Title
Navajo Electrification for Sustainable Development: The Potential Economic and Social Benefits

Journal
American Indian Culture and Research Journal , 28(2)

ISSN
0161-6463

Authors
Bain, Craig
Ballentine, Crystal
DeSouza, Anil
et al.

Publication Date
2004-03-01

DOI
10.17953

AMERICAN INDIAN CULTURE AND RESEARCH JOURNAL 28:2 (2004) 67–79

Navajo Electrification for Sustainable Development: The Potential Economic and Social Benefits

BAIN, BALLENTINE, DESOUZA, MAJURE, SMITH, AND TUREK

Using data from the United States Census 1990, the Energy Information Administration estimated in 2000 that 36.8 percent of the 29,375 occupied housing units on the Navajo Nation lacked electricity. The Navajo Nation has very low population densities, and the large distances between homes make the cost of providing conventional sources of electricity prohibitive.[1] Arizona Public Service, the primary provider of electricity in Arizona, estimates the cost of erecting power lines to be roughly $25,000 to $30,000 per mile, an impossible sum for most families in this region, where the unemployment rate hovers around 50 percent. Given the extremely low population densities, it is simply inconceivable that many houses could be connected to the power grid. More recent calculations, based on Census 2000 data, show that between 10,000 and 23,000 homes need some type of electricity provision system that is not connected to the grid. An estimate of 18,000 homes appears to be a reasonable current target figure (this number could very well increase as the population grows). The predicted cost of any program providing electricity and the associated appliances to these homes falls between $115 and $350 million.[2] Using the baseline figure of 18,000 homes, the estimate is roughly $235 million. These are costs above the typical construction costs for the expected new housing units.

The authors have completed an analysis of the potential success of a small business operating on the Navajo Nation installing self-contained solar systems, including battery storage, for these 18,000 homes. Several scenarios were analyzed, and the individual prices of the systems ranged from $10,000 to $19,000, depending on the size of the system and the level of retail markup.

The following authors, all from Northern Arizona University, collaborated on this article: Craig Bain, professor of accounting; Crystal Ballentine, graduate assistant; Anil DeSouza, graduate assistant; Lisa Majure, associate professor of finance; Dean Howard Smith, professor of economics and applied indigenous studies; and Jill Turek, undergraduate research assistant.

In all cases, the pro forma income statements show profitable business opportunities, but only if the revenue stream can be assured.

However, even a rudimentary examination of the current demographic, economic, and social conditions experienced by the residents of the Navajo Nation points to a clear conclusion that many individual families would be overwhelmed by the financial requirements of paying for these systems. The most favorable estimate is roughly sixty dollars per month over fifteen years, and this amount does not cover regular maintenance costs. As such, it will be imperative for outside funding and subsidies to be made available if the people of the Navajo Nation are going to be able to participate in an electrified twenty-first century.

This paper details the concomitant secondary consequences of an electrification program. As with all economic activity, there are many secondary and resulting influences that will ripple through the economic and social systems of the Navajo Nation. There is a substantial potential that the overall long-term benefits of an electrification program exceed the costs. In this paper, we discuss these potential benefits.

CURRENT DEMOGRAPHICS

The low median age of twenty-four years indicates that a large segment of the population is made up of young people. This is compared to a median average in the United States of 35.4. On the reservation, 55.6 percent of the population is between the ages of ten and thirty-four years of age. This is the population segment that will make up the majority of the work force in the decades to come. The relative size of this age group suggests the need for new opportunities for people who will make up the future work force.[3]

Data from the Census 2000 on income and housing differentiates the Navajos from the rest of Arizona's residents. Per capita income is $7,578 for Navajos as compared to $20,275 for Arizona and $19,082 for the rest of the United States. Median household income is $21,136 as compared to $40,556 for Arizona. The median value of owner-occupied housing units is an extremely low $25,500. The median value for Arizona is $121,300. Note also that 24.8 percent of Navajo housing units are crowded with more than 1.5 occupants per room as compared to 4.2 percent for the state as a whole.

