Country Report

Denmark & Greenland

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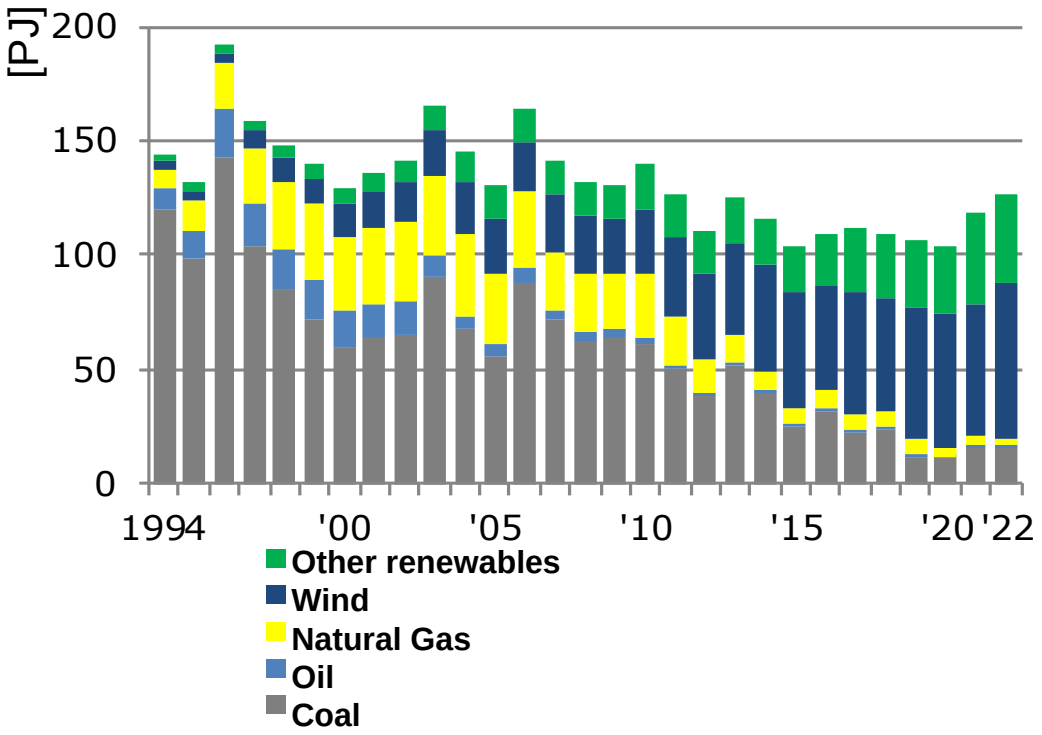
Created by CRS. Map information from the U.S. Department of State and ESRI.

Denmark

Latitude 54,3° - 57,7° N

Denmark is to be climate neutral by 2050.

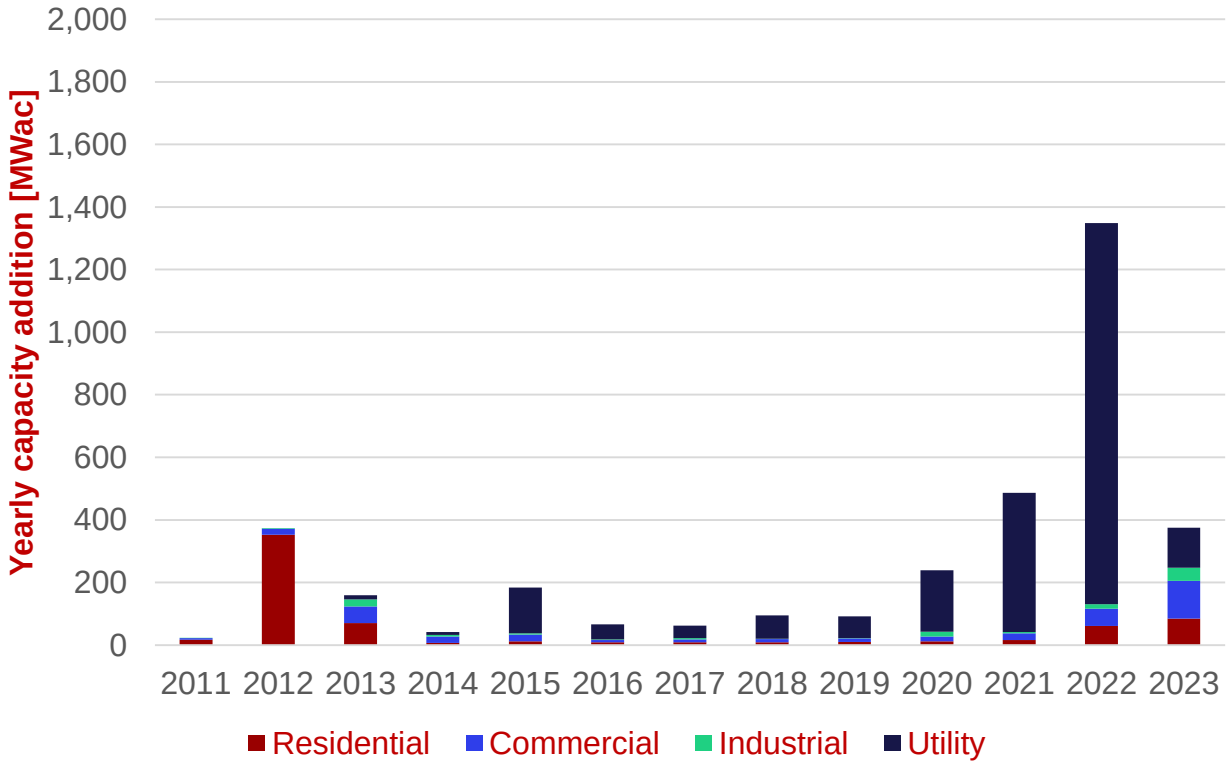
Electricity production distributed according to fuel used



