World fossil energy consumption entirely replaced by biomass as renewable source

Data

World primary energy consumption in 1 year:

- 4059 Mton oil
- 3 223 Gm^3 natural gas (=2905.6 Mtoe)
- 7.5 Gton coal (=3724 Mtoe)

Replacement by biomass

We want to replace, in energy-equivalent terms, all fossil fuel by renewable biomasses:

- coal by wood (for **electricity** generation)
  with coal plant electrical efficiency = 40%, but wood plant efficiency = 20%
- oil by bioethanol (for **mobility** fuels)
- gas by biogas (for **heating** in buildings and industry)

Use the following simplified conversions
(we justify these conversion factors in the 'Biomass' chapter of the course) :

- we can grow 2 kg wood per year per m^2 of forest, with lower heating value = 17 MJ/kg
- we can obtain 3000 L bioethanol (heating value = 21 MJ/L, ρ = 0.78 kg/L) per year per hectare (=10'000 m^2) of biomass fields such as wood, corn, sugar cane, manioc
- we can digest agro-wastes from 1 hectare of land to 2000 m^3 of methane contained in biogas (lower heating value of methane CH_4 = 10 kWh/m^3)

Questions :

1. What would be the land-use for all this biomass to replace all fossil fuel?
2. Compare the obtained result with the available forest and agricultural area (11% and 3% of the Earth surface, respectively) – cf. course slides
3. Compare it also with the yearly biomass production of 32 Gtoe in forests and 3.6 Gtoe in agriculture.