World fossil energy consumption entirely replaced by biomass as renewable source ?

Data

World primary energy consumption:

- 4059 Mton oil, of equivalent chemical formula $C_7H_{14}N_{0.1}O_{0.1}S_{0.3}$
  (=> molar weight = 110 g/mol), ρ = 0.88 kg/L
- 3 223 Gm^3 natural gas (=2905.6 Mtoe), ρ = 0.7 kg/m^3,
  → take as equivalent to methane CH_4 (=> molar weight = 16 g/mol)
- 7.5 Gton coal (=3724 Mtoe), heating value 20 MJ/kg, carbon content 0.5 carbon/kg coal
  (molar weight of carbon = 12 g/mol)

Replacement

1.
We need 2 * 3724 Mtoe energy equivalent in wood to replace coal (to account for only half the electrical conversion efficiency, 20% instead of 40%) = 7450 Mtoe wood equivalent = 312 EJ = 18.35 Gt wood of 17 MJ/kg heating value. Compared with the yearly wood energy production in forests (32 Gtoe), we would require 1/4th (7.45 Gtoe) of this amount, showing the scale needed to replace coal by wood.

If we can grow 2 kg per m^2 in renewable fashion, these 18.35 10^{12} kg grow on **9.18 10^{12} m^2 woodland**. To harvest this sustainably, if we assume **a 25 year growth** cycle, we then use every year 1/25th of the area, i.e. **3.67 10^{11} m^2 woodland**.

The globe surface is 4.π.(6'378'000 m)^2 = 5.1 10^{14} m^2, of which 11% is forest land, i.e. 5.6 10^{13} m^2. Hence 0.66% (=3.67 10^{11} m^2 of 5.6 10^{13} m^2) of total forest area on Earth would be needed every year to replace coal for electricity, and then allowed to grow back.

2.
We need 4059 Mtoe ethanol equivalent (21 MJ/L).

4059 Mtoe = 170 EJ, which is 8.1 10^{12} L (with 21 MJ/L heating value for ethanol).

This requires 2.7 10^9 hectare cropland (if ethanol yield is 3000 L/hectare), i.e**. 2.7 10^{13} m^2** of agricultural land. Total current agricultural land is 3% of the globe, or 1.53 10^{13} m^2.
In other words, we would almost need to double the now used agricultural land only to replace oil by ethanol!

3.
We need 3223 Gm^3 gas = 3.223 10^{12} m^3 and can generate this from agrowaste at a rate of 2000 m^3 methane per year and hectare of agricultural land. Hence we need 1.61 10^9 hectare, or **1.61 10^{13} m^2**. Again this alone would use all the current agricultural land!

In total we would need 4.31 10^{13} m^2 agricultural land (=8.5% of the planet, i.e. **30% of all land**!) and 3.67 10^{11} m^2 woodland. Clearly **liquid and gaseous biofuels are limited**. This is less so with **solid biomass**, due to its bigger energy density and growth density.
In fact, the main bottleneck in energy supply today is liquid fuel for mobility and the world's high dependence on oil for it as its almost exclusive source.