



Mitigating impacts of wind energy facilities on birdlife

Wind energy in Norway

- Installed capacity of 2582 MW
- Annual electricity production of 8.2 TWh
- 42 Operational wind-power plants
- 20 wind-power plants under construction
- 26 with consession





Smøla wind-power plant

- Wind-power plant with 68 2-2.3 MW wind turbines (2002-2005)
- 150 MW installed capacity, 356 GWh annual production
- Smøla is an archipelago with one main island (274 km²) and over 5000 islets and skerries (~2000 inhabitants)
- Circa 60 white-tailed eagle territories



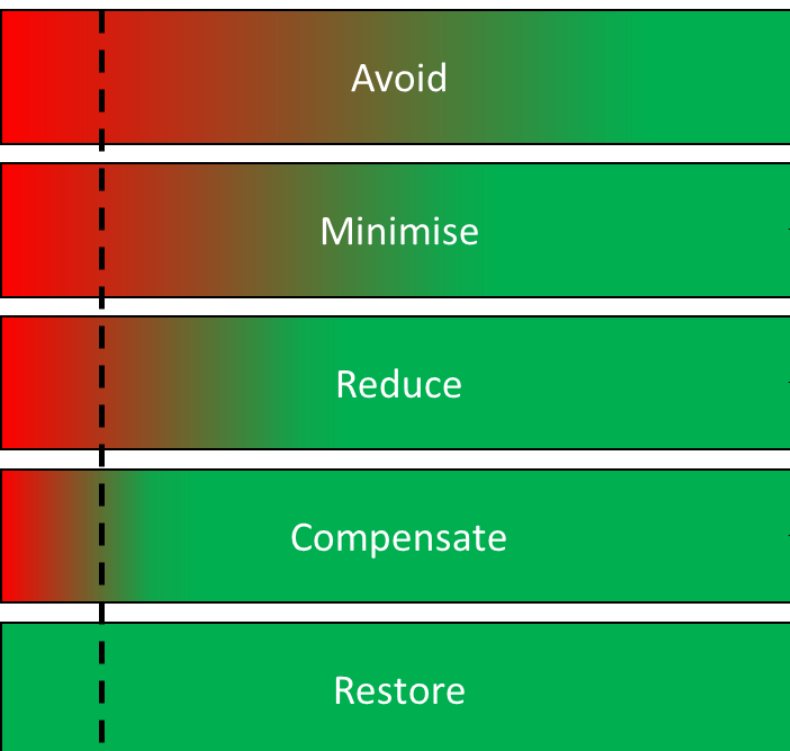


A decade of research on Smøla

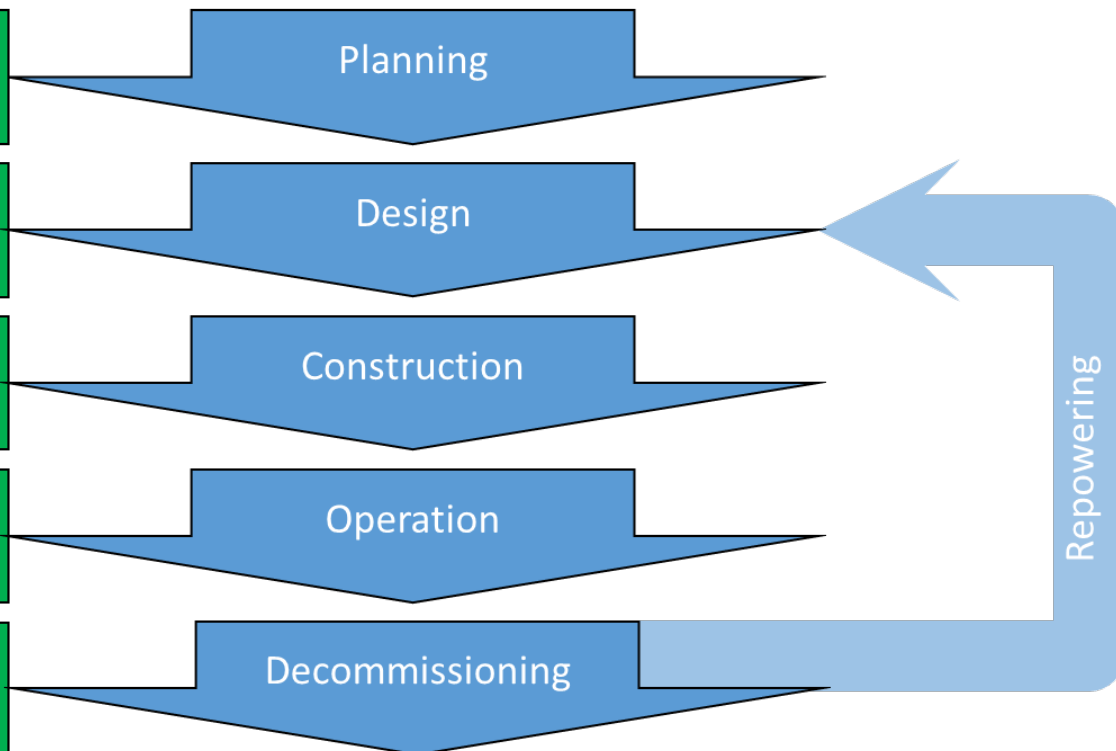
- BirdWind (2006-2011)
 - «Improve the information base and develop tools for the energy sector and authorities for optimal siting and conflict reduction of wind-power plants»
- INTACT (2013-2017)
 - «Test the efficacy of mitigation measures and develop tools to reduce the collision risk of birds with wind turbines»

