Scaling Up Alternative Energy

SPECIALSECTION

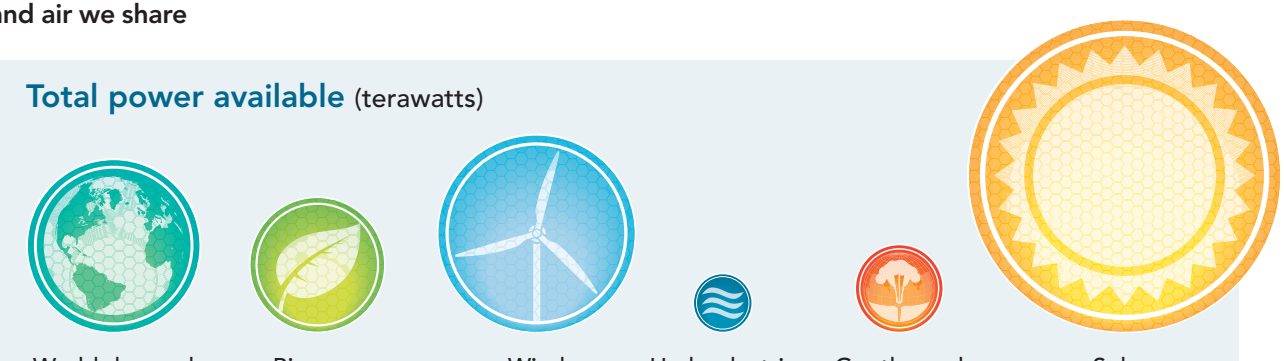
NEWS

Energy's Tricky Tradeoffs

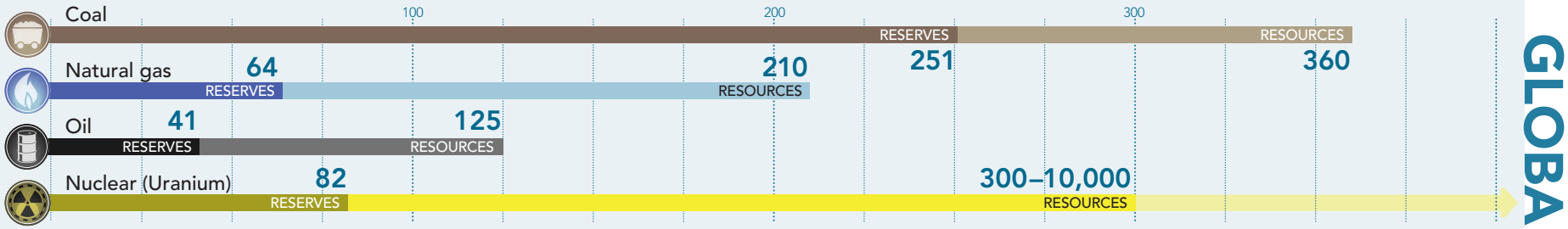
The world's "energy problem" is in fact a slew of technological and sociological challenges involving the use of the land, water, and air we share

I've got sunshine, plenty of sunshine …
Sooner or later, humanity must move away from fossil fuels, finite resources that produce planet-warming greenhouse gases. At first blush, Earth appears to have power to spare. The total power from sunlight striking the ground is a whopping 101,000 terawatts, and experts estimate that we could capture enough of that to exceed by a wide margin the 15 terawatts of power that the world's population now consumes.

Total power available (terawatts)



How much is left? (years)



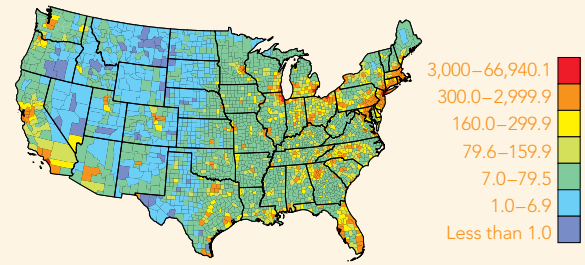
SOURCE: *WORLD ENERGY ASSESSMENT 2000*/UNDP; *WEA 2004*/UNDP; *REPORT OF THE INTL. GEOTHERMAL ASSOCIATION TO THE U.N. COMMISSION ON SUSTAINABLE DEVELOPMENT 2001*; SCLATER *ET AL., JOURNAL OF GEOPHYSICAL RESEARCH* **86** (1981); NASA

