HYGCEL research presentation

# HYGCEL WP2 T2.1 - Wind, solar, and $CO_2$

## Resource potentials in infrastructure development

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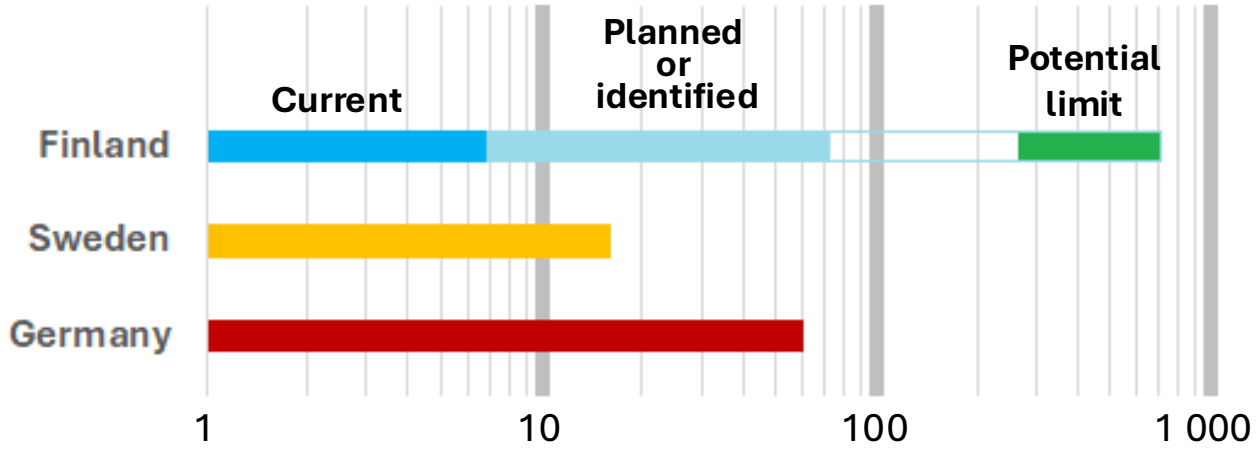
# State of Finnish wind power

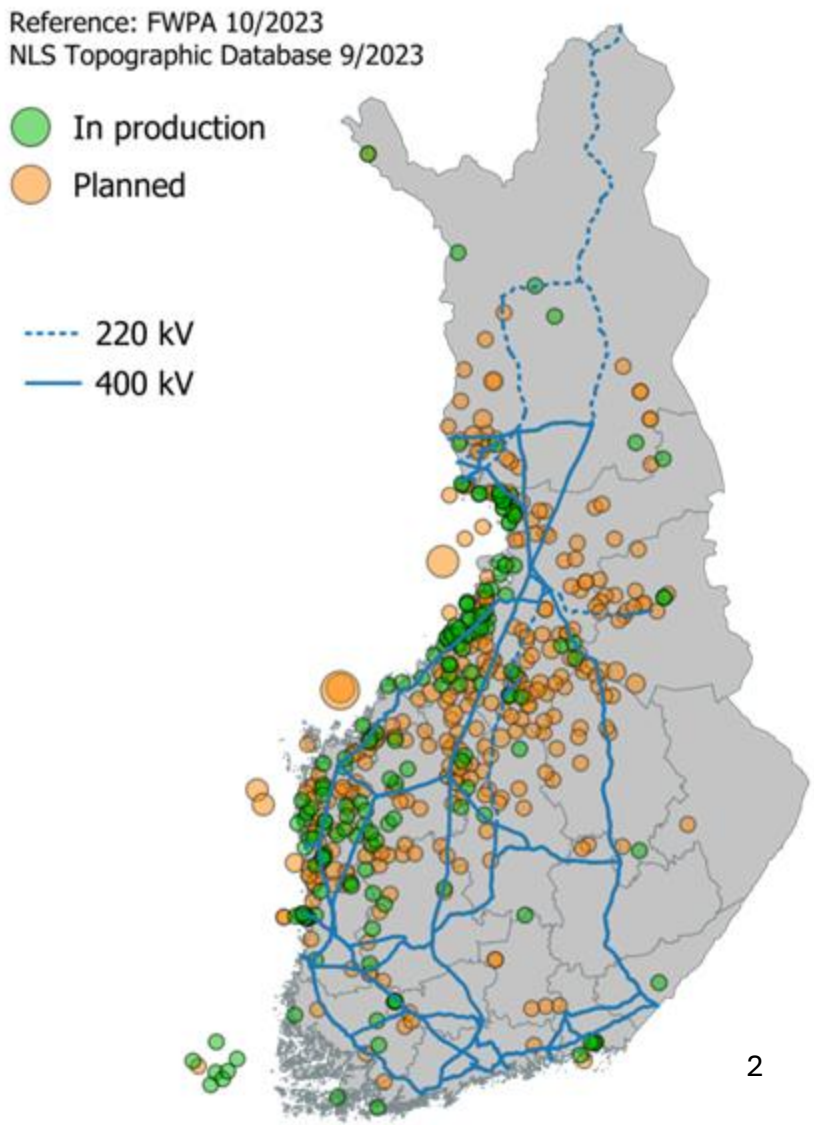
- Transformative energy shift:
  - 7.3 GW in operation. Being planned [1]:
    - 72.9 GW onshore (~150 – 200 TWh)
    - 69.9 GW offshore
- Still room for growth compared to peers

Installed onshore wind power (GW)
Logarithmic scale!




