power becomes more competitive. With a $100 per tonne tax on emitted carbon, coal would cost 6.6 cents per kilowatt-hour and natural gas would range between 4.8 and 6.7 cents, the report says.

To overcome the high risk of being first to build a new commercial reactor, the report calls for the federal government to "provide a modest subsidy [in the form of a production tax credit] for a small set of 'first mover' commercial nuclear plants to demonstrate cost and regulatory feasibility." The report urges other steps to overcome the regulatory uncertainties facing nuclear power.


MIT

Moniz

The second problem confronting commercial nuclear power is safety, and the report calls for maintaining the current standard of "less than one serious release of radioactivity accident for 50 years from all fuel cycle activity." The standard "implies a tenfold reduction in the expected frequency of serious reactor core accidents," a reduction that "should be possible to achieve in new light-water reactor plants."

The nuclear power industry concedes that public confidence in nuclear power was seriously eroded by the 1976 nuclear accident at the Three Mile Island reactor in Pennsylvania and by the Chernobyl reactor meltdown in 1986 in Ukraine. Public resistance to nuclear power has played an important part in the industry's stagnation, so safety has to be a central concern in renewal efforts.

The third hurdle that nuclear power advocates must overcome is radioactive waste. According to the report, "the management and disposal of high-level radioactive spent fuel from the nuclear fuel cycle is one of the most intractable problems facing the nuclear power industry throughout the world. No country has yet successfully implemented a system for disposing of this waste."

The report's authors believe geologic waste repositories can work, but they point to the one site being studied in the US, Nevada's Yucca Mountain, as an example of the difficulty of the problem. Despite 15 years of effort, Yucca Mountain still hasn't been licensed, and even if it is, "new repository capacity equal to the nominal storage capacity of Yucca Mountain would have to be created somewhere in the world every three or four years" if nuclear power is significantly expanded, the report says.

The report recommends that, in addition to Yucca Mountain, DOE launch a research program to "determine the viability of geologic disposal [of waste] in deep boreholes."

The fourth challenge to nuclear power expansion is proliferation. "The current international safeguards regime is inadequate to meet the security challenges" of a dramatically expanded use of nuclear power, the report states. "The reprocessing system now used in Europe, Japan, and Russia that involves separation and recycling of plutonium presents unwarranted proliferation risks. We conclude that, over at least the next 50 years, the best choice to meet these challenges is the open, once-through fuel cycle."

The transmutation debate

Perhaps the most critical analysis of the MIT report came from physicist Burton Richter, director emeritus of SLAC. Richter, who is chair of the Accelerator Transmutation of Waste subcommittee of DOE's Nuclear Energy Research Advisory Committee, wrote a six-page paper detailing disagreements with the recommendations on future directions of nuclear energy R&D.

"I agree with most of it," Richter said of the report. But in his work on the DOE advisory committee, he said he has "come to believe that transmutation [the transformation of one element into another by bombardment of nuclei with particles] has real potential." Richter noted that waste from the once-through fuel cycle recommended by the report "requires isolation from the environment for on the order of 300 000 years." Transmutation, Richter said, "has the potential to reduce the required isolation time to on the order of a thousand years, greatly reducing concerns about unlikely geophysical events." Moniz responded that the report advocates more research money for transmutation, but the horizon for that technology is too distant to play a role in current efforts to revive nuclear power. Richter said the MIT study should have placed greater emphasis on the cost of carbon sequestration for fossil fuels, which would level the economic playing field and make nuclear power competitive with fossil fuels. Moniz said the authors of the study used a "merchant plant model," meaning they determined costs based on private sector financing. "We based conclusions on actual experience," he said.

Deutch said he hopes the nuclear report is the first in a series of MIT studies on various energy issues. "I think carbon sequestration would be the next study we'd like to take on," he said. **Jim Dawson**

Baja Site Vies to Host Telescopes

The jury is still out on San Pedro Mártir's becoming a major ground-based astronomy site, but it's in the running thanks to its clear skies, proximity to the US, and other scientific and political virtues.

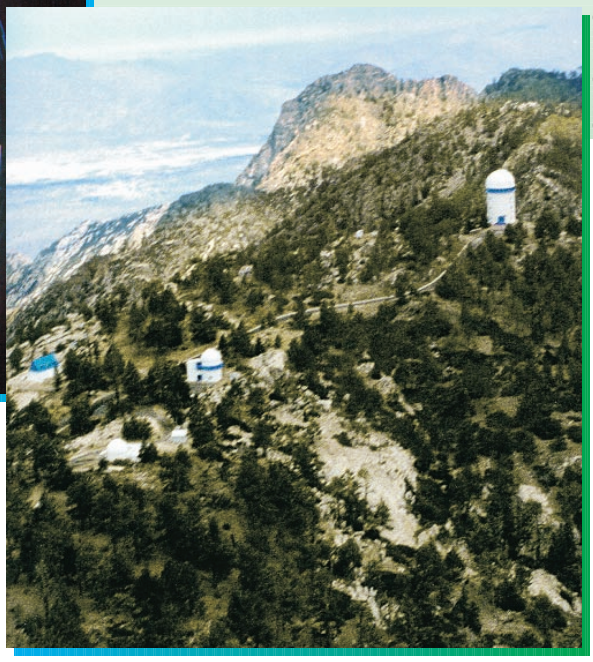
The growing name recognition of San Pedro Mártir is both evidence of, and a catalyst for, astronomers in Mexico and the US eyeing the Baja California site as a possible new hot spot for ground-based telescopes.

