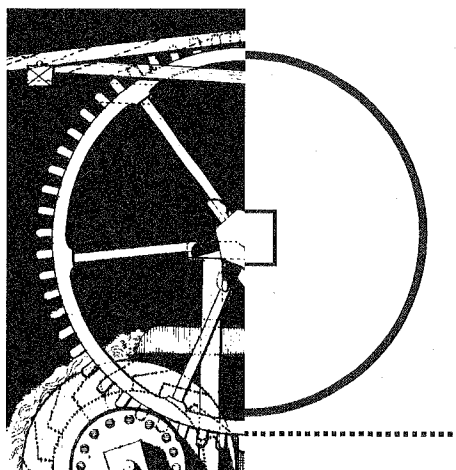


# Public Entrepreneurship Networks

Prepared by

David Laws, Lawrence Susskind,  
James Abrams, Jonna Anderson,  
Ginette Chapman, Emily Rubenstein,  
and Jaisel Vadgama



**The Environmental  
Technology and  
Public Policy Program**

Department of Urban Studies and Planning  
Massachusetts Institute of Technology

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# INTRODUCTION

## Overview

The tasks of environmental management are not what they used to be. Established roles and practices no longer fit with emerging problems and challenges. Sustainable development most clearly confounds traditional categories of practice, posing an apparent choice between environmental quality and economic development that must be reframed for both objectives to be achieved at the same time.

The institutional ground is also shifting. Project after project opens up new roles and responsibilities for private firms and civic organizations. Without their help, environmental goals will never be achieved. New partnerships and alliances are forming so fast that it is hard to keep track of them. Yet, unless we can harness these networks, responsibility for achieving sustainable development will fall entirely on government, which cannot shoulder the burden by itself.

In this report we draw out the implications these trends have for administrative agencies. In the dizzying array of organizational interactions that animate sustainable technology development, we trace what we call public entrepreneurship networks, which shape action, but remain largely invisible. This perspective highlights the new demands and opportunities opened by the overlapping participation of firms, financial institutions, NGOs, and citizens groups as government's partners in promoting sustainable development. It also offers new insights into what makes action strategies effective.

Unless government agencies learn to operate as part of these networks, the goal of achieving sustainability will never be met. Their active involvement is essential for public entrepreneurship networks to operate effectively. To respond to this challenge, government agencies at all levels must be ready to take on new roles and responsibilities. The net effect is a dramatic revision in the scope and nature of government's role in ensuring that "green" technologies are actually used.



## The Policy Challenge

The marriage between environment and development has been uneasy since the Brundtland Commission first wed the terms under the heading of sustainability. Many observers have suggested that this cannot be a marriage of equals. On one side, environmentalists argue that there must be strong limits on development. Advocates on the other side argue that development should not be sacrificed to achieve environmental protection. These parties agree upon one thing, however, ecological protection conflicts with economic development. Sustainability hangs from the horns of this dilemma.

Policy-making in the Netherlands has been distinctive because it has tried to address this dilemma head on. Sustainability only loses its meaning if the relationship between environment and development is posed as a tradeoff. The Dutch Policy Document on Environment and Economy refused to accept this tradeoff, however. It treated this tension as forming a challenge: "environmental and economic interests must become inseparably linked in future decision-making."

The Policy Document grounded this challenge by identifying options in transport, construction, and agriculture where both sets of goals could be addressed. New processes like the recycling of waste moulding sand and practices like flexible construction (in which the layout of a building can be altered without damage) provide a grounded vision of how one goal can be achieved by achieving the other goal as well. New information technologies offer the possibility of enabling more environmentally aware industrial design and production, shifting transportation demand and optimizing the delivery of a variety of environmentally relevant goods and services.

Scrutiny of production processes ranging from semi-conductor fabrication to metal plating has yielded ways of reducing waste by using chemicals that also improve the bottom line of the firm. A "slow change" in business's view of environment as a cost can now be discerned. Environmental improvements are now construed in commercial, market, and image terms. Firms must respond to social and political demands for corporate policies and practices that reflect environmental goals. Financial services and investors are grappling with different ways for using environmental criteria to rate risks and opportunities for investments. These developments root environmental concerns directly in economic activity.

