

ANEO

Storskala Solkraftverk i Norge og Norden

IEEE-seminar 21.11.2022

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Om Aneo

Norges nest største vindkraftaktør



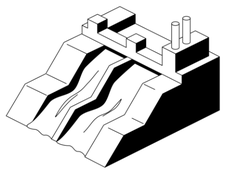
928 GWh årlig produksjon

Ett av de ledende nasjonale miljøene for energiforvaltning fornybar produksjon



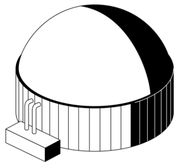
6 TWh under forvaltning hvorav 1 TWh tredjeparter

Eier 18,98% av TrønderEnergis vannkraftproduksjon



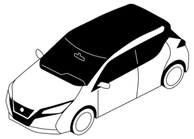
346 GWh årlig produksjon

Eierskap i en ledende nordisk biogassaktør

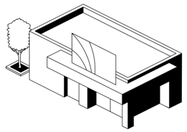


Betydelig eierandel i Scandinavian Biogas Fuels (børsnotert i Stockholm)

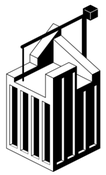
Flere nasjonalt ledende posisjoner nedstrøms



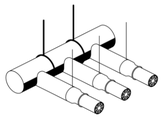
Aneo Mobility
Elbil-ladeløsninger til borettslag og næringskunder



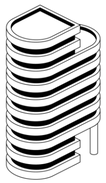
Aneo Retail
Leverer og administrerer bærekraftig energiinfrastruktur til dagligvarebutikker



Aneo Build
Leverer og administrerer ladecontainere for elektrifisering av bygge- og anleggsplasser

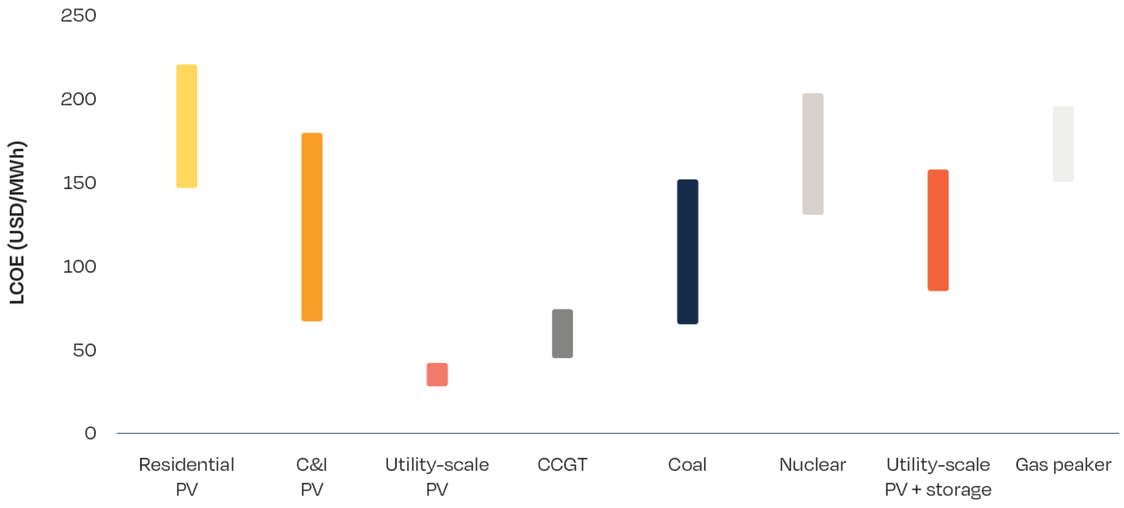


Aneo Industry
Energieffektivisering og nullutslipp til prosessindustrien



Aneo Real Estate
Solenergiløsninger for næringsbygg

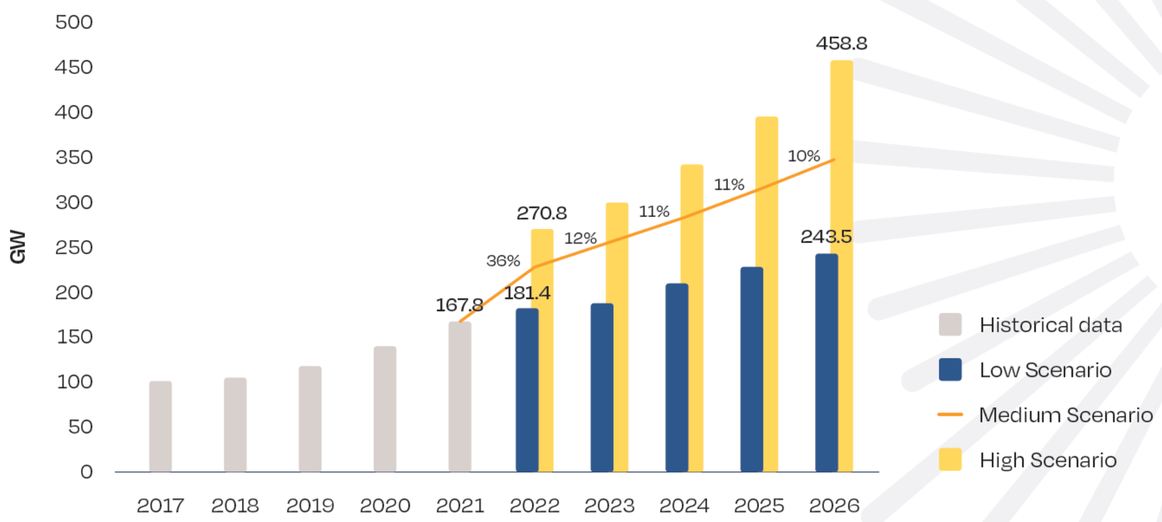
FIGURE 4 SOLAR ELECTRICITY GENERATION COST IN COMPARISON WITH CONVENTIONAL POWER SOURCES 2021



SOURCE: Lazard (2021). Nominal terms, post-tax.

© SOLARPOWER EUROPE 2022

FIGURE 14 WORLD ANNUAL SOLAR PV MARKET SCENARIOS 2022 - 2026



© SOLARPOWER EUROPE 2022

Kilde: SolarPower Europe – Global Market Outlook for solar Power, 2022-2026



https://www.pv-magazine.com/2022/11/28/norway-to-nearly-triple-annual-pv-additions-in-2022-says-research-firm/

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ENERGI

Satser stort på solkraft i Norge: Har planer for 14 bakkemonterte kraftverk

Norske Energeia betaler millioner til norske kommuner for å leie tomter til solkraftverk.



Energeia ønsker å få til solenergi i kombinasjon med beitedrift. Her fra Energeias anlegg i Nederland. *Foto: Energeia*



Erik Martiniussen Journalist

24. nov. 2022 - 05:00

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Denne Ekstra-saken kan leses gratis av alle du deler den med. Kopier lenke

Energeia vil bygge fire store solkraftverk i kommunene Gjøvik, Søndre Land og Østre Toten. Som kompensasjon tilbyr de kommunene millioner i tomteleie – eller direkte eierskap i kraftverkene.

Kilde: https://www.tu.no/artikler/satser-stort-pa-solkraft-i-norge-har-planer-for-14-bakkemonterte-kraftverk-br/523884?key=a4woZlh3

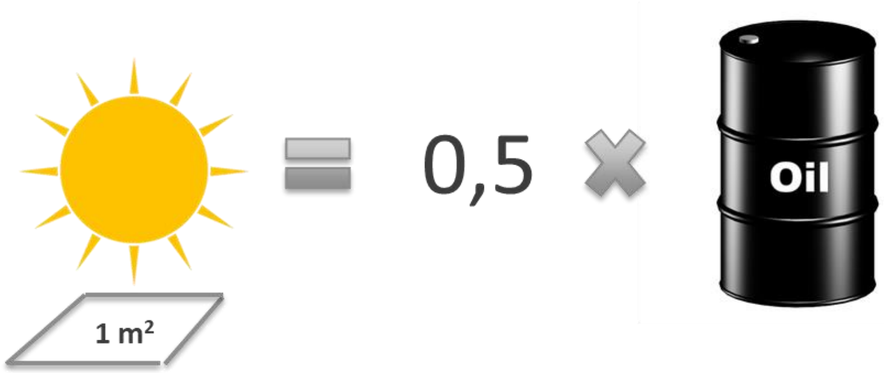
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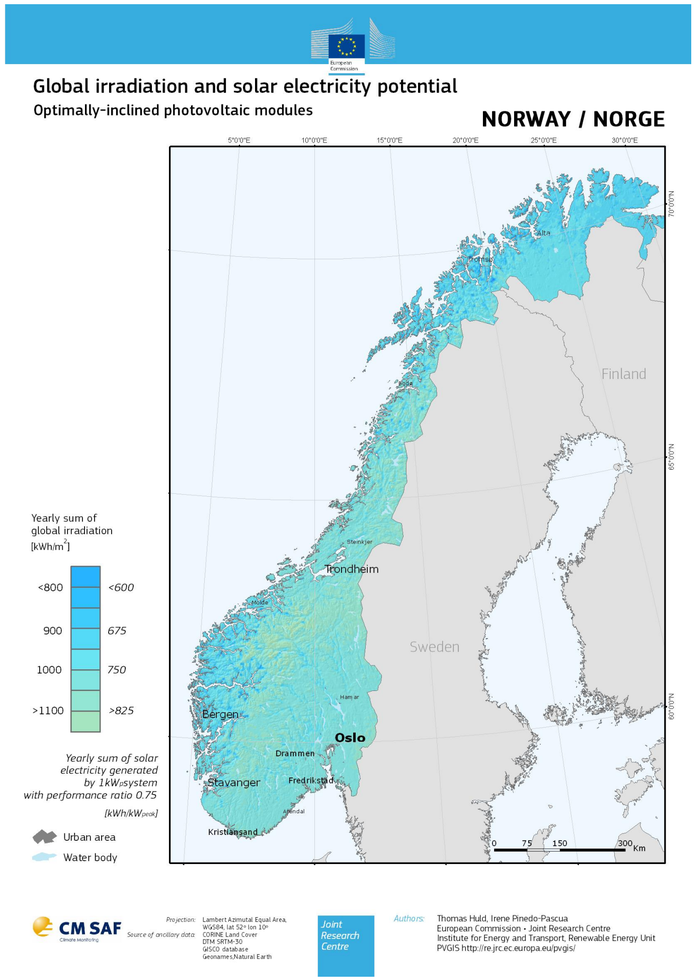
Ordforklaringer

- kWp – kilowatt «peak» = solcellens ytelse målt ved standard testbetingelser, STC
- STC – Standard Test Conditions:
  - Innstråling = 1000 W/m^2
  - Spektrum = AM 1,5
  - Temperatur = 25°C
- kWh/kWp = spesifikk ytelse – nøkkeltall for sammenligning av ulike designalternativer og kraftverk
- Pnom = forhold mellom DC- og AC-ytelse på kraftverket

