Supplementary materials

Wind power potential in low environmental sensitivity areas of Spain: a regional assessment*

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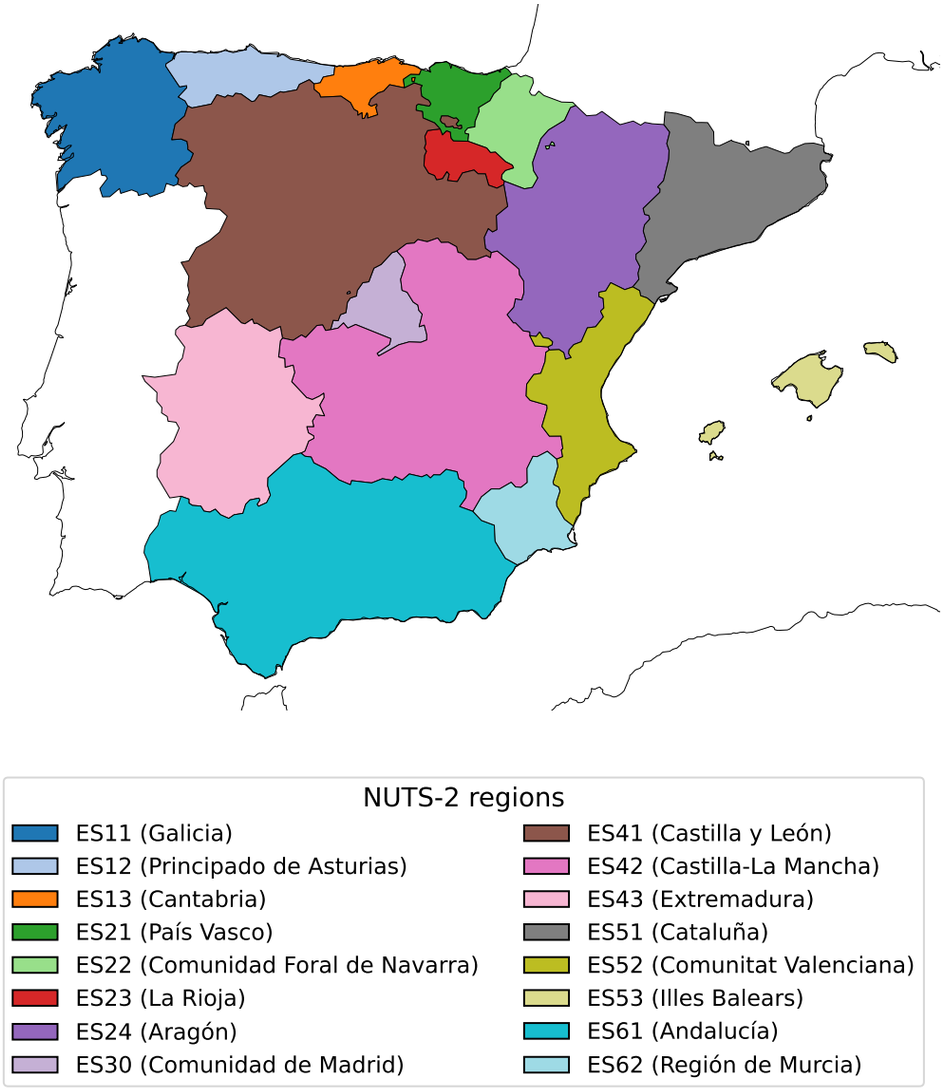
*Preprint - not peer reviewed. This manuscript may be submitted to a journal.
DOI: https://doi.org/10.5281/zenodo.18196580

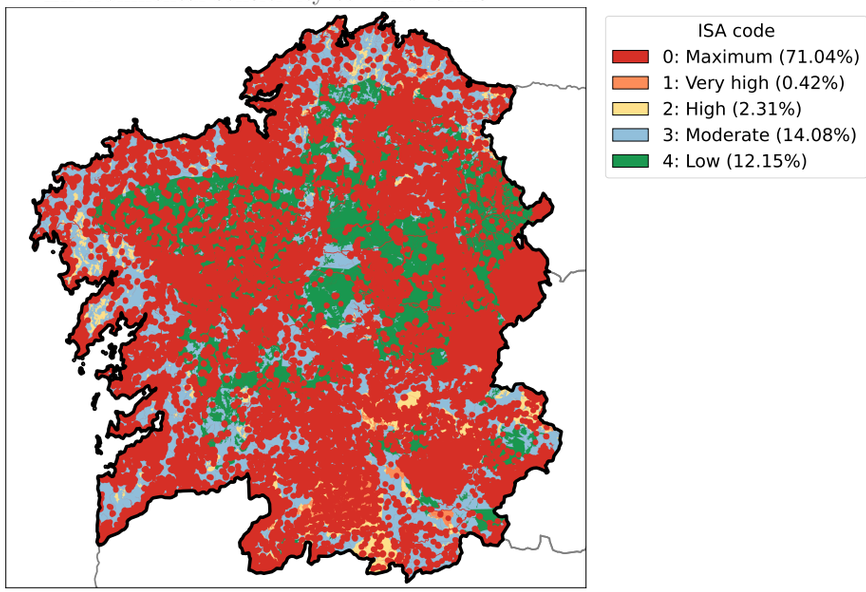
Summary of main hypotheses:

- The environmental sensitivity assessment is based on the ISA index performed by MITECO (link). Here, the potential in "Low sensitivity" areas, corresponding to the lowest of the five defined ISA classes, is estimated. However, low sensitivity does not imply that an environmental impact assessment is unnecessary for wind farm development. Wind farms may also be located in other ISA classes following a preliminary environmental impact assessment.
- Wind resource from the New European Wind Atlas, wind speed at 100 m height, year 2013.
- Software: atlite
- Wind power density: 10 MW/km^2
- Power curve from wind turbine model: Vestas V112–3 MW.
- Correction factor to account for wind farm losses: 0.93
- Capacity factor threshold: 0.30 ($\sim$ 2 600 equiv. hours)

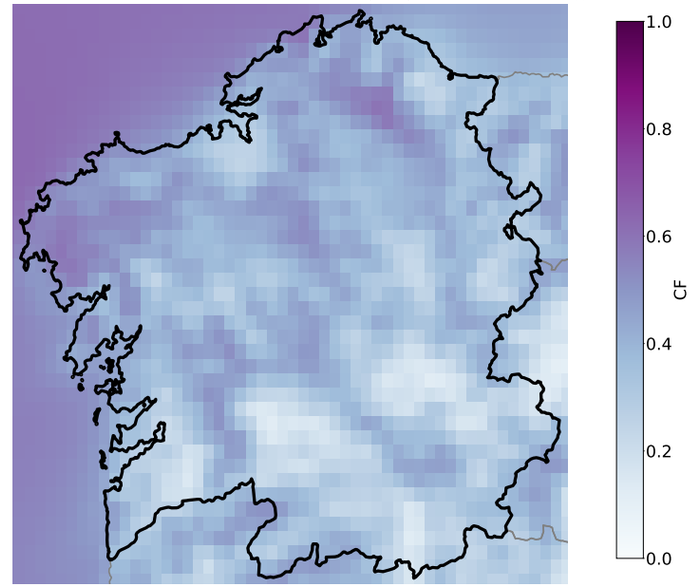


Galicia (ES11)

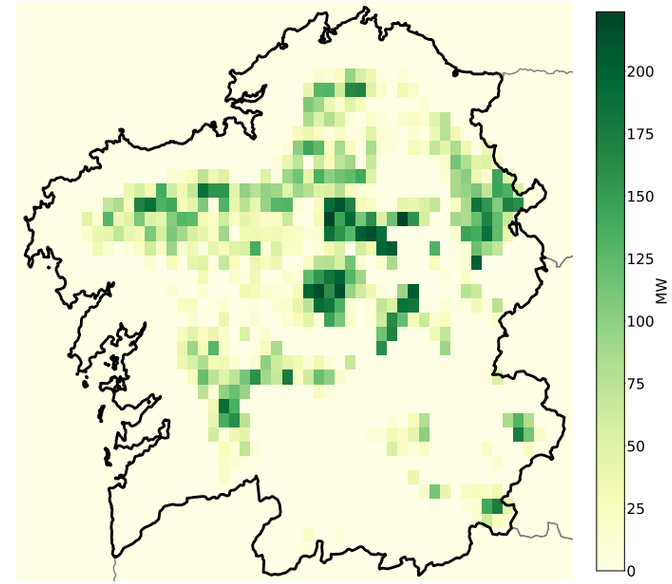
Environmental sensitivity to wind farms



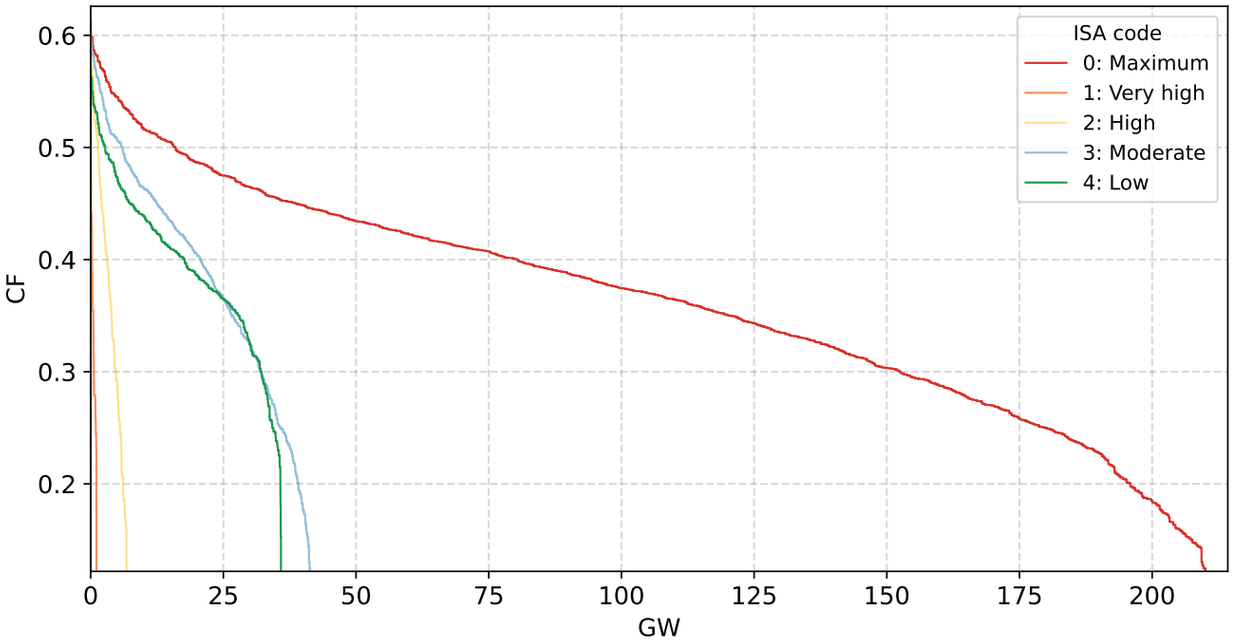
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



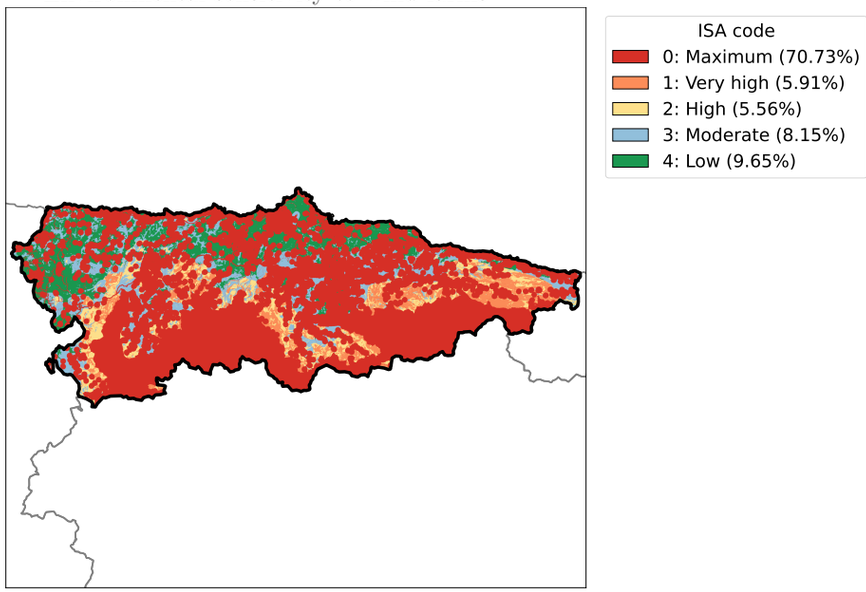
Wind power potential vs. capacity factor



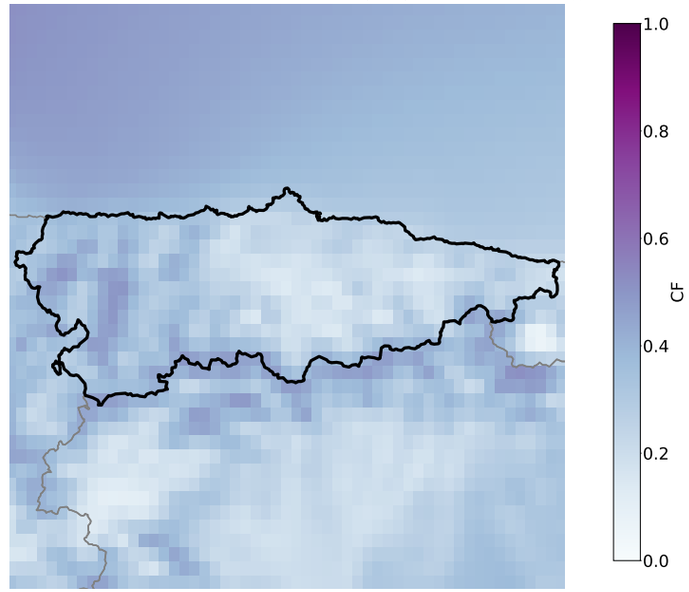
- **LAND:** **10.86%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **32.1 GW** could be installed in these areas. Installed wind power capacity in Galicia in Dec/2024 was **3.89 GW**.
- **ENERGY:** **115.6 TWh** could be generated with this potential capacity. This represents around **865%** of the actual electricity demand in the region.

