



Fall 1997

Pollution Control in the Informal Sector: The Ciudad Juarez Brickmakers' Project

Allen Blackman

Geoffrey J. Bannister

Recommended Citation

Allen Blackman & Geoffrey J. Bannister, *Pollution Control in the Informal Sector: The Ciudad Juarez Brickmakers' Project*, 37 Nat. Resources J. 829 (1997).

Available at: <https://digitalrepository.unm.edu/nrj/vol37/iss4/3>

This Article is brought to you for free and open access by the Law Journals at UNM Digital Repository. It has been accepted for inclusion in Natural Resources Journal by an authorized editor of UNM Digital Repository. For more information, please contact amywinter@unm.edu, lsloane@salud.unm.edu, sarahrk@unm.edu.

ALLEN BLACKMAN AND GEOFFREY J. BANNISTER*

Pollution Control in the Informal Sector: The Ciudad Juárez Brickmakers' Project

ABSTRACT

Low-technology unlicensed micro-enterprises known as "informal" firms are a significant source of pollution in developing countries that are virtually impossible to regulate in the conventional manner. This paper describes an example of an innovative and promising approach to the problem: the Ciudad Juárez Brickmakers' Project, a private-sector-led initiative aimed at abating highly polluting emissions from Ciudad Juárez, Mexico's approximately 300 informal brick kilns. We draw four lessons from the Project's history. First, private-sector-led initiatives can work – indeed they may be more effective than public sector initiatives – but they require strong public sector support. Second, necessary conditions for effective environmental management in the informal sector include enlisting the cooperation of local organizations, relying upon peer monitoring, and offsetting compliance costs. Ineffective strategies include promoting too-advanced technologies and intervening in informal markets. Third, pollution control strategies that provide the greatest environmental benefits may be less appropriate than low-cost intermediate strategies. Finally, in volatile developing economies, market-based environmental initiatives in the informal sector are bound to be fragile.

I. INTRODUCTION

In developing countries, population growth, rural-urban migration, and government efforts to tax and regulate have spurred the rapid expansion of an informal sector comprised of low-technology micro-

* The authors are, respectively: Fellow, Resources for the Future (phone 202-328-5073; fax 202-939-3460; e-mail blackman@rff.org); and Assistant Professor, Anderson Schools of Management, University of New Mexico, Albuquerque (tel. 505-277-8892; fax 505-277-7108; e-mail bannister@anderson.unm.edu). Please address correspondence to Allen Blackman. The authors gratefully acknowledge the financial support of the Tinker Foundation. Special thanks to the brickmakers of Ciudad Juárez, Octavio Chavez, Jocelyn Drennan, Hubert Eldrige, the Mexican Federation of Private Health and Community Development Associations (FEMAP), Nancy Lowery, Francisco Nuñez, Carlos Rincon, the Texas Natural Resources Conservation Commission (TNRCC), and John Wirth. The opinions expressed in the paper are the authors' alone and do not necessarily reflect the views of any of the above-named organizations or individuals.

enterprises that operate outside the purview of the state. Although historically seen as little more than a collection of street merchants, today the informal sector is increasingly recognized as a leading contributor to Gross Domestic Product (GDP) and a hotbed of innovation and entrepreneurship.¹ This emerging view is borne out by recent research. According to Gustav Ranis and Frances Stewart, the informal sector accounts for over half of non-agricultural employment in both Latin America and Africa.² Estimates of its contribution to GDP in various countries range from 20 to 40 percent.³

But while many policymakers and academics now recognize that the growth of the informal sector has generated important economic benefits, to date they have almost completely ignored the environmental impacts. This oversight may have to do with the persistence of the fiction that the informal sector is comprised only of environmentally benign retail and service oriented activities. Actually, it includes many pollution intensive activities such as leather tanning, brick and tile making, automotive repair, wood finishing, metalworking, electroplating, and small-scale mining.⁴ Given the sheer number of such firms in developing countries, the aggregate environmental impacts are likely to be significant. The limited literature that exists supports this view.⁵ According to Ahmed Hamza,

While in people's minds, industrial pollution is mainly contributed by large primary and conversion industries, . . . the bulk of pollution in urban areas is the result of dispersed

1. Nathaniel C. Nash, *Informal Latin Economy Saves the Day*, N.Y. TIMES, Mar. 21, 1992, at L37, L41. See also HERNANDO DE SOTO, *THE OTHER PATH: THE INVISIBLE REVOLUTION IN THE THIRD WORLD* (1989). Gross Domestic Product (GDP) is a measure of the total value of goods and services a country produces in a given year.

2. GUSTAV RANIS & FRANCIS STEWART, *V-GOODS AND THE ROLE OF THE URBAN INFORMAL SECTOR IN DEVELOPMENT 18-20* (Yale Univ. Econ. Growth Ctr. Discussion Paper No. 724, 1994).

3. DAN BILLER & JUAN DAVID QUINTERO, *POLICY OPTIONS TO ADDRESS INFORMAL SECTOR CONTAMINATION IN URBAN LATIN AMERICA: THE CASE OF LEATHER TANNERIES IN BOGOTA, COLOMBIA 3* (The World Bank, Latin Am. Technical Dep't, Env'tl. Div., Dissemination Note No. 14, 1995).

4. For example, in Mexico, 38% of informal firms are classified as industrial. U.S. DEP'T OF LABOR, *OCCASIONAL PAPER NO. 1, THE INFORMAL SECTOR IN MEXICO 21a*, (1992).

5. DAN BILLER, *INFORMAL GOLD MINING AND MERCURY POLLUTION IN BRAZIL* (The World Bank Policy Research Working Paper No. 1304, 1994); *Environmental Management of Small and Medium Size Industries*, INDUSTRY AND ENVIRONMENT, April/May/June 1987, at 2 (1987); see also AHMED HAMZA, UNITED NATIONS CENTER FOR HUMAN SETTLEMENTS URBAN MANAGEMENT PROGRAM, *IMPACTS OF INDUSTRIAL AND SMALL-SCALE MANUFACTURING WASTES ON URBAN ENVIRONMENT IN DEVELOPING COUNTRIES 6* (1991); BILLER & QUINTERO, *supra* note 3.

Citizens' Environmental Advisory Committee to the El Paso City Council played a pivotal role in creating this awareness.³⁵

Motivated by these national and local events, in 1989 the Ciudad Juárez environmental authority, the Municipal Council for Ecology, undertook a campaign to convince brickmakers to substitute clean-burning propane for dirty traditional fuels.³⁶ To our knowledge, this was the first concerted effort to abate emissions from brick kilns in Ciudad Juárez.

The Municipal Council's leadership of the propane initiative was short-lived, however. In 1990, FEMAP, a private non-profit organization based in Ciudad Juárez, took charge. According to Project leaders, the city transferred control of the propane initiative to FEMAP because of FEMAP's expertise in grass roots organizing in poor *colonias*, including several brickmaking *colonias* in Ciudad Juárez.³⁷

As a non-profit service organization, FEMAP grafted social and economic objectives onto the strictly environmental goals pursued by the Municipal Council for Ecology. A FEMAP report on the Brickmakers' Project lists two rather broad objectives:

- (1) To help reduce environmental pollution by encouraging the use of less polluting energy sources and implementation of technology to insure complete combustion.
- (2) To help improve standards of well-being and quality of life for brickmaking families and others like them, by preserving production capacity, modernizing their small enterprises, improving productivity and product quality, and increasing income through avoidance of intermediaries.³⁸

35. El Paso Mayor Suzie Azar created the eight member Citizen's Environmental Advisory Committee in the mid 1980s to advise member of the city council on environmental matters. Telephone Interview with Anne Allen, Citizens' Environmental Advisory Committee to the El Paso, Tex. City Council (Jan. 10, 1996). This committee helped to popularize the statistic that traditional brick kilns are the third or fourth leading source of air pollution in El Paso-Ciudad Juárez. Telephone Interview with Carlos Rincon, Project Director, Environmental Defense Fund (Dec. 5, 1995). Dr. Rene Franco Barreno, then director of the Ciudad Juárez Municipal Council of Ecology and the founder of the propane initiative, was a frequent participant in the Citizens' Environmental Advisory Committee to the El Paso, Tex. City Council. Telephone Interview with Carlos Rincon, Project Director, Environmental Defense Fund (Jan. 31, 1996).

36. Interview with Enrique Suárez, Executive Director, FEMAP, in Ciudad Juárez, Chihuahua, Mex. (Feb. 1, 1996); Interview with Rene Franco Barreno, former President of Ciudad Juárez Municipal Council of Ecology, in Reno, Nevada (Apr. 19, 1996).