Det er nok solenergi i Norge

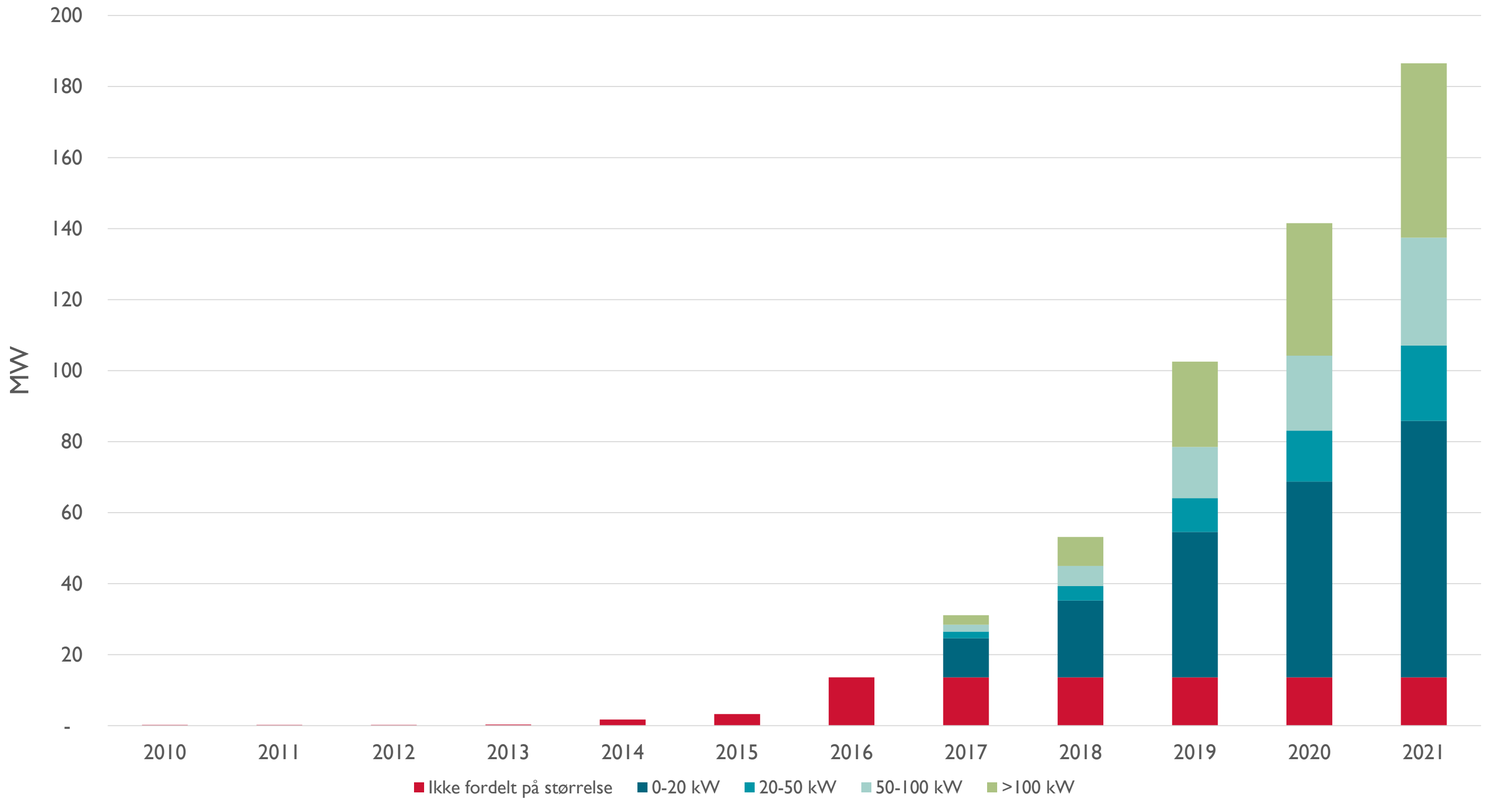
Norge: 900 kWh/m²/år





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Utvikling av solkraft i Norge - Akkumulert



Ny installert effekt av solkraft i Norge for 2022 forventes å lande på ca 140 MWp

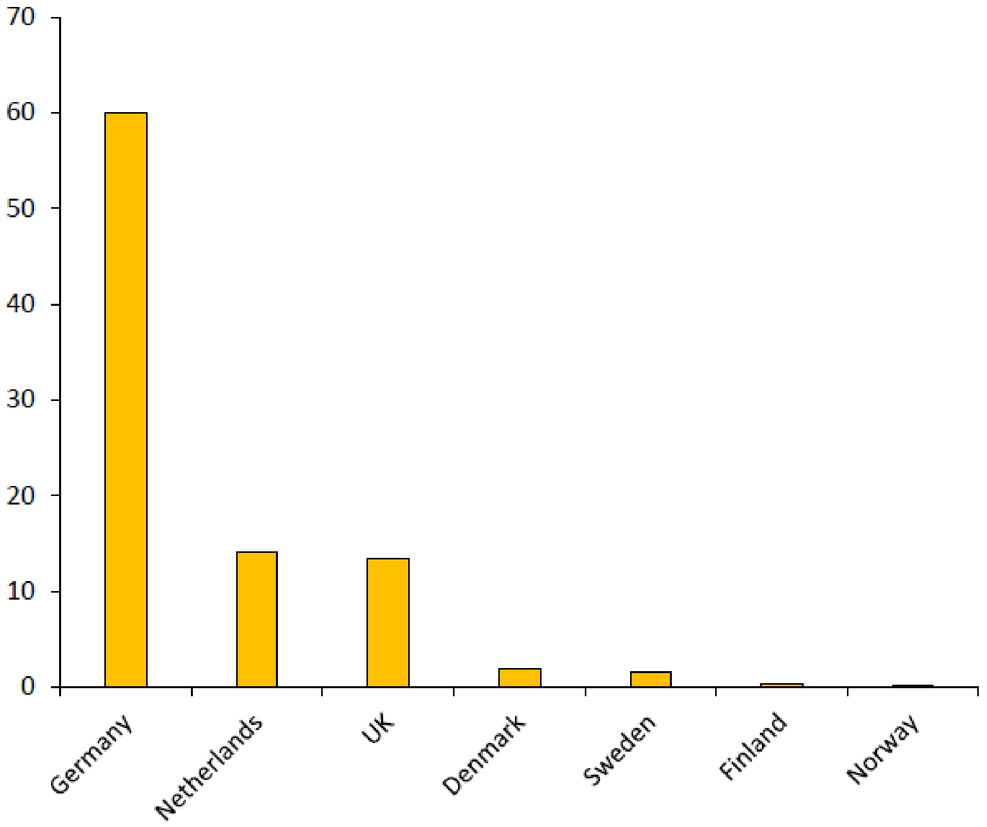
-Akkumulert ca 320 MWp

Solar in the Nordics – Resource potential

Nordics lagging far behind European comparable countries

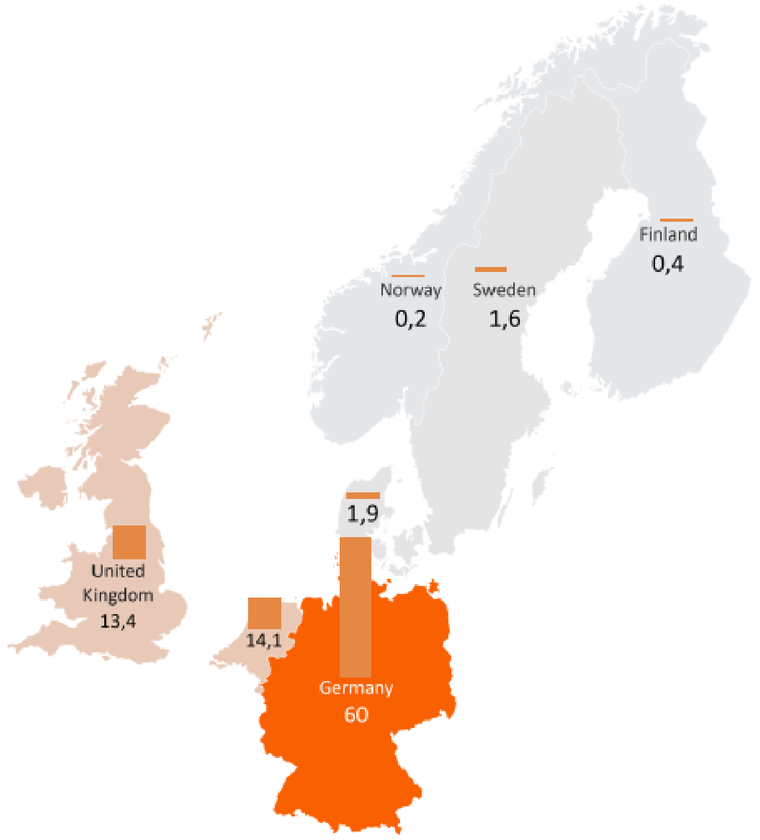
Installed capacity of Solar PV for select European countries

