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caREL
computer aided
Renewable Energy Language

EUROPÄISCHE UNION:
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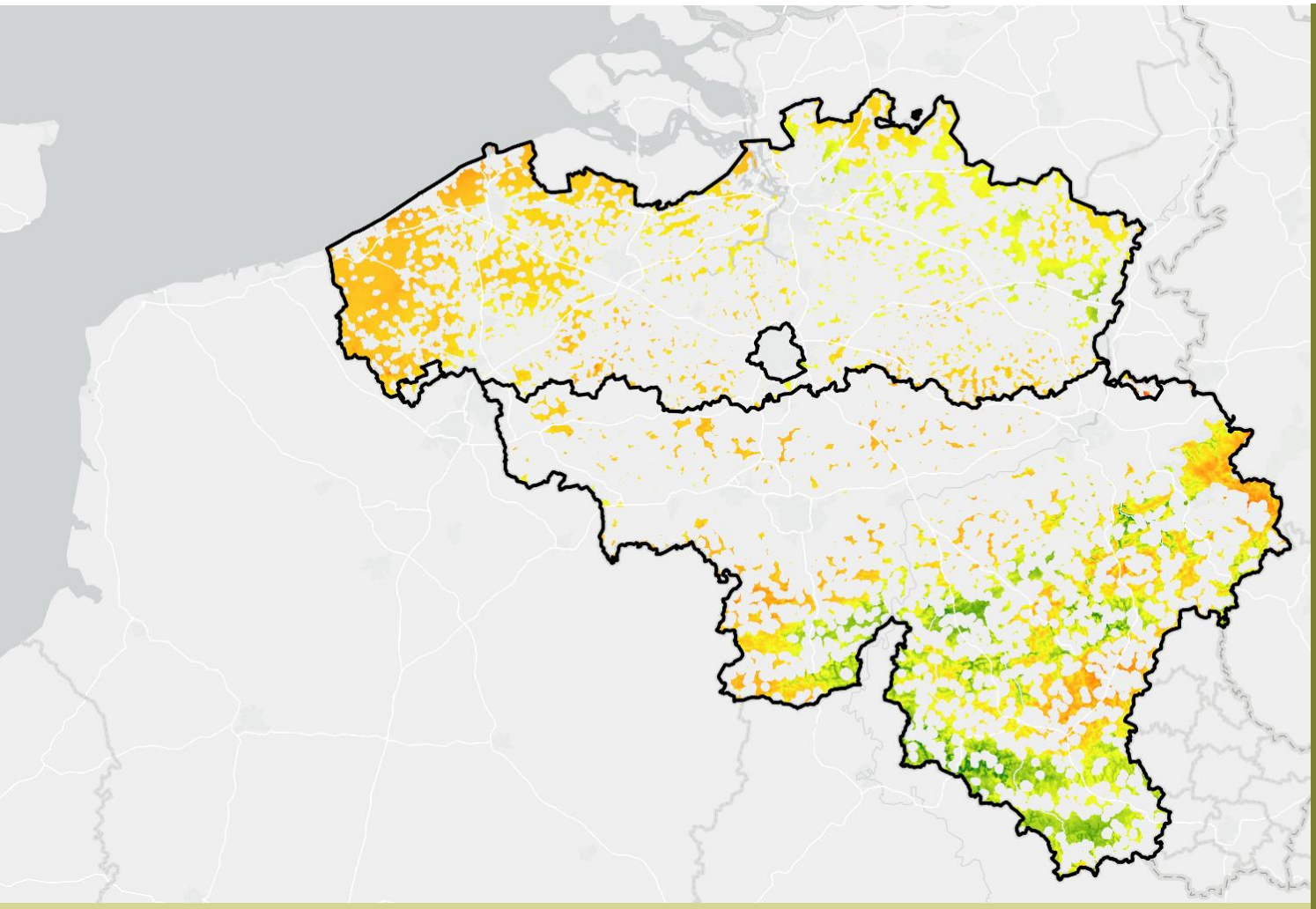

caREL - Wind potential analysis

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caREL – Computer-Aided Renewable Energy Language
Frankfurt University of Applied Sciences - Laboratory for Geoinformation