37. Interview with Enrique Suárez, *supra* note 36. Other factors may have played a role as well, including the expectation that the propane initiative would be able to secure funding from Solidarity Enterprises, a federal microenterprise development program.

38. FEMAP, *supra* note 23, at 2.

This paper will focus on the Project's efforts to achieve its environmental objectives. However, as the discussion below will illustrate, these efforts were, to some degree, shaped by the Project's concurrent social objectives.

B. The Role of NAFTA and Mexican Politics

Although the Brickmakers' Project did not succeed in converting more than 30 percent of Juárez's brickmakers to propane until the end of 1993, by the end of 1991 it had already begun to generate an extraordinary amount of publicity, institutional participation, and some outside funding.³⁹ Two national and international events which focused unprecedented attention on border environmental issues were largely responsible: the 1991 debate over the North American Free Trade Agreement (NAFTA) and the 1991 Mexican midterm Federal elections.

Both the Bush and Salinas administrations committed enormous political capital to the Free Trade Agreement, yet, to the surprise of both administrations, during the spring 1991 debate in the United States congress over granting the Bush administration 'fast track' authority to negotiate the treaty, environmentalists organized an angry and vociferous opposition. They argued that a free trade agreement would spur still more rapid and uncontrolled development along the border.⁴⁰ The NAFTA negotiators efforts to allay these concerns by developing the Integrated Environmental Plan for the United States-Mexican Border fell flat and the debate about the border environment continued unabated throughout the NAFTA negotiations and the subsequent congressional battle over ratification.⁴¹

39. As late as December 1992, no more than 15 percent of the brickmakers in five principal brickmaking *colonias* in Ciudad Juárez—some 50 to 60 brickmakers—were using propane. FEMAP, *supra* note 23, at 21.

40. On the NAFTA debate see Jan Gilbreath & John Benjamin Tonra, *The Environment: Unwelcome Guest at the Free Trade Party*, in *THE NAFTA DEBATE: GRAPPLING WITH UNCONVENTIONAL TRADE ISSUES* (M. Delal Baer & Sidney Weintraub eds., 1994).

41. Produced jointly by the USEPA and its Mexican counterpart SEDUE, the Integrated Environmental Plan (IEP) for the Mexican-U.S. Border Area purported to be a master plan for dealing with border environmental problems. US ENVIRONMENTAL PROTECTION AGENCY, *INTEGRATED ENVIRONMENTAL PLAN [IEP] FOR THE MEXICAN-U.S. BORDER AREA: FIRST STAGE 1992-1994* (1992). The IEP attracted intense criticism for a lack of funding, limited opportunities for public participation, and general vagueness. See, e.g., JAN GILBREATH RICH, *PLANNING THE BORDER'S FUTURE: THE MEXICAN-U.S. INTEGRATED BORDER ENVIRONMENTAL PLAN*, (US-Mex. Policy Studies Program, LBJ School of Public Affairs, University of Tex. at Austin Occasional Paper No. 1, 1992).

medium/small-size industries which in many regions comprise the major part of manufacturing activities.⁶

In Mexico, small-scale traditional brick kilns are a notorious informal sector source of urban air pollution. According to one estimate, there are approximately 20,000 traditional brick kilns in the country.⁷ Many large cities support several hundred kilns. These kilns are fired with a variety of cheap highly polluting fuels including plastic refuse, used tires, manure, wood scrap, and used motor oil.⁸ In many cities, traditional kilns are a leading source of air pollution.⁹ Even where they are not, the kilns constitute a serious local health hazard to the residents of the impoverished neighborhoods that usually abut brickyards, as well as to brickmakers themselves.¹⁰

The most common regulatory strategy has been to ban the use of dirty fuels. However, many of these efforts have failed. For example, efforts to promote cleaner fuels such as propane and creosote in Saltillo, Coahuila, Torreon, Coahuila, and Zacatecas, Zacatecas have met with limited success.¹¹

In general, controlling pollution created by informal firms is especially difficult for four reasons. First, by definition, informal firms have few preexisting ties to the state. Second, such firms are difficult to monitor since they are small, numerous, and geographically dispersed. Third, intensely competitive informal firms are under considerable pressure to cut costs regardless of the environmental impacts. And finally, informal firms sustain the poorest of the poor. As a consequence, they may appear to both

6. HAMZA, *supra* note 5, quoted in Carl R. Bartone, Local Management of Hazardous Wastes from Small-Scale and Cottage Industries 3 (paper presented at the fifth Pacific Basin conference on Hazardous Waste, Pacific Basin Consortium for Hazardous Waste Research Nov. 1993) (on file with the *Natural Resources Journal*).

7. Anders T. Johnson ET AL., Successful Modernization of an Ancient Industry: The Brickmakers of Ciudad Juárez, Mexico (Apr. 25, 1994) (on file with *Natural Resource Journal*).

8. See, e.g., Allen Blackman & Geoffrey J. Bannister, Traditional Brickmaking in Northern Mexico: The Problem of Pollution Control in an Informal Industry (1997) (on file with *Natural Resources Journal*; presented at the 1997 meeting of the Assoc. of Borderland Scholars, Albuquerque, N.M.) [hereinafter Blackman & Bannister (1997)].

9. See, e.g., Blackman & Bannister (1997), *supra* note 8.

10. Although there is plentiful anecdotal evidence that smoke inhalation is harmful, there is scant information on the health risks borne by brickmakers in particular. See, e.g., the studies cited in DAVID BRADLEY ET AL., A REVIEW OF ENVIRONMENTAL HEALTH IMPACTS IN DEVELOPING CITIES (The World Bank, Urban Management Program, Discussion Paper No. 6, 1992). An exception is a cursory study of the pulmonary function of brickmakers in Saltillo, Coahuila. *Informe de Resultados del Estudio Pulmonar Realizado a Personas que Laboran y Viven cerca del las Ladrilleras* (July 17, 1996) (on file with *Natural Resources Journal*). The study found that of 55 subjects tested, only 29 presented with "normal" pulmonary functions.

11. For a description of these efforts see Blackman & Bannister (1997), *supra* note 8.

regulators and the public as less appropriate targets for regulation than larger, wealthier firms. Given these constraints, the application of conventional command and control regulation is bound to be problematic if not completely impractical.¹² Hence, pollution control in the informal sector will require innovative approaches.

The Ciudad Juárez Brickmakers' Project (hereafter, "the Project") which has worked to abate highly polluting emissions from the city's approximately 300 traditional brick kilns since 1990, is an example of an innovative approach. In the three years between 1991 and 1994, it was successful in persuading at least half of Ciudad Juárez's brickmakers to fire their kilns with clean-burning propane.

The Project is innovative for several reasons. First, it is not headed by a regulatory authority but by a non-governmental organization, the Mexican Federation of Private Health and Community Development Associations (FEMAP).¹³ In addition, it has enlisted the participation of a diverse set of private- and public-sector stakeholders. And finally, its leaders have worked to establish a cooperative instead of an adversarial relationship with brickmakers, creating incentives for voluntary compliance as well as penalties for non-compliance.

This paper reviews the history of the Brickmakers' Project in order to distill lessons about pollution control in the informal sector. It draws upon a variety of sources including an extensive survey administered to 95 brickmakers in July of 1995, interviews with project participants, and primary and secondary written sources. The next section of this paper provides background on air pollution in El Paso-Ciudad Juárez and on traditional brickmaking. The third section details the history of the Brickmakers' Project. The concluding section distills lessons from this history.

12. Command and control regulation, the dominant approach to pollution control in virtually every country, requires an environmental authority to promulgate and enforce regulations governing the abatement technologies firms use and/or the amount of abatement they undertake. For a review of the literature on environmental regulation, see Maureen Cropper & Wallace Oates, *Environmental Economics: A Survey*, 30 J. ECON. LITERATURE 675, 740 (1992).

13. Founded in Ciudad Juárez in 1973, FEMAP administers health care and microenterprise development projects in 25 Mexican states. FEMAP, general brochure (undated) (on file with *Natural Resources Journal*); see also, INSTITUTO DE ECOTECHNOLOGIA, WHY IS THIS NEWS? (undated) (on file with *Natural Resources Journal*).