Principado de Asturias (ES12)

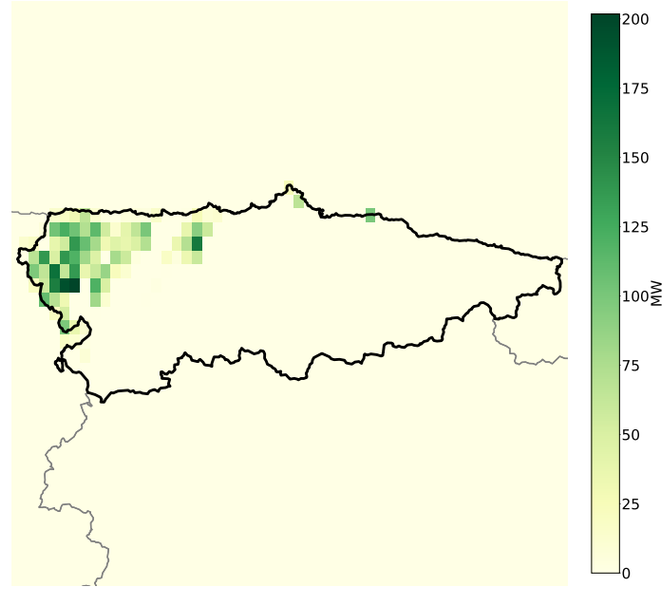
Environmental sensitivity to wind farms



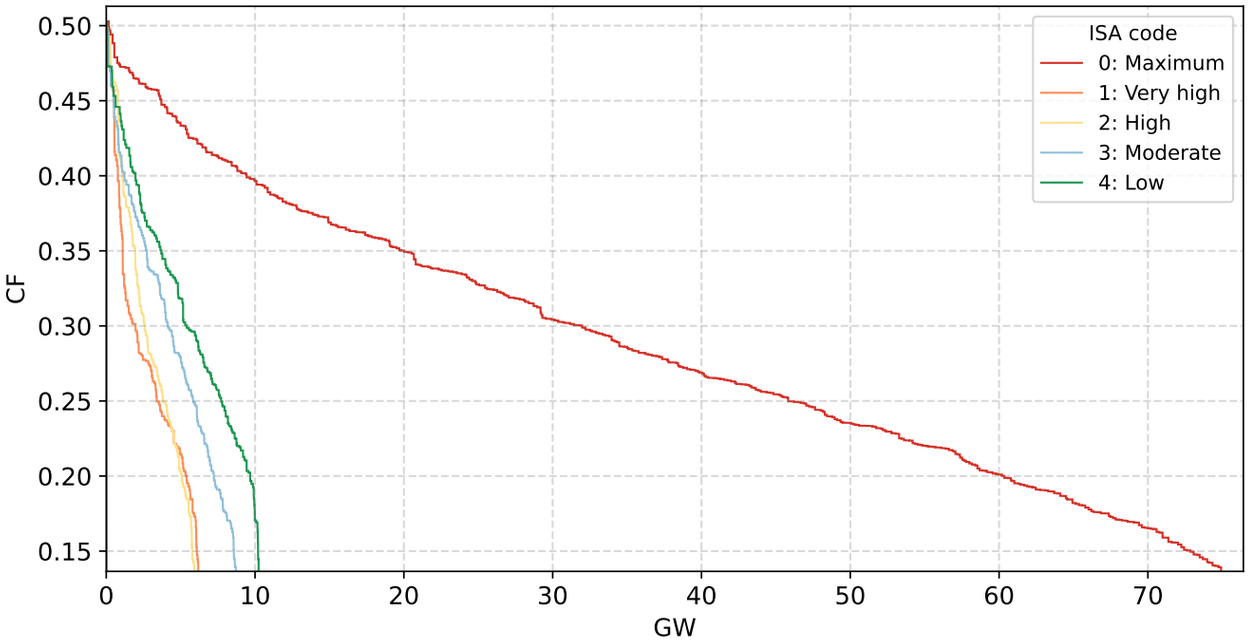
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



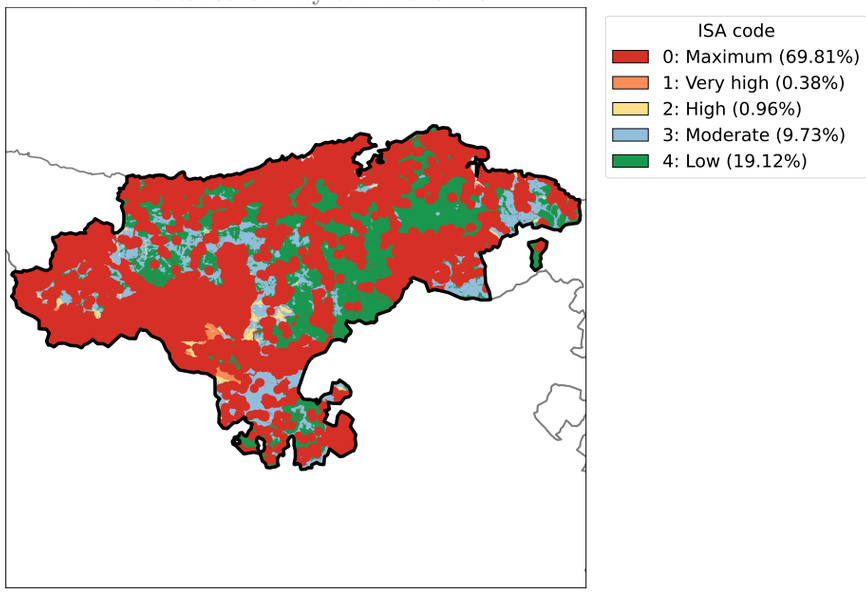
Wind power potential vs. capacity factor



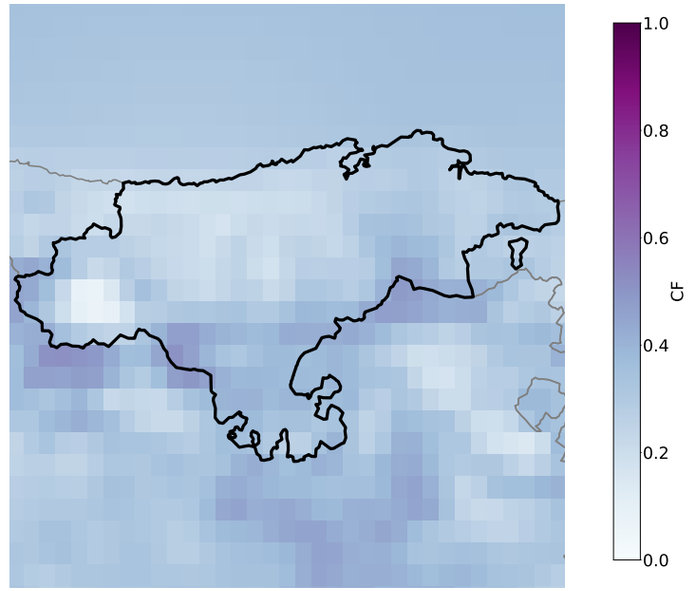
- **LAND:** **5.1%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **5.41 GW** could be installed in these areas.
  Installed wind power capacity in Principado de Asturias in Dec/2024 was **0.7 GW**.
- **ENERGY:** **18.08 TWh** could be generated with this potential capacity.
  This represents around **199%** of the actual electricity demand in the region.

Cantabria (ES13)

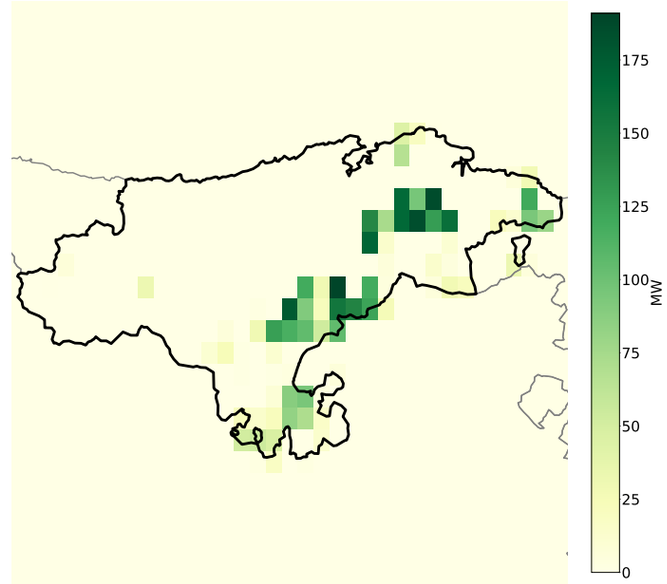
Environmental sensitivity to wind farms



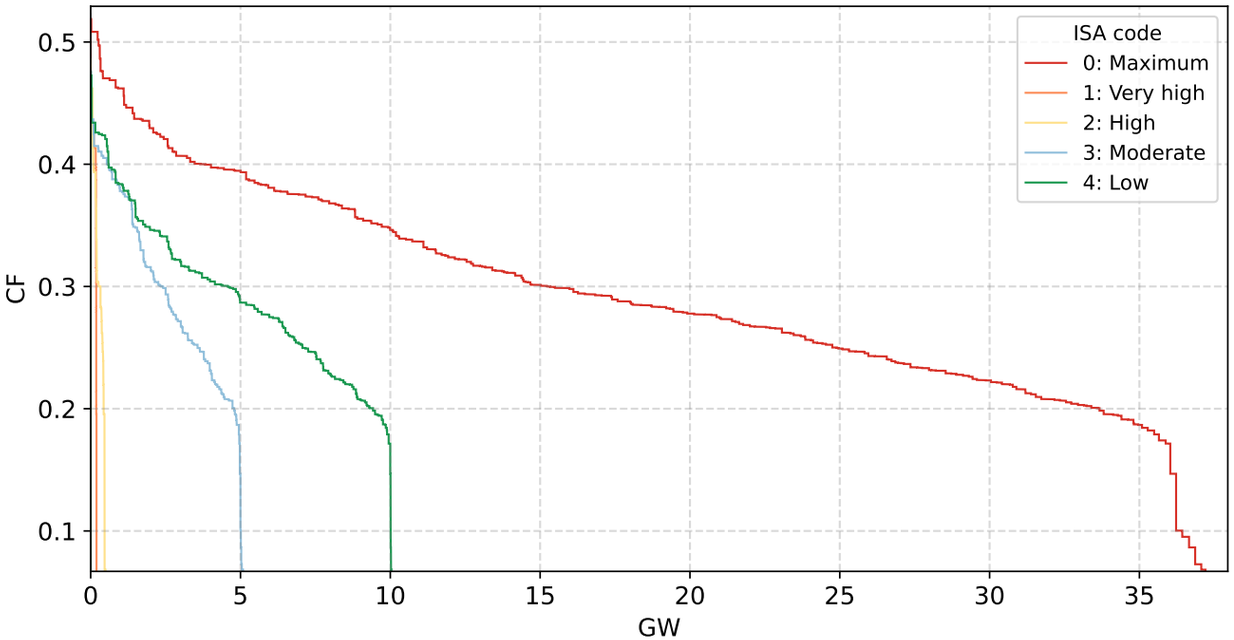
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



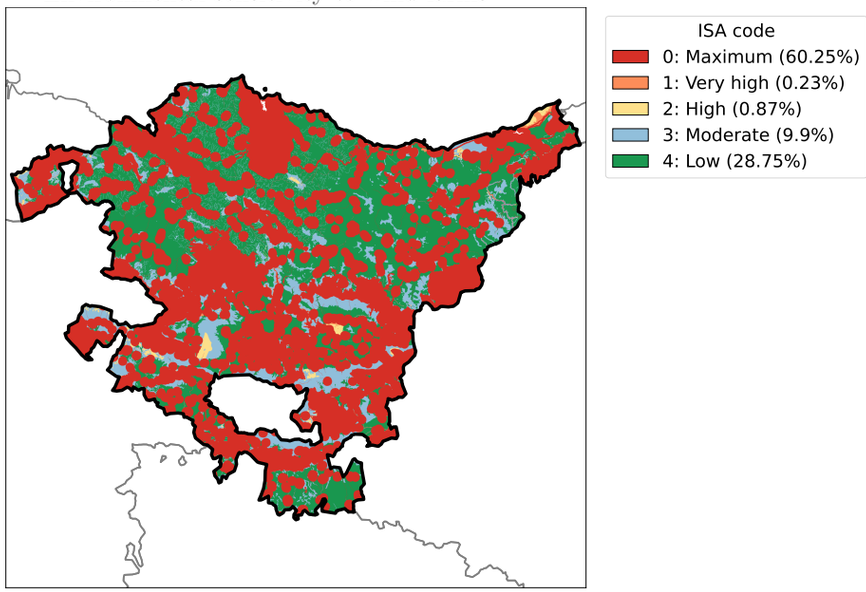
Wind power potential vs. capacity factor



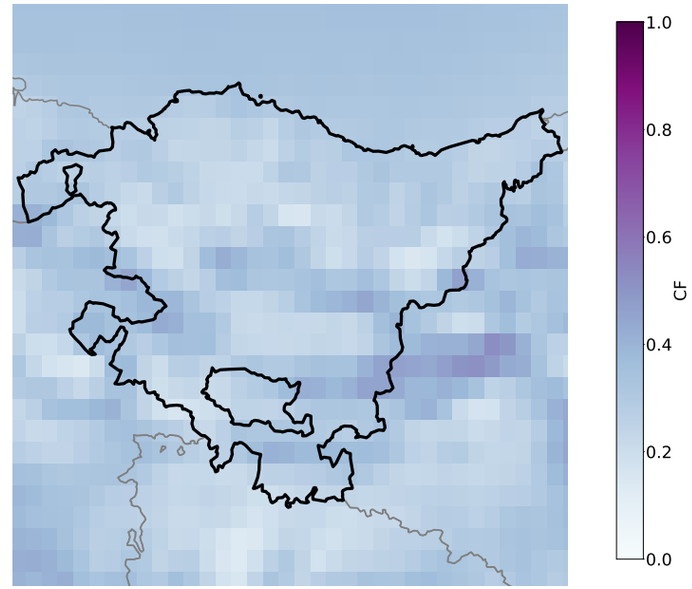
- **LAND:** **8.59%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **4.58 GW** could be installed in these areas.
  Installed wind power capacity in Cantabria in Dec/2024 was **0.04 GW**.
- **ENERGY:** **13.99 TWh** could be generated with this potential capacity.
  This represents around **380%** of the actual electricity demand in the region.

País Vasco (ES21)

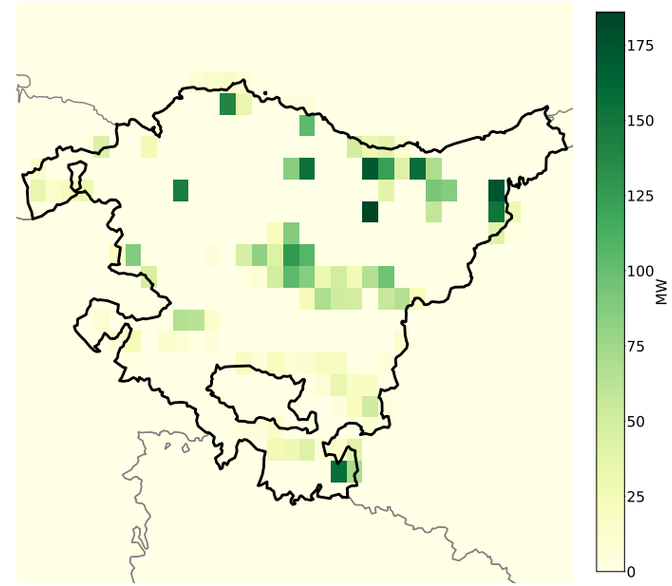
Environmental sensitivity to wind farms



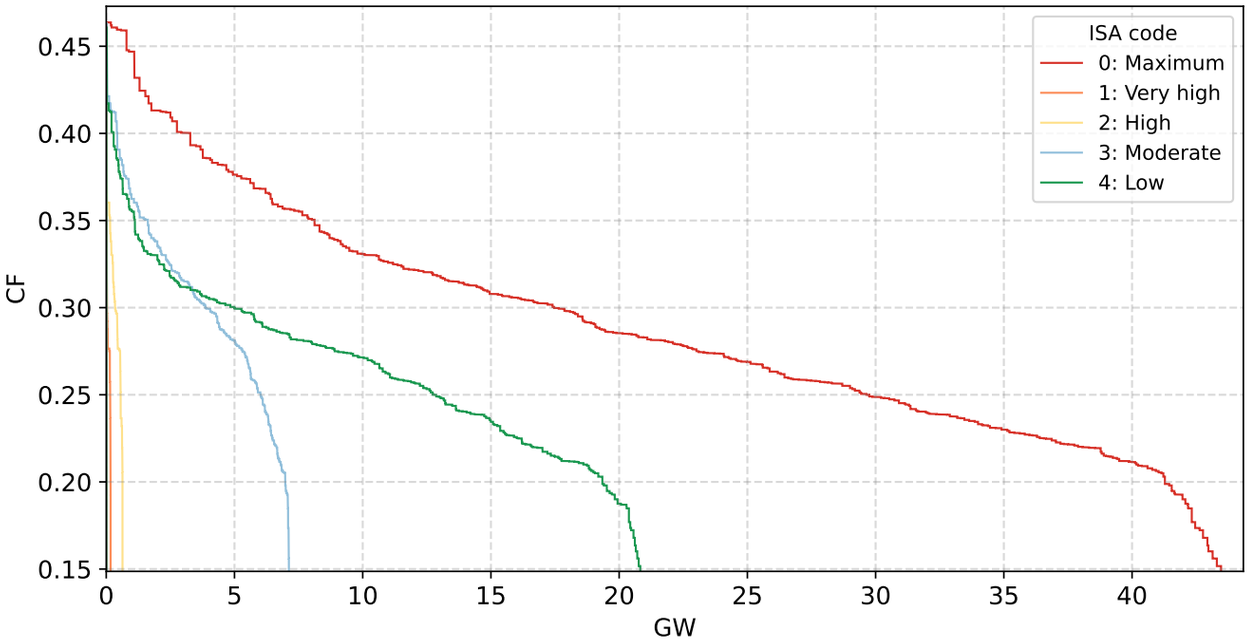
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



