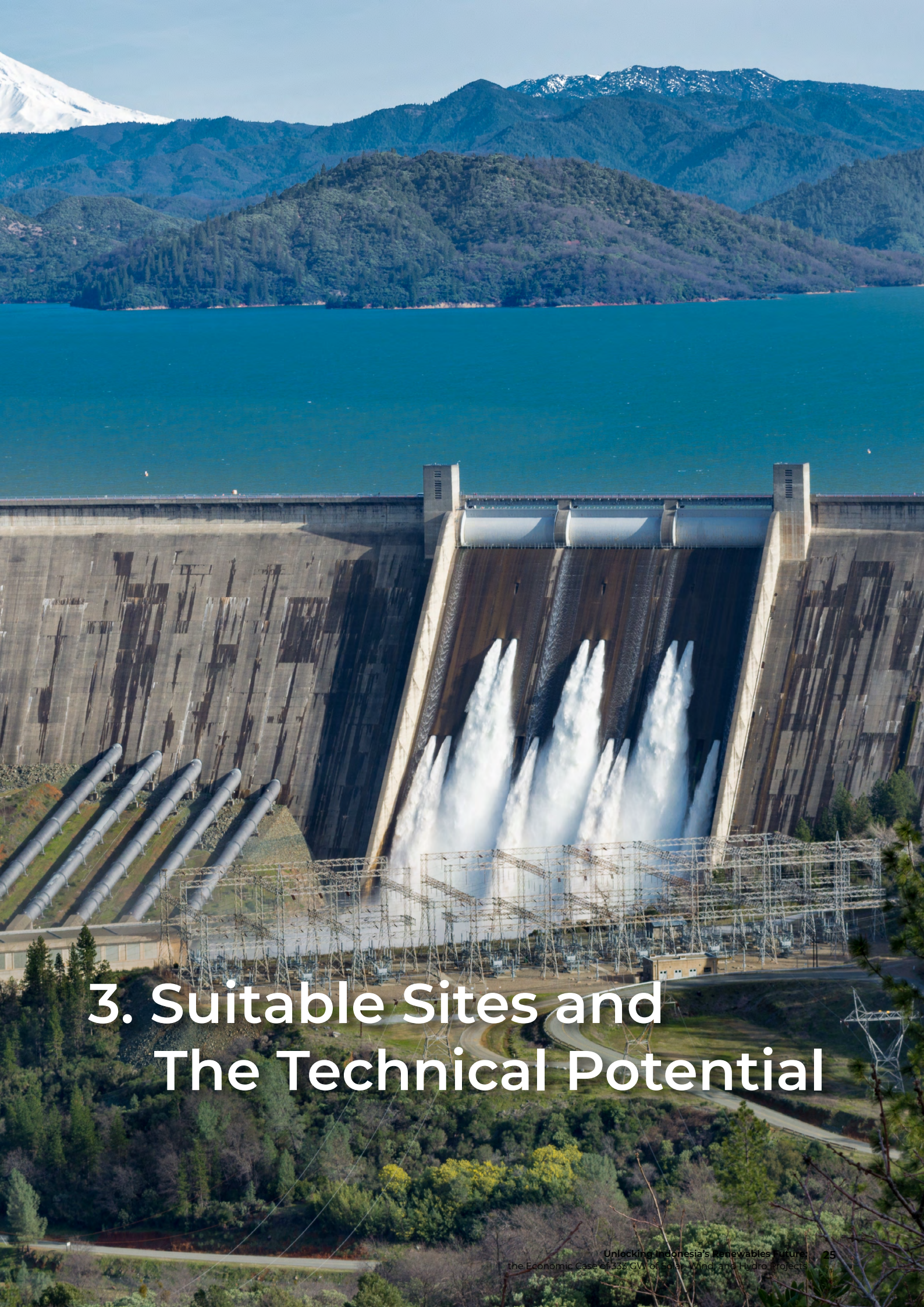

3. Suitable Sites and The Technical Potential

Based on the results of geospatial analysis with updated constraint parameters, **341** potential site locations for wind power, **781** site locations for solar power, and **458** site locations for mini-hydropower are identified. The total capacity that can be installed at all these site locations is around **584.53 GW**. The potential site locations are distributed in all provinces of Indonesia, as shown in Table 14. Provinces with the highest wind potential are East Nusa Tenggara, South Papua, Maluku, and South Sulawesi. For solar power, those with the highest technical potential are found in East, Central, and West Java and also South Sulawesi. As for mini-hydro power, provinces with the highest potential are located in North Sumatera, East Java, and South Sulawesi.