The census data shows that only 44 percent of the working-age population is in the labor force. This compares to 61 percent for Arizona. The unemployment rate among Navajos is 25 percent, as compared to 5.6 percent for Arizona.[4] The poverty rate is 42 percent as compared to 14 percent for Arizona. Of the employed civilian population, 47 percent is employed by some level of government, as opposed to 15 percent for Arizona. Thus, roughly 17.5 percent of the working-age population, or only one in six people, work in the private sector, as opposed to roughly half the Arizona population. As such there is an immense need to develop the private sector of the Navajo Nation's economy. There is also a concomitant low likelihood that families can afford to install solar installation systems on their own.

ECONOMIC DEVELOPMENT

The Navajo Nation is facing two economic major needs: employment and economic development. Economic development on the Navajo Nation should not be looked upon in the traditional way in which pure profit is the main consideration. Although profit must still be a factor, the Navajo value system and "ways of knowing" must also be embraced. The culture and traditions should be taken into account and highly valued or else no progress will be made.[5] The drivers for success must operate in spiritual harmony and not threaten the preservation of cultural identity. Solar power is an ideal source of development because it does not solely depend on scarce resources in danger of being depleted and instead protects them for future generations. The sun's rays will not cease to shine in this region, thus making solar power the ideal renewable energy.[6] Harnessing the sun's energy for use will lead not only to direct opportunities for the people in education and employment but also to a myriad of secondary opportunities for them. This can all be done in a way that does not detract from their culture but helps to preserve it. The Navajo Nation has an opportunity to harness a renewable source of energy. This energy can aid in developing their burgeoning economic system and sustain their social and cultural values. It is important to note that the success of such an electrification project will result in much more substantial social, cultural, and economic changes than simply installing solar panels on houses in luxurious Scottsdale, Arizona.

Economic development, a process that involves every part of the social system, can help maintain tribal character. It is vital to formulate all development plans with an understanding of how they affect the overall societal makeup. Only when the tribe both has control of its resources and can sustain its identity as a distinct civilization does economic development make sense; otherwise, the tribe must choose between cultural integrity and economic development. A common misconception involves the seeming conflict between maintaining a tribe's cultural heritage and increasing economic activity on the reservation. However, a main purpose of this work is to show that cultivating the economy can confirm and develop the tribal culture. Maintaining the cultures and strengthening sovereign powers is a manifest imperative in Indian country. One way to achieve this goal is to develop tribal resources—in this case the sun's rays—in a manner that respects the cultural context.[7]

Economic development occurs when diverse activities and businesses are given the opportunity to prosper and flourish against a stable political background. Dean Howard Smith argues that the development process requires import replacement and new products and markets resulting from creativity and entrepreneurship.[8] As Jane Jacobs states: "Development depends on co-developments. I mean that development can't be thought of as a 'line,' or even as a collection of open-ended lines. It operates as a web of interdependent co-developments. No co-development, no development."[9]

The development of a solar electrification program will stimulate a web of economic and social codevelopments, and in order for the economic system to benefit fully from an opportunity like solar power, the whole system should be examined and taken into account. According to a 1989 study done on the

Navajo Nation, approximately 87 cents out of each dollar earned were taken off the reservation to border towns where goods and services were purchased.[10] This means that only 13 cents of each dollar earned were actually spent on the reservation. The money spent on the reservation is then recycled as it is spent again. The term for this is the *multiplier effect* and it works as follows: "The total effect of that single dollar is $1.15. If the situation is turned around such that 87% of every dollar of income is spent on the reservation, then the single dollar creates up to $7.69 of additional spending."[11] Those individuals working on the reservation profit from the dollars they bring in rather than losing the money to commercial entities found off the reservation. Although major efforts have been made to increase retail opportunities in the last decade, the provision of solar power and related employment opportunities would make additional expansion possible.

