Cross-border Environmental Management and the Informal Sector: The Ciudad Juárez Brickmakers' Project

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Abstract

The considerable difficulties associated with cross-border environmental management are compounded when polluters are unlicensed micro-enterprises such as auto repair shops and traditional brick kilns; such "informal sector" firms are virtually impossible to regulate in the conventional manner. This paper describes an example of an innovative and promising approach to the problem: the Cd. Juárez Brickmakers' Project, a private-sector-led, binational initiative aimed at abating highly polluting emissions from Cd. Juárez's approximately 350 informal brick kilns. We draw three lessons from the Project's history. First, private-sector-led cross-border 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 unions and political organizations, relying upon peer monitoring among informal firms, and providing inducements to offset compliance costs. Ineffective strategies include promoting too-advanced and therefore inappropriate technologies and intervening in informal markets. And finally, the history of the Brickmakers' Project suggests that, in volatile developing economies, even well designed voluntary market-based environmental initiatives in the informal sector are bound to be fragile.

Key words: US-Mexican border, informal sector, environment, brickmaking

JEL Classification Nos.: O17, O54, L61, Q25, Q28

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Allen Blackman and Geoffrey J. Bannister[1]

1. INTRODUCTION

The considerable difficulties associated with cross-border environmental management are compounded when polluters are unlicensed micro-enterprises such as auto repair shops and traditional brick kilns that, according to Ranis and Stewart [1994], provide at least 50% of all non-agricultural jobs in Latin America and Africa. Such "informal sector" firms are difficult to regulate for four reasons. First, by definition, they have few preexisting ties to the state. Second, they are small, numerous, and geographically dispersed. Third, they generally operate in highly competitive markets and, as a result, are under considerable pressure to cut costs regardless of the environmental impacts. And fourth, they sustain the poorest of the poor and, therefore, may appear to both regulators and the public as less appropriate targets for regulation than larger, wealthier firms.

Given these constraints, even if cross-border coordination between environmental authorities can be achieved, conventional command and control regulation is unlikely to be practical. New approaches are called for. The Ciudad Juárez Brickmakers' Project, which has

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worked to abate highly polluting emissions from the city's approximately 350 small-scale brick kilns since 1990, is an example of such an approach. This project is innovative first because it is not headed by an environmental authority but by a non-governmental organization, The Mexican Federation of Private Health Associations and Community Development (FEMAP for its initials in Spanish). In addition, it has:

- enlisted the participation of private and public sector stakeholders from both sides of the border;
- focused on developing and diffusing pollution prevention technologies;
- 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 chapter reviews the history of the Brickmakers' Project in order to distill lessons about cross-border environmental management and the informal sector. We draw upon a variety of sources including an extensive survey administered to 90 traditional brickmakers in July of 1995, interviews with project participants, and primary and secondary written sources.[2]

The Brickmakers' Project did not achieve its immediate objective of converting the brickmakers in Cd. Juárez to clean-burning propane -- though at one time over one-half of the brickmakers were using propane, as of current writing, virtually all of them have reverted to

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[2] For the section on "El Paso Ciudad Juárez Air Quality" our main sources were: Bath and Rodriquez, 1983; and Nuñez, Vickers and Emerson, 1994. For the sections "Traditional Brickmaking in Ciudad Juárez," "Strategies," and "The Peak and Decline of the Brickmakers' Project," we relied mainly on our own survey research described in detail in Blackman and Bannister, forthcoming. For the sections on "Birth of the Brickmakers' Project," "Mexican Federal Support," and "Participation in the Brickmakers' Project" and "Looking Ahead" we relied mainly on conversations with Project participants and on FEMAP reports. For the section on "NAFTA and Mexican Politics" our principal sources were: Mumme, 1991; and Kublicki, 1994.

burning debris. Nevertheless, its innovative efforts to build a cross-border multi-sector coalition and to create incentives for pollution prevention in the informal sector were successful, and were probably harbingers of things to come. We draw three lessons from the Project's history. First, private-sector-led cross-border 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. Second, necessary conditions for effective environmental management in the informal sector include enlisting the cooperation of local unions and political organizations, relying upon peer monitoring among informal firms, and providing inducements to offset compliance costs. Ineffective strategies include promoting too-advanced and therefore inappropriate technologies and intervening in informal markets. Finally, the history of the Brickmakers' Project suggests that, in volatile developing economies, voluntary market-based environmental initiatives in the informal sector are bound to be fragile, even when well designed.

