Report 2.1.3.
Scenario Building Based on Case Studies

Europäischer Fonds für regionale Entwicklung (EFRE)
Der Oberrhein wächst zusammen mit jedem Projekt

RES-TMO

In the third deliverable for RES-TMO, the spatial distribution of the potentials at the country level calculated in Report 2.1.1., the distance of the usable area of the potentials from the grid infrastructure found in Report 2.1.2, and the distribution and characteristics of the municipalities are analyzed in order to provide insight that enables the building of future research scenarios and case studies.

Main Author: Zeina Najjar
Editors: Professor Barbara Koch & Ines Gavrilut
Researchers: Zeina Najjar

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Recap: Distribution of Countries with Highest Potential

As was calculated in Report 2.1.1., the potential distribution by countries is displayed below.

Solar PV

Agro PV

As can be seen in the figure below, France has the highest potential when it comes to Agro-PV. It is followed by Germany and then Switzerland.

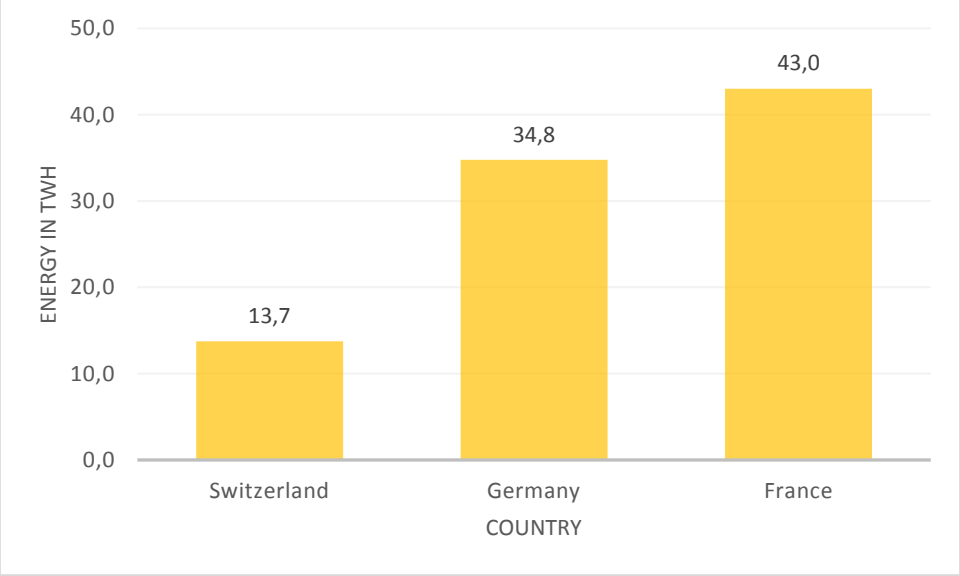


Figure 1: The Agro-PV potential per country taken from Report 2.1.1

GM-PV

As can be seen in the figure below, Germany has the highest potential when it comes to GM-PV. It is followed by France and then Switzerland.