[1] Tuulivoimayhdistys

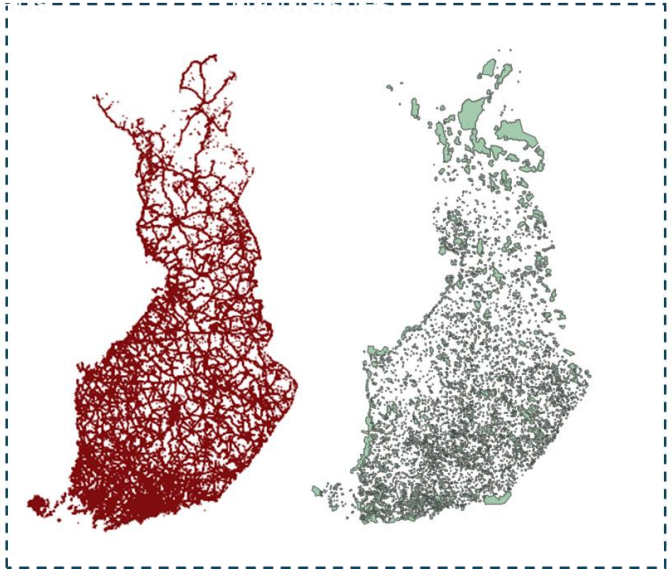
**Current and planned wind power sites**



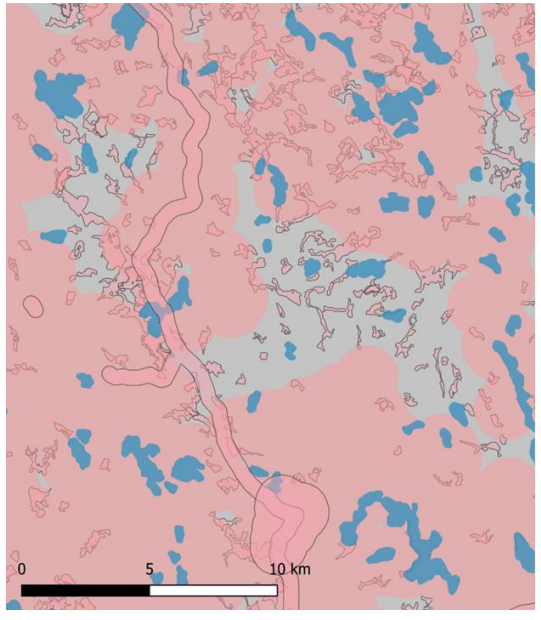
# Procedure description and methodology

How are we identifying potential wind farm sites?

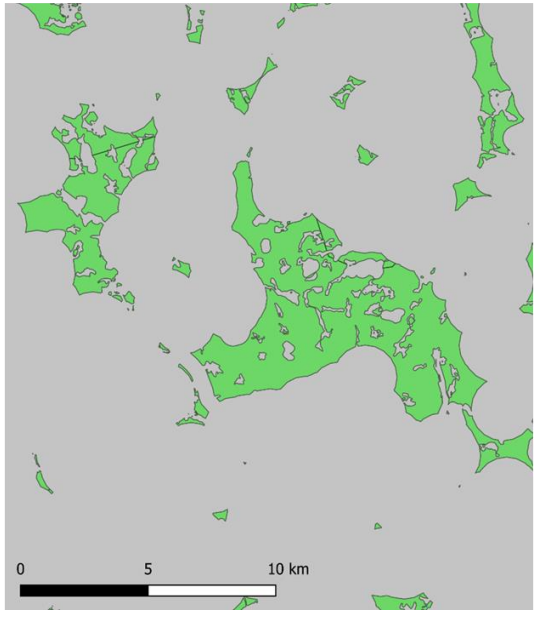
- First, “exclusion zones” are created from geospatial data layers
  - Built-up areas
  - Nature sites
  - Airports
  - Lakes
  - Small islands
  - Shooting ranges
  - Major roads
  - Buildings
  - Border zone
  - Swamp areas
  - …



