Østrup wind farm

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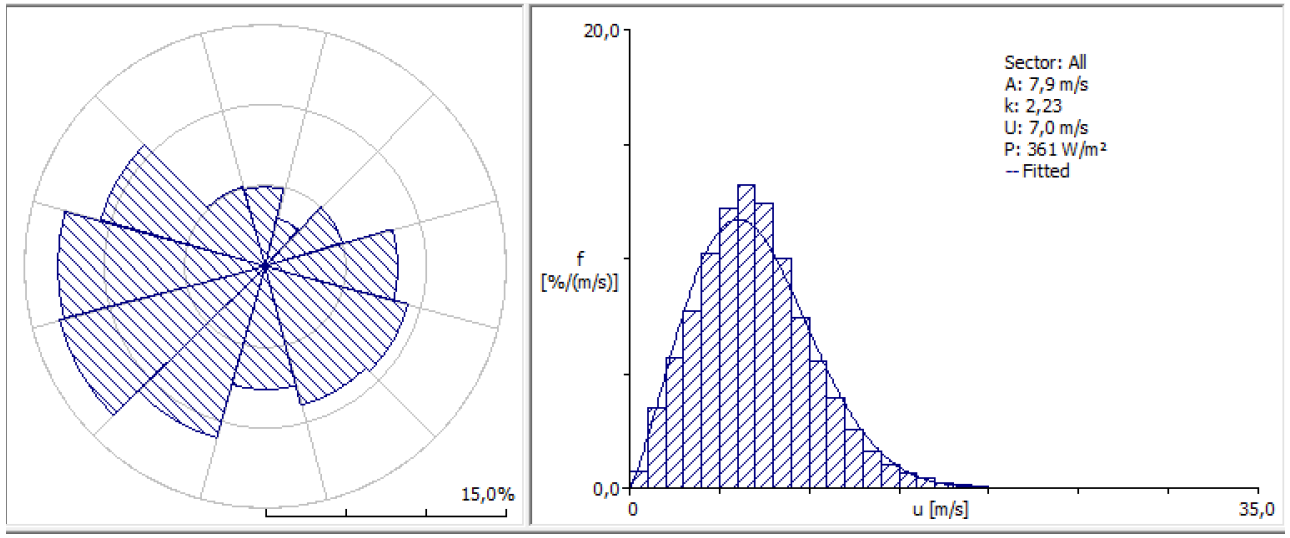
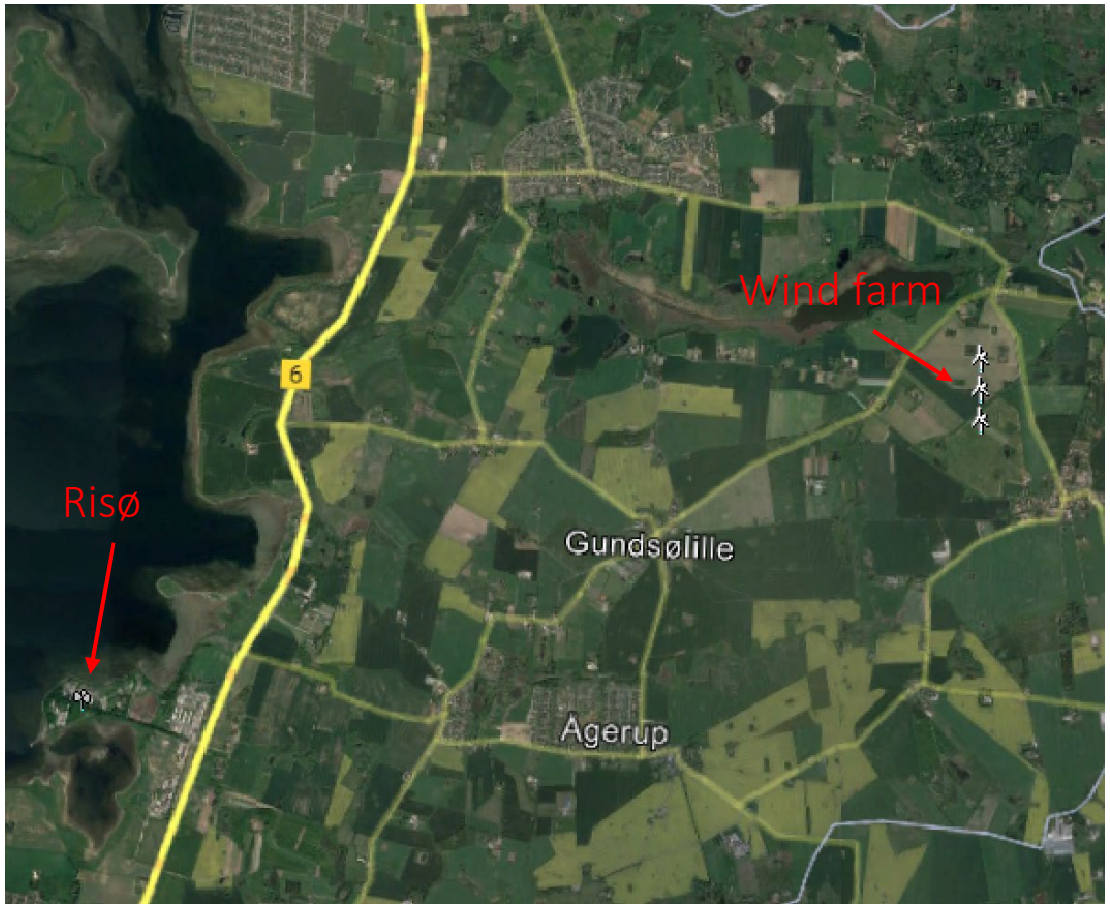
Investigated as part of the DTU Course 46200 “Planning and Development of Wind Farms” January 2023 and with inspiration from the “Vind In Roskilde(VIROS)” project conducted by DTU Wind and Energy Systems