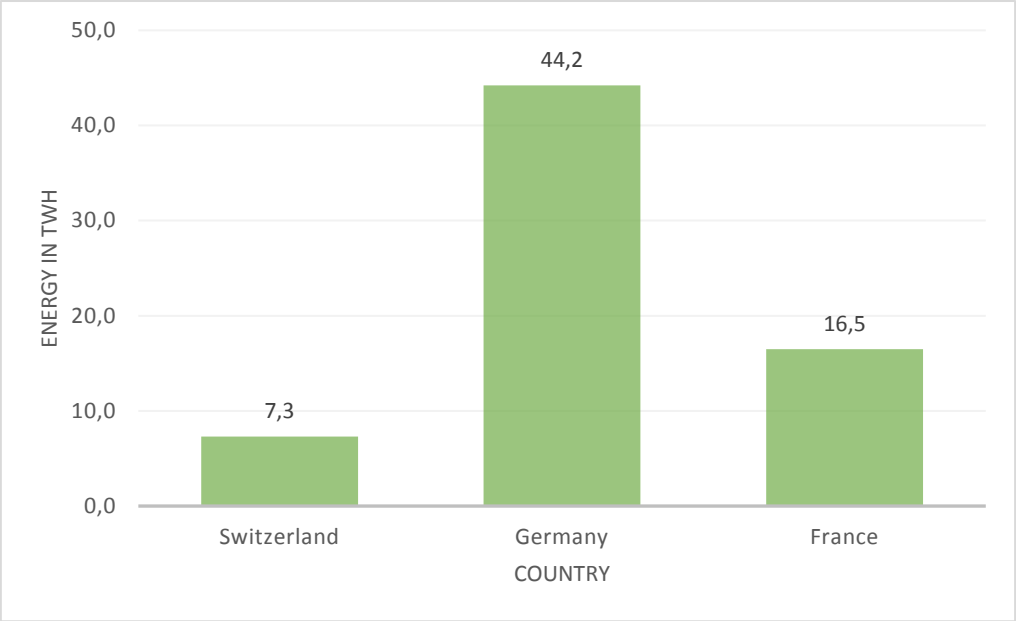


Figure 2: The GM-PV potential per country taken from Report 2.1.1

Rooftop PV

As can be seen in the figure below, Germany has the highest potential when it comes to Rooftop-PV. It is followed by France and then Switzerland.

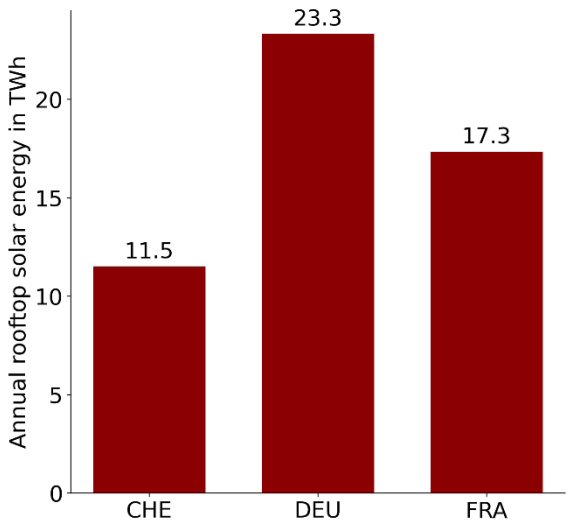


Figure 3: The Rooftop PV potential per country taken from Report 2.1.1

Wind

As can be seen in the figure below, France has the highest potential when it comes to wind energy. It is followed by Germany and then Switzerland.