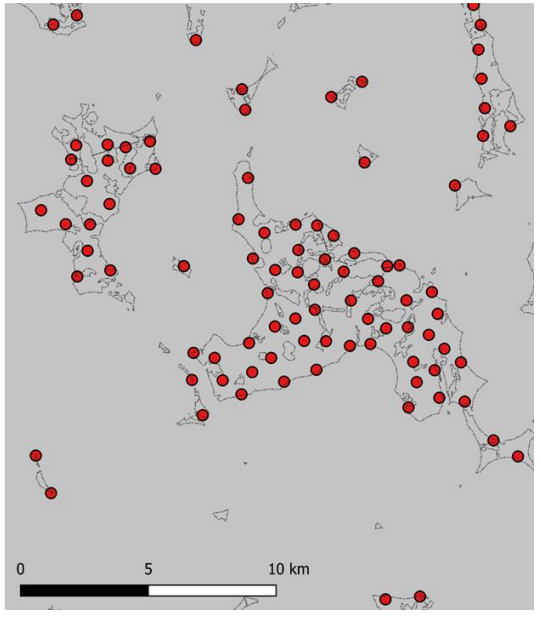
Prohibitive areas




Allowed areas

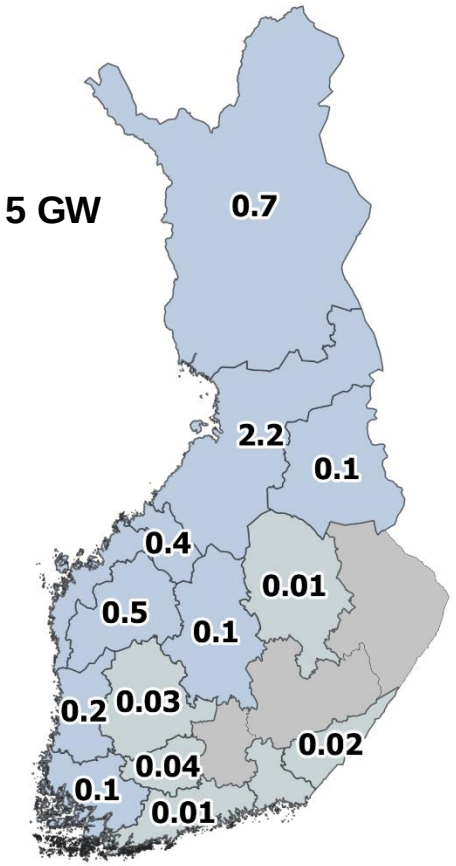



Possible turbine placement

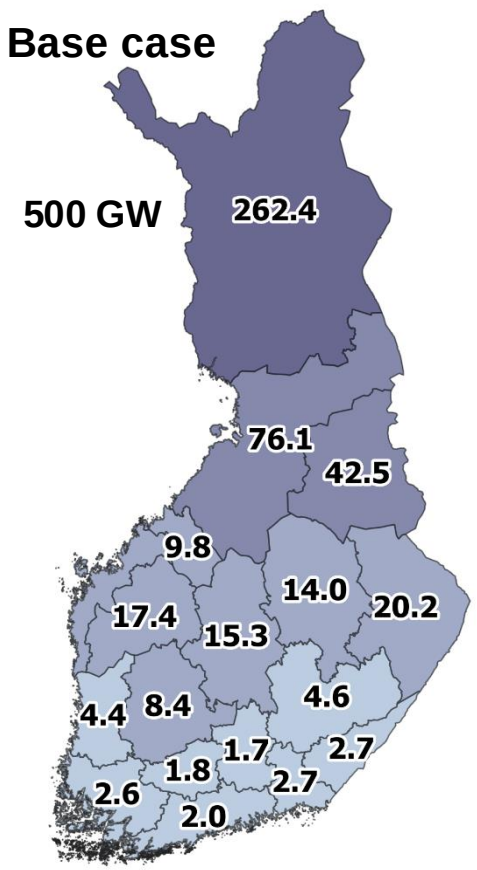


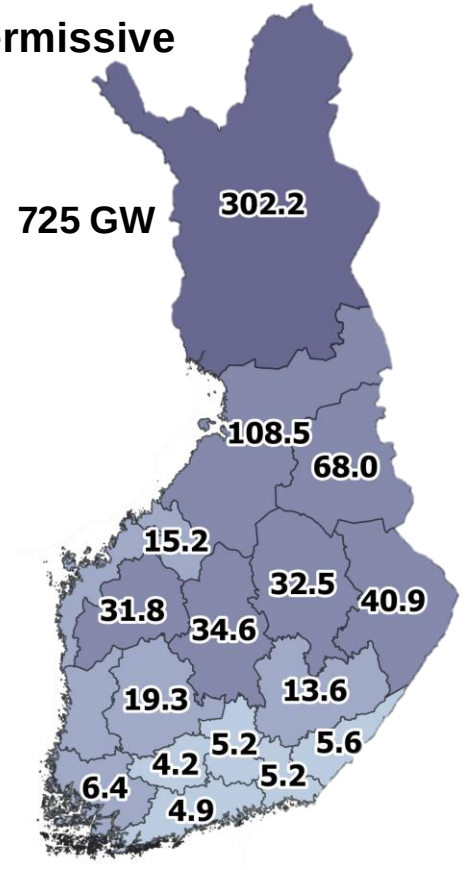
# Theoretical wind potential
(land-use point of view)

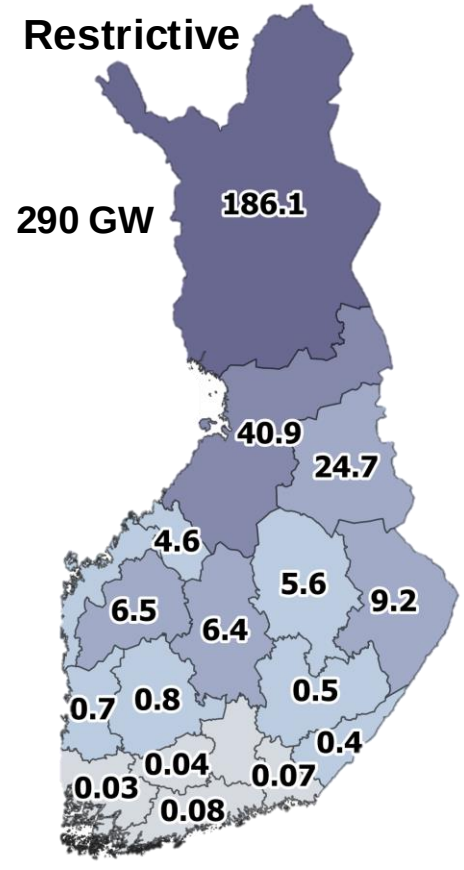
- Current capacity




- Three different scenarios shown
  - High sensitivity to parameter selection
  - Practical and techno-economic limit is likely much lower



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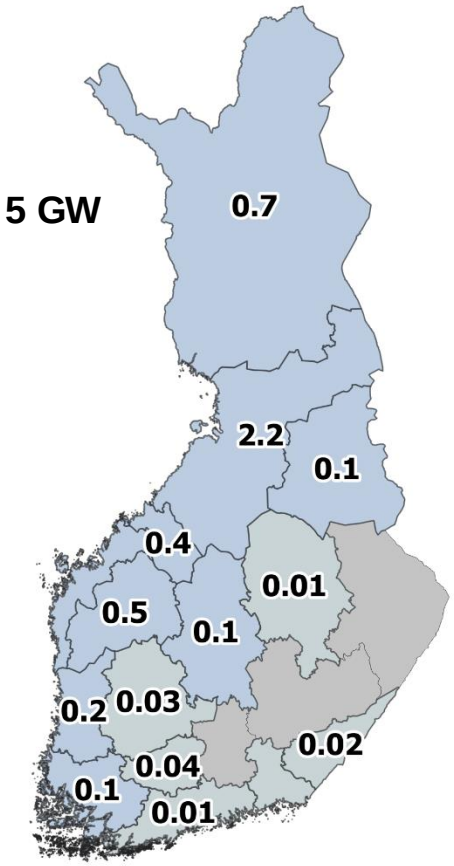