The site has been home to Mexico's national observatory since the 1970s. The largest and newest of its three telescopes is 2.1 meters in diameter and has been in use for more than two decades. But over the past couple of years, momentum has been mounting to develop the 2800-meter-high site, which is located about 300 kilometers southeast of San Diego, midway between the Pacific Ocean and the Gulf of California. San Pedro Mártir, proponents say, could rival any existing telescope site.

Turning San Pedro Mártir into a world-class astronomy site got a boost early this year when two groups in Mexico merged their previously competing plans for large optical telescopes. Astronomers at the Institute of Astronomy, Optics, and Electronics in Puebla bring to the table an agreement with the University of Arizona's Steward Observatory to cast an 8-meter-class mirror, while the Institute of Astronomy at the National Autonomous University of Mexico (UNAM) runs the observatory at San Pedro Mártir. Now the project leaders are seeking additional partners and deciding whether to build a single-mirror or binocular telescope.

Another boost came from outside Mexico. With several large projects in the works in the US, astronomers "are taking a fresh look at where would be the optimum place to site a facility," says the National Optical Astronomy Observatory's Alistair Walker, cochair of the site selection committee for the Thirty Meter Telescope (see PHYSICS

JESÚS GALINDO



SILVIA TORRES

Clear skies at San Pedro Mártir might make the Baja California site competitive for state-of-the-art astronomy.

TODAY, August 2003, page 22). In addition to being a candidate host for the TMT, San Pedro Mártir is one of six locations being tested for the Advanced Technology Solar Telescope, and will likely be considered for the Large Synoptic Survey Telescope.

The fresh look includes an analysis of cloud cover and water vapor from about five years of satellite data. André Erasmus, a consulting meteorologist based at the South African Astronomical Observatory in Cape Town, compared 15 sites in North and South America for the TMT team. In terms of cloud cover, San Pedro Mártir, with cloud-free nighttime hours 73% of the time, is "superior to other existing sites in North America, and comparable to sites elsewhere," Erasmus says. "But if you were focusing on infrared astronomy, it's not the site you would pick—it's not high enough and dry enough." The site is excellent for infrared observations roughly 10% of the time, he says. Overall, the competition is stiff, adds Caltech's George Djorgovski, cochair of the TMT site selection committee. He ticks off Mauna Kea in Hawaii, the Canary Islands off the coast of Spain, various sites in Chile, and perhaps other, undeveloped sites as being as good as or better than San Pedro Mártir.

As might be expected, Mexican astronomers are less cautious in their endorsement of San Pedro Mártir. "It appears to be one of the best places in the world to do astronomy—and the best in the Northern Hemisphere," says Remy Avila of UNAM's Morelia campus. "It's the quality of the site that is pushing astronomers to go there, and it is not far from the US." Avila measures atmospheric turbulence to aid in the design of adaptive optics and says that he documented nine consecutive nights with very low turbulence at high altitudes at San Pedro Mártir. "I thought that was good, but I didn't realize how good, how unusual it was, until I talked to colleagues around the world." But, Avila notes, long-term comparisons of high-altitude turbulence at various sites have not yet been made.

Weighing intangibles

Surface winds, geologic stability, and light pollution also figure into siting a telescope. And after scientific and technical parameters have been considered, the final site decision factors in "intangibles," says Djorgovski. They include politics, road access, added costs of building at higher altitudes, and so on. For example, purely on the basis of clear skies and good seeing, California has sites as good as or better than San Pedro Mártir, Djorgovski says. "But they are all politically unattainable because they are in national forests or national parks. It would be a nightmare [to get the necessary permits]."

Moving to Mexico could skirt the opposition from environmentalists and native groups that increasingly beleaguers new projects in the US—examples include the controversy over protecting red squirrels on Mt. Graham, Arizona; the revoked permit that this past spring sent VERITAS, a cosmic-ray detector, scrambling to find a new home; and the stalled Keck outriggers on Mauna Kea. "In all of America, building more telescopes is almost prohibited by environmental activists," says Roger Angel, an astronomer at the University of Arizona in Tucson. "It's very sad."

Meanwhile, Mexico continues its campaign to attract telescopes to San Pedro Mártir. Two years ago, the government designated the site and its surroundings a national park to protect against future light pollution. "This good site has to be a trigger to develop better astronomy here [in Mexico], and better science generally," says José Franco, director of UNAM's Institute of Astronomy. "I'd like to move as fast as possible. In 10 years, I'd love to have a first-class international observatory."

Toni Feder

Antievolutionists Lose Critical Fight in Texas Textbook Decision

A months-long effort in Texas to weaken the scientific explanation of evolution in high-school biology textbooks failed in early November when the State Board of Education approved 11 books and other material that had been vetted by a panel of biologists. With an 11-to-4 vote, the board rejected attempts by social conservatives, as well as members of the Discovery Institute, a Seattle-based creationist organization, to include what they claimed were significant weaknesses in Darwin's theory of evolution through natural selection.

"I think this is very good, not just