Table 4. Refiltered technical potential capacity

Criteria	Technical Potential Capacity (MW)		
	Solar Utility Scale	Wind Utility Scale	Mini-hydro Utility Scale
Aceh	7,740.53	2,152.00	50.58
Bali	740.76	20.00	82.54
Banten	3,926.53	980.00	5.97
Bengkulu	1,425.62	12.00	27.72
Yogyakarta	4,293.93	700.00	0
DKI Jakarta	0	0	0
Gorontalo	3,755.37	1,892.00	13.61
Jambi	3,298.15	120.00	0
West Java	22,308.14	6,184.00	119.85
Central Java	38,794.01	8,320.00	40.44
East Java	93,510.29	7,256.00	260.32
West Kalimantan	10,093.06	2,116.00	0
South Kalimantan	10,611.28	604.00	0
Central Kalimantan	15,721.80	540.00	0
East Kalimantan	26,676.75	12.00	0
North Kalimantan	2,061.05	464.00	0
Bangka Belitung Islands	1,870.12	108.00	0
Riau Islands	2,547.99	472.00	0
Lampung	265.46	424.00	42.73
Maluku	1,397.57	41,120.00	0.80
North Maluku	111.69	144.00	0
West Nusa Tenggara	3,809.05	7,972.00	7.69
East Nusa Tenggara	9,556.13	65,624.00	10.03
Papua	1,434.79	40,00	0
West Papua	0	4,588.00	0
Southwest Papua	1,283.84	38.00	0
Papua Mountains	0	1,432.00	0
South Papua	0	53,536.00	0
Central Papua	0	168.00	0
Riau	5,387.77	36.00	0
West Sulawesi	3,222.78	944.00	29.31
South Sulawesi	13,720.18	25,260.00	150.41

Criteria	Technical Potential Capacity (MW)		
	Solar Utility Scale	Wind Utility Scale	Mini-hydro Utility Scale
Central Sulawesi	6,667.57	5,996.00	140.44
Southeast Sulawesi	6,084.96	796.00	0
North Sulawesi	12,989.12	2,820.00	135.72
West Sumatera	5,019.97	1,000.00	134.93
South Sumatera	5,292.00	184.00	31.51
North Sumatera	10,933.55	1,776.00	493.85
Total	**336,551.79**	**246,200.00**	**1,778.44**