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1. INTRODUCTION

The algorithm presented here can be used to identify areas on which an economically viable installation of wind turbines could take place. The mean annual wind speeds at a height of 150 m, taken from the Global Wind Atlas, serve as the basis for the analysis. Above a wind speed of 6.5 m/s, it can be assumed in principle that the area is suitable for wind power use. Settlement areas (plus buffer zones), trunk roads and railways (plus buffer zones) and protected areas (plus buffer zones, if applicable) are considered exclusion areas for the construction of wind power plants. These areas are overlaid and intersected with the wind speed data. The remaining areas that are not subject to any exclusion criteria and at the same time achieve a minimum wind speed of 6.5 m/s are considered potential areas.

2. DISTANCE REGULATIONS

There are many different distance regulations for wind turbines within the EU[1]. In principle, each country sets its own regulations. In certain cases, these differ even more on a regional level. In some states, a volume limit is used. These range from 35 dB to 65 dB and often distinguish between daytime and night-time noise levels and the use of affected areas. In other countries, the rotor diameter, the turbine height or the height of nearby buildings serve as a limit. The most common is the definition of a general minimum distance. Often a distinction is made between settlement areas and commercial/industrial areas with a lower distance. Distances to nature conservation areas are highly dependent on the type of conservation area. Not every appropriately designated area is affected by wind turbines to the same extent, and individual assessments must therefore often be carried out for nature conservation areas.

The following minimum distances were used for the calculation carried out:

- 1000 m for settlements
- 200 m for highways
- 200 m for the railway network

These distances represent an approximate average of the various distance regulations. They can be adjusted as desired in the calculation model and can be reduced or increased as required.

3. PROJECT AREAS

For the analysis of wind potential areas, five T-areas were selected in the following EU countries:

- Belgium (nationwide)
- Denmark (nationwide)
- Estonia (nationwide)

[1] European Commission: Wind potentials for EU and neighbouring countries, Publications Office of the European Union, Luxembourg 2018

- Slovenia (nationwide)
- Spain (regions of Galicia and Asturias).

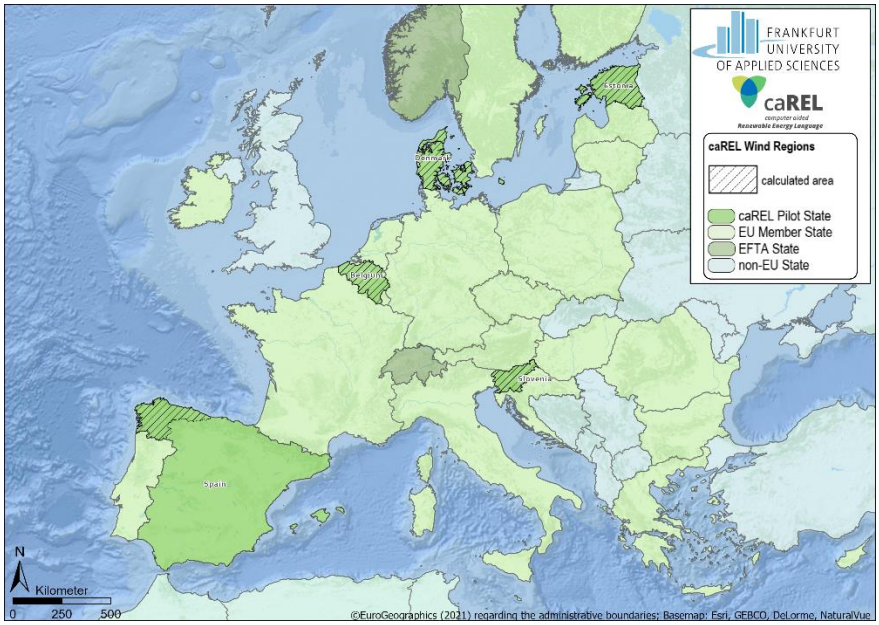

Figure 1 – Pilot State Overview

These are the same five states in which solar potential analyses were carried out. Due to the larger area of Spain compared to the other states, the calculation was only carried out in two regions, which together have a comparable area. Figure 1 shows a graphical overview of the selected project areas. For these test areas, the necessary input data for an analysis are available as open data. If an analysis is to be carried out in other states, it must first be checked whether the necessary data is available.