GW_{DC}



Installed capacity of Solar PV for select European countries

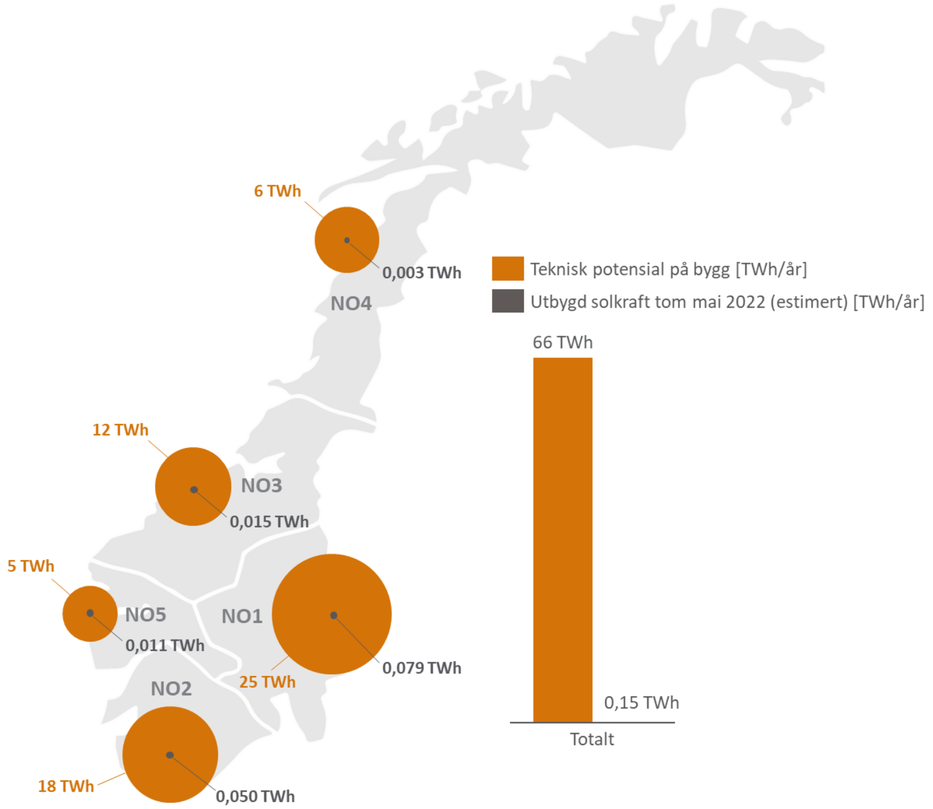
GW_{DC}

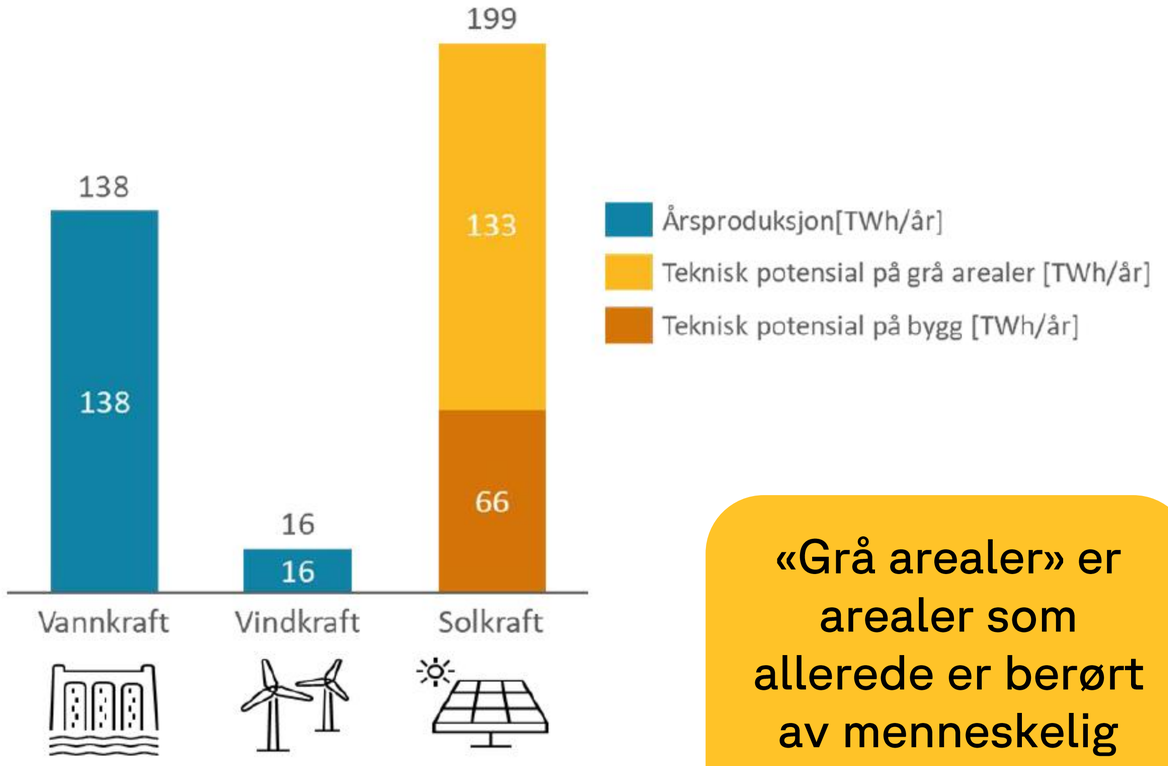


Powered by
© GeoNames, Microsoft, Tom

RystadEnergy

Teknisk potensial for solkraft i Norge er ca. 200 TWh/år





«Grå arealer» er arealer som allerede er berørt av menneskelig aktivitet

Kilde: Multiconsult / Solenergiklyngen

Hva er storskala solkraft?



Foto: Jolyroom



Foto: Solgrid

Norges største solkraftverk – 3,8 MWp –
ASKO Vestby





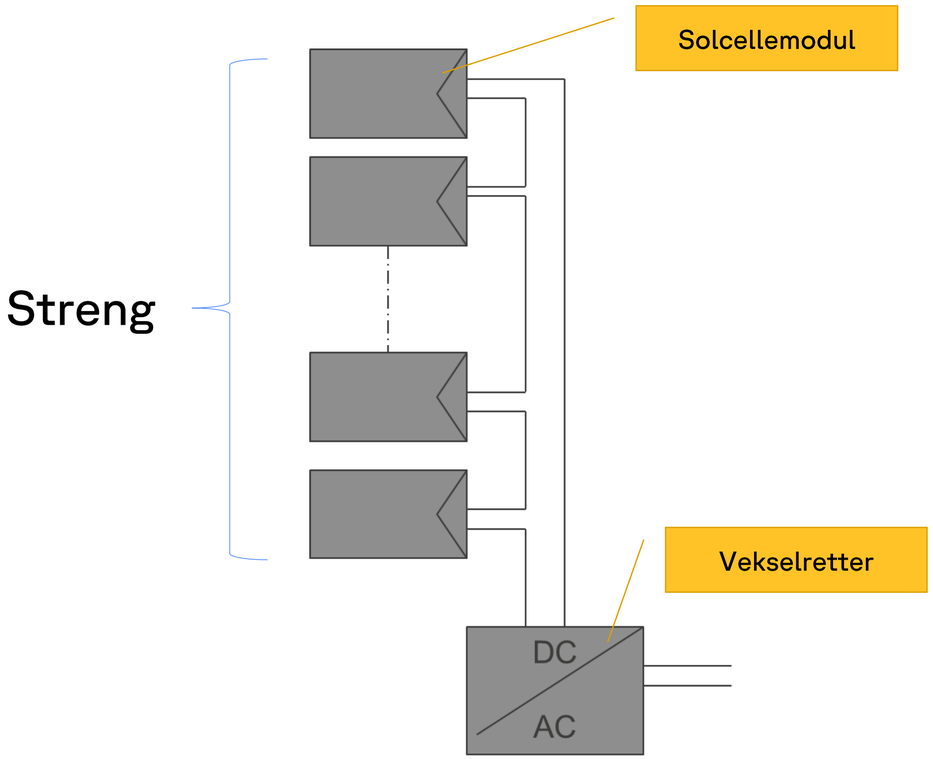
Foto: Multiconsult

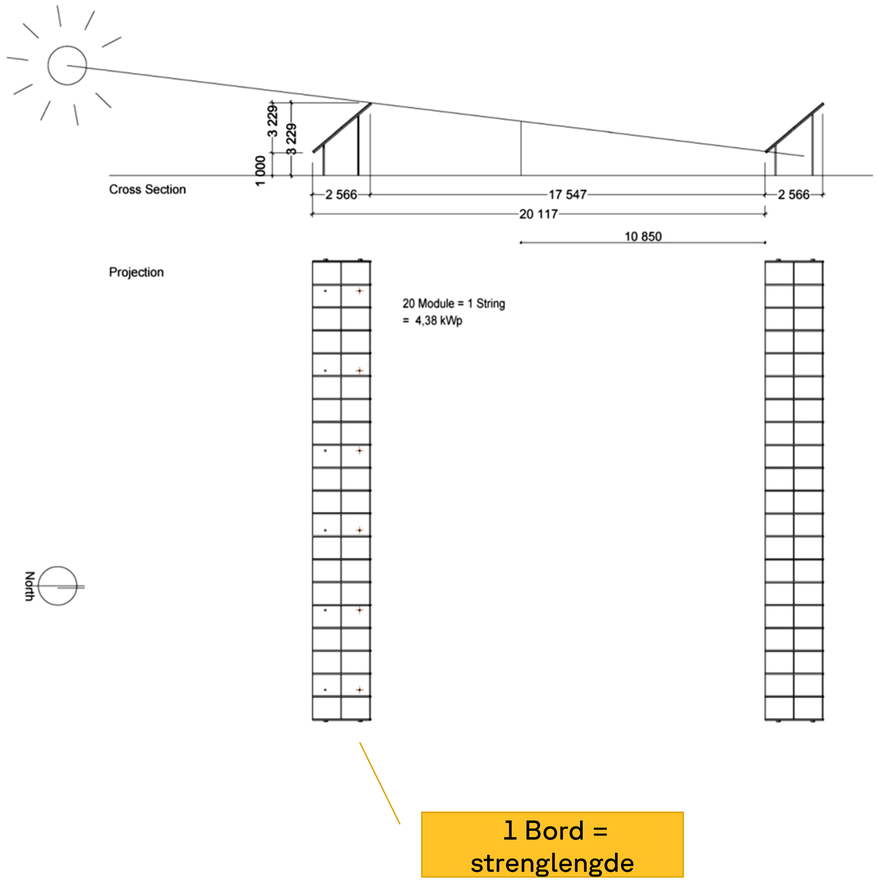
Hvordan bygge solparker på Norsk?

- “Beste praksis for bakkemontert solkraft”
  - Kommentert av Naturvernforbundet, DNT og Noregs Bondelag
- Arealbruk
- Biologisk mangfold
- Rammebetingelser