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The Policy Document also suggests that our optimism should be limited. It stresses that while steps can be taken that are both economically and environmentally beneficial, we should not expect these goals to converge spontaneously. The Policy Document stresses that "government must also act" and outlines some policies that "can be taken in close cooperation with industry to bring sustainable economic development closer." The program outlined recognizes the need for an affirmative public role while accepting the fact that it would be self-defeating to try to legislate this convergence.

The policy document is rooted in the experience of using the technique of backcasting. Backcasting has provided a social technology that underscores importance of maintaining a long run perspective to guide sustainable development. The "prospective hindsight" that backcasting generates (in a democratic and institutionally feasible way) highlights the degree of change needed to push the convergence of environmental and economic goals forward.

The other side of this relationship is an acute awareness of the pool of technologies that are developed but not in use. This awareness cuts two ways. It suggests that the problem is not solely one of long-term development of new technological options. A supply of options that are intriguing from an environmental perspective already exists. At the same time the very existence of this pool highlights the problem of transition. It is neither easy nor clear how to initiate a program of experimentation and development that would move these technologies into broader use.

## **Public Entrepreneurship Networks**

Public entrepreneurship responds to this challenge. It acknowledges shifts in institutional resources among private sector and citizens groups that have moved the locus of initiative and change outside the state. Policy development increasingly occurs in an intermediate arena that is neither governmental nor private. Interaction and negotiation between the government and the private sector has become unavoidable as firms have developed internal capacities for analysis and action. Their increasing competence has highlighted the importance securing their active participation to make policy effective. Environmental and citizens groups have increased their capacity to pursue their aspirations outside of state policy.

The cases reviewed in this report acknowledge these trends, but suggest that successful policy-making still depends on the ability of the government to

work collaboratively with the private sector and citizens groups. At the same time, the robustness of this institutional transformation means that strategies for pursuing sustainable development will need to be synchronized with changes in organizational relationships.

Our approach explores an insight compatible with this emerging institutional environment. One way that radical change happens in complex systems is when "something starts somewhere and grows." We work from the assumption that radical change is necessary and a pool of available "greener" technologies creates a ready supply of positive first steps. The *public entrepreneurship network* (PEN) is our model to capture the dynamics of change and the implications for action by government agencies and other actors interested in sustainable development. Five key features distinguish public entrepreneurship networks:

- A pattern of *inter-organizational cooperation* that spans public, private, and civic spheres and develops through
- Interaction in *problem centered networks*.
- Public regarding *local initiative* supported by a set of
- Specific *organizational* roles related in an
- *Institutional ecology* that facilitates development.

Public entrepreneurship networks combine local initiative that has a distinctively entrepreneurial character with a strong orientation to sustainability and other public goals. This is accomplished in part because of the variety of organizations that participate in these networks. Public entrepreneurship networks are characterized by both the pattern of development and the key facilitative roles that have to be played for development to thrive.

These roles stress facilitative rather than managerial activities and tend to parallel the range of entrepreneurial roles that private sector actors have played in the dynamic economic sectors like information technology over the past few decades. They include:

- *Pioneers* who recognize opportunity, seize initiative, and catalyze action by making commitments.
- *Public venture capitalists* who understand and embrace risk and package financial, social, and human capital to meet project driven needs.
- *Superintendents* who provide an environment in which innovation can flourish by fostering the development of relationships that are sustained through formal and informal networks.
- *Mediators* who build consensus on goals and direction and bring directed problem-solving to bear on conflicts that threaten to stall or derail the development of ventures.
- *Stewards of the common good* who focus attention on the common good, maintain standards for responsible behavior, and facilitate the coalescence of democratic community around programs of action.

Given what is at stake, it is neither practical nor desirable to rely on private and non-governmental actors to consistently fill these roles. Government must participate to ensure that public entrepreneurship networks function effectively and stay oriented to publicly endorsed goals. Yet government action must not threaten the ecology of relationships that generates the attention and energy that make these networks effective.

This sets a challenge for government agencies. Their participation is essential. Yet efforts to “legislate” change may disrupt the very patterns of development they seek to promote. Identifying public entrepreneurship networks and understanding how they work is only the first step. Government must learn how to facilitate the creation of these networks and enhance their impact.

## Relation to Other Policy Approaches

PEN offers a distinctive analysis of the problem of development that has implications for the shape and character of the government role in sustainable development. To highlight PEN's distinctive character we compare it with a sample of other approaches to promoting sustainable development.