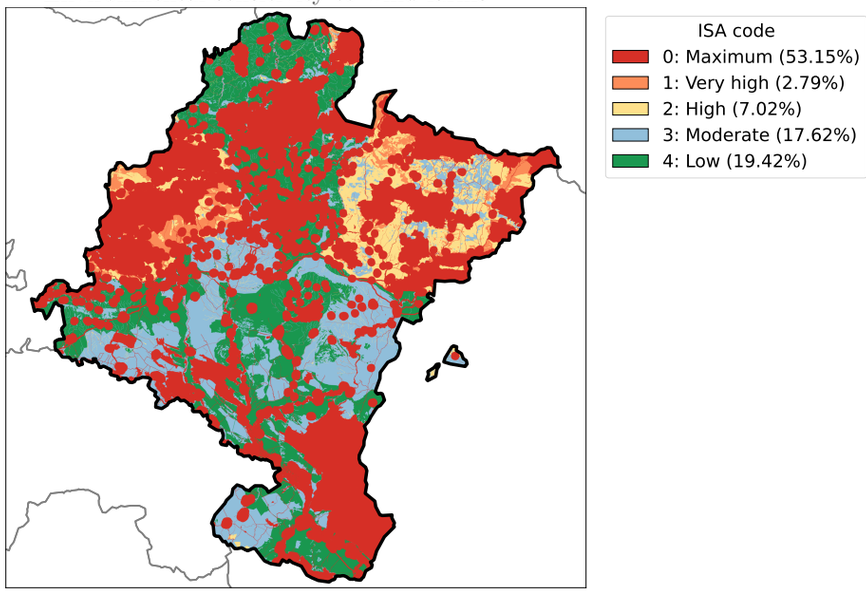
Wind power potential vs. capacity factor



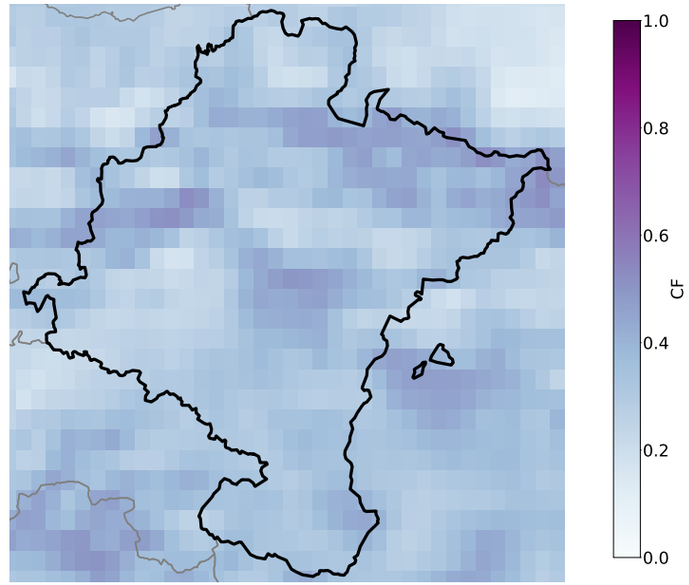
- **LAND:** **6.91%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **5.0 GW** could be installed in these areas.
  Installed wind power capacity in País Vasco in Dec/2024 was **0.15 GW**.
- **ENERGY:** **14.46 TWh** could be generated with this potential capacity.
  This represents around **93%** of the actual electricity demand in the region.

Comunidad Foral de Navarra (ES22)

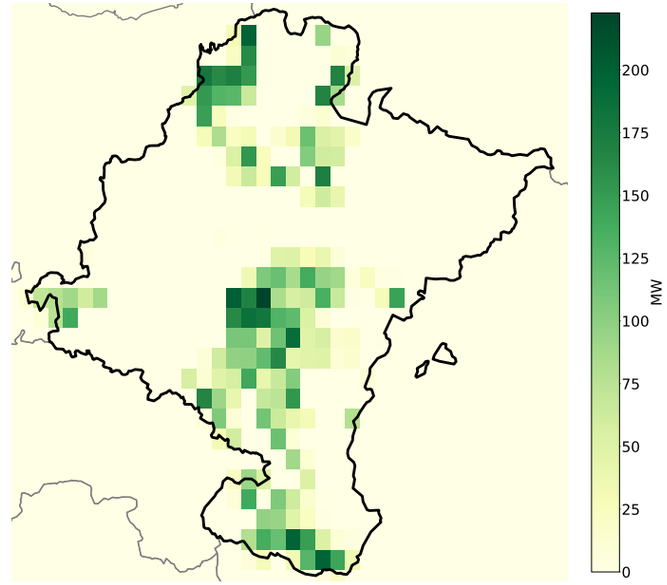
Environmental sensitivity to wind farms



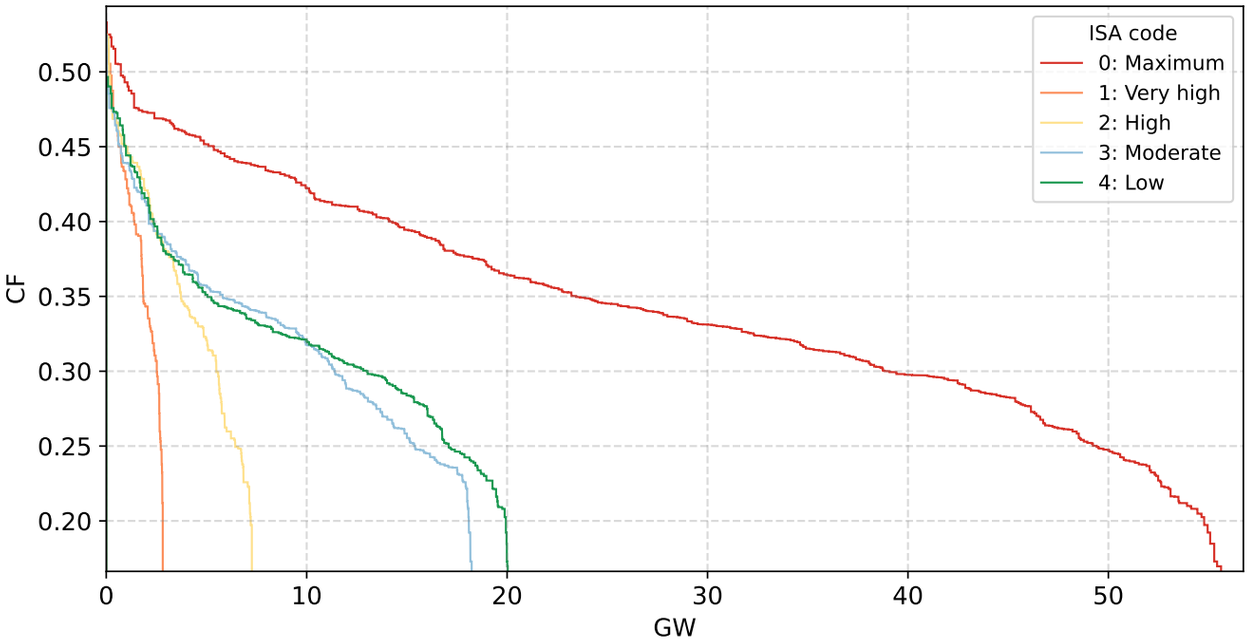
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



Wind power potential vs. capacity factor



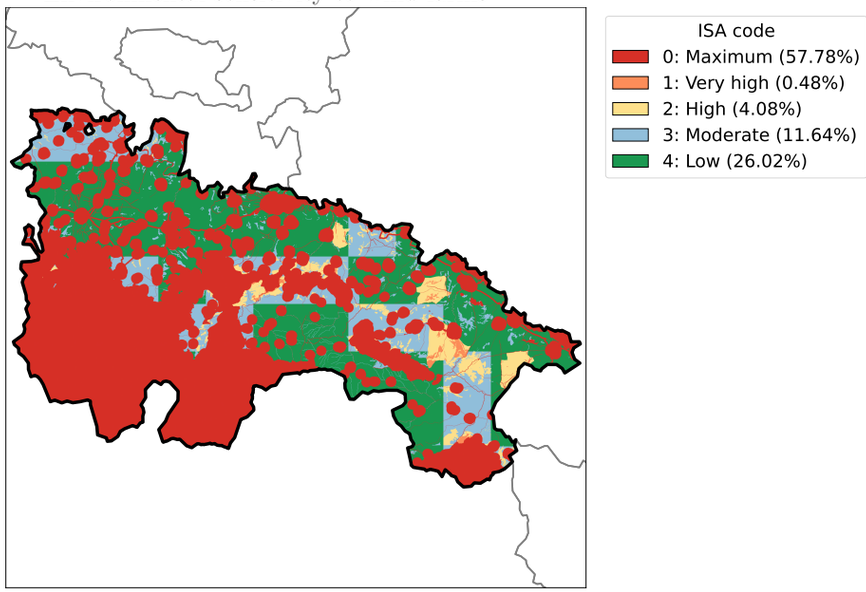
- **LAND:** **12.55%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **13.04 GW** could be installed in these areas.

  Installed wind power capacity in Comunidad Foral de Navarra in Dec/2024 was **1.36 GW**.
- **ENERGY:** **40.64 TWh** could be generated with this potential capacity.

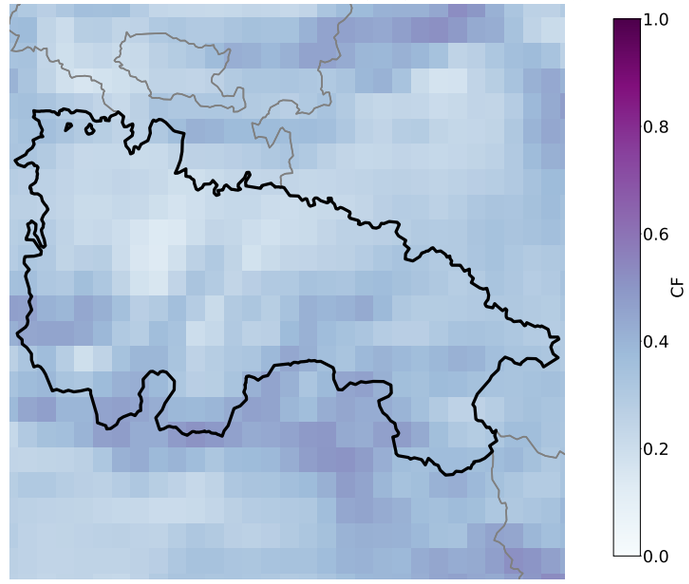
  This represents around **788%** of the actual electricity demand in the region.

La Rioja (ES23)

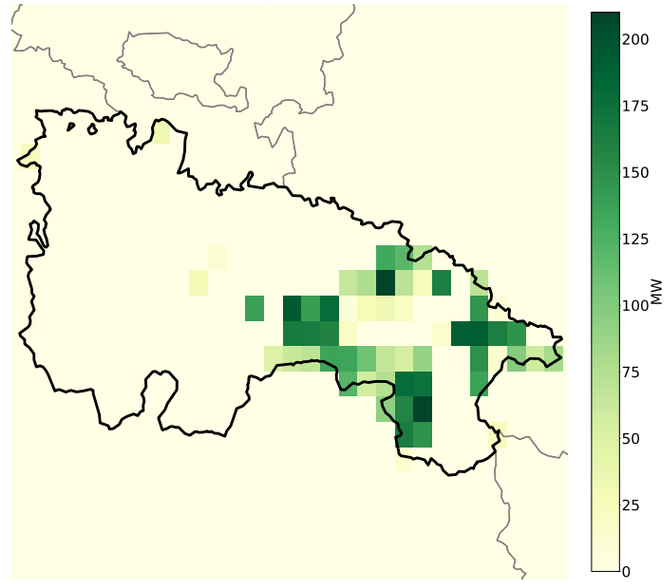
Environmental sensitivity to wind farms



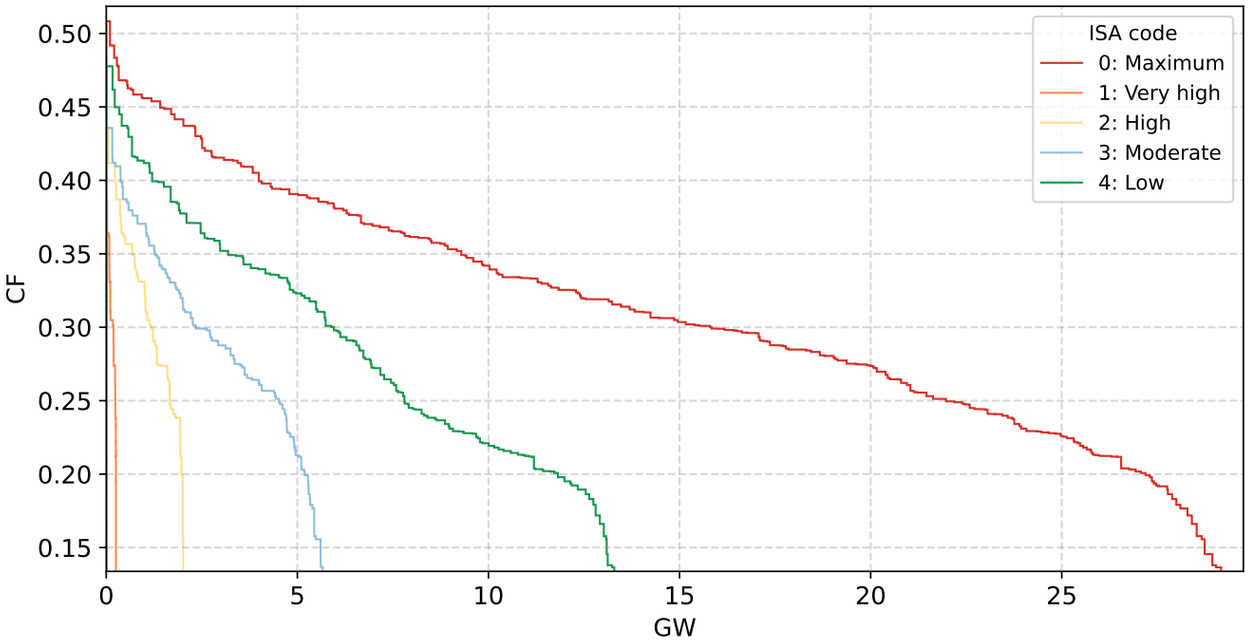
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