Overview/Wind resource assessment

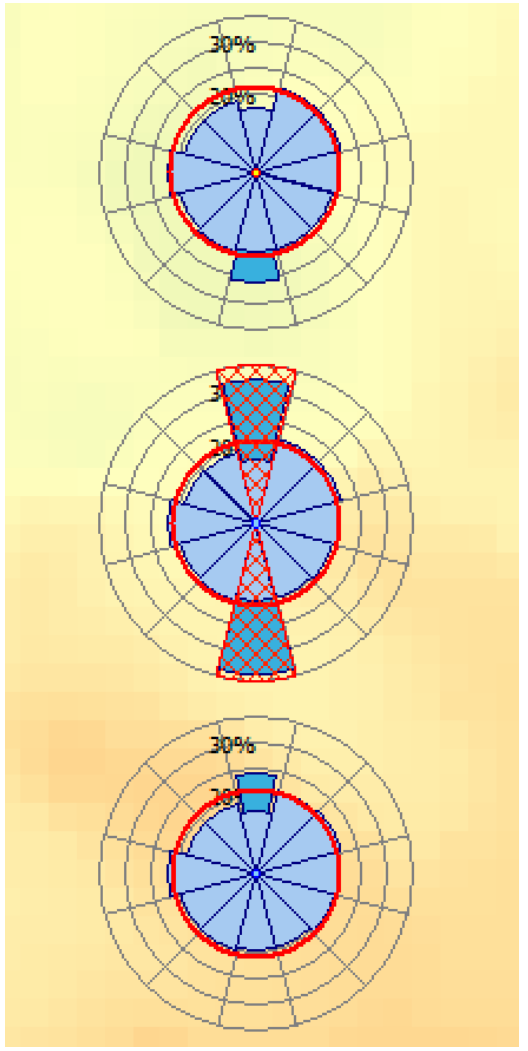
- No steep terrain/hills
- No complex terrain
- Wind climate from Risø met. Mast (2012-2016)



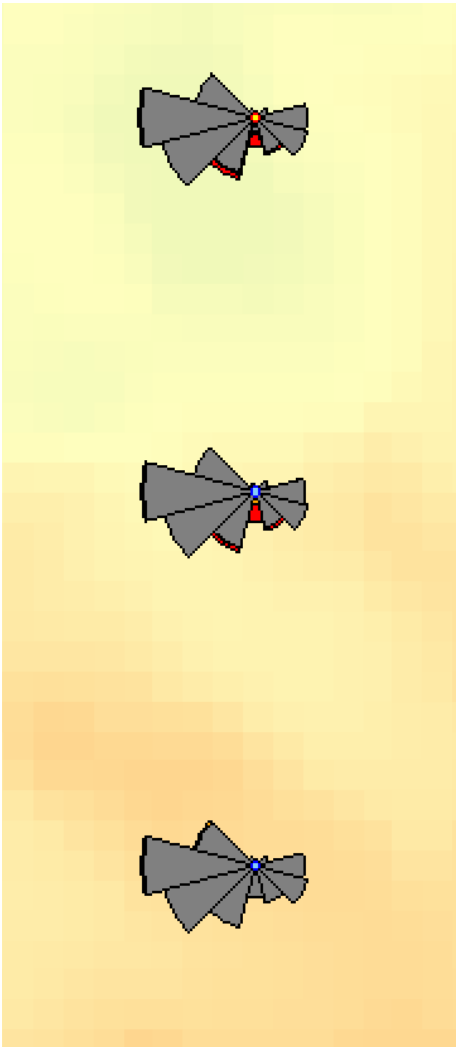


Wind farm calculations

- Technical losses:
  - Turbine availability: 98%
  - Internal transmission loss at full Production: 1.5%
  - Grid availability: 99.99% [1]
- Uncertainty estimates based on provided course material:
  - Combined AEP uncertainty of 12.75%
- AEP_{50}: 24.73 GWh, CF: 28.5 %
- AEP_{90}: 19.76 GWh, CF: 22.8 %