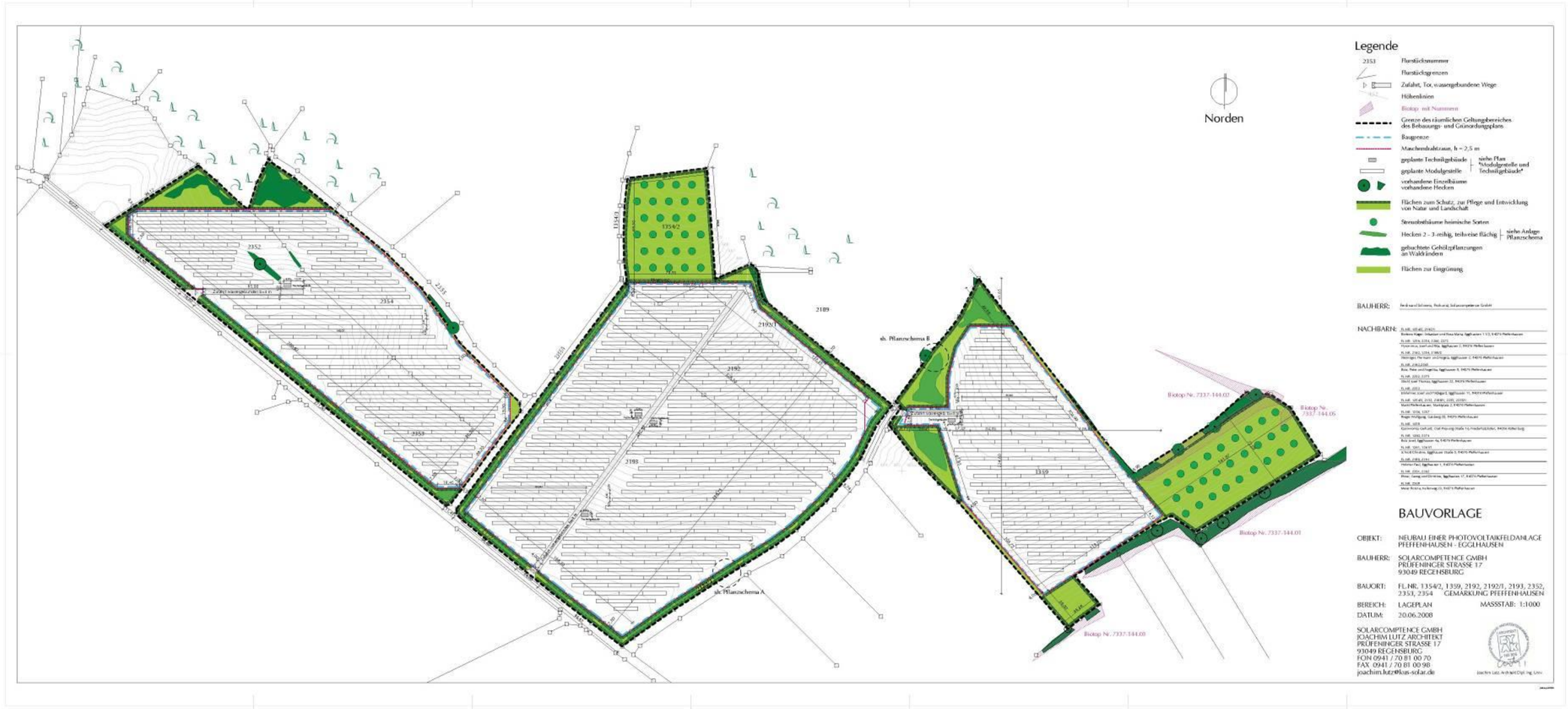


Oppbygging av solkraftverk

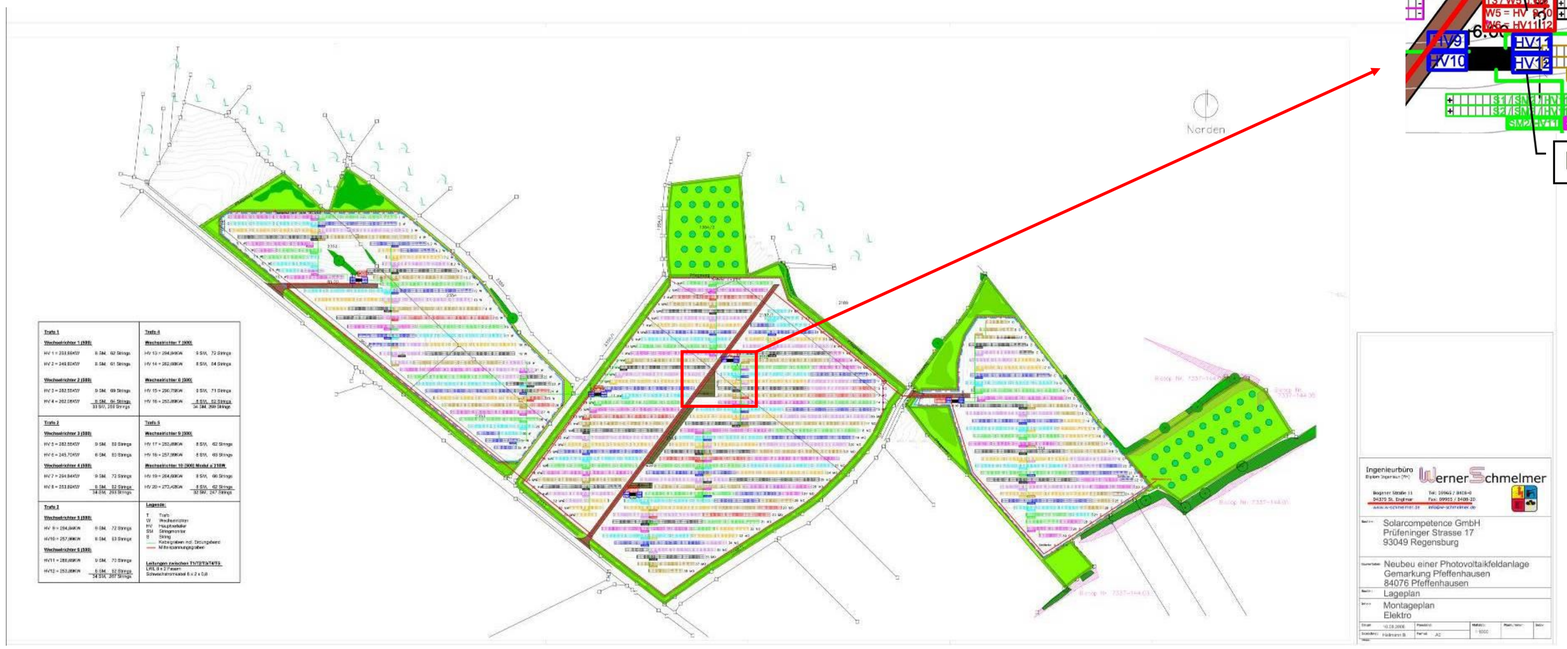


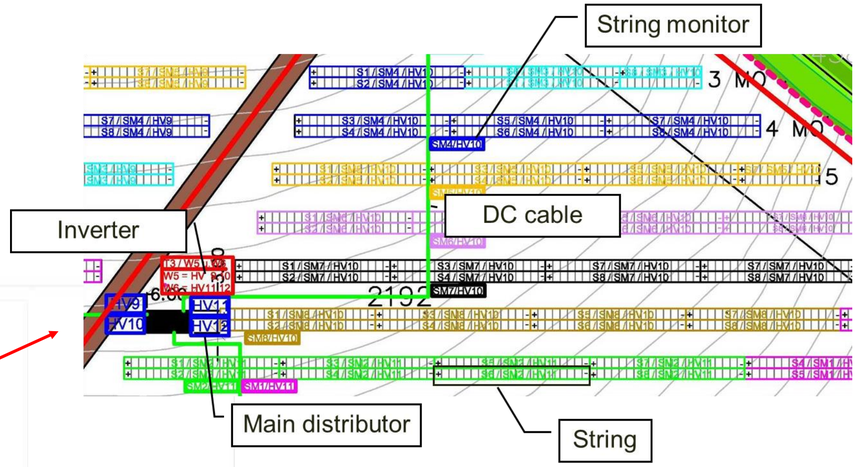


Byggetegning



Elektrisk Lay-out





Reversibel installasjon

- Installasjonsteknikkene for solkraftverk er reversible
- Normal fundamentering:
  - Ramming
  - Ballast
  - Jordskruer
- Arealet skal normalt tilbakeføres til original tilstand etter konsesjonsperioden





Foto: Sunna





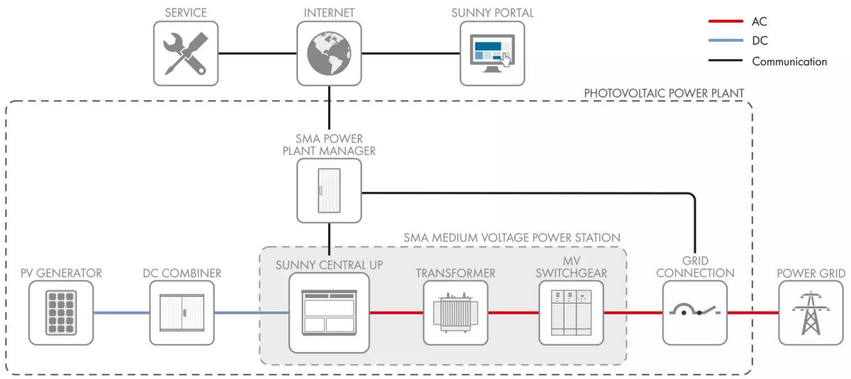


Foto: Sunna

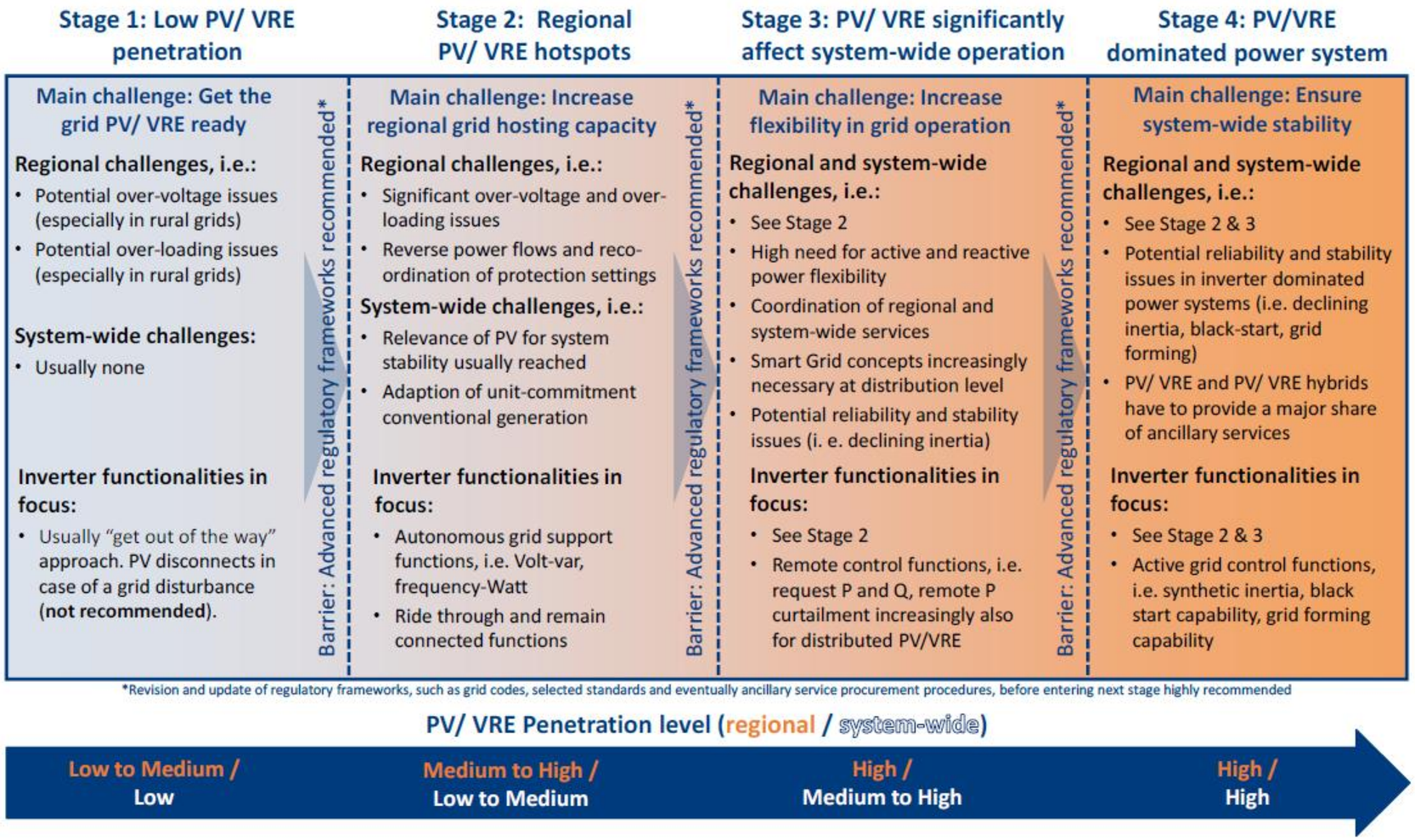
Vekselrettere for store kraftverk

- 1500 V DC inngang
  - Lengre strenger
  - Mindre tap
  - Lavere kostnader
- Prefabrikerte enheter med vekselretter og transformator
- Dynamisk kontroll av
  - Reaktiv effekt
  - utmating (Spenningsregulering)





Utfordringer med PV i nettet



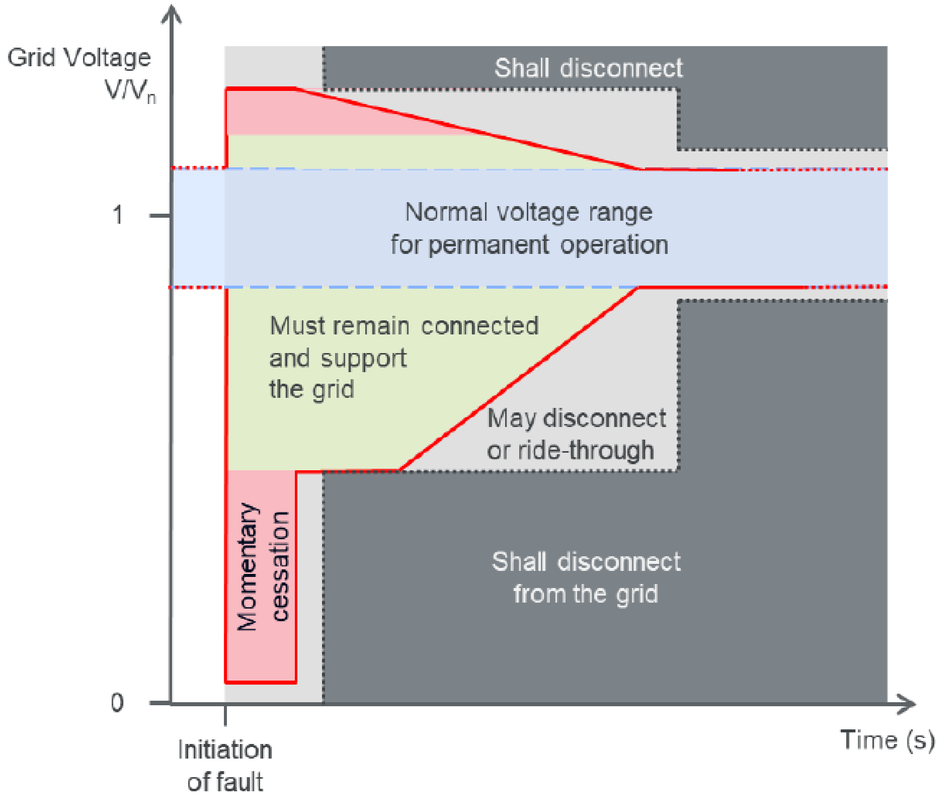
Kilde: https://iea-pvps.org/key-topics/pv-as-an-ancillary-service-provider/