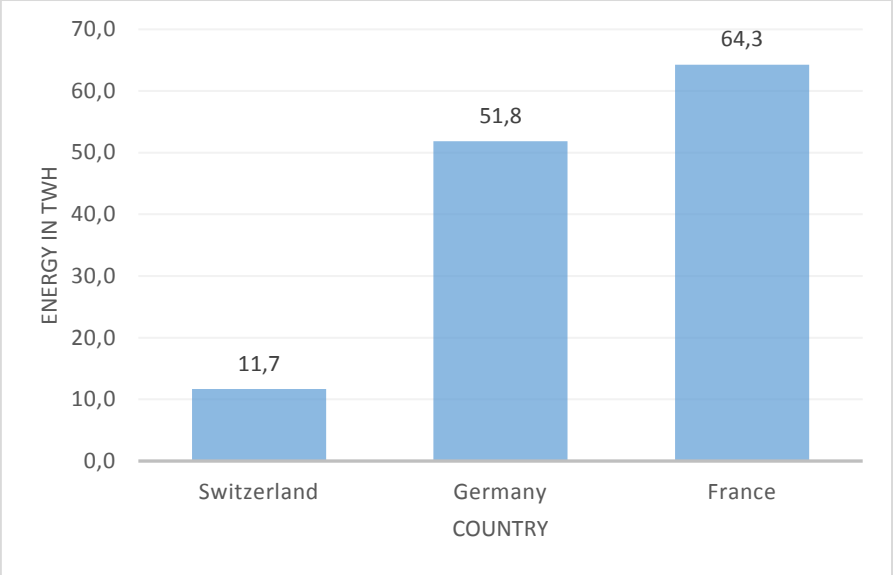
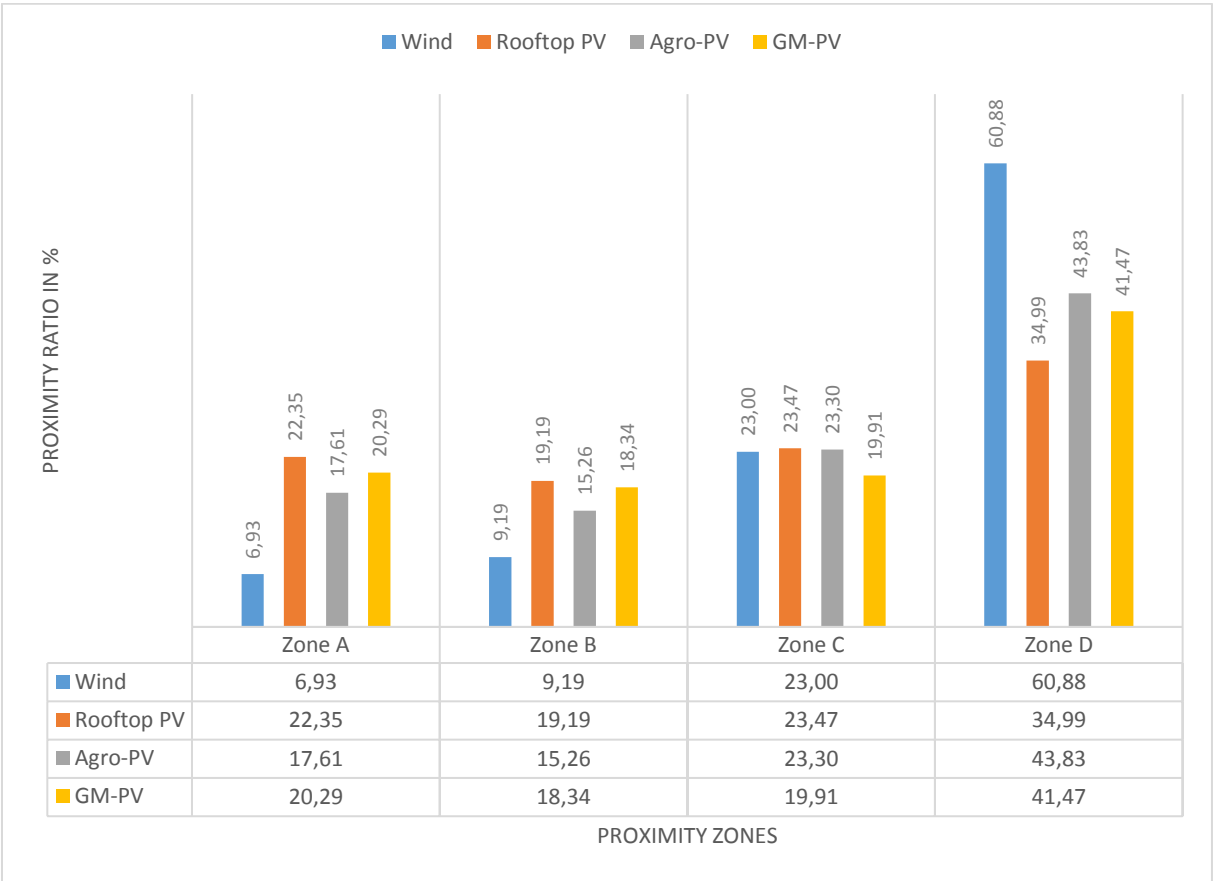


Figure 4: The wind potential per country taken from Report 2.1.1

Recap: Distances from Electricity Network

In Report 2.1.2, the distances from the electricity network were also studied and the final results are shown below:



	Zone A	Zone B	Zone C	Zone D
Wind	6,93	9,19	23,00	60,88
Rooftop PV	22,35	19,19	23,47	34,99
Agro-PV	17,61	15,26	23,30	43,83
GM-PV	20,29	18,34	19,91	41,47

Figure 5: Distances of the usable area for each RES from the electricity grid as taken from Report 2.1.3.

The methodology used and the results were previously discussed in Report 2.1.2, but the most important findings as per that report are that: "Solar PV has larger potentials located closer to the grid than wind energy does. Within solar PV, the closest to the grid is rooftop PV followed closely by GM-PV, while Agro-PV is the farthest solar PV type from the grid."

Distribution of Municipalities with Highest Wind and Solar Potential

For this part, the distribution of the fifty municipalities with the highest potential are considered in order to gain insight on their distribution per country.

Solar PV

Agro PV

As can be seen in the figure below, Germany has the highest number of municipalities with high potential of Agro-PV.