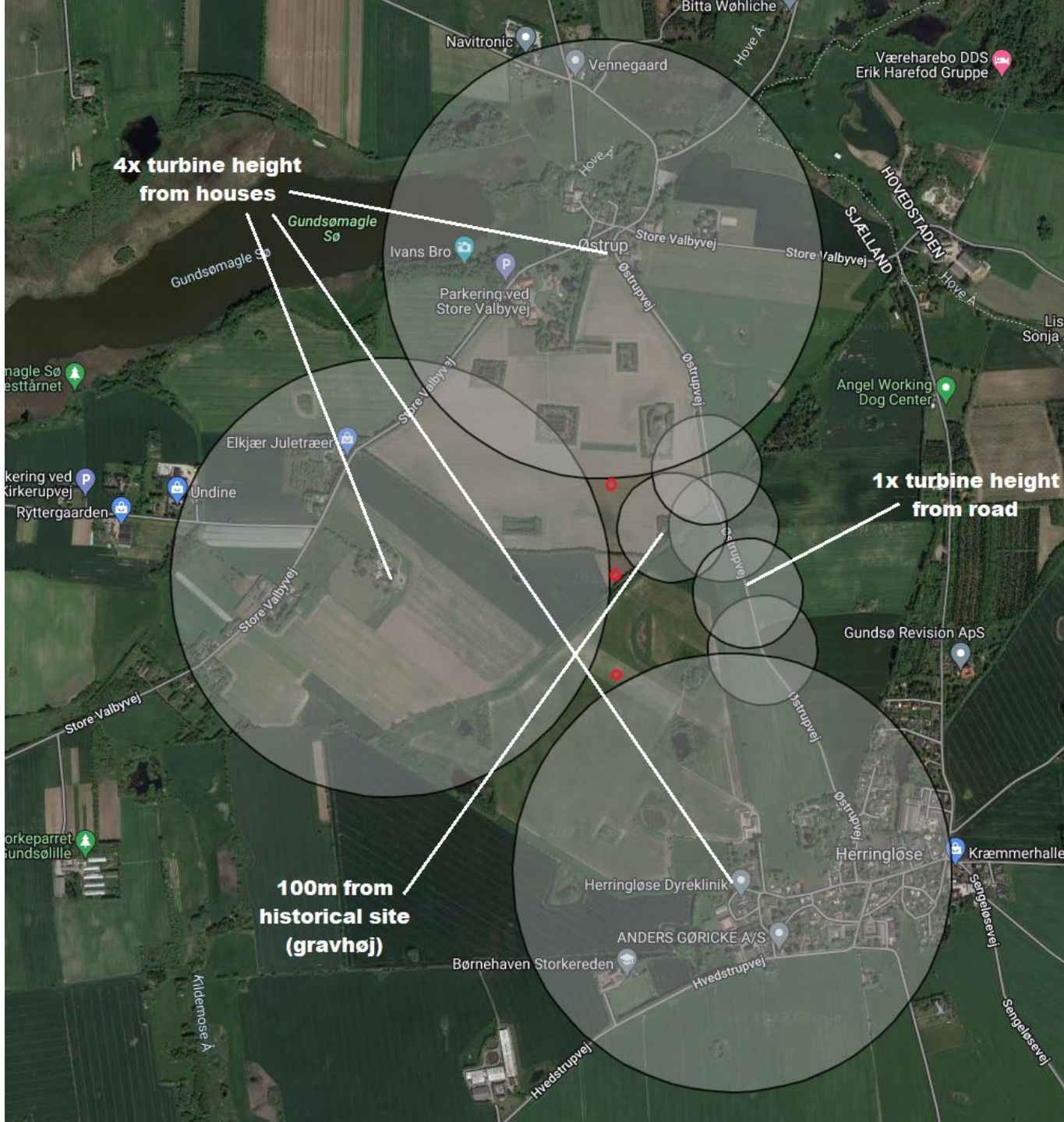
Sector management



Energy production rose

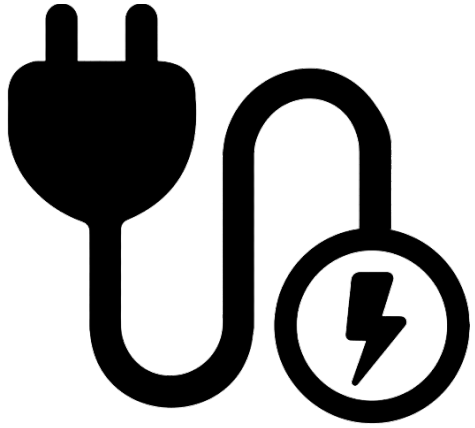
Wind farm design and planning

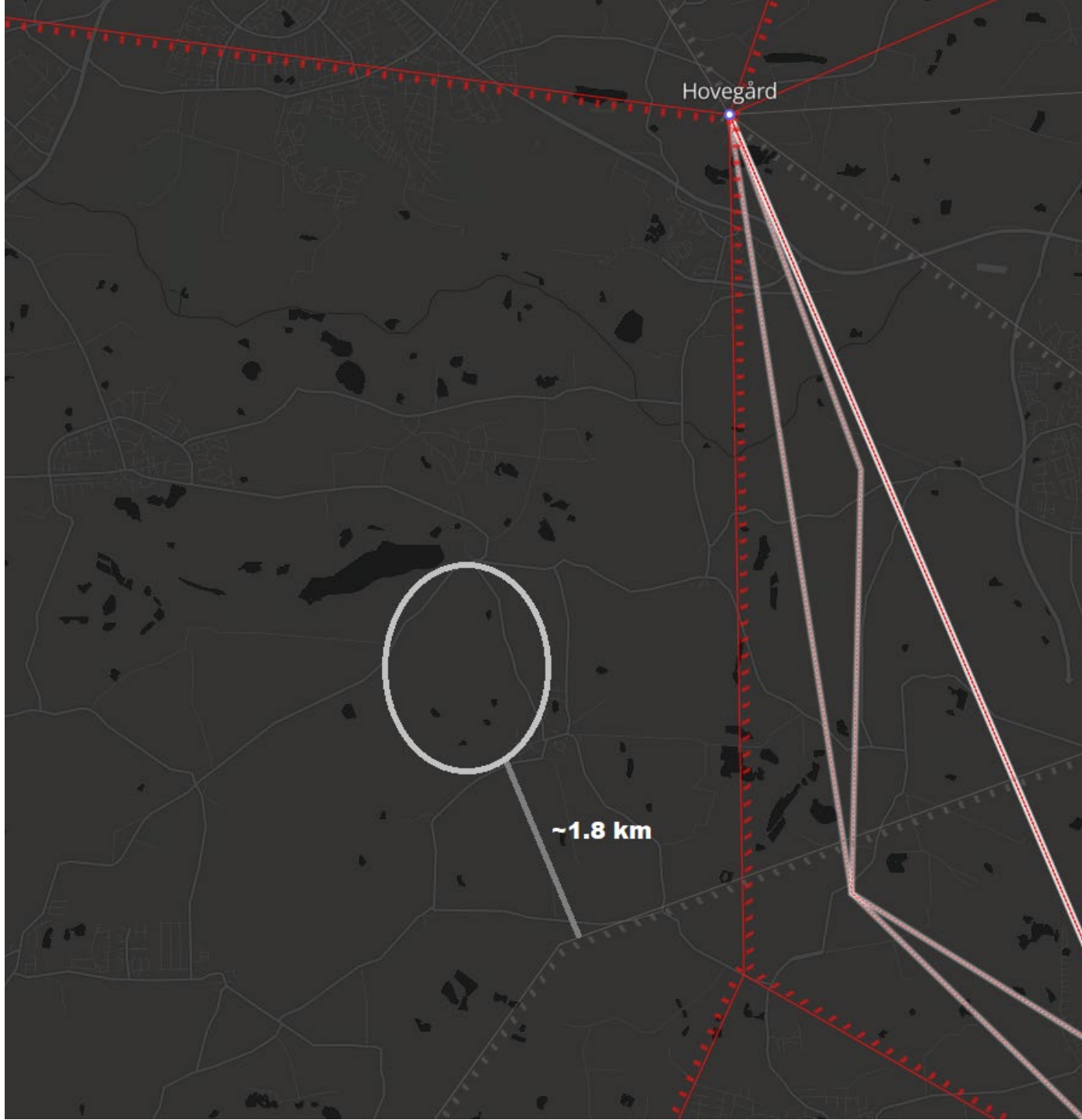
- Only one design due to lack of space
- Other possible solutions
- 3 x Vestas V112-3.3MW IIA



Grid connection

- Substation at Hovegård
- Direct connection to 132kV cable
- Step-up Transformer
- Other possibilities





Wind farm economics

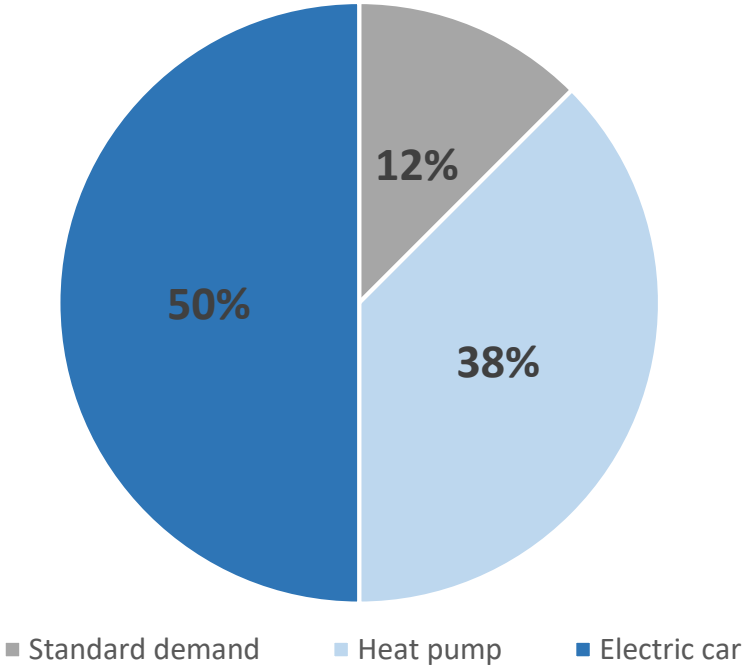
Base Scenario (P-90)