For example, the typical labor costs for installing a system is $700. Over the years, if 18,000 systems were installed, then direct wages would exceed $12 million. Using the $7.69 value for a multiplier, total expenditures would approach $100 million. Using a figure of $25,000 for each job created, slightly less than 4,000 secondary jobs could be created. Adding in the wages for the support staff and management of the installation business would further increase the number of secondary jobs.

By introducing solar power businesses to the reservation, the tribe is "refueling" itself. Refueling is like eating a good meal. When the body and mind are enriched nutritionally, then there is power to both gather more nutrients and expand activities elsewhere. When the solar power businesses get started, the results of increasing hours of clean-burning indoor light, jobs, and other benefits that come from clean electricity will allow other aspects of life to flourish, like the practices of the rich Navajo culture.

As the economic development process continues and a more diverse selection of goods and services is offered on the reservation, less money will be taken off the reservation to buy goods and services. Rather, people will spend their money at retail and service businesses on the reservation. The term for this is *import replacement.* It is a vital part of the economic development process. It means that goods and services that once were imported from off the reservation now become available within the Navajo Nation. When this is done, the dollar can be recycled, and less money will leak out of the nation.

In order to replace imports with domestically produced goods and services, the whole economy must be developed. The goal is to seek diversification rather than mere expansion of existing goods and services—there needs to be a qualitative codevelopment rather than just an increase in the quantity of goods and services already offered. When electricity becomes available, diversification on the economic landscape will flourish, and demand for goods and services never before experienced will arise, such as light fixtures, bulbs, and related accessories. Both manufacturing and retail businesses have the potential to blossom as a result of a newfound need for items like refrigerators, fans, extension cords, and computers, all of which could be sold on the reservation. If the tribe allows for or provides businesses that sell these items, then fewer goods would need to be imported from border towns, and

leakage of money off the reservation will decrease. The tribe will profit from the increase of revenue as well as employment.[12] As the number of businesses rises, monopolies will lose power in the face of increased local competition for dollars. According to a study completed in 1994, this has proved true in the case of grocery stores—when there was only one trading post or store in a large geographical region of the reservation, the prices were high. The study compared prices at trading posts and on- and off-reservation groceries stores. The isolated trading posts had higher prices than the on-reservation grocery stores and substantially higher prices than the off-reservation stores.[13] As more stores opened, prices were forced down by competition.

The development of solar power could also provide opportunity for manufacturing goods. As the technicians begin to develop their skills installing and implementing the systems, entrepreneurial ideas could arise. Small components of the systems may be locally produced. Alternatively, entrepreneurs may devise new and better designs for components. Solar power is still an evolving renewable resource technology, and there is room for improvement. The Navajo Nation will be ahead of the rest of the world in the implementation of a tool the rest of the planet needs. This is what Jacobs discusses as the "web of codevelopments." There is no way of foretelling the future, but the strong entrepreneurial nature of the Navajo culture almost assures the creation of new opportunities, products, and services.

Implementing solar power on the Navajo Nation addresses not only economic needs but social needs as well. The lack of jobs and income are two of the most pressing issues that reservation communities face.[14] They tend to create a downward spiral in the quality of life of individuals living on any reservation—people who see no opportunity for improvement often turn to substance abuse and domestic unrest. Those who develop skills and then seek highly specialized jobs tend to leave the reservation in order to find work; a "brain drain" divests the population of its most talented members. The creation of the solar power industry and the subsequent economic development will provide jobs and income. One can expect a reduction in various social ills to follow. Fewer skilled people may choose to leave the reservation if there are good local opportunities for them to use their talents. The experience of earning a steady income gives hope for improvement. With this increase of activity, a reduction in substance abuse is likely and individuals will begin to envision ways to enrich their lives. This is another example of how "refueling" can lead to a better future.[15]