PEN is most clearly distinct from the "California Model" of technology forcing in which government's authority to set and enforce standards is used to promote change. This model draws on command-and-control regulatory traditions and extends them to sustainable technology development. In California, as in other cases, the technology forcing approach has had limited impact in producing practical commitments to change.

Technology forcing focuses attention on the definition of regulatory requirements and issues like timing that influence the enforcement of these standards. The development process receives less attention. Whereas PEN draws on the interest and commitment of firms and non-governmental actors and encourages them to move beyond traditional regulatory roles and become more actively engaged in problem solving, technology forcing deepens the commitment to traditional roles and zero-sum patterns of interaction.

The California Zero Emissions Vehicle (ZEV) mandate provides an important example of the limitations of technology forcing approaches.<sup>1</sup> The policy, which mandates that the equivalent of 10 percent of the vehicles sold in the state meet a standard of zero emissions by 2003, has thus far proven more successful in generating debate about the definition of the enforcement standards than bringing about change in technology use.<sup>2</sup> After some initial positive effects on interest and investment in the design of electric cars, development has stalled.<sup>3</sup> Few electric cars have been sold in the state, and manufacturers continue to debate with regulators about which technologies should receive ZEV credit.

The strict guidelines have also limited flexibility and impaired communication, hindering efforts to promote innovation. Because the mandate offers little opportunity to discuss which technologies would best meet the interests of all parties and serve environmental goals most effectively, it may have disrupted vehicle and infrastructure development for other more potentially beneficial technologies such as fuel cell and

compressed natural gas.<sup>4</sup> Although California revised the mandate in 1998 and 2001 to allow automakers to meet a portion of the requirement with such “zero emission credit” vehicles, the controversy has created considerable confusion among automakers about what technologies to adopt.

The California experience is consistent with more general reviews of technology forcing approaches. While they may be attractive because of their historical prominence, directness, and continued importance in guaranteeing baseline commitments to public and environmental health, regulatory standards have been unsuccessful in prompting innovation and change.<sup>5</sup> A notable exception is the outright bans in cases like PCBs and CFCs.<sup>6</sup> The standard reason for this weakness is the emphasis standards place on existing technologies. From the perspective of PEN, we would also highlight the thin networks that are generated and the character of the problems that occupy attention in those networks.

Covenants have been used historically to change just these dynamics and are much closer to PEN as an approach to environmental policy. Covenant programs in the Netherlands have been credited with improving environmental performance in many sectors of the Dutch economy.<sup>7</sup> Despite their success in introducing greater flexibility in the development of enforcement procedures, covenants have primarily focused on regulation rather than innovation.

Programs in the United States such as *Project XL* and the *Common Sense Initiative* have highlighted the problem with assuming that innovation will result from introducing flexibility into environmental enforcement. Rather than producing new technological development, the programs have been characterized by traditional public-private antagonism over regulation. Discussion between firms and environmental agencies often centers on the potential shape of enforcement procedures and their legality rather than focusing directly on the innovation process. PEN suggests a response to this dilemma by stepping away from regulatory approaches and focusing directly on producing technological change.

PEN also differs from covenants by moving the locus of action outside the state. Despite the greater flexibility offered the firms in developing enforcement programs, covenants still rely on government affirmation and direction to approve the regulatory program and trigger change. Rather than relying on government agencies to promote innovation through regulation, PEN focuses on policy development that occurs in an intermediate arena

that is neither public nor private. This approach extends the model of collaboration that characterized successful covenants to new kinds of partnerships focused on innovation and characterized by closer and more ongoing patterns of interaction.

PEN overlaps with programs like constructive technology assessment (CTA) and strategic niche management (SNM) that are concerned with the management of technology in society.<sup>8</sup> Like CTA, PEN highlights the constructive potential of social interaction around technology. It can reshape the terms in which technologies are understood and actions evaluated. The identification of "de facto CTA" led to comparable insights about the active role that groups outside of government play in shaping the development of technology.<sup>9</sup>

Unlike CTA, however, PEN does not focus exclusively on anticipating the effects and social acceptance of new technologies, but is concerned directly with the development process. How does change start and grow? This extends the focus on societal learning to embrace strategic concerns about how development occurs in a world where interests and concrete organizational goals are at least as influential as curiosity and a commitment to learning.

