Integrating solar energy and agricultural production

START annual meeting 2024

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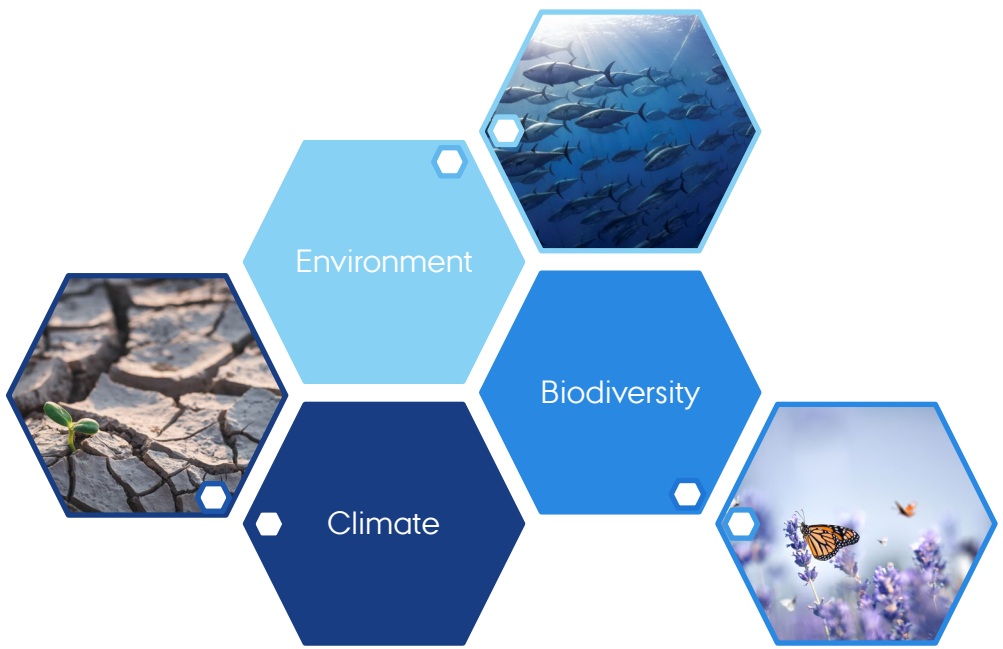
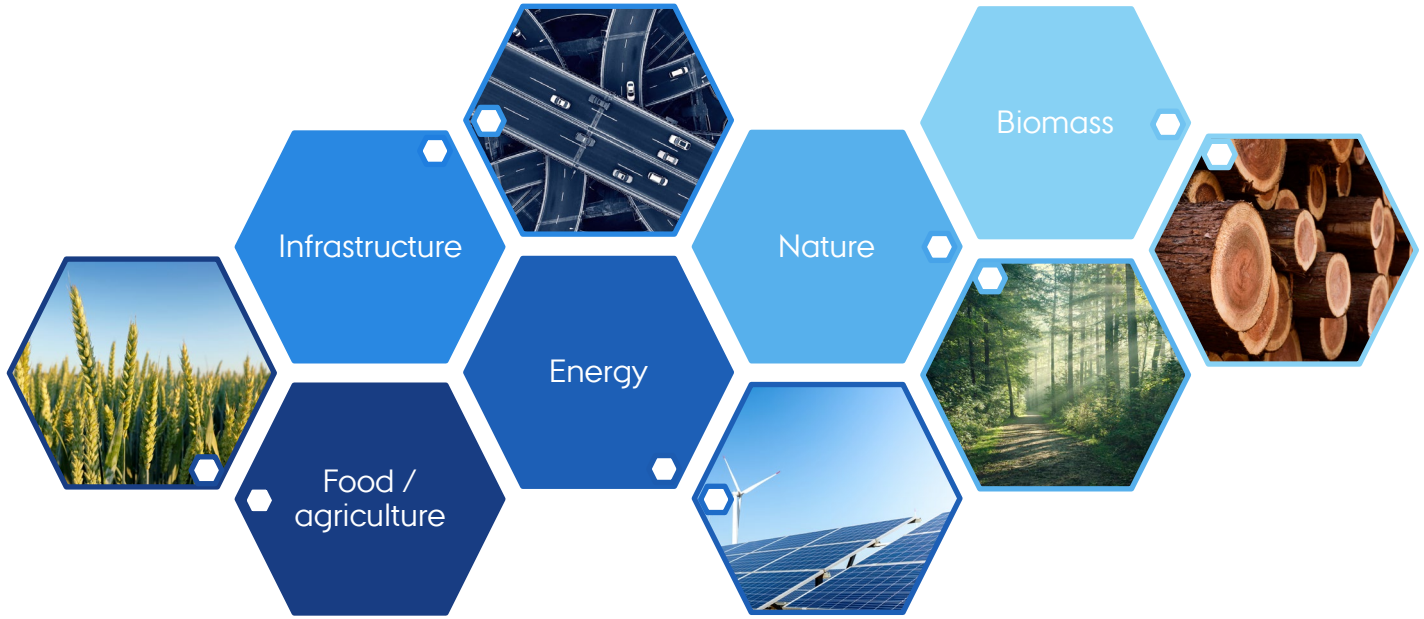
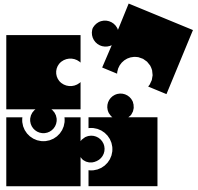
Aarhus University