Capacity (MW)	9.9
CAPEX, real 2023 (mDKK) [3]	90.53
OPEX, real 2023 (mDKK) [3]	1.49
Inflation – 2025 onwards (%)	2
Annual Production (GWh)	19.7
Electricity Price (DKK/MWh)	800
Lifetime (years)	20
WACC (%)	6.4
Corporate Tax (%)	22
Valuation Year	2023
Commissioning Year	2026

- NPV = 54.47 mDKK
- IRR = 11 %
- LCOE = 665 DKK/MWh
- Cost per share = 4,582 DKK/MWh
- Payback Time = 11 years

Wind farm economics

- Annual electricity demand from average household:
  - Standard demand: 1 MWh
  - Heat pump: 3 MWh [4]
  - Electric car: 4 MWh [5]
- Total electricity demand = 8 MWh per year



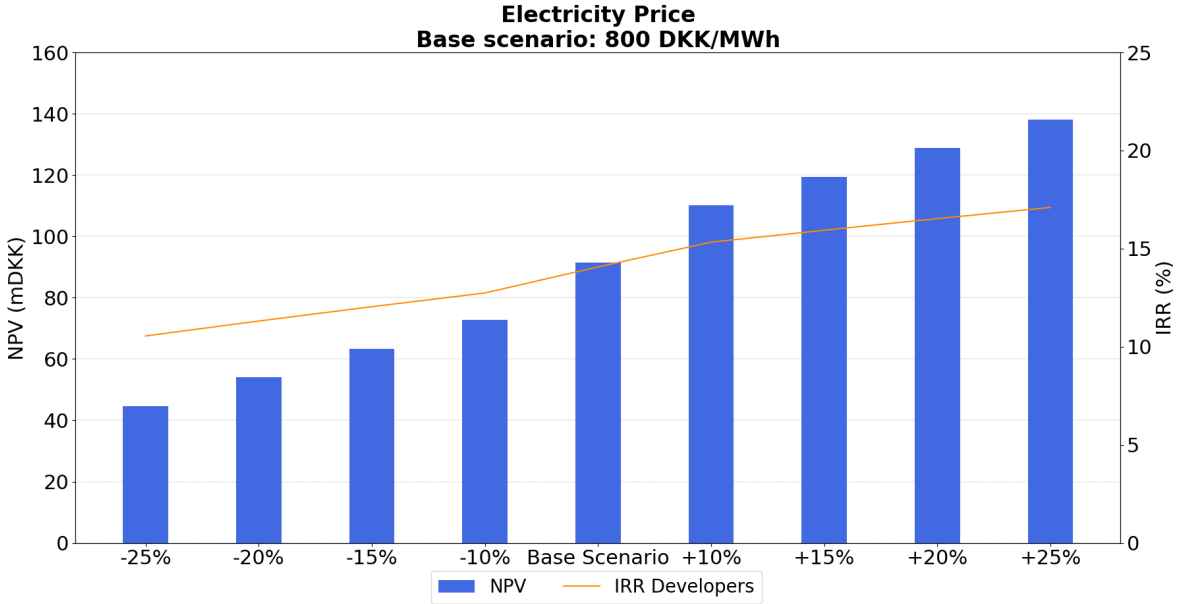
- Annual energy production: 19.7 GWh → Potential supply to 2,470 homes
- Estimated population in the general area: 425 people → 100% coverage!

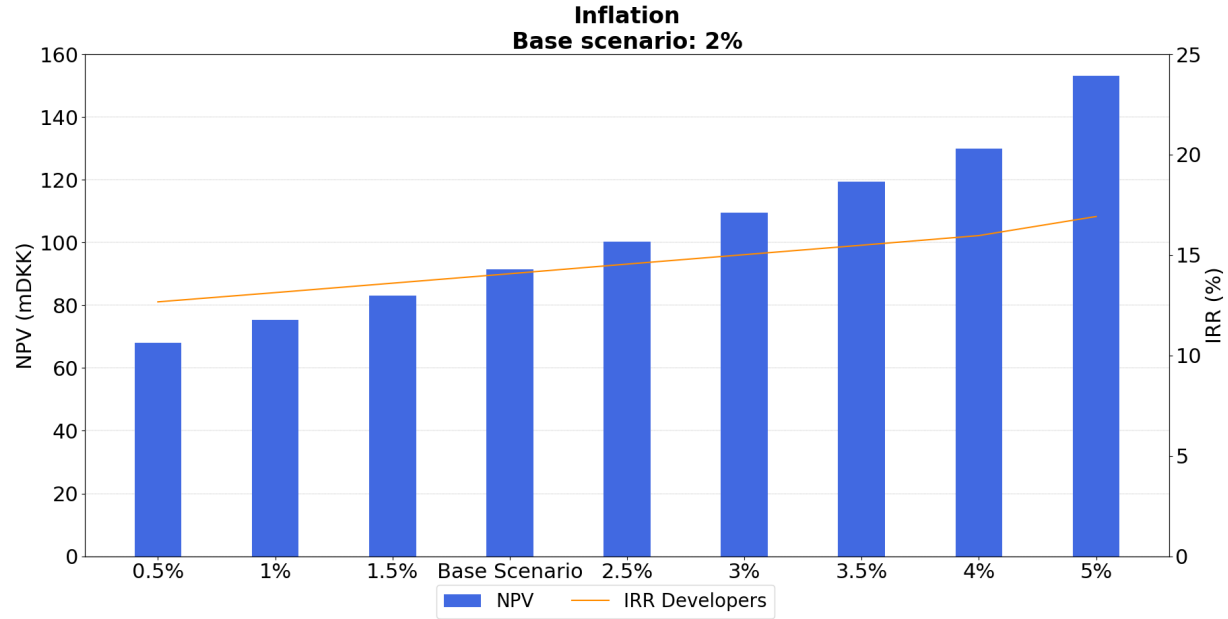
Sensitivity Analysis (P-50)