Here PEN's focus is more similar to strategic niche management (SNM). SNM takes the development of viable technologies as its focus. It focuses on technology developers as the active agents. With respect to government it asks, what level and type of protection is necessary to foster experimentation and produce technologies that are viable in the market? PEN looks at government as a more direct participant whose status is differentiated by the breadth of its concerns and the special resources it brings.

The model of change is also different. SNM takes variation and selection as the model for social change collapsing many distinctions under the rubric of selection. PEN, in contrast, looks at change as development in a network of relationships and develops a form of analysis that brings out the characteristics of these networks. Where SNM takes the market as an evolutionary environment, PEN focuses on the ecology of roles that support development in venture oriented programs. Public entrepreneurship networks could serve many of the functions of a strategic niche. Overall, PEN is distinguished by the model of development, a focus on the venture (which sets a scale for analysis), and the effort to describe a robust set of roles for government agencies and other organizations interested in

sustainable development.

## Organization of the Report

This report is organized into four sections. The first presents the case of SunLine Transit Agency in California. SunLine's exemplary experience in changing from outdated to advanced technology provides a detailed illustration of the pattern of development that characterizes the PEN model. The exposition of the case is followed by an analysis of the pivotal moments in the history and the roles that SunLine and other actors played in the process. The third section of the report takes these roles as the focus of analysis and relates findings from other cases to them. Following the conclusions is an appendix that provides accounts of these cases at varying levels of detail.

The first goal of this report is to clearly render a distinctive pattern of development that builds on what we take to be some durable and significant change in the institutional landscape of industrialized democracies. The second goal is to analyze this pattern in a way that identifies the implications for practice in public administration, private enterprise, and civic organizing. Each level of organization is oriented to these two goals. Together we hope they contribute to opening a conversation about new forms of practice and to promoting change.

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### <sup>i</sup> The California experience with technology forcing

The California zero-emission vehicle (ZEV) mandate remains one of the most visible cases of technology forcing. The California Air Resources Board initially adopted the mandate in September 1990, claiming that advances in electric vehicle (EV) technology had advanced far enough for near-term wide scale implementation. Adopted as part of the Low Emission Vehicle and Clean Fuels program, the program stated that at least 2 percent of new car sales represent ZEVs in 1998, and would increase to 5 percent and 10 percent in 2001 and 2003, respectively (California Environmental Protection Agency, August 2000). Major auto companies lobbied aggressively against the mandate from the outset of the program, claiming that the standards would result in dramatically increased automobile prices (Brown, 59). As typical of technology forcing programs, CARB maintained that the high initial price of EVs would decrease with economies of scale, and would eventually reach levels competitive with conventional vehicles.



CARB also established a biennial review process for the program, which served as a focal point for debate about the mandate. Although the reviews in 1992 and 1994 were characterized by "intense lobbying" from the auto industry, the agency upheld the standards and maintained that technological development was on course to meet the 1998 deadline (Brown, 59). Auto manufacturers, however, stridently disagreed with this conclusion, and continued to assert that battery technologies had not advanced enough to provide sufficient driving range and would be prohibitively expensive to produce. These concerns appeared to be validated in 1996 when CARB eliminated the requirements for 1998 and 2001, leaving only the 10 percent mandate for 2003. Echoing the concerns of automakers, CARB explained the abandonment as an acknowledgement of technological necessity, arguing that "this is not a political decision, it is a technical decision" (Brown, 59).

The introduction of the first EVs began to raise questions about the ability of the technology to meet the goals of the parties involved and serve environmental goals. Despite the postponement of the ZEV mandate, GM introduced the first EV (titled the EV1) in December 1996, which generated lukewarm market demand. With a driving range of approximately 140 miles, few consumers were willing to lease the vehicles despite heavy subsidies from the GM to cover high battery costs. Moreover, even after several years of production, the EV1 (and other electric vehicles introduced by Toyota and Ford) also failed to produce the economies of scale and reduced costs predicted by CARB. Manufacturers and CARB staff agreed that only a major technological breakthrough would substantially reduce costs, and production would require manufacturers to continue to incur significant losses. In March 2000, GM announced it would end production of the EV1 after only selling 950 vehicles since its introduction. An executive engineer at Toyota summarized the situation by describing the mandate as "a technology development program that didn't deliver as expected . . . this is a technology that should not be commercialized because it's not cost-effective" (Polkavic, 9 September 2000).