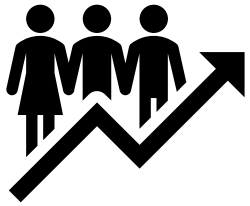
Landuse





Crises



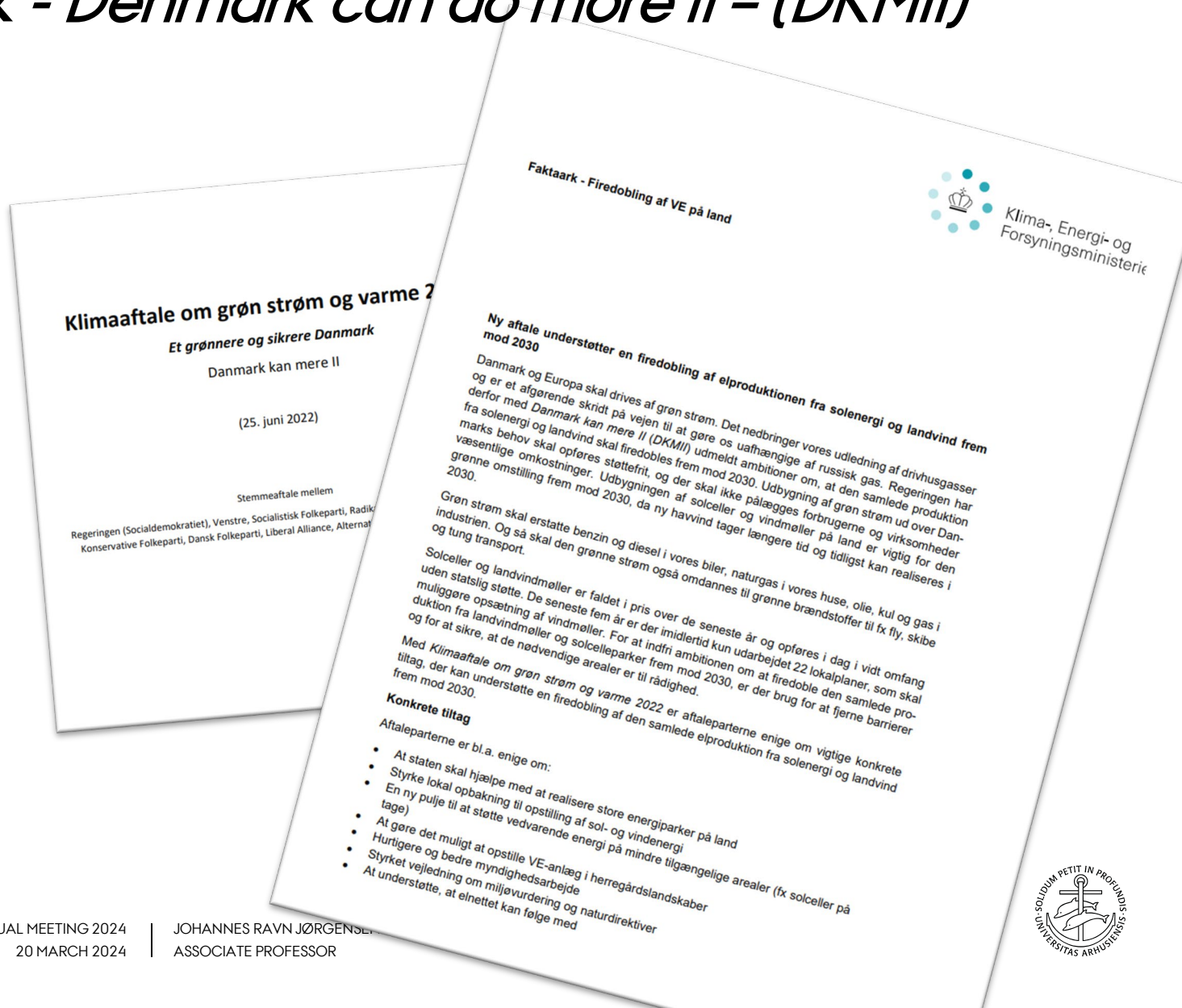


Essentials

Climate agreement on green electricity and heating 2022 - A greener and safer Denmark - *Denmark can do more II – (DKMII)*

- The total production from solar energy and onshore wind should be quadrupled by 2030 compared to 2021.

- The Ministry of Climate, Energy and Utilities estimate that 0.95 of the agricultural land will be needed to produce 20 GW solar energy production by 2030.



Klimaaftale om grøn strøm og varme 2

Et grønnere og sikrere Danmark

Danmark kan mere II

(25. juni 2022)

Stemmeaftale mellem

Regeringen (Socialdemokratiet), Venstre, Socialistisk Folkeparti, Radik
Konservative Folkeparti, Dansk Folkeparti, Liberal Alliance, Alternat

Faktaark - Firedobling af VE på land

Klima-, Energi- og Forsyningsministerie

Ny aftale understøtter en firedobling af elproduktionen fra solenergi og landvind frem mod 2030

Danmark og Europa skal drives af grøn strøm. Det nedbringer vores udledning af drivhusgasser og er et afgørende skridt på vejen til at gøre os uafhængige af russisk gas. Regeringen har derfor med *Danmark kan mere II (DKMII)* udmeldt ambitioner om, at den samlede produktion fra solenergi og landvind skal firedobles frem mod 2030. Udbygning af grøn strøm ud over Danmarks behov skal opføres støttefrit, og der skal ikke pålægges forbrugerne og virksomheder væsentlige omkostninger. Udbygningen af solceller og vindmøller på land er vigtig for den grønne omstilling frem mod 2030, da ny havvind tager længere tid og tidligst kan realiseres i 2030.

Grøn strøm skal erstatte benzin og diesel i vores biler, naturgas i vores huse, olie, kul og gas i industrien. Og så skal den grønne strøm også omdannes til grønne brændstoffer til fx fly, skibe og tung transport.

Solceller og landvindmøller er faldet i pris over de seneste år og opføres i dag i vidt omfang uden statslig støtte. De seneste fem år er der imidlertid kun udarbejdet 22 lokalplaner, som skal muliggøre opsætning af vindmøller. For at indfri ambitionen om at firedoble den samlede produktion fra landvindmøller og solcelleparker frem mod 2030, er der brug for at fjerne barrierer og for at sikre, at de nødvendige arealer er til rådighed.

Med *Klimaaftale om grøn strøm og varme 2022* er aftaleparterne enige om vigtige konkrete tiltag, der kan understøtte en firedobling af den samlede elproduktion fra solenergi og landvind frem mod 2030.