Denmark

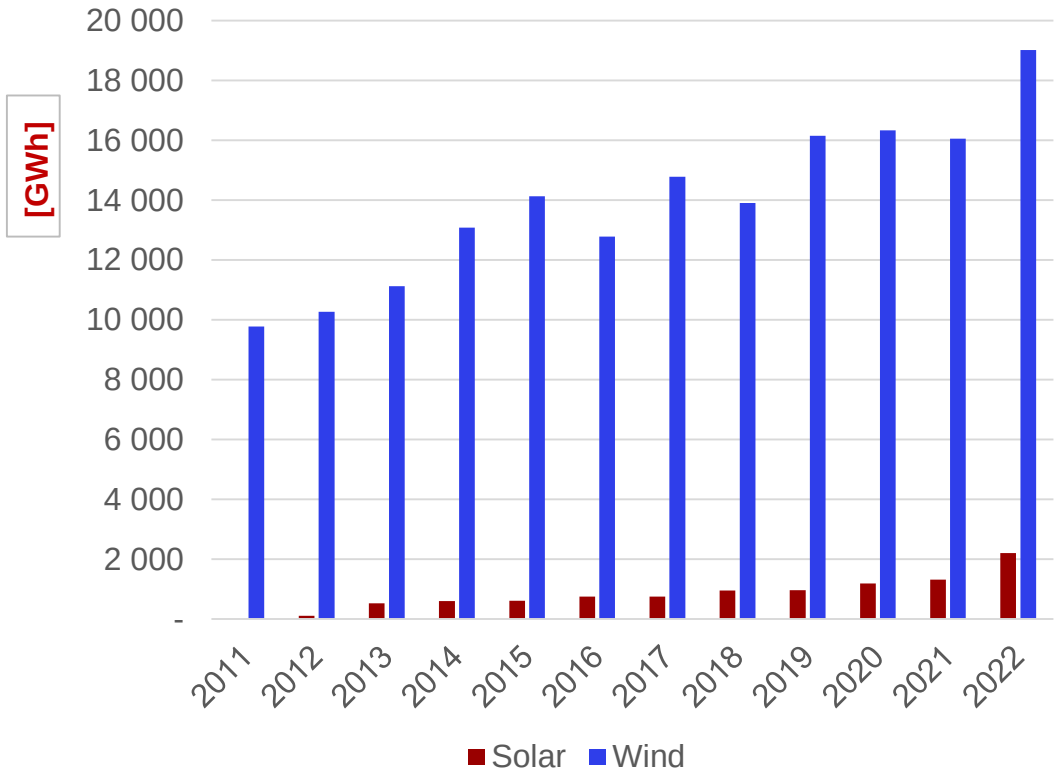
Capacity factor 0,85 – 0,95 kWh/Wp

PV Installations



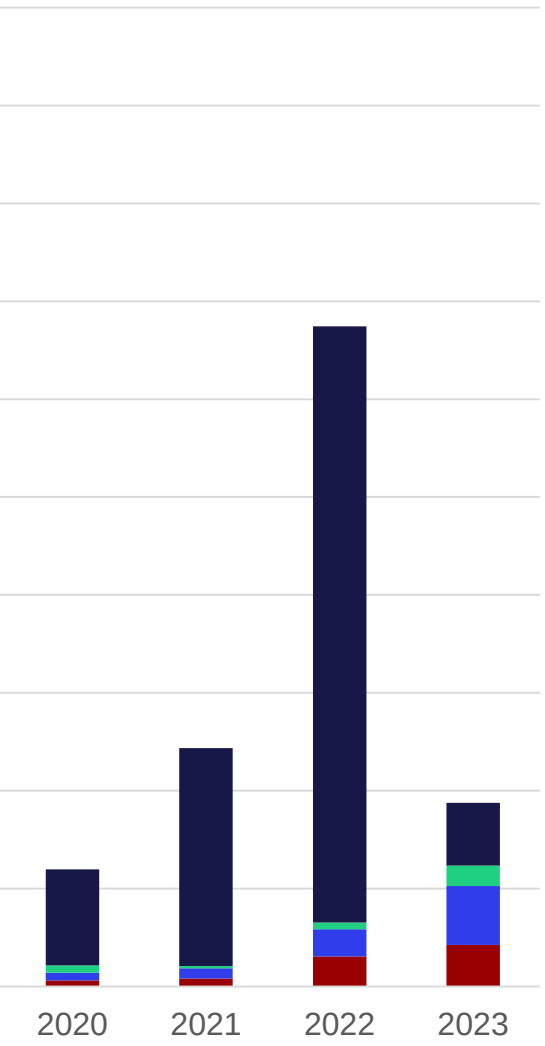
Source: Jan Vedde; European Energy A/S

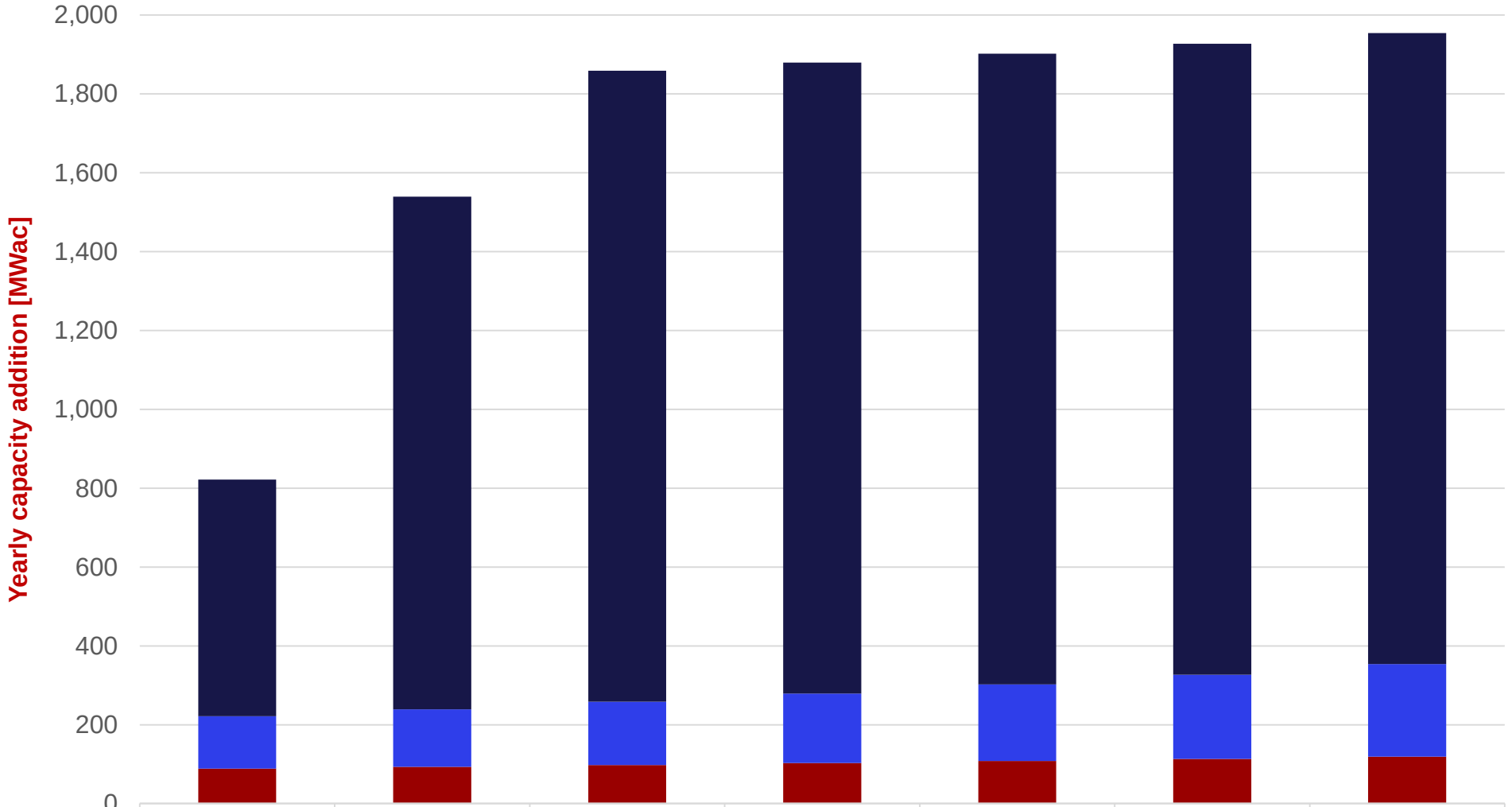
PV Production



Source: Energistyrelsen, Energistatistik

Forecasted PV deployment in Denmark by November 7th 2023