a. Solar PV Power

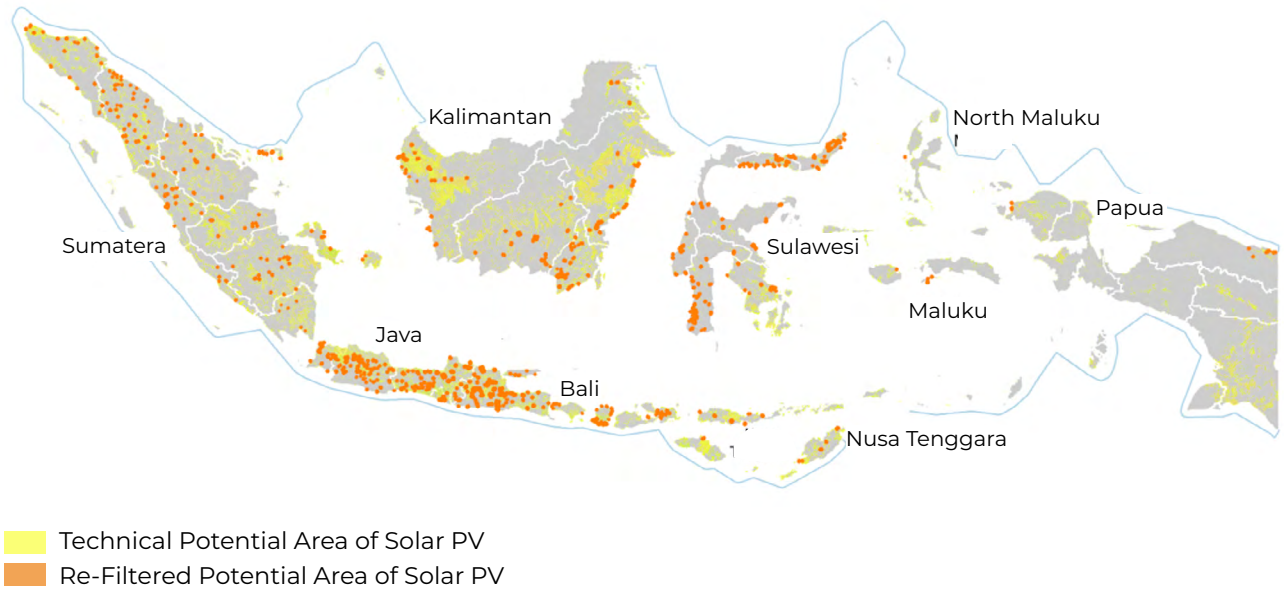

Figure 14. Technical potential area of solar power in Indonesia

Solar power has the highest technical potential among other RE sources based IESR's earlier findings (2021). Re-filtered results in Figure 14 show that the total technical potential of ground-mounted solar power in Indonesia is **336.5 GW**. There is a significant decrease in suitable land for solar PV of more than 90% from the previous study. This decrease is caused by stricter parameters being implemented for filtration. Two most significant factors are the limitation of solar irradiance threshold being kept at the limit of 4.5 kWh/m2/day and the selection of only a 10 km radius buffer area from the substation and HV line. Furthermore, new parameters such as the exclusion of residential areas, water bodies, or dams and adding hazard restrictions also significantly reduced the total potential area's size. As a result, there are 781 sites with an average of **428.43** Ha per potential site. The provinces with the most potential sites for ground-mounted solar power implementation are West Java, Central Java, and East Java. Based on the three provinces, the total solar power capacity that can be implemented is around **76.37** GW.