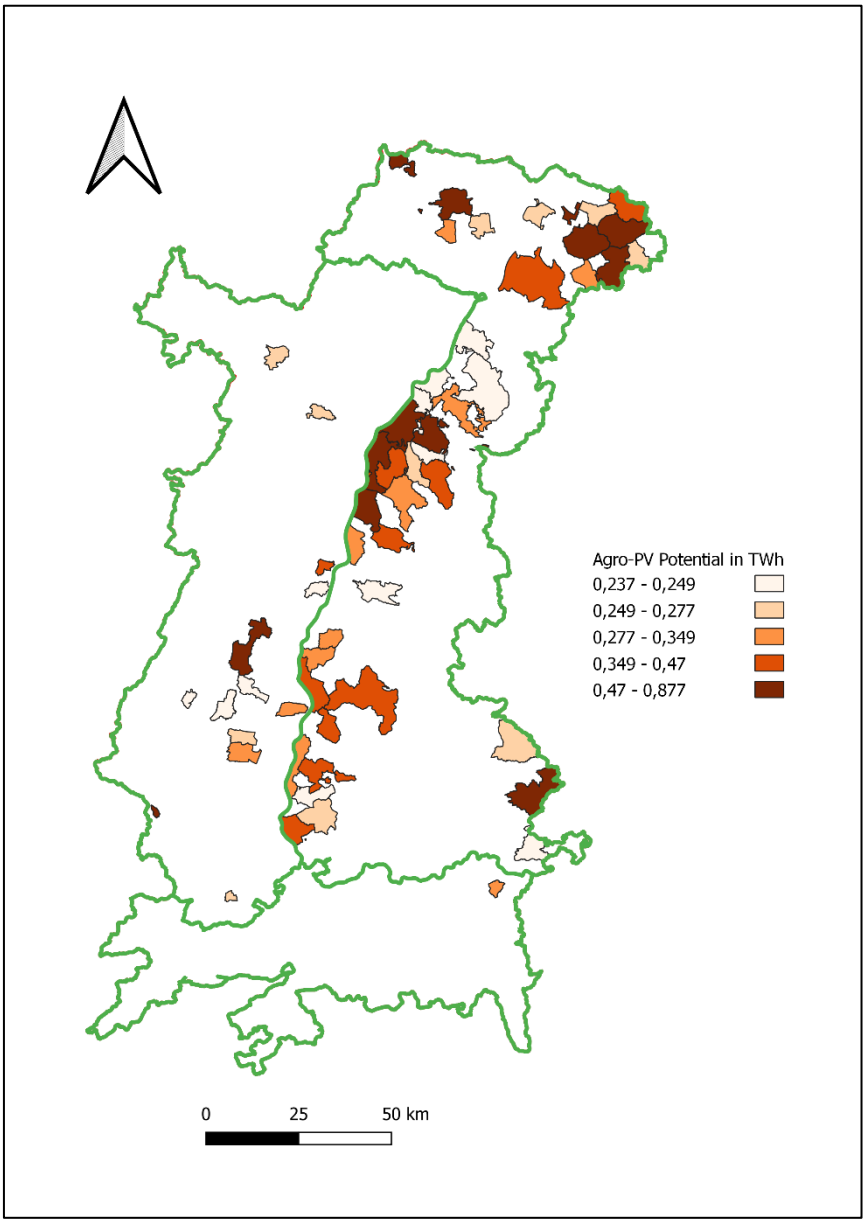


Figure 6: The 50 municipalities with the highest Agro-PV Potential in TWh/yr in the URR

GM-PV

As can be seen in the figure below, Germany has the highest number of municipalities with high potential of GM-PV.