Applying the Mitigation Hierarchy

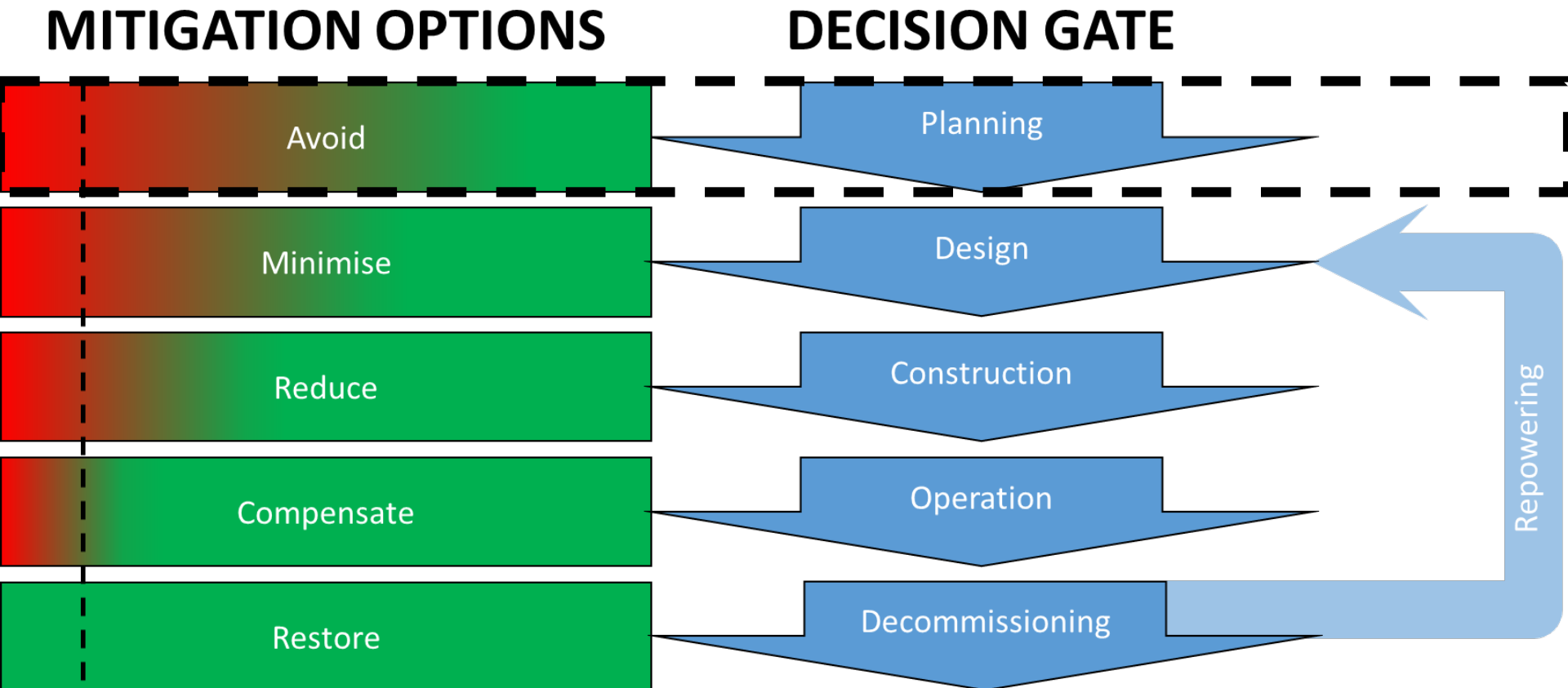
MITIGATION OPTIONS



DECISION GATE



Applying the Mitigation Hierarchy



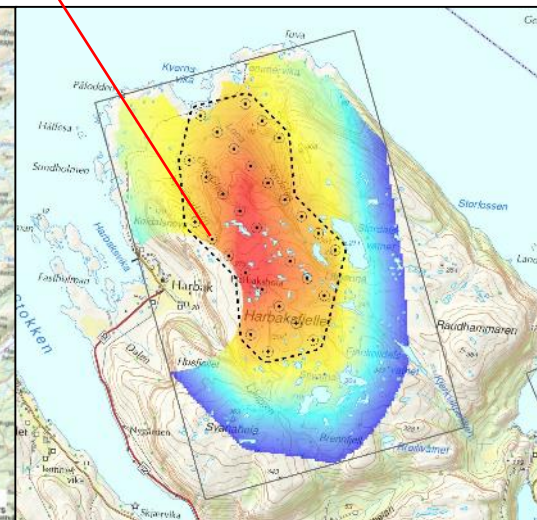
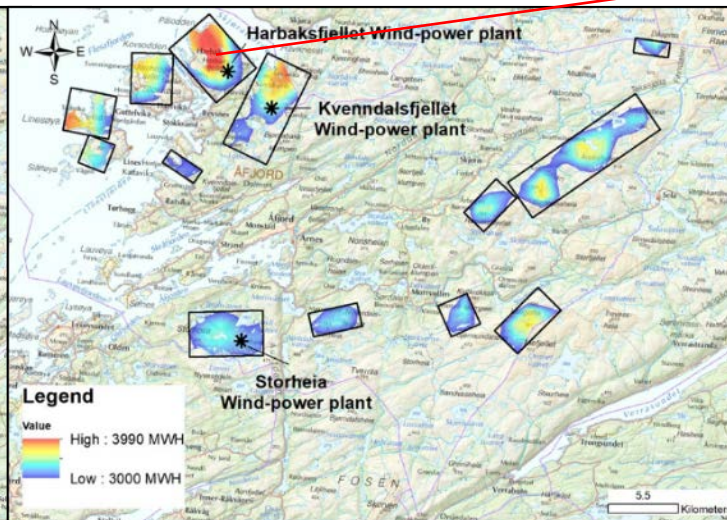
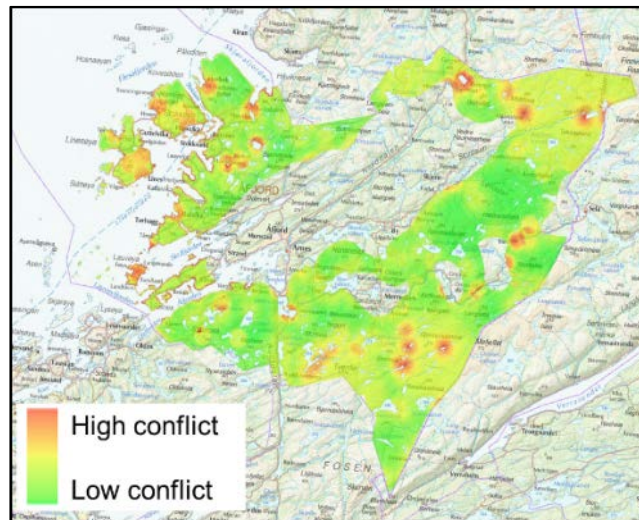
ConSite Wind Toolbox