II. BACKGROUND

El Paso-Ciudad Juárez Air Quality

Air quality in the sister cities of El Paso, Texas, and Ciudad Juárez, Chihuahua is the worst on the United States-Mexican border and among the worst in North America.¹⁴ In 1995, the city of El Paso was classified by the United States Environmental Protection Agency as a "moderate" nonattainment area for both carbon monoxide and particulate matter, and El Paso county was classified as a "serious" non-attainment area for ozone.¹⁵

Poor air quality in the sister cities stems from rapid industrialization and population growth over the last several decades and from the fact that the cities are located in a high desert valley that fosters temperature inversions.¹⁶ The leading sources of air pollution in the region are, in order of magnitude: vehicle emissions, dust from unpaved roads, industrial pollution, and open air fires.¹⁷ Not surprisingly, the locations of these sources reflect the relative levels of development on each side of the border. Open-air fires used in brickmaking and residential heating, unpaved roads, cement plants, and a relatively old vehicular fleet in Ciudad Juárez are major sources of particulate matter and carbon monoxide. North of the border, the ASARCO copper smelter and the Chevron oil refinery are major sources of sulfur oxides, nitrogen oxides, and heavy metals.¹⁸

Principally fired with scrap wood and sawdust that is often impregnated with toxic resins, laminates and varnishes, Ciudad Juárez's approximately 300 small-scale brick kilns are frequently cited as the third or fourth leading contributor to air pollution in both Ciudad Juárez and El Paso.¹⁹ Although brick kilns are primarily associated with carbon monoxide

14. Francisco Nuñez ET AL., *Solving Air Pollution Problems in Paso del Norte* 1 (October 1994) (on file with *Natural Resources Journal*).

15. Telephone Interview with Miguel Parra, Air Investigator, TNRCC (Mar. 21, 1996).

16. From 1980 to 1990, the population of Ciudad Juárez grew at an average annual rate of 3.47 percent while that of Mexico as a whole grew at 1.92 percent. During the same time period, the population of El Paso grew at an average annual rate of 2.79 percent while that of the United States grew at an average annual rate of 1.26 percent. UNITED STATES BUREAU OF THE CENSUS, *COUNTRY AND CITY DATA BOOK* (1994); INSTITUTO NACIONAL DE ESTADISTICA, *GEOGRAFIA E INFORMATICA, ESTADOS UNIDOS MEXICANOS: RESUMEN GENERAL: XI CENSO GENERAL DE POBLACION Y VIVIENDA, 1990* (1992).

17. TOM BARRY, *THE CHALLENGE OF CROSS-BORDER ENVIRONMENTALISM* 38-39 (1994).

18. C. Richard Bath & Victoria Rodriguez, *Comparative Binational Air Pollution Policy in El Paso, TX and Ciudad Juárez, Chihuahua*, 6 *BORDERLANDS* 171 (1983).

19. See e.g., Martha Mendoza, *LANL Helping Mexico Clean Up Border Smog*, *Albuquerque Journal*, Nov. 5, 1995, at C1, C3; Johnson ET AL., *supra* note 7. Though widely used, this statistic is undocumented. According to the TNRCC, no emissions inventory has ever been

and particulate emissions, depending on the fuels used, they may also emit volatile organic compounds, nitrogen oxide, sulfur dioxide, heavy metals, and carbon dioxide, the most important greenhouse gas.²⁰

Traditional Brickmaking in Ciudad Juárez

The problem of emissions from traditional kilns in Ciudad Juárez has been greatly exacerbated by the city's growth. Ciudad Juárez' approximately 300 brick kilns are clustered in eight poor *colonias* located throughout the city: Anapra, División del Norte, Francisco Villa, Fronteriza Baja, Kilómetro 20, México 68, Satellite, and Senecu 2.²¹ When brickmakers squatted in these *colonias* 25 or 30 years ago, all were situated on the outskirts of the city. Today, however, because of urban sprawl, many are located in residential neighborhoods. As a result, brick kilns have sparked considerable controversy; they were the most frequent subject of complaints to the Ciudad Juárez municipal environmental authority in 1994.²²

Despite growing pressure, a number of considerations make it politically difficult to act on complaints about traditional kilns. First, brick making is a significant source of employment. According to FEMAP, the non-governmental organization that leads the Brickmakers' Project, brickmaking in Ciudad Juárez provides over 2,000 jobs directly and 150 jobs indirectly in transportation and wholesaling.²³

Second, brickmaking is an extremely small-scale, low-technology activity and, as a result, most brickmakers are impoverished. On average, each kiln employs six workers who perform all tasks by hand.²⁴ Studies have put the brickmakers' monthly profit when burning traditional fuels at between 450-900 pesos (\$60-\$120 at an exchange rate of 7.5 pesos to the

performed for Ciudad Juárez. Telephone Interview with Archibald Clouse, Interim Region Manager, TNRC (Jan. 6, 1996).

20. Johnson ET AL., *supra* note 7, at 3. The authors report that tests of emissions from traditional brick kilns burning five different fuels—sawdust, contaminated sawdust, used motor oil, propane (old burner), and propane (new burner)—showed the two "least desirable" fuels to be used motor oil and contaminated sawdust. Kilns burning these fuels emitted relatively high levels of volatile organic compounds and carbon monoxide.

21. Dirección Municipal de Ecología, Juárez Kiln Distribution (January 1995) (pamphlet on file with *Natural Resources Journal*).

22. Brick kilns were the subject of one quarter of all complaints. Dirección Municipal de Ecología, Complaints According to their Origin, (on file with *Natural Resources Journal*).

23. FEMAP, Report for December 1992—January 1994, at 5 (1994).

24. FEMAP, Summary of Brick Kiln Census (on file with the *Natural Resources Journal*). Traditional brickmaking involves four tasks: mixing earth and clay, molding the mixture into bricks, drying the bricks in the sun, and firing them in a primitive adobe kiln.

dollar).²⁵ This sum compares to the monthly minimum wage in the north of Mexico of about 480 pesos (\$64).²⁶ Not surprisingly, socioeconomic conditions are poor. Most brickmakers live next to their kilns in rudimentary houses with no drainage or running water. On average, kiln owners have three years of schooling. Approximately 25 percent are illiterate. Most brickmakers are over 40 years of age, quite old in comparison to the population as a whole (Table 1).²⁷

Finally, abating kiln emission in Ciudad Juárez is politically sensitive because the brickmakers are well organized.²⁸ Fifty-nine percent of the brickmakers surveyed belonged to a local organization. There are two rival political factions among the brickmakers. The first faction is comprised of organizations affiliated with the *Partido Revolucionario Institucional* (PRI), the dominant national political party. These include the *Confederación de Trabajadores Mexicanos* (CTM) and the *Frente Nacional de Organizaciones Ciudadanas* (FNOC). Many of the brickmakers in these organizations also belong to the *Sindicato de Ladrilleros y Trabajadores de la Cal*, the PRI affiliated Brickmakers' Union. The PRI affiliates tend to represent the relatively affluent brickmakers. Their leaders act as intermediaries between the brickmakers, the city government, and federal agencies. Because of their ties to the political establishment, (whether controlled by the PRI or its principal opposition party, the *Partido Acción Nacional* or PAN), these organizations have been successful in extracting concessions from the municipal government.²⁹ The PRI affiliates were one of the main instruments used by the city government (at that time PAN) and FEMAP to persuade brickmakers to adopt propane.³⁰

25. ALLEN BLACKMAN & GEOFFREY J. BANNISTER, COMMUNITY PRESSURE AND CLEAN TECHNOLOGY IN THE INFORMAL SECTOR: AN ECONOMETRIC ANALYSIS OF THE ADOPTION OF PROPANE BY TRADITIONAL MEXICAN BRICKMAKERS, *JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT*, 35 (1998); FEMAP, *supra* note 24. It is difficult to calculate the profit from informal activities precisely owing to poor record keeping and the use of family labor.

26. BANCO DE MEXICO, *THE MEXICAN ECONOMY 1995* (1996). Minimum wage figures are for April-Sept. 1995 at 18.3 pesos per day. The monthly figure is calculated assuming 26 days of work per month.

27. BLACKMAN & BANNISTER, *supra* note 25; FEMAP, *supra* note 24.

28. BLACKMAN & BANNISTER, *supra* note 25, FEMAP, *supra* note 24.

29. For example, in responding to the authors' survey, the leader of one PRI affiliate mentioned that members of his union received subsidies on water bills as well as permits for dredging a local canal for clay. ALLEN BLACKMAN & GEOFFREY J. BANNISTER, *JUAREZ BRICK KILN QUESTIONNAIRE* (Version 4.1 1995) (blank survey on file with the *Natural Resources Journal*; survey data on file with the authors).

30. PRI affiliates dominate certain brickmaking *colonias* such as Satellite, have a sizable proportion of others such as México 68, and are completely absent from some of the poorest *colonias* such as Anapra.