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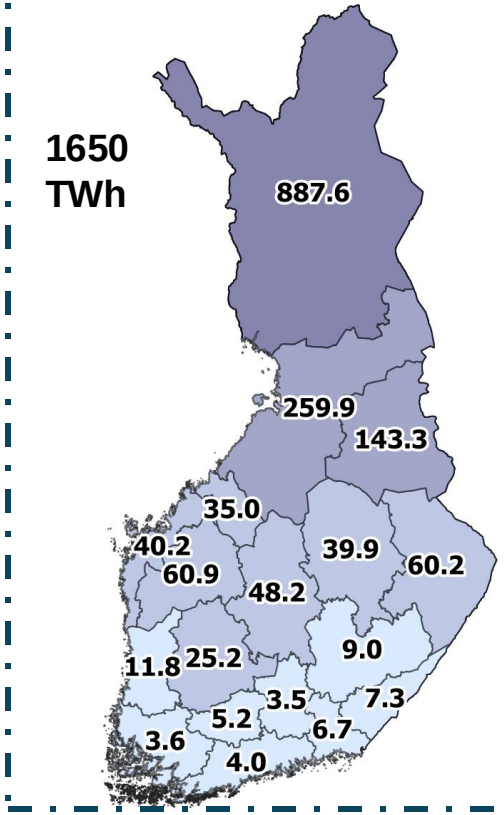
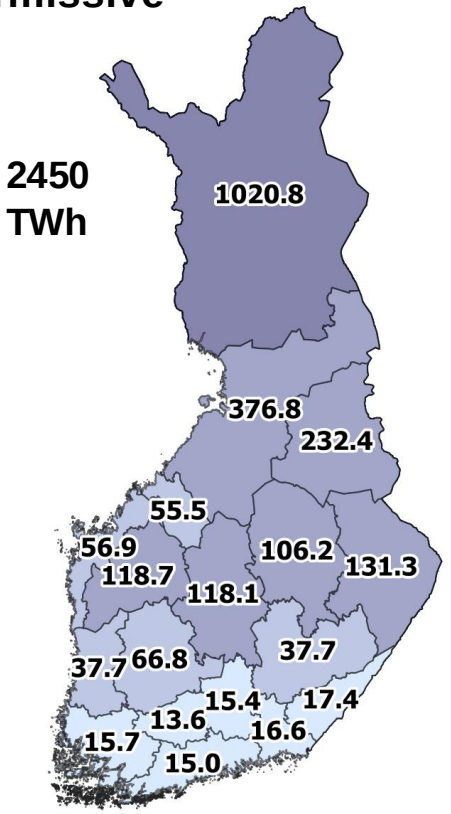
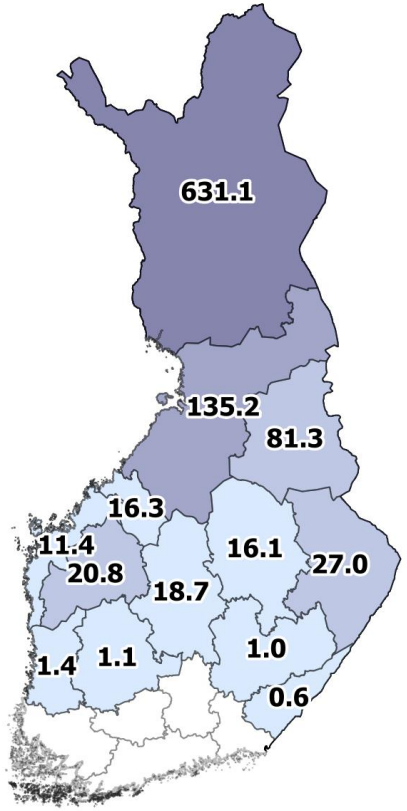
**Base case**