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, and the concluding section distills lessons from this history.

2. BACKGROUND

El Paso-Ciudad Juárez Air Quality

Air quality in the sister cites of El Paso, Texas and Ciudad Juárez, Chihuahua is the worst on the US-Mexican border and among the worst in North America [Nuñez, Vickers, and Emerson, 1994, p. 1]. The problem stems from rapid industrialization and population growth

over the last several decades and the fact that the cities are located in a mountain valley that is subject to temperature inversions.[3] 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. 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. In 1995 the city of El Paso was classified by the US 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 [Barry, 1994, pp. 38-39; Bath and Rodriquez, 1983; Parra, 1996].

Binational efforts to control air pollution in Cd. Juárez-El Paso date back at least to the 1970's, but thus far have not resulted in much concerted action. According to Richard Bath, key reasons include, on the US side, a lack of coordination among different levels of government, a lack of public support, and overly ambitious abatement goals and, on the Mexican side, a dearth of financing and commitment. Moreover, binational cooperation has

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[3] 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 US grew at an average annual rate of 1.26 percent [US Bureau of Census, 1994; INEGI, 1992].

been hampered by sovereignty concerns. Recent binational efforts have focused on the creation of an Air Quality Management District in El Paso and Ciudad Juárez.[4]

Traditional Brickmaking in Ciudad Juárez

Ciudad Juárez's approximately 350 small-scale brick kilns have traditionally been fired with inexpensive highly polluting fuels such as garbage, used tires, and wood scrap often impregnated with toxic resins, laminates, and varnishes.[5] As a result, a number of sources contend that brick kilns are the third or fourth leading contributor to air pollution in the Ciudad Juárez-El Paso area.[6] Though brick kilns are primarily associated with carbon monoxide emissions, depending on the fuels used, they also emit particulate matter, volatile organic compounds, nitrogen oxide, sulfur dioxide, heavy metals, and carbon dioxide, the most important greenhouse gas.[7]

Ciudad Juárez' brick kilns are clustered in eight poor *colonias* located throughout the city: Anapra, Division del Norte, Francisco Villa, Fronteriza Baja, Kilometro 20, Mexico 68, Satellite, and Senecu 2. When brickmakers squatted in these *colonias* 25 or 30 years ago, all

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[4] For a history and analysis of efforts to control air pollution along the border, see Bath and Rodriquez, 1983, and Johnstone, 1995, pp. 39-40, and Nuñez and Emerson, 1994.

[5] Sawdust, scrap wood and pecan shells and other combustibles are generally distributed to brickmakers by independent agents who collect the material from the Maquiladoras. Often, the Maquiladoras pay these agents to take it away.

[6] For example, Johnson, Soto, and Ward, 1994, p. 2; and Mendoza, 1995, pp. C1, C3. Though widely used, this statistic is undocumented. According to the Texas Natural Resources Conservation Commission, no emissions inventory has ever been performed for Cd. Juárez.

[7] According to Johnson et al. [1994], 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.

were situated on the outskirts of the city. Today, however, because the city has grown, many of the *colonias* are centrally located and traditional kilns can now be seen along main avenues and near the major industrial parks. Because of their location, brick kilns' emissions have sparked considerable controversy; they were the most frequent subject of complaints (one in every four) to the Ciudad Juárez municipal environmental authority in 1994 [Dirección Municipal de Ecología de Ciudad Juárez, 1995].

On average, each of Cd. Juárez's 350 kilns employs 6 workers and, as a result, brickmaking is a significant source of employment [FEMAP, 1991]. According to FEMAP, the non-governmental organization that leads the Brickmakers' Project, brickmaking in Cd. Juárez provides over 2,000 jobs directly and 150 jobs indirectly in transportation and wholesaling. Brickmaking in Cd. Juárez is a microcosm of a national industry comprised of an estimated 15,000 operations supporting 100,000 families concentrated in or near large urban areas such as Saltillo, Guadalajara, Monterrey and the Federal District. FEMAP estimates that 2,500 to 3,000 traditional kilns are situated in border cities [Johnson, Soto and Ward, 1994, pp. 2 and 5].