Employment opportunities within the solar power businesses themselves will be available immediately and continue into the future. Diné College—the tribal college with its main campus in Tsaile, Arizona—is a perfect place to hold training classes. There people will learn how solar panels work and how to install, maintain, and repair them. In addition to acquiring technical skills, tribal members will need to fulfill the general education requirements of typical associate degrees, leading to secondary social developments described below.[16]

If this highly specialized niche of the economy is filled by Navajo people, they may eventually be well positioned to export solar power products and

services to consumers outside the reservation. Use of this renewable power is expected to increase as the United States and other nations move away from their dependency on fossil fuels. The Navajo Nation will be ahead of the game and have a more comprehensive understanding of solar energy systems and their uses. This could be a perfect opportunity for it to capitalize on its early immersion in the business and begin to export its skills and services to markets beyond reservation borders.

OPERATIONAL ASPECTS

In February 2001, the Arizona Corporation Commission (ACC) adopted the Environmental Portfolio Standard (EPS), which requires all regulated utility companies that sell retail electricity in Arizona to generate a percentage of their electricity from renewable resources. The standard requires regulated utilities to generate a minimum of 0.2 percent of their total retail energy sales from renewable sources in 2001. The percentage will increase to 1.1 percent in 2007.

As a result, Arizona Public Service (APS) has adopted an EPS Credit Program. Customers in APS service territory who live in remote areas without access to electricity from APS's distribution system (the grid) and who purchase and have installed complete solar systems to provide their electricity are also eligible for the EPS Credit Purchase Program. Customers purchasing a new solar electric system of five kilowatts or less for their remote (off-grid) homes can receive an EPS energy purchase rebate of $2 per photovoltaic watt of DC electricity. Remote solar customers must sign an EPS credit purchase agreement assigning APS access to the EPS credits for twelve years.[17] For example, a 1,000-watt solar system qualifies the customer to receive a direct payment of $2,000 from APS. It should be pointed out that this is a private transaction between APS and the purchaser of the solar system. It is not a tax credit of any kind. Additionally, the supplier of the solar equipment need not be related to APS—the buyer can purchase a system from any supplier. By purchasing the rights to the solar panel, APS gets credit from the state government toward the renewable portfolio requirements.

The Navajo Nation should seize the opportunity to be at the forefront of the renewable energy industry, starting with electrifying its own households by solar power. As the electrification process continues within the reservation borders, a generation of specialized technicians will be trained. The movement of the rest of the state and other locations toward renewable power will create a high demand for this type of labor. At this point, the skilled and experienced Navajo workforce will be in demand. A niche workforce such as this can demand a high wage. The specialization in solar power is potentially a large development vector for the Navajo people.

In April 2000, President Clinton visited the Navajo Nation. Somewhat naïve in regard to the circumstances of life on the reservation and the present degree of access to computers and the Internet in Navajo households, he stated, "I am here because I believe that new technologies like the Internet and wireless communications can have an enormous positive impact on the Navajo nation."[18] Although it may be a little far-fetched to imagine that in the

near future every home will have such access, an electrification program would certainly stimulate the demand for a variety of goods and services associated with computer and wireless technologies. These include hardware, education, and culturally appropriate software programs.

Providing electricity to the Navajo population will cost up to $350 million over the next decade or more.[19] This expenditure will, in turn, stimulate a wide variety of secondary economic development. Such economic development will inevitably create new forms of social development as well.

SOCIAL AND CULTURAL DEVELOPMENT

Electricity is a convenience that most people take for granted. Imagine a schoolchild trying to complete homework by the light of a kerosene lamp. Consider, too, that the child woke up at 5:00 a.m. to catch a bus and begin a sixty-mile ride to school, with two-thirds of that distance on an unimproved road. After a full day of school and a long drive home, the young child is responsible for various household chores, and then she sits down to try her homework. Already this child is placed at a disadvantage in a very competitive Western society.

