Renewable electrical self-sufficiency on islands

There are 17 million people in Europe living on 2500 small islands. Islands are interesting cases to try and meet the electricity consumption entirely from locally available renewable sources.

Consider the case of an island with 600 inhabitants and year-round average electrical needs of 250 W_{el} / person. We will cover electricity needs by a wind turbine, or a sea turbine, or a wave power generator.

Data:

The average annual wind speed is 6 m/s (on land and sea). The wind turbine's rated wind speed is twice the average wind speed. The annual electricity generated from a wind turbine corresponds to the turbine running at its rated power for an equivalent annual load of 20%.

The wind turbine rated power coefficient C_p is assumed to be 40% and constant over the wind speed operating range, that of the sea-turbine 30%. In very simplified terms, we consider a constant peak tidal current of 1.5 m/s (i.e. spring tide = neap tide); the average power generated by the sea-turbine is 40% of the power generated at peak tidal current (cf. derivation in the course slides).

The efficiency of the wave power generator is taken as 70%. The typical amplitude of the waves out at sea around the considered island is 1.3 m. The wave power generator annual load for these conditions is taken as 50%, and the tidal sea-turbine is assumed to operate year-round.

Questions:

a) Dimension the devices such that <u>each</u> of them (a wind turbine, a sea turbine, a wave power generator) could theoretically supply <u>on its own</u> the total electricity need for the island's inhabitants, on a yearly average basis.

b) What has to be taken further into account, for each of the choices (wind turbine, sea turbine, wave power generator), to address this case more realistically, i.e. where are the limitations in each case?