Traditional brickmaking is an extremely labor intensive activity. All required tasks are performed by hand. First, clay, earth, and water are mixed together, sometimes with a pinch of sawdust or other organic material. Often the earth and clay are extracted from the areas surrounding the kilns resulting in a pitted landscape.[8] The mixture is then molded into bricks

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[8] The famous sunken park in Mexico City (El Parque Hundido) on Avenida Insurgentes - a large park that is two meters below the level of the street - was the result of just such excavations performed by a cluster of brickmakers that were moved out of the city thirty years ago.

which are dried in the sun for one to three days, depending on the weather. Workers can make up to 1,000 bricks in one twelve hour day. Once dry, the bricks are loaded into an adobe kiln, a square roofless structure that contains a number of brick arches built into a sunken floor. The arches both support the bricks stacked on top of them and form a combustion chamber underneath. Average kiln capacity is about 10,500 (2" by 5" by 10.5") bricks. After baking and cooling, bricks are unloaded from the kiln directly into a truck for transportation or onto a "patio" of land beside the kiln.

Each cycle of production (molding, drying, loading the kiln, firing, unloading) takes about 11 days on average, which theoretically allows for about 2.3 firings per month, or 27 firings per year [FEMAP, 1991]. In practice, the average number of firings is 1.5 per month for two reasons. First, from November to March rain and cold weather inhibit molding, drying, and firing. More important, in the last year, the market for bricks has been extremely soft owing to a construction slowdown that has accompanied Mexico's macroeconomic downturn. In the summer of 1995, traditional brickmakers were holding extensive unsold inventories.

Studies have put the brickmakers' profit per firing (when burning debris) at anywhere from 300-600 pesos ($40-$80 at an exchange rate of 7.5 pesos to the dollar) [authors' survey, FEMAP, 1991].[9] This compares to the monthly minimum wage in the north of Mexico of

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[9] It is difficult to calculate the profit from informal activities precisely owing to poor record keeping and the use of family labor.

about 480 pesos ($64) and illustrates the very small margin of profit that brickmakers must work with [Anonymous, 1996].[10]

Most brickmakers are over 40 years of age, quite old in comparison to the population as a whole. On average they have five years of schooling, though many have much less and approximately a quarter cannot read or write. Living conditions are primitive. Most brickmakers live next to their kilns in small houses with no drainage or running water. The large majority have no access to health services [authors' survey and FEMAP, 1991].

Seventy one percent of the brickmakers we surveyed belonged to a local organization. There are two main rival political factions among the brickmakers. The first is comprised of organizations affiliated with the nationally dominant Institutional Revolutionary Party (*Partido Revolucionario Institucional* -- PRI) such as the Federation of Mexican Workers (*Confederación de Trabajadores Mexicanos* -- CTM) and the National Federation of Citizens' Organizations (*Frente Nacional de Organizaciones Ciudadanas* -- FNOC). Many of the brickmakers in these organizations also belong to the PRI affiliated Brickmakers' Union (*Sindicato de Ladrilleros y Trabajadores de la Cal*). 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, be it PRI or PAN (PAN stands for the *Partido Acción Nacional*, the PRI's principal opposition party), these organizations have been successful in extracting concessions for their members. For example, the leader of one brickmakers' union mentioned that members of his union

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[10] Minimum wage figures are for March 1996 at 18.7 pesos per day. The monthly figure is calculated assuming 26 days of work per month.

received subsidies on water bills as well as permits for dredging a local canal for clay. Brickmaker organizations were one of the main instruments used by the city government (at that time PAN) and FEMAP to help convert brickmakers to the use of LP gas. PRI affiliates dominate certain brickmaking *colonias* such as Satelite, have a sizable proportion of others such as Mexico 68, and are completely absent from some of the poorest *colonias* such as Anapra.

The poorest *colonias* are dominated by a rival organization, the Committee for Popular Defense (*Comite de Defensa Popular* -- CDP) linked to the national Worker's Party (*Partido del Trabajo* -- PT). The CDP has traditionally been opposed to the political establishment having been formed to fight the city government's attempts push out squatters. Members of the CDP have continuously resisted attempts to regulate brickmaking activities by the Ciudad Juárez government, and in particular they resisted adopting propane.

3. HISTORY OF THE BRICKMAKERS' PROJECT

The Birth of the Brickmakers' Project

At every stage, the Cd. 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 new-found 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. In just three years between 1988 and 1991,

Mexican Federal expenditures on the environment increased from $95 million to $1.8 billion, the equivalent of 0.7 percent of Mexico's GDP [Mumme, 1991, p. 10; Kublicki, 1994, p. 93].