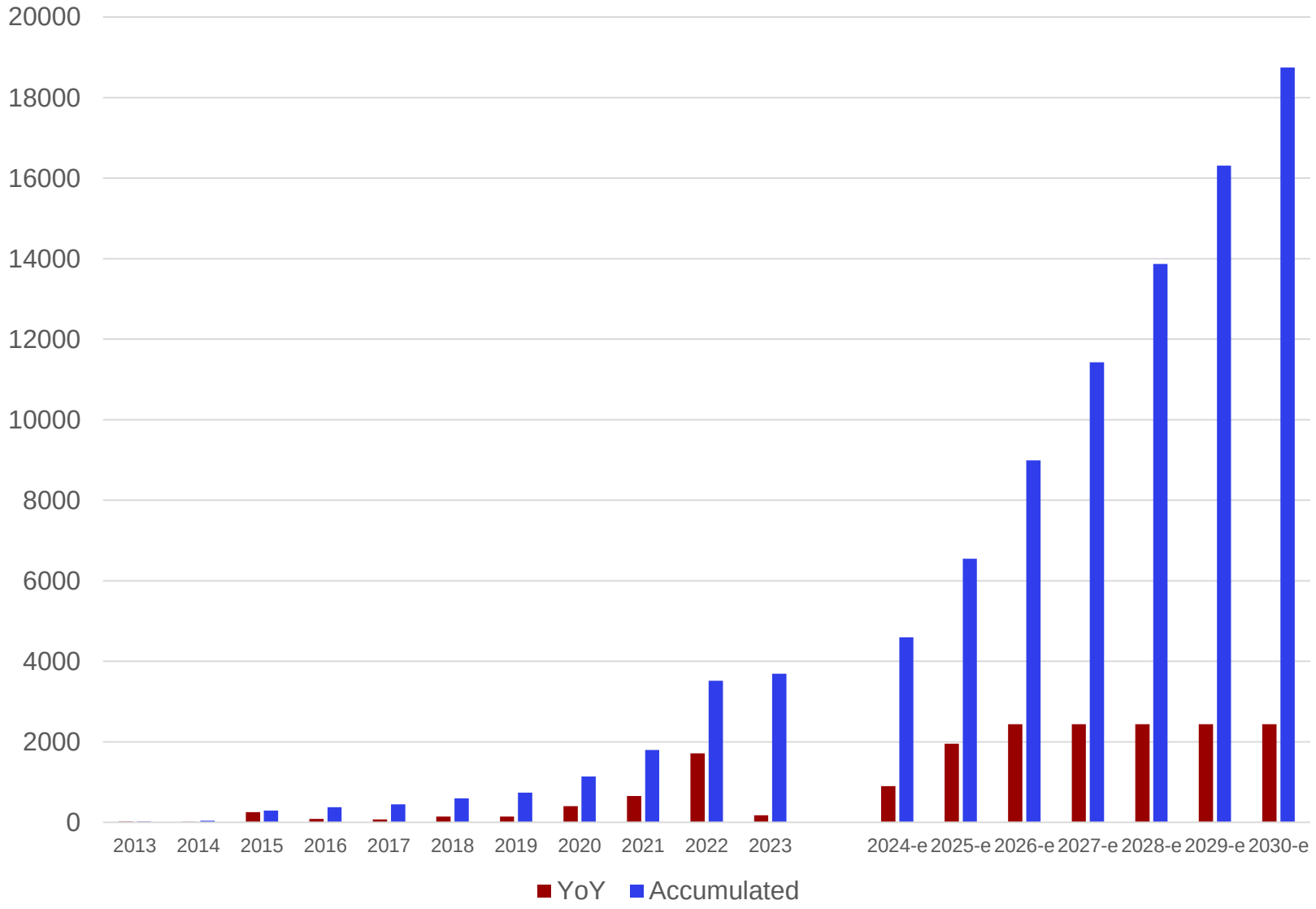




	2024-e	2025-e	2026-e	2027-e	2028-e	2029-e	2030-e
Utility	600	1,300	1,600	1,600	1,600	1,600	1,600
Commercial	133	146	161	177	194	214	235
Residential	89	93	98	103	108		

Source: Jan Vedde; European Energy A/S

Perspectives:
Area consumption/utility (ha)



Field-based PV can contribute up to 43% of the green power we will need in 2030.