The poorest *colonias* are dominated by a rival organization, the *Comité de Defensa Popular* (CDP) which is linked to the national *Partido del Trabajo* (PT).³¹ Formed to fight the city government's attempts to evict squatters, the CDP has traditionally opposed the political establishment and resisted attempts to regulate brickmaking. In particular, it has resisted efforts to convince brickmakers to use cleaner fuels. Forty percent of the brickmakers in our sample belonged to a PRI affiliate, 19 percent to the CDP, and the remaining 41 percent were independent.

III. HISTORY OF THE BRICKMAKERS' PROJECT

A. The Birth of the Brickmakers' Project

At every stage, the Ciudad Juárez Brickmakers' Project has been shaped by national and international political trends as well as by local concerns and efforts. On the level of national politics, the Project was, broadly speaking, spawned by the Mexican Federal government's newfound emphasis on environmental protection in the late 1980s. Heralded by the emergence of the environment as an important issue in the 1988 Federal elections and by the passage of a new comprehensive Federal Ecology Law that same year, this new environmentalism was by no means mere rhetoric.³² In just three years between 1988 and 1991, federal expenditures on the environment by the Mexican government increased from \$95 million to \$1.8 billion, the equivalent of 0.7 percent of Mexico's GDP.³³ The growing importance of environmental issues put pressure on the Ciudad Juárez municipal government to give higher priority to environmental protection.³⁴

On the local level, an important antecedent to the Brickmakers' Project was a widening recognition during the 1980s that traditional brick kilns in Ciudad Juárez are an important source of air pollution. An activist

31. BLACKMAN & BANNISTER, *supra* note 25; FEMAP, *supra* note 24.

32. Steven Mumme, *Clearing the Air: Environmental Reform in Mexico*, ENV'T, Dec. 1991, at 6, 9-11.

33. Nicolas Kublicki, *The Greening of Free Trade, NAFTA, Mexican Environmental Law, and Debt Exchanges for Mexican Environment Infrastructure Development*, 19 COLUM. J. ENVTL. L. 59, 93 (1994).

34. Interview with Enrique Suárez, Executive Director, FEMAP, in Juárez, Mexico (Dec. 11, 1995).

The 1991 Mexican midterm Federal election also focused attention on border environmental issues. Pre-election polls indicated that 60 percent of Mexicans considered the environment to be a high priority.⁴²

The upshot of these events was that by the fall of 1991, for the first time, the border environment became an important issue for both the United States and Mexican Federal governments. Both countries stepped up regulatory enforcement along the border and initiated a number of environmental projects and programs.⁴³ Funding to deal with long neglected border environmental issues that had previously been chronically scarce suddenly became available.⁴⁴

The NAFTA debate combined with the genuine, if newfound, emphasis on the environment in Mexico created a special opportunity for FEMAP. The Brickmakers' Project was tailor-made to suit the political purposes of the Salinas administration. Not only did it involve cleaning up the border but it also embraced private sector initiative and the modernization of traditional microenterprises, two hallmarks of the administration's ambitious economic reforms.⁴⁵ As an established NGO, FEMAP was excellently placed to take advantage of this commonality of interests. The Brickmakers' Project also complemented American efforts to defuse environmental opposition to NAFTA.⁴⁶

C. Mexican Federal Support

In 1991 FEMAP was able to obtain an 800,000 peso trust fund for the Project directly from the office of President Salinas through Solidarity Enterprises (*Empresas Solidaridad*), the microenterprise development branch

42. Mumme, *supra* note 32, at 27. On the politicization of the environmental issue, see Steven Mumme & Robert Sanchez, *Mexico's Environment Under Salinas: Institutionalizing Reform*, REV. OF LATIN AM. STUD. (1990) at 44, 81.

43. Also, in November of 1991, with an \$88 million World Bank loan, Mexico set in motion a plan to decentralize and reform its environmental regulation; the states were encouraged to pass and enforce their own environmental legislation subject to a Federal floor established by the 1988 Ecology Act. Kublicki, *supra* note 33, at 84.

44. On stricter enforcement see Bryan W. Husted & Jeanne M. Logsdon, *The Impact of NAFTA on Mexico's Environmental Policy*, 28 GROWTH AND CHANGE 24. For a description EPA sponsored border environmental activities see U.S. ENVIRONMENTAL PROTECTION AGENCY, EPA 160-B-95-001, COMPENDIUM OF EPA BINATIONAL AND DOMESTIC US/MEXICO ACTIVITIES (1995).

45. For a discussion of Mexico's economic reform initiative see NORA LUSTIG, MEXICO: THE REMAKING OF AN ECONOMY (1992); PEDRO ASPE ARMELLA, ECONOMIC TRANSFORMATION THE MEXICAN WAY (1993).

46. Carol Browner, Director of the U.S. Environmental Protection Agency, visited a FEMAP demonstration site in March 1993. FEMAP, *supra* note 23.

of the urban development program PRONASOL.⁴⁷ This 800,000 peso fund was then used to leverage an 8,000,000 peso line of credit from NAFIN, the Mexican Federal development bank that finances small business projects. All of these moneys were earmarked for the exclusive use of brickmakers.⁴⁸ Thanks to this high level of support, the Project was well launched by 1994, the last year of the Salinas administration.⁴⁹

D. Participation in the Brickmakers' Project

One of the most noteworthy achievements of the Brickmakers' Project has been to construct a broad base of institutional support that cuts across national and sectoral boundaries. A 1994 FEMAP report lists as participants 12 Mexican private sector institutions, seven Mexican public sector institutions, and five American institutions.⁵⁰ The key Mexican

47. FEMAP, *supra* note 23. PRONASOL (*Programa Nacional de Solidaridad*) was a program initially administered within the office of the Presidency that offered matching funds to poor urban communities for the installation of sewers, electricity and other basic infrastructure. In April of 1992 PRONASOL was merged with the environmental agency (SEDUE) to create SEDESOL, a cabinet-level ministry.

48. FEMAP, general brochure, *supra* note 13. Interview with Enrique Suárez, *supra* note 34.

49. The Salinas administration made quite a show of its support for the Brickmakers' Project. Luis Donaldo Colosio, then head of SEDESOL, and later the PRI's presidential candidate, delivered the first installment of his agency's funds personally. Salinas himself appeared with FEMAP officials in Ciudad Juárez on three separate occasions in February 1993, August 1993, and in October of 1994. Carlos Irigoyen, *Anuncian Plan Ecológico*, DIARIO DE JUÁREZ, February 13, 1992, reprinted in FEMAP, general brochure (undated) (on file with *Natural Resources Journal*); FEMAP, *supra* note 23; *Compromiso Ecológico es Moral, no Político: CSG*, DIARIO DE JUÁREZ, August 6, 1993, reprinted in FEMAP, general brochure (undated) (on file with *Natural Resources Journal*). FEMAP, ECO-TEC Report for October 1994-March 1995 (1995).

50. The Mexican private sector participants were: FEMAP, Asociación Gilberto (a Mexican charitable organization), Grupo Peñoles (a large Mexican mining conglomerate), Ciudad Juárez propane companies, CONCANACO (a national federation of chambers of commerce), CANACINTRA (a national federation of manufacturing industries), COPARMEX (a federation of big business owners), Economic Development of Ciudad Juárez (a local businessmen's organization), Instituto Tecnológico y de Estudios Superiores de Monterrey ("Monterrey Tech.") Ciudad Juárez Campus, construction companies in Ciudad Juárez, and the brickmakers. The Mexican public sector participants were: SECOFI (the Federal Ministry of Commerce and Industry), NAFIN (a Federal economic development bank), SEDESOL (the federal environmental agency from 1992 to 1995), Municipal and State Governments, Universidad Autónoma de Ciudad Juárez, INFONAVIT (the Federal workers' housing agency), and Solidarity Enterprises (the Federal microenterprise development program). The American participants were: El Paso Natural Gas Co., Los Alamos National Laboratory, the Gas Research Institute (Chicago, IL), the University of Texas at El Paso, and the Southwest Center for Environmental Research and Policy (SCERP) (a USEPA funded consortium of United States and Mexican universities focusing on US-Mexican border

private sector participants (aside from FEMAP and the brickmakers) were the local propane companies that provided credit, training, and propane equipment. The key public sector participants were NAFIN and Solidarity Enterprises which provided funding, and the municipal government which enforced a prohibition on the burning of dirty fuels. The key American participants were El Paso Natural Gas and Los Alamos National Laboratory which provided engineering expertise and funding. The next section discusses the contributions of the Project participants in more detail.