- 1. Study area
- 2. Calculate Social criteria maps
- 3. Calculate Technological criteria maps
- 4. Calculate Ecological criteria maps
- 5. Calculate siting maps

Spatial multi-criteria decision support tool for optimal siting of wind-power plants based on **ecological**, **societal** and **technological** criteria

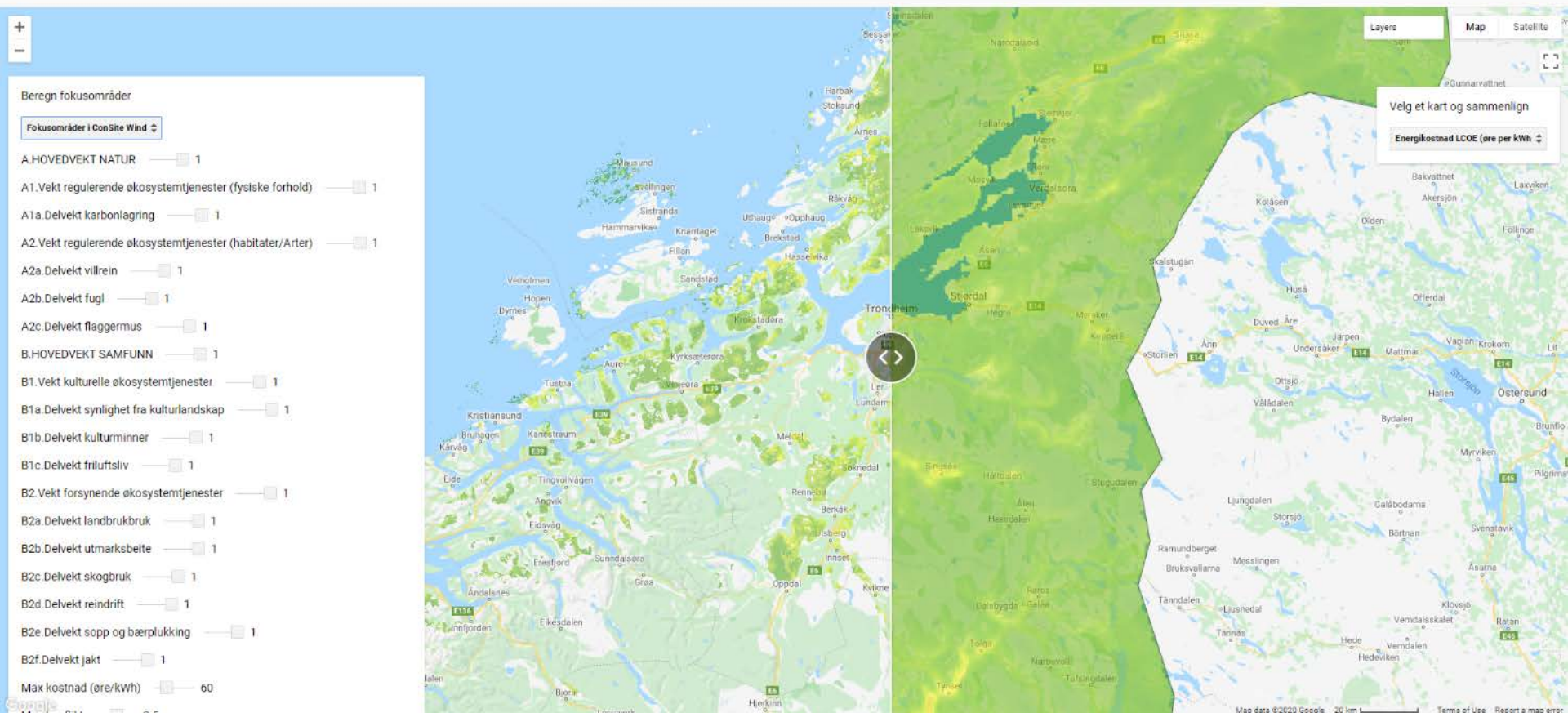
Identify	Value
26. Wind resources: Minimum suitability	0.374821
26. Wind resources: Mean suitability	0.393223
26. Wind resources: Maximum suitability	0.393223
26. Distance to powerlines: Minimum conflict	0.488752
26. Distance to powerlines: Mean conflict	0.581559
26. Distance to powerlines: Maximum conflict	0.557145
26. Distance to roads: Minimum conflict	0.388926
26. Distance to roads: Mean conflict	0.493275
26. Distance to roads: Maximum conflict	0.5
26. Topographical variables: Minimum conflict	0.89595
26. Topographical variables: Mean conflict	0.891242
26. Topographical variables: Maximum conflict	0.107744
26. Distance to cultural heritage: Minimum conflict	0.471323
26. Distance to cultural heritage: Mean conflict	0.540216
26. Distance to cultural heritage: Maximum conflict	0.002323
26. Distance to cultural landscapes: Minimum conflict	0.008127
26. Distance to cultural landscapes: Mean conflict	0.003982
26. Distance to cultural landscapes: Maximum conflict	0.339817
26. Noise disturbance: Minimum conflict	0.075146
26. Noise disturbance: Mean conflict	0.303985
26. Noise disturbance: Maximum conflict	0
26. Fragmentation of productive agricultural and forestry land: Minimum conflict	0
26. Fragmentation of productive agricultural and forestry land: Mean conflict	0.002112
26. Fragmentation of productive agricultural and forestry land: Maximum conflict	0.000011
26. Distance to important sites for biodiversity: Minimum conflict	0.550322
26. Distance to important sites for biodiversity: Mean conflict	0.552375
26. Distance to important sites for biodiversity: Maximum conflict	0
26. Distance to coastal areas: Minimum conflict	0.5
26. Distance to coastal areas: Mean conflict	0.003791
26. Distance to coastal areas: Maximum conflict	0.000028
26. Distance to protected nature areas: Minimum conflict	0.000379
26. Distance to protected nature areas: Mean conflict	0.000379
26. Distance to protected nature areas: Maximum conflict	0
26. Distance to undeveloped nature areas: Minimum conflict	0
26. Distance to undeveloped nature areas: Mean conflict	0
26. Distance to undeveloped nature areas: Maximum conflict	0