Charles Wilkinson provides the following discussion between President Peterson Zah, the former president of the Navajo Nation, and a non-Indian concerning the Navajo creation story and recent evidence showing migration patterns. The person asked Zah how the creation story could be true:

Pete paused, to show respect, I think, rather than to reflect. Then he replied: "Both versions are true."

"How can that be?" the non-Indian asked.

"It depends," Pete said, "on where you are, in what context you are in."[20] Wilkinson goes on to explain the importance of oral traditions and how those traditions are passed down from generation to generation. In a household with electricity, the child described above would have a better chance not only to do homework in a more suitable atmosphere but also to spend more important and meaningful time with her elders and parents. This is just one example of the powerful ways in which an electrification program could promote the social development of the Navajo population.

Electrification allows cooking and cleaning to be accomplished in much less time. It also makes possible various improvements in formal and informal education. If a student needs help with her homework, perhaps she will be able to access information on her computer and then spend time with her grandmother learning various traditions and stories. As Wilkinson states: "How can you have education without Coyote? Education without grandfather?"[21] Or grandmother? Devoting less time to household chores and simultaneously improving the educational atmosphere provide an opportunity for developing dignity and respect for traditions and culture. Children in literally thousands of households could more readily learn the skills and knowledge necessary in the modern economy, as well as those that will enable them to maintain Navajo culture. In the words of Zah, the children will be able not only to function in both places and contexts but also to bridge those contexts.

Improved lighting and heating and timesaving devices will allow further social and cultural growth. Smith and many others have discussed the extensive hogan-based industry of arts and crafts on the Navajo Nation. Electrification can permit more residents to engage in weaving, smithing, and other artistic activities.[22] This will lead to greater economic activity and stimulate new interest in cultural activities and their significance, thereby facilitating the sort of informal education discussed above.

An electrification program will support the preservation of Native language in two ways. First, the oral traditions mentioned above are best shared in the indigenous language, so the informal education that would be facilitated by access to electricity is likely to take place in Navajo. Secondly, the installation teams and the sales staff for electrification projects are far more likely to be successful if they speak Navajo. Furthermore, since many of the most isolated homes are maintained by people with limited skills in English, the program will function best and be perceived as respectful if the installation and service staff speak Navajo.

The institution of an electrification program will also lead to two secondary educational developments. First, many potential employees do not currently speak Navajo. Therefore the need for employees who are conversant in Navajo will generate increased demand for training in Navajo language and culture. Secondly, many of the Navajos who will work in the electrification program will need to acquire technical training, primarily at Diné College, where they will also fulfill general education requirements by taking courses such as English and mathematics and have access to courses on Navajo subjects.

Jacobs discusses the importance of maintaining prior knowledge while integrating new ideas and technologies. As the electrification program and its associated offshoots prosper, diverse and unforeseen codevelopments will undoubtedly occur. The younger generation will harness the modern technologies and find unexpected ways to combine them with traditional wisdom.

The full extent of the Navajo Nation's development and expansion as a result of the electrification program is unknown. In addition to the economic and cultural effects, however, it is clear that the physical health of the tribe will also be affected.

HEALTH IMPLICATIONS

The electrification program is associated with a wide range of potential health benefits. These are primarily related to the refrigeration of food and medicines and improvements in interior air quality.[23]

The variety of foods consumed on the reservation will be greatly increased when refrigeration is possible and fresh milk, vegetables, and fruit can be stored for extended periods. The broader range of available foods, of course, will ensure a more nutritionally varied diet for the Navajo people.[24] Fresh produce and dairy products can replace many of the dried and canned foods that they now rely upon, which tend to be of much lower nutritional value. Better eating patterns will enable families to avoid some of the dietary causes of diabetes and other diseases that are prevalent within the Navajo population.

Insulin and other medications can be kept cool in a refrigerator. Many Navajo families need to maintain supplies of medicines but are unable to do so without refrigeration, so their otherwise treatable diseases go untreated.

The use of electric lights indoors at night would make kerosene lamps unnecessary, thereby improving the interior air quality of homes. This would reduce the incidence of various respiratory ailments.