Konkrete tiltag

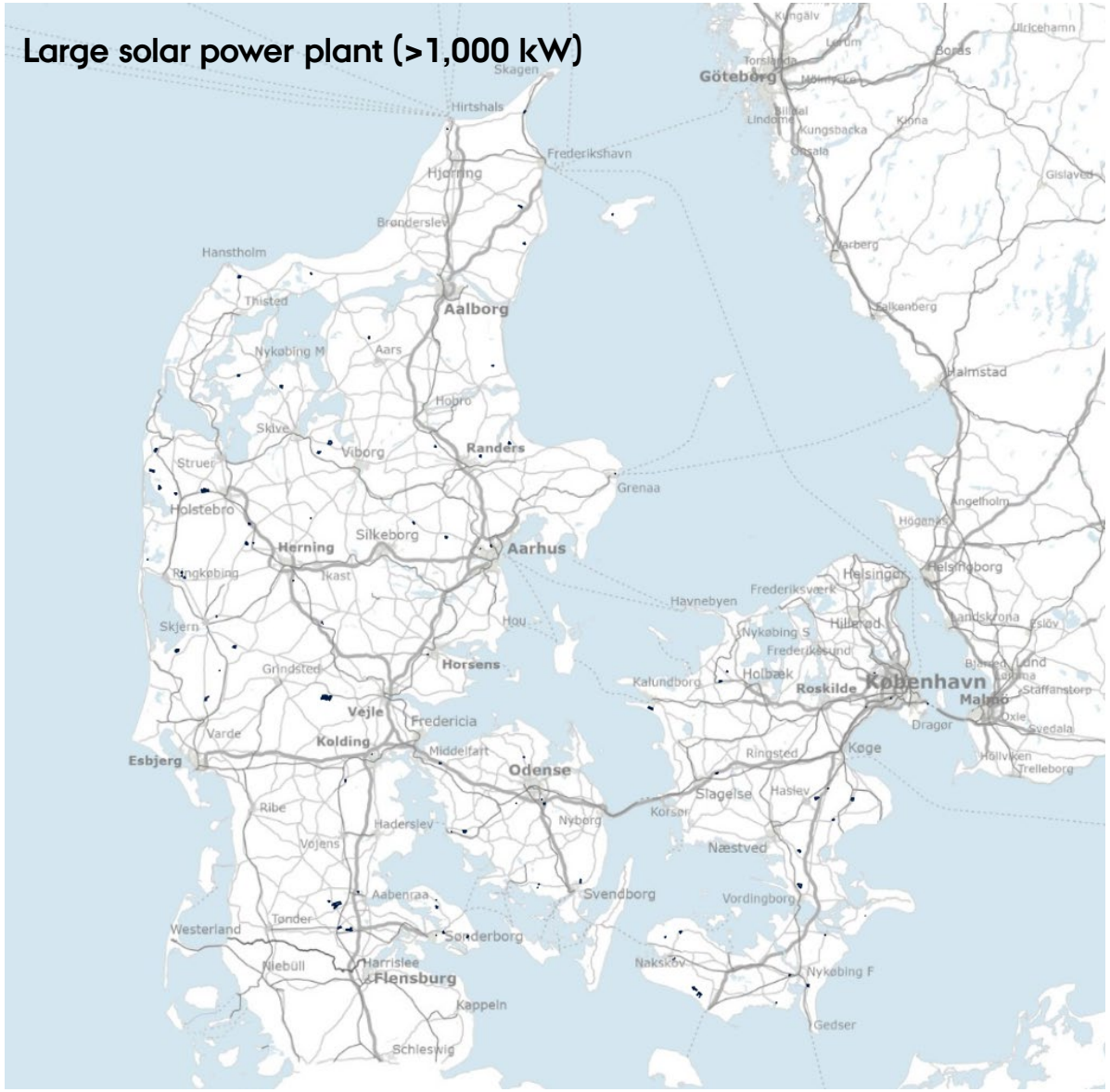
Aftaleparterne er bl.a. enige om:

- At staten skal hjælpe med at realisere store energiparker på land
- Styrke lokal opbakning til opstilling af sol- og vindenergi
- En ny pulje til at støtte vedvarende energi på mindre tilgængelige arealer (fx solceller på tage)
- At gøre det muligt at opstille VE-anlæg i herregårdslandskaber
- Hurtigere og bedre myndighedsarbejde
- Styrket vejledning om miljøvurdering og naturdirektiver
- At understøtte, at elnettet kan følge med

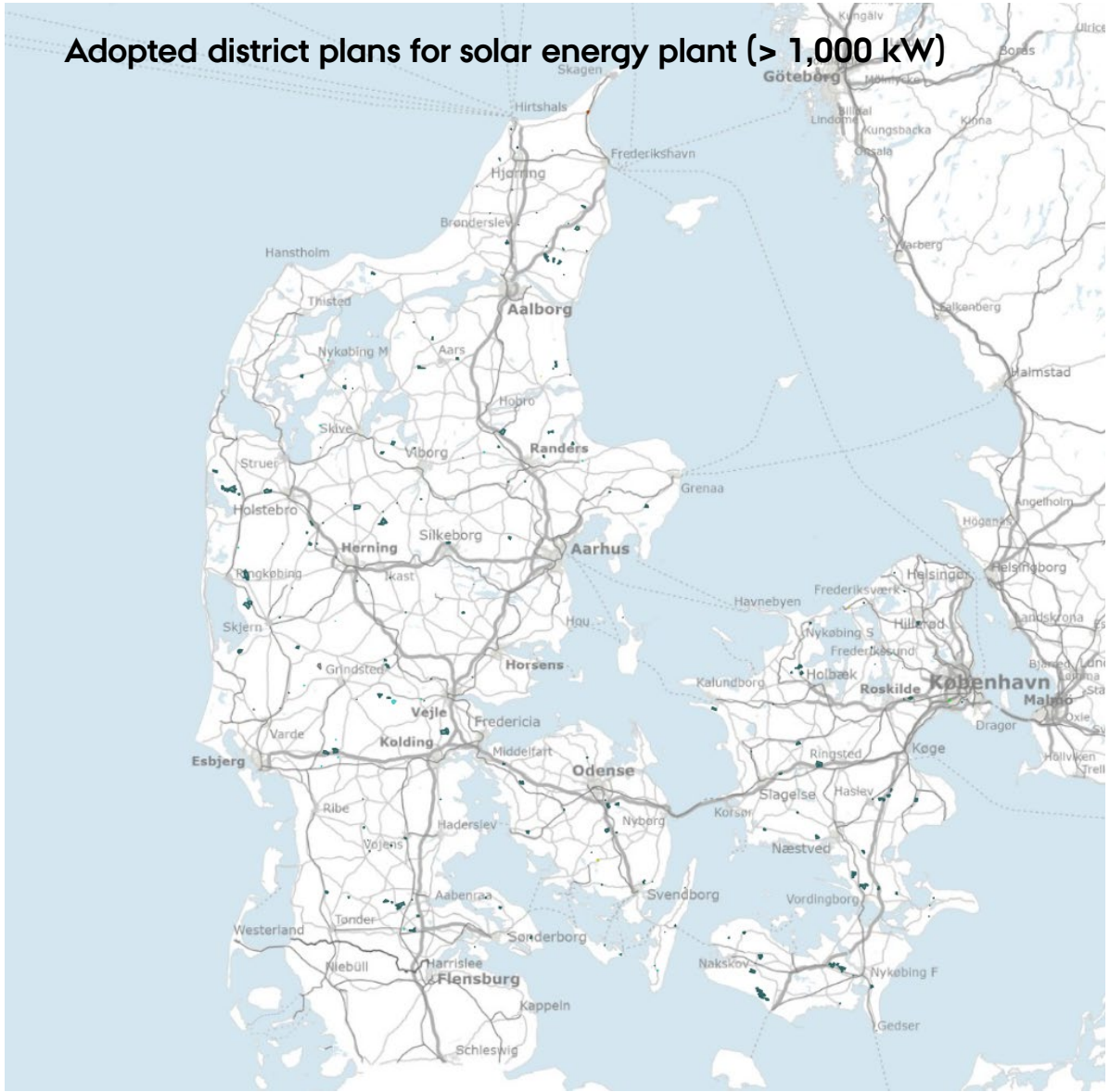
Climate agreement on green electricity and heating 2022 - A greener and safer Denmark - *Denmark can do more II – (DKMII)*

