

Curtain Open Setting	A A		B B		E E		F F		G G	
	Image	SQM	Image	SQM	Image	SQM	Image	SQM	Image	SQM
100%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50%	0.60	0.63	0.47	0.63	0.47	0.63	0.52	0.51	0.53	0.52
20%	0.24	0.26	0.15	0.19	0.19	0.24	0.16	0.21	0.24	0.22
10%	0.12	0.14	0.03	0.05	0.09	0.10	0.07	0.10	0.11	0.14
5%	0.14	0.12	0.02	0.03	0.05	0.04	0.02	0.04	0.07	0.08
0%	0.045	0.045	0.005	0.004	0.003	0.003	0.002	0.007	0.022	0.036

Table 2: Light intensity

December 17, 2025
Malmö, Sweden



Sky glow

One way to quantify the amount of light pollution is to look at sky glow. The brightness of the sky is split up into 9 categories, from 1 (no light pollution, for example in the middle of the ocean), to 9 (center of a city with many streetlights). The estimate from Ludvig Svensson is that the amount of light escaping from the greenhouse would place the area around the greenhouse in category 2 or 3, although it is hard to make an exact determination.

Number Code	Map Color Code	Label	Sky Mag.	Naked Eye Limit Mag.	320mm Limit Mag.	M31 visible?	M31 visible?	Central Galaxy visible?	Zodiacal light visible?	Light Pollution
1		excellent dark sky	22.00–21.99	≥ 7.5	> 17	obvious	–	casts shadows	striking	airglow apparent
2		average dark sky	21.99–21.89	7.0–7.49	16.5	easy with direct vision	–	appears highly structured	bright, faint yellow color	airglow faint
3		rural sky	21.89–21.69	6.5–6.99	16.0	easy with averted vision	–	complex structure	obvious	LP on horizon
4		rural/suburban transition	21.69–20.49	6.0–6.49	15.5	difficult with averted vision	obvious	only large structures	halfway to zenith	low LP
5		suburban	20.49–19.50	5.5–5.99	14.5–15.0	–	easy with direct vision	washed out	faint	encroaching LP
6		bright suburban	19.50–18.94	5.0–5.49	14.0–14.5	–	easy with averted vision	visible only near zenith	–	LP to 35°
7		suburban/urban transition	18.94–18.38	4.5–4.99	14.0	–	difficult with averted vision	invisible	–	LP to zenith
8		city sky	< 18.38	4.0–4.49	13	–	–	–	–	bright to 35°
9		inner city sky	–	≤ 4.0	–	–	–	–	–	bright at zenith

Table 3: Light pollution

When looking at the area where the greenhouses will be, the skyglow is already at the low end of category 4, meaning the amount of added sky glow will be minimal.