On the local level, an important antecedent to the Brickmakers' Project was a growing recognition during the 1980s that traditional brick kilns in Cd. Juárez are an important source of air pollution in the sister cities. An activist Citizens' Environmental Advisory Committee to the El Paso City Council played a pivotal role in creating this awareness.[11]

The first effort to introduce propane into the brickyards in Cd. Juárez was the campaign undertaken in 1989 by Dr. René Franco Barreno, then director of the Municipal Council for Ecology in Ciudad Juárez. To our knowledge, this was the first concerted effort to abate emissions from brick kilns in Cd. Juárez. Dr. Franco's short-lived campaign succeeded in enlisting a number of organizations that later played a key role in the Brickmakers' Project, notably the local office of the Federal Ministry of Commerce and Industry (SECOFI) and the local propane retailers. In 1990, Dr. Franco turned the Project over to FEMAP, a well established, private non-profit organization based in Cd. Juárez. Founded in 1973 by an energetic community leader, Mrs. Guadalupé de la Vega, FEMAP administers health care and microenterprise development projects in 25 Mexican states and has had considerable experience working in Cd. Juárez's poor *colonias*.

FEMAP's first step, in 1991, was to administer a census of brickmakers in Cd. Juárez covering such issues as production, markets, and socioeconomic status. FEMAP also

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[11] According to Carlos Rincon, The El Paso Citizens' Environmental Advisory Committee helped to popularize the statistic that traditional brick kilns are the third or fourth leading source of air pollution in El Paso-Cd. Juárez [Rincon, December 5, 1995].

cultivated ties to local propane companies. These companies ultimately stepped up their participation in the Project, permitting brickmakers to purchase propane on credit, providing training and equipment (tanks and vaporizers) and donating glazed brick used to reconstruct kiln arches to enable them to withstand the heat generated by burning propane [Rincon, December 5, 1995; Suárez, 1995].

Despite the assistance of the propane companies, for a number of reasons including the inevitable difficulties associated with convincing an initial group of producers to risk changing centuries-old methods, a lack of strong regulatory pressure until 1992, and the time consuming nature of grassroots organizing, the Project did not succeed in converting more than 30 percent of brickmakers to propane until the end of 1993. As late as December 1992, by FEMAP's count, no more than 15 percent of the brickmakers in five principal brickmaking *colonias* in Cd. Juárez (some 50 to 60 brickmakers) were using propane [FEMAP, 1994, p. 21]. Yet even as early as 1991 the Brickmakers' Project had begun to generate an extraordinary amount of publicity, institutional participation, and some outside funding. What factors were responsible?

NAFTA and Mexican Politics

Two national and international events in the early 1990's focused unprecedented attention on border environmental issues: the NAFTA debate and the Mexican midterm Federal elections of 1991. 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 US congress over granting the Bush administration 'fast

track' authority to negotiate the treaty, environmentalists organized an angry and vociferous opposition arguing that a free trade agreement would spur still more rapid and uncontrolled development along the border. Also, they argued that despite the high level of environmental protection ostensibly afforded by Mexico's 1988 Ecology Law, enforcement in Mexico was extremely lax and, therefore, a free trade agreement would create incentives for dirty US firms to relocate in Mexico [OTA, 1992, p. 123]. The NAFTA negotiators responded by promising to prepare a master plan to deal with border environmental problems. But when the Integrated Environmental Plan for the US-Mexican Border (IBEP) was released in draft form in August of 1991, it attracted scorching criticism in 18 hearings in a number of border cities (including in El Paso) set up to elicit citizen 'participation.' Far from allaying environmentalists' concerns, the IBEP fueled the debate about the border environment, which continued unabated throughout the NAFTA negotiations and the subsequent congressional battle over ratification.

A second factor contributing to the heightened attention devoted to border issues in 1991 was the Mexican midterm Federal election. As in the 1988 election, environmental issues received considerable attention. Pre-election polls indicated that 60 percent of Mexicans considered the environment to be a high priority [Mumme, 1991, p. 27].

The upshot of these events was that by the fall of 1991, for the first time ever, the border environment became an important issue for both the US and Mexican Federal governments simultaneously. Both countries stepped up enforcement along the border and initiated a number of environmental projects and programs. Financing to deal with long neglected border environmental issues -- chronically scarce before -- suddenly became available. Also, in November of 1991, with World Bank support, 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, 1994, p. 84].