Capacity	Solar cells (GW)	Onshore wind turbines (GW)	Landuse	Solar cells	Onshore wind turbines
Current capacity (2021)	2.0	4.7	Area, ha (2021)	1,600	18,400
Expected capacity (2030)	8.5	5.7	Area, ha (2030)	24,500	32,100
DKMII (quadrupling in 2030)	20.0	8.2	New land requirement by 2030	22,900	13,700
Difference compared to KF22	11.5	2.5	Pct. of agricultural land (2021)	0.1	0.7
			Pct. of agricultural land (2030)	0.9	1.2

Large solar power plant (>1,000 kW)



Adopted district plans for solar energy plant (> 1,000 kW)



Solar power plant - Not in my backyard!

Areas found suitable for solar farms in Slagelse municipality

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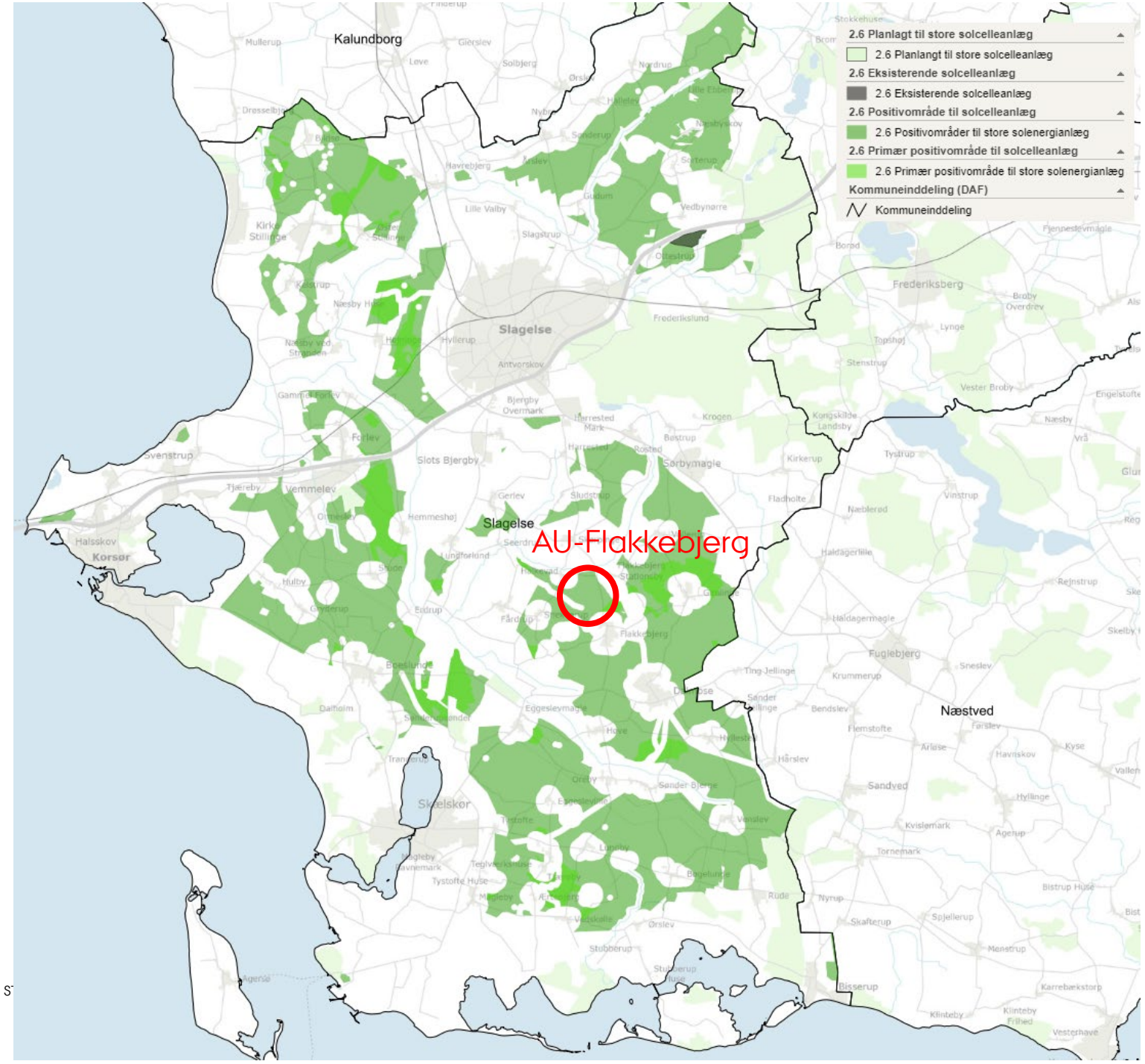
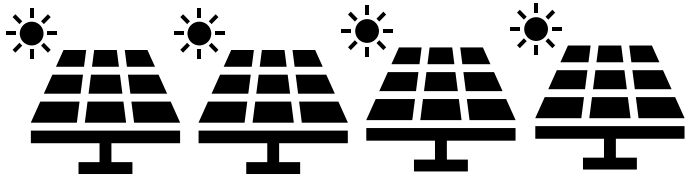