Corresponding to 250 - 300 PV-plants on 17000 ha or 0.7% of the agricultural area

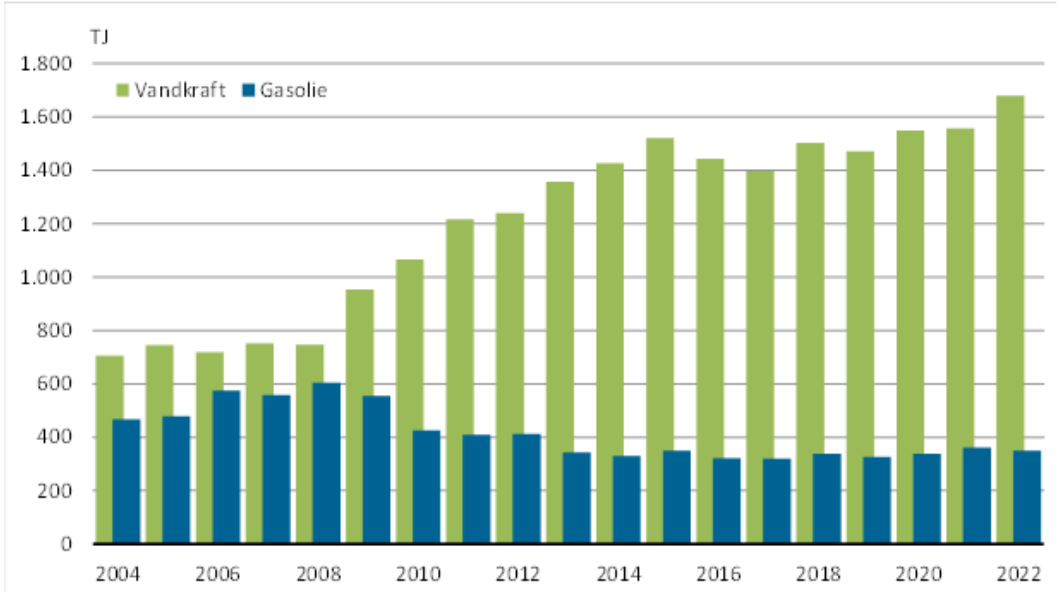
Utilization of low-lying soils, contribution to carbon reductions in agriculture

Source: Jan Vedde; European Energy A/S

Greenland

Latitude 59,8° - 70,7° N (83,6°)

Electricity production distributed according to fuel used



Kilde: Nukissiorfiit

NUKISSIORFIIT

As a utility company, Nukissiorfiit is responsible for producing and delivering electricity, water and heat to the majority of consumers in Greenland. Nukissiorfiit's public service obligation covers 17 cities and 53 settlements .

All isolated electrical power systems **without interconnection** to each other.

Source: Nuklissiorfiit

Energy Policy

Sektor plan 2017:

Cheap, modern and green energy and water for everyone

- The prices must be lowered for electricity and water
  - single price system for electricity and water
- In 2030, the public energy supply must be based on renewable energy to the greatest extent possible
- Going forward, Nukissiorfiit will use renewable energy sources such as hydropower, wind and solar energy in the energy supply.
- Igaliku: a pilot project with a hybrid plant combining wind turbines and solar panels with a battery bank.
- In 2018, the plan is for Nukissiorfiit to erect two smaller wind turbines in Sisimiut

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Consumer prices for electrical power

	DKK/kWh	€/kWh
Electric power	1,75	0,230
Heat	0,71	0,095
Interruptible power	0,490	0,065
Power from REN		
- in towns without hydropower	0,74	0,099
- in towns with hydropower	0,00	0,000

Production cost for electrical power

Location	Electric power [DKK/kWh]	Electric power [€/kWh]	Type
Nuuk	0,75	0,100	Hydro
Sisimiut	0,86	0,115	Hydro
Maniitsoq	2,70	0,360	Diesel
Igaliku	13,01	1,746	Hybrid
Eqalugaarsuit	23,82	3,176	Diesel
Qeqertat	60,56	8,075	Diesel