GLOBAL

Give me land, lots of land …
Wind and sunshine deliver energy in a far less dense form than coal, oil, or natural gas. For example, San Jose, California, has just over 1 million residents and consumes an average of 740 megawatts of electrical power. To supply that power, coal mines and coal-fired power plants would have to cover 3,800 hectares of land. In comparison, a wind farm would have to cover 53,000 hectares, an area bigger than the city itself. Unlike a coal mine, however, the wind farm could be used to grow crops at the same time.

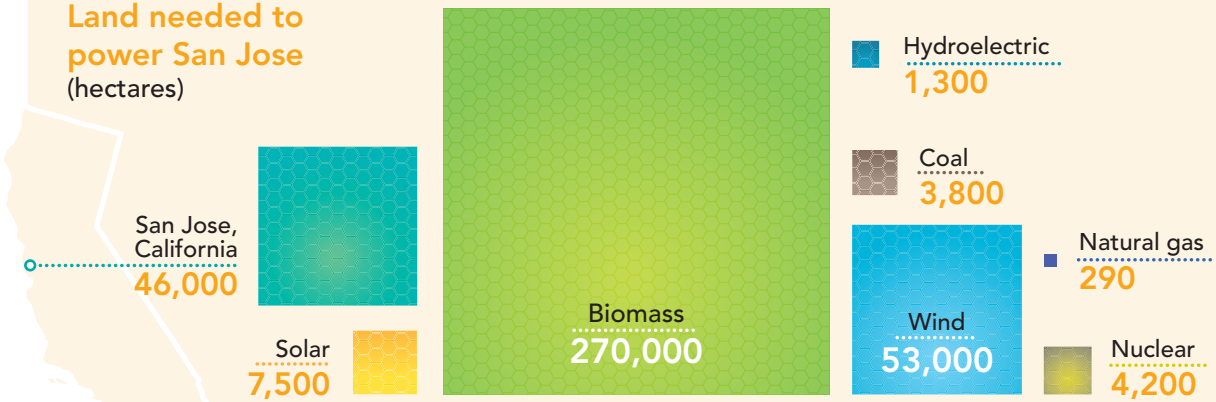
Another issue: The sun doesn't necessarily shine the brightest and the wind doesn't blow the fiercest where most people live. And technologies have yet to emerge to store and transport vast amounts of energy generated from sunshine or wind. So delivering that energy where it's needed when it's needed remains a problem.

Population in the U.S. (per square mile)



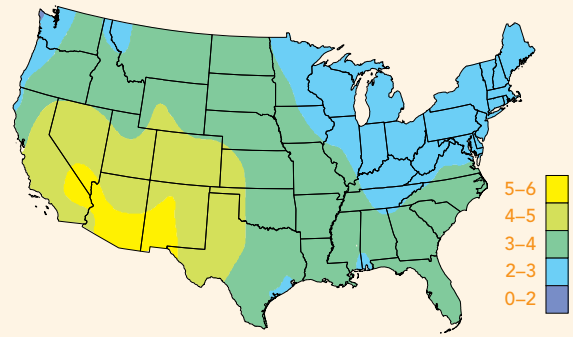
Published by AAAS

Land needed to power San Jose (hectares)



SOURCE: D. SPITZLEY *ET AL.*, UNIV. OF MICHIGAN CENTER FOR SUSTAINABLE SYSTEMS (2004); *ELECTRICITY FROM RENEWABLE RESOURCES*, NAS (2010); DOE