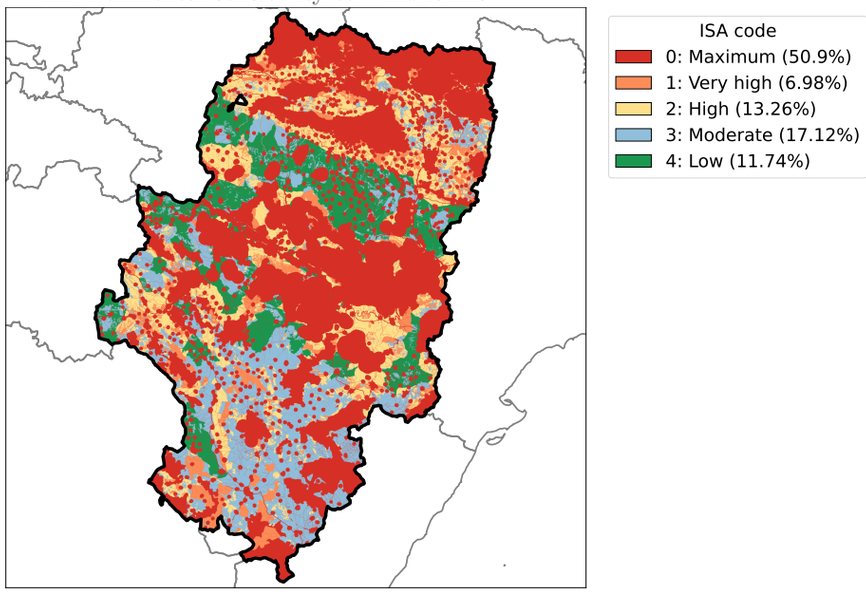
Wind power potential vs. capacity factor



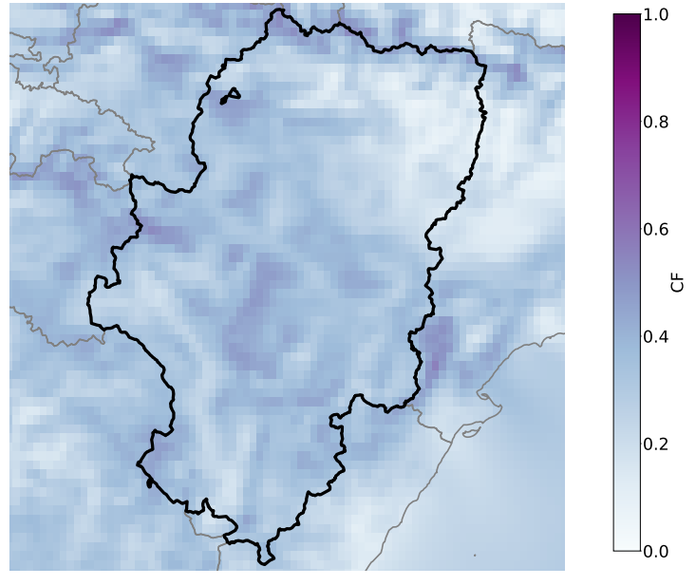
- **LAND:** **11.8%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **5.96 GW** could be installed in these areas. Installed wind power capacity in La Rioja in Dec/2024 was **0.45 GW**.
- **ENERGY:** **19.09 TWh** could be generated with this potential capacity. This represents around **1204%** of the actual electricity demand in the region.

Aragón (ES24)

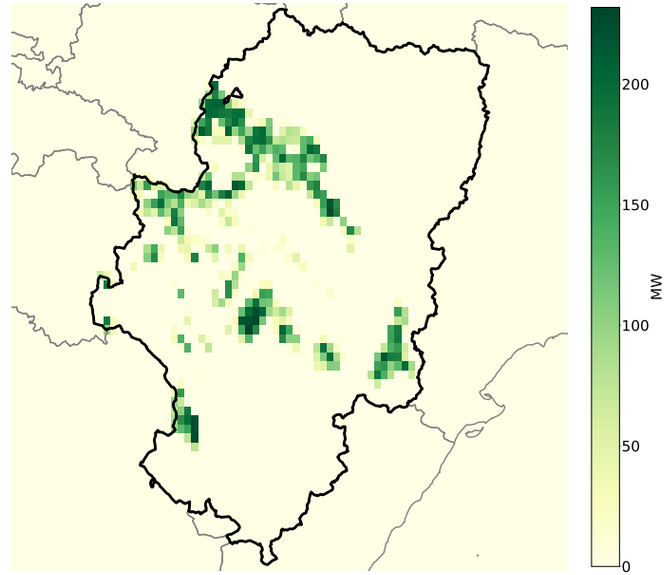
Environmental sensitivity to wind farms



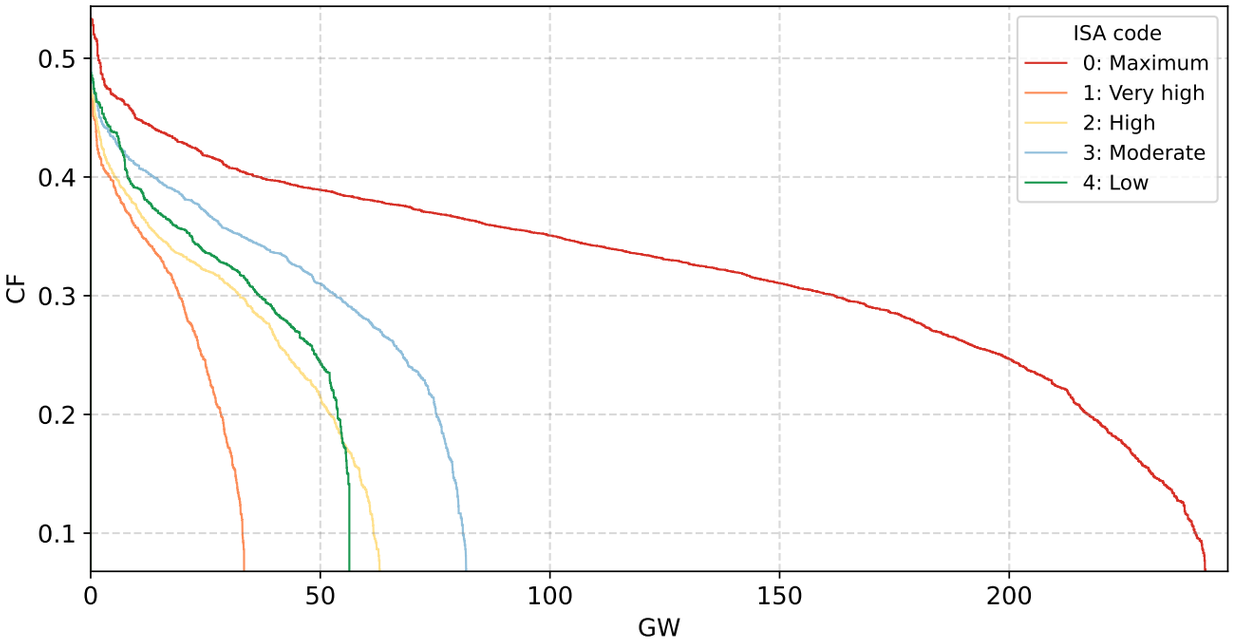
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



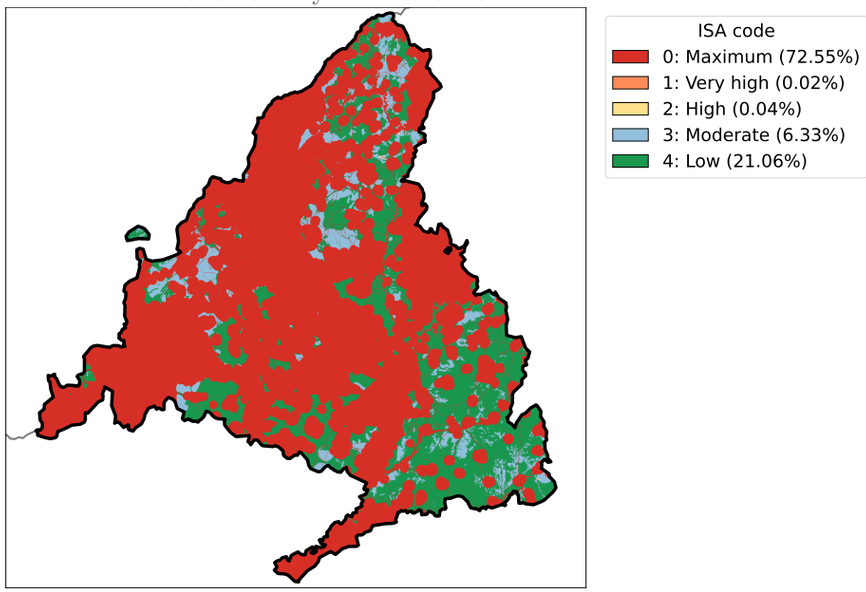
Wind power potential vs. capacity factor



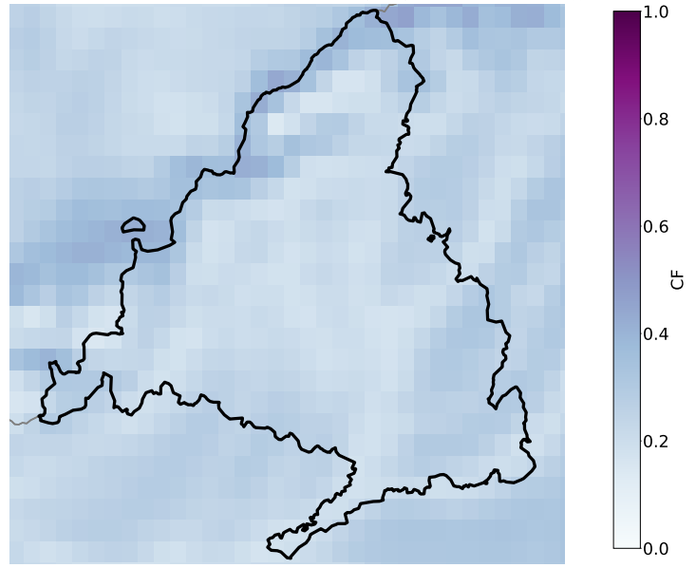
- **LAND:** **7.7%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **36.76 GW** could be installed in these areas.
  Installed wind power capacity in Aragón in Dec/2024 was **5.04 GW**.
- **ENERGY:** **118.86 TWh** could be generated with this potential capacity.
  This represents around **1159%** of the actual electricity demand in the region.

Comunidad de Madrid (ES30)

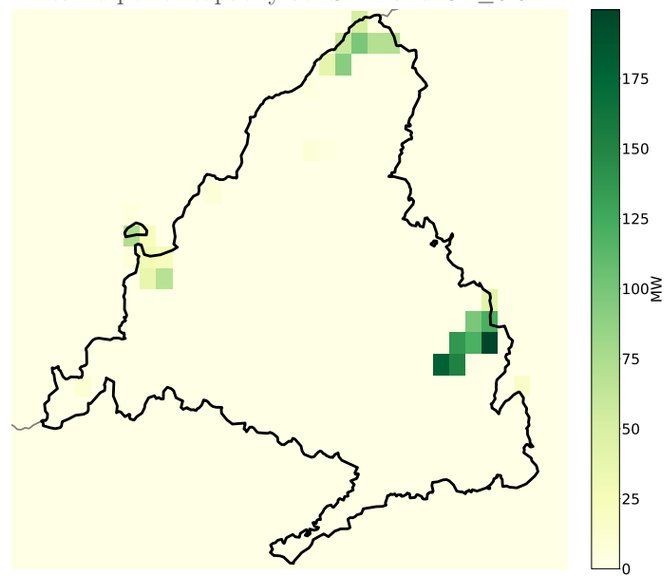
Environmental sensitivity to wind farms



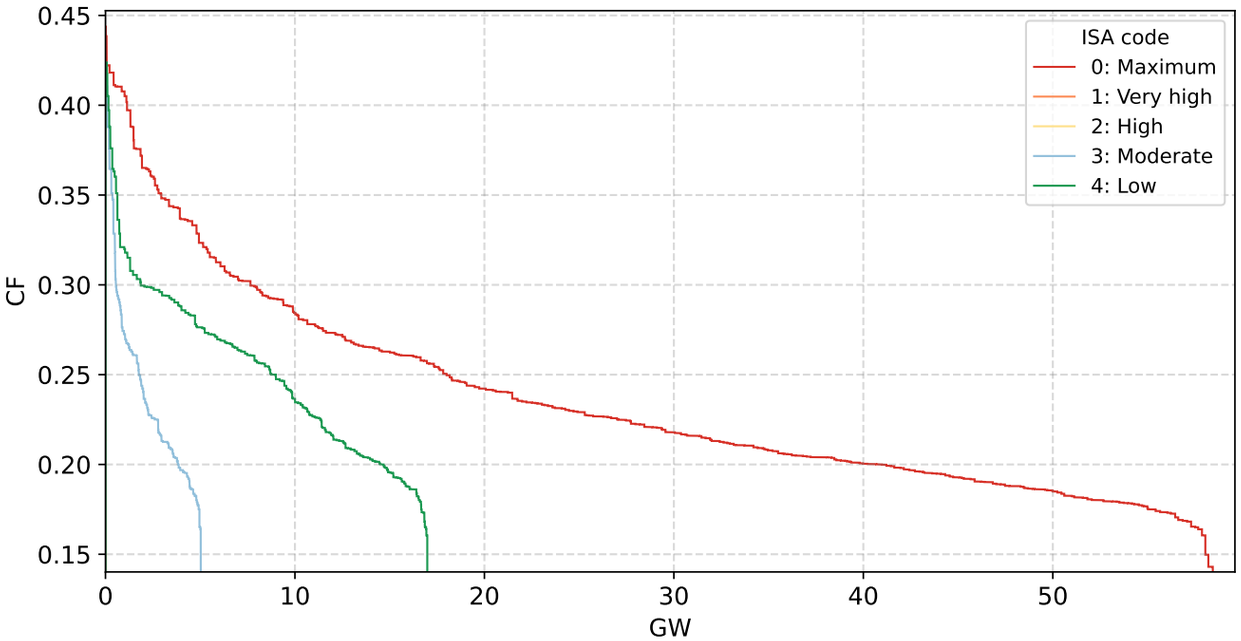
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



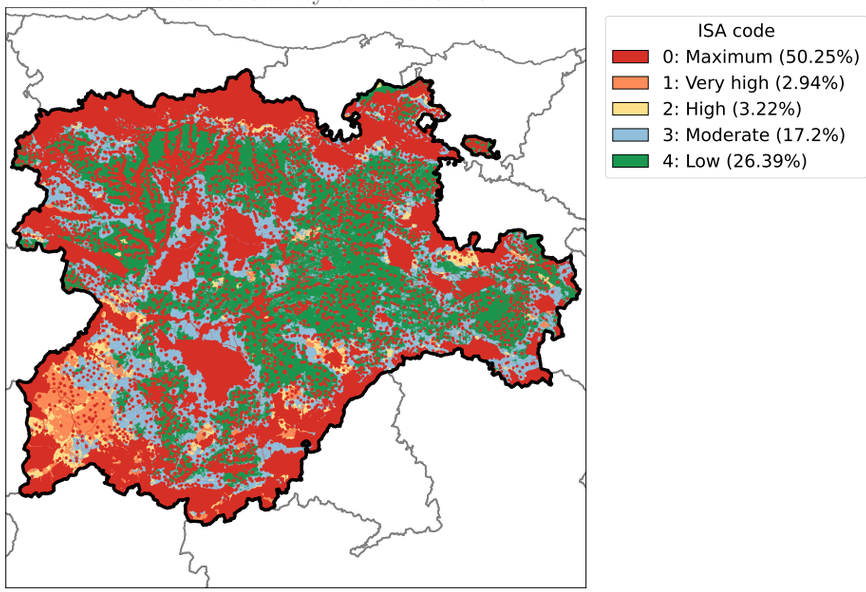
Wind power potential vs. capacity factor



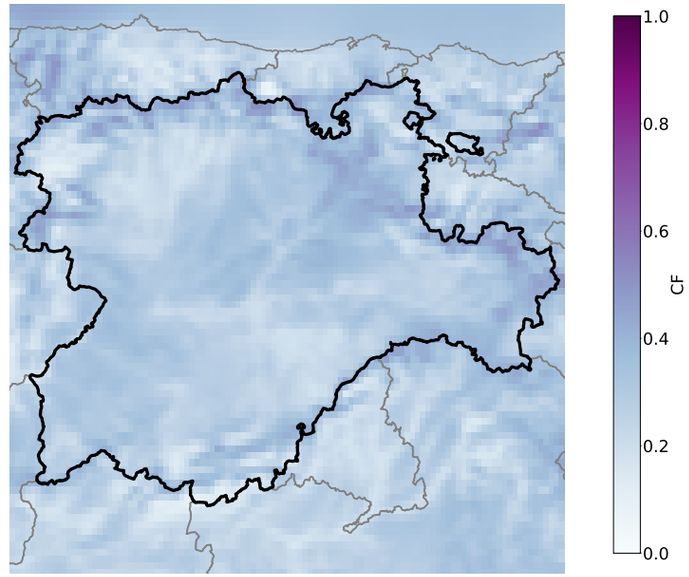
- **LAND:** **2.32%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **1.86 GW** could be installed in these areas.
  Installed wind power capacity in Comunidad de Madrid in Dec/2024 was **0.0 GW**.
- **ENERGY:** **5.5 TWh** could be generated with this potential capacity.
  This represents around **20%** of the actual electricity demand in the region.