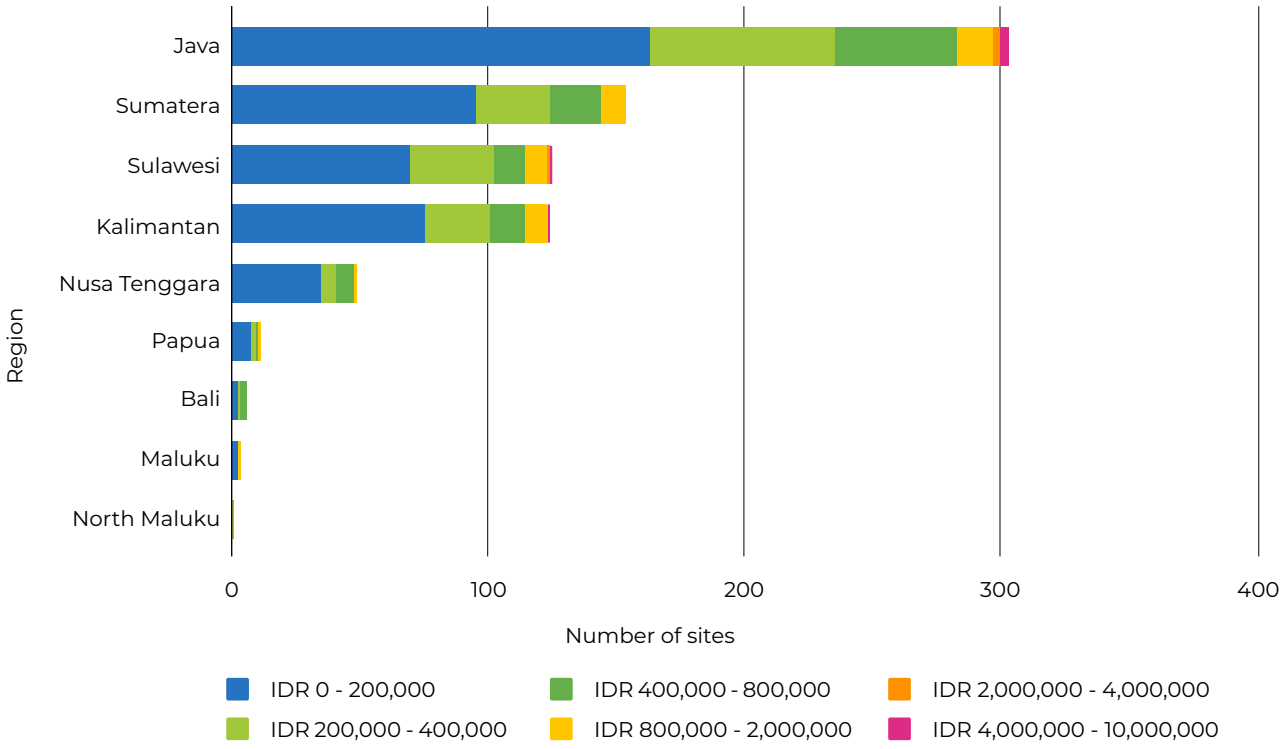

Figure 15. Solar potential site's land price variation by region

Land price distribution for solar potential sites varies in each region. On average, the sites occupy land with prices ranging from IDR 10,000 to IDR 10,000,000 per m^2. As shown in the Figure 15, most of the solar sites are located at the lower to middle prices between IDR 100,000 and IDR 300,000. By region, Java has the most land price variation ranging from lowest to highest price. With a land use assumption of 0.01 km^2/MW, the relatively expensive land cost conditions will impact the investment viability in solar power development—which will be explained in the next chapter.

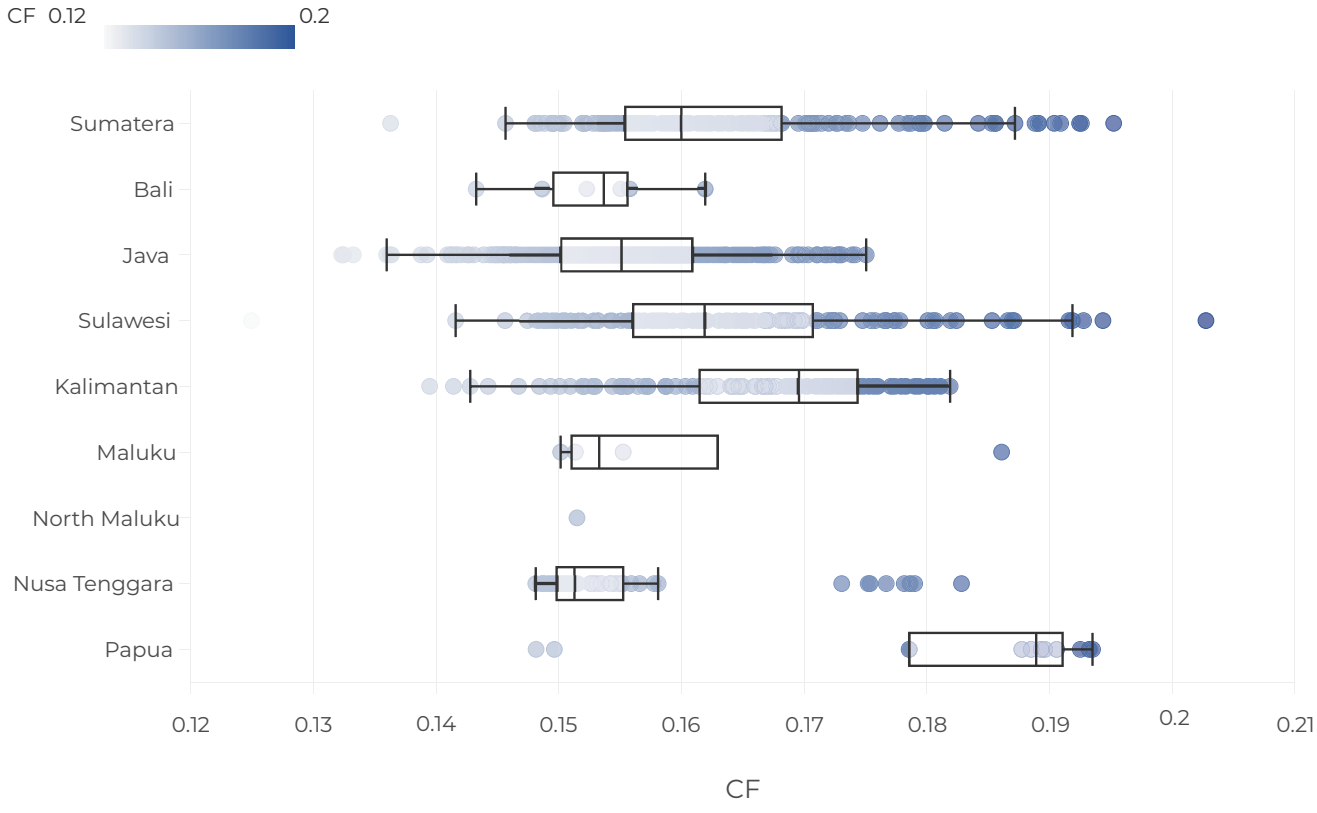

Figure 16. Solar capacity factor distribution per region

On average, the CF of solar power at 781 potential site locations is around 16.2%, with a range of 12.5-20.3%. Based on the results of geospatial analysis, the lowest CF value is in Java, while the largest CF is concentrated in Sumatera, Sulawesi, and Papua. Sites with the largest CF will have an increased feasibility due to the higher electricity generation compared to other locations.