**Permissive**

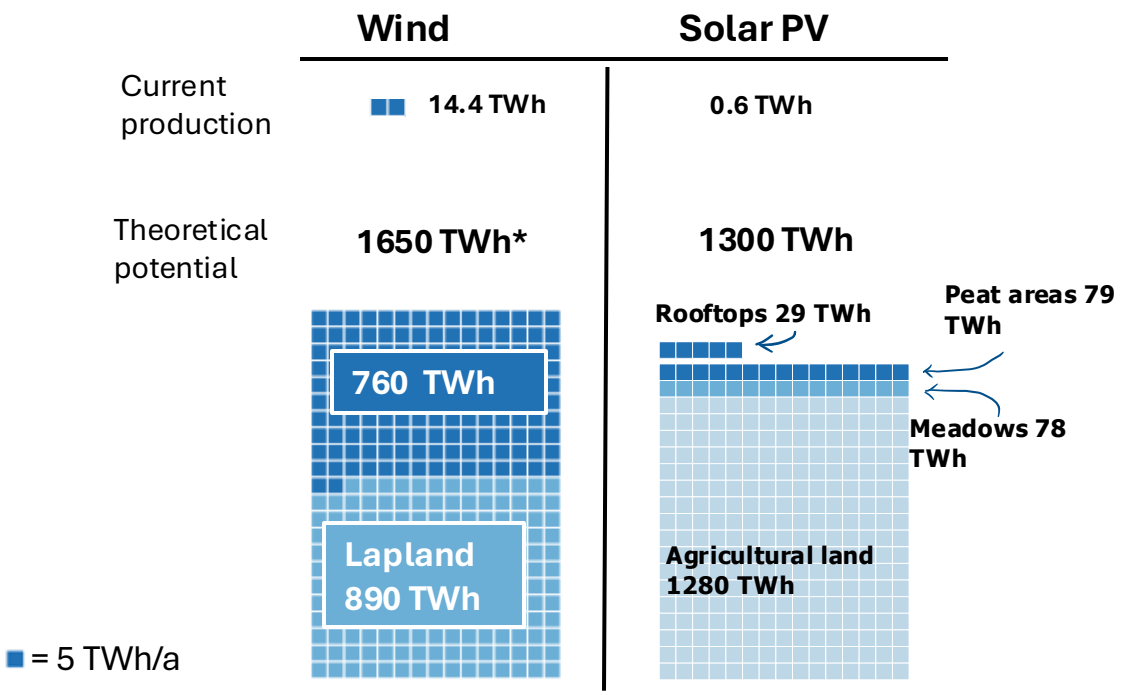


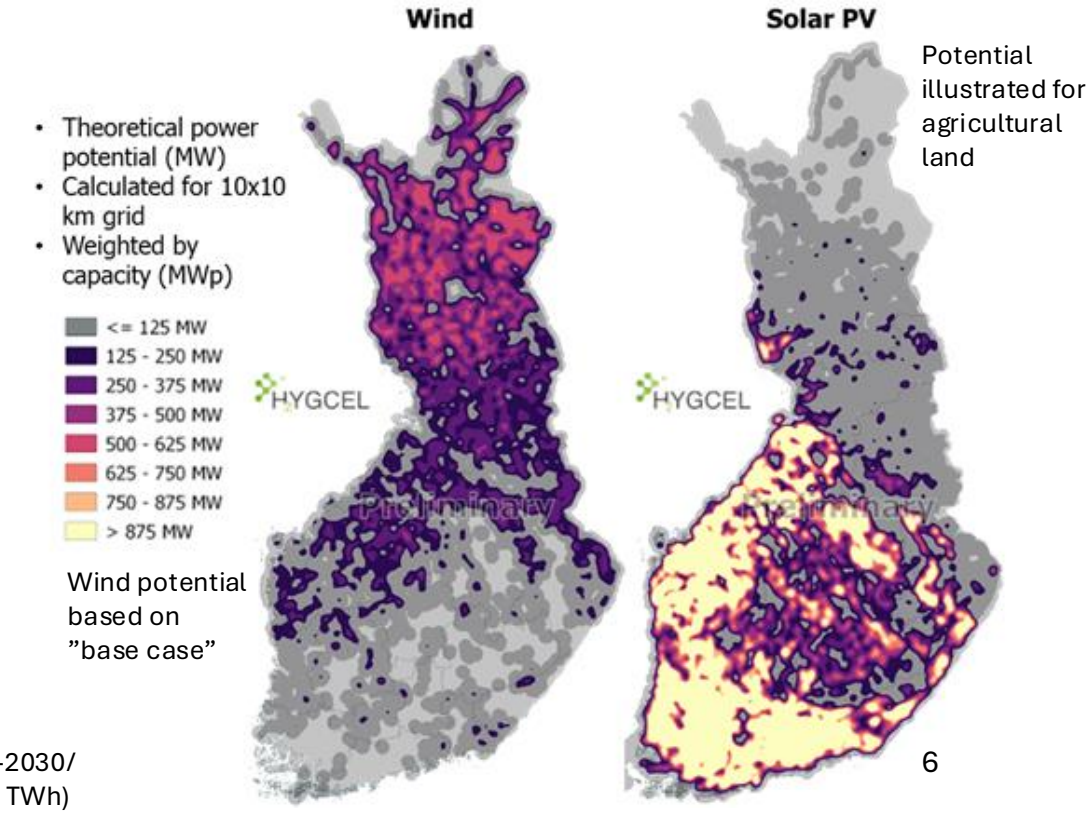

**Restrictive**



# Finland could supply 10% of EU's renewable electricity

- EU electricity demand ~3500 TWh by 2030, ~4500 TWh by 2050 [1]
- Available renewable potential exceeds Finland's domestic energy needs → export strategy needed with EU collaboration
- Finland's renewable power supply will be determined by social acceptance, demand and techno-economics
- Production sites for wind and solar complement each other