The NAFTA debate combined with the genuine, if new-found, 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. As an established NGO, FEMAP was excellently placed to take advantage of this commonality of interests. The Brickmakers' Project also greatly appealed to Americans looking to defuse environmental opposition to NAFTA. Carol Browner, Director of the US Environmental Protection Agency, made a high profile visit to a FEMAP demonstration site in March 1993 [FEMAP, 1994, p. 15].

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 of the urban development program PRONASOL.[12] This 800,000 peso fund was then used to leverage a 8,000,000 peso line of credit from NAFIN, the

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[12] 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 basic infra-structure such as sewers and electricity. In April of 1992 PRONASOL was merged with the environmental agency (SEDUE) to create SEDESOL, a cabinet-level ministry.

Mexican Federal development bank that finances small business projects. All of these moneys were earmarked for the exclusive use of brickmakers [FEMAP, undated a; Suárez, 1995; FEMAP, 1994, p. 8]. The Salinas administration made quite a show of its support for the Brickmakers' Project. Luis Donaldo Colosio, then head of SEDESOL, and later PRI's presidential candidate, delivered the first installment of his agency's funds personally in December of 1992. Salinas himself made appearances with FEMAP officials in Cd. Juárez on three separate occasions in February 1993, August 1993 and in October of 1994 [Irigoyen, 1992; FEMAP, 1994, p. 14; Anon., 1993b; FEMAP, 1995, p. 4]. Thanks to this high level of support, the Project was well-launched by 1994, the last year of the Salinas administration, and was already being heralded by US and Mexican officials as a model of binational cooperation.

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 the following organizations as participants:

Public sector:

- SECOFI (the Federal Ministry of Commerce and Industry)
- NAFIN (a Federal economic development bank)
- SEDESOL (the Federal environmental agency 1992-1995)
- Municipal and State Governments
- Universidad Autónoma de Cd. Juárez
- INFONAVIT (the Federal workers' housing agency)
- Solidarity Enterprises (a Federal microenterprise development program, before 1992 administered within PRONASOL, after 1992 within SEDESOL)

Private Sector:

- FEMAP
- Associación Gilberto (a Mexican charitable organization)
- Grupo Peñoles (a large Mexican mining conglomerate)
- Cd. 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 Cd. Juárez (a local businessmen's organization)
- Instituto Tecnológico y de Estudios Superiores de Monterrey ("Monterrey Tech.") Cd. Juárez Campus
- Construction Companies in Cd. Juárez
- Brickmakers

United States:

- El Paso Natural Gas Co.
- Los Alamos National Laboratory
- Gas Research Institute (Chicago, IL).
- University of Texas at El Paso
- Southwest Center for Environmental Research and Policy (SCERP) (a consortium of US universities)

While the hard work of Project organizers was instrumental in soliciting the participation of all of these organizations, the publicity created by NAFTA, a commonality of interests between the Project and the various organizations involved, FEMAP's well established community ties, and a palpable bandwagon effect contributed as well. What roles did the various organizations play?

The national and local business federations -- CONCANACO, CANACINTRA, COPARMEX, and Economic Development of Cd. Juárez -- served as bridges between the brickmakers, the construction and propane companies, the municipal government, and the Project organizers. (The brickmakers were linked to CANACINTRA through the various local organizations. The construction and propane industries were well represented in

CONCANACO as well as COPARMEX.) Grupo Peñoles contributed engineering expertise in very early efforts to improve kiln efficiency and donated materials to be used in adapting kilns to propane [Suárez, 1995]. INFONAVIT issued an order in August 1993 decreeing that all its contractors use "ecological bricks" -- bricks fired with propane -- instead of 'dirty' bricks and brick substitutes such as cinderblock [Anon., 1993a].

While NAFIN, the Federal economic development bank, and Solidarity Enterprises, the Federal microenterprise development program, participated as funders, the key public sector actor was the Municipal Government of Cd. Juárez and, in particular, the city environmental authority. As discussed below, for about a year this office strictly enforced a prohibition on the burning of debris. The state government of Chihuahua's principal role seems to have been to provide administrative, hortatory, and political support to the city government.[13] Personnel from the Monterrey Tech., Cd. Juárez Campus helped to develop technical and management training courses for brickmakers.