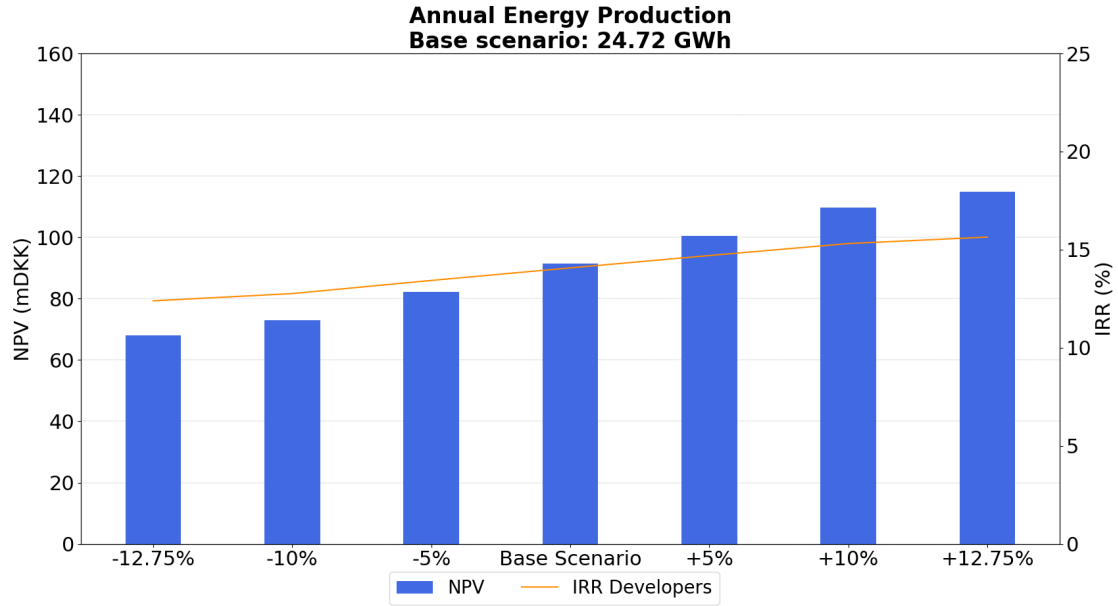
5 key parameters:

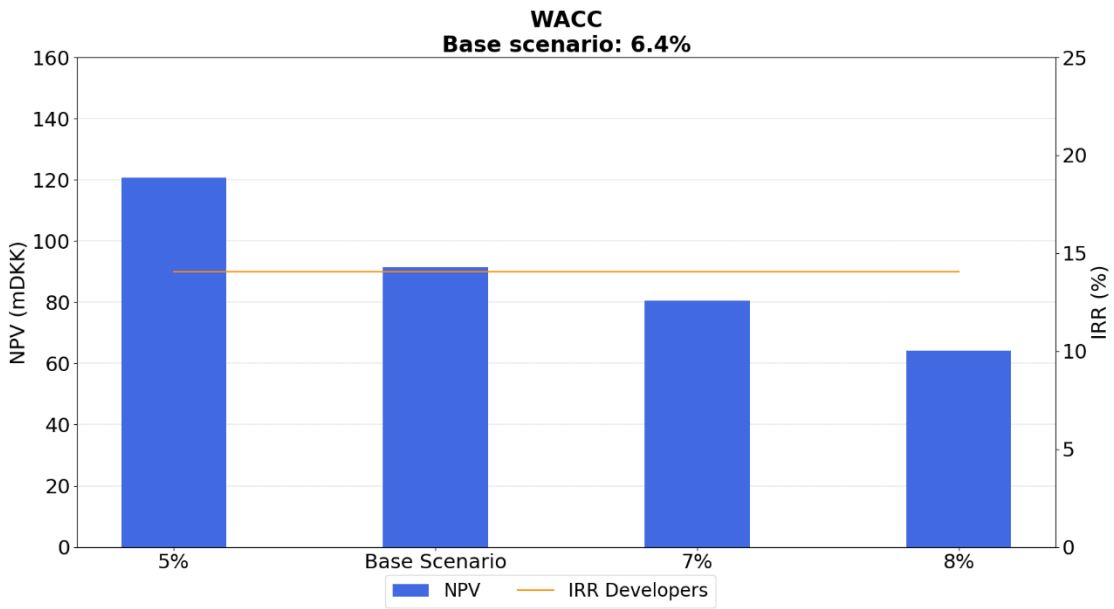
SCENARIOS

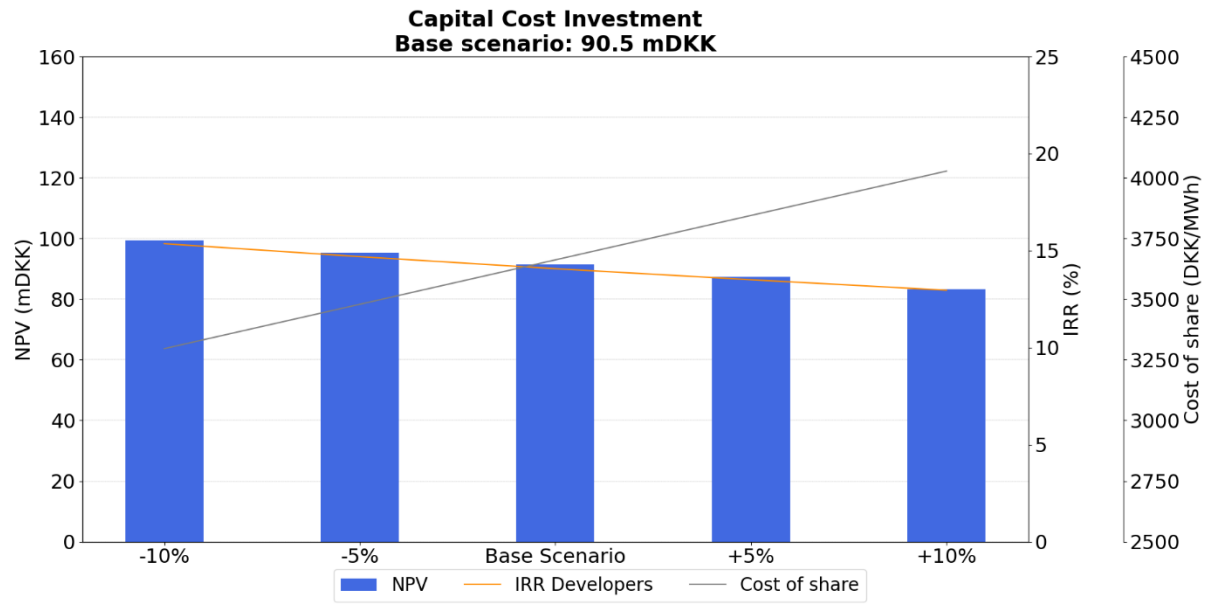
Electricity Price	Inflation	Annual energy production	WACC	CAPEX
-25 %	0.5 %	-12.75 %	5 %	-10 %
-20 %	1 %	-10 %	Base scenario	-5 %
-15 %	1.5 %	-5 %	7 %	Base scenario
-10 %	Base scenario	Base scenario	8 %	+5 %
Base scenario	2.5 %	+5 %		+10 %
+10 %	3 %	+10 %		
+15 %	3.5 %	+12.5 %		
+20 %	4 %			
+25 %	5 %			


