Among all the **energy-supply** technologies, the four with the biggest potential today are solar power, wind power, bio-energy, and nuclear power. Deep geothermal heat and power may also have large potential, though it has yet to be demonstrated at scale in Europe. Figure 1 visualizes, for illustration, the sizes of solar, wind, bio-energy, deep geothermal, and nuclear facilities that would each supply **12 kWh per day per person**. (I am not recommending this particular energy mix; I picked equal amounts from each source so as to make it easy to see the exchange rates, and easy to visualize alternative mixes.)

- To deliver 12 kWh per day per person from wind (for everyone in Hungary) would require wind farms with a total area of 2500 km² – 4.2 Balatons – roughly a seventy-fold increase in Hungary’s wind power over 2011 levels. [Assumption: Windfarms deliver roughly 2.0 W/m². April 2011 capacity was 329 MW. The wind capacity required to deliver 5 GW on average would be about 22.7 GW, assuming an average load factor of 22%.]

- To get 12 kWh per day per person from nuclear power would require 5 nuclear power stations with an average output of one gigawatt – a roughly 2.5-fold increase over today’s levels in Hungary. [The four power stations at Paks have a capacity of 2 GW.] On the map, these facilities are not shown to scale. They would occupy an area of about 5 km².

- To get 12 kWh per day per person from bio-energy would take roughly 10 000 km² – 11% of Hungary’s land area (17 Balatons), assuming energy crops have a net power per unit area of 0.5 W/m². This chemical energy could replace some of today’s oil and natural-gas consumption.

- To supply 12 kWh per day per person from deep geothermal sources would require, say, 500 wells each delivering 10 MW. (Get photo to visualize.) (This is nearly three times as much as the deep geothermal potential that was described as achievable in GKM 2008.) (Need to clarify whether they were delivering heat only, not electricity – I expect so.) These wells have been visualized by 500 points on the map.

- To supply 12 kWh per day per person on average from solar power (for everyone in Hungary) requires solar parks with total area of 900 km² (that’s 1% of the area of Hungary, or a little over 1.5 Balatons). [Assumption: solar parks in a location where the insolation is on average 3–3.5 kWh/d/m² (125–146 W/m²) deliver on average 5.5 W/m².]

- To supply 12 kWh per day per person on average from solar power in someone else’s desert requires roughly 370 km² of concentrating
solar power stations (roughly two thirds of a Balaton). [This visualization assumes that concentrating solar power stations can deliver an average power per unit area of about $15 \text{ W/m}^2$, and that the losses in transmission are 10%.]

Figure 1. Visualizing sustainable energy options, on the supply side, for Hungary. Grey-green square: wind farms. Purple dots: nuclear power stations (not to scale). Light-green square: bio-energy plantations. (Some of these could occupy the same land as the wind farms.) Blue square in the southeast: solar photovoltaic parks. Yellow square in the southwest: concentrating solar power facilities in someone else's desert, to scale. Red dots (not to scale): deep geothermal facilities, each delivering 10 MW.

Of course there are other technologies I haven’t mentioned in this short note, which can also contribute to a plan that adds up. Home-mounted solar hot water panels, for example, can easily deliver at least half of the hot-water demand of a typical family in almost all climates; seasonal heat storage systems might allow excess heat to be harvested in the summer and stored until the winter; and clean coal and clean gas with carbon capture and storage are crucial technologies to reduce the risks associated with fossil-fuel burning. And finally, I must emphasize that the focus on the supply side in this note does not imply that I have forgotten about demand reduction through more efficient technologies or lifestyle changes that reduce energy consumption, for example switching from car-driving to public transport, cycling, and walking; flying less; and buying less stuff.
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David J.C. MacKay

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