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

Data

https://ourworldindata.org/grapher/global-primary-energy

World primary energy consumption in 2023:

2023 in terawatt-hours	
Modern biofuels	1,318 TWh
Other renewables	781 TWh
Solar	1,642 TWh
Wind	2,325 TWh
Hydropower	4,240 TWh
Nuclear	2,738 TWh
Gas	40,102 TWh
Oil	54,564 TWh
Coal	45,565 TWh
Traditional biomass	11,111 TWh
Total	164,385 TWh

- 33.2% = 54'564 TWh oil (=196,4 EJ = 4688 Mton oil, using 41,9 PJ per Mtoe)
- 24.4% = 40'102 TWh gas (=144,4 EJ = 4010 Gm^3 natural gas, using 10 kWh per m^3 NG)
- 27.7% = 45'565 TWh coal (= 164 EJ = 8.42 Gton coal, using 19.5 MJ per kg coal)

At the same time we see that in 2023 'traditional biomass' (essentially wood) accounts for 11'111 TWh (=40 EJ) or 6.8% of the total primary energy, and 'modern biofuels' account for 1'318 TWh (4.7 EJ) or 0.8% of the total.

Replacement

1.

We need 40/25 * 164 EJ energy equivalent in **wood** to replace coal (to account for the electrical conversion efficiency difference, 25% instead of 40%) 262,4 EJ wood = 15.4 Gt wood of 17 MJ/kg heating value. Compared with the yearly wood energy production in forests (32 Gtoe = 1341 EJ), we would require 19,6% or almost 1/5th of this amount, showing the scale needed to replace coal by wood.

For an average 2 kg wood per m^2 growth, these 15.4 10^{12} kg grow then on 7.7 10^{12} m^2 woodland (7.7 million km^2, the size of Australia). To harvest this sustainably, if we assume a 30 year growth cycle, we then would need to chop down every year 1/30th of the area, i.e. 2.57 10^{11} m^2 woodland (257'000 km^2, an entire forest about the size of New-Zealand or the UK).

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 (56 million km^2). Hence 0.257/56 = 0.46% of total forest area on Earth would be needed every year to replace coal for electricity, and then allowed to grow back. Technically doable, but a massive scar on the planet, and a logistic nightmare.

2.

We need 196.4 EJ **biodiesel** equivalent. With the energy equivalent of 33 MJ/L, this is 5.95 10^{12} L = 5.95 10^9 m^3 = 5.95 km^3 = a cube of 1.8 km edge length, or alternatively a volume somewhere in between the Lake of Brienz (5.2 km^3) and the Lake of Thun (6.5 km^3), the 2 lakes on both sides of Interlaken (BE).

Since the yield of biodiesel is very low with 1000 L (just 1 m^3 !) / ha (10'000 m^2), we would need 5.95 10^9 ha of plantations = 5.95 10^{13} m^2 = 5.95 10^7 km^2 = 59.5 million km^2

Total current agricultural land is ≈3% of the globe surface, or 1.53 10^{13} m^2 (15,3 million km^2).

In other words, we would need to quadruple all agricultural land only to replace oil by biodiesel from classic production. Hence this is entirely utopical.

3.
We need 4010 Gm^3 gas = 4 10^{12} m^3 and could generate this from agro-waste at a rate of 2000 m^3 methane per year and hectare of agricultural land. Hence we need $4.10^{12}/2000$ = 2 10^9 hectare = 2 10^{13} m^2 =2 10^7 km^2 = 20 million km^2. Again this alone would use more than all the current agricultural land.

Comment :
clearly liquid and gaseous biofuels are very limited.
This is less so with solid biomass, due to its higher energy density and growth density.
It illustrates also why fossil fuels have been so successful and in demand (high energy density and 'easy' logistics (pipelines)).