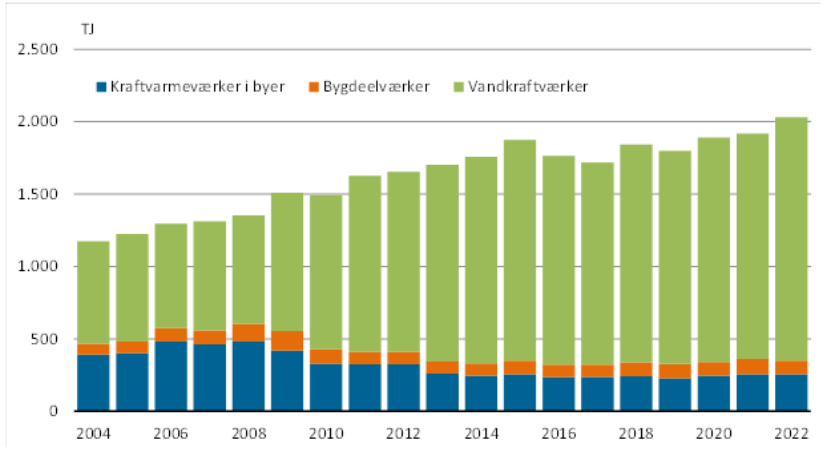
Source: Nuklissiorfiit

Renewables in Greenland
Hydropower

Operational Hydro Power Plants

Source: https://hydropower.gl

Electricity production distributed by production plant



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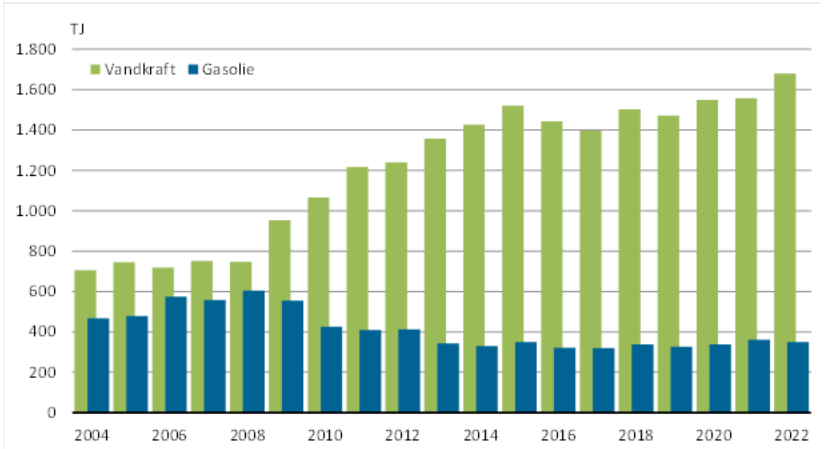
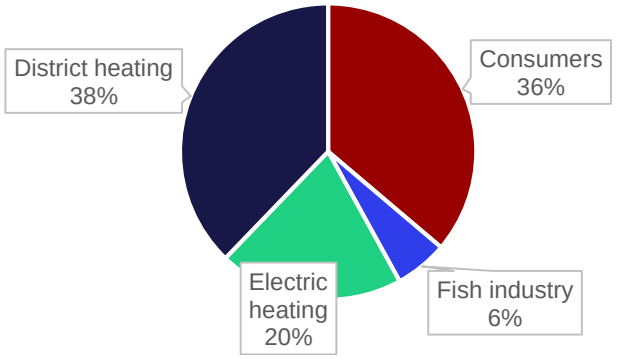
Electricity production distributed according to fuel used



Kilde: Nukissiorfiit

Name	Supply area	Commissioned	Expansion	Capacity (MW)
Buksefjorden	Nuuk	1993	2008	45
Tasiilaq	Tasiilaq	2004	(2017-2021)	1,2
Qorlortorsuaq	Narsaq og Qaqortoq	2008		7,6
Sisimiut	Sisimiut	2010		15
Paakitsoq	Ilulissat	2013		22,5
Total				**91,3**

Electric Power Consumption 2022
2169 TJ ~ 603 GWh



Sources: Nukissiorfiit

Installed grid connected Wind Turbine Capacity in Greenland

	Number	Capacity [kW]
Installed	2	50
	1	6 (taken down)
Planned for 2024	1	15

Installed grid connected PV

Planned PV for 2024

2022-11-11	Capacity [MW_p]
Owned by privates	2.06
Owned by Nukissiorfiit	0.62
Planned by Nukissiorfiit 2024	0.27
Total	**2.95**

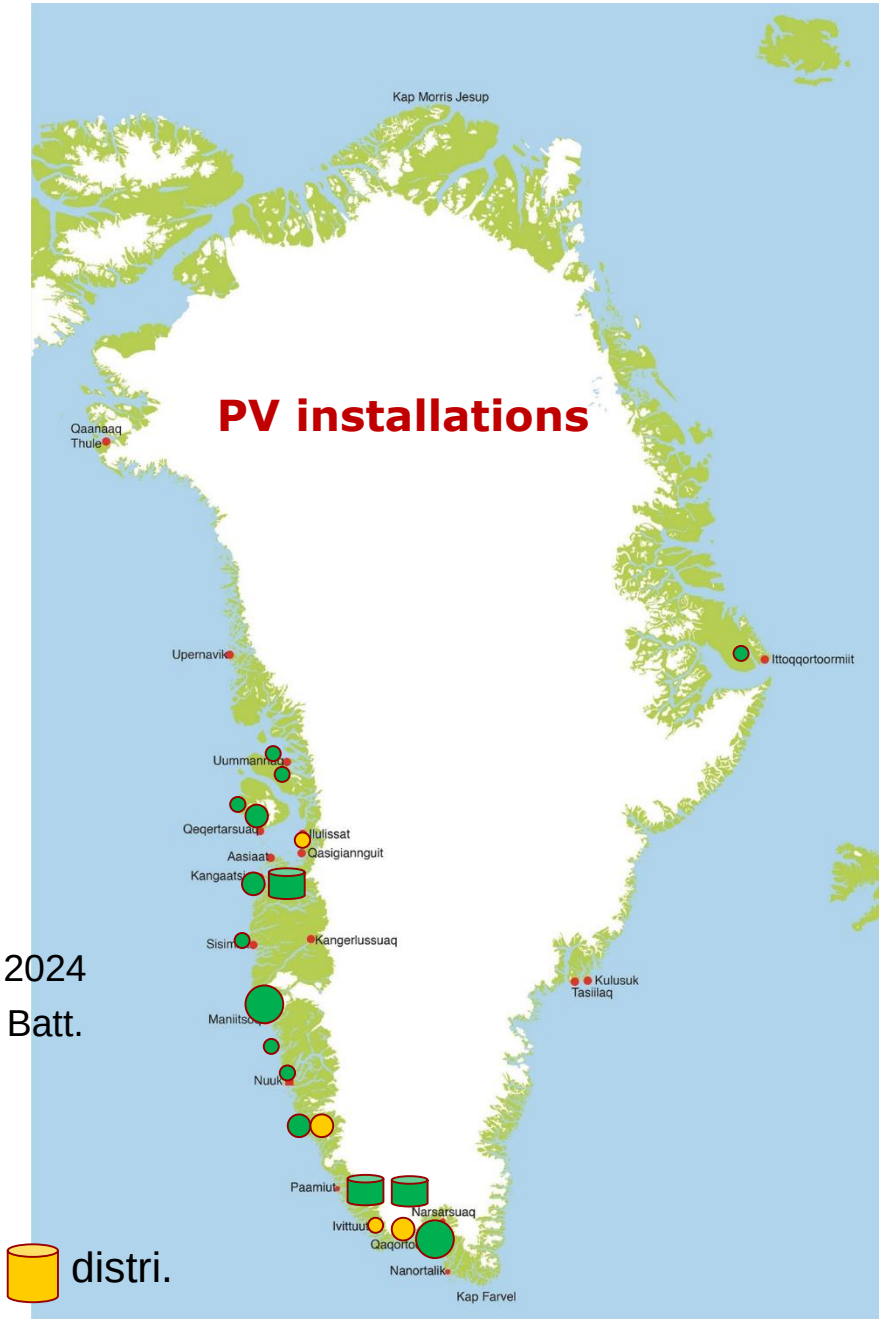
Solar energy (Nukissiorfiit) accounted for less than 0.1% of the total primary energy production in 2022, and is not yet included in the energy statistics.