Although the hard work of Project organizers was instrumental in securing the participation of a diverse group of stakeholders, this work was facilitated by a number of factors. These included: FEMAP's strong community, business and political ties, the publicity created by NAFTA, a palpable bandwagon effect, and a commonality of interests between the Project and the various organizations involved.⁵¹ For example, on the last point, Los Alamos National Laboratory's participation buttressed efforts to reposition itself as a center of environmental research and technology transfer to the private sector. El Paso Natural Gas' contributions to the project generated favorable public relations, and the participation of American universities was facilitated by the availability of significant funding for border environmental projects. It bears emphasis, however, that community spirit was an important motive as well.⁵²

environmental issues).

Of these organizations, several played relatively minor roles and are not discussed in the text. The national and local business federations served as bridges between the brickmakers, the construction and propane companies, the municipal government, and the Project organizers. Grupo Peñoles contributed engineering expertise in early efforts to improve kiln efficiency. The Universidad Autónoma de Ciudad Juárez conducted a study of brickmakers. The state government of Chihuahua furnished political support. Personnel from Monterrey Tech. helped to develop training courses for brickmakers. American universities, funded by SCERP, helped to develop brickmaker training courses, and conducted research on methods of improving kiln fuel efficiency. (Interview with Carlos Rincon, *supra* note 35. Interview with Enrique Suárez, *supra* note 34; *Ordenan a INFONAVIT Utilizar Ladrillo Ecológico*, DIARIO DE JUÁREZ, Aug. 5, 1993 reprinted in FEMAP, general brochure (undated) (on file with *Natural Resources Journal*); FEMAP, *supra* note 13. For a description of EPA funded activities see U.S. ENVIRONMENTAL PROTECTION AGENCY, *supra* note 44.

51. FEMAP enjoys strong ties to community, business, and political leaders, in part because its founder and president, Guadalupe de la Vega, is a member of a prosperous Ciudad Juárez family with considerable holdings in retailing and industry. These ties were particularly helpful in securing the participation of the national business federations. Telephone interview with Carlos Rincon, *supra* note 35 and telephone interview with Nancy Lowery, Program Coordinator, Center for Environmental Resource Management, University of Texas at El Paso (Dec. 5, 1995).

52. Several of the project engineers from El Paso Natural Gas and Los Alamos National Laboratory often worked nights and weekends without remuneration in difficult conditions. See, e.g., Jeryl Z. Marcus, *The Brickmakers Story*, PIPELINER, Feb. 1994, at 21. This was certainly

E. Strategies

In attempting to induce the brickmakers to switch to propane, project leaders and participants were faced with five key obstacles. First, adopting propane required brickmakers to obtain and learn to use relatively expensive equipment. Second, at the beginning of the Project, regulatory and hortatory pressure to abate kiln emissions was for the most part extremely weak. Third, although the brickmakers themselves were most affected by kiln emissions, most did not perceive them to be imminently harmful. Fourth, the traditional brickmaking industry and the construction industry that buys from it are intensely competitive. Consequently, there was considerable pressure for individual brickmakers to cut costs by burning dirty fuels and for individual construction firms to purchase the least expensive building materials. Finally, and most important, throughout the Project's life, the cost of propane was higher than the cost of debris. Moreover, this cost differential increased significantly over time. In the early 1990s, PEMEX, Mexico's state run petroleum company, began to gradually eliminate long-standing subsidies on propane in conjunction with the Salinas administration's economic liberalization program and to dampen a black market for subsidized Mexican propane on the border (Chart 1). At the beginning of 1992, per brick energy costs for propane were 29 percent higher than for scrapwood. By July 1995, this differential had risen to 162 percent.⁵³

Participants in the Brickmakers' Project have promoted a broad range of initiatives designed to overcome each of these barriers including: the donation of propane equipment, setting up technical extension services, disseminating information on the health impacts of burning debris, formal and informal regulation, technological innovation, and market intervention.

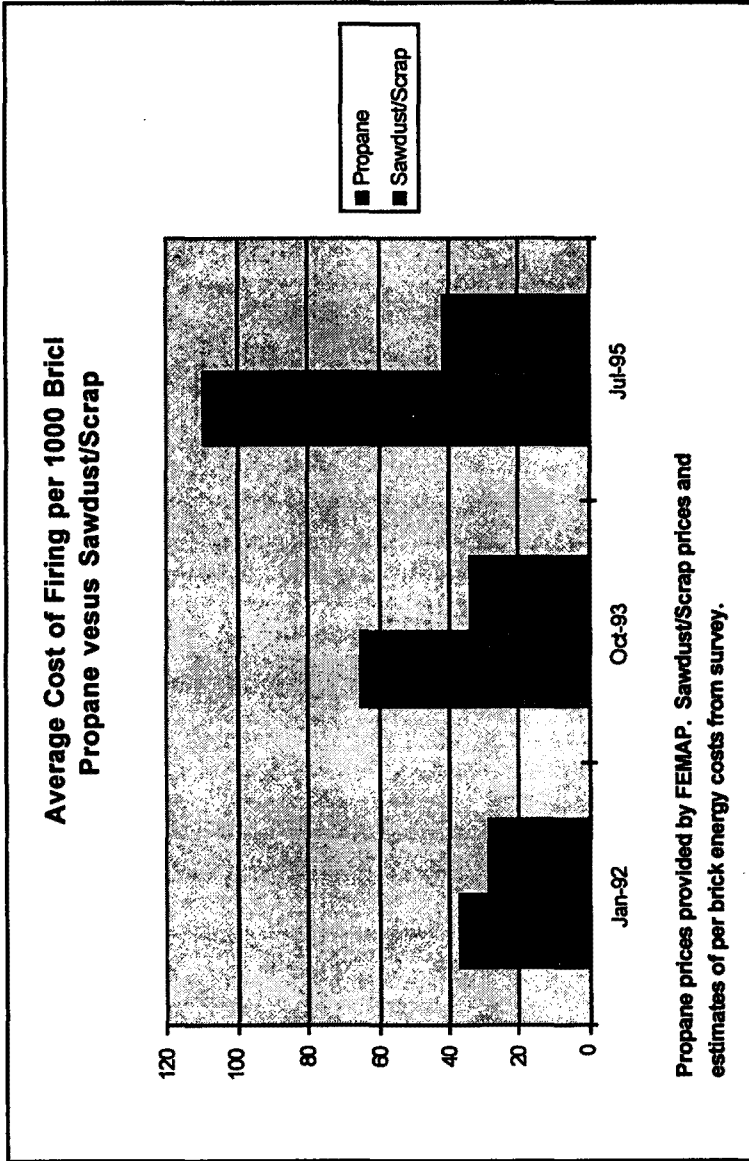
1. Propane Equipment

The Brickmakers' Project was quite successful in creating access to propane equipment. In our sample of 59 propane users, propane companies in Ciudad Juárez provided free equipment in every case (Table 1). Of the 36 brickmakers interviewed who never used propane, none said that a key

also true of FEMAP personnel, many of whom volunteered their time.

53. At the beginning of 1992, propane prices were approximately 0.24 pesos per liter. For the average brickmaker this implied a cost of 37.02 pesos per 1000 bricks fired with propane versus 29.77 pesos per 1000 bricks fired with scrapwood. By July 1995, the price of propane had risen to 0.71 pesos per liter, implying a cost of 109.52 pesos per 1,000 bricks fired with propane versus 41.78 pesos per 1,000 bricks fired with scrapwood. Propane prices were provided by FEMAP. Estimates of the per brick energy costs are based on authors' survey data. BLACKMAN & BANNISTER, *supra* note 29.

Chart 1.



reason was that the required equipment had not been available or affordable.

2. Technical Extension

A number of organizations and individuals have provided training in the use of propane including: Ciudad Juárez propane companies (who seem to have taken the lead early on), FEMAP, El Paso Natural Gas, and extension agents from both Monterrey Tech., and the Ciudad Juárez campus. FEMAP has attempted to institutionalize its extension services by establishing "ECO-TEC," a center devoted to applied research on brickmaking and to training brickmakers in management and the use of clean technologies.⁵⁴ Although today ECO-TEC plays a key role in FEMAP's brickmaker program, it did not begin operations until 1994, after the adoption of propane in Ciudad Juárez had already been derailed by increases in propane prices.

It is not clear from our survey how important other sources of technical extension were in facilitating the adoption of propane. On one hand, 68 percent of brickmakers who used propane cited the "provision of information" as having played some role in their decision to adopt and nine percent cited it as the key reason (Table 2). On the other hand, 90 percent of all respondents claimed that no "technical assistance" was available to them (Table 1).

