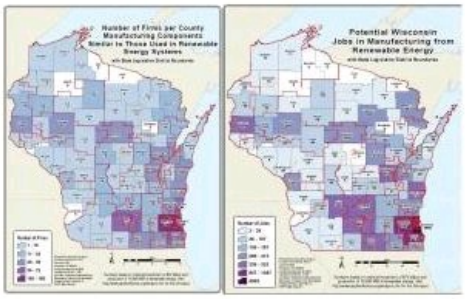
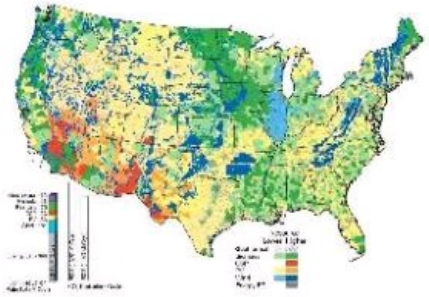
MAPPABLE INDICATORS

GIS and Renewable Energy Sources





Solar parks, wind farms and biomass are examples of renewable energy sources. Use of such not only improves air, water and soil quality, but also brings economic and social benefits to a region. GIS is conventionally used for mapping the potential of renewable energy sources and restrictions on their exploitation. The author identifies indicators for quantifying the economic, social and environmental benefits of renewable energy sources, their nice property being that they can be represented on maps using GIS tools. Mapping examples from northern America are provided.

GIS can save time and money when determining where and how renewable energy sources (RES) should be exploited and used. GIS enables identification of areas with high potential for developing RES, and regions with restrictions on their exploitation, such as environmentally or culturally sensitive areas. GIS also supports estimation of the output of RES in areas available for exploitation, as well as economic, social and environmental benefits; and examination of whether or not economic development goals, social equity and environmental protection have been achieved. The degree to which, for example, a solar park is profitable as an exploit for investors can be expressed as the ratio between gross income and project price, together with the payback period. But exploitation and use of RES also bring economic benefits at regional level, along with social benefits and improvement to the environment.

Economic Benefits
A region, province or state (more generally an administrative unit) may benefit from exploiting and using RES through:

- federal and state subsidies
- lower energy bills
- increase in foreign direct investment (FDI)
- increase in real-estate value
- increase in RES supplier revenues
- decrease in dependency on energy imports
- increase in security of energy supply
- economic value of the entire supply chain involved in RES.

The level of subsidies will determine RES investments and development. Federal and state subsidies can be simply mapped and do not need a derived parameter as indicator (Figure 1). Lower energy bills resulting from use of RES can be indicated by comparison with average electricity and natural-gas prices across an administrative unit. Increase in FDI can be quantified either as percentage of contribution of RES to the total FDI on all energy sources, and as percentage of contribution to the gross domestic product (GDP). An indicator for the increase in real-estate value is change in house prices (in %) per administrative unit due to reduction in, for example, air pollution (in %); this usually estimated using the Hedonic Price Method. Other indicators of economic benefits which can be presented on maps are shown in Table 1.

Economic Benefits	Mappable Indicators
Income in total EES suppliers'	Amount of RES (in kWh) locally generated and locally sold and exported; number of RES

revenues	users
Decrease in dependency on energy imports and increased security of energy supply	Net energy import in civil equivalents
Improvement in economic value distributed over the RES technologies supply chain	Number of firms manufacturing RES compenents; total payment to RES investors; taxes paid by RES suppliers; total payments of salaries and benefits to employees involved in RES, average level of operational costs of RES suppliers

Table 1. Economic and recommended mappable indicators which can be assigned to administrative units.

Social Benefits
Social benefits include generation of employment, particularly in rural communities, for example through the construction of wind farms. A simple indicator is the number of firms within an administrative unit manufacturing RES components and the potential jobs they may create (Figure 2). Another indicator is the number of local jobs provided by RES industry per kWh of electricity generated. A reduction in impacts on human health resulting from air quality improvement is an important social benefit. In remote communities of poorer countries the use of RES can contribute to reduction in or avoidance of travel time for collecting kerosene for lamps. The saved time can be used for working or learning, even during evening hours.

Environmental Benefits
The main environmental benefits of RES are reductions in air pollution and greenhouse-gas emissions. Other benefits, depending on region and energy sources used, might also be significant. For example, in regions using oil as the main energy source the increased use of RES would reduce water and soil pollution and impacts on aquatic and terrestrial biota. In regions using nuclear energy, now or in the future, an increase in use of RES would reduce or avoid radioactive waste generation and water and soil pollution. The most convenient indicator is the carbon reduction potential in million metric tons of carbon per year (MtC/yr) (Figure 3).

Further Reading

- Domínguez, J., and Amador, J., 2007, Geographical Information Systems Applied in the Field of Renewable Energy Sources, 52, pp 322-326.
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- U.S. Department of Energy. 2008, Energy Efficiency and Renewable Energy. Springfield, VA.
- Yue, C.-D., Wang, S.-S., 2006, GIS-based Evaluation of Multifarious Local Renewable Energy Sources: a Case Study of the Chigu Area of Southwestern Taiwan. Energy Policy, 34, pp 730-742.