4. CALCULATION MODEL

Figure 2 shows the calculation model for the wind potential areas. It shows the different input data (in green) and the individual calculation steps (in orange).

The mean annual wind speeds at a height of 150 m taken from the Global Wind Atlas (see chapter 4) serve as the starting point. First, areas with wind speeds of less than 6.5 m/s are excluded before the data set is cut to the corresponding project area. For the settlement areas, highways and rail networks, the following three calculation steps are carried out separately, one after the other:

1. buffer generation with corresponding distance area
2. calculation of a difference between buffered area and project area to create a mask
3. intersection of the corresponding mask with the average wind speeds.

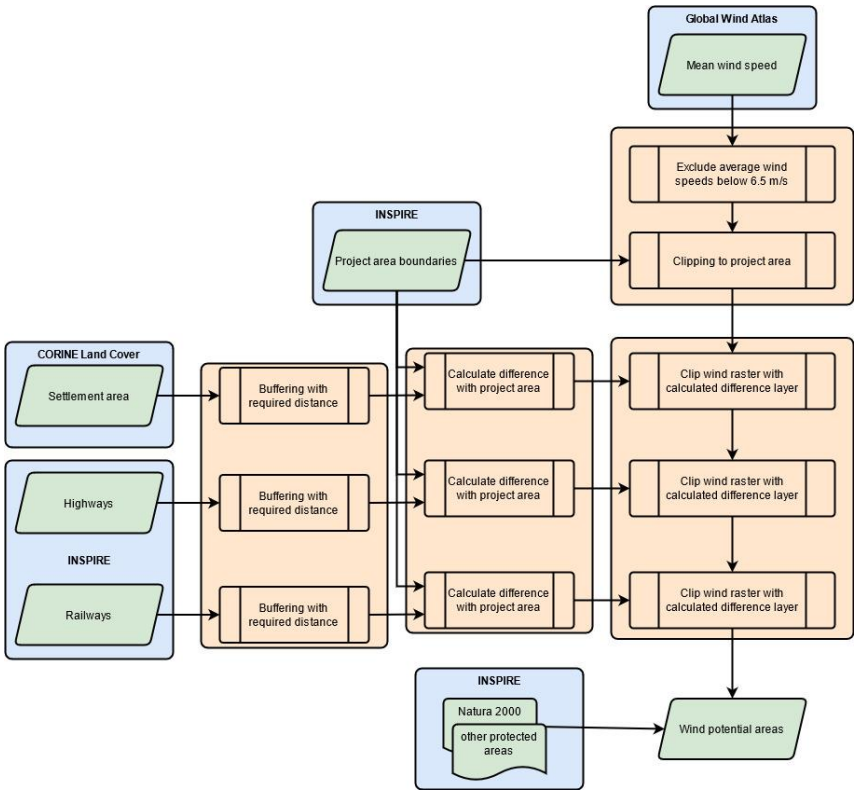

Figure 2 – Model Overview Wind potential algorithm

By intersecting the distance areas with the wind speeds, a grid is created for the project area with the areas that do not lie within a distance area and have a wind speed of more than 6.5 m/s. The grid is then used to create a mask for the project area.

The model is implemented using various QGIS algorithms, which are connected in series via graphical modelling to form a single process (cf. Figure 3). The corresponding parameters, for example the buffer radius for the distance areas, can be adjusted before the calculation. When the model is executed, only the output data and the storage location of the result need to be specified. The process then runs independently without further input.