Electricity Price
Base scenario: 800 DKK/MWh
NPV (mDKK)
IRR (%)
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
-25%
-20%
-15%
-10%
Base Scenario
+10%
+15%
+20%
+25%
NPV
IRR Developers


Inflation
Base scenario: 2%
NPV (mDKK)
IRR (%)
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
0.5%
1%
1.5%
Base Scenario
2.5%
3%
3.5%
4%
5%
NPV
IRR Developers


Annual Energy Production
Base scenario: 24.72 GWh
NPV (mDKK)
IRR (%)
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
-12.75%
-10%
-5%
Base Scenario
+5%
+10%
+12.75%
NPV
IRR Developers


WACC
Base scenario: 6.4%
NPV (mDKK)
IRR (%)
160
140
120
100
80
60
40
20
0
25
20
15
10
5
0
5%
Base Scenario
7%
8%
NPV
IRR Developers

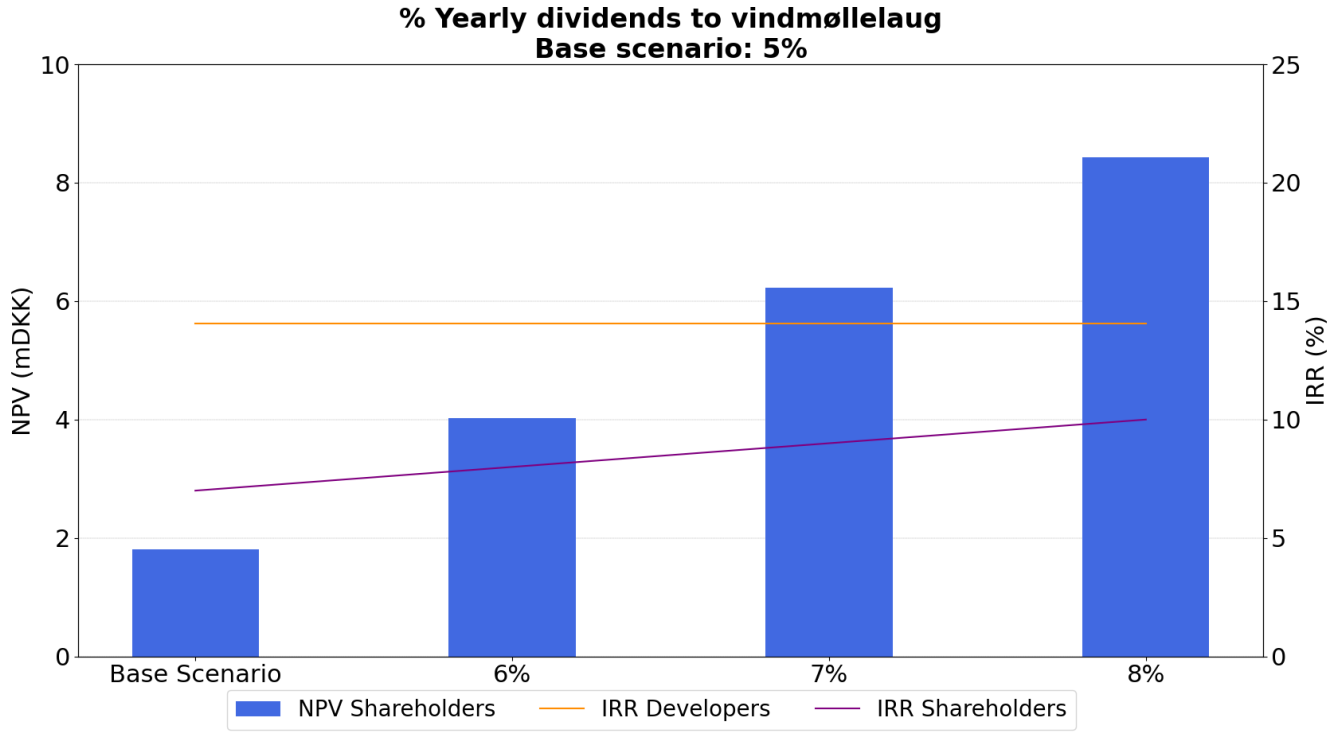

Capital Cost Investment
Base scenario: 90.5 mDKK
NPV (mDKK)
IRR (%)
Cost of share (DKK/MWh)
160
140
120
100
80
60
40
20
0
25
20
15
10
5
0
4500
4250
4000
3750
3500
3250
3000
2750
2500
-10%
-5%
Base Scenario
+5%
+10%
NPV
IRR Developers
Cost of share

The case of Vindmøllelaug

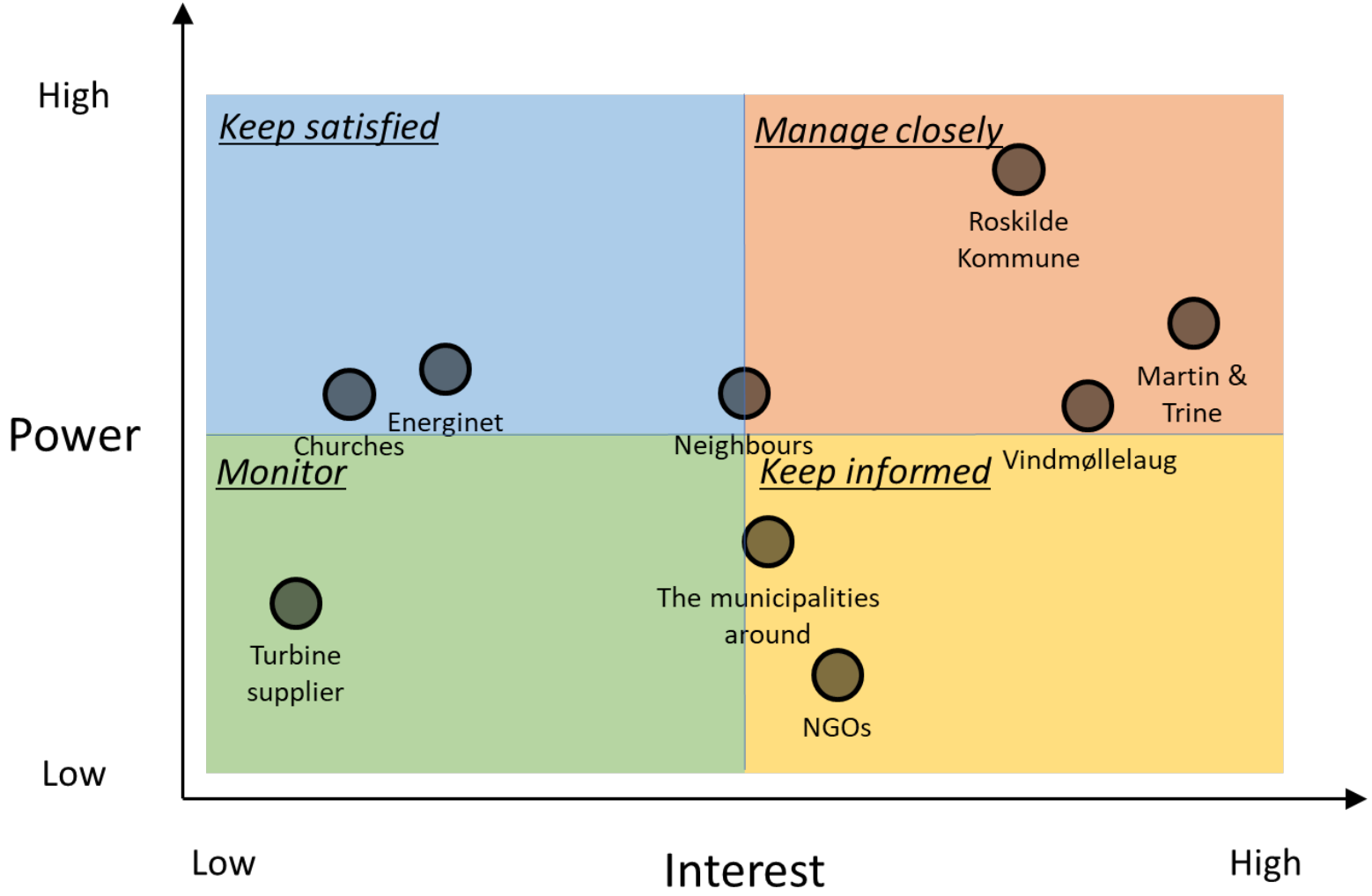
- Possibility to form a community and buy shares of the project
- Dividends will vary yearly – returns should be attractive
- Bank interest rates projected at 4.92 % [2]