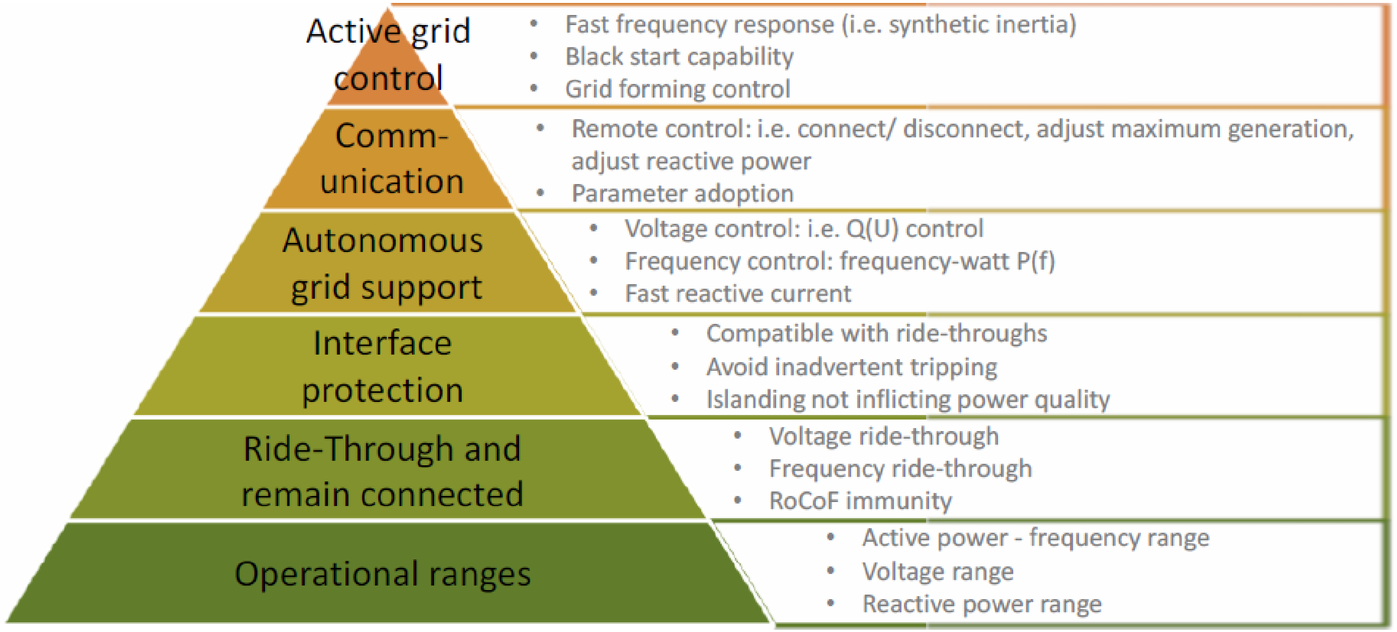
The developments in the grid-codes worldwide are the result of a fundamental paradigm shift regarding the approach for connecting DER,

moving from a “fit and forget” practice and towards an active integration of DER into the power systems

IEA PVPS – Task 14

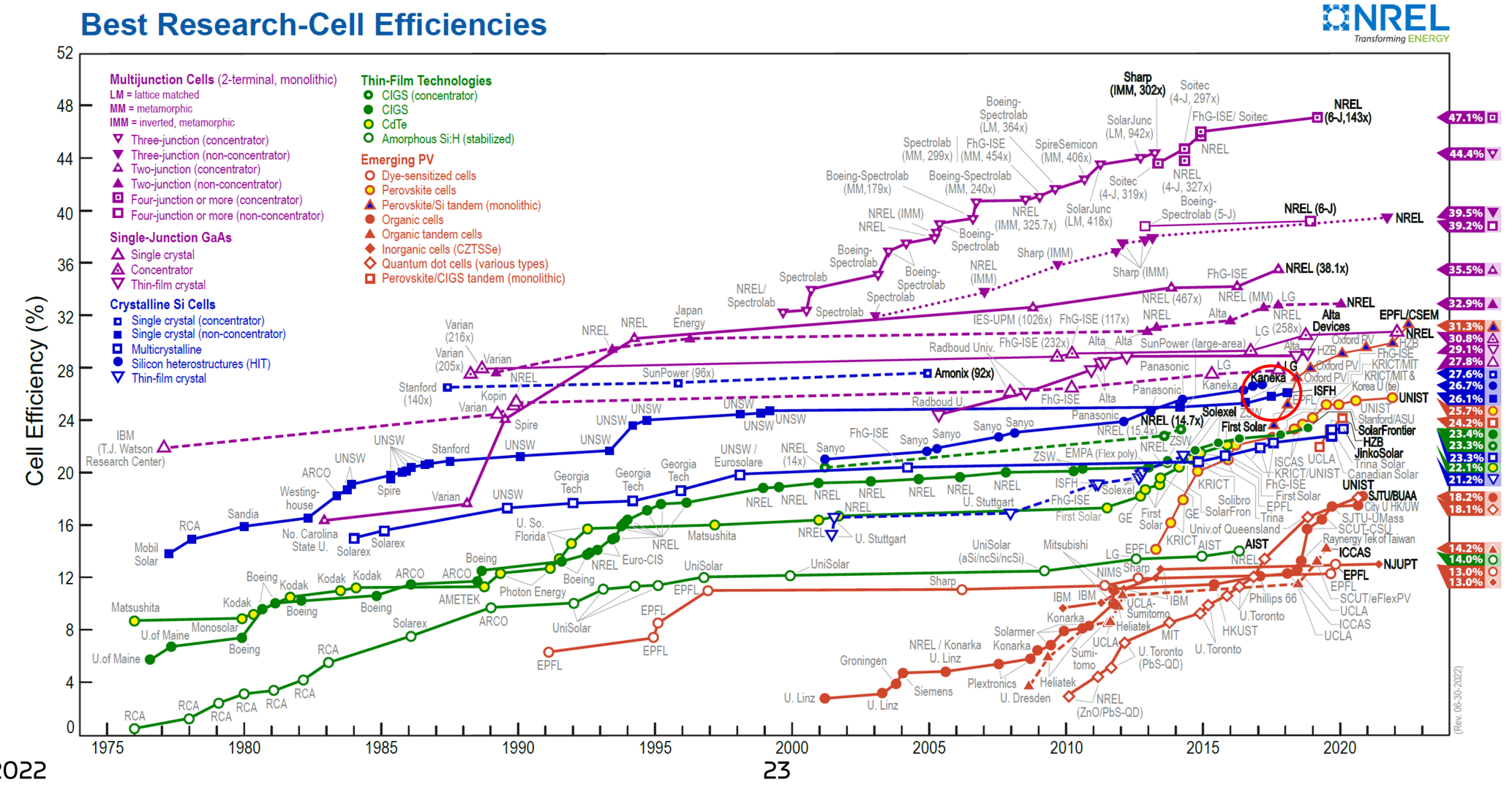
Prioritering av funksjoner





Relevant Standard: https://ieeexplore.ieee.org/document/8332112

Solcellemoduler - Virkningsgrad



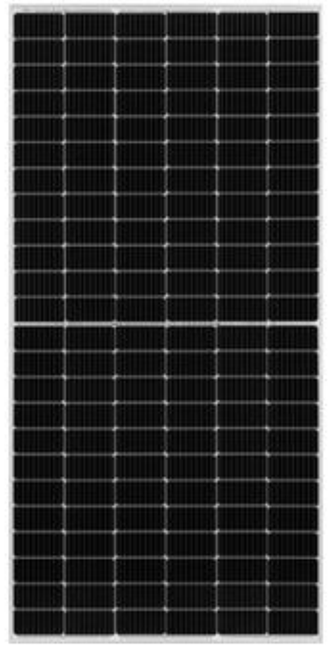
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Solcellemoduler - Utvikling

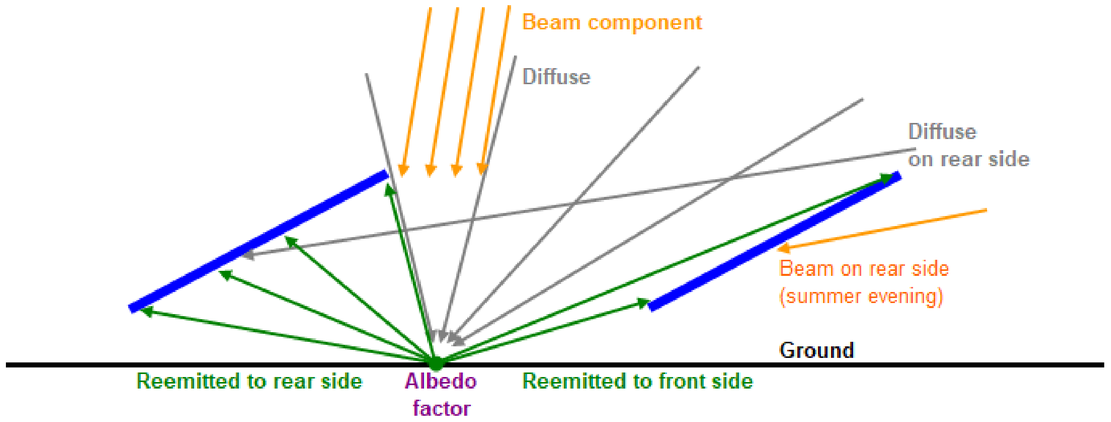
- Økt virkningsgrad
  - Monokrystallinsk
- Større wafer
- Half-cut celler
- Redusert bruk av bly og sølv
- Større solcellemoduler
  - 400 Wp – 800 Wp
- «shingeled design»