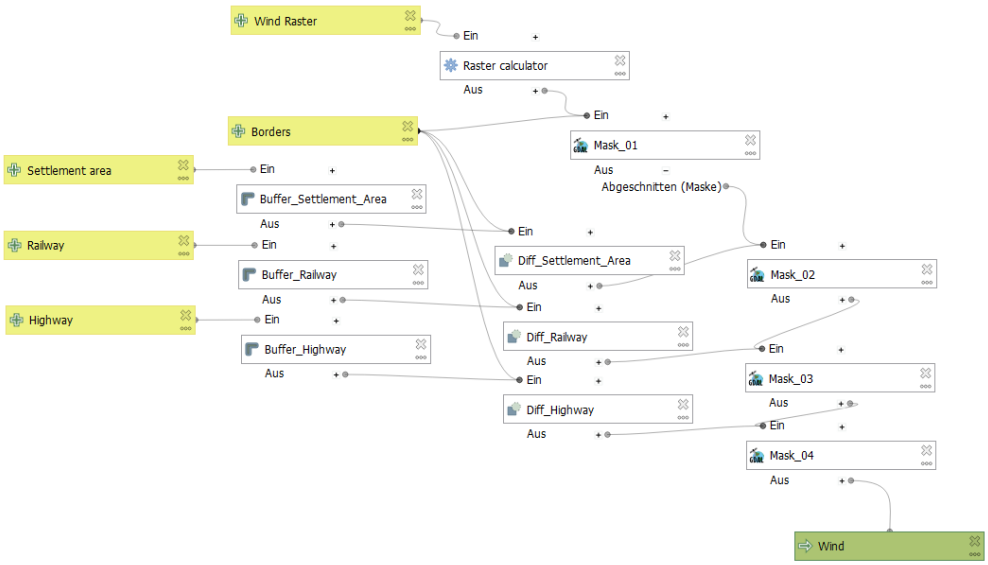

Abbildung 1 – graphical modelling QGIS

5. INPUT DATA

Only open, freely accessible data sets were used as input data for the calculation of the wind potential areas. These had to be partially prepared. The acquisition and preparation of the corresponding data is briefly described below.

5.1 MEAN WIND SPEEDS AT 150 HEIGHT

The Global Wind Atlas[2] serves as the data basis for the mean wind speeds at 150 m height. The Global Wind Atlas is a free, web-based application that offers freely downloadable data sets on various wind parameters. It is managed by the Technical University of Denmark (DTU). The data is licensed under the Creative Commons Attribution 4.0 International licence[3]. The mean wind speeds can be downloaded for heights of 10, 50, 100, 150 and 200 m in .tif format. Since the data sets are tailored to the corresponding project area during the calculation of the wind potential areas and the areas with speeds of less than 6.5 m/s are excluded, no further pre-processing of the data is necessary.

5.2 SETTLEMENT AREA

The CORINE Land Cover[4] dataset of the Copernicus Land Monitoring Service is used to identify settlement areas. The dataset, derived from satellite imagery, divides land cover into 44 classes and is available across Europe. The most recent version of the dataset is from 2018. Access to the data is based on the principle of full, open and free access, which is laid down in the Copernicus Data and

[2] https://globalwindatlas.info/
[3] https://creativecommons.org/licenses/by/4.0/
[4] https://land.copernicus.eu/pan-european/corine-land-cover

Information Policy Regulation[5]. The data is available in both GeoTiff raster format with a resolution of 100 m and as a vector dataset in ESRI shapefile format and can be downloaded directly from the Copernicus website. The vector data set is used for the analysis of the wind potential areas. Class 1 - Artificial Surfaces of the Corine Land Cover is used to identify the settlement areas. Not all subcategories of this class are considered. Figure 4 shows an overview of the classes used.

The corresponding polygons are then intersected with the project area to obtain only the relevant areas and to reduce the size of the data set. The data set obtained in this way serves as the initial data set for the calculation of the distance areas to settlements in the calculation of the wind potential areas.

