Solar panels:

$P/A = r \times H \times PR$

Gives the the power per m^2 for a given solar irradiance H. r is efficiency of panel, and PR is performance ratio to account for system losses.

Wind Turbine:

$P (W) = 1/2 \times \rho \times v^3 \times A$

Gives the power per square meter of the circle traced by the blades for a given wind velocity v. Also dependent on p, which is air density.

The optimization function would determine the square meters of wind needed. This could then be translated to number of solar panels, or maybe size vs number.

https://windpower.generatorguide.net/wind-speed-power.html

Hydro power:

$P = m \times g \times H_{net} \times \eta$

M is mass flow rate i kg/s and is related to both the flow of the river, and the size and capacity of the hydroturbine.

https://www.fstgenerator.com/no/50kw-micro-vertical-kaplan-turbine-generator-for-low-head-hydropower-product/

https://cdforster.en.made-in-china.com/product/HJCRImQDTaWL/China-50kw-75kw-100kw-Low-Head-Kaplan-Turbine-for-Micro-Hydro-Generator.html
Solar radiation in Funchal/Madeira (Portugal)
https://en.tutiempo.net/solar-radiation/funchal-madeira.html

Scenario 1: African Villages, subsahara (2.991458, 35.432551)
A hypothetical small village in central Africa with no electricity.

Assuming 600 inhabitants, in 100 households that have the following consumption pattern:

06-09 - 2000 W
9-4 500 W
5-10 3500 W
11- 01 2500 W
01-06 300 W

This assumes that the inhabitants generally have a low consumption.

In addition we can have a mostly constant load from agricultural industry at day at about 20 kW and 5 kW at night.

This gives a peak of about 2 MW

All three energy sources,

```
Optimal Solution Found:
Solar Installation:
  Area required:            1147.1 m²

Wind Installation:
  Number of turbines:       0
  Turbine diameter:         36 m

Hydro Installation:
  Installed turbines:       1
  Installed capacity:       125077.5 kW

Battery System:
  Capacity:                 2700.1 kWh

Total Project Cost: $2.90 million
```

Scenario 2: Canadian 'ranch' (52.346567, -126.893076)
12 hour drive from Vancouver - time zone LA
No hydro.

Assumes a single household but high energy demand due to heating. Can also assume a large amount of people living at the ranch.

06-09 - 8000 W
9-4 6500 W
5-10 12000 W
10-01 - 7000 W
02-06 5000 W

No hydro and low on solar, Winter and Summer

Scenario 3: Madeira (32.840654, -17.227074)
Only solar and wind, but high wind speed, winter
Assuming that you will redesign the entire energy system to see how the program handles large systems.

Demand for whole island:
06-09 - 100MW
9-4 60 MW
5-10 150 MW
11- 01 80 MW
02-06 45 MW

https://open-meteo.com/en/docs/historical-weather-api#start_date=2025-02-03&end_date=2025-02-09&hourly=wind_speed_100m,direct_normal_irradiance

https://sunsolartilt.com/pages/calculator

https://hybridpowersystems.org/Madeira2022/power-system-madeira-porto-santo/

Model output

Optimization
Windmill area is diameter 4.5 m^2 ref. Typical dimensions of a 2MW offshore wind turbine on monopile... | Download Scientific Diagram
Need assumptions on how much roof coverage. Say 0.5x mounted on roofs for Madeira. 0.2 for Canada.

Location	PV (m2). 1.25x area	Windmills (#, size). diameter^2	Windmill base size 176.7m^2	Hydro (#)	Batteries (kWh). 30m2 per MWh	Cost (USD)	Total space required
Kenya	826.1	0, 36m	0	1	2354.8	$2.6M	1103 m2
Canada	1841.3	0, 19.4m	0	0	1766.0	$1.6M	1894 m2
Madeira	3 312 818.8	50, 151m	8835	10	2 492 215.7	$2.7B	2 154 113 m2

Area calculations:
Kenya: 826.1 * 1.25 + 2354.8/1000 * 30 = 1103
Canada: 1841.3 * 1.25 * 0.8 + 1766.0/1000 * 30 = 1894.28
Madeira: 3312818.8*1.25 * 0.5 + 8835+ 2 492 215.7/1000 * 30 = 2 127 487
Windmill base size Template Article

Environment
"Fauna score" is found by ⅓(Richness + Avg. rarity + Total rarity)
"Vegetation score" is normalized from [-1, 1] to [0, 100]

Location	Richness	Avg. rarity	Total rarity	Fauna score	Vegetation score
Kenya	64	34	34	44	55
Canada	38	68	51	52	100
Madeira	9	60	30	33	100

Model score per location
We use the formula (⅔ fauna score + ⅓ vegetation score)^-1 / (Installation area) * 100

Location	Score
Kenya	1.14
Canada	0.01
Madeira	0.21

Score calculations:
Kenya: (⅔ * 0.44 + ⅓ * 0.55)^(-1) * 600 / 1103 = 1.14
Canada: (⅔ * 0.52 + ⅓ * 1)^(-1) * 10 / 1894 = 0.01
Madeira: (⅔ * 0.33 + ⅓ * 1)^(-1) * 250 000 / 2 154 113 = 0.21