Electrification will also enable the Navajo people to take advantage of health care delivery systems, such as telemedicine, that depend upon wireless communications.[25] Patients with illnesses like diabetes or hypertension could take physical readings and electronically transmit their data to a health clinic. The medical staff could then analyze the results and respond to the patient with the necessary assistance.

ADDITIONAL ISSUES

A solar electrification program has enormous potential to benefit members of the Navajo Nation individually and collectively. This is not to suggest that all the ramifications would be positive, or that all Navajo people favor such a program.[26] Problems related to electrification will certainly arise. Access to television and the Internet, for instance, could have a destructive effect on traditional Navajo culture. Any electrification program must recognize and attempt to address such problems.

Many of the families who now reside in unelectrified homes on the reservation have made a conscious decision about their lifestyle and prefer to live in a traditional Navajo manner. They have elected not to move into population centers such as Tuba City and Chinle. It is apparent that some households that are presently unelectrified would not choose to accept electrification when it becomes available. Paul Denetclaw of the Navajo Tribal Utility Authority (NTUA) estimated that 95 percent of the Hopi families offered electrification opted for the wires.[27] Additionally, many of the buildings that would be targeted for electrification are in serious need of renovation or replacement. We must bear in mind that the estimate of 18,000 houses proposed at the outset of this article is just that—an estimate. Some of the families may decide not to have their dwellings electrified, and it will not make sense to electrify all buildings now standing.

The underlying research for this article focused on the development of a solar-based installation, maintenance, and repair sector on the Navajo Nation. Other avenues, including the use of wind- and biomass-based energy sources, are also available for developing an electrification program. Indeed, the recently published high-resolution wind map for the state of Arizona will be evaluated by the current research team to discover the best locations for wind energy.[28] The next step would be to analyze the Navajo Nation's land to determine which sites are best suited for wind, solar, and cogeneration energy sources.

CONCLUSIONS

The Navajo Nation has the highest proportion of homes without electricity compared to any city, state, or region in the United States.[29] As it moves into the new century and searches for a strategy to achieve self-sufficiency and self-determination, electrification will play an important role. Individual solar and storage units can give families the energy independence to meet their basic needs. This will require an overall investment of between $115 and $350 million. Using a baseline and reasonable estimate of 18,000 homes, the total investment is approximately $235 million.[30] The greatest barrier to completing an electrification program is its cost. Yet the benefits of electrifying the Navajo Nation, as explained above, are far more significant that would be realized by providing solar panels for an equal number of homes in, say, Scottsdale, Arizona.

The Navajo Nation is now in the process of developing a comprehensive energy policy to address the needs of the tribe. One component of it would apply energy-derived revenues to the cost of rural electrification. Such revenues would provide only initial funding, however, not the entire amount. Similarly, the existing program between NTUA and Sandia National Laboratories to install two hundred units is a good start, but is barely 1 percent of the estimated need. Although the required investment is substantial, it is not as much as, say, the cost of annual forest fire suppression in the United States. As such, it is recommended that the Navajo Nation explore a wide variety of funding opportunities.

The development of an electrification program holds potential for improving the lives of many Navajo families. However, it is recommended that homes be heated in the winter with a fuel source other than electricity. At present, 76 percent of Navajo homes are heated using either liquid propane gas or wood. These sources should continue to be used because electrical heating can be unreliable during extended periods of bad weather if the storage batteries run down.

The Division of Economic Development of the Navajo Nation can facilitate small business start-ups on the reservation. It is expected that several different types of small installation, maintenance, and repair businesses could be successful.[31] Chapter-level workshops can be developed, with bilingual presentations, to explain the social, cultural, and economic possibilities of an electrification program.[32] The workshops should also discuss the potential negative aspects of such a program. The economic benefits realized from self-sufficiency, improved safety and health, and employment opportunities have the potential to meet or exceed the costs of an electrification program. Such a program could also place the Navajo Nation, Navajo entrepreneurs, and the Navajo workforce at the head of the rapidly expanding renewable energy industry.[33] In this manner, the electrification effort can be seen as an investment in future self-sufficiency and development appropriate to traditional Navajo values.