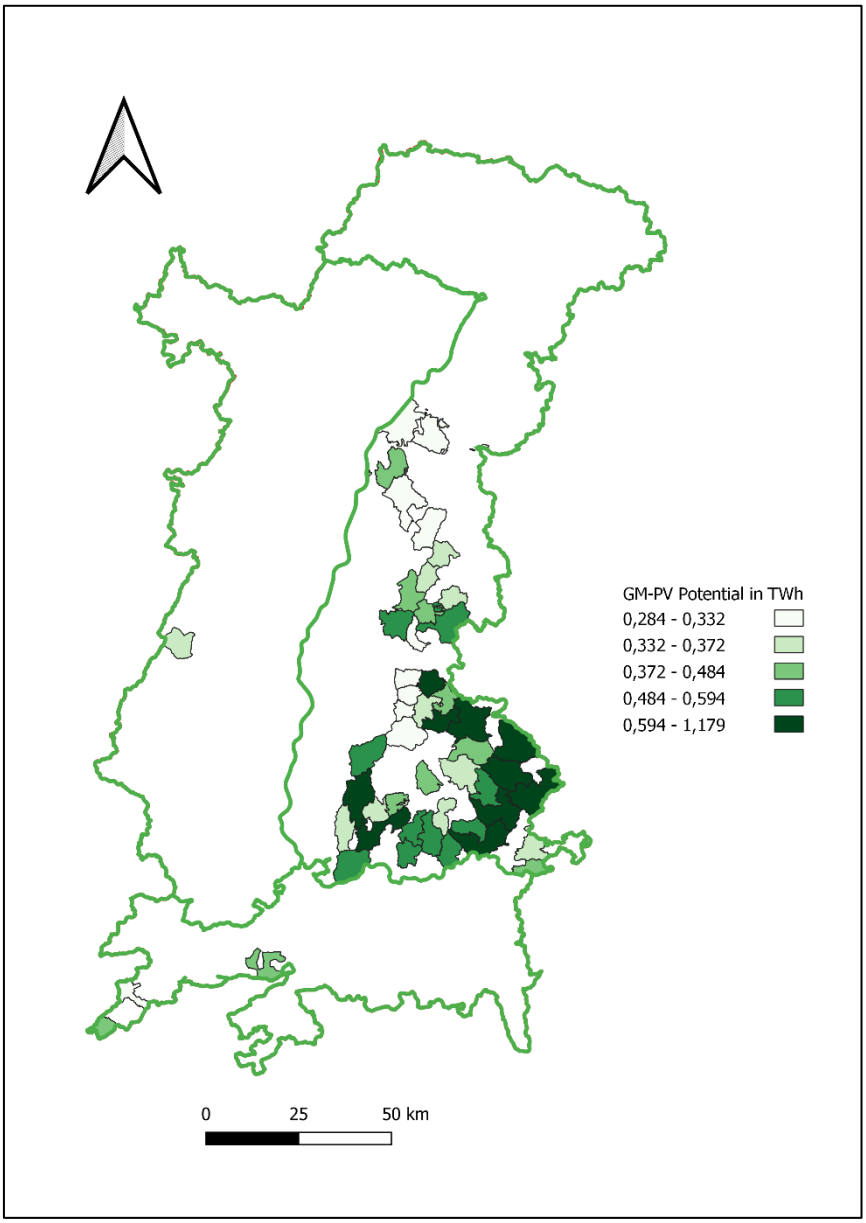


Figure 7: The 50 municipalities with the highest GM-PV Potential in TWh/yr in the URR

Rooftop PV

As can be seen in the figure below, Germany has the highest number of municipalities with high potential of rooftop-PV.

