Chapter 13

Land use for energy

"Changes in land use associated with energy development can have a significant impact on the quality of the physical, social, economic, and visual environment. Local air quality, water quality, water availability, noise levels, the municipal tax base, land values, job opportunities, and the character of the community itself may be affected."

US Department of Energy Report about land use and energy in 1975.

Land use is a crucial issue when addressing the energy-water-food nexus. The competition for land is apparent in several ways. The world is facing increasing food demands due to both increasing average incomes and the rise in population. At the same time, it is feared that the agriculture yield will drop because of water scarcity.

It is argued that solar PV and wind power may require fertile land and consequently threaten food production. On the contrary, solar PV provides a large benefit by using not land but spare rooftops. The land area requirements for different types of electricity generation can be compared (Olsson, 2015). Large hydropower requires a certain area for the reservoir. Often there is a multi-purpose reservoir, used for water storage and flood protection besides hydropower. For wind power the total area enclosed by the site boundary is defined as the land use, although the area between the towers can often still be

doi: 10.2166/9781780409443_0159

land use, although the area between the towers can often still be utilised for agriculture or forest. Offshore wind will of course have an environmental impact as well, but the area seldom competes with other uses. Solar PV does not necessarily need to occupy fertile land. Small-scale PV and solar heating installations have minimal land impact, as they are actively integrated into buildings and structures they serve.

The power and energy outputs from a given area are summarised in Table 13.1. It is obvious that solar PV is very competitive in regard to land use, even if the capacity factor is relatively low for the actual area. In the US the National Renewable Energy Laboratory (NREL) (www.solarindustrymag.com/online/issues/) has studied the land footprint of utility-scale solar generation. There is a wide range of total land use. The average total land use was estimated at 8.9 acres (around 36,000 m^2) per MW, or around 28 MW/km^2 (compare with Table 13.1).

Table 13.1 Energy output from a given area for different renewable sources (Olsson, 2015).

	Hydropower	**Wind**	**Solar PV**
Power density MW/km^2	0.1–17	5–8	20–110
Capacity factor	0.6	0.3	0.2
Annual energy output GWh/km^2	0.5–90	13–21	35–190

The wind power land use requirement depends on both the size of the turbines and the extent of the terrain. In a hilly area the wind turbines may be located along the ridgelines. Wind towers on flat terrain are often positioned more uniformly and may require a larger land area. The footprints for wind farms in the United States average around 333,000 m^2 per MW or a power density of 3 MW/km^2 (NREL, 2012b).

The space between the wind turbines on a farm can be large. However, only a small fraction (3–5%) of the land required is disturbed by the wind energy structures. The rest of the land could be utilised for agriculture and transport links. Naturally, in remote areas there will seldom be large wind farms; instead there will be stand-alone wind turbines, with quite a small land footprint.

The global share of rooftop PV systems is not known. In many countries there are no separate statistics for rooftop PV and utility-scale PV. World Energy Council (WEC, 2016, Table 7) reports that in only four major solar PV countries (Germany, Japan, the US and Australia) do the land savings as a result of rooftop installations exceed 200,000 acres or 85,000 hectares (=850 km^2).

Solar panels are used in innovative ways to save both land and water (see 8.3.4; WEC, 2016). In Japan the 13.7 *MW* Yamakura floating solar power station is composed of more than 50,000 solar modules, covering a water surface area of 180,000 m^2 : or 76 MW/km^2. They are mounted on the Yamakura Dam reservoir, located in the Chiba Prefecture east of Tokyo. The panels will reduce water evaporation from the dam as well as saving fertile land. The plant was put into full operation in March 2018.

A similar structure is being developed in India . In the first stage of a solar panel project in the province of Gujarat in north-western India, a 750 *m* section of a water canal is covered with solar panels, generating 1 *MW* of electric power. Covering the canal with solar panels will save agricultural land as well as decreasing the water loss via evaporation (Shukla *et al*., 2016). According to WEC (2016) the solar panels of this canal could save a lot of land, five acres per *MW*. This corresponds to a solar panel power of 50 MW/km^2 (compare Chapter 8.2–8.3).