Sensitivity Analysis

- 20 % shares assumed
- Yearly dividends range from 5% to 8%
- P-50 probability
- Cost of share at 3,662 DKK/MWh

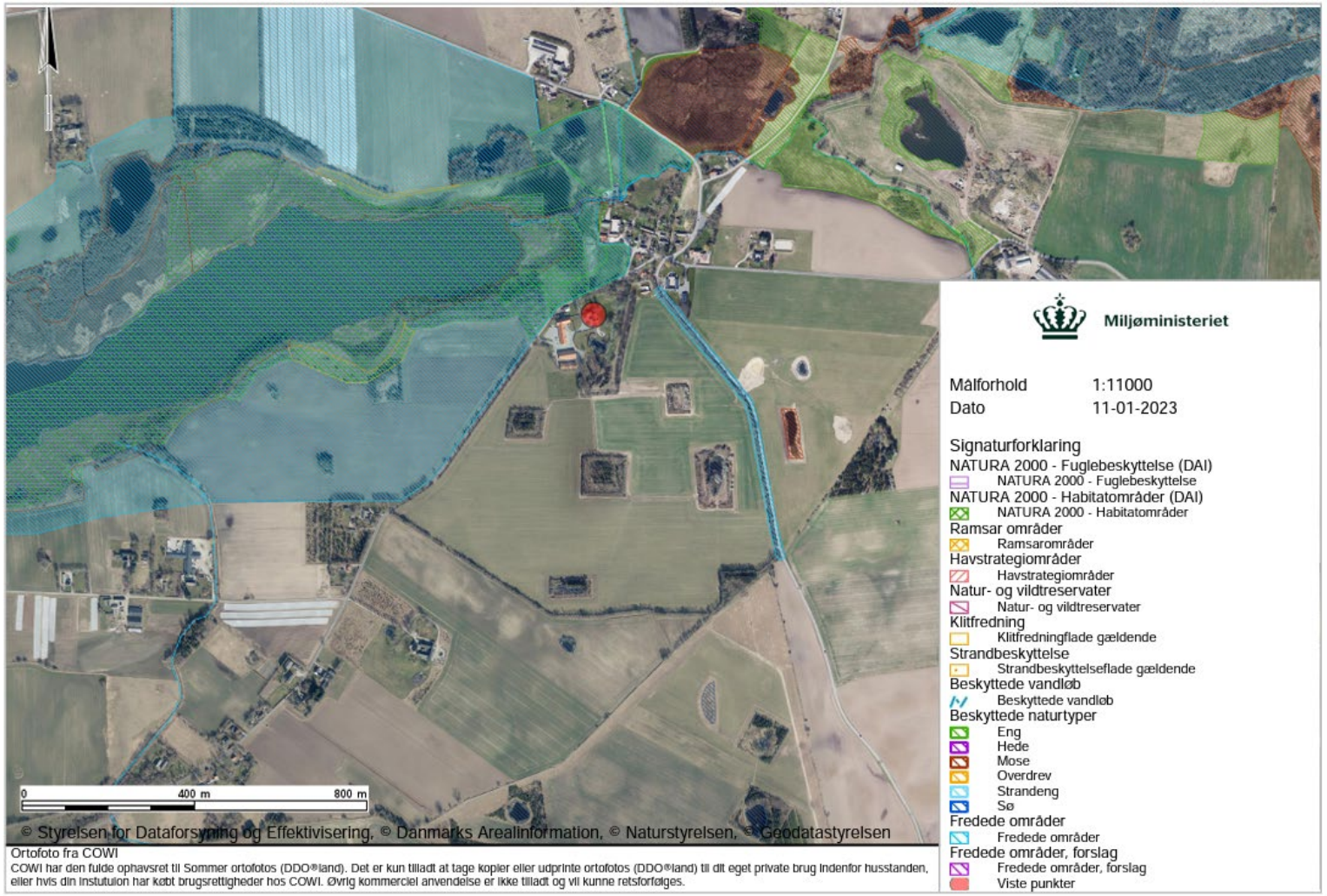


Stakeholders' visualization

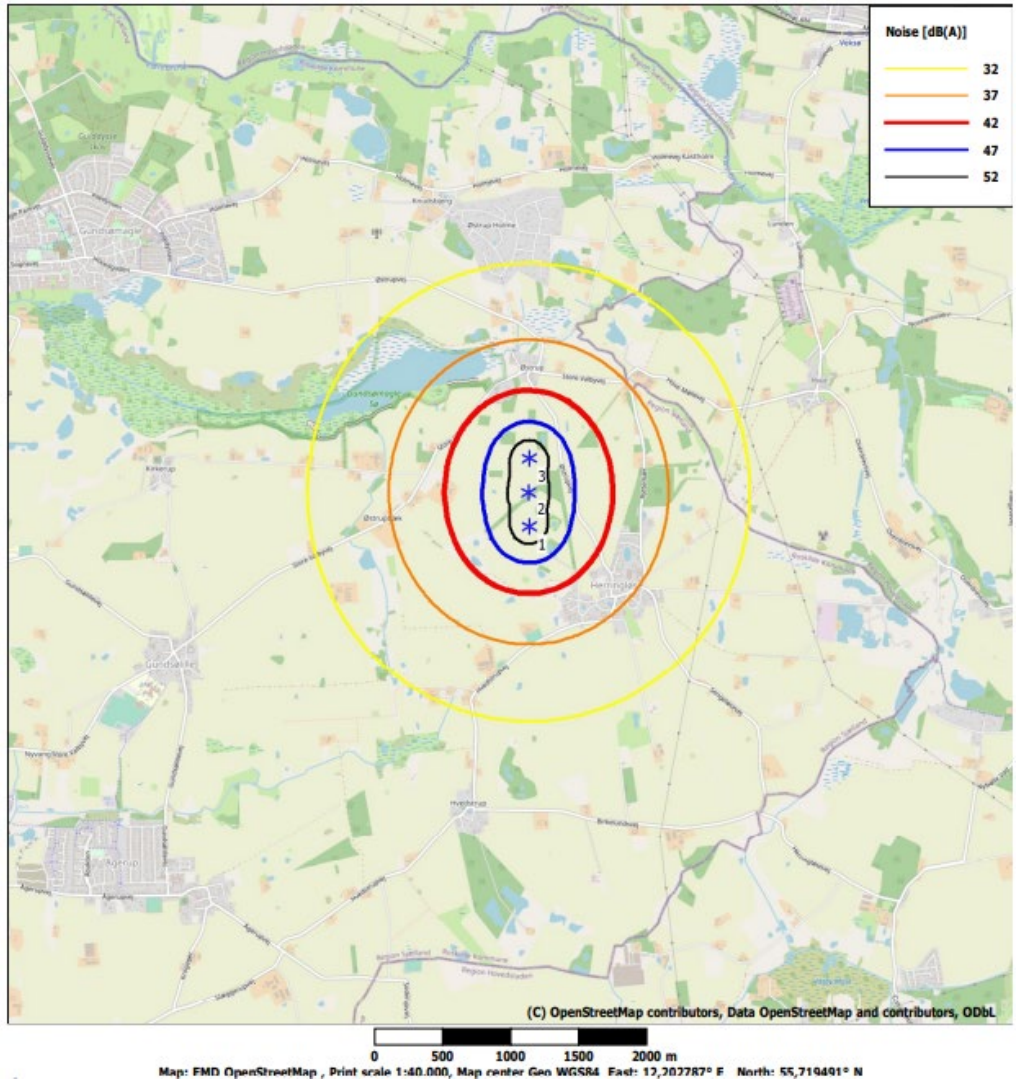


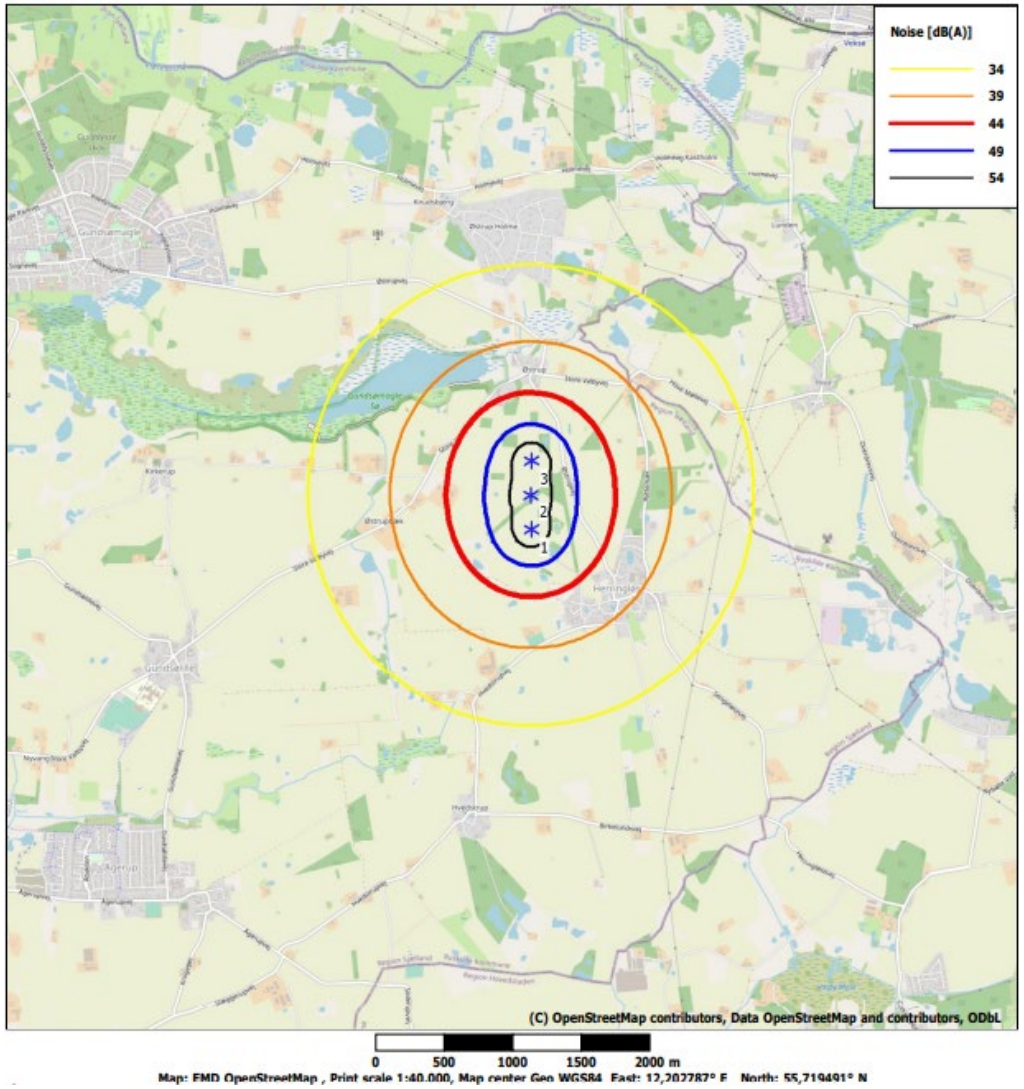
Protected areas nearby

- Natura 2000 areas
- Lake as a potential risk
- No birds' migratory paths
- Protected species: Night Owl territory



Noise impacts at 6 m/s and 8 m/s





Wind turbines at the end of life

- Between 85% and 95% can be recycled
- The challenge –> Blades –> Mechanical or chemical recycling
- Other solutions: Children's playground, noise cancellation walls, bicycle shelter, etc.


Thank you for your attention!