Castilla y León (ES41)

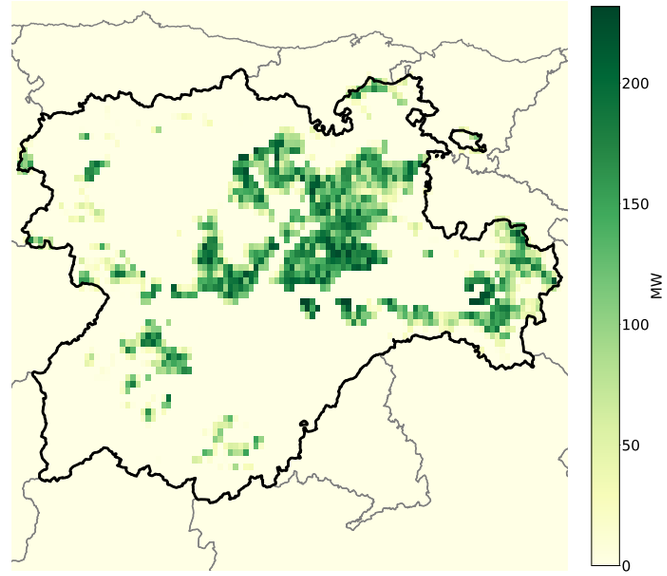
Environmental sensitivity to wind farms



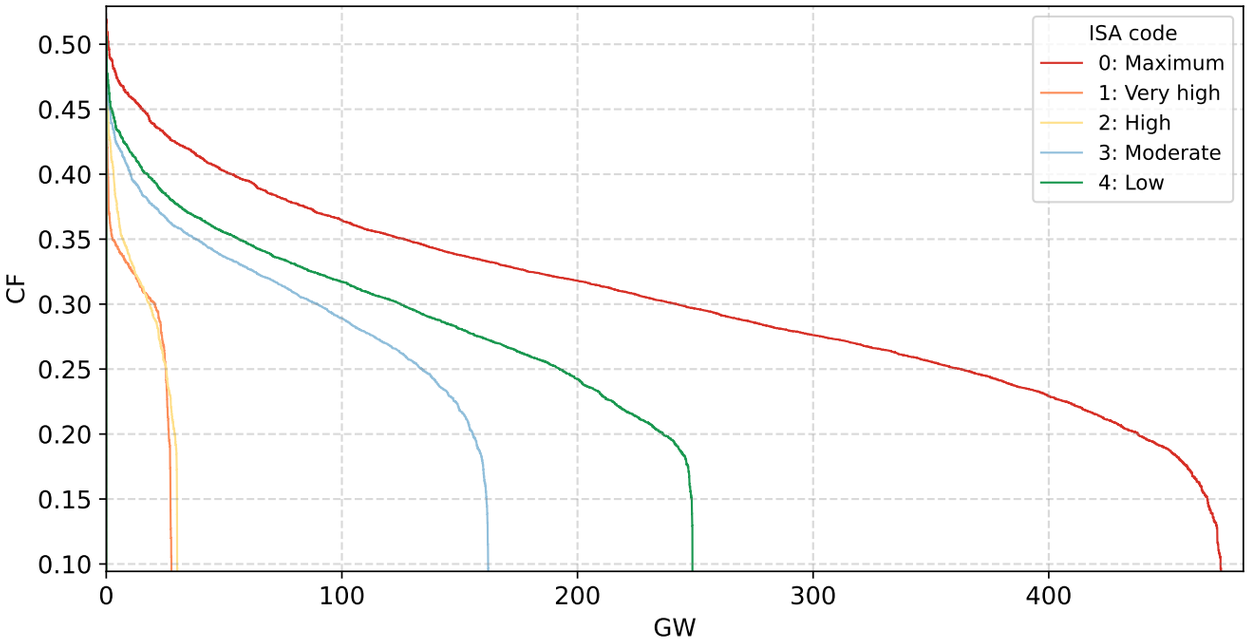
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



Wind power potential vs. capacity factor



- **LAND:** **13.26%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).

- **WIND POWER CAPACITY:** **124.94 GW** could be installed in these areas.

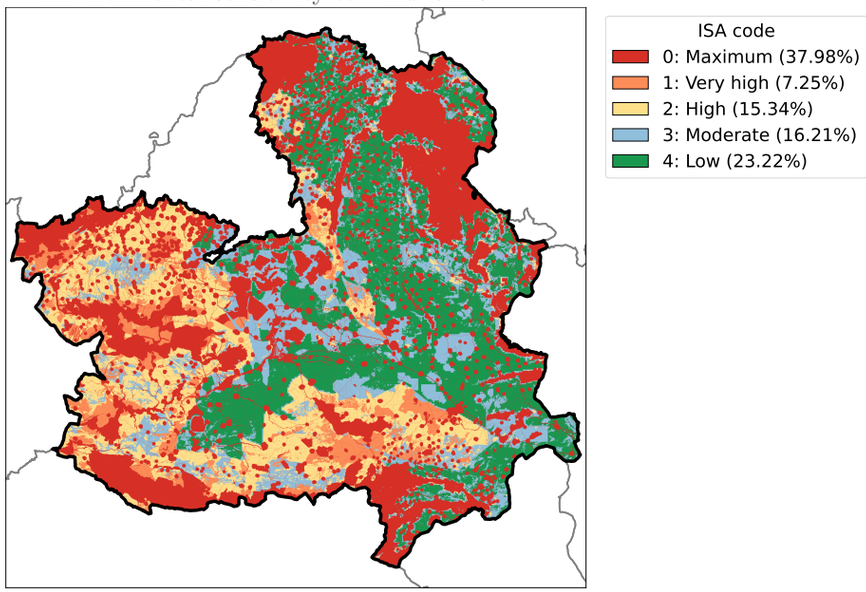
  Installed wind power capacity in Castilla y León in Dec/2024 was **6.62 GW**.

- **ENERGY:** **385.81 TWh** could be generated with this potential capacity.

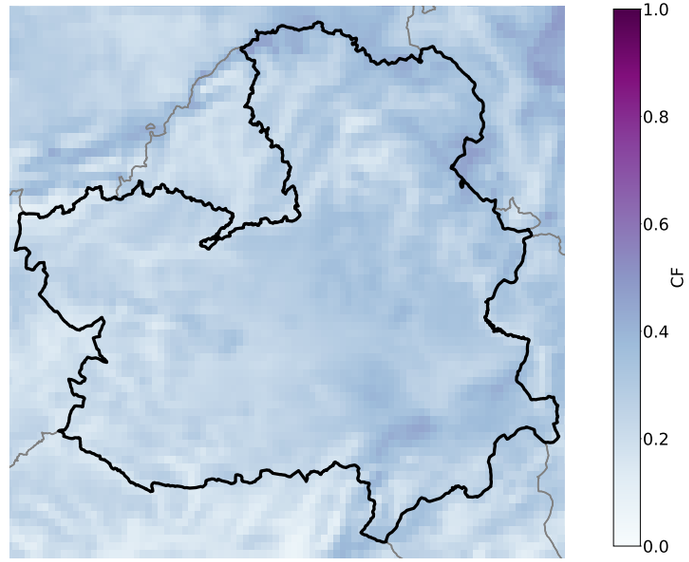
  This represents around **2852%** of the actual electricity demand in the region.

Castilla-La Mancha (ES42)

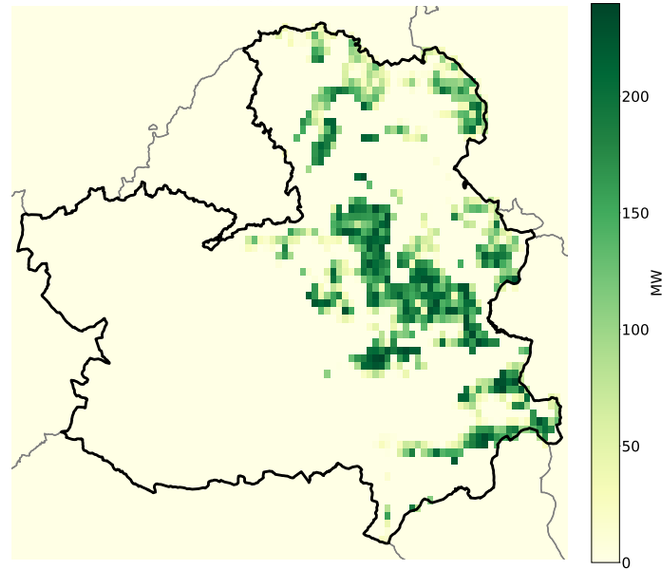
Environmental sensitivity to wind farms



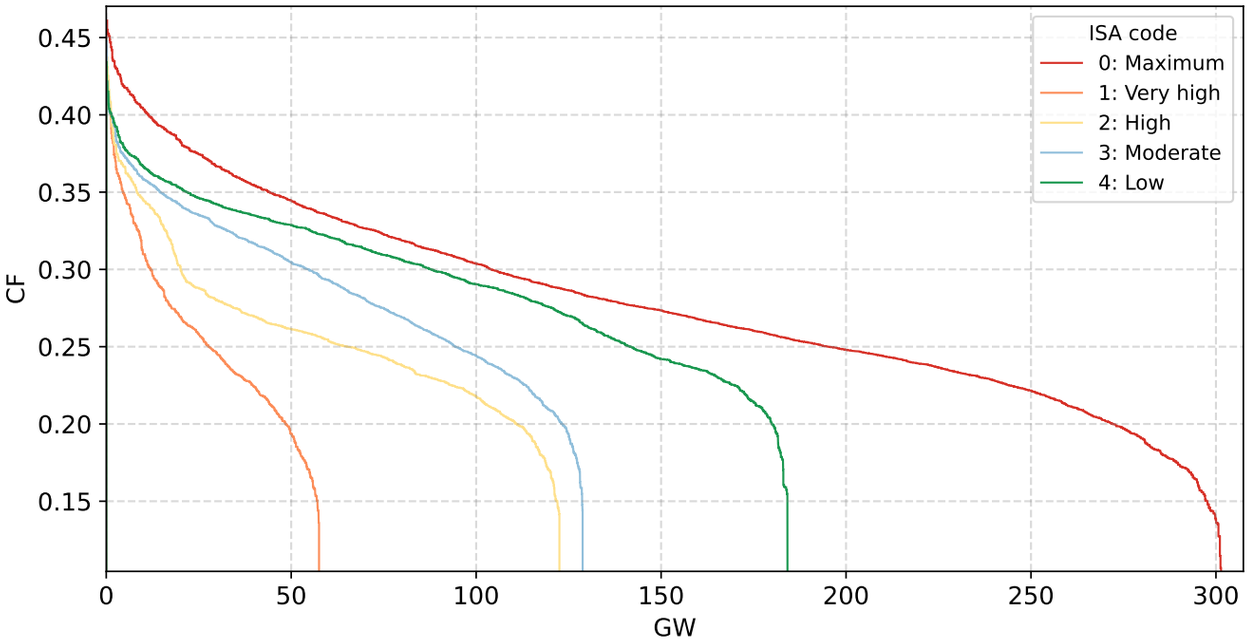
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



Wind power potential vs. capacity factor



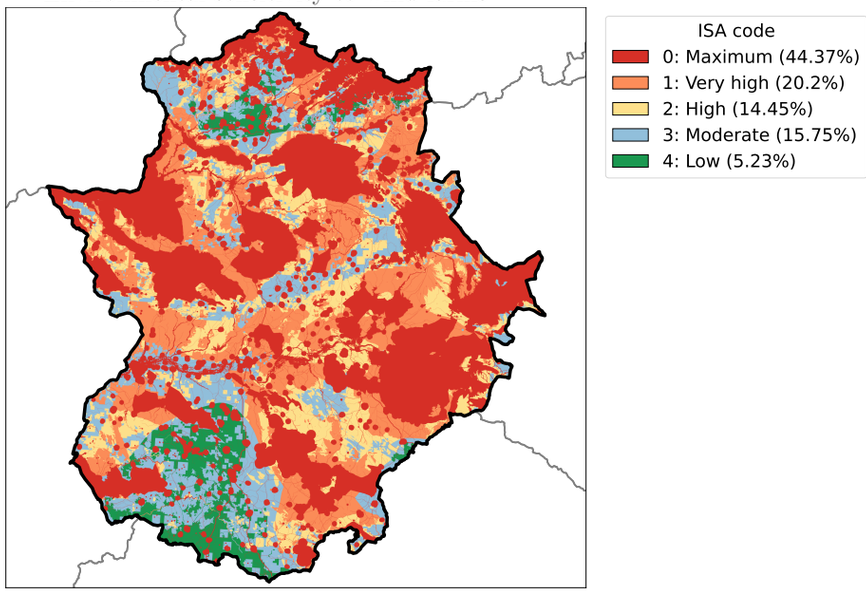
- **LAND:** **11.08%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **88.03 GW** could be installed in these areas.

  Installed wind power capacity in Castilla-La Mancha in Dec/2024 was **4.86 GW**.
- **ENERGY:** **258.76 TWh** could be generated with this potential capacity.

