quence-tag databases or whole-genome sequence information. The development of these tools will be essential for helminthology questions to compete successfully in the real world of grant requests and study sections.

The situation resembles the abyss in which public health officials found themselves when Multi-Drug Resistant (MDR) tuberculosis arose in the late 1980s; there were few researchers or trained students interested in staying in the field, and no drug alternatives. The immediacy and threat of MDR TB rapidly induced funding of high-risk, technology-driven grants over a period of 4 to 8 years, which resulted in mycobacteria study becoming a vibrant, active field.

For a number of years, several philanthropic foundations have recognized the global importance and neglected nature of helminthic infections. Their efforts have been critical but not sufficient to sustain the level or focus of effort needed. We propose an "Affirmative Action for Worms" program that could attract senior and junior scientists from other fields, foster those few languishing investigators who know these systems, and entice researchers into the high-risk areas of worm-related technology development and applied usage. A 5-year, highly competitive program of $40 to $50 million, that fostered and integrated bench and field research with multiple-level training programs could lead to a real reversal in the current downward spiral of research.

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POLICY FORUM: ENERGY

Exploiting Wind Versus Coal

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Much of the recent energy debate in the United States has focused on increasing coal use. However, the cost of wind energy is now less than that of coal. Shifting from coal to wind would address health, environmental, and energy problems.

Energy costs from a new coal power plant are low [(3.5 to 4 ¢/kWh) (*1*)], but coal-mine dust kills 2000 U.S. miners yearly, and since 1973, the federal black lung–disease benefits program has cost $35 billion (*2*). Coal emissions also cause acid deposition, smog, visibility degradation, and global warming; its particles increase asthma, respiratory and cardiovascular disease, and mortality (*3*). Health and environmental costs bring the total costs to 5.5 to 8.3 ¢/kWh (*4*).

Wind is a clean energy source. We estimate its costs as follows: installing a 1500-kW turbine with a 77-m rotor diameter and design life of 20 years costs $1.5 million (*4*–*7*), which pays for the turbine (80%), grid connection (9%), foundation (4%), land (2%), electrical installation (2%), financing (1%), roads (1%), and consultancy (1%) (*4*, *7*). Amortizing this over 20 years at 6 to 8% interest gives $131,000 to $153,000 per year. Adding annual operation and maintenance (O&M) (*4*, *6*, *7*) leads to an estimated annual cost of $149,000 to $183,000.

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A turbine's annual energy output (kilowatt-hours/year) is about $P \times 8760 \times (0.087V - P/D^2)$ (*7*), where P is rated power (in kilowatts), V is mean annual wind speed (meters/second) at rotor height ~50 m, D is rotor diameter (meters), and 8760 is hours/year. With a mean annual 50-m wind speed of 7 to 7.5 m/s [which occurs across all of North Dakota, 70% of South Dakota, and large tracts of the West, Great Plains, East, and Northeast (*8*)], the turbine energy produced is 4.7 to 5.2 × 10^6 kWh/year. Dividing turbine cost by energy produced and adding manufacture and scrapping costs (*7*) gives the energy cost of a large turbine as 3 to 4 ¢/kWh. Reported costs for large plus small Danish turbines are 4 ¢/kWh (*9*). These numbers suggest that the total costs of wind energy are less than those of coal energy.

Under the 1997 Kyoto Protocol, the United States proposed to reduce greenhouse gas emissions to 7% below 1990 levels. As of 1999, the target could be satisfied by replacing 59% of 1.89 × 10^{12} kWh/year (*10*) in coal energy with 214,000 to 236,000 turbines, thereby reducing coal-CO_2 emissions (499 Tg-C/year) (*11*) by 59%. At six turbines per square kilometer, the turbines could be spread over 194 × 194 km^2 of farmland or ocean.

Alternatively, every 36,000 to 40,000 turbines could displace 10% of U.S. coal at a cost of $61 to $80 billion, including O&M plus initial costs (also the present value of payments to date from the black lung–disease benefits program). This could be supported at no net federal cost by investing 3 to 4% of one year's $2.02 trillion budget in turbines and selling the electricity over 20 years. Similarly, California could provide 10% of its 1999 electricity (2.35 × 10^{11} kWh/year) (*12*) by buying 4500 to 5000 turbines at 7.5 to 9.9% of one year's $101 billion budget and selling the electricity over 20 years.

One concern with turbines is harm to birds This might be mitgated by siting turbines out of migration paths. Also, turbine output is unresponsive to electricity demand. This is moot when wind is one of many energy sources. Finally, remote turbines require extra transmission lines. This cost can be offset with turbine mass production. Government promotion would also catalyze private investment.

By 2000, Germany had 6113 MW of installed turbines, more than the United States (2554 MW) or Denmark (2300 MW) (*13*). Sweden and Denmark have wind parks offshore, where winds are faster than over land. Clearly, the United States has not maximized its wind potential.

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