American organizations also played a noteworthy and highly visible role. Both El Paso Natural Gas and Los Alamos National Laboratory provided engineers to design and test improved kilns and burners. In addition, El Paso Natural Gas provided at least $100,000 towards Project operating expenses [FEMAP, Undated b]. Funded by the US Environmental Protection Agency via the Southwest Center for Environmental Research and Policy, US

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[13] It is interesting to note that since November 1992, both the governor of Chihuahua and the mayor of Ciudad Juárez have been members of PAN and that the governor since 1992, Francisco Barrio Terrasas, was mayor of Ciudad Juárez in the early 1980s.

universities became involved in developing brickmaker training courses, and conducting research on methods of improving kiln fuel efficiency.[14]

Like their Mexican counterparts, the institutional interests of these American organizations favored participation in the Brickmakers' Project. El Paso Natural Gas' contributions to the project generated favorable public relations. Los Alamos National Laboratories participation jibed with its efforts to reposition itself as a center of environmental research and technology transfer to the private sector. American universities were driven by the availability of significant funding for border environmental projects. It bears emphasis, however, that community spirit was also clearly an important motive for these organizations, especially for certain employees. 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.[15] This was certainly also true of FEMAP personnel, many of whom volunteered their time.

As for the brickmakers themselves, as discussed in the next section, though almost a third said that improving the environment was their key motivation for switching to propane, almost all mentioned various inducements or sanctions.

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

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[14] For a description of EPA funded activities see USEPA, 1995.

[15] See e.g., Marcus, 1994.

to obtain and learn to use relatively expensive new equipment. Second, at the beginning of the Project, regulatory and hortatory pressure to abate kiln emissions was for the most part extremely weak. Third, though the brickmakers themselves were most affected by kiln emissions, most did not perceive them to be imminently harmful. Fourth, the traditional brick kiln industry and the construction industry that buys from it are intensely competitive and, as a result, 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 since in the early 1990s, PEMEX, Mexico's state run petroleum company, began to gradually eliminate long-standing subsides on propane in the border region (in conjunction with the Salinas administration's economic liberalization program and to dampen a black market for subsidized Mexican propane in the United States). At the beginning of 1991, propane prices were approximately 0.24 pesos per lire. 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, a difference in per brick energy costs of 29 percent. By July 1995, the price of propane had risen to 0.71 pesos per liter, implying an average cost of 109.52 pesos per 1000 bricks fired with propane versus 41.78 pesos per 1000 bricks fired with scrapwood, a difference in per brick energy costs of 162 percent.[16] Participants in the Brickmakers' Project have promoted a broad range of initiatives designed to overcome each of these barriers

[16] Propane prices were provided by FEMAP and the estimates of the per brick energy costs are based on our survey data.

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.

Propane Equipment

The Brickmakers' Project was quite successful in creating access to propane equipment. In our sample of 59 propane users, equipment was provided free of charge by propane companies in Cd. Juárez in every case (though in two cases the brickmakers themselves eventually purchased their own equipment). Of the 36 brickmakers we interviewed who never used propane, not one said that a key reason was that the required equipment had not been available or affordable.

Technical Extension

A number of organizations and individuals have provided training in the use of propane including: Cd. Juárez gas companies (who seem to have taken the lead early on), FEMAP, El Paso Natural Gas, and extension agents from Monterrey Tech., Cd. 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. The center was built in the summer and fall of 1993 using land donated by the municipal government of Ciudad Juárez and funds obtained from Solidarity Enterprises, El Paso Natural Gas, and the FEMAP Foundation, a fundraising arm of FEMAP based in El Paso. The ECO-TEC complex includes office space for administrators, classrooms

and dormitories for brickmakers, several experimental kilns, and brickmaking facilities.[17] FEMAP officials envision ECO-TEC as a national center of brickmaker research and training. Though 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 Cd. 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, 67 percent of 58 brickmakers who used propane cited the "provision of information" as having played some role their decision to adopt and 9 percent cited it as the key reason. On the other hand, 88 percent of all respondents claimed that no "technical assistance" was available to them.

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. This tolerance began to evaporate when Cd. 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 the definition of what constituted "dirty fuel" changed over time [Cruz, 1993]. A peer monitoring mechanism was instituted to facilitate enforcement: citizens were encouraged to call Nuñez's office with

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[17] FEMAP, 1994b, pp. 3 and 4; Su·rez, 1995; ECO-TEC has tried to recover costs -- a requirement for all FEMAP projects -- by selling the bricks manufactured in its experimental kilns to construction companies and by selling its extension expertise to Mexican States and Municipalities.

complaints about brick kiln emissions. Nuñez's office then dispatched an enforcement team which 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. (Though enforcement during this period was relatively vigorous, it was never universally effective. A significant proportion of brickmakers, at least 30 percent, continued to burn debris throughout the strict enforcement regime.) FEMAP administrators were supportive of this crackdown. It did not last, however. As propane prices continued to rise in 1993, opposition to the new regime grew among brickmakers. Eventually the municipal government relaxed the rule, officially permitting brickmakers to burn sawdust untainted by resins or varnishes. 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.[18] The regulation of brick kiln emissions has slackened relative to the Villareal regime [Rincon, 1995].