Estimated totally 3 GWh PV ~ 0,5%

Consumption 600 GWh

Battery totally 534 kWh → 1994 kWh (2024)

Sources: Nukissiorfiit, LED Solar, Ela



Front runner projects

Sarfannguit

Erection of the first grid connected wind turbine in Greenland

6 kW Proven wind turbine

AEP up to: 16 800 kWh

2012

Sisimiut

Installation of one of the first grid connected PV systems 7,05 kWp

Assaqutaq

Small isolated hybrid system

PV 5*85Wp

HAWT 100W

VAWT 107W

Storage 3 *12V 200Ah

Inverter 750 W

Thanks to a large number of DTU students PhD, Master, Bachelor and summer course projects

Grid connected PV system in Greenland

30 Trina Solar PC05. 235Wp
P = 7,05 kW_p
Danfoss TLX PRO+ 8K

	Sisimiut	DTU
T_c	7.25°C	11.63°C
η	15.18%	14.96%

		Sisimiut		DTU	
P	$\left[\frac{kWh}{year}\right]$	6,900		7,018	
I_T	$\left[\frac{kWh}{m^2 year}\right]$	1,038	100%	1,071	100%
I_b	$\left[\frac{kWh}{m^2 year}\right]$	647.8	62.4%	607.4	56.7%
I_d	$\left[\frac{kWh}{m^2 year}\right]$	356.5	34.4%	435.7	40.7%
I_r	$\left[\frac{kWh}{m^2 year}\right]$	33.31	3.2%	28.32	2.6%

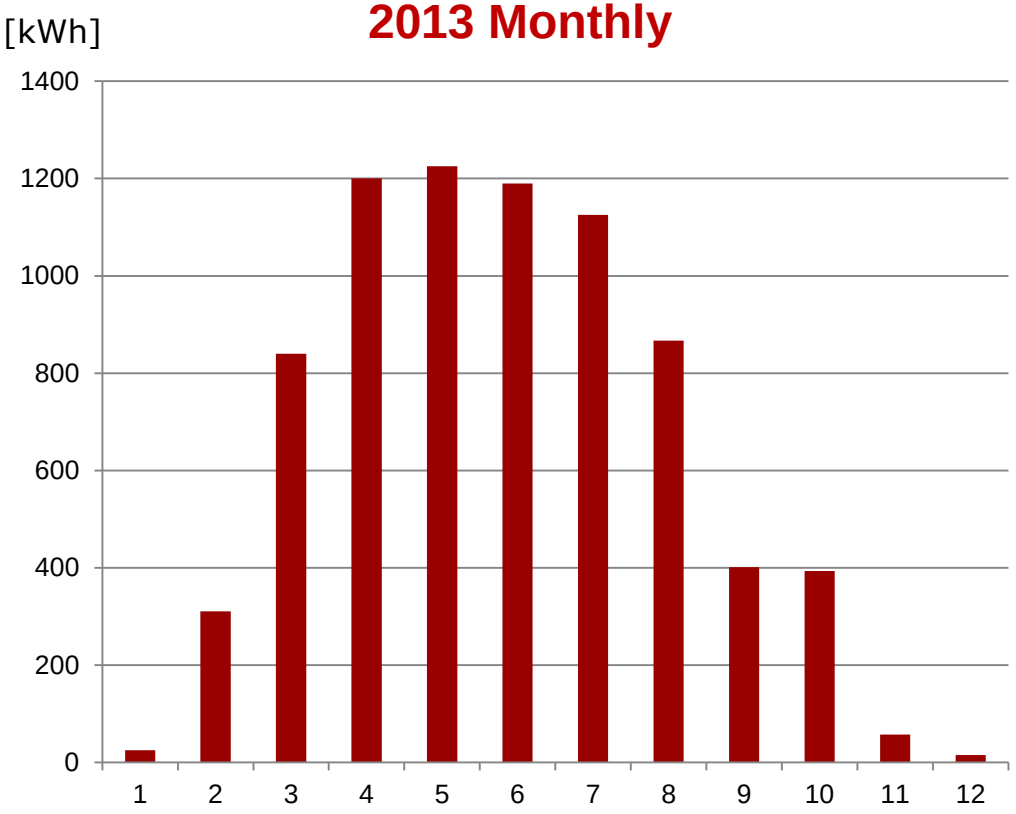
2013 **7648 kWh**

Source: Loui Algren, Feasibility of Photovoltaics in Greenlandic Power Systems; MSc.-project 2012