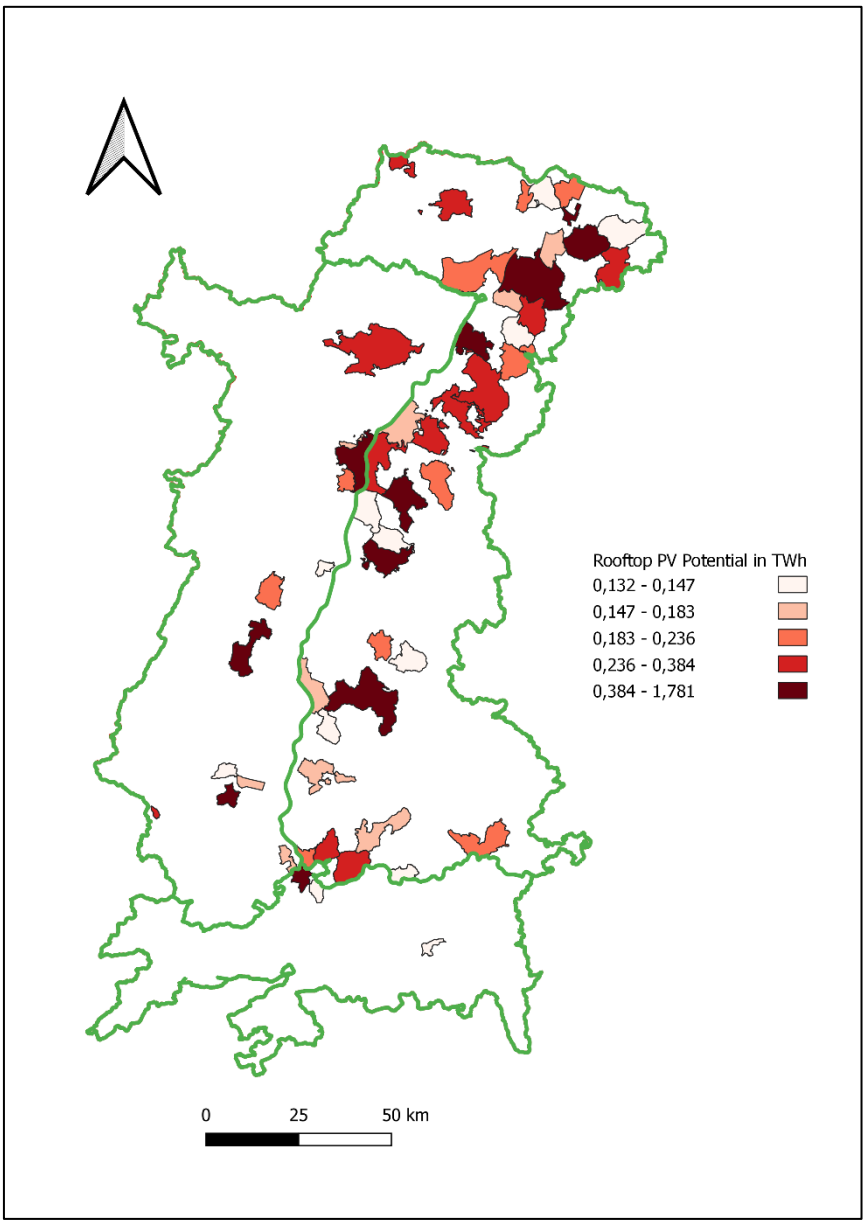


Figure 8: The 50 municipalities with the highest Rooftop PV Potential in TWh/yr in the URR

Wind

As can be seen in the figure below, Germany has the highest number of municipalities with high potential of wind energy.