Although the range of $115 million to $350 million is a rather imprecise estimate of the cost of electrification, there is no doubt that the installation and maintenance of solar units and the provision of the appropriate appli-

ances represent a substantial business opportunity for the Navajo Nation over the next decade or so. Conversely, there is a great need for financial resources if the people of the Navajo Nation are going to be able to participate in an electrified twenty-first century. If funding can be secured to begin an electrification program, the secondary economic, social, and health benefits could be substantial. An electrification program can stimulate a move toward true self-determination and self-sufficiency for the Navajo Nation.

ACKNOWLEDGMENTS

This project was completed with partial funding from BP plc, Sandia National Laboratories contract no. 29921, the National Renewable Energy Laboratory contract no. ADK-2-32617-01, and Sustainable Energy Solutions. Thanks go to Justin Baxter, Melissa Ann Gruber, and Jennifer Raymond for their input on this project. Tom Acker, Levi Esquerra, Wayne Fox, and Ronald Trosper supplied valuable feedback. Robert "Bud" Annan, Shirley A. Becker, Sandra Begay-Campbell, Paul Denetclaw, Brett KenCairn, and Stephanie McKinney contributed important observations and encouragement. Jeri Dennis and Sandra Hutchinson helpfully commented on budget issues. Sean Seitz from American Solar Electric determined the cost quotes for residential off-grid solar power systems. Ken Lorek provided useful editorial comments on an earlier draft of this paper. Finally, thanks go to Bruce Johnson of BP for suggesting the project and keeping the idea alive.

NOTES

1. Office of Coal, Nuclear, Electric and Alternate Fuels, US Department of Energy, "Energy Consumption and Renewable Energy Development Potential on Indian Lands," Energy Information Administration, www.eia.doe.gov/cneaf/solar.renewables/page/pubs.html, accessed April 2000.

2. See Craig Bain, Crystal Ballentine, Anil DeSouza, Lisa Majure, Dean Howard Smith, and Jill Turek, "Economic and Social Development Stemming from the Electrification of the Housing Stock on the Navajo Nation," working paper, College of Business Administration Working Paper Series, Northern Arizona University, Flagstaff, 2002, http://www.cba.nau.edu/faculty/workingpapers/pdf/Smith_electrif.pdf, for detailed calculations related to the demand estimates and details of the cost estimates contained herein. In order to focus on the developmental aspects of an electrification program, this paper refers to Bain et al. in lieu of providing all the calculations.

3. See US Census Bureau, "DP-1: Profile of General Demographic Characteristics: 2000," http://factfinder.census.gov/bf/_lang=en_vt_name=DEC_2000_SF1_U_DP1_geo_id=25000US2430.html, accessed 2 September 2004; Arizona State government, "Table DP-1: Profile of General Demographic Characteristics: 2000, geographic area: Navajo Nation Reservation and Off-Reservation Trust Land, AZ-NM-UT" (Arizona portion), http://www.de.state.az.us/links/economic/webpage/popweb/280042430.pdf, accessed 2 September 2004; Arizona State government, "Table DP-1: Profile of General Demographic Characteristics: 2000, geographic area: Arizona," http://www.de.state.az.us/links/economic/webpage/popweb/04004.pdf.

4. Estimates of unemployment rates on Indian reservations vary according to the definitions used. As such, there can be several "official" estimates for any one reservation. See Dean Howard Smith, *Modern Tribal Development: Paths to Self-Sufficiency and Cultural Integrity in Indian Country* (Walnut Creek, CA: Altamira Press, 2000) for a discussion of the difficulties involved in estimating employment and unemployment rates.