3. Regulatory Pressure

Project participants have been intermittently successful at promoting propane use by ratcheting up formal and informal penalties associated with the burning of debris. Prior to 1992, burning debris was more or less tolerated by Municipal authorities.⁵⁵ This tolerance began to evaporate when Ciudad Juárez elected a new Municipal President, Francisco Villarreal, in November 1991. Partly as a result of the political climate discussed above, Villarreal and the director of his ecology office, Francisco Nuñez, orchestrated a crackdown on brick kiln emissions. The use of "dirty" fuel to fire brick kilns was banned, though, as explained in the next section, the definition of what constituted "dirty fuel" changed over

54. The center includes office space, classrooms, dormitories, and experimental kilns. Envisioned as a national center of brickmaking training and research, it was built in the summer and fall of 1993 using land donated by the city government and funds obtained from Solidarity Enterprises, El Paso Natural Gas, and the FEMAP Foundation, a fundraising arm of FEMAP based in El Paso. Instituto de Investigaciones Ecotecnológicas FEMAP Report for December 1993-August 1994 3, 4 (1994); Interview with Enrique Suárez, *supra* note 34.

55. Johnson ET AL., *supra* note 7, at 3; Interview with Carlos Rincon, Project Director, Environmental Defense Fund, in Ciudad Juárez, Mex. (July 21, 1995); Telephone Interview with Carlos Rincon, *supra* note 35.

time.⁵⁶ A peer monitoring mechanism was instituted to facilitate enforcement: citizens were encouraged to call Nuñez's office with complaints about brick kiln emissions. Nuñez's office then dispatched an enforcement team that routinely jailed violators for 24 to 36 hours and sometimes fined them as well. For several months in late 1992 and 1993, propane was the only permissible clean fuel. (Although enforcement during this period was relatively vigorous, it was never universally effective. A significant number of brickmakers, at least 30 percent, continued to burn debris throughout the strict enforcement regime).⁵⁷ FEMAP administrators were supportive of this crackdown.⁵⁸

Informal regulation, actively encouraged by project organizers, also influenced brickmakers' production decisions. Both FEMAP and the city authorities worked intensively with leaders of the local brickmakers' organizations to encourage propane use. In March of 1993, the leaders of all of the brickmakers' organizations were brought together to hammer out an agreement on permissible fuels and to set a deadline for the switch to such fuels.⁵⁹ Some of the brickmaker organizations were quite cooperative, especially those with close relationships to the political establishment. As discussed above, politics and patronage played an important role. Moreover, local organizations in some *colonias* enforced strict rules on permissible fuels, no doubt motivated in part by a desire not to be undercut by neighbors using cheap fuel (Table 1). Other organizations like the CDP actively opposed the push for propane use.⁶⁰

Our survey results suggest that formal and informal regulation played an important role in brickmakers' adoption decisions, though it is not clear which was more influential. A quarter of brickmakers who

56. Juan Manuel Cruz, *Proyectoria Constitución de Cooperativas los Productores de Ladrilleros*, NORTE DE CIUDAD JUÁREZ, Feb. 8, 1993.

57. Most of the holdouts were brickmakers living in the relatively isolated *colonia* of Anapra and those affiliated with the CDP. Blackman & Bannister, *supra* note 25. Materials Required to Manufacture Brick and Juárez Kiln Distribution, Dirección Municipal de Ecología de Ciudad Juárez, *supra* note 21.

58. Recently this regulatory scheme has been dismantled. Beginning in 1995, PROFEPA, the Federal Attorney General's Office for Environmental Protection (created in 1992) assumed primary responsibility for enforcement along the US-Mexican border. Federal authorities had technically assumed responsibility for point sources of emissions within 100 kilometers of the United States border under the terms of the 1983 US-Mexico Border Environmental Agreement known as the La Paz Agreement. ENVIRONMENTAL PROTECTION AGENCY, EPA 160-K-94-001, ENVIRONMENTAL PROTECTION ALONG THE U.S.-MEXICAN BORDER 3 (1994). In practice, however, Federal participation in day to day enforcement efforts—at least with regard to brick kilns in Ciudad Juárez—was limited until 1995. The regulation of brick kiln emissions has slackened relative to the Villarreal regime. Interviews with Carlos Rincon, *supra* notes 35, 55.

59. FEMAP, 1994, *supra* note 23, at 12.

60. BLACKMAN & BANNISTER, *supra* note 25.

adopted propane cited "outside pressure" as the key reason (Table 2). Over three quarters were aware of government regulations regarding fuel choice and, of these, the majority saw the regulations enforced. Over half of the brickmakers reported that local organizations influenced their fuel choices, and over a third said that neighbors, as distinct from local organizations, had an influence (Table 1).

4. Education

FEMAP used one-on-one discussions with individual brickmakers and organized training sessions to educate brickmakers about the harmful effects of burning dirty fuels.⁶¹ Judging from our survey results, these efforts have not had a great impact. Only about one in ten brickmakers in our sample associated any adverse health effects with brickmaking and even more surprisingly, only about one in ten believed that firing with propane was "healthier" than firing with debris (Table 1). In fact, 26 of the 95 brickmakers surveyed believed that dangerous fumes were emitted when kilns were fired with propane.⁶²

5. Market Intervention

Project leaders pursued two strategies to reduce competitive pressures to burn cheap dirty fuels. First, in March 1993, they helped to negotiate an agreement among leaders of all the major brickmakers unions, including those that opposed the propane program, to fix the price of bricks at 250 pesos per 1,000.⁶³ The price floor was meant to be high enough to allow all brickmakers to afford propane. Predictably, however, many of the brickmakers who were still burning debris began to cheat, selling at prices below the agreed upon floor, and the agreement soon collapsed. Second, Project leaders tried to organize a boycott of bricks fired with debris and brick substitutes such as cinderblock. In 1993, FEMAP and the city government were able to get construction companies to agree to participate, and in August of 1994, the Federal Government ordered INFONAVIT (the

61. In addition, an effort was made to reach a broader audience by producing and distributing a comic book on health issues, a project funded jointly by El Paso Natural Gas and the Southwest Center for Environmental Research and Policy. Unfortunately, by the time this comic book was ready for distribution in January 1995, the conversion effort had already been derailed by a rise in propane prices.

62. Rumors to this effect were spread by brickmakers opposed to the adoption of propane. Nevertheless, these rumors may have some basis in fact since leaking propane lines and improperly adjusted tanks and burners can emit noxious fumes. In 1995 two brickmakers who used propane died. While it is far from clear that propane actually had anything to do with these deaths—the official causes were cirrhosis and a heart attack—persistent rumors to this effect reflect a prejudice that is not uncommon among the brickmakers.

63. FEMAP, *supra* note 23, at 12.

federal Workers' Housing Agency) to participate as well.⁶⁴ Unfortunately, neither INFONAVIT nor the construction companies consistently complied with their agreements, and the arrangement floundered.

6. Technological Change

Project participants devoted a great deal of effort to attempting to lower the variable costs of using propane by improving kiln fuel efficiency. Engineers from El Paso Natural Gas, Los Alamos National Laboratories and, to a lesser extent, Grupo Peñoles and the Gas Research Institute in Chicago have been involved. Many of the early experimental kilns required radical departures from traditional kilns, such as: (1) an electric heat source and conveyor belt, (2) multiple propane burners inserted into the sides of the kiln, and (3) a multi-chambered kiln.⁶⁵ More recent prototypes use a traditional kiln complete with arches and a sunken firebox as a starting point.⁶⁶

Engineers have also worked to improve fuel efficiency at low cost by modifying burners, the fuel mixture, the manner in which bricks are stacked, the way that the kiln opening is covered, and the way the bricks are dried prior to firing. Fifty-four percent of the adopters in our sample modified their kilns when they began to use propane (Table 1). But in two thirds of the cases the modifications consisted of rebuilding arches or strengthening walls to enable them to better withstand more intense heat generated by propane; energy savings was not a consideration. Thus, although the Project succeeded in introducing technologies such as improved burners and although it did persuade a great many brickmakers to change age-old production methods (both significant achievements in themselves), as of current writing, it has not developed and diffused affordable and low technology innovations that significantly reduce the variable costs of using propane by improving fuel efficiency.

F. Peak and Decline of the Brickmakers' Project

The high-water mark of the Brickmakers' Project, as measured by the percent of brickmakers using propane, probably occurred in the fall of 1993. Estimates of the percent of brickmakers using propane at this time

64. Interview with Enrique Suárez, *supra* note 34.

65. FEMAP, *supra* note 54. Los Alamos National Laboratories, Mexican Brick Kiln Study, March 18-20, Report LAUR-94-1322, (1994); Johnson, ET AL., *supra* note 7.