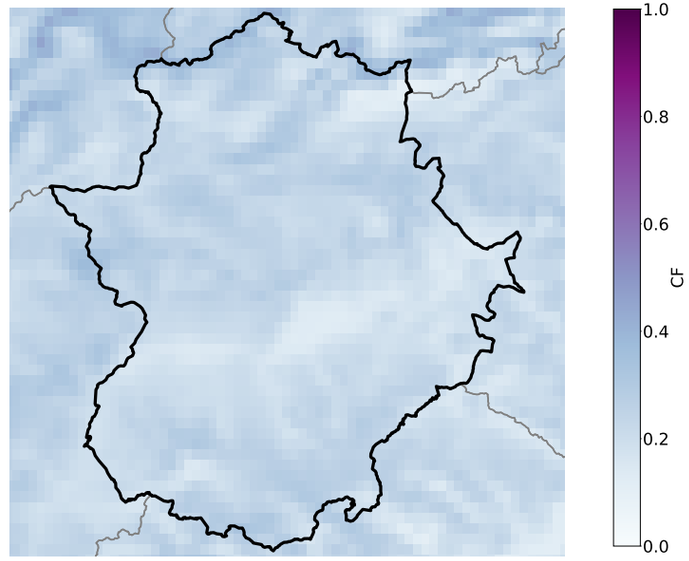
  This represents around **2272%** of the actual electricity demand in the region.

Extremadura (ES43)

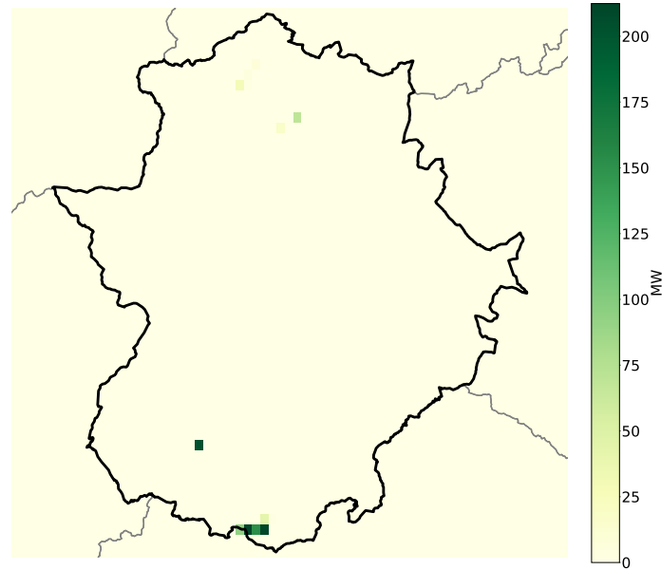
Environmental sensitivity to wind farms



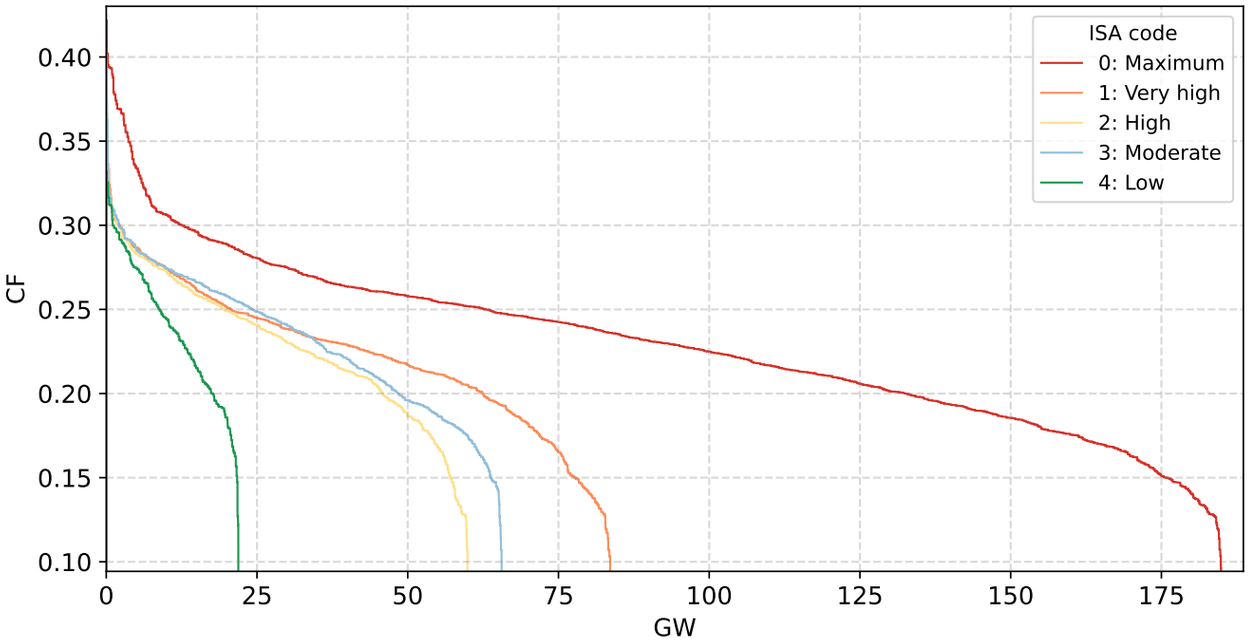
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



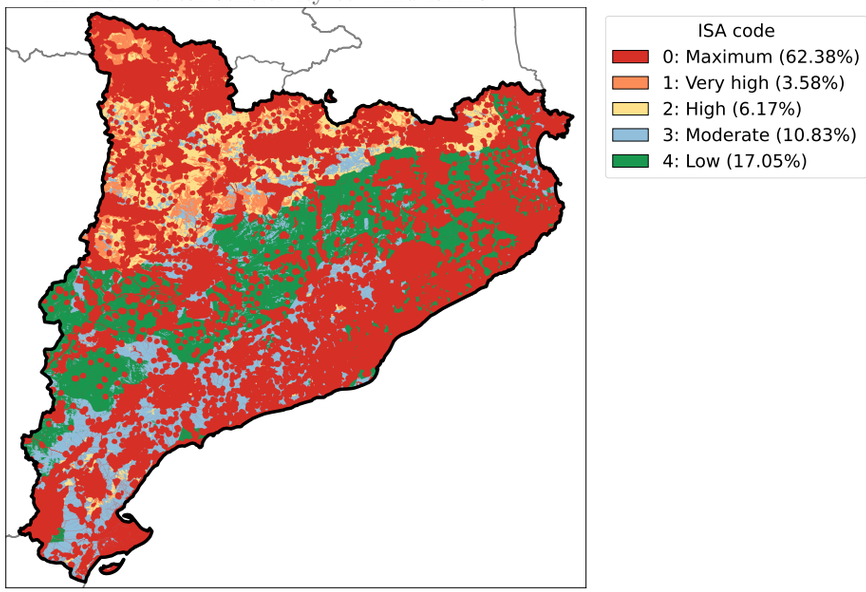
Wind power potential vs. capacity factor



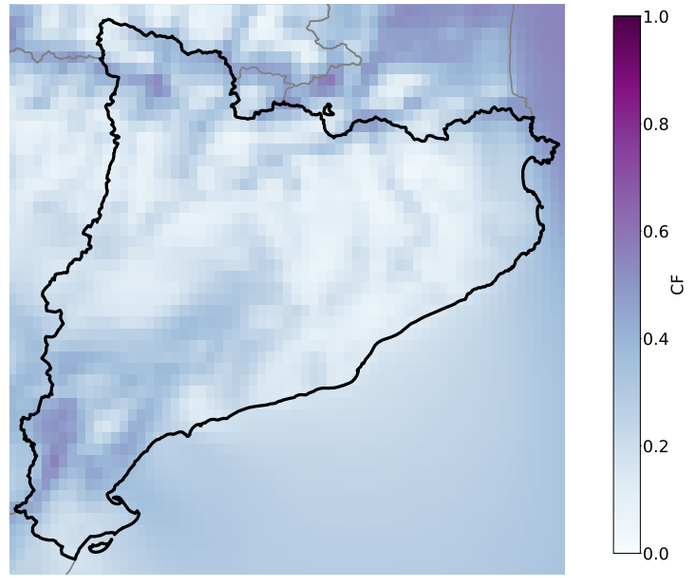
- **LAND:** **0.25%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **1.05 GW** could be installed in these areas.
  Installed wind power capacity in Extremadura in Dec/2024 was **0.04 GW**.
- **ENERGY:** **2.91 TWh** could be generated with this potential capacity.
  This represents around **59%** of the actual electricity demand in the region.

Cataluña (ES51)

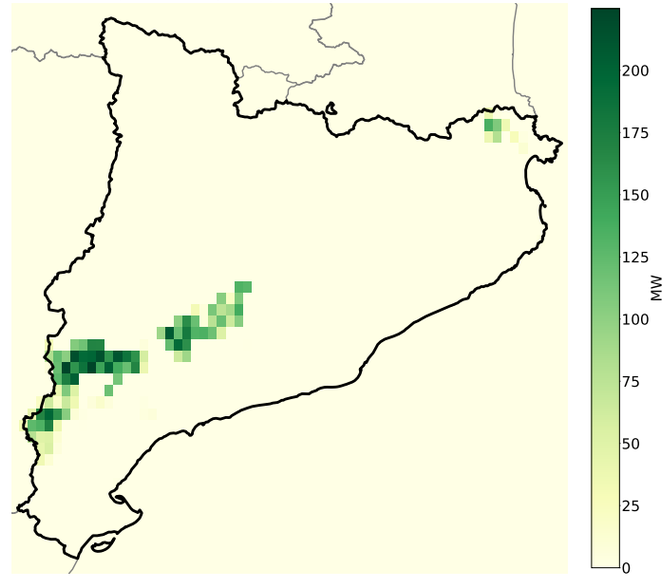
Environmental sensitivity to wind farms



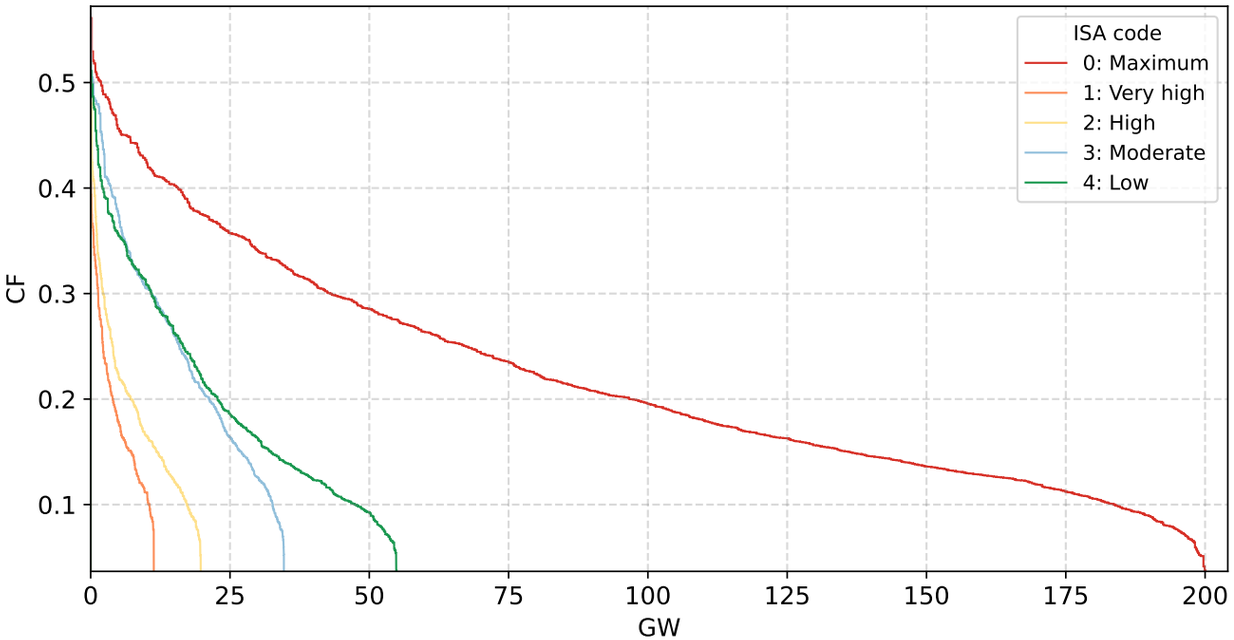
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



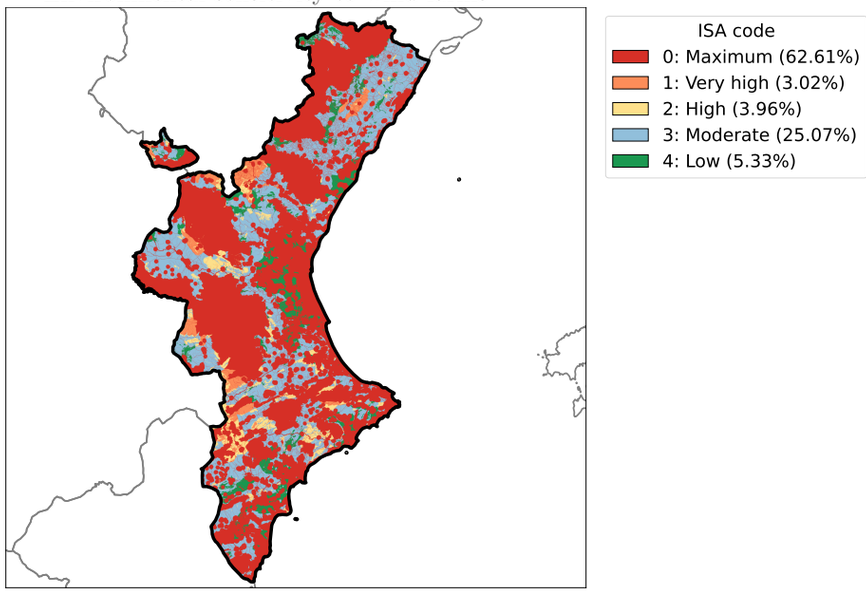
Wind power potential vs. capacity factor



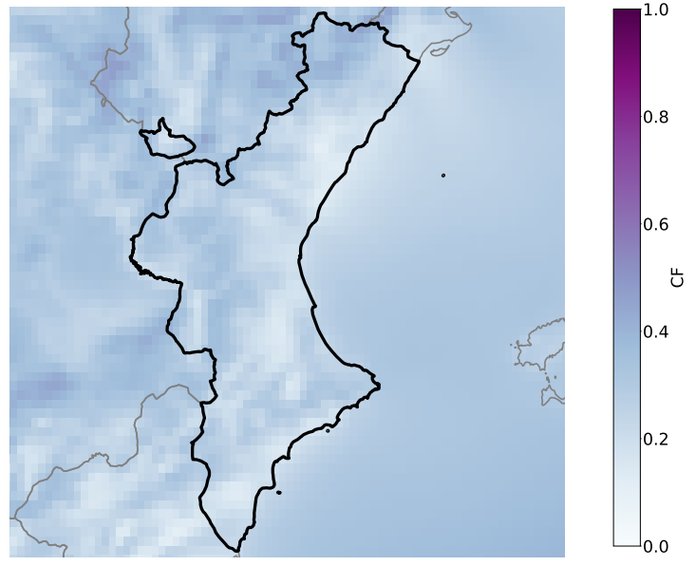
- **LAND:** **3.38%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **10.85 GW** could be installed in these areas.
  Installed wind power capacity in Cataluña in Dec/2024 was **1.37 GW**.
- **ENERGY:** **34.64 TWh** could be generated with this potential capacity.
  This represents around **79%** of the actual electricity demand in the region.