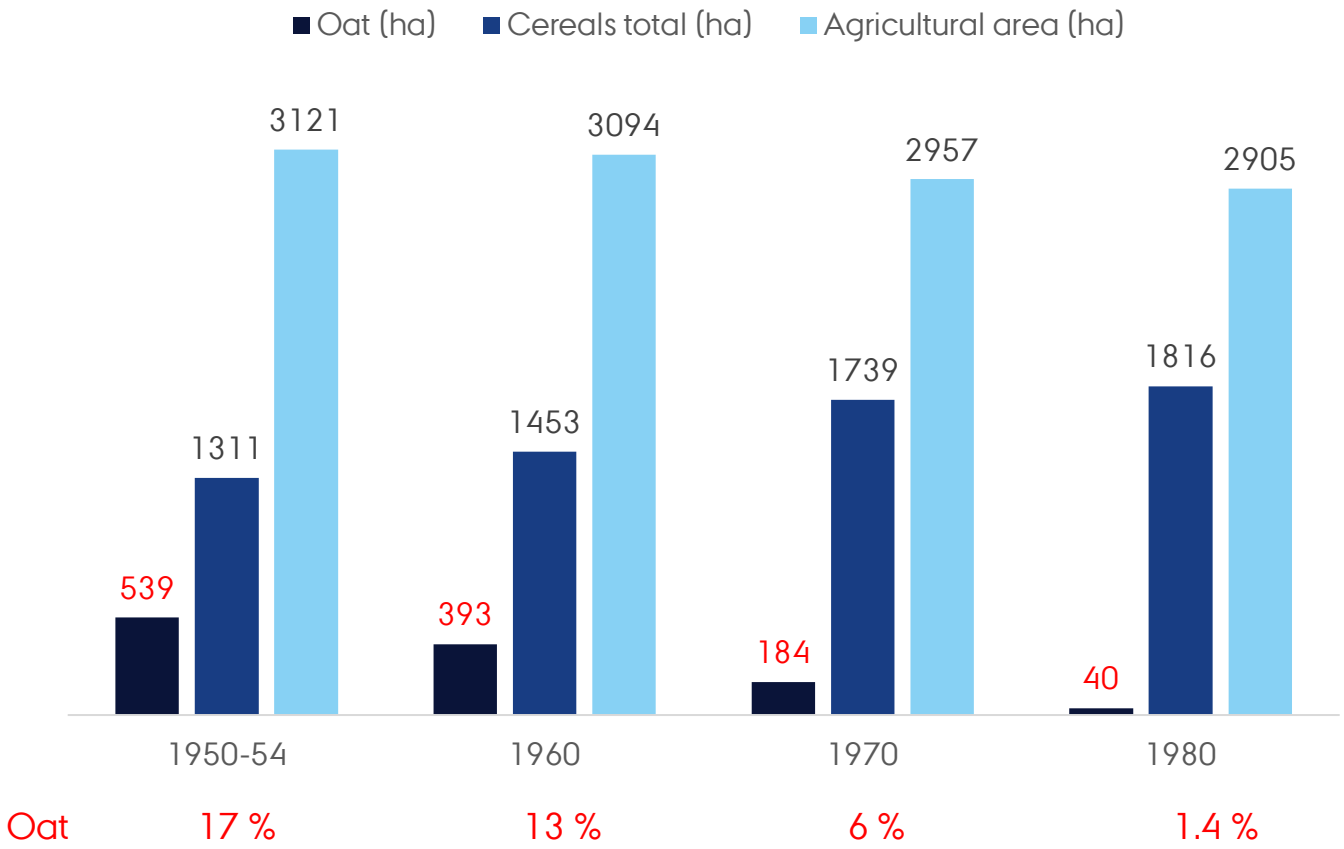
Competition for agricultural land - either/or?