b. Wind Power

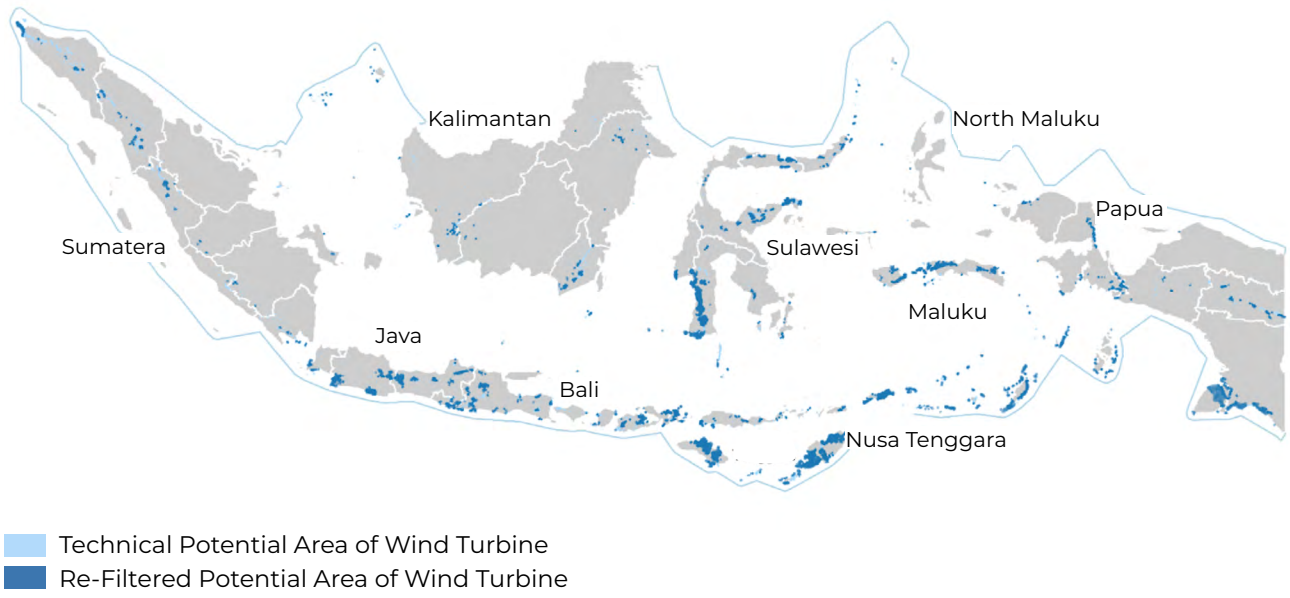

Figure 17. Technical potential area of wind power in Indonesia

Wind power has a total technical potential of **246.2 GW** scattered across Indonesia. Although the mean annual wind speed in Indonesia is only 4.9 m/s, a minimum wind speed of 5.5 m/s at 100 meters hub was applied to the model to acquire as much potential area of wind resource as possible, thus adding more area from previous limitation of 6.6 m/s at 100 meters hub. After applying constraints and other parameters, the result is a total area of **843.72 Ha** with **341 potential sites**. To determine the overall potential capacity of each site, grids were created based on turbine specifications with a capacity of 4 MW in those potential areas. The findings show that most of the wind sites are located in the eastern part of Indonesia. All provinces in Indonesia have wind power potential, with the highest being East Nusa Tenggara, South Papua, and Maluku.