400-430 Wp



2-sidige moduler

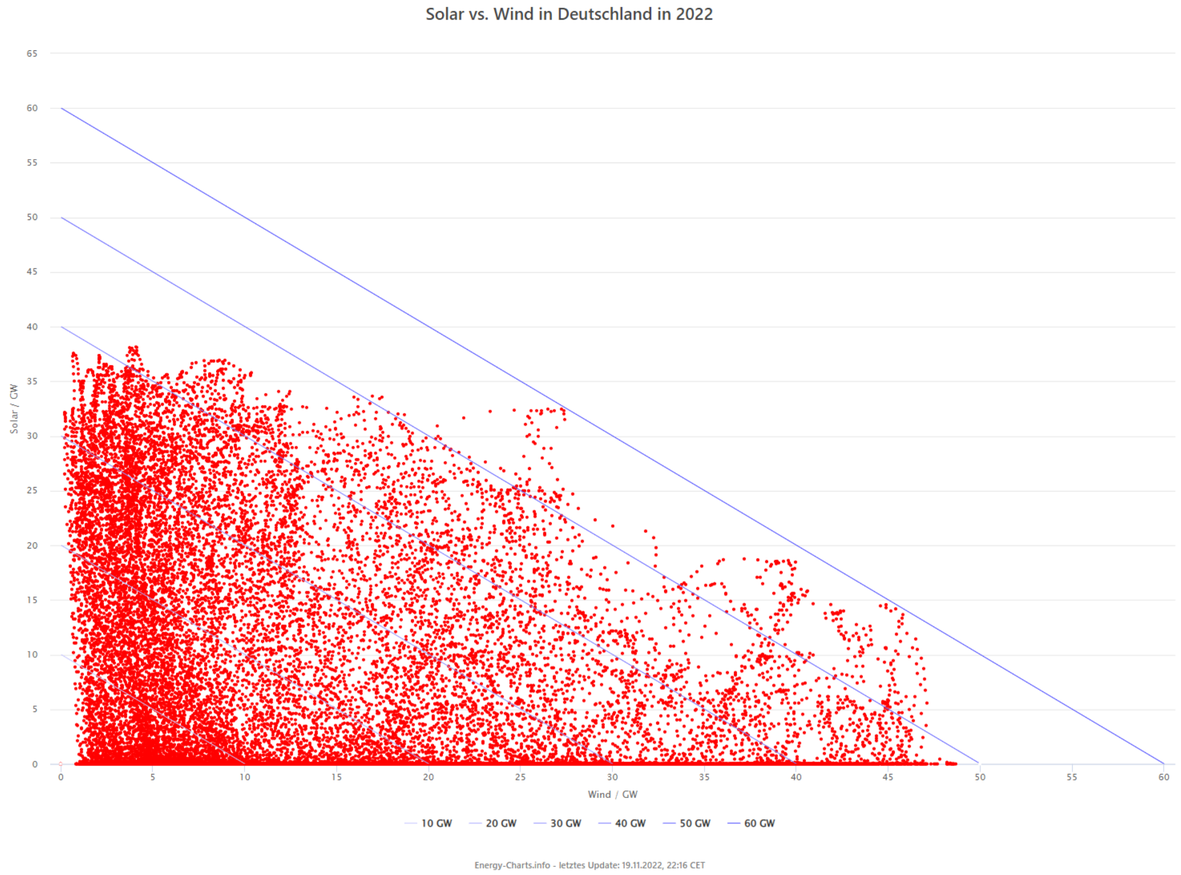


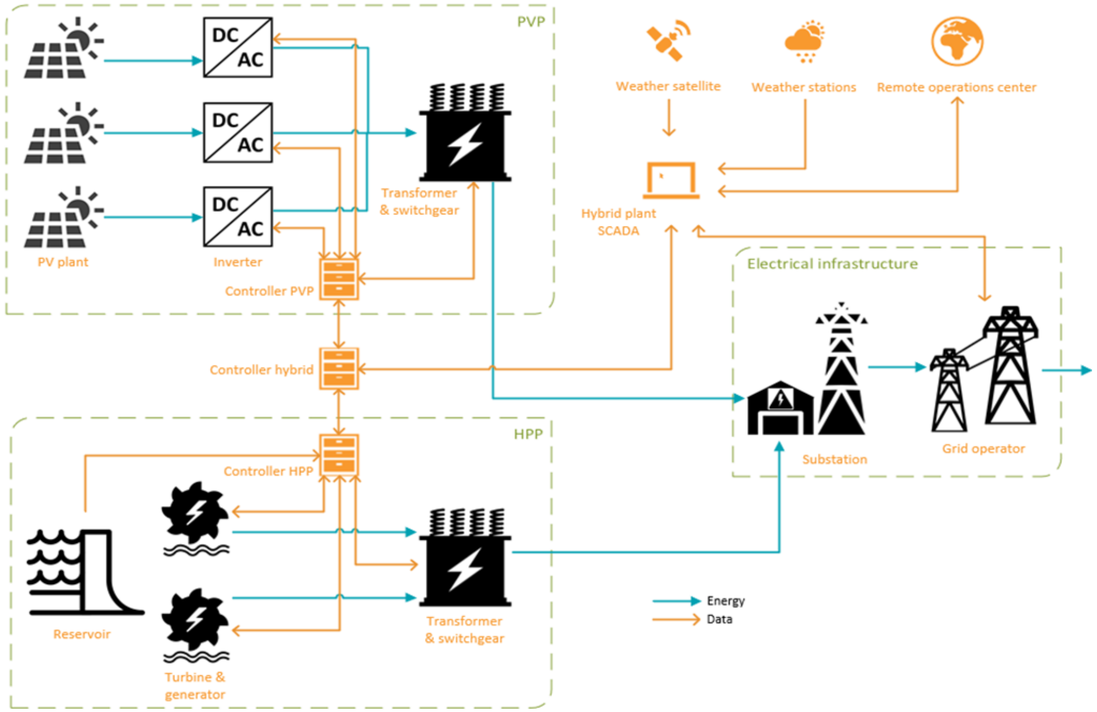
Illustrasjon: PVSyst



Foto: Sunna

Trender – hybrid vind / vann





Illustrasjon: Stanislas Merlet, PhD-student, NTNU

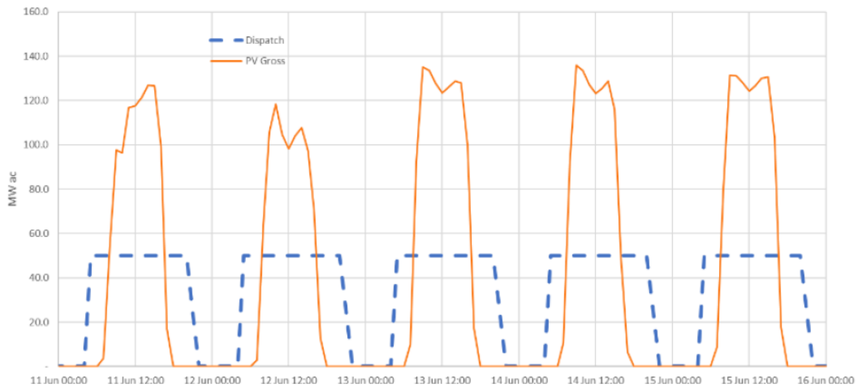
Figur: energy-charts.info

Trender – Hybrid lagring

RMIPPP
540MW solar and 225/1,140MWh battery

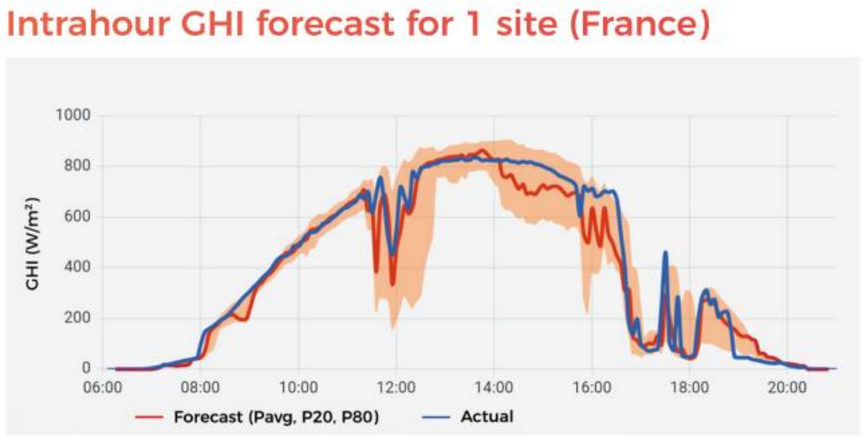
- 20-year PPA with Eskom providing 150 MW of dispatchable capacity
- Dispatch of Contracted Capacity is required between 5:00 am and 21:30 pm – all year
- Capex of ZAR 16.4 billion (USD 962 million)
- 76% non-recourse debt from lender group incl. Standard Bank and BII
- Scatec sole provider of EPC, O&M and AM services

RMIPPP: Dispatch requirement



Kilde: Scatec

Krafthandel - Forecasting





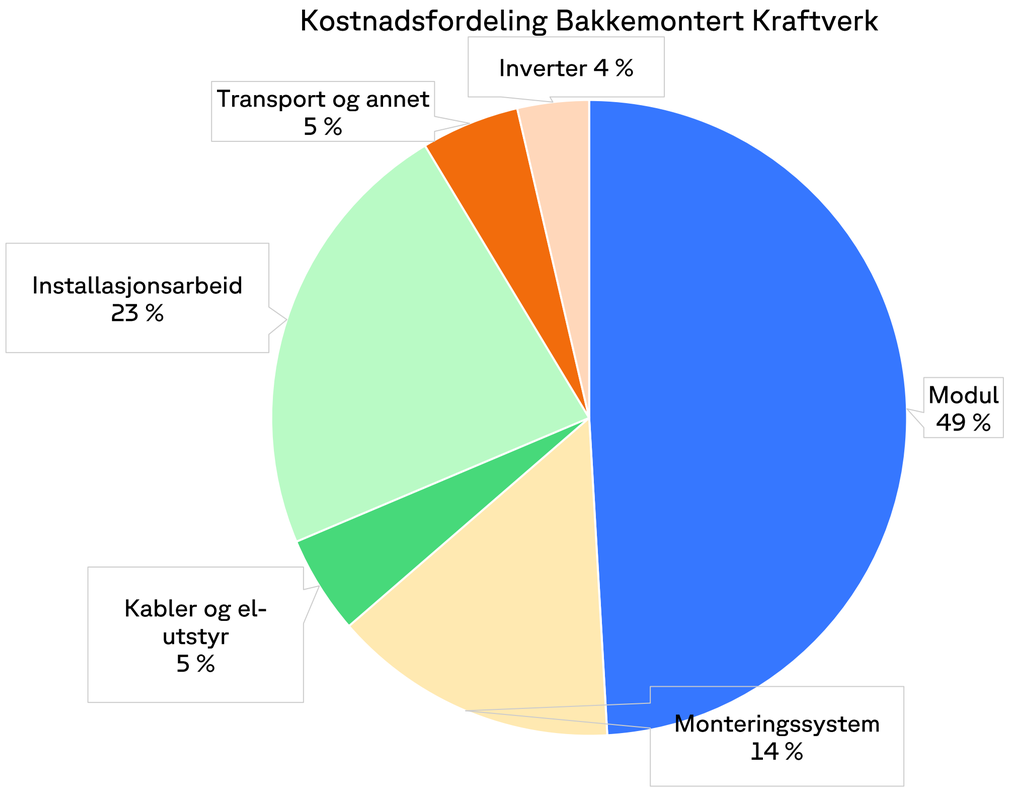
Kilde: www.steady-sun.com



Kilde: Energy-charts.info

Kostnader

- Kostnadene for solkraft har økt som følge av Korona
- Systemkostnad i dag er omtrent 6 – 8 NOK/Wp
- Før Korona var kostnaden ca 5,5 NOK/Wp
- Spesifikk ytelse i Norge er normalt 900 – 1250 KWh/kWp