ConSite Wind Google Earth Engine

Earth Engine Apps Experimental

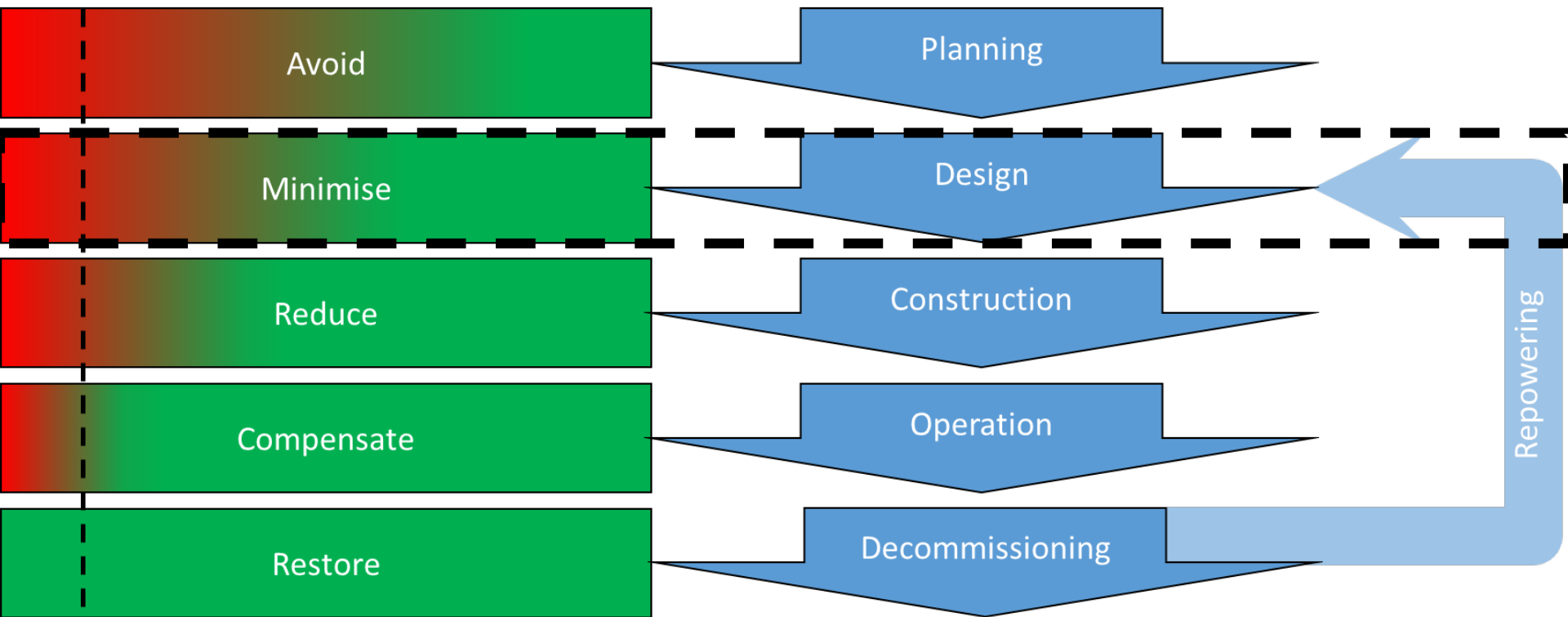
Search places



Applying the Mitigation Hierarchy

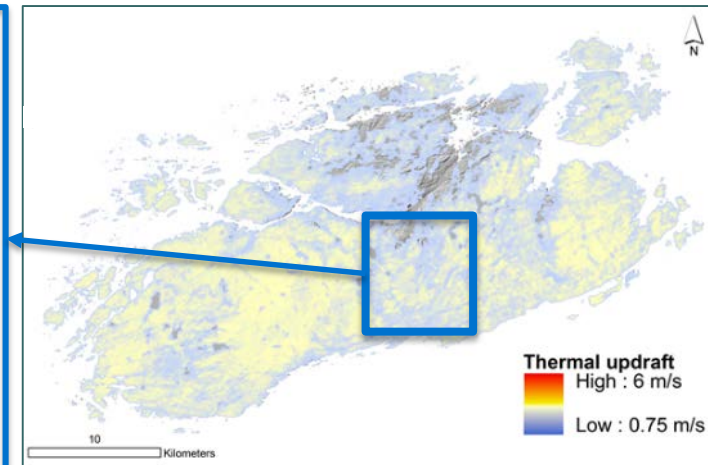
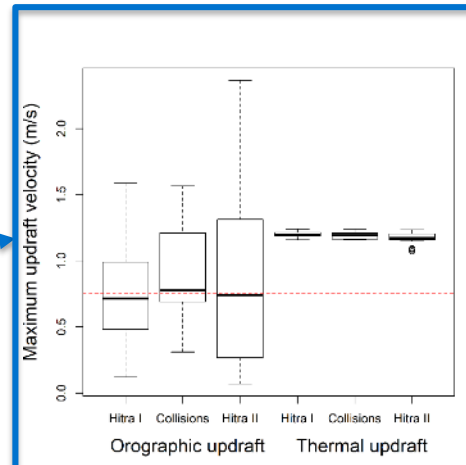
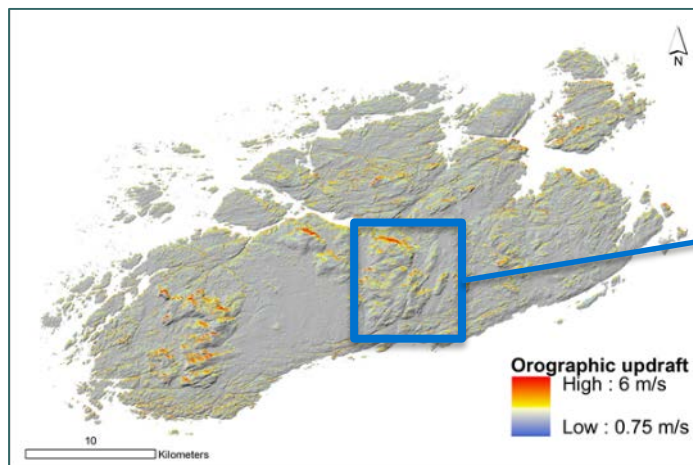
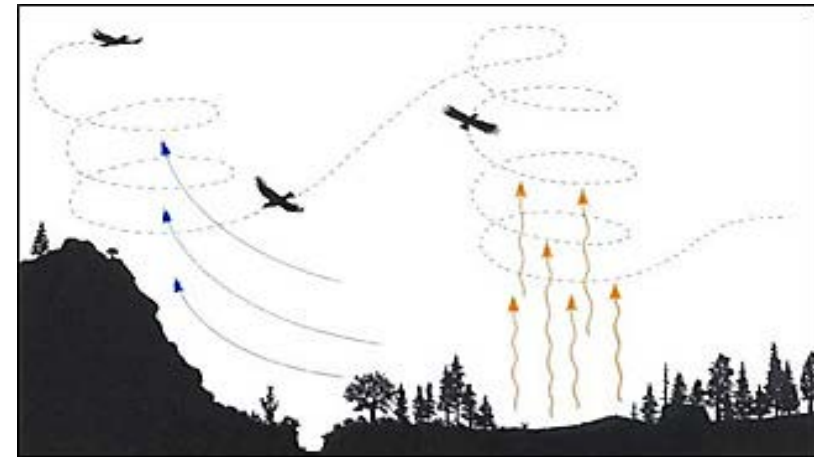
MITIGATION OPTIONS

