Europe's future is renewable

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Europe has enough solar and wind resources to meet its electricity demand entirely from renewable sources. A new study by researchers at the Institute for Transformative Sustainability Research (IASS) in Potsdam shows that many regions and municipalities could meet their electricity demand using electricity systems based exclusively on renewables. However, their development would exacerbate land use pressure around metropolitan areas and larger conurbations.

The findings of the study are presented online on an interactive map covering Europe's regions and cities. Users can simply zoom into a region or village—from Landau in Germany's Rhineland-Palatinate region to Berlin, and from Menton on the French Riviera to the Italian capital of Rome—the map identifies the potential for electricity generation from renewables across Europe and reveals whether regions could meet their electricity demand from renewable sources.

"Our results show how difficult it is, especially in the case of densely populated cities such as Berlin, to meet electricity demand from renewable energy sources," explains lead author Tim Troendle—"but the technology is now sufficiently advanced that even this would be feasible if metropolitan areas were to join forces with their surrounding regions." Rural regions and urban areas with extensive rural hinterlands could meet their electricity demand entirely from renewable sources: at the local level, 75 percent of municipalities can access sufficient solar and wind resources to meet their annual electricity demand.

Achieving electricity autarky across four administrative levels

Developing a self-sufficient, regenerative electricity supply requires the availability of sufficient open surfaces or land that could be used for energy generation. As part of their research for the study, the scientists collated data to identify eligible areas and surfaces and determine renewable electricity yields at the continental, national, regional and municipal levels.

Led by Professor Johan Lilliestam, the authors from the IASS and ETH Zurich determined the technical potentials of roof-mounted and ground-level photovoltaic systems as well as onshore and offshore wind turbines by analysing the availability and eligibility of land areas. Their analysis takes into account current land cover and land use by towns as well as agricultural use and included altitudes and local climatic conditions, which could limit electricity generation from renewable sources. This enabled the researchers to determine potential electricity yield, taking into account the technical constraints.

But if future energy systems are to be sustainable and enjoy broad acceptance across society, they will not be able to exploit their full technical potential. To reflect this, the researchers excluded certain areas such as nature reserves and arable land, where energy infrastructure would harm the landscape or prevent agricultural activities. Data on electricity consumption from 2017 were used to gauge demand. In line with previous analyses, the authors were able to demonstrate that the technical and social potential of renewable electricity is

greater than demand at continental and national levels. In order to also achieve electricity autarky at the sub-national level, however, regions would have to assign large shares and sometimes their entire undeveloped land to electricity generation from renewable energies, according to the study.

The prospects for Europe

If socio-technical constraints are applied, the total potential electricity output at the continental level is 15,000 TWh/a more than four times the current demand. Even when severe social constraints are applied, reducing the technical potential by over 90 percent, Europe could still potentially generate enough electricity from renewable sources to achieve electricity autarky at the continental level, and in each individual country.

At the regional and municipal levels, the authors see the lowest relative potential within city borders: For example, Oslo shows the lowest potential, as less than a quarter of the city's demand for electricity can be met through local energy generation from renewable sources. Other urban areas also lack sufficient technical and social potential, including the Ile-de-France (Paris), Dublin and Berlin. But these cities could achieve electricity autarky by cooperating with surrounding regions to form self-sufficient metropolitan regions. The study also shows, however, that the pursuit of local autarky can concentrate electricity generation in already densely populated areas—an outcome that may or may not be desirable and which regions would need to consider.

"Ultimately, it is a balancing act between self-sufficiency and more intensive local land use on the one hand and the acceptance of imports together with greater cooperation with other municipalities, regions and countries in Europe on the other," says Troendle. But in principle, 100% renewable electricity self-sufficiency is possible on all administrative levels from continental to regional, and often even on the municipal level, especially if mechanisms for electricity trading between regions and countries can be established.

More information: Tim Tröndle et al, Home-made or imported: On the possibility for renewable electricity autarky on all scales in Europe, *Energy Strategy Reviews* (2019). DOI: 10.1016/j.esr.2019.100388

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