Solkraft i Arktis

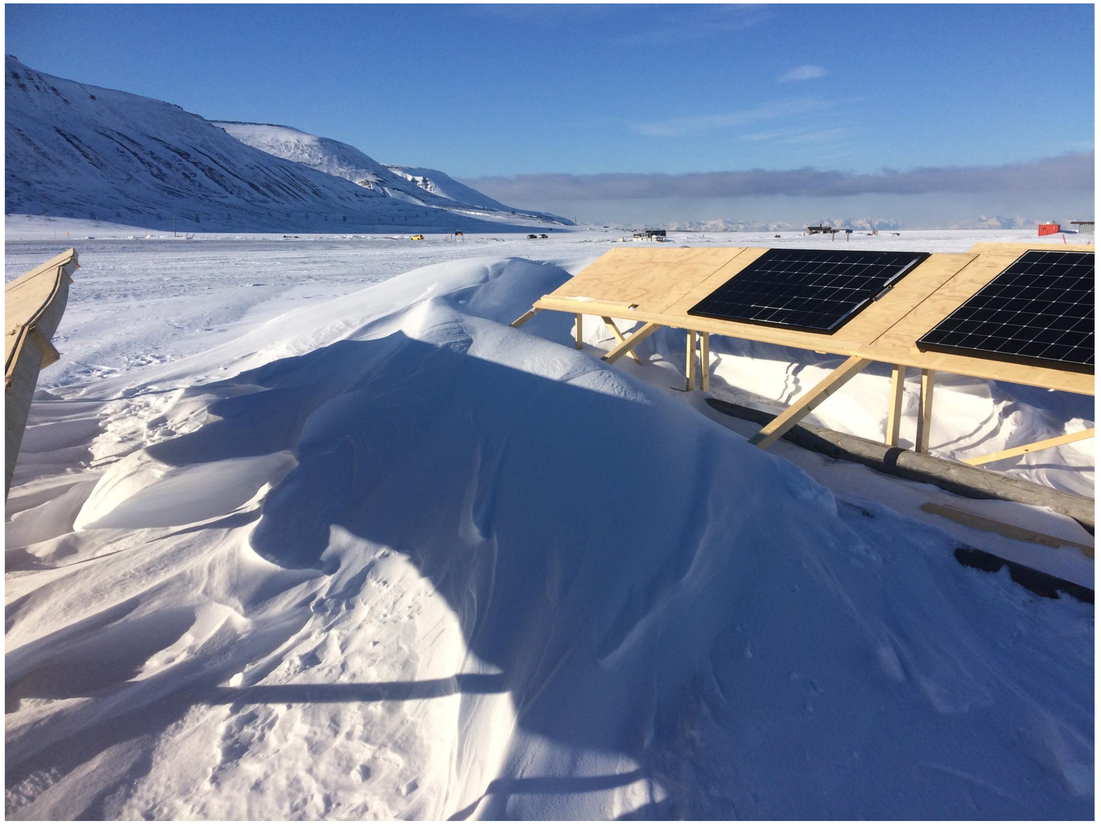
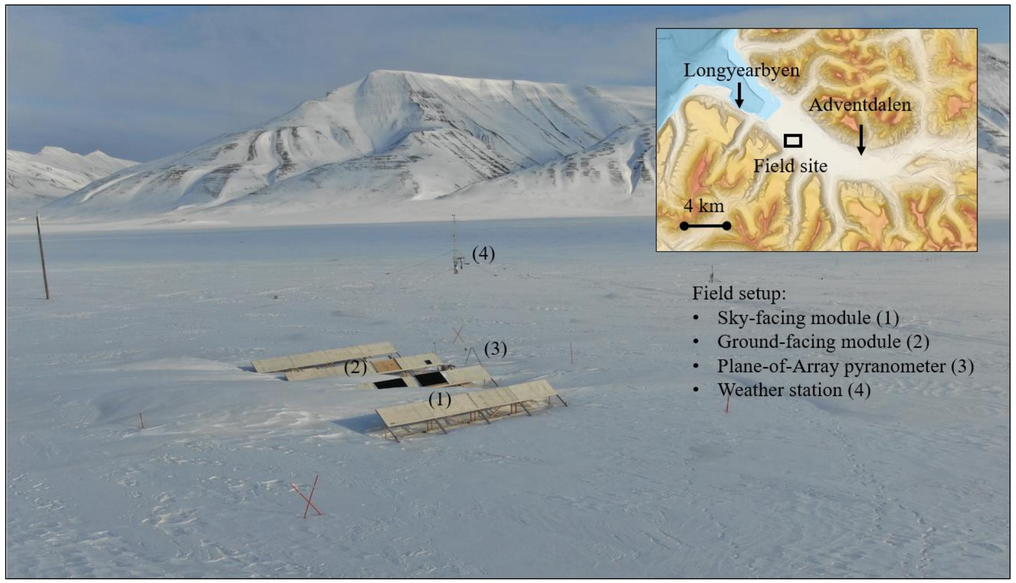
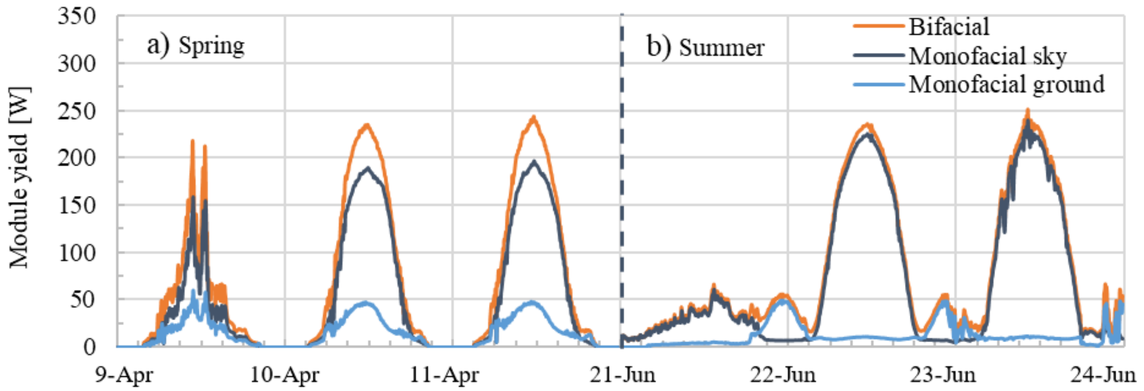


Foto: Multiconsult



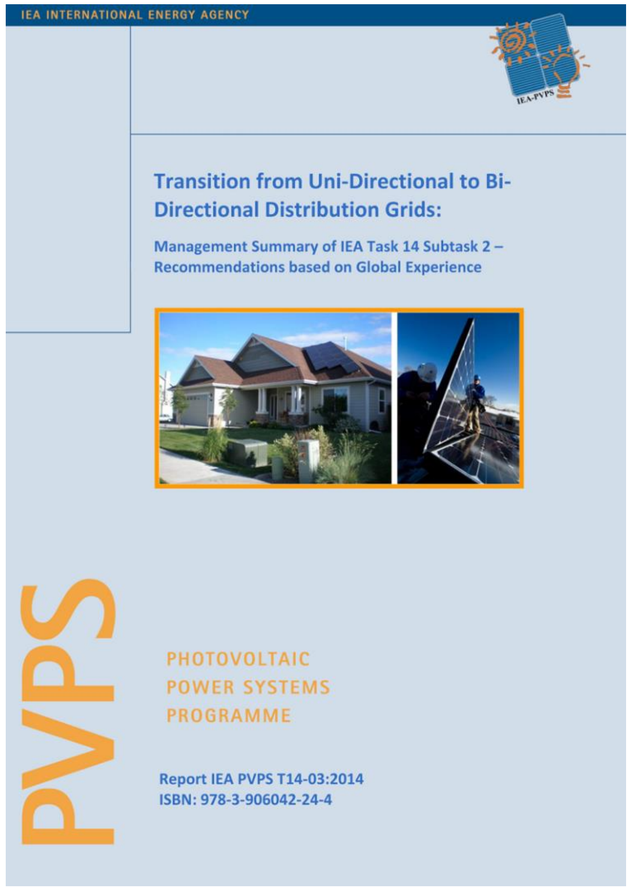


Kilde: Frimanslund et. Al. Polar solar power plants – investigating the potential and the design challenges

Oppsummering

1. Utbygging av storskala solkraft i Norge begynner nå
2. Mange prosjekter er allerede under utvikling og vi kan forvente en rask økning av solkraft i det norske kraftsystemet
3. Vekselrettere kan bidra med flere tjenester til nettet, og tilkoblingskriteriene bør tilpasses dette på et tidlig tidspunkt i utviklingen

Solkraft og kraftnett



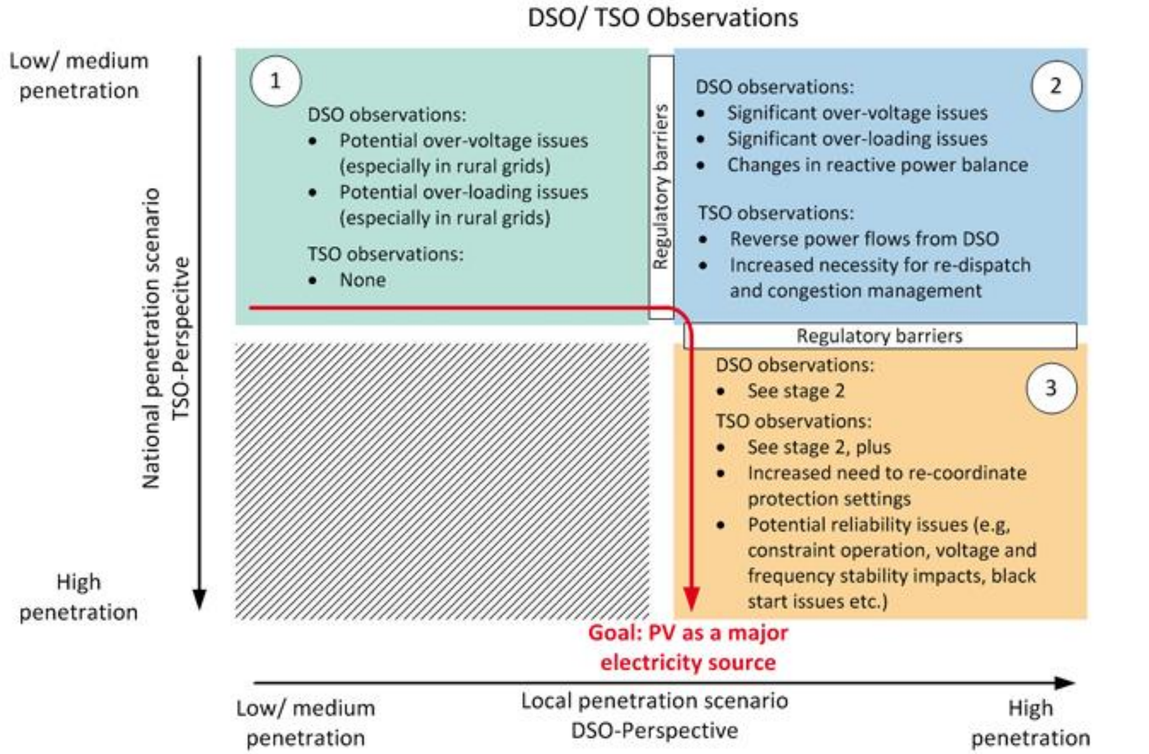


Figure 4: Definition of PV penetration stages and potential technical observations by distribution system operators (DSO) and transmission system operators (TSO)

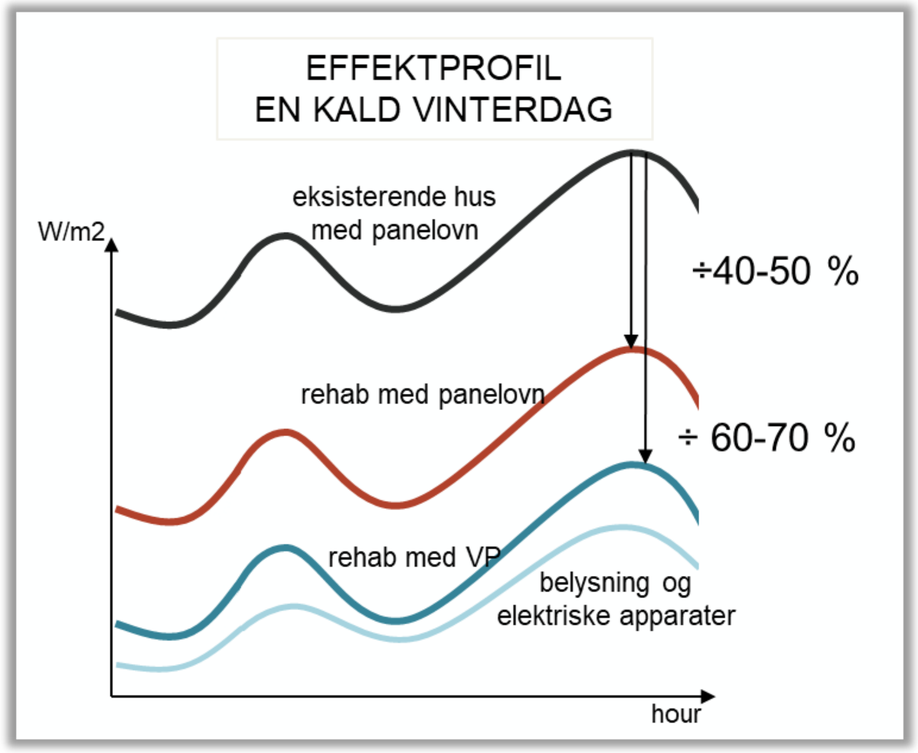
Kilde: https://iea-pvps.org/key-topics/transition-from-uni-directional-to-bi-directional-distribution-grids-iea-pvps-task-1403-2014/