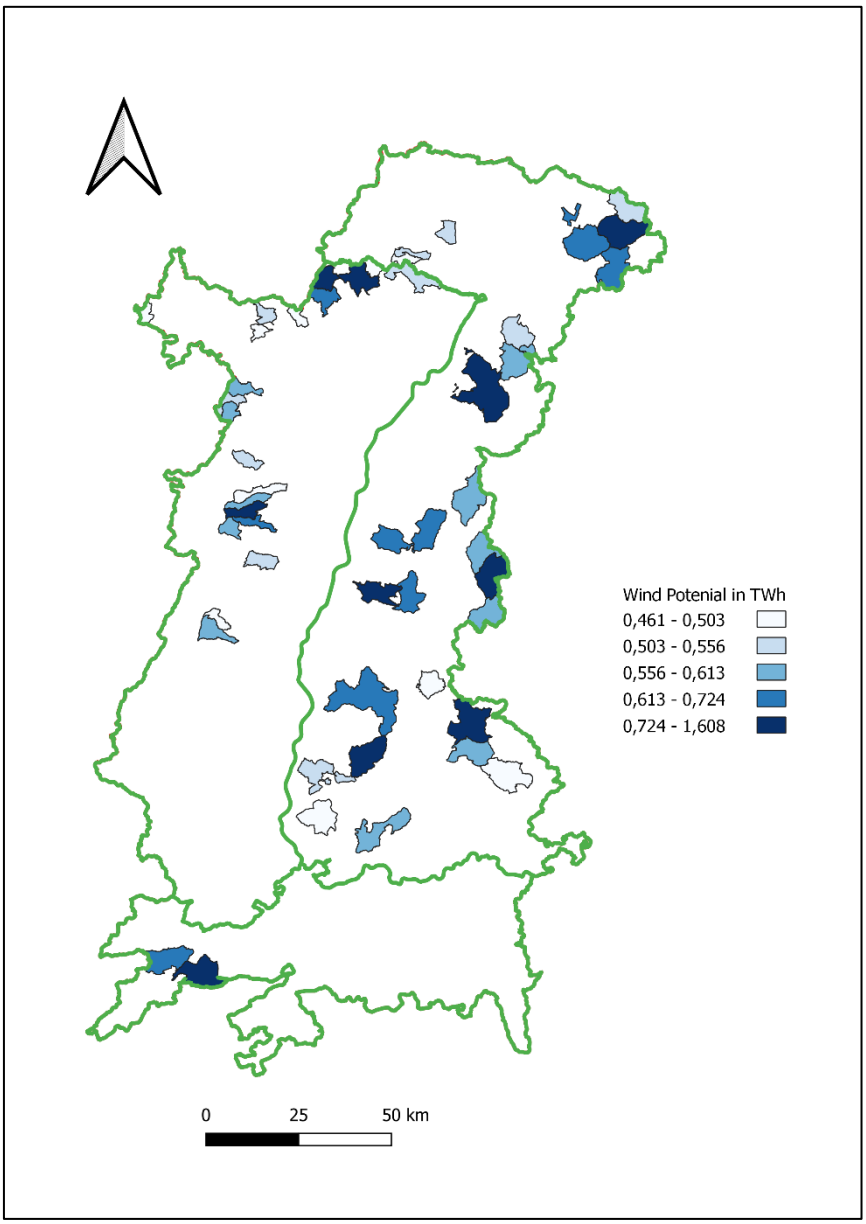


Figure 9: The 50 municipalities with the highest Wind Potential in TWh/yr in the URR

Quantitative Analysis of the Municipalities and their Potential

In this section, a quantitative analysis of the potential of RES (solar PV and wind) of municipalities is analyzed in the form of two ratios. Ratio A depicts the ratio of the number of municipalities with zero potential to the number of total municipalities and ratio B depicts the ratio of the number of municipalities with above-average potential to the number of total municipalities. The two ratios help give some insight on the logic behind the distribution of the potentials per country.

Solar PV

Agro PV

Table 1: Ratio A and ratio B calculated for the Agro-PV potential of the municipalities in the URR

Agro-PV	Number of Municipalities with 0 Potential	Total Number of Municipalities	Ratio A	Average Potential per Municipality (in TWh)	Number of Municipalities with Higher than Average Values	Ratio B
France	128	868	0,15	0,05	346	0,40
Germany	88	377	0,23	0,09	126	0,33
Switzerland	37	464	0,08	0,03	159	0,34

GM-PV

Table 2: Ratio A and ratio B calculated for the GM-PV potential of the municipalities in the URR

GM-PV	Number of Municipalities with 0 Potential	Total Number of Municipalities	Ratio A	Average Potential per Municipality (in TWh)	Number of Municipalities with Higher than Average Values	Ratio B
France	442	868	0,51	0,02	240	0,28
Germany	40	377	0,11	0,12	111	0,29
Switzerland	328	464	0,71	0,02	93	0,20

Rooftop PV

Table 3: Ratio A and ratio B calculated for the rooftop PV potential of the municipalities in the URR

Rooftop PV	Number of Municipalities with 0 Potential	Total Number of Municipalities	Ratio A	Average Potential per Municipality (in TWh)	Number of Municipalities with Higher than Average Values	Ratio B
France	1	867	0,001	0,02	204	0,24
Germany	1	377	0,003	0,06	106	0,28
Switzerland	1	462	0,002	0,02	151	0,33

Wind

Table 4: Ratio A and ratio B calculated for the wind potential of the municipalities in the URR

Wind	Number of Municipalities with 0 Potential	Total Number of Municipalities	Ratio A	Average Potential per Municipality (in TWh)	Number of Municipalities with Higher than Average Values	Ratio B
France	123	868	0,14	0,08	745	0,86
Germany	81	377	0,21	0,13	321	0,85
Switzerland	168	462	0,36	0,03	294	0,64

The Usable Area per Country

Another important criteria is the usable area per country. The ratio of the usable area per country to the total URR usable area is calculated below for each RES and the results are given in %.