PV production

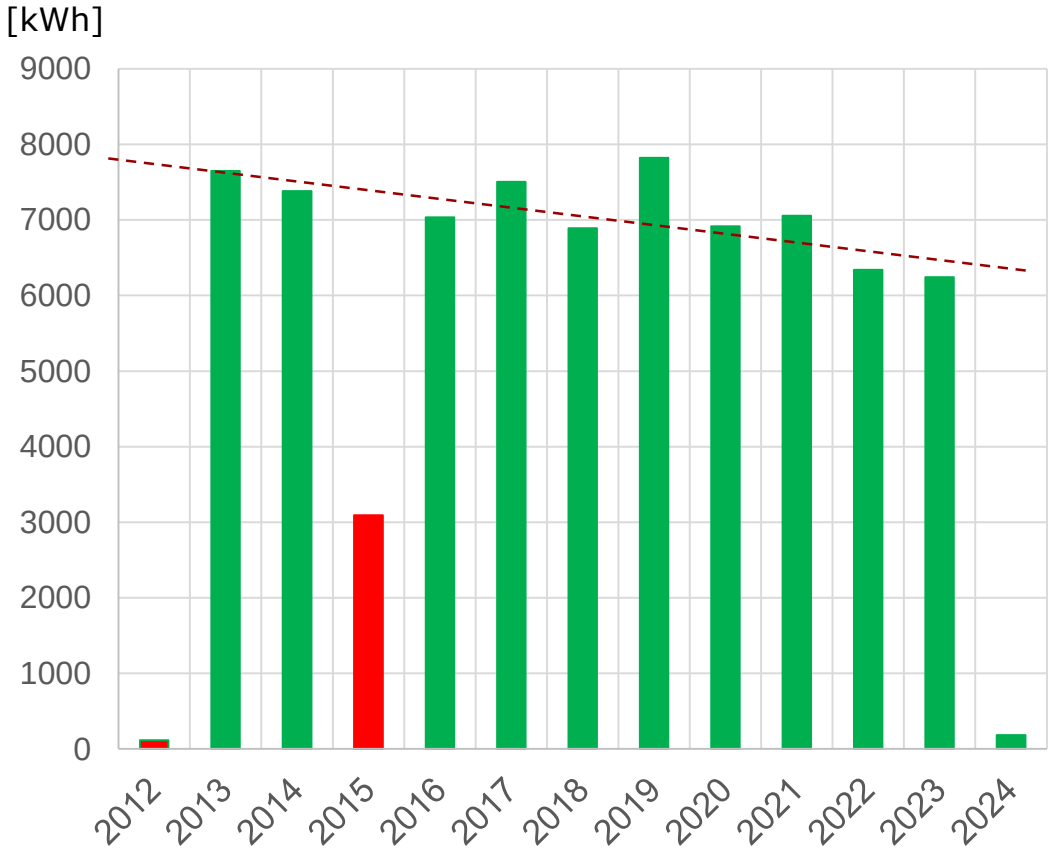
Capacity factor: 1,086 - 0,926 kWh/Wp

2013 Monthly

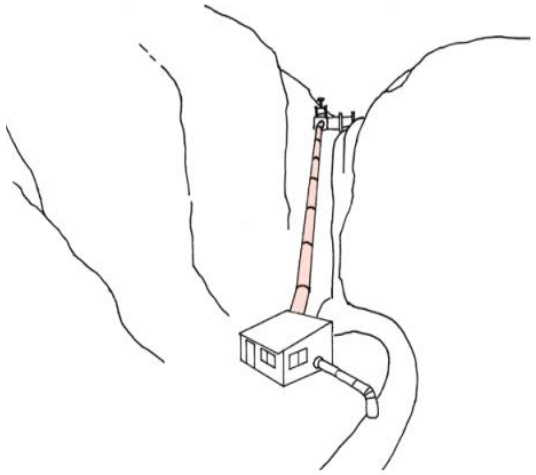


Annually

Reduction ~ 1,5%/år



Frequency Stability of an Isolated Hybrid Power System in Ilulissat

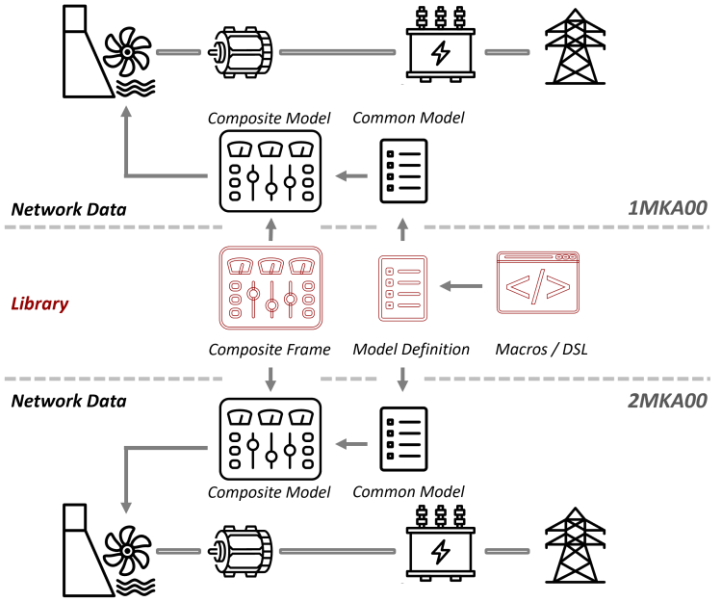


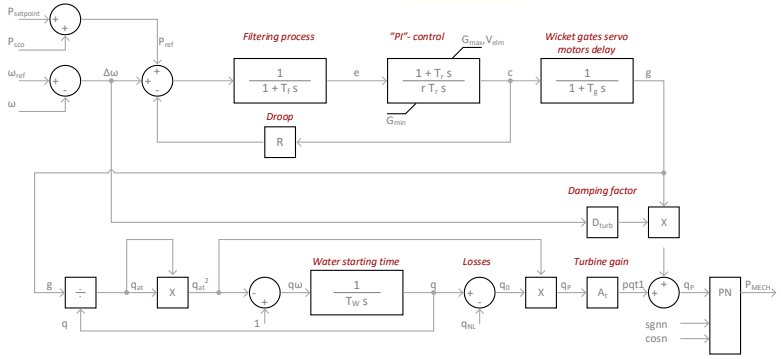
Martin Johannessen, Master Thesis 2024

PowerFactory – Model

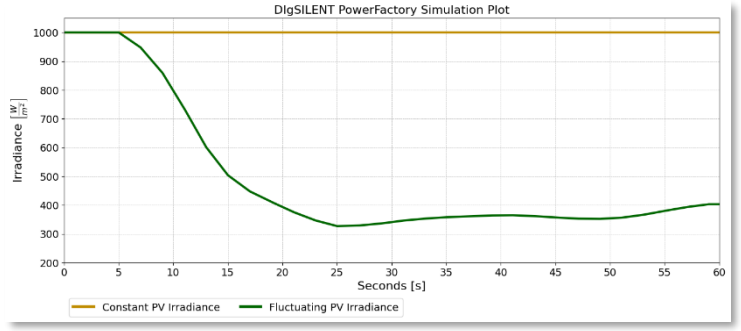
- *Hydropower plants 2*7.5 MVA*
- *Ilulisat electric grid*