DECISION GATE



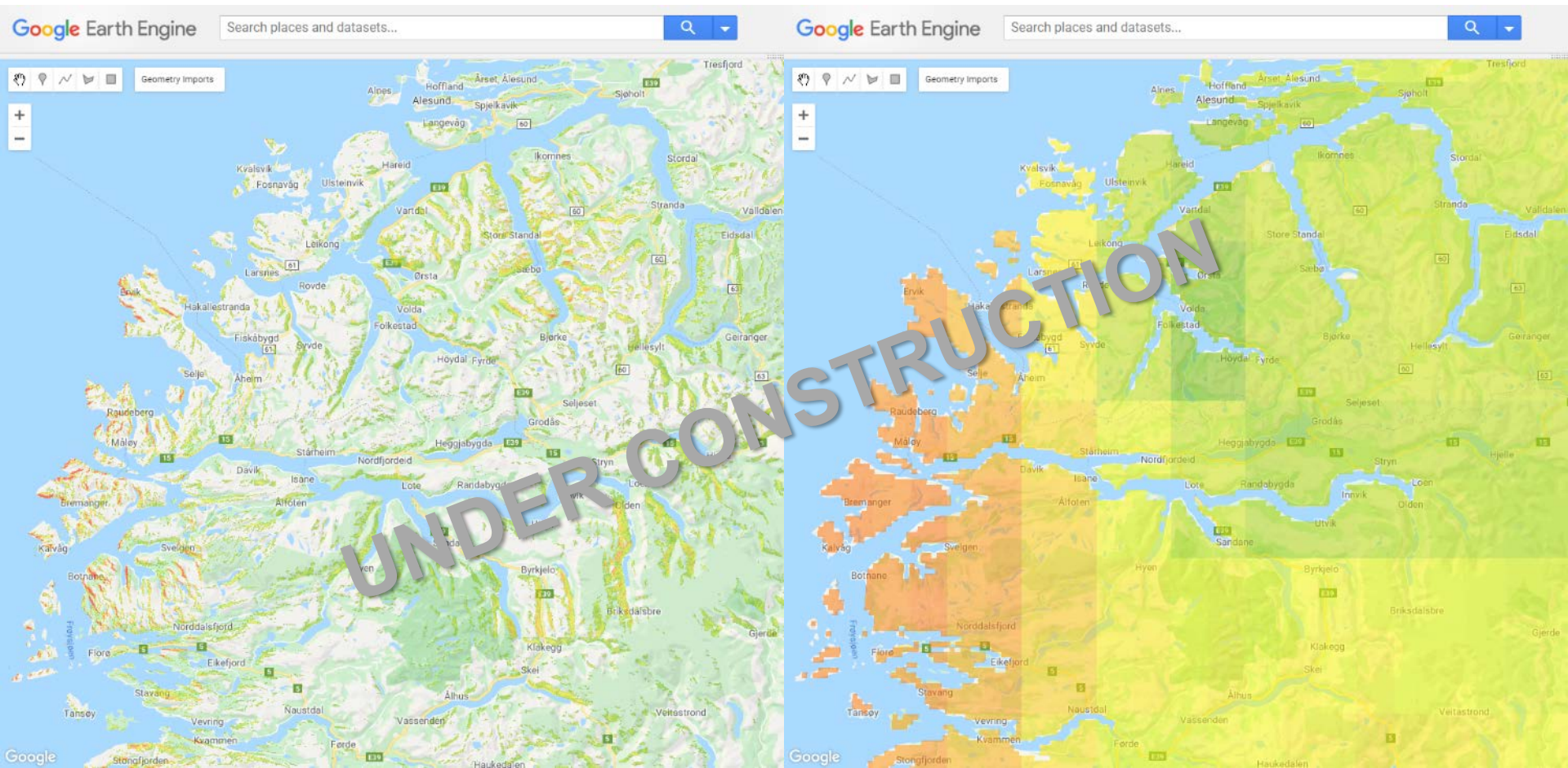
Bird-friendly micro-siting of turbines

- GIS tool for identifying wind turbine locations with increased collision risk for soaring birds which are attracted to updrafts