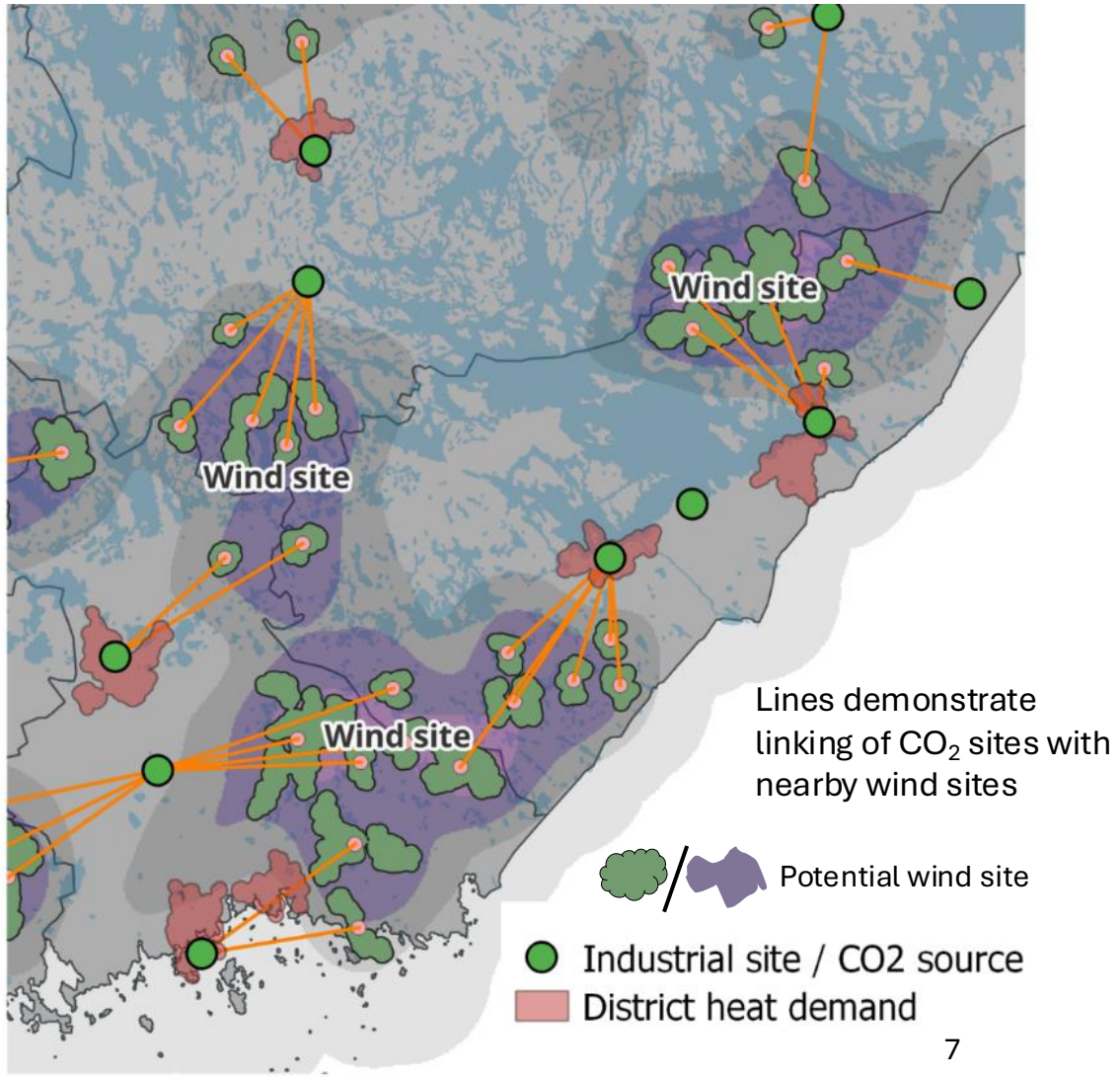



[1] https://www.statista.com/statistics/1418493/electricity-demand-by-sector-and-scenario-european-union-2030/
* based on our "base case"-scenario land-use assumptions (potential in scenarios varied between 700 – 2500 TWh)

# PtX is sensitive to local conditions

- Each location is unique: different constraints and opportunities
- Location and design of an PtX industrial cluster will depend on several factors, like the availability of renewable power or $CO_2$
  - Customized solutions for power supply, hydrogen storages and heat
  - Small production volumes are easier to place
- RFNBO regulation concerning connection requirements will be in a decisive role

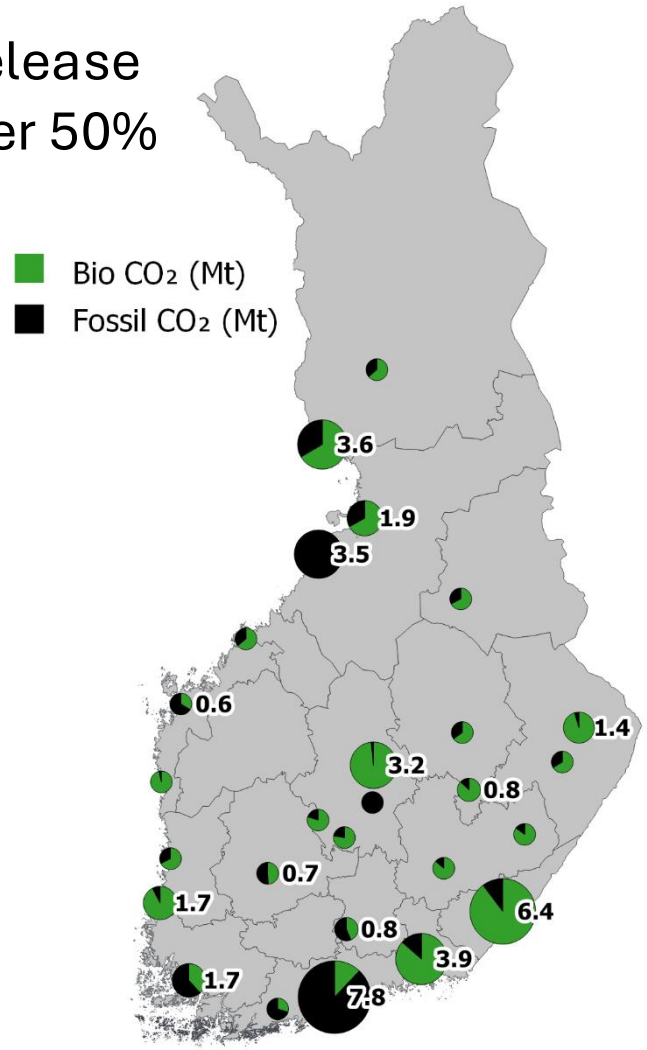


# Carbon dioxide as a resource

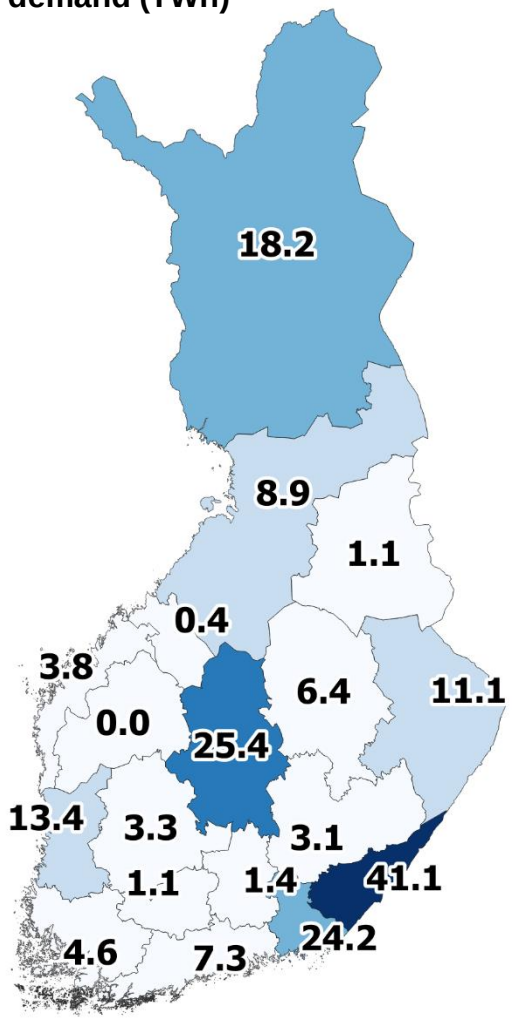
- Large point sources of $CO_2$ in Finland release over 41 Mt of $CO_2$ annually, of which over 50% originates from biomass