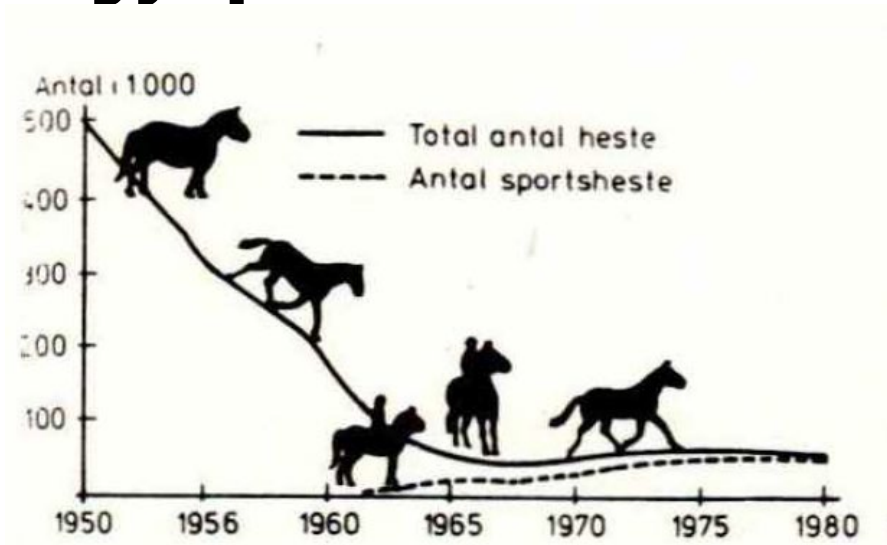
Food production

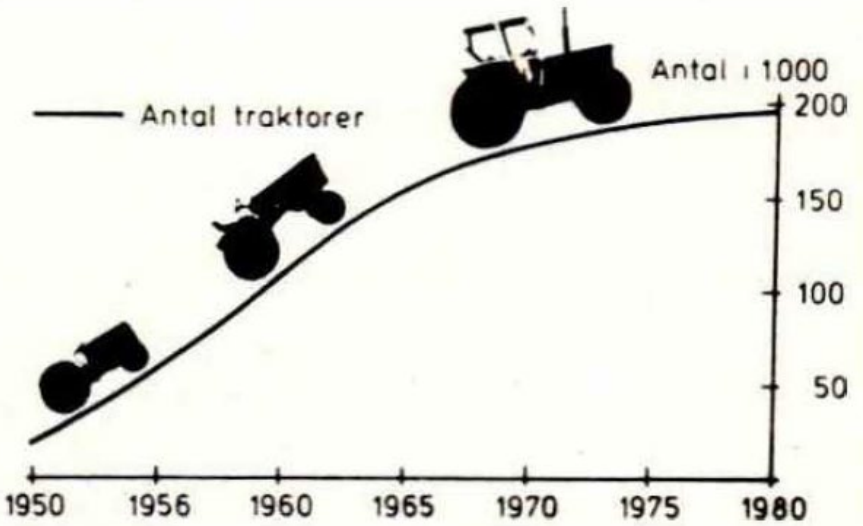
Energy production



Agricultural landuse for energy production – from oat to diesel







Kilde: Skriver, J. (2017). Traktordriftens gennembrud i Danmark 1945-65. Bol og By: Landbohistorisk Tidsskrift, 2(1).

Agrivoltaics

Photovoltaic system (solar panels on mounting structure)

Agricultural system (different crops)

Agrivoltiac system (combined)

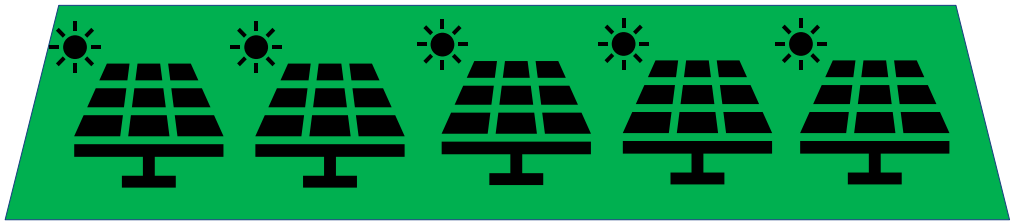
Land equivalent ratio in an AgriPV

Land Equivalent Ratio (LER) is the sum of the respective yields in cropping systems with two crops grown together compared to the crops grown in monoculture. If LER > 1, there is a positive effect.

An example of LER > 1 from a German experiment with combined a wheat crop and solar panel installation (AgriPV):

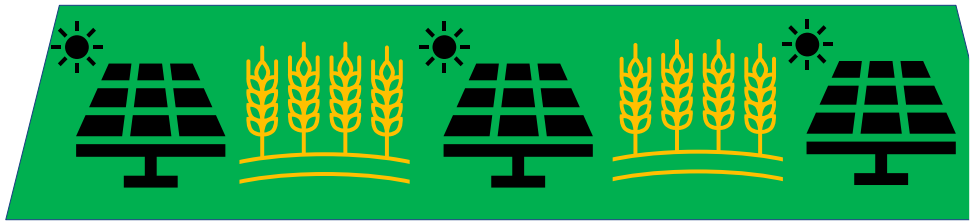
Separated agricultural and energy production on 2 ha

1 hectare with 100% wheat

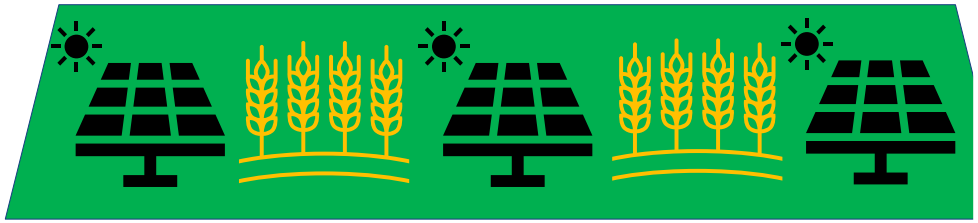


1 hectare with 100% solar energy

Combined agricultural and energy production on 2 ha



1 ha with 80% wheat yield and
80% solar energy yield



1 ha with 80% wheat yield and
80% solar energy yield

160% wheat
160% solar energy
LER ~ 1,5

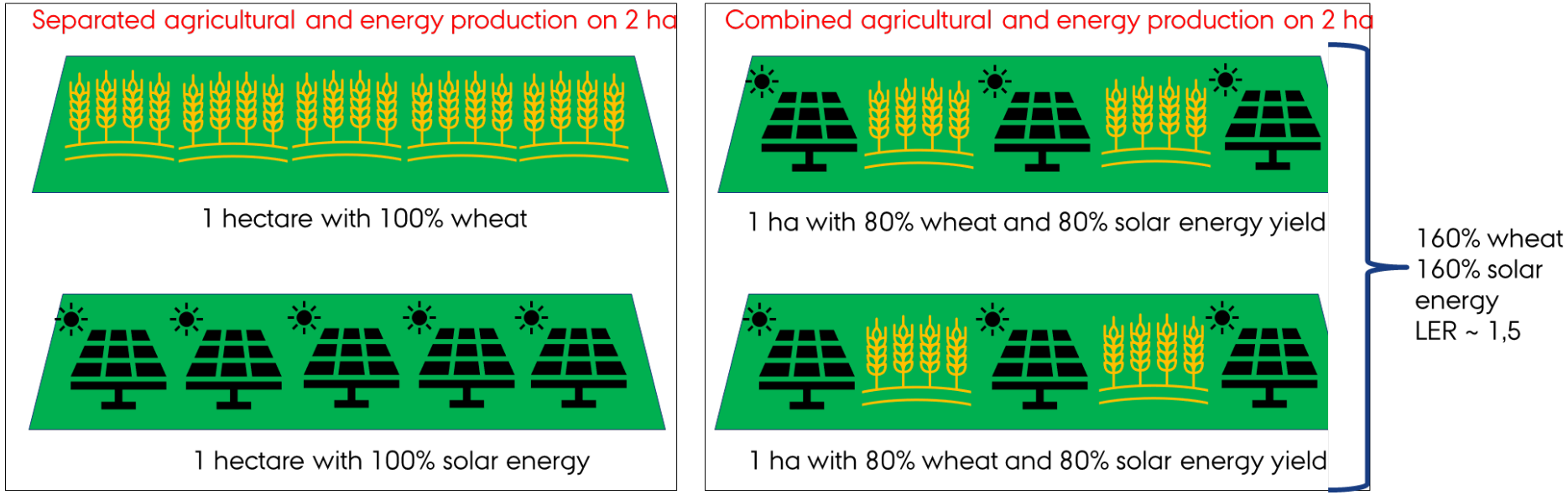
Kilde: Trommsdorff et al., 2021, https://doi.org/10.1016/j.rser.2020.110694