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 [FEMAP, 1994, p. 12]. Some of the brickmaker organizations were quite cooperative, especially those

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[18] Actually, Federal authorities technically assumed responsibility for point sources of emissions within 100 kilometers of the US border under the terms of the 1983 US-Mexico Border Environmental Agreement known as the La Paz Agreement [USEPA, 1994, p. 3]. In practice, however, Federal participation in day to day enforcement efforts -- at least with regard to brick kilns in Cd. Juárez -- was limited until 1995.

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. Other organizations like the CDP actively opposed the push for propane use.

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. Over a quarter of brickmakers who adopted propane cited "outside pressure" as the key reason. Over three quarters were aware of government regulations regarding fuel choice and, of these, the majority has seen the regulations enforced. Over half of the brickmakers reported that local organizations influenced their fuel choices, and a third said that neighbors, as distinct from local organizations, also did.

Education

FEMAP sought to educate brickmakers about the harmful effects of burning dirty fuels via one-on-one discussions with individual brickmakers and in organized training sessions. In addition, an effort was made to reach a broader audience by distributing a comic book on the health advantages of burning clean fuels, 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.) Judging from our survey results, these efforts have not had a great impact on brickmakers perceptions of the private health benefits of propane use.

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. Twenty nine percent of the brickmakers surveyed believed that dangerous fumes were emitted when kilns are fired with propane. Rumors that propane is harmful were spread by brickmakers opposed to the adoption of propane. Nevertheless these rumors may have some basis in fact since when propane lines and tanks leak and burners are not adjusted properly, noxious fumes can be emitted. Recently 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.

Market Intervention

Project leaders pursued two strategies to reduce competitive pressures to cut costs by burning dirty fuels. First, in March of 1993, they helped to negotiate an agreement among leaders of all of the major brickmakers unions (including the ones that opposed the propane program) to fix the price of bricks at 250 pesos per thousand [FEMAP, 1994, p. 12]. 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 organizers tried to mandate a market for "ecological bricks," fired with propane. In 1993, FEMAP and the city government were able to get construction companies to agree to

buy these ecological bricks instead of dirty bricks and brick substitutes such as cinderblock and, as noted above, in August of 1994, the Federal Government ordered INFONAVIT to use only ecological bricks [Suárez, 1995]. Unfortunately, neither INFONAVIT nor the construction companies consistently complied with their agreements to use only ecological bricks, and the arrangement floundered.

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 all been involved. Many of the early experimental kilns required radical departures from traditional kilns, e.g., (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 [FEMAP, 1994b; LANL, 1994; and Johnson et al., 1994]. More recent prototypes use a traditional kiln complete with arches and a sunken firebox as a starting point. Engineers have also worked to develop low-cost measures for improving fuel efficiency such as new burners, changing 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, 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, though the Project did succeed in introducing technologies such as improved burners, and

though it did persuade a great many brickmakers to change age-old production methods (both significant achievements in themselves), as of current writing, it had not yet developed and diffused affordable and low-technology innovations that significantly reduce the variable costs of using propane by improving fuel efficiency. In fairness it must be said that not even the most efficient experimental kilns tested at ECO-TEC would make propane attractive at current relative prices.

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. The exact number of brickmakers who were using propane at this time is unclear. According to some estimates, fully 70 percent of the brickmakers in Cd. Juárez were using propane. A 1994 FEMAP report states that as of April 1993, 55 percent of brickmakers were using propane. In our sample, which is probably strongly biased towards the brickmakers who were more likely to have used propane, 62 percent claimed to have ever used propane.[19]

With propane prices rising, by early 1994, brickmakers began abandoning propane in droves. In the course of our interviews in Cd. Juárez in July 1995, we found only one brickmaker who still used propane. In turn, this price increase created pressures which caused key participants in the Brickmakers' Project to defect. The most important defection was the

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[19] Our sample is probably biased towards propane users because we interviewed brickmakers who happened to be working at their kilns when we administered our survey. These were most likely to have been large-scale, active, relatively wealthy brickmakers, the same type of brickmakers most likely to adopt propane. Also, 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.

municipal government which stopped enforcing a ban on burning debris in late 1993, removing the principal "stick" in the program and leaving only the "carrots" such as subsidies and patronage. Brickmaker organizations increasingly dropped out as they were undercut by brickmakers using dirty fuels. Finally, as noted above, construction companies and the Federal workers housing agency which had agreed to purchase ecological bricks reneged.