As automakers began to shift their research to other more cost effective technologies including electro-chemical fuel cells, hybrid vehicles, and mini-cars, the mandate created considerable debate about what technologies should be recognized in the regulations. Automakers argued that these and other technologies such as natural gas would be cheaper to produce, more marketable due to their longer driving ranges, and generate greater environmental impact through actual sales. CARB first responded to these concerns at the 1998 biennial review after sales of electric vehicles failed to reach projections, modifying the mandate to allow automakers to satisfy up to 6% of the ZEV requirement with low emission "partial-ZEV" (PZEV) vehicles (California Air Resources Board, October 2000). In order to represent a PZEV, vehicles must qualify under CARB regulations as a Super Ultra-Low Emissions Vehicle (SULEV), as well as produce zero evaporative emissions and contain a 150,000-mile warranty for air pollution control equipment (California Air Resources Board, October 2000).

Considerable debate surrounded the decision about which automobiles would qualify for PZEV status, with some SULEV vehicles such as the Honda Accord SE and Civic GX being excluded due to their failure to meet emission system warranty requirements. Even hybrid vehicles such as the Toyota Prius and Honda Insight failed to qualify as PZEV vehicles, leaving manufacturers' most technologically advanced vehicles with zero credit in the mandate. After witnessing several shifts in regulatory signals throughout the 1990s, the situation left automakers confused about what technologies to adopt. Indeed, with some

environmental groups claiming that such hybrid vehicles represented more environmentally sustainable technologies than EVs, the standards may have reduced the incentive to provide more beneficial products (O'Dell, 14 February 2000). Gearing up for the 2000 biennial review, a spokesman for the GM technology division noted "we are looking at various product alternatives and would like to move forward. But we will not do so until we understand what the final rules will be" (O'Dell, 18 October 2000).

Confrontation over what technologies should qualify under the mandate continued as automakers and CARB continue their highly divergent strategies to developing environmentally sustainable automobiles. Hoping that CARB would further reduce the ZEV mandate in its 2000 biennial review, manufacturers continued to focus research on more cost-effective technologies such as hybrid vehicles while simultaneously discontinuing their electric vehicle production. Although automakers launched their most visible campaign against the ZEV mandate in 2000, garnering considerable national press coverage and favorable editorials, CARB ultimately upheld the 1998 regulations. Despite the fact that manufacturers had ceased production of their electric vehicles, officials directed the automakers to resume manufacturing or face penalties. Some companies such as Ford vowed to meet the requirements, while others questioned whether the ZEV mandate still represented a credible threat to the automakers. Many felt that the requirements represented an infeasible goal (only 3,300 electric vehicles had been sold or leased throughout the entire country since 1996) and would again result in a game of regulatory chicken with little impact on technological innovation.

The CARB mandate has proven more successful in generating confrontation between automakers and the state than producing technological change. As the 2000 biennial staff report asserts, "the challenge is to determine how to achieve sustainable success in the field." The mandate has failed to generate such success by developing and sustaining an antagonistic environment that limits the potential for creating innovative strategies that might have served the interests of the parties involved more effectively. Faced with a zero-sum situation, automakers have strategized to escape the ZEV requirements due to their purported initial high cost constraints. Whatever the merits of this argument, ZEVs may have faced a more nurturing environment had the automakers not been faced with regulations that made manufacturing the vehicles a negative proposition. While automakers have taken the position that producing hybrid and other non-EV products represents the best solution, and therefore have thus far failed to resume production of electric vehicles, their course of action will either result in a regulatory train wreck or repeated modifications in the mandate. Either way, technological innovation will not occur as rapidly as would result from a strategy focused on development rather than regulation.