Justification for establishing an AgriPV

There must be a positive interaction between the solar panel installation and agricultural production for AgriPV to make sense in relation to:

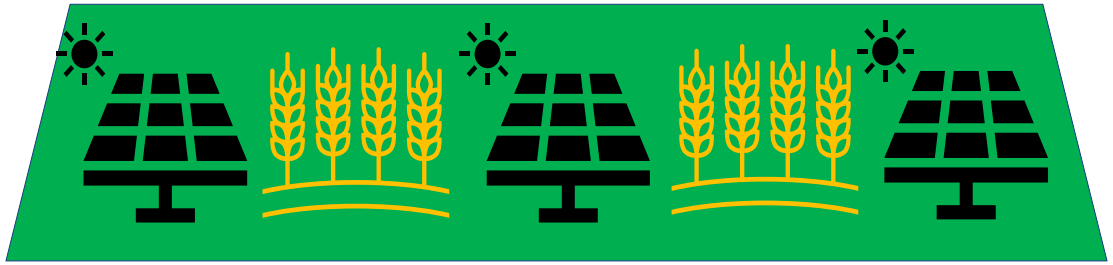
- Production - energy and agricultural production should deliver more than 100% or LER > 1
- Climate (reduction in greenhouse gas emissions)
- Environment (reduced leaching etc.)
- Biodiversity (flora and fauna)

If there is no positive interaction, AgriPV is a "no go"



Considerations regarding cultivation in an AgriPV system

- Should AgriPV be located on prime agricultural land?
- Identification of crops suited for cultivation in an AgriPV system?
- Size and driving pattern of farm machinery
- Transport of harvested material out from the cultivation area between the solar panels
- Do the solar panels have a positive or negative effect on crop growth in relation to windbreak, evaporation, diseases, and pests?
- The solar panels are fragile and sensitive to dust and impact



Historic changes in field sizes in Denmark

- 192,000 farms in 1950 - 30,678 in 2022.
- Specialization, efficient and rational farming have pushed the cultivated area to be uniform with fewer but larger fields.
- The requirement for winter green fields and the greater yield potential by winter crops have made the agricultural landscape more uniform.

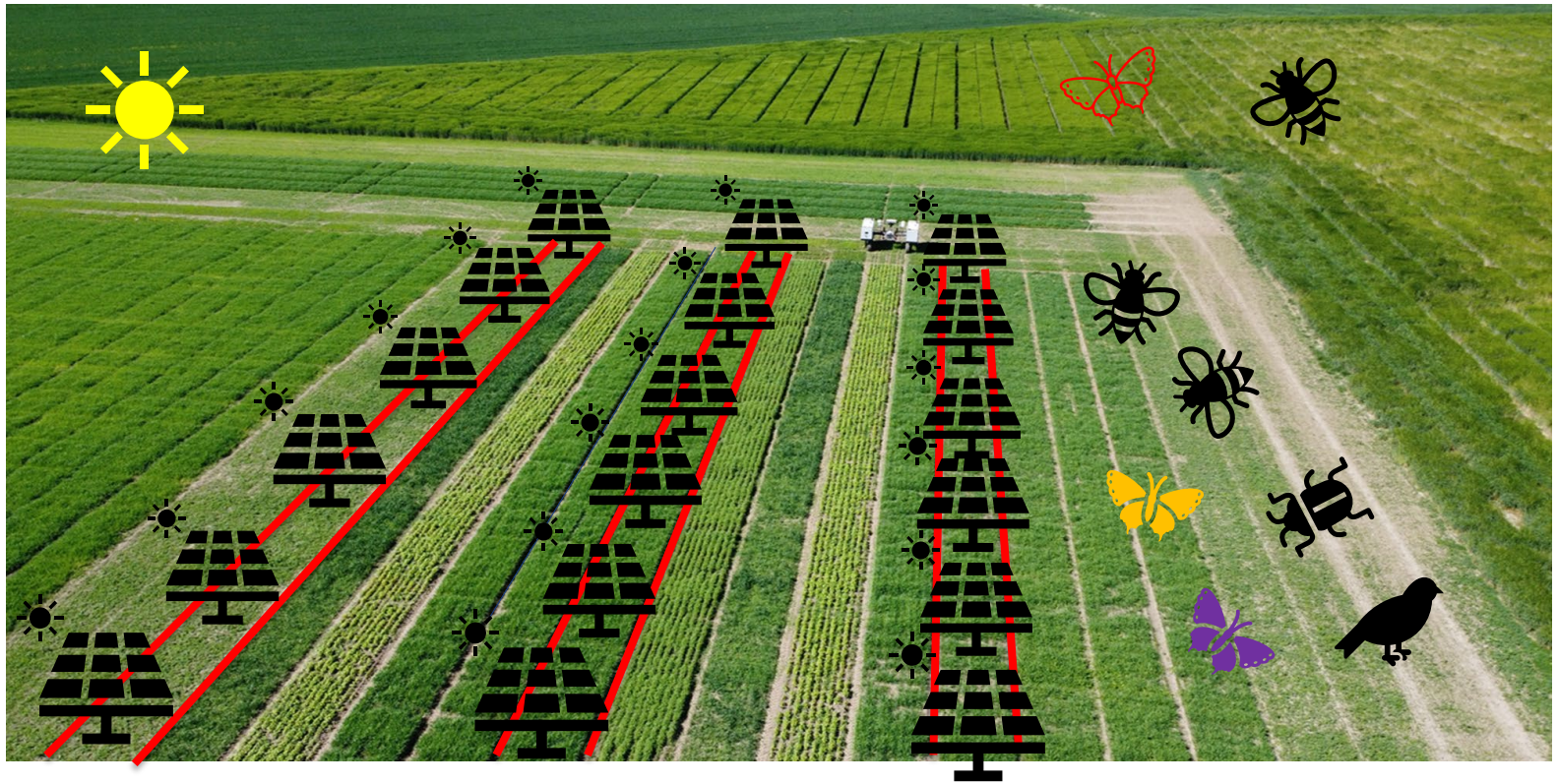
- Outcome:
  - fewer hedges and field boundaries
  - monoculture on larger fields
  - reduced biodiversity in the agricultural landscape