Looking Ahead

Despite the failure of the propane initiative, FEMAP continues to work on promising solutions to the brick kiln pollution problem and the Brickmakers' Project may yet prove successful in converting the brickmakers to cleaner fuels and more efficient kilns. Today, for all intents and purposes, FEMAP has given up on trying to convince the Cd. Juárez brickmakers to use propane and is now promoting natural gas which burns as cleanly as propane but is far less expensive. The main obstacle to using natural gas is the considerable permanent infrastructure required. Whereas propane can be delivered and stored in portable tanks, natural gas must be piped in. Also, expensive decompressors are needed at pipeline junctions. There are no natural gas pipelines in any of the *colonias* where the brickmakers are located, though in some there are pipelines 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. Having conducted tests in several *colonias* it plans to use Federal moneys remaining in the trust fund it administers to subsidize the adaptation of traditional kilns to natural gas. FEMAP has also been seeking to help brickmakers diversify into higher value products such as "Saltillo tile" and roof tile and to break into the US market

for these goods. FEMAP hopes that a higher sales price will enable the brickmakers to afford clean fuels [Alfaro Mata, 1995; Rincon, July 1995].

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 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.[20]

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.

4. LESSONS FOR CROSS-BORDER ENVIRONMENTAL MANAGEMENT

The principal lessons of the Brickmakers' Project for cross-border environmental management entail: the promise of grass roots private sector led initiatives; effective strategies for pollution control in the informal sector; and the fragility of voluntary market-based environmental initiatives in the informal sector.

The Promise of Grass-roots Private Sector Led Initiatives

In many 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

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[20] For a description, see EPA, *ibid.*

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 initiatives hold considerable promise as a means of addressing cross-border environmental problems, and informal sector pollution problems in particular. Moreover, the Brickmakers' Project illustrates that such initiatives enjoy a number of advantages over state-run programs. First, the Project's binational composition suggests that private-sector-led initiatives can effectively sidestep the bureaucracy and sovereignty disputes that often confound government attempts at international cooperation. Second, the enthusiasm that the Project generated among funders, participants, and the public at large suggests that private-sector-led initiatives may be able to draw more freely on public sympathy for border environmentalism than top-down bureaucratic initiatives.

But does the qualified success of the Brickmakers' Project imply that border environmental problems might best be left to private sector grassroots organizers? Definitely not since, in all likelihood, the Brickmakers' Project would not have had as much success without unusually strong US 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, US 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 and 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 Cd. 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 thus that private sector grass roots binational 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: the number, size, dispersion and anonymity of informal firms make them exceedingly difficult to monitor; intense competition biases them towards the lowest 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 Cd. 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 (dedicated to "improving the quality of life for individuals . . .") and, as such, envisioned the Project as a means of improving the lives of the brickmakers as well as the environment.[21] Indeed, some of the Project's activities, such as management training, and the recent effort to diversify the 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 nonadopters. 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

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[21] FEMAP, undated b, p. 1. According to FEMAP's 1994 report, the two objectives of the Brickmakers' Project are: (1) "To help reduce environmental pollution ... [and] (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." (p. 2).

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.[22] 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 Projects' 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.[23] By contrast, most of the early experimental kilns were designed by highly trained engineers, and involved radical departures from existing kilns.

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[22] 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.

[23] See, e.g., Barnes et al., 1993; Stewart, 1977.

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 's attempts to manipulate the market for bricks -- by fixing the price of bricks in March of 1993, and, later that same year, attempting to mandate the use of ecological bricks -- 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.[24]

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 informal sector employees. Beyond rhetoric, establishing such a relationship translates into 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,

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[24] See, e.g., Lal, 1985.

new clean technologies must be appropriate, that is both affordable and low technology. And finally, attempts to manipulate informal markets simply do not work.

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 US-Mexican border. Does the history of the propane initiative'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. 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 Cd. 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 (whose profit margins are exceedingly small) are bound to be fragile, even when well designed and well implemented.

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