Comunidad Valenciana (ES52)

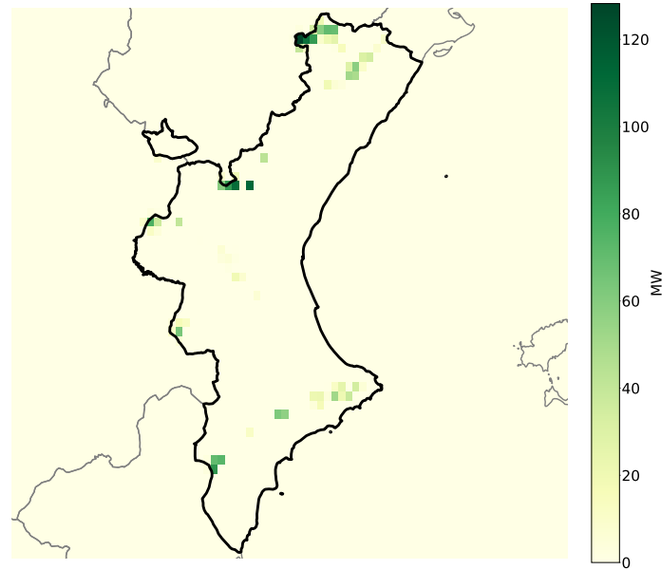
Environmental sensitivity to wind farms



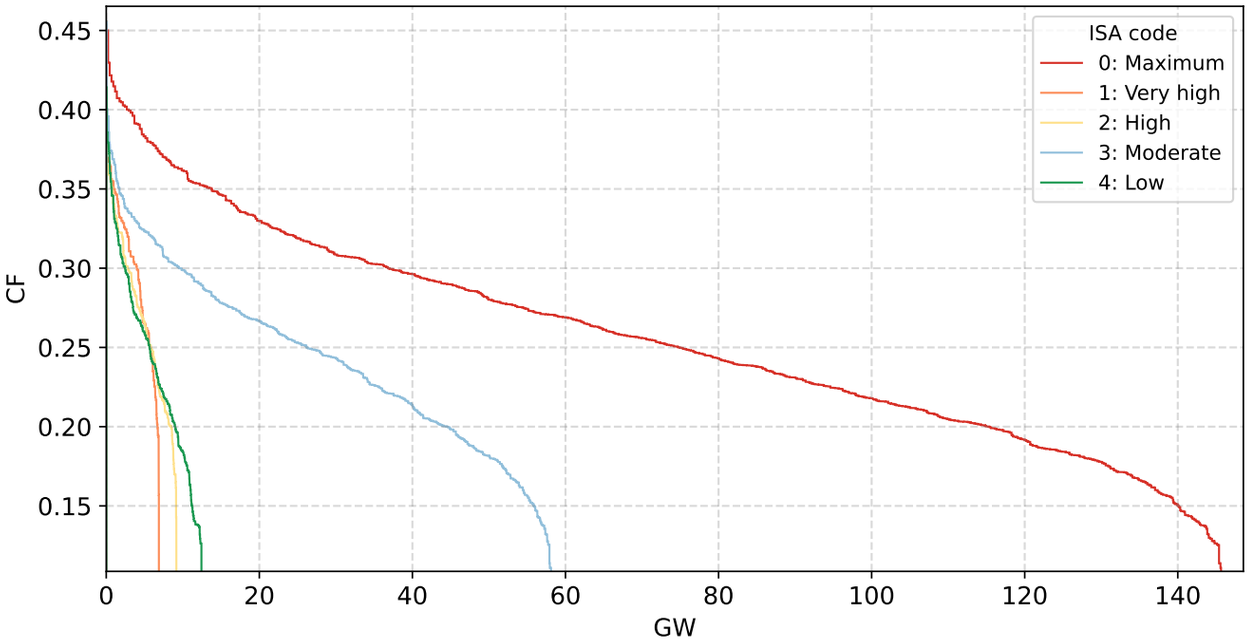
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



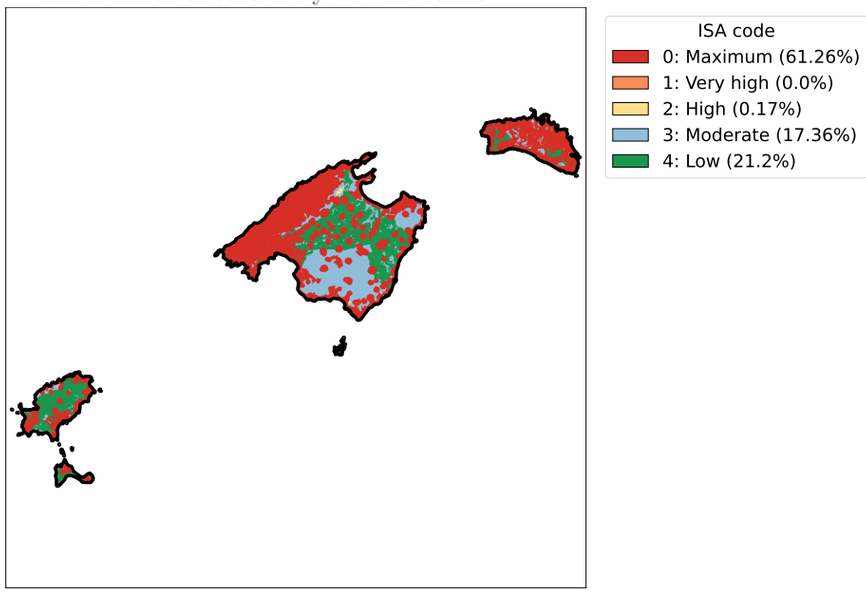
Wind power potential vs. capacity factor



- **LAND:** **1.06%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **2.46 GW** could be installed in these areas.
  Installed wind power capacity in Comunidad Valenciana in Dec/2024 was **1.24 GW**.
- **ENERGY:** **7.21 TWh** could be generated with this potential capacity.
  This represents around **27%** of the actual electricity demand in the region.

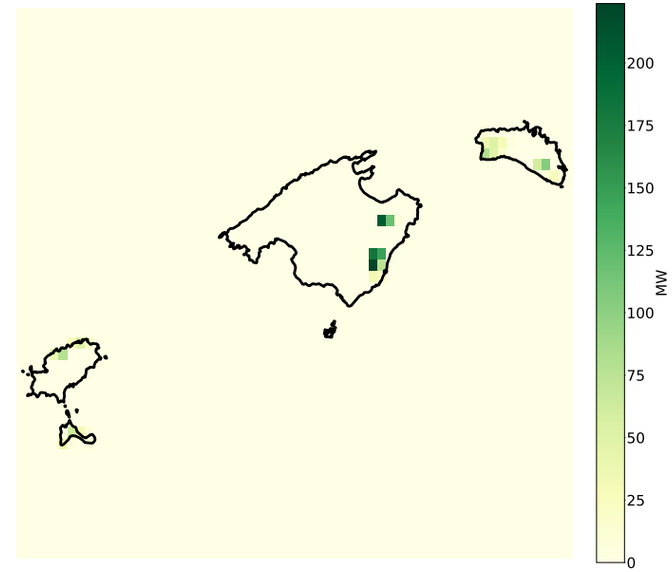
Islas Baleares (ES53)

Environmental sensitivity to wind farms

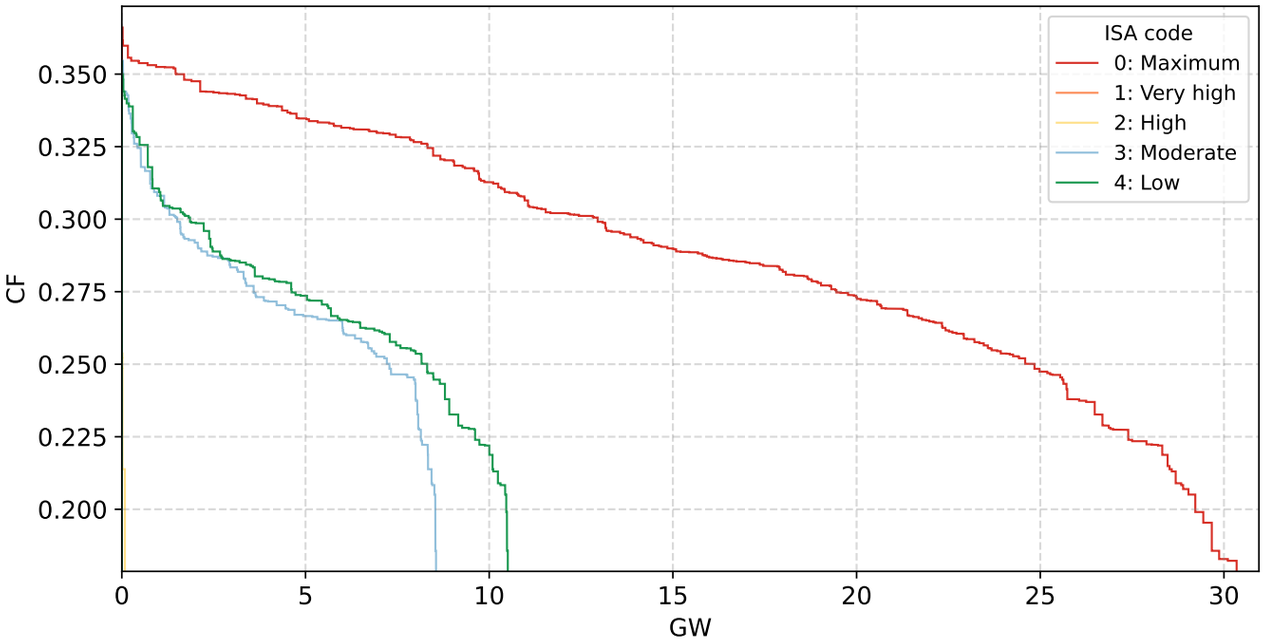


Wind power capacity factor (CF) at 100 m. height

Wind power capacity at ISA-4 and CF≥0.3



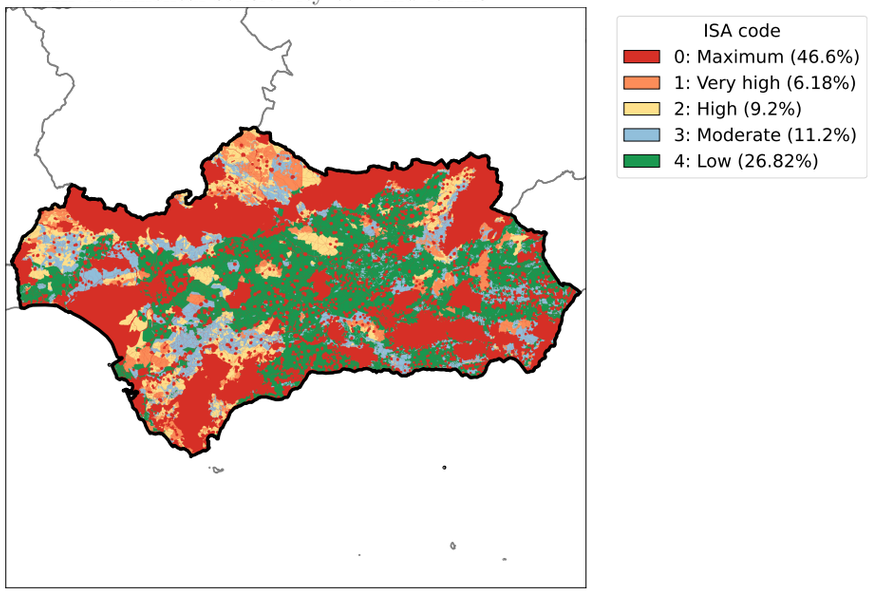
Wind power potential vs. capacity factor



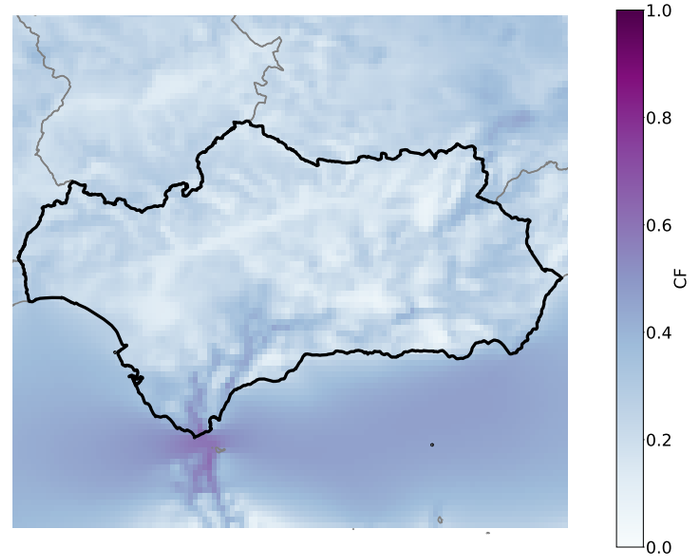
- **LAND:** **3.72%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **1.86 GW** could be installed in these areas.
  Installed wind power capacity in Islas Baleares in Dec/2024 was **0.0 GW**.
- **ENERGY:** **5.15 TWh** could be generated with this potential capacity.
  This represents around **84%** of the actual electricity demand in the region.

Andalucía (ES61)

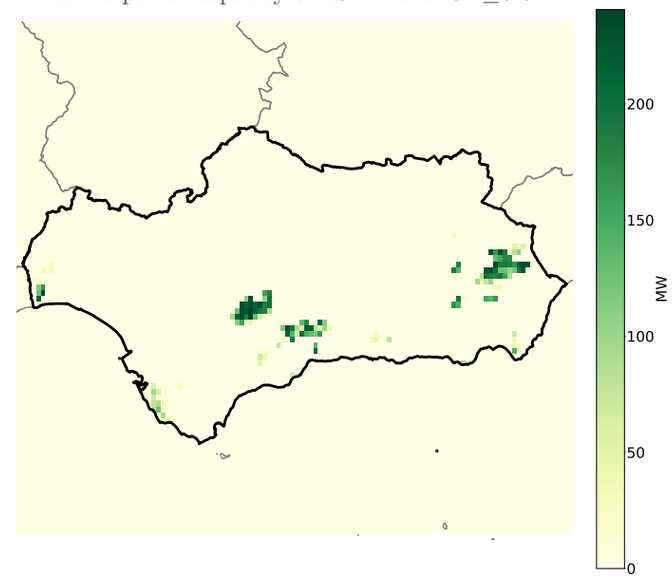
Environmental sensitivity to wind farms



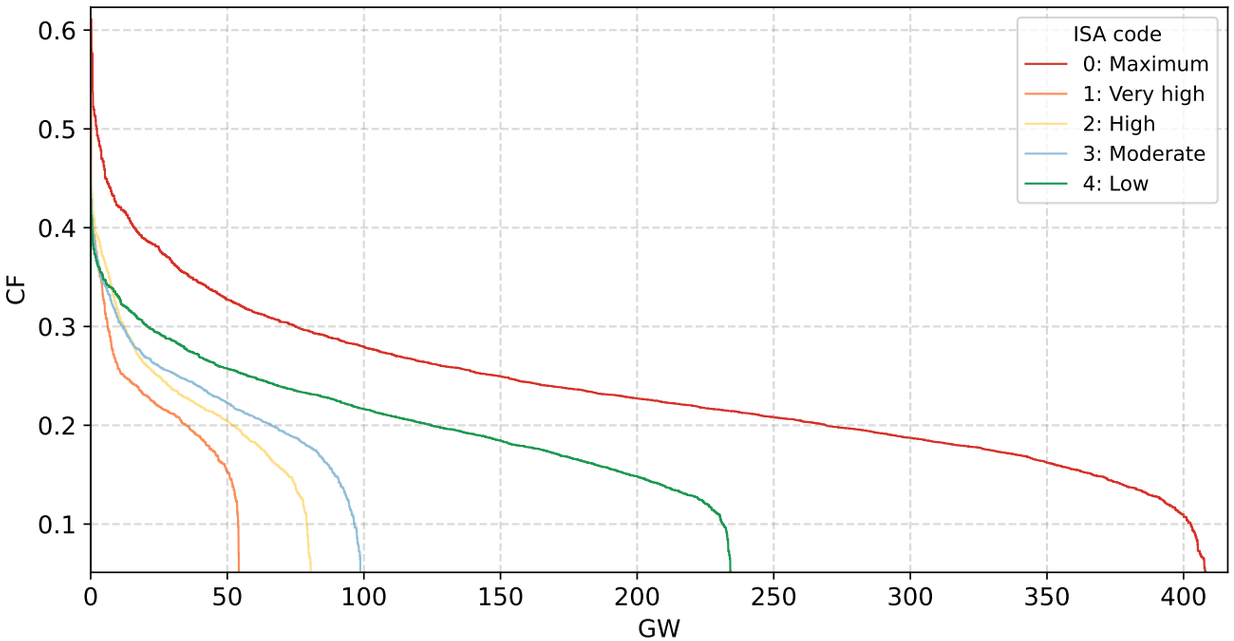
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