# **Part I:**

## **An Exemplar of Sustainable Technology Development**

*There's nothing in the world like what we're doing right here...actually making hydrogen from the sun, and putting it into vehicles and running [them] on the street. People are talking about [doing] it, but we've got equipment that's doing it right now.... [It's the] sort of thing that gets going, and it's gathering no moss as we keep going down the trail. (Dick Cromwell, General Manager, SunLine Transit)<sup>9</sup>*

*There are a lot of things that we've done that no one else thought about doing.... Or maybe they were just restricted and couldn't even go into that arena.... But no one told us we couldn't do it. (George Earl, Director of Maintenance, SunLine Transit)<sup>11</sup>*

The headquarters of the SunLine Transit Agency, a government entity that provides bus service in Southern California's Coachella Valley, are unimpressive. Located in Thousand Palms, near Palm Springs, the agency's administrative "campus" includes a trailer that the director found abandoned in the desert. The boardroom was built from another trailer, one that was once used as the field office for a construction project. The only permanent structure in the complex is the maintenance building.

SunLine's hydrogen fuel is produced at one of two on-site reformers, Haynes explained. The larger of the two is tied to a bank of photovoltaic cells that is currently under construction. Another construction project will provide a shaded walkway where visitors to the facility can view the reformer, the storage tanks, and the photovoltaic array. Plans are underway to get electricity for producing fuel from nearby wind farms. The smaller of the two reformers is frequently used in school tours to show children how hydrogen fuel is produced. Under a nearby carport were two small fuel cell vehicles that have been in use for several years.

Standing there, looking at those futuristic vehicles and hearing Haynes talk about the company's remarkable work, it was hard to imagine that just seven years ago SunLine was considered a technological backwater with a poor

service record. At that time, the agency operated an aging diesel fleet that couldn't handle the hot, dry, dusty conditions so common in the desert. George Earl, Director of Maintenance at SunLine, explained the problem: "In the summertime, I'd have half the fleet just sitting dead in the road because they couldn't operate in this environment. We never had a maintenance program. We were too busy putting out fires all the time."

So, how did SunLine transform itself into a recognized leader in alternative-fuel technology and a partner in the continuing development of transportation technology?

## **The Turning Point**

The transition began with a crisis that peaked on a summer day in 1993, when two-thirds of SunLine's fleet went out of service. In the course of dealing with this crisis, SunLine's board of directors realized that the agency could not survive, much less provide high-quality service, with second-hand buses. They needed wholesale change. They needed a new fleet of buses.

Dick Kelly, the Chairman of SunLine's Board at the time, approached General Manager Dick Cromwell. As Cromwell recounts, Kelly said, "Dick, we need to get new buses, so let's go get new buses. Everybody else has new buses, why don't we have new buses?"

"Oh, by the way," Kelly added, "Make them alternative fuel."

This decision to use new technology is surprising, because it was made in the face of a history of irregular service and a out of a desire to enhance dependability. If the agency could not provide dependable service with familiar equipment, why did they think they could do it with new, complex, and unfamiliar equipment? Board members now say their decision was driven largely by a desire to preserve the region's clean air (which is prized by residents) and tourism, which is the Coachella Valley's economic base.<sup>13</sup>

Several other factors apparently also drove the decision. First, SunLine's board trusted the agency's management team to carry out the decision effectively. Second, the board itself had "vision" and was interested in "trying new things."<sup>14</sup> Third, the board gave management its full backing and created a "safety net" in which management could act without fear of being blamed if the transition did not proceed smoothly.

Those we interviewed disagreed about whether there was yet another factor. According to Cromwell, "ignorance was a partner." He said the board acted

"somewhat out of blindness" and with a sense that there was "nothing to lose." Some board members agreed with this explanation. They said they didn't fully comprehend the ramifications of the commitment they were making.<sup>15</sup>

Kelly, on the other hand, said they did have some idea what they were doing. He said his experience bringing electric vehicles into Palm Desert and the knowledge he and other board members had about alternative fuels were important factors. For example, he and Cromwell had seen a CNG bus at an American Public Transit Association (APTA) meeting in Toronto, and marveled at how clean the emissions were. He believed fuel cell buses were the ideal vehicle, but he realized the technology was not ready. Based on this cumulative experience, Kelly felt they were simply taking a well-calculated chance.

It should be noted that the board's commitment was provisional at this point, since the money for the buses was not yet available. The board simply gave Cromwell and his staff the opportunity and incentive to explore the technical and financial options that were available. This provisional commitment could always be withdrawn if the information Cromwell uncovered did not support it. At the same time, the decision did create a space within which the organization could act.<sup>16</sup>

Cromwell used the time after this provisional decision was made to learn and build agreement within and outside the organization regarding which path, if any, to take. The learning took place via a progression of problems that were triggered by Dick Kelly's charge to "make [the new buses] alternative fuel."