- 24 Mt bio-$CO_2$
- 175 $TWh_{el}$

→ $H_xC_x$

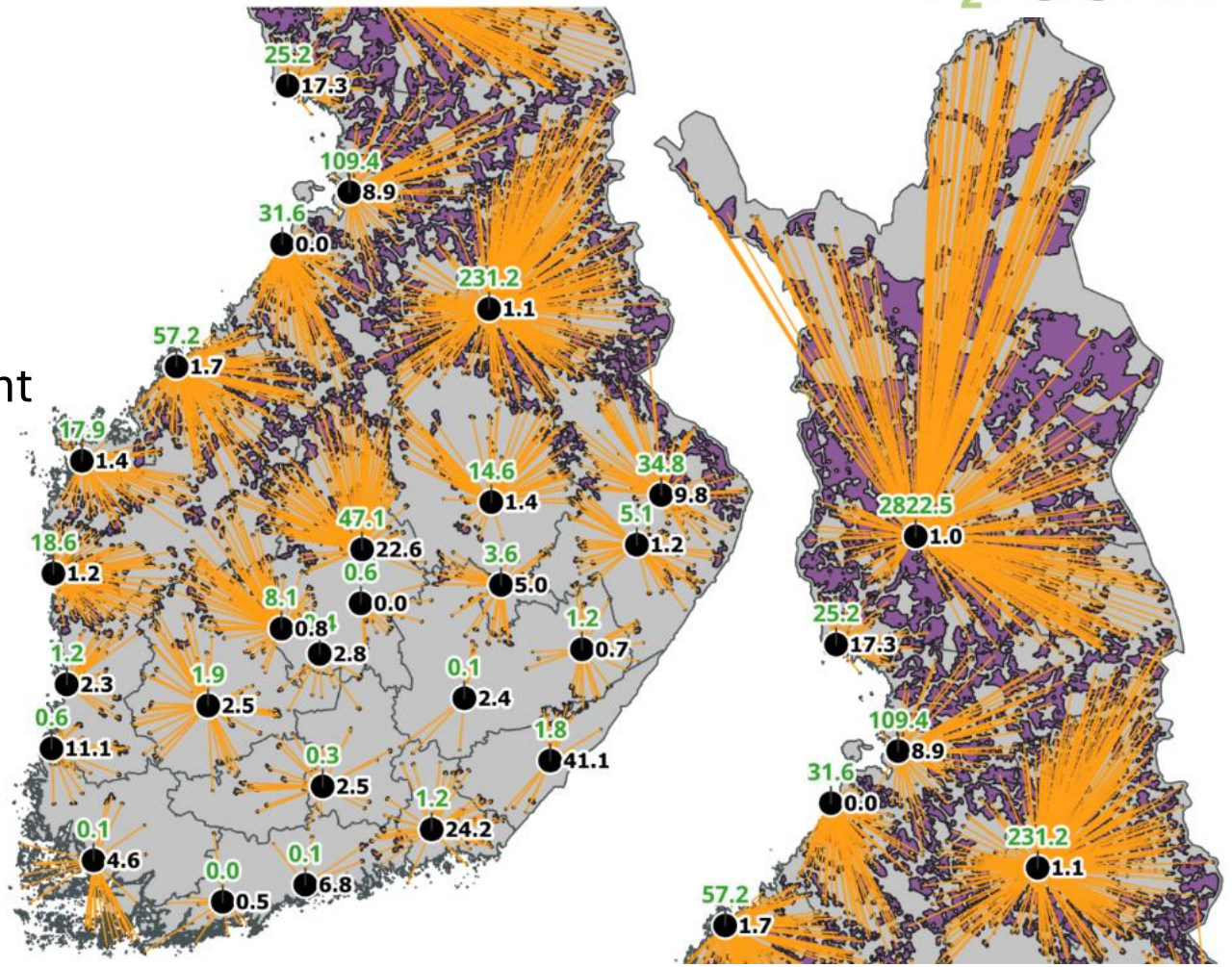



- $BioCO_2$ conversion electricity demand (TWh)



# There are several ways to connect the resources

- Renewable power generation capacity is spread across large areas and unevenly
- A demonstration (orange lines in the figure) was made to connect wind sites and $CO_2$ point sources.
  - Regions of surplus and deficit areas are formed
  - Transport infrastructure is needed
  - Resources might need to be connected from far
- Time window is open for deciding the placement of industrial clusters:
  - National strategies needed to guide the development?

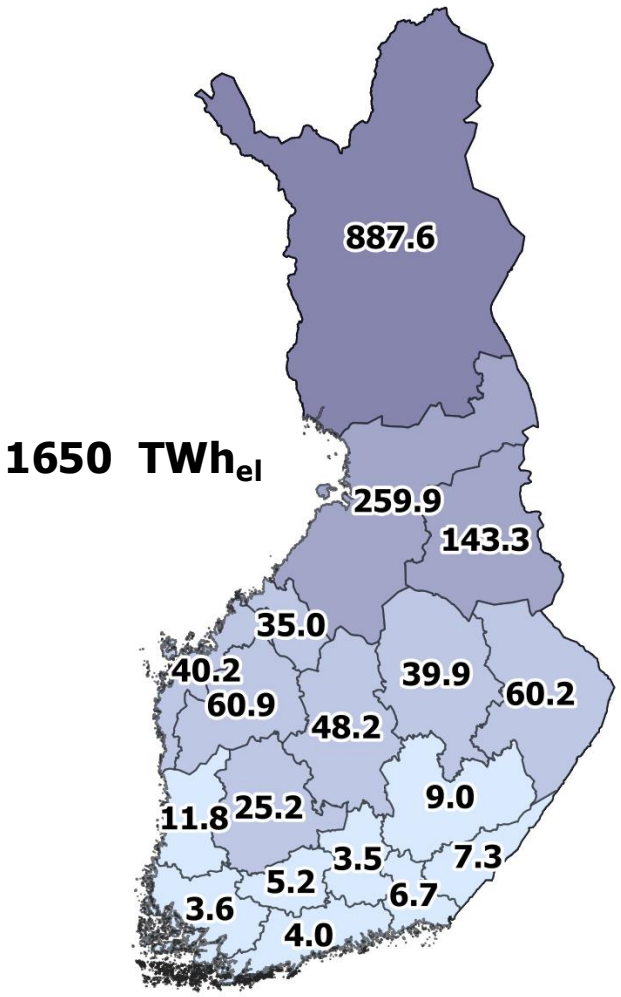



Green: Wind potential (TWh)