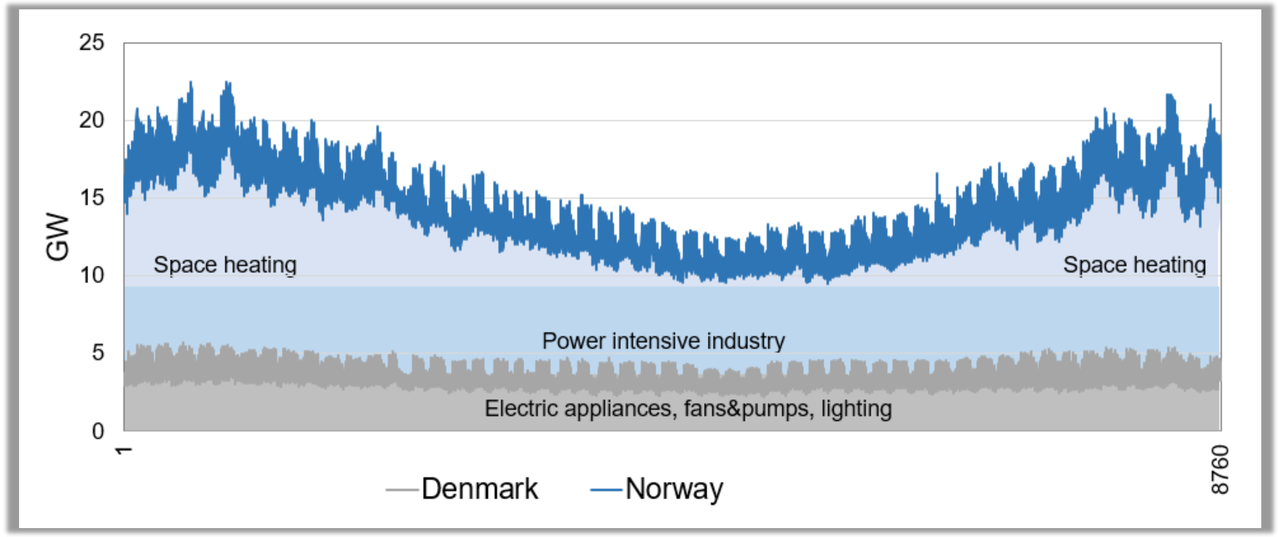
Planlagte solkraftverk i Norge

- Seval Skog – 130 GWh/år
- Mehlum Solkraftverk – 40-50 GWh/år
- Øystadmarka – 120 – 240 GWh/år
- Buer Solkraftverk – 1 GWh/år
- Furuseth Solkraftverk – 6,4 GWh/år
- Equinor (Frøya) – 1 GWh/år



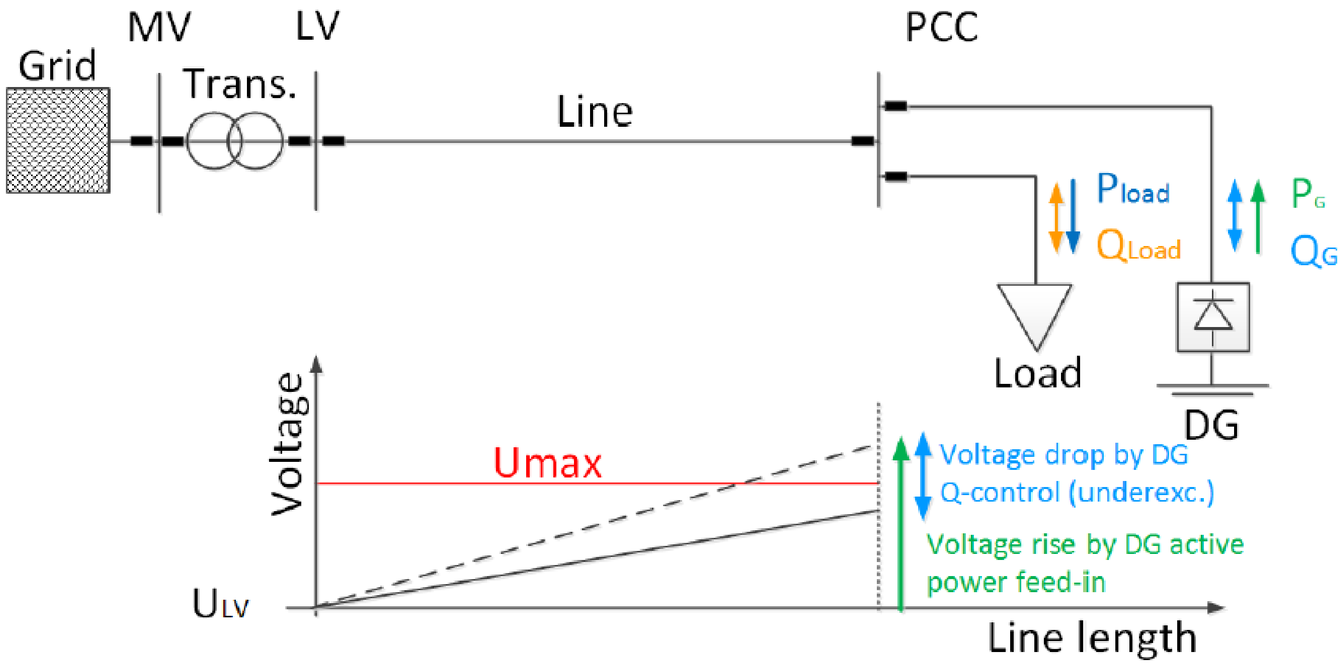
ENØK er sentralt for bedre utnyttelse av kraftnettet

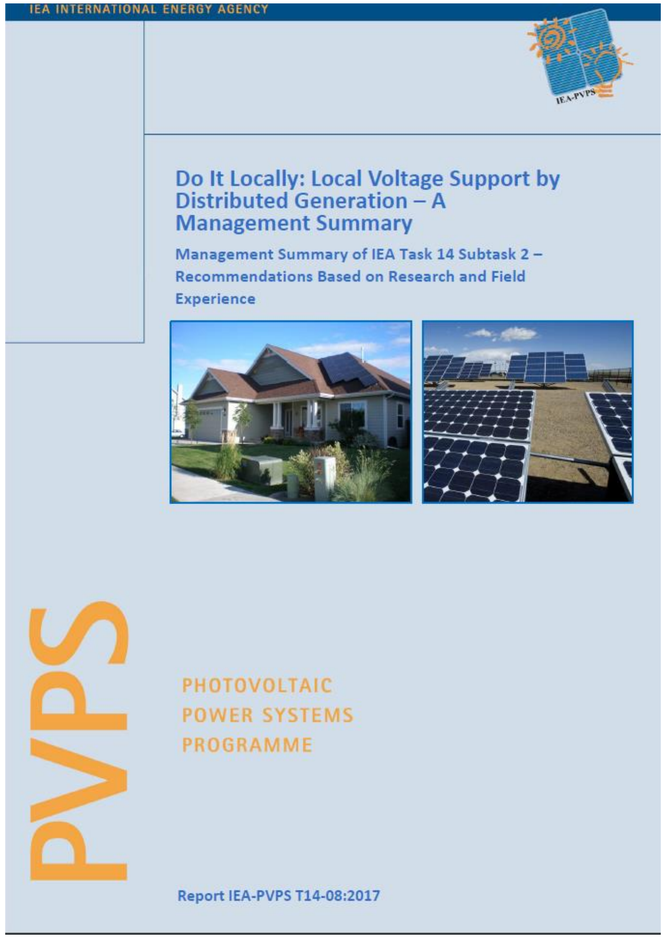




Kilde: SINTEFs beregninger i FlexBuild-prosjektet (Sartori, Lindberg et al., 2022)

Overspenning





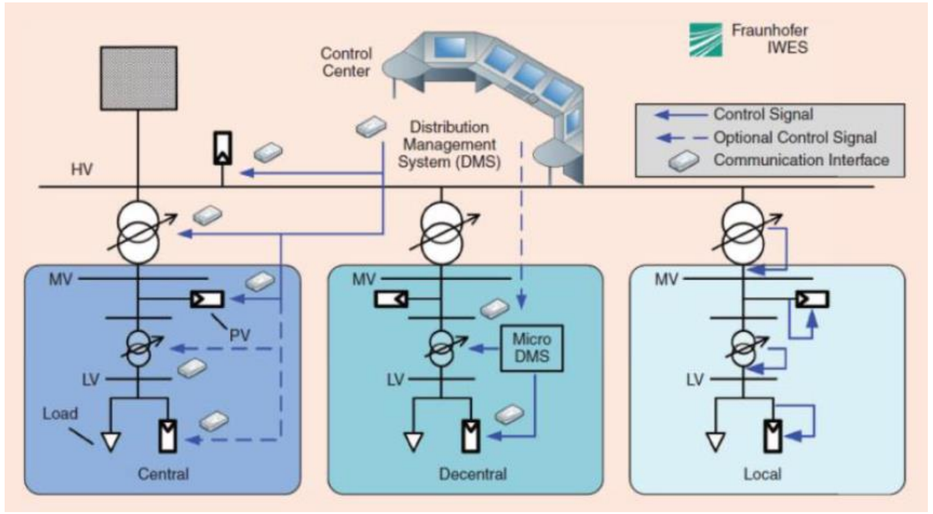
Kilde: https://iea-pvps.org/key-topics/t14-08-report-do-it-locally-2017

Kontrollstrategier med reaktiv effekt

Table 3: Comparison between different reactive power control strategies by DG (based on [7])

Category	Reactive power control strategy		
	Fixed power factor	*Cosφ (P) characteristic*	*Q(U) characteristics*
Effectiveness to mitigate voltage rises [7]	↑ highest effectiveness, all DG systems equally contribute to voltage support ↓ undifferentiated Q-provision, e.g. unwanted voltage reduction also in load dominated feeders	↑ high effectiveness, all DG systems equally contribute to voltage support ↘ undifferentiated Q-provision, e.g. unwanted voltage reduction also in load dominated feeders (to a smaller extent than fixed power factor control)	↗ effectiveness usually slightly less, compared to cosφ(P) control; only DG at critical PCC provide voltage support ↗ can also provide voltage support in case of under-voltage at the PCC
Impact on reactive power demand in distribution grids [7], [36]	↓ usually highest Q-provision of DG systems	↘ partially unneeded Q-provision of DG systems (to a smaller extent than fixed power factor) ↘ usually high reactive power ramps by DG systems	↗ Q-provision only at PCCs and at times when voltage support is required o reactive power ramps by DG systems depend on voltage variations at PCCs
Impact on existing voltage regulators [46], [63]	↑→↓ depending on the location of the voltage regulators (e.g. R/X ratio) and the applied control configurations, DG reactive power control can either increase or decrease the voltage regulator operations. In the investigated case studies a proper Q(U) control (volt/var) supported the grid voltage effectively, while the number of voltage regulator operations remained on the same level or was reduced.		
Impact on grid losses [9] [7]	↓ usually highest grid losses	↘ usually increased grid losses	↗ usually no unnecessary increase of grid losses
Complexity of DG parameterization [7], [14]	↑ simple parameterization o awareness is required for the sign convention of Q-provision (under-/ overexcited operation)	↗ simple parameterization, but highest voltage rise at PCC, which does not always occur during the highest PV feed-in ↘ plant dimensioning should be considered o awareness is required for the sign convention of Q-provision (under-/ overexcited operation)	↘ more complex parameterization; compromise between effectiveness and additional reactive power provision by DG o awareness is required for the sign convention of Q-provision (under-/ overexcited operation)
Cost-Benefit-Analysis [30],[33]	↑ ↗ → DG Reactive power control can avoid or delay expensive grid reinforcement measures. The cost saving potential depends especially on the grid structure and the controller parameterizations.		
Controller stability [48], [49], [50], [51]	o Open-loop control – no voltage stability problems are expected.		o Closed-loop control: Stability problems can occur if the control parameterization is not appropriate. If parameterized appropriately, stability issues are of no concern.
Legend: ↑: advantage, ↓: disadvantage o: not rated			

[9] Impact of PV reactive power control on the grid losses is strongly case sensitive. For example, in the study [63] the fixed power factor control and the intelligent volt/var control (Q(U)) could reduce the line losses in the grid.



Et produkt – mange bruksområder og samme virkningsgrad