66. FEMAP ECO-TECHNOLOGICAL RESEARCH INSTITUTE, Report for October 1994-March 1995 (1995).

vary. In our sample, which probably contains a disproportionate number of adopters, 62 percent claimed to have used propane.⁶⁷

By the fall of 1993, pressures created by the rising price of propane became severe. Brickmakers began abandoning propane in droves. Other key participants in the Brickmakers' Project also began to defect. The most important defection was the municipal government that in late 1993, in the face of mounting opposition to the ban on burning debris, changed its official policy to sanction the burning of sawdust untainted by resins or varnishes. This had the effect of removing the principal "stick" in the propane initiative, leaving only the "carrots" such as subsidies and patronage. Brickmaker unions and neighborhood organizations increasingly dropped out as operators using dirty fuels undercut them. As noted above, construction companies and the Federal workers housing agency, which had agreed to boycott dirty bricks, also reneged. By July 1995, to our knowledge, only one brickmaker in Ciudad Juárez was still using propane.

Though the brickmakers have abandoned propane, they have not reverted to burning the dirtiest fuels such as tires, used motor oil, and plastic containers. Only one of our 95 survey respondents still used tires in July 1995, and only one burned used motor oil. Both combined these fuels with sawdust. Twenty-nine percent used sawdust exclusively, 18 percent scrap wood exclusively, and the remaining 53 percent, some combination of the two.⁶⁸

The Project's success in reducing brickmakers' use of the dirtiest fuels was a result of the continued application of both formal and informal regulatory pressure after the propane initiative collapsed. On the formal side, after the municipal government relaxed pressure on brickmakers to adopt propane, it continued to discourage the use of fuels other than sawdust.⁶⁹ After de facto regulatory control passed to the Federal Government in 1995, a countrywide prohibition on the uncontrolled

67. Our sample is probably biased towards propane users because we did not interview brickmakers in two distant isolated colonias—Anapra, and Fronteriza Baja—where, by all accounts, few if any brickmakers ever used propane. A 1994 FEMAP report states that as of April 1993, six months prior to the presumed high-water mark, 55 percent of brickmakers were using propane. FEMAP, *supra* note 54.

68. Our survey may underestimate the number of brickmakers who were burning dirty fuels for two reasons. First, survey respondents may have been unwilling to admit to using these fuels. And second, our survey excluded brickmakers in the remote *colonia* of Anapra where the primary fuel is reputed to be tires. However, the extent of the bias in our survey is probably not great. Our enumerators observed very little evidence of the use of tires or plastics in the brickyards. Also, according to the city government, fewer than 4 percent of all the kilns in Ciudad Juárez are located in Anapara. Dirección Municipal de Ecología de Ciudad Juárez, *supra* note 21.

69. Telephone interview with Carlos Rincon, *supra* note 35; BLACKMAN & BANNISTER, *supra* note 29.

burning of battery cases, tires, and used motor oil took effect.⁷⁰ On the informal side, after moving away from propane, many local organizations continued to enforce bans on burning the dirtiest fuels.⁷¹

G. Looking Ahead

Despite the failure of the propane initiative, FEMAP continues to work on promising solutions to the brick kiln pollution problem. Today, for all intents and purposes, FEMAP has given up trying to convince the Ciudad Juárez brickmakers to use propane. It now promotes natural gas that burns as cleanly as propane but is far less expensive.

There are significant obstacles to the use of natural gas, however. Most important, considerable permanent infrastructure is required.⁷² Whereas propane can be delivered and stored in portable tanks, natural gas must be piped directly to kilns. Also, expensive decompressors are needed at pipeline junctions. There are no natural gas pipelines in any of the brickmaking *colonias*, although some pipelines are located nearby. FEMAP estimates that it would cost \$800,000 to \$1,000,000 to install all of the necessary infrastructure, and is currently helping to solicit funds from a variety of sources.⁷³

FEMAP also seeks to help brickmakers diversify into higher value products such as "Saltillo tile" and roof tile and to break into the United States market for these goods. FEMAP hopes a higher sales price will enable the brickmakers to afford clean fuels.⁷⁴

Engineers at El Paso Natural Gas, Los Alamos National Laboratory and the University of Utah continue to push ahead with efforts to engineer more fuel-efficient kilns. At the University of Texas at El Paso, a project is

70. These materials were declared hazardous wastes requiring special disposal in the Official Mexican Norm NOM-052-ECOL-1993, establishing the characteristics of hazardous wastes, the listing thereof and the limits that render a waste hazardous due to its environmental toxicity. DIARIO OFICIAL (Official Mexican Gazette) on October 22, 1993. For the full text of this norm see STP TECHNICAL PUBLISHERS, 1997. *MEXICO: ENVIRONMENTAL LAWS AND NORMS*. NORTH VANCOUVER, BC, CANADA. D3-1 to -D3-30.

71. Interview with Carlos Rincon, *supra* note 55; BLACKMAN & BANNISTER, *supra* note 29.

72. In addition to the infrastructure problem, Project administrators attempting to engineer a switch to propane will face many of the same obstacles that stymied the switch to propane, namely, weak regulatory pressure, intensely competitive input and output markets, and the availability a lower cost dirty fuel.

73. Telephone Interview with Francisco Alfaro Mata, Director of ECO-TEC (April 24, 1995). Having conducted tests in several *colonias* FEMAP plans to use Federal moneys remaining in the trust fund it administers to subsidize the adaptation of traditional kilns to natural gas.

74. *Id.*; Interview with Carlos Rincon, *supra* note 55.

underway to design solar kilns that would, in effect, par-cook bricks before they are fired, thereby reducing the time that the kiln needs to be fired.⁷⁵

As for the brickmakers themselves, the failure of the propane initiative has left some cynical and disaffected. This is not surprising given that some brickmakers incurred significant costs in time as well as money in switching to propane and then back to debris. Predictably, the failure of the initiative has provided grist for the local organizations that have opposed it all along.

IV. LESSONS FOR POLLUTION CONTROL IN THE INFORMAL SECTOR

The Brickmakers' Project holds at least four lessons for pollution control in the informal sector. These concern: the promise of grass roots private-sector-led initiatives; effective strategies for pollution control; first- vs. second-best abatement strategies; and the fragility of voluntary market-based environmental initiatives.

The Promise of Grassroots Private Sector Led Initiatives

In several respects, the Brickmakers' Project is a success story. It has attracted a remarkable amount of publicity and support. Though the diffusion of propane among the brickmakers was limited and temporary, it nevertheless represents a significant achievement in view of the obstacles involved, especially the reduction in propane subsidies, without which propane use probably would have continued to grow. Thus, the Project illustrates that private-sector-led initiatives hold considerable promise as a means of addressing informal sector pollution problems. They would seem to enjoy a number of advantages over state-run programs. Most importantly, the willingness of the majority of the brickmakers to cooperate with the project suggests that private-sector-led initiatives may be best suited to engage firms that by their nature are bound to be wary of sustained contact with regulatory authorities. Also, the enthusiasm that the Project generated among funders, participants, and the public at large suggests that grass roots private-sector-led projects may be able to draw more freely on public sympathy for environmentalism than top-down bureaucratic initiatives.

The qualified success of the Brickmakers' Project, however, does not imply that informal sector environmental problems are best left to private sector grassroots organizers. In all likelihood, the Brickmakers' Project would not have had as much success without unusually strong United

75. For a description, see U.S. ENVIRONMENTAL PROTECTION AGENCY, *supra* note 44.

States and Mexican Federal support, the support of the municipal and state governments, and the leadership of a well-established politically savvy non-governmental organization.

As discussed above, United States and Mexican Federal support for the border environment largely grew out of the NAFTA fight coupled with the emergence of environmentalism as a Mexican electoral issue. It took the form of funding, publicity, and pressure applied to state and municipal governments. FEMAP might not have been able to initiate or sustain a high level of effort without Federal support. The same might be said of other participants in the Project including the University of Texas at El Paso, Monterrey Tech., El Paso Natural Gas, and Los Alamos National Laboratory. Federal support aside, it is doubtful that the Project could have made as much progress in diffusing propane without the willingness of the Ciudad Juárez Municipal government to crack down on the burning of debris.

Finally, FEMAP is not a typical grassroots organization. It enjoys strong political and business ties that have helped to attract Federal support, convince other institutions to participate, elicit the cooperation of local governments, and generate publicity. A less well-established and well-connected organization would have had much more difficulty organizing such an effort.