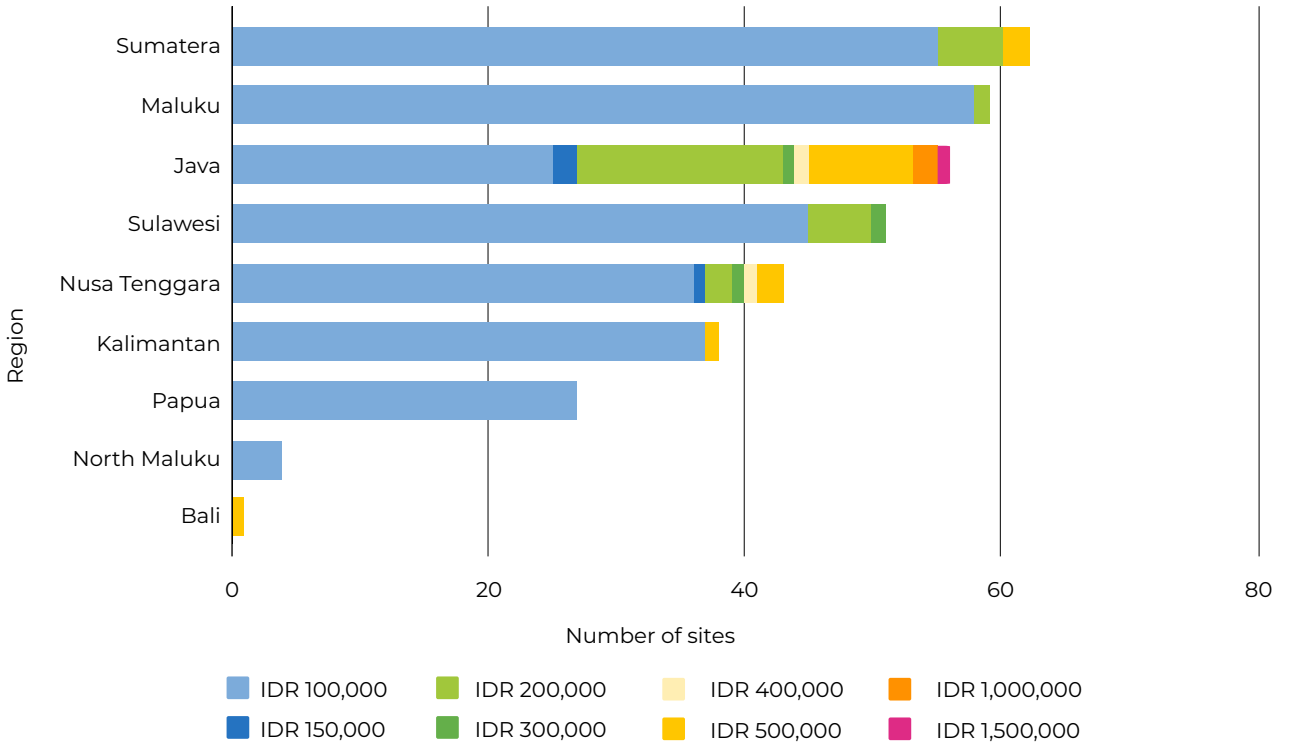

Figure 18. Wind potential site's land price variation by region

On average, wind potential sites occupy land with prices ranging from IDR 100,000 to Rp 1,500,000 per m^2. As shown in the Figure 18, most of the wind sites are located on land with relatively low prices. By region, Java has the most land price variation ranging from lowest to highest price. In contrast, more isolated regions like Papua and Maluku have the lowest range or below IDR 200,000 per m^2.