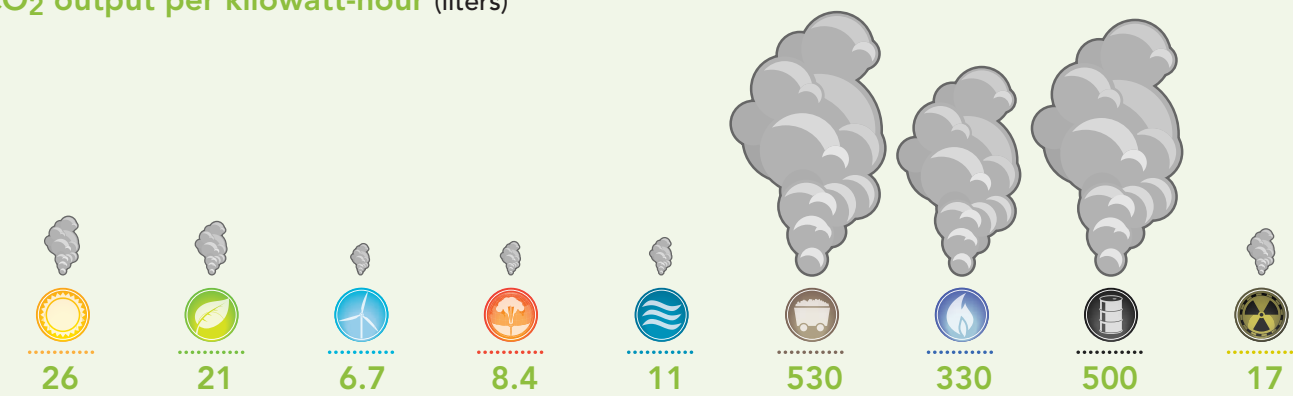
Average daily sunshine (kilowatts per square meter)



SOURCE: U.S. CENSUS BUREAU (TOP); NREL (BOTTOM)

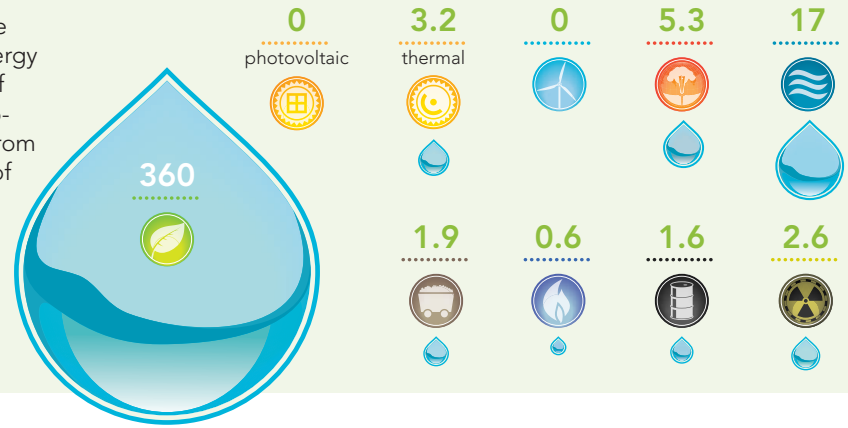
CO_2 output per kilowatt-hour (liters)

SOURCE (TOP): DOE; AWEA; DOE/EPA; *ELECTRICITY FROM RENEWABLE RESOURCES*, NAS (2010); (BOTTOM): DOE; AWEA



A river runs through it.
The energy problem is also a water problem. Work on your computer all day, and you'll use about 1 kilowatt-hour of electricity. If that energy comes from coal, you'll have used 1.8 liters of water. If it comes from solar thermal technologies, you'll use 68% more water. Use power from biomass crops and you'll also use hundreds of liters of water to grow the fuel. Of course, fossil fuels produce heat-trapping carbon dioxide gas. If your kilowatt-hour of energy comes from coal, it produces 0.9 kilograms or 530 liters of pure CO_2—enough to fill 265 large soda bottles.

Water consumption per kilowatt-hour (liters)



No single solution.
To replace fossil fuels, most experts foresee using a mixture of energy sources and technologies. And they say that large gains can be made in improving the efficiency of existing technologies—as much as 60% in industrial processes. Still, reducing overall energy demand may not be easy. In 2007, the city of San Jose instituted a 15-year program that, among other things, seeks to reduce the per capita consumption of electricity and natural gas by 50%. After 2 years, such consumption was down by just 0.5%. **–ADRIAN CHO**

PERSONAL