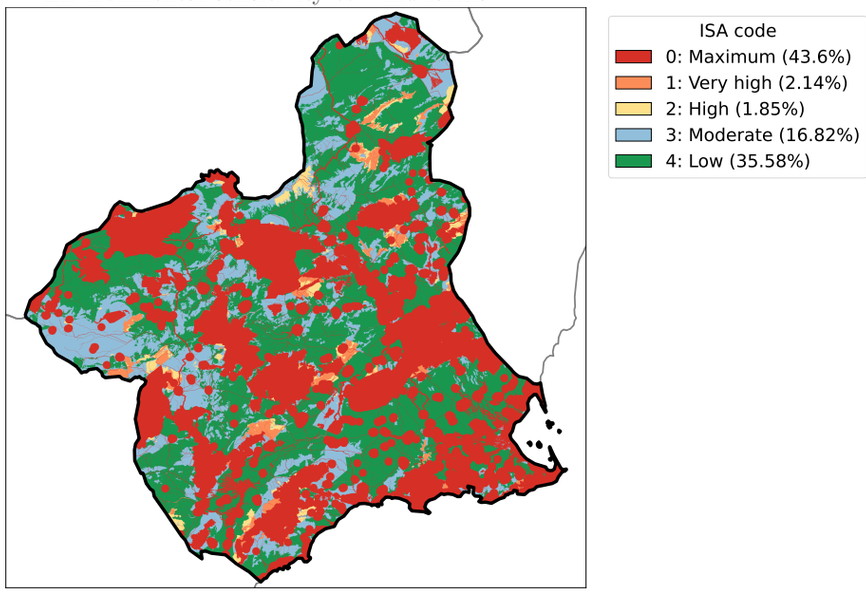
Wind power potential vs. capacity factor



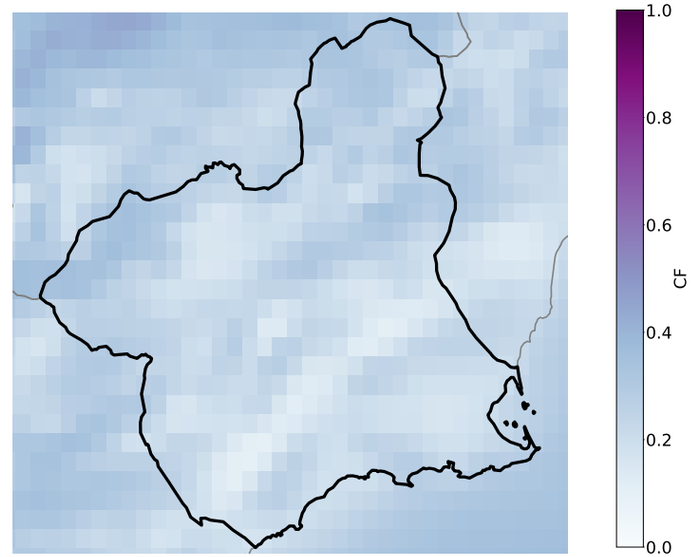
- **LAND:** **2.37%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **20.78 GW** could be installed in these areas.
  Installed wind power capacity in Andalucía in Dec/2024 was **3.61 GW**.
- **ENERGY:** **60.63 TWh** could be generated with this potential capacity.
  This represents around **157%** of the actual electricity demand in the region.

Región de Murcia (ES62)

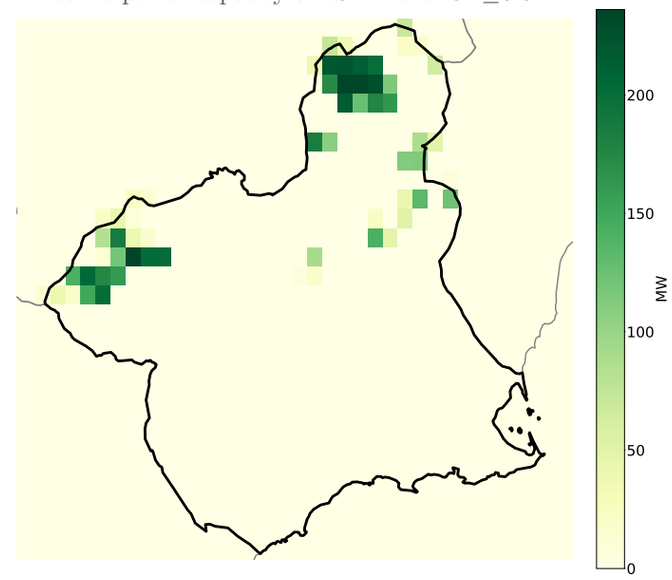
Environmental sensitivity to wind farms



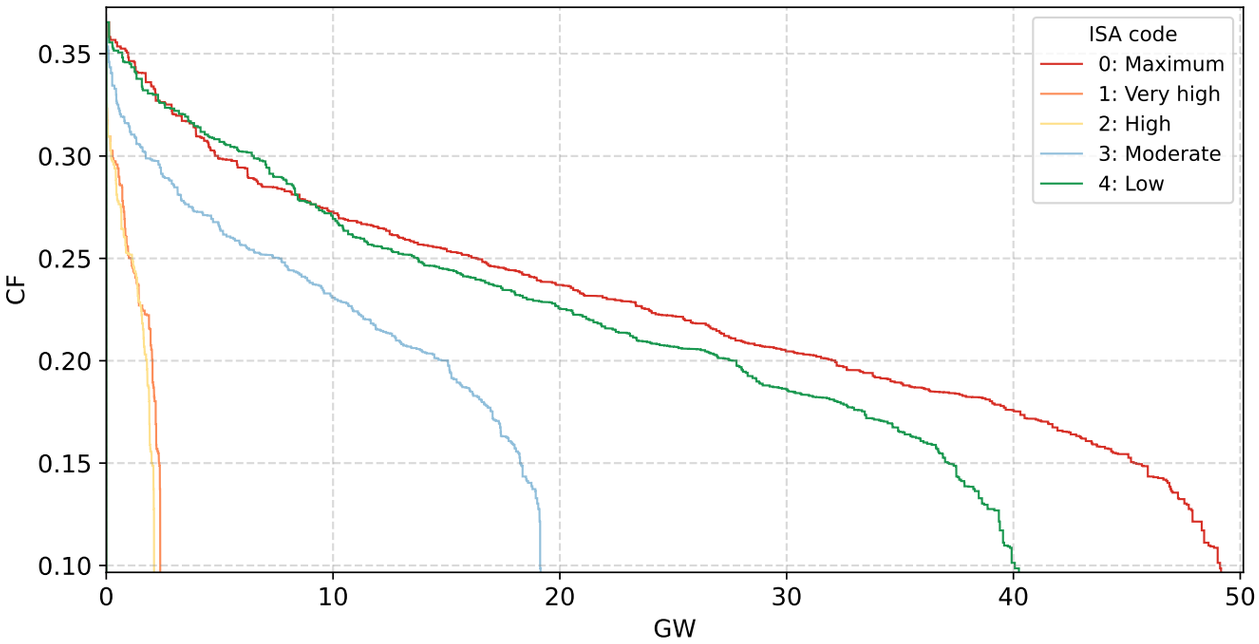
Wind power capacity factor (CF) at 100 m. height



Wind power capacity at ISA-4 and CF≥0.3



Wind power potential vs. capacity factor



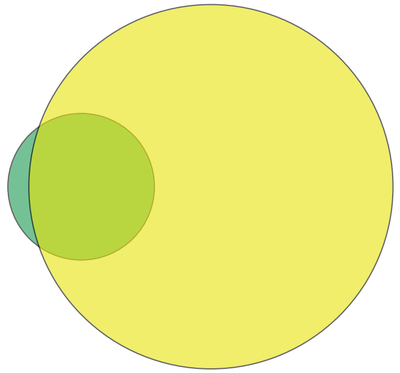
- **LAND:** **5.75%** of the region combines low enviromental sensitivity (ISA-4) and high wind resource (CF>0.3).
- **WIND POWER CAPACITY:** **6.51 GW** could be installed in these areas.
  Installed wind power capacity in Región de Murcia in Dec/2024 was **0.26 GW**.
- **ENERGY:** **18.42 TWh** could be generated with this potential capacity.
  This represents around **203%** of the actual electricity demand in the region.

P_{ISA4}: Technical potential (ISA-4)

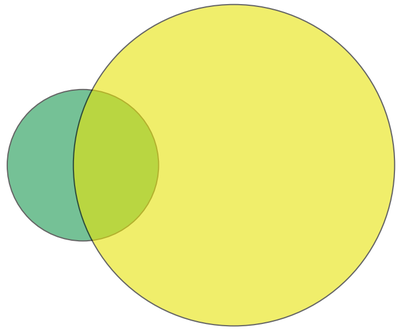
P^{CF^*}: Economic potential ($CF \geq 0.3$)

$P^{CF^*}_{\text{ISA4}}$: Techno-economic potential (ISA-4 and $CF \geq 0.3$)

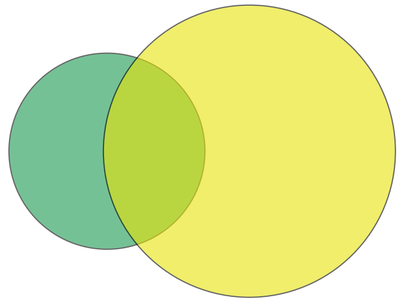
Galicia (ES11)



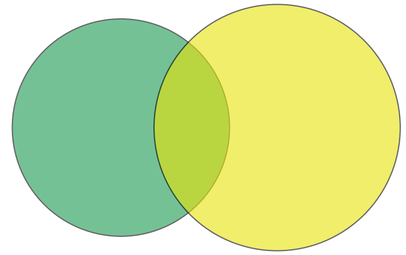
Principado de Asturias (ES12)



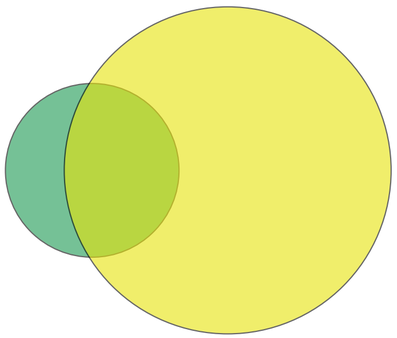
Cantabria (ES13)



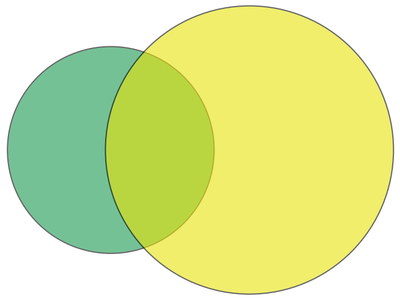
País Vasco (ES21)



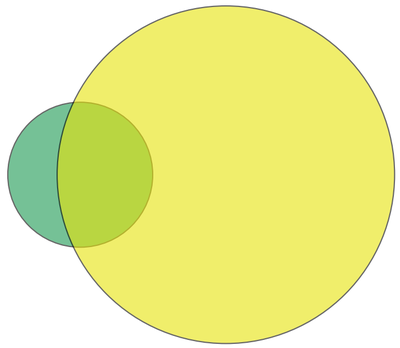
Comunidad Foral de Navarra (ES22)



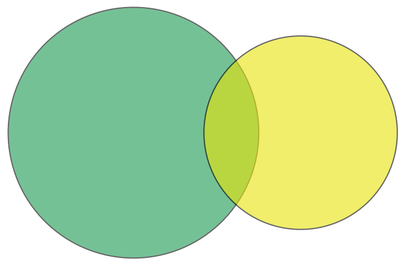
La Rioja (ES23)



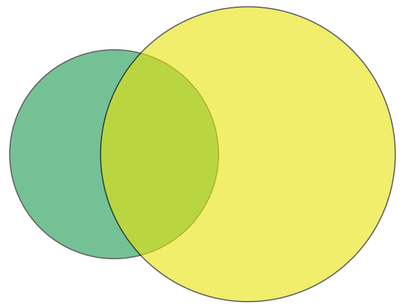
Aragón (ES24)



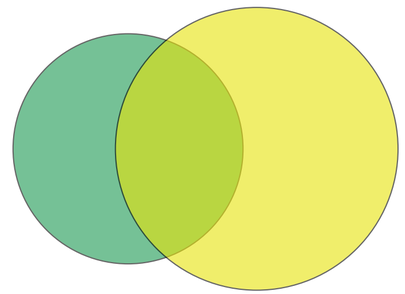
Comunidad de Madrid (ES30)



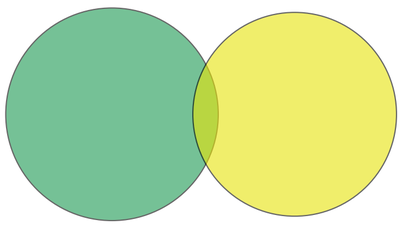
Castilla y León (ES41)



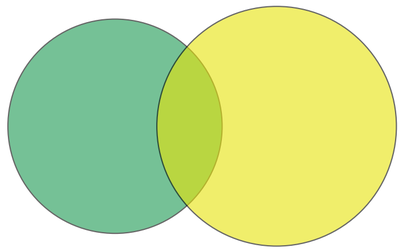
Castilla-La Mancha (ES42)



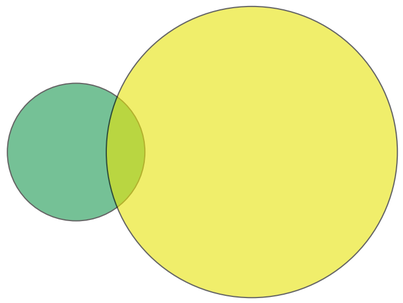
Extremadura (ES43)



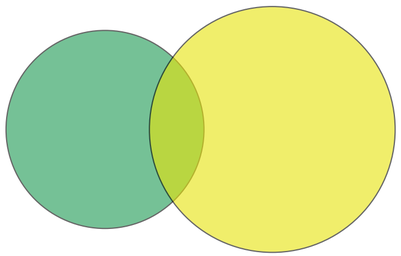
Cataluña (ES51)



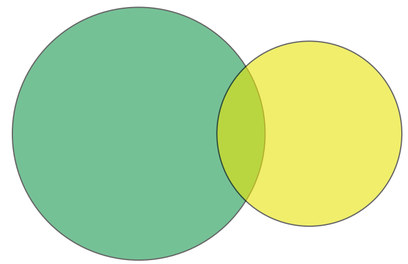
Comunidad Valenciana (ES52)



Islas Baleares (ES53)



Andalucía (ES61)



Región de Murcia (ES62)