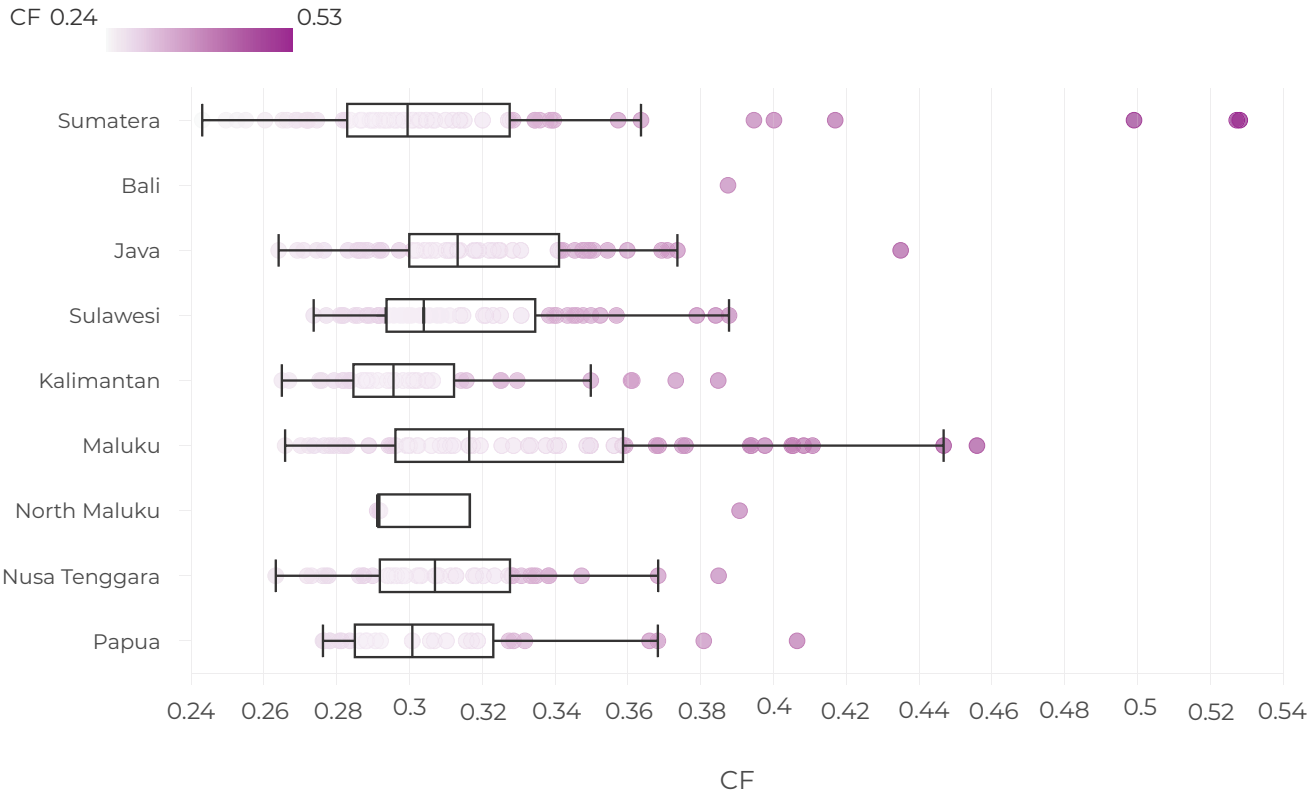

Figure 19. Wind capacity factor distribution per region

On average, the CF of wind power at 341 potential site locations is around 31.5%, with a range of 24.3-52.8%. Based on the results of geospatial analysis, the lowest CF value is in Sumatera, while the largest CF is also in the same region. Sites with the largest CF will increase the feasibility of wind power projects because the potential energy that can be produced will be higher than in other locations.