Updraft tool Google Earth Engine

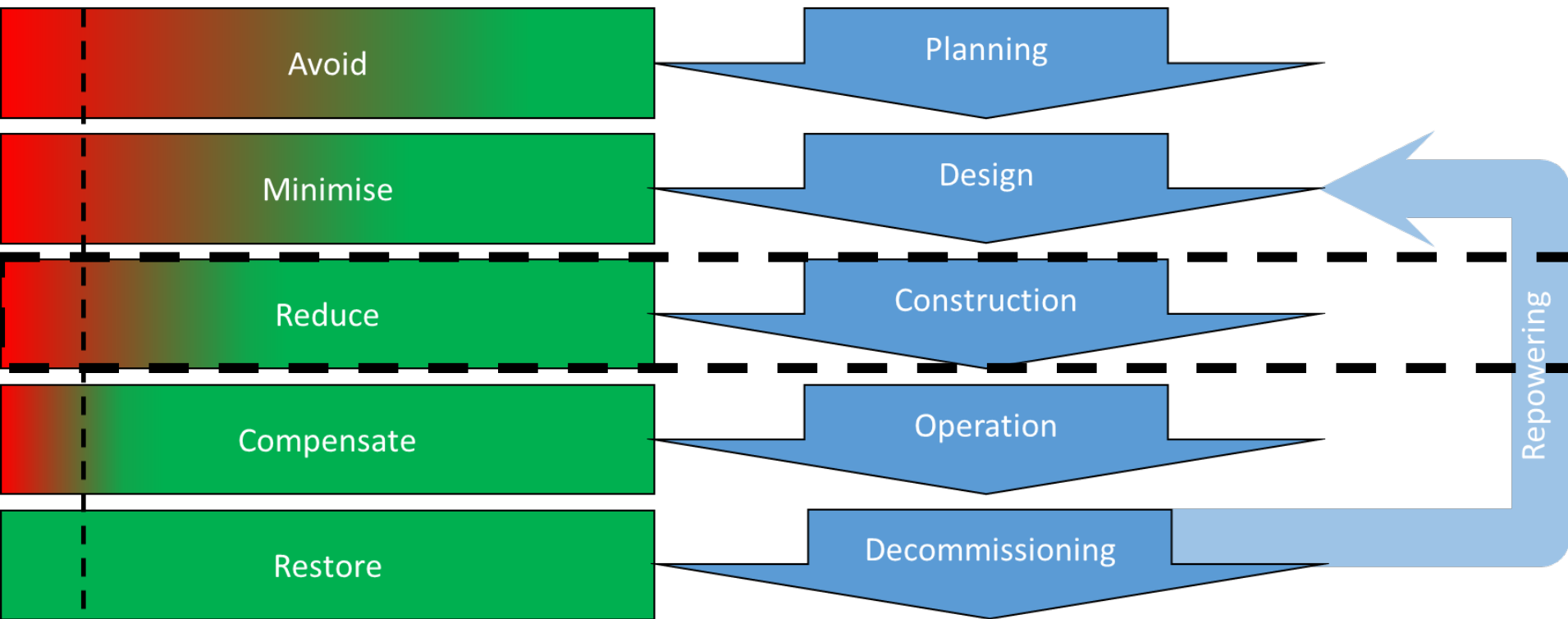




Applying the Mitigation Hierarchy

MITIGATION OPTIONS

DECISION GATE







Painting of wind turbines

- Rotor blade – one of three was painted black to reduce ‘motion smear’
 - Only minor changes in bird behaviour...
 - ...but collision rates decreased by 71%
- Turbine tower – lower 10m was painted black to visually increase the horizon
 - Ptarmigan collision rates decreased by 53%...
 - ...with highest effect during spring and autumn





Reminders for painting

- Visual effects in the landscape
- On-the-ground painting
- Exemption from regulatory color schemes
 - Civil Aviation Authorities
 - Licensing authority
 - ...

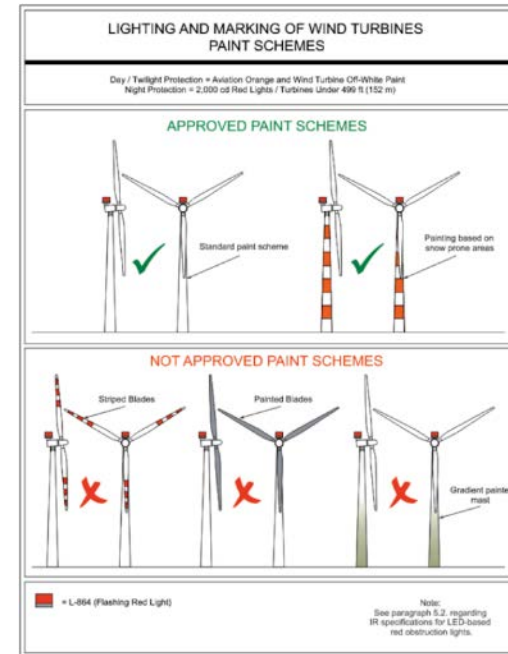


Figure A-28. Lighting and Marking of Wind Turbines – Paint Schemes





Pilot ultra-violet 'light fence'

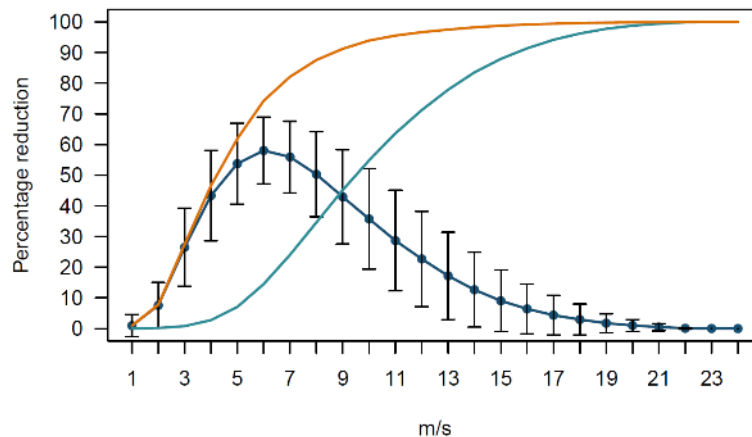
- Test the use of UV-light to deter birds from wind turbines in periods of reduced visual conditions (dusk/dawn, night, fog)
 - 12-27% lower bird activity compared to nights without lighting
 - Birds flew 7 m higher versus 40-50 m long rotor blades