Solar PV

GM-PV

Table 5: The per country percentage of usable area to the total usable area for the RES GM-PV

Country	GM-PV Usable Area/Total Area in %
Switzerland	11
Germany	65
France	24

Agro-PV

Table 6: The per country percentage of usable area to the total usable area for the RES Agro-PV

Country	Agro-PV Usable Area/Total Area in %
Switzerland	47
Germany	15
France	38

Rooftop PV

Table 7: The per country percentage of usable area to the total usable area for the RES rooftop PV

Country	Rooftop PV Usable Area/Total Area in %
Switzerland	22
Germany	45
France	33

Wind

Table 8: The per country percentage of usable area to the total usable area for the RES wind

Country	Wind Usable Area/Total Area in %
Switzerland	10
Germany	39
France	51

Analysis of the Potentials and their Distribution

Some important observations for the obtained results presented above are:

Switzerland has the lowest potential out of the three countries in all cases when it comes to all types of solar PV and wind distribution (Figures 1, 2, 3, & 4). It also has the lowest number of municipalities in comparison to the other two countries (Tables 1, 2, 3, & 4) and land area which could be the reason for the lower potentials calculated. The Swiss part of the URR occupies approximately 3,583 km^2 or 17 % of the studied area. Germany and France, on the other hand, respectively occupy more comparable areas of 9,652 km^2 (45%) and 8,325 km^2 (38%) of the total area, which could explain why Switzerland is lagging behind in terms of RES potential as much of the study is dependent on area. The exception would be the usable area for Agro-PV in Switzerland which is the largest of the three countries as can be seen from Table 6.

Moreover, Germany has the largest potential when it comes to rooftop PV and GM-PV (Figures 2 & 3) as well as the highest percentage of municipalities with high potential out of the fifty municipalities with the highest potential for all cases of solar PV and wind (Figures 6, 7, 8, & 9). Germany also has the highest percentage of usable are when it comes to rooftop PV and GM-PV (Tables 2 & 3), which could explain the high potentials calculated. Germany also has the highest number of inhabitants in comparison to the other two countries which could explain the availability of usable areas for rooftop PV and consequently the potential related to rooftop PV. Equally important for the availability of rooftop potential are the two factors: availability of rooftop surface area and solar irradiation.

When it comes to Agro-PV and wind, France has the highest potential in comparison to Germany and Switzerland (Figures 1 & 4), but still the fifty municipalities with the highest potential are in both cases concentrated in Germany (Figures 6, 7, 8, & 9). However, France also has a higher number of municipalities in the study area than Germany and Switzerland (Tables 1, 2, 3, & 4). In addition, France has the highest percentage of usable area to total usable area in the case of wind (51%) as can be seen in Table 8. As mentioned before, Switzerland has in fact the largest share of the percentage of usable area when it comes to Agro-PV (Table 6) which means that France probably receives higher solar irradiation values at the stage of the theoretical potential. Furthermore, when it comes to Agro-PV, Germany has the highest value of ratio A and France has the highest value of ratio B which means that France has the highest percentage of municipalities from the total number to have higher than average values and Germany has a large percentage of municipalities with zero potential of the total (Table 1). In turn, France has the highest potential of Agro-PV.

In the case of GM-PV, Switzerland has the highest value of ratio A (highest percentage of municipalities with zero potential) as can be seen in Table 2 which could contribute to the fact that Switzerland has the lowest potential for GM-PV. Ratio B on the other hand is comparable for Germany and France which have higher potentials of GM-PV. Interesting enough, for rooftop-PV, all of the countries have a small ratio A meaning that there is a very small number of municipalities with no potential as can be observed in Table 3. Meanwhile, Switzerland has the highest number of municipalities with above-average values in this category. Finally, for wind energy, Switzerland has the highest value of ratio A and France and Germany have comparable values of municipalities with above average potential values (Table 4).

On the other hand, by taking into consideration the study of the distances of the usable area of the RES from the grid from Figure 5, it can be observed that GM-PV and rooftop PV also have the highest percentage of usable area that is located close to the electric grid components or located in zone A & zone B as explained in Report 2.1.2. The highest potential for both and the largest usable area is found in Germany, so it is also possible that Germany is better connected than the other two countries or that the study is limited as specified in Report 2.1.2 by the availability of public country grid data.

Conclusion

Understanding the distribution of the potentials per municipality and country in the study region could help decision makers on the municipality level and country level understand the strengths and weaknesses in terms of the availability of the RES potential and its distribution so that the future development plans of the different municipalities could be adapted accordingly.