5. Joseph Anderson and Dean Howard Smith, "Managing Tribal Assets: Developing Long Term Strategic Plans," in *Science and Native American Communities*, ed. Keith James (Lincoln: University of Nebraska Press, 2001).

6. The Navajo Nation has very good solar resources. The solar rating for all Navajo lands are either the highest or second highest as determined by National Renewable Energy Laboratories (NREL). Solar maps provided by NREL for Arizona, New Mexico, and Utah can be found at: Sustainable Energy Solutions, http://www.cba.nau.edu/ses/Resource/maps.asp, accessed August 2004. The Navajo Nation is indicated on each map.

7. Smith, *Modern Tribal Development.*

8. Ibid.

9. Jane Jacobs, *The Nature of Economies* (New York: Random House, 2000), 19.

10. R. Yazzie, "Convenience Stores: The Third Wave of Navajo Retail Outlets," *Navajo Nation Economic Development Forum* 1 (November–December 1989), n.p.

11. Smith, *Modern Tribal Development,* 49.

12. However, it is recommended that the Navajo Nation waive the Navajo Business Activity Tax for the installation of the solar systems.

13. Dean Howard Smith, with Merle-Katrin Alex, Patrick Kiley, Patrick Magnuson, Fritz Matter, Jason Ott, Steven Nicoluzakis, Steven Soli, and Rebecca Warfield, "Locating Retail Facilities within the Navajo Partioned Lands: A Field Test," unpublished report, Center for American Indian Economic Development, College of Business Administration, Northern Arizona University, May 1994.

14. See Smith, *Modern Tribal Development,* 95.

15. See ibid., chap. 12, for a discussion of the "pernicious triad" of unemployment, dropout rates, and brain drain.

16. In conjunction with Sandia National Laboratories, staff anf faculty at San Juan Community College, Southwest Indian Polytechnic Institute, and Coconino County Community College, Sustainable Energy Solutions are working on the development of such an associate degree program.

17. This will be limited to the Arizona portion of the Navajo Nation.

18. Randy Lilleston, Ian Christopher McCaleb, and Major Garrett/CNN, "Clinton Highlights Public-Private Partnership To Bridge Technology Gap," http://www.cnn.com/2000/ALLPOLITICS/stories/04/17/digital.divide/index.html, accessed 17 April 2000.

19. The Sustainable Energy Solutions research group at Northern Arizona University continues to develop ways to identify and locate those households in need of electricity and to evaluate their ability to contribute to the monthly cost of the new systems.

20. Charles Wilkinson, *Fire on the Plateau: Conflict and Endurance in the American Southwest* (Washington, DC: Island Press, 1999), 58–9.

21. Ibid, 70.

22. Smith, *Modern Tribal Development,* 64.

23. First Solar is experimenting with a 50-watt solar refrigeration system. These units will sell for less than $2,000.

24. Sandra Begay-Campbell of Sandia National Laboratories highlighted the importance of nutritional variation.

25. Shirley Ann Becker, professor of computer information systems at Northern Arizona University, indicated the important potential of telemedicine.

26. An anonymous referee suggested including this section.

27. Conversation with Dean Howard Smith, n.d.

28. The wind map was presented to the public on August 8, 2003, at the Southwest Renewable Energy Conference in Flagstaff, Arizona. The map was developed by TrueWind Solutions with funding from the National Renewable Energy Laboratory, the state of Arizona, APS, Tucson Electric Power, and Salt River Project. The map was coordinated and will be managed by Sustainable Energy Solutions.

29. Special thanks to an anonymous referee for substantive suggestions regarding this section of the paper.

30. See Bain et al., "Economic and Social Development," 4, for the details concerning the estimates.

31. See Bain et al., "Economic and Social Development," for details.

32. The local governance units of the Navajo Nation are called *chapters*.

33. The Sustainable Energy Solutions research group at Northern Arizona University is working on an ongoing project with the Navajo Nation to explore renewable energy "farming" and the development of markets.