Operational adjustments

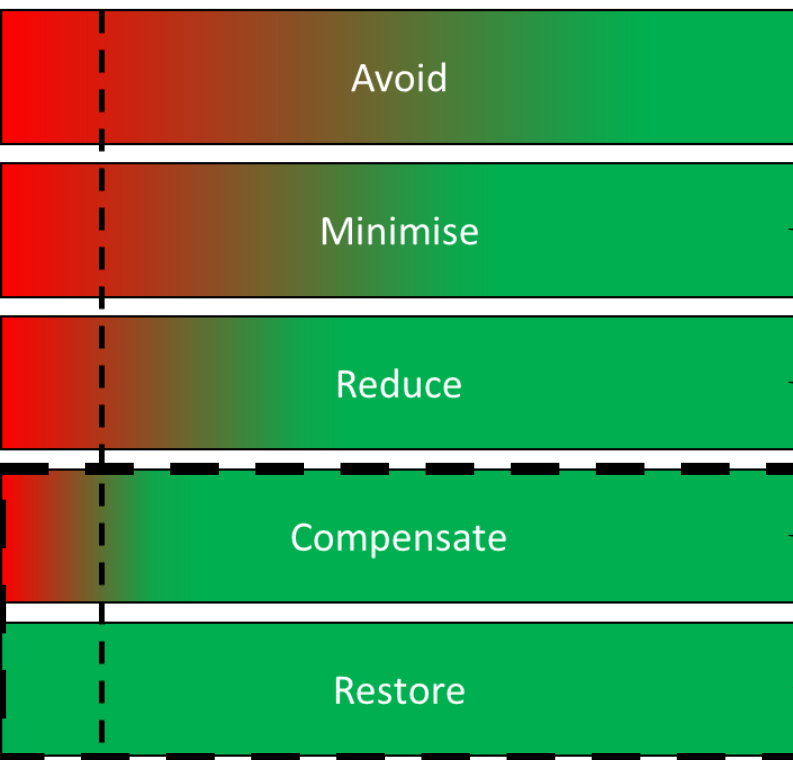
- Adjustments of turbine cut-in speed to minimize collision risk per kWh
 - Minor seasonal effects
 - Wind speed large effect