c. Mini-hydro Power

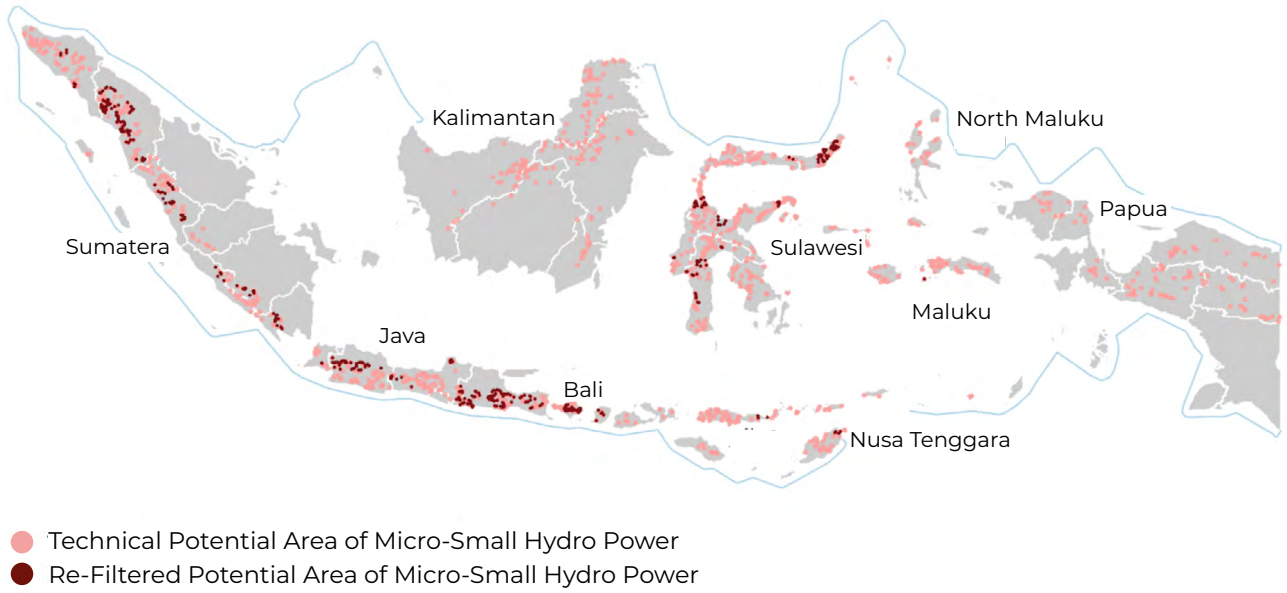

Figure 20. Technical potential sites of micro to small hydro-power in Indonesia

Hydropower is more reliable and less dependent on weather conditions compared to solar and wind. It can also provide flexible energy generation to meet fluctuating demands. Based on IESR (2021), micro and small hydropower can reach a potential of up to 28 GW in Indonesia. Updated parameters and constraints further filter the potential, resulting in 1.7 GW remaining technical potential of micro to small hydropower. There are a total of 458 potential sites, which are primarily distributed in East Java, North Sumatera, and North Sulawesi.

Hydro sites are mainly located in locations with a low range of land prices of around IDR 100,000. By region, Java has the most land price variation ranging from lowest to highest price of IDR 100,000 to IDR 10,000,000. Although the potential sites are more distributed in Sumatra and Sulawesi, most sites have low land price ranges, which indicates that more feasible development could be implemented there. Hydro sites have relatively low land costs due to their minimum land requirements conditions compared to solar or wind farms. Unlike solar and wind energy, which are intermittent and dependent on weather conditions, hydropower provides a stable and continuous energy supply from surface run-off. Therefore, it could become a supplementary source for other RE sources utilization and attract more investment.

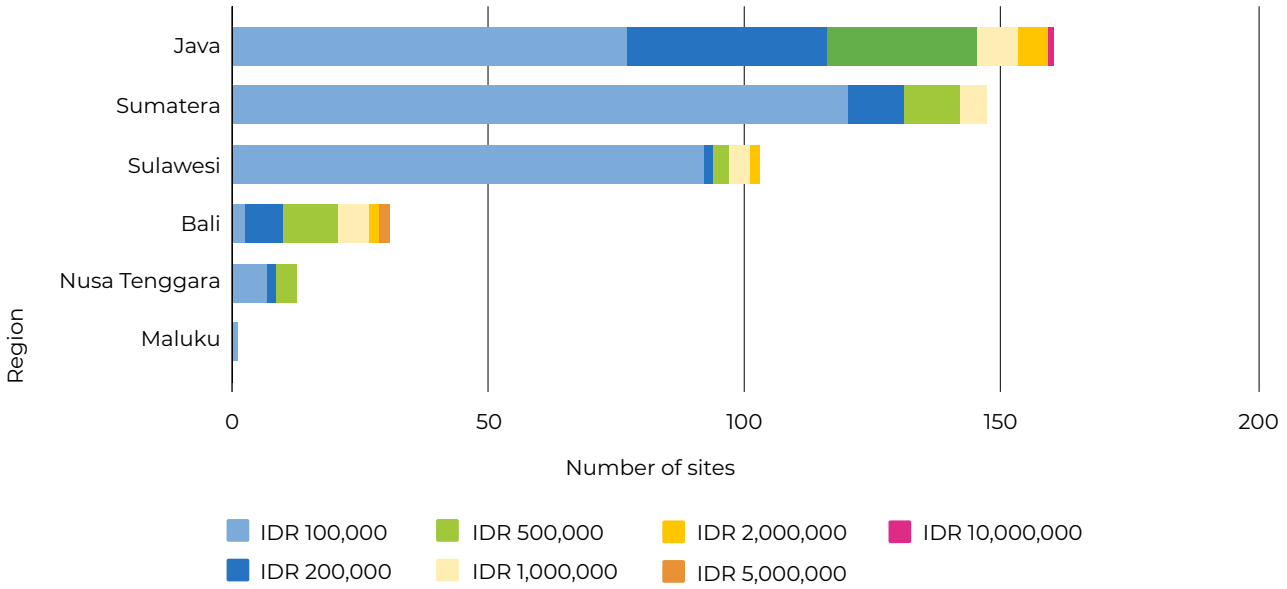

Figure 21. Hydropower potential site's land price variation by region

Studies and historical data showcase that run-of-river mini-hydro projects generally have a typical CF in the range of 40-60%, in accordance to experts' input and the common practice of mini-hydropower design in Indonesia. Therefore, to simplify the model, the CF for mini-hydropower is assumed to be 50% at all potential site locations. However, the determination of these assumptions has the consequence that the energy yield from mini-hydropower is less representative of the river water flow conditions in each potential site location.

4. Economic Viability of RE Projects