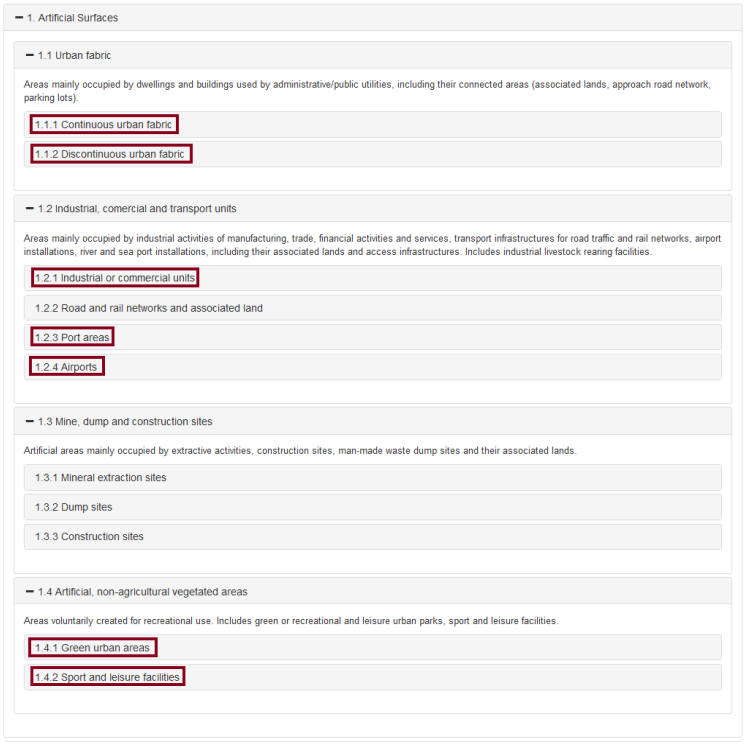

Figure 4 - used CORINE Land Cover classes

The corresponding polygons are then intersected with the project area to obtain only the relevant areas and to reduce the size of the data set. The data set obtained in this way serves as the initial data set for the calculation of the distance areas to settlements in the calculation of the wind potential areas.

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R1159

5.3 TRANSPORT AREA (HIGHWAYS)

The INSPIRE Annex I Transport Networks dataset serves as the data basis for the transport areas of trunk roads. The provision of this dataset differs in the different pilot countries.

For Estonia, a WFS can be found via the INSPIRE Geoportal[6]. It uses the corresponding INSPIRE schema for Road Transport Networks. The dataset can be filtered and the appropriate roads identified via the RoadLink and FunctionalRoadClass types. The dataset is available as Open Data under a Creative Commons equivalent CC BY 4.0[7] licence.

For Spain, a WFS in the INSPIRE Road Transport Networks schema is also available via INSPIRE[8]. The processing is analogous to the Estonian dataset. The dataset is subject to Attribution 4.0 International (CC B 4.0)[9].

Nationwide data for Belgium is available via the IGN (Institut géographique national). An enquiry revealed that the nationwide INSPIRE datasets are available for a price between €15,000 and €123,500. Alternatively, the data from the EuroRegionalMap at a scale of 1:250,000 can be used. These are freely available via the NGI portal[10].

For Denmark, the data can be obtained via an INSPIRE Atom feed[11]. They are available in the Road Transport Network data model, which is specified by INSPIRE. The attribute functionalclass can be used to identify the hierarchy level of the respective road. The data may be used worldwide, free of charge, freely copied, distributed and published, and used commercially and non-commercially[12].

Data on the Slovenian road network is available via an INSPIRE Atom feed[13] of the Consolidated Cadastre of Public Infrastructure. However, this only contains topographic information on the network and no attribute reflecting the hierarchy level of a road. The few roads in Slovenia that are classified as trunk roads can nevertheless be identified by their name. There are no restrictions on the public use of the dataset.

[6] https://inspire.geoportaal.ee/geoserver/TN_transportetak/wfs?service=WFS&version=2.0.0&request=GetCapabilities
[7] https://geoportaal.maaamet.ee/docs/Avaandmed/Licence-of-open-data-of-Estonian-Land-Board.pdf
[8] https://servicios.idee.es/wfs-inspire/transportes?REQUEST=GetCapabilities&SERVICE=WFS&VERSION=2.0.0
[9] http://www.ign.es/resources/licencia/Condiciones_licenciaUso_IGN.pdf
[10] https://ac.ngi.be/catalogue?tab=overview&subtab=overview_catalogue
[11] https://ftp.sdfe.dk/main.html?download&weblink=14b07c40fc1d5109e4bbf9de1ff6cc34
[12] https://sdfe.dk/media/2916594/vilkaar-for-brug-af-frie-geografiske-data_2016.pdf
[13] https://eprostor.gov.si/ods/atom?type=feed&content=service&id=8

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