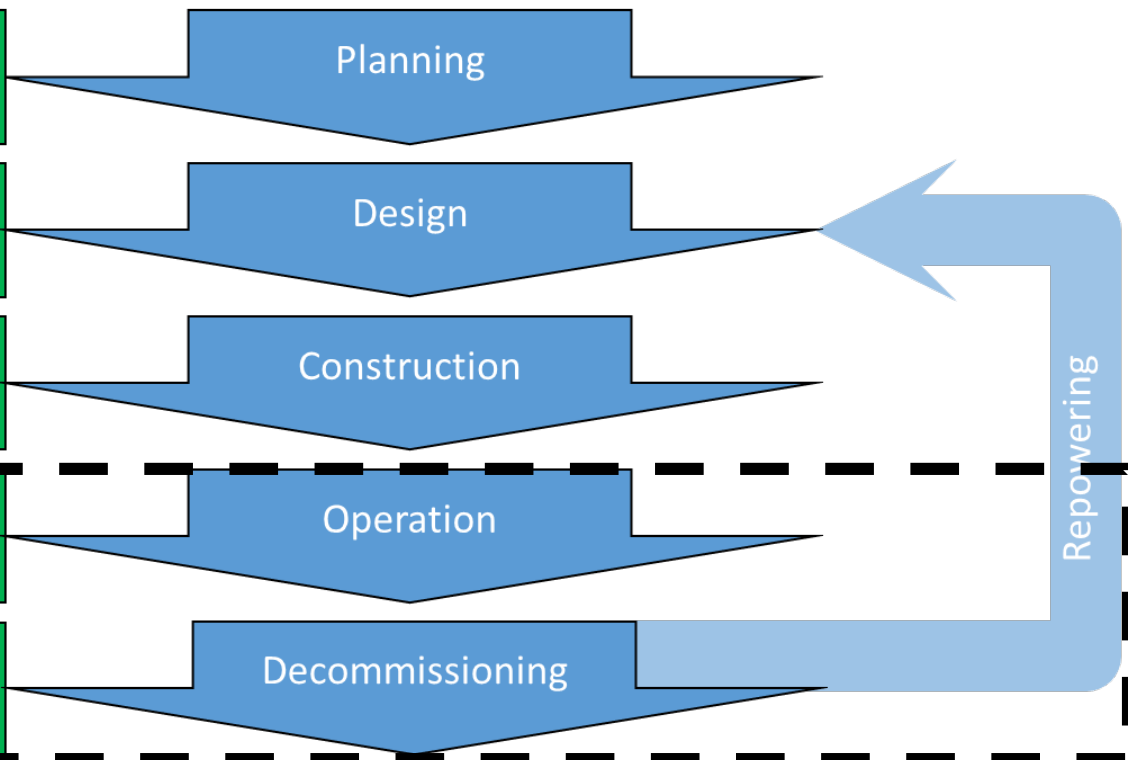


Applying the Mitigation Hierarchy

MITIGATION OPTIONS



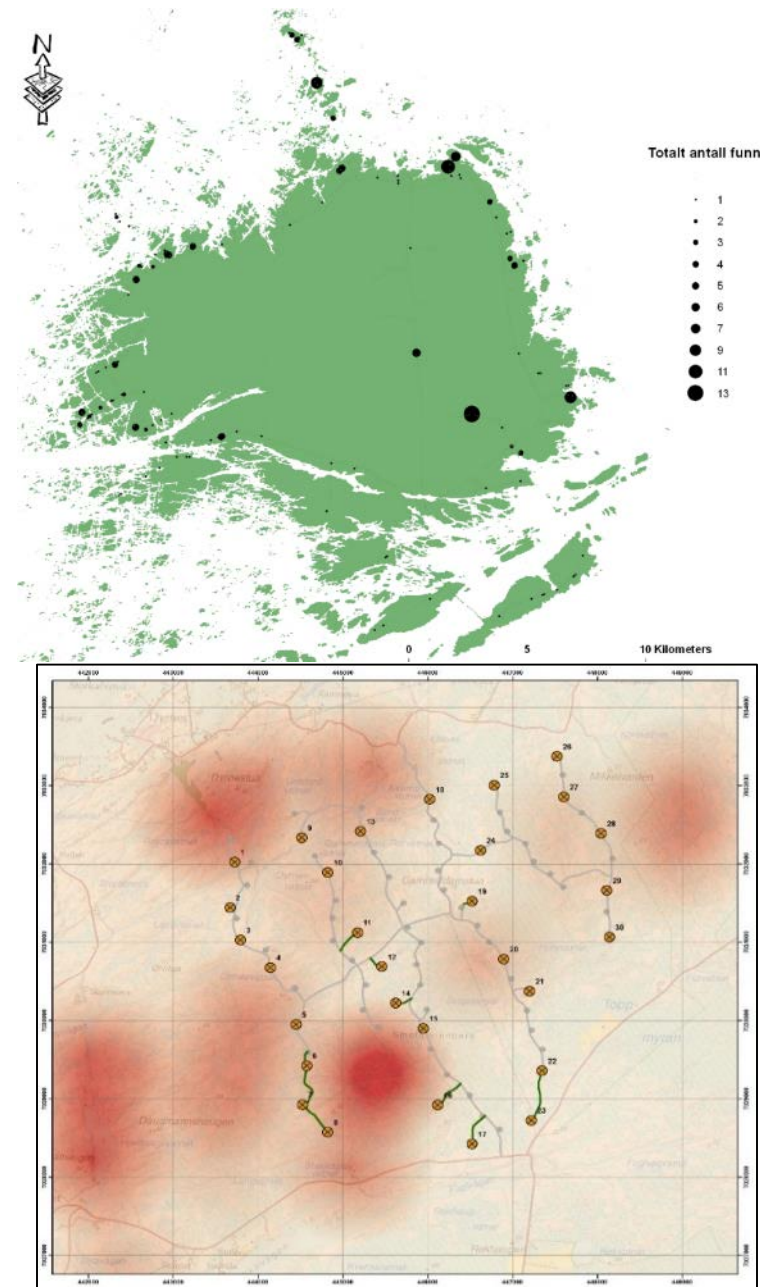
DECISION GATE





Unknown options?

- Potential to compensate for electrocution mortality instead of wind turbine collisions
- Potential for a ‘repowering’ of Smøla wind-power plant (30 5MW turbines)





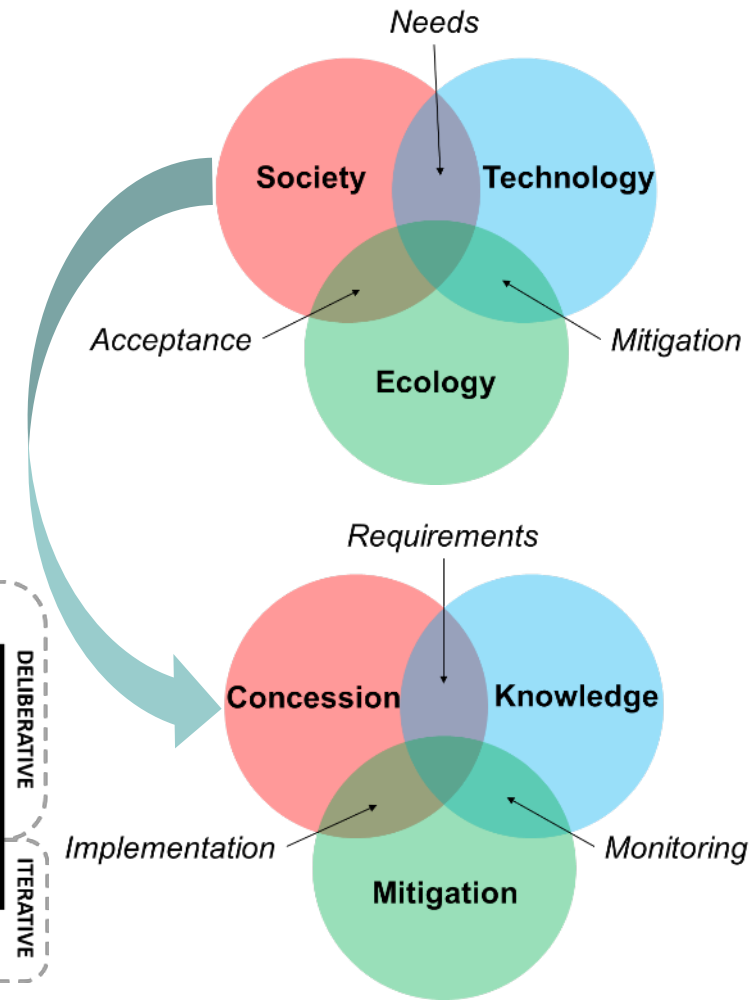
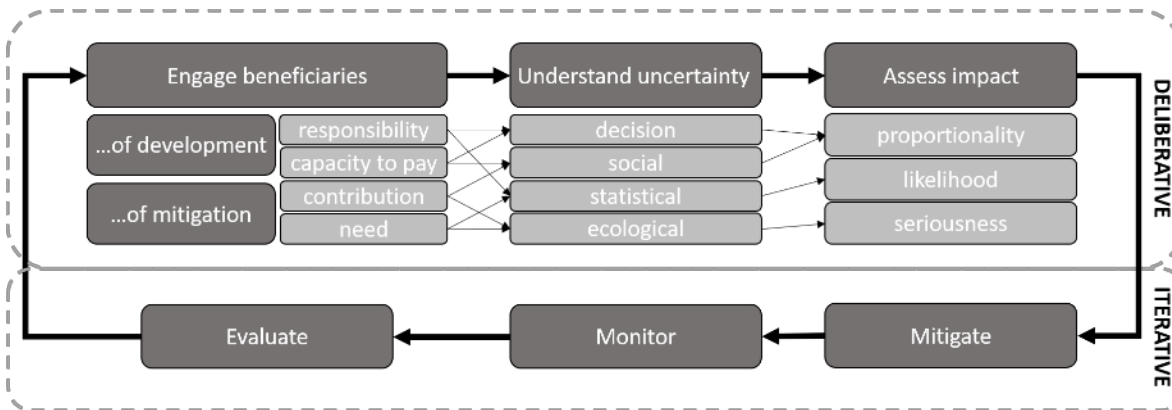
With birds in its wake
Painted wings, feathered blades
Art of reduction





When is implementation warranted?

- Wind energy with the least environmental impact per kWh requires balancing multiple interests, and acting upon this





Recommended reading

- May, R., Nygård, T., Falkdalen, U., Åström, J., Hamre, Ø., Stokke, B.G. 2020. Paint it black: Efficacy of increased wind-turbine rotor blade visibility to reduce avian fatalities. *Ecology & Evolution*. <https://doi.org/10.1002/ece3.6592>
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- May, R.F. 2015. A unifying framework for the underlying mechanisms of avian avoidance of wind turbines. *Biological Conservation* 190: 179-187.



Thank you for your attention!