Høve 1954

Høve 2023

Biodiversity with non-crop plants under solar panels - introducing non-crop corridors

- Increased biodiversity in farmland with low biodiversity
- Creates habitat for insects, and animals
- Potentially reduces the need for pesticides
  - beneficial insects will be present in the fields
- Increases pollinators
- Aesthetically pleasing - better to look at panels with diverse plant growth underneath than without



AgriPV - Outlook

- AgriPV's potential is immense in EU, with just 1% of arable land potentially hosting over 700 GW of solar capacity.
- Agri-PV interacts with the goals of the European Green Deal (EGD):
  - clean energy,
  - energy transition,
  - sustainable agriculture,
  - food security,
  - biodiversity,
  - rural development and
  - research & innovation
- The EU Solar Energy Strategy calls for a roughly fourfold increase in additional photovoltaic from 2021 to 2030. Approximately 50% of this capacity is expected to be deployed in agricultural areas.
- Legislation and regulation for use photovoltaic and claim for AgriPV is coming in Italy, Spain, France, Germany….. and Denmark?

THE AGRIVOLT PROJECT

START: 15-4-2023, END: 31-12-2028

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Objectives and the success criteria:

- To demonstrate the potential of solar-tracking photovoltaic panels in an AgriPV research platform
- To demonstrate the crop and PV productivity – target 80% of reference
- To develop and validate a climate, environmental and biodiversity friendly food production in the shaded and semi-shaded environment of a AgroPV system
- To implement, validate and demonstrate the use of agricultural robots in a AgroPV system.
- To evaluate climate, environmental and biodiversity impact of an AgriPV system
- To evaluate economic and social perspective and reveal relevant stakeholders' perception of AgriPV systems

AGRIVOLT – the AgriPV at AU-Flakkebjerg

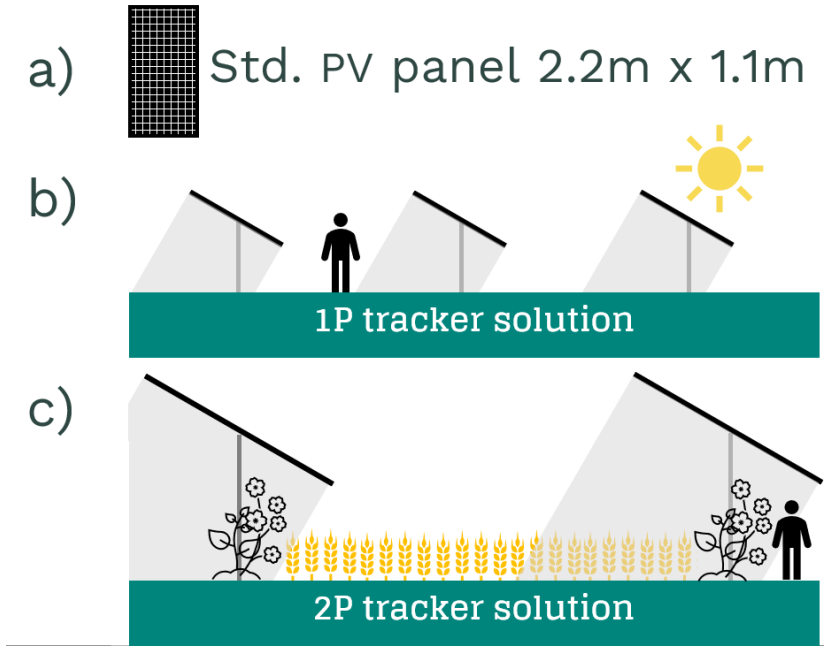
The Agrivolt system is a 1 MW test system on a 2 ha JB6 soil.

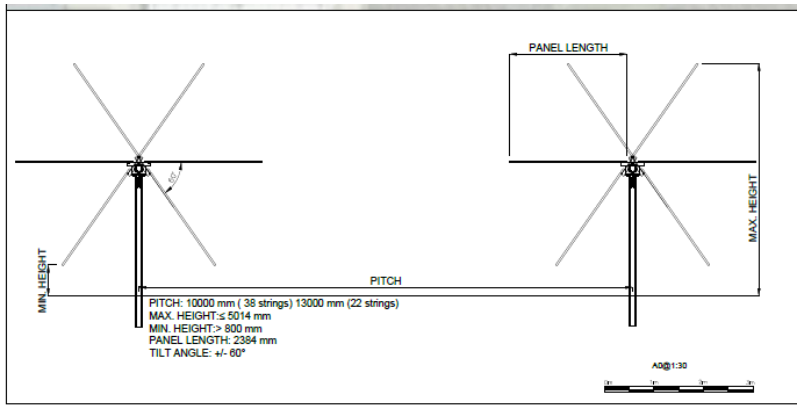
It is a "2P tracker setup":

- 2 solar panels mounted so that they can follow the movement of the sun (+/- 600) during the day.
- Rotational axis north/south. Height 3-5 m above the ground

Distance between panels 12 m for field trials with agricultural crops, as well as strips for biodiversity.

- The crops will primarily be managed by a field robot.
- Reference area.





Innovation Fund Denmark

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