Thus, the first lesson of the Brickmakers' Project is that private sector led initiatives can work—indeed they may be more effective than public sector initiatives—but they require strong public sector support and some ability on the part of project organizers to leverage this support.

Effective Strategies for Pollution Control in the Informal Sector

As noted above, environmental management in the informal sector is inherently difficult for a number of reasons. The number, size, dispersion and anonymity of informal firms make them exceedingly difficult to monitor. Intense competition biases them towards least-cost inputs. And poverty in the informal sector weakens political will to impose stiff compliance costs. Despite these obstacles, the Brickmakers' Project was, for a time, successful in inducing brickmakers in Ciudad Juárez to adopt a clean technology that in most cases *raised* production costs. What organizational strategies were responsible?

First, Project organizers encouraged a cooperative relationship with the brickmakers, not the adversarial relationship that exists between most regulators and polluters. Instead of focusing solely on punishing non-adopters, Project organizers sought to reward adopters by providing equipment, credit, technical extension, subsidies, and less visible patronage. Just as important, they worked to develop good relationships with brickmakers both individually and as represented by various organizations.

This cooperative approach was effectively built into the Project from the beginning. FEMAP is a social service organization and envisioned the Project as a means of improving the lives of the brickmakers as well as of reducing air pollution. Indeed, some of the Project's activities, such as management training and the recent effort to diversify brickmakers' products have been primarily oriented towards economic development, not environmental management. Also, as a non-governmental organization with no enforcement powers, FEMAP had little choice but to adopt a cooperative approach.

FEMAP's cooperative approach helped to defuse opposition to stiff enforcement measures. FEMAP encouraged both formal and informal enforcement. It supported the municipal government's crackdown on non-adopters. The municipal government strengthened enforcement by setting up a peer monitoring system wherein city authorities responded to citizen complaints. Project organizers also encouraged informal enforcement by labor unions and neighborhood associations. This may have been an increasingly easy task as adopters had an incentive to ensure that their neighboring competitors switched to propane as well.⁷⁶ One must note, however, that the success of the Brickmakers' Project in promoting both formal and informal enforcement depended largely on the fact that neighbors could observe violations because they could see or smell toxic smoke. Other types of informal sector pollution, such as the dumping of waste oil into sewers by mechanics, would not be so easily detected.

While providing inducements and promoting enforcement seem to have succeeded in convincing brickmakers to adopt propane, efforts to introduce energy-efficient kilns, educate the brickmakers regarding private health and safety issues, and to manipulate the market for bricks were less successful, either because they were poorly implemented or simply ill-conceived. The Project's inability to design and diffuse innovations that significantly improved kiln fuel-efficiency seems mainly due to the difficulty of the task, but is at least partly attributable to a failure to have embraced two well-established principals for introducing new technologies in low income settings. First, to the extent possible, intended adopters should participate in designing and building the innovation. And second, new technologies must be 'appropriate', that is both affordable and consistent with existing levels of technology.⁷⁷ By contrast, most of the early

76. In this sense, competition among the brickmakers seems to have worked in favor of the project. This suggests that, if enough firms can be brought on board by hook or crook, eventually competition will ensure that the adoption of a cost-increasing clean technology becomes self-perpetuating.

77. See, e.g., Douglas Barnes ET AL., *The Design and Diffusion of Improved Cooking Stoves*, 8 WORLD BANK RESEARCH OBSERVER 119, 128-30 (1993); FRANCES STEWART, *TECHNOLOGY AND UNDERDEVELOPMENT* (2d ed. 1977).

experimental kilns were designed by highly trained engineers and involved radical departures from existing kilns.

Our survey results also suggest that the Brickmakers' Project may have missed an opportunity to promote the adoption of propane by educating brickmakers about the private health benefits of burning propane instead of debris and/or the importance of the proper use of propane. As mentioned above, few respondents perceived burning propane to be 'healthier' than burning debris.

It is clear that all of the Project organizers' attempts to manipulate the market for bricks—by fixing the price of bricks in March 1993, and, later that same year, organizing a boycott of bricks produced using dirty fuels—failed utterly. In most cases, contravening market forces in developing countries simply does not work; monitoring is too difficult and cheating is too easy, especially in the informal sector.⁷⁸

To conclude, the Brickmakers' Project suggests four lessons for environmental management in the informal sector. First, effective environmental management requires establishing a cooperative instead of an adversarial relationship with firms, one based on recognizing the socio-economic needs of those who depend on informal sector activities. Beyond rhetoric, establishing such a relationship entails encouraging the participation of local unions and political organizations and, even more concretely, providing a variety of inducements to offset the costs involved in producing more cleanly, including subsidies on new inputs, credit, and technical extension. Second, environmental regulations can be enforced in the informal sector by relying on peer monitoring and on informal regulation as well as formal regulation. Third, new clean technologies must be appropriate, that is, both affordable and low technology. Finally, attempts to manipulate informal markets simply do not work.

Second-best Strategies

The contrast between the collapse of the propane initiative and the success of efforts to reduce the use of the particularly dirty fuels such as used tires and plastics suggests that, in retrospect, it might have been a better strategy to promote conversion to relatively clean traditional fuels such as untainted sawdust than to push for the adoption of propane. The broad lesson is that, in the informal sector where firms operate on slim profit margins and where the costs of implementing any pollution control strategy are likely to be high, it is critical that policy makers weigh the costs of various strategies against the benefits. In some cases, the strategies that provide the greatest environmental benefits may be less appropriate than

78. See, e.g., DEEPAK LAL, *THE POVERTY OF DEVELOPMENT ECONOMICS* (1985).

intermediate strategies that confer fewer benefits at lower cost. Just as certain first-best technologies may be inappropriate in the informal sector, certain first-best pollution control strategies may also be inappropriate. This lesson has direct implications for other Mexican cities where emissions from informal brick kilns are a serious problem.

The Fragility of Voluntary Market Based Environmental Initiatives in the Informal Sector

Ultimately FEMAP's propane program was undermined by steady reductions in subsidies to propane on the United States-Mexican border. Does the program's demise hold any lessons? On one hand, this history might be seen as evidence of a failure on the part of the Mexican government to coordinate conflicting policy initiatives. While the Federal government actively supported and funded the effort to convert brickmakers to propane, it simultaneously supported the liberalization program that undermined it.⁷⁹ But this liberalization program was part of a broad economic reform. The economic benefits of this reform may well have outweighed the costs, including the environmental costs. To reduce these environmental costs, the Mexican government might have subsidized propane use by key low-income users who were bound to substitute into dirty fuels. But such a policy would have been difficult to implement and likely to perpetuate the black market in subsidized propane.

It seems equally unfair to fault the organizers of the Brickmakers' Project. Propane prices only began to increase in 1992. By this time, an initial group of the brickmakers in Ciudad Juárez had already switched to propane and the Project had completely organized itself around the strategy of engineering a switch. Also, project organizers are now promoting an alternative strategy — the adoption of natural gas.

Thus, the overarching lesson to be learned from the demise of the propane initiative is somewhat bracing: in volatile developing economies, voluntary market based environmental initiatives among informal sector firms are bound to be fragile, even when well designed and well-implemented.

79. See LUSTIG, *supra* note 45. The removal of subsidies on propane was one element of this liberalization program.

Table 1. Summary Statistics

Socio-economic status		
Avg. age	47	
Avg. years formal education	3	
Live within 100M kiln	53	%
LPG use		
Adopted LPG	62	%
Access to free LPG equip. (LPG users)	100	%
Modified kiln (LPG users)	54	%
Given inducements to adopt (LPG users)	12	%
Assistance		
Believe technical assistance is available	10	%
Received technical assistance	1	%
Believe financial assistance is available	25	%
Received financial assistance	5	%
Formal regulation		
Aware of government regulations	77	%
Observed enforcement	75	%
Local organizations		
Member of local organization	59	%
Member of PRI affiliate	40	%
Member of CDP	19	%
Local organization influenced fuel choice	52	%
Neighbors influenced fuel choice	38	%
Health		
Aware of health problems	10	%
Believe use of LPG "healthier" than debris	11	%

Source: authors' survey, n = 95

Table 2. Factors affecting the decision to adopt LPG

Factors	Percent of adopters who identified this factor as having ...	
	had some impact	been "most important"
Access to free LPG equipment	86	21
Info. provided by city, et al.	68	9
LPG suppliers extended credit	49	6
LPG is more convenient	25	8
Good for environment	26	25
Outside pressure	26	25
Other	7	7

Source: authors' survey, n = 59