Additional PV – plant 1- 10 MW_p

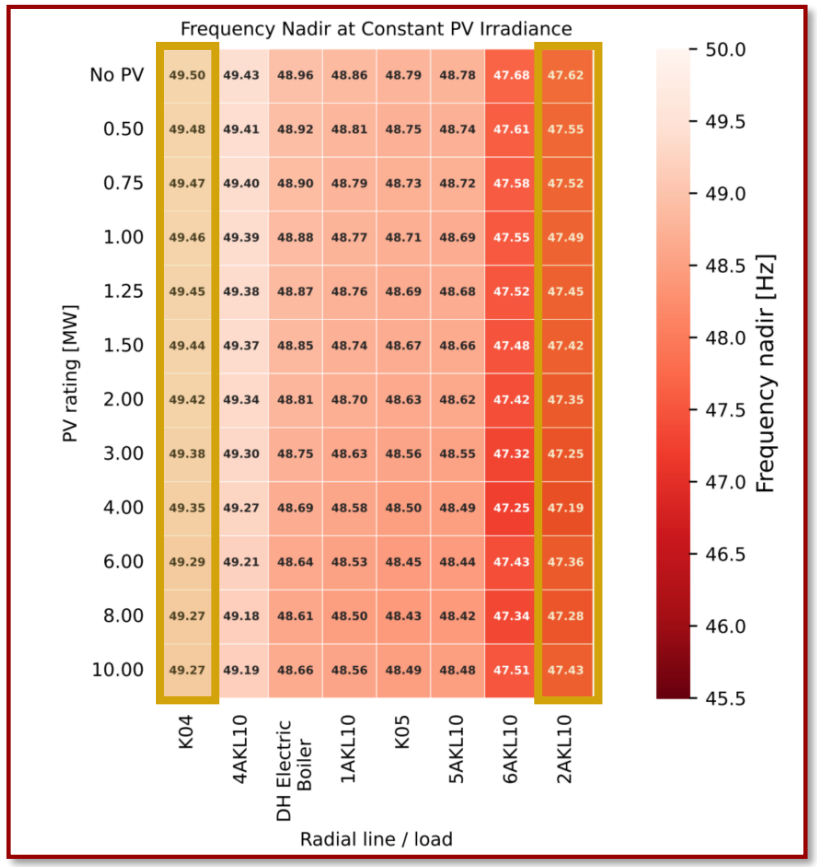




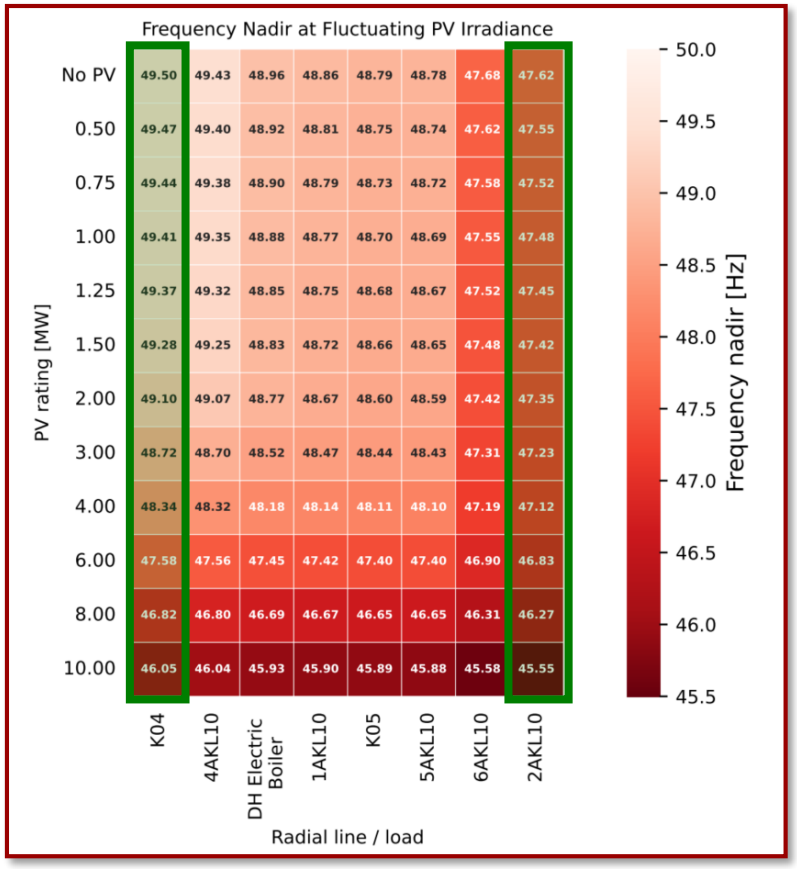
PV Penetration and Fluctuating Irradiance



Load increase (~ 10%)
Constant radiance



Simultaneous load increase (~ 10%) and in Fluctuation solar radiance (1000 → 300 W/m^2)



Frequency Stability of an Isolated Hybrid Power System in Ilulissat

Partial conclusion

- 2 turbines in operation (2*7.5 MVA)
- Connection of approx. 10% extra load on a specific feeder /sub line
- 1 MWp PV and simultaneously fast fluctuating radiance 1000 - 300 W/m^2
- The electrical system should still be frequency stable (f>47.5 Hz) in such a reasonably likely case

Final remarks - Greenland

Wind

Requires local maintenance experience

Intermittent production caused by actual wind condition

Limited size of wind turbine in relation to the isolated grid – potential stability problems

Photo Voltaics

Once installed, almost no maintenance is required.

Limited production in winter depending on latitude

Intermittent production caused by the radiation fluctuations

No production periods are known

Limited size of PV-plant in relation to the design of the isolated grid

Keep it simple!