Black: $CO_2$ conversion electricity demand (TWh)

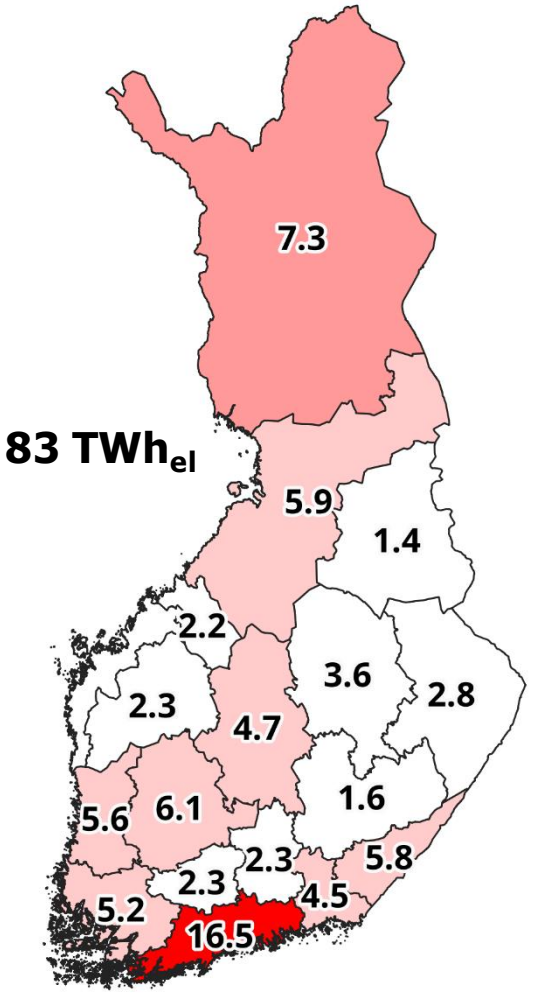
# Electricity balance

**Theoretical wind potential, base case**



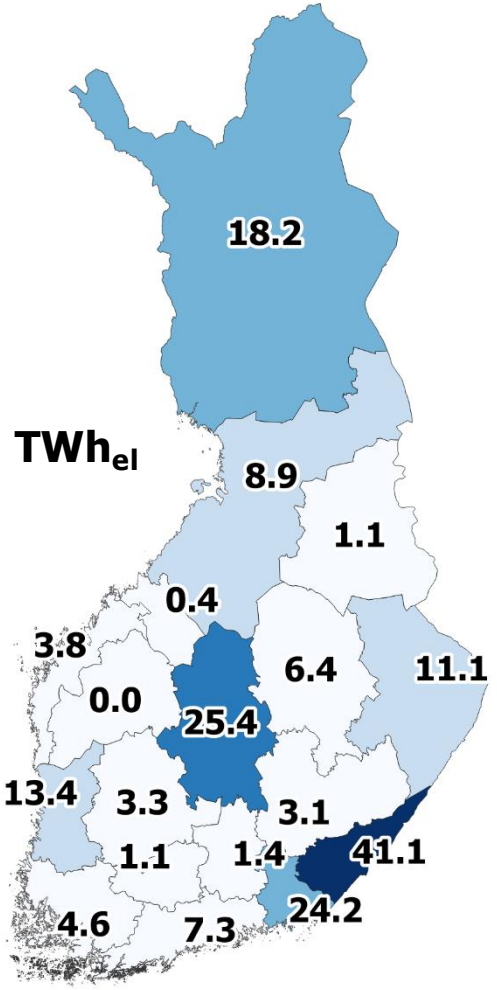

1650 $TWh_{el}$

**Electricity demand, current ($TWh_{el}$)**



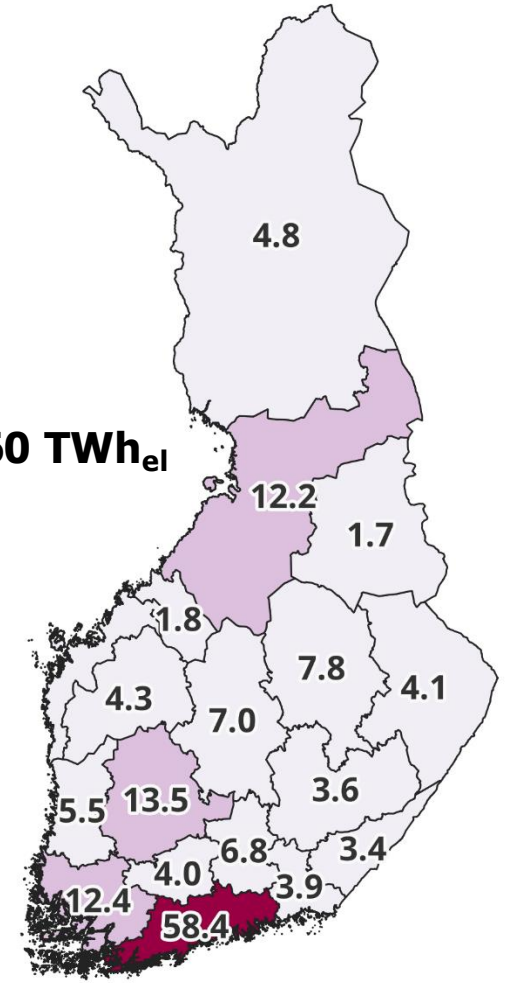

83 $TWh_{el}$

**Bio-$CO_2$ conversion electricity demand ($Twh_{el}$)**




175 $TWh_{el}$

**Electrolyser electricity consumption to fulfill district heat demand ($TWh_{el}$)**




160 $TWh_{el}$

# Finland's distributed PtX resources create unique production locations

**Key messages**

- Renewable power potential is significant, dimensions of sustainability
- Wind and solar resources provide balancing of regional differences
- Wind and solar resources provide temporal balancing
- Local resources are always different, requiring tailored solutions
- Transport of resources will be required, in one form or another