December 17, 2025
Malmö, Sweden

WARMM

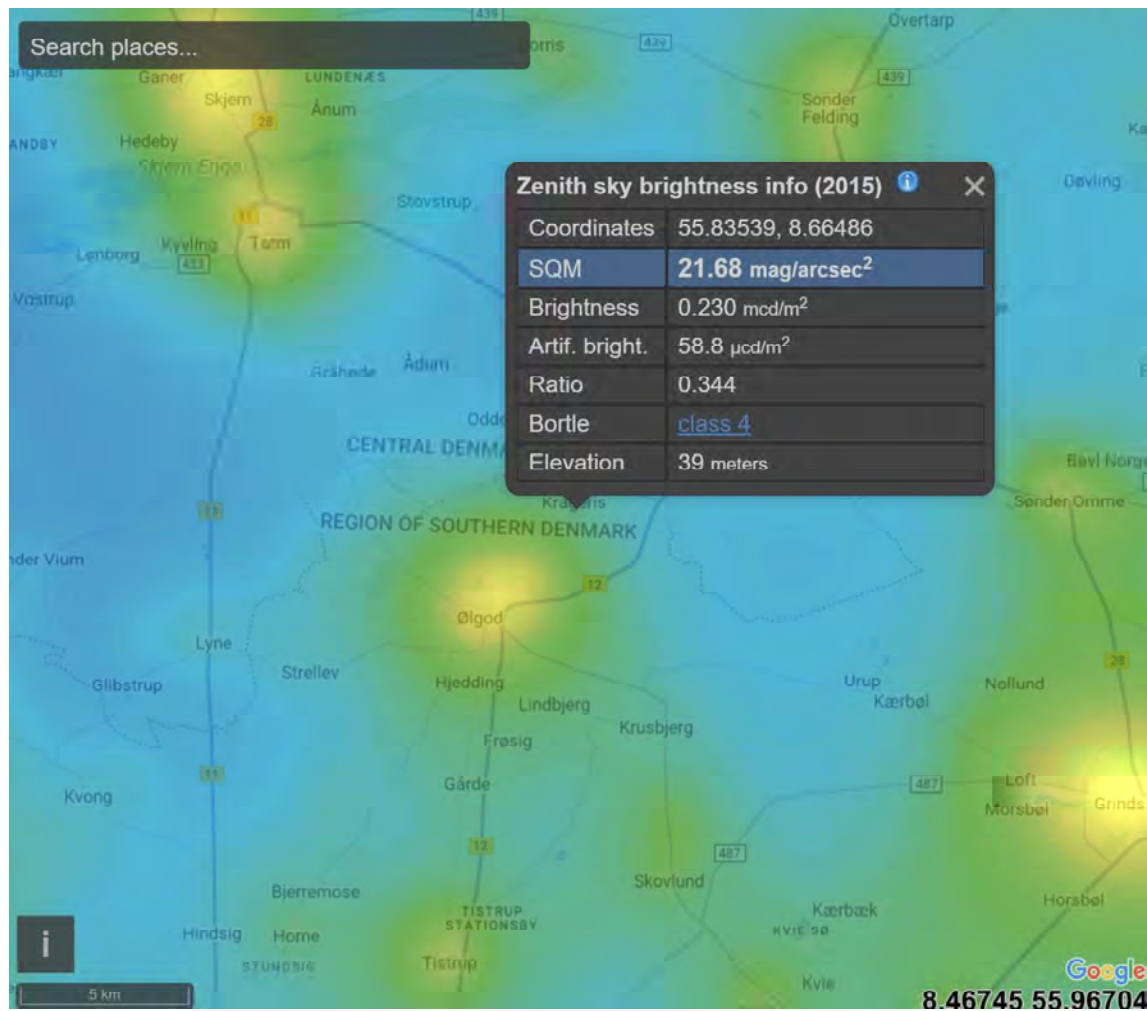


Figure 4: Light pollution map of Site 23

Source:

<https://www.lightpollutionmap.info/#zoom=10.00&lat=55.8354&lon=8.6649&state=eyJiYXNlbWFWljoiTGF5ZXJCaW5nUm9hZCIsIm92ZXJsYXkiOiJ3YV8yMDE1Iiwib3ZlcmxheWNvbG9yIjpmYWxzZSwib3ZlcmxheW9wYWNpdHkiOiI2NiIsImZlYXR1cmVzb3BhY2I0eSI6Ijg1In0=>

December 17, 2025
Malmö, Sweden

WARIM

Growlights during the day

During the winter period, the lights are usually on full during the entire lighting period (approximately 16-18 hours a day). This is required, because the amount of sunlight is too low to ensure good crop growth, the growlights supplement this to make sure the total amount of light received during the day stays high enough and at the right lightspectrum. The greenhouse climate-computer uses direct measurements and weather reports to plan the amount of light to use during the day. In addition to the sunlight and weather it also calculates electricity prices, heat supply, market price on the crop and other factors. All to optimise the production efficiency in correlation to the cost of producing the final product.

For example, on very dark and cloudy late afternoons, there could be a scenario where light escaping from the greenhouse would be barely visible. But in those cases, the screens will most likely be closed by the climate computer, since the amount of sunlight is far too low to be useful for the crop, and it will be a better decision, economically speaking, to close the screens to save the heat and increase the artificial light instead of having to do both.

One of the main reasons that the screens need to be pulled back during daytime is for the bumblebees to orientate while pollinating. Sunlight helps them do this more easily than using just artificial light.

The lights are dimmable, allowing the grower (climate system) to use the exact amount of required additional spectrum depending on the day and thereby to reduce energy costs while optimising production

Full sunlight has around 2000 $\mu\text{mol}/\text{m}^2/\text{s}$ of photosynthetically active radiation. The installed lights are around 300-400, depending on the crop choice.

December 17, 2025
Malmö, Sweden

WARMM

To show the effect of the lights during the day, a picture has been added to this document. The picture shown was taken on 24-09-2024, at 11h39, in Frövi, Sweden. By this time, the GH was fully operating and had the capacity to use the lights at 100%.