## Choosing the Right Alternative

The first problem was the choice of a fuel. SunLine's staff explored electricity, propane, fuel cells, and liquefied natural gas (LNG) before settling on compressed natural gas as the preferred option. This exploration process was important for building support for and understanding of the concept of alternative fuels. George Earl, the maintenance director, described his initial reaction to the decision to shift to alternative-fuel technology, and how he came to support it.

It was a little scary, because I didn't know what we were getting involved in. I wanted the old buses to go away.... We started questioning different technologies..., and I was involved in all that. We started asking a lot of questions. I visited properties, I would go to different places and see what they were doing, what their problems were. We had a choice of electric, propane, LNG, and CNG. Electric's not feasible for the desert here. It...wouldn't give us the range we needed, and the technology just wasn't there at that point. Propane... doesn't work well when the climate gets cold because you have a hard time starting vehicles.... LNG [was] kind of scary.... [W]hen I went and viewed an LNG station...the guy's out there with all this gear on, fueling these vehicles. [T]hat's not very user-friendly to me.

Earl also explained that LNG and propane would be delivered to SunLine's pumps by truck, like gasoline. Ideally, SunLine wanted a fuel they could manufacture on site, because the Coachella Valley is prone to earthquakes, and they didn't want an earthquake hampering their fuel deliveries. "That's one of the reasons we started really looking at CNG," Earl said. "And then the [Southern California] Gas Company came bouncing in the door and said, 'We'll put this in for you,' which was great."

As Earl implied, the exploration process included trips to transit agencies that were trying CNG and other fuels, as well as trips to equipment manufacturers. For example, Earl visited a transit agency in Tacoma, Washington that was trying alternative-fuel technology. "I didn't see anything [there that] anybody was really scared of," he said.

The internal process of learning and developing support was tied to an effort to build support outside the organization for CNG. The biggest external challenge was to find financing for the buses. SunLine's board, which is made up of elected officials from each of the local municipalities and the county, gained the support of other local and state leaders for the project. In Cromwell's words, "I had senators and congressmen, I had every elected official. I had every school board member. I had everybody." His account of how he got the support of a Native American tribe suggests the character of this process.

I went to Richard Malonovich, who was a friend of mine from school days—he's the tribal chairman of the Agua Caliente band in Palm Springs—and said, "You know Richard, we want to convert our diesel buses to natural gas. And it seems to me that...it's pretty tough for you as a tribe and your philosophy of protecting the earth and the land and the air to do that in this modern world. But you know, supporting clean air through natural gas seems like it would be a good thing to do." And he said, "Funny you should say that. My son came home the other day and gave me a story about 'Dad, you know we ought to be doing this because this is a way we can fulfill our commitment to the earth.'" So he signed up.

The board's lobbying effort proved sufficient to get \$2.5 million from Congress, in the form of a "rider" that the local congressman attached to a federal appropriations bill. This was still about \$10 million short of the total SunLine needed to buy the new fleet of buses, however. Putting together the funding package that would allow them to move ahead required a different kind of innovation. Cromwell explained that the rest of the money ultimately came from the U.S. Department of Transportation.

At about that time...the federal government decided they would allow you to obligate capital money that you normally get...annually...through what they used to call Section 9 grant, and they allowed us to obligate that into the future. First time it was ever done. And so I financed the \$9.5 million into the future with Section 9 money....

The board's solidarity and commitment to the new technology was tested soon after SunLine cleared these financial hurdles. After the board and staff collectively chose CNG from the available technological options, they selected a Orion, a Canadian manufacturer, to provide the new fleet of buses. Soon after they finalized the contract, however, Orion filed for bankruptcy and was taken over by the Canadian government. Cromwell described the problem and the solution they devised:

So we fly to Canada and we meet with the Minister of Finance, and he turns us over to a fellow by the name of Tanaka.... The vendors wouldn't supply the parts to Orion. So the deal was made that we would give them our \$2.5 million grant to start things flowing again. So on one Saturday morning we brought our board here and we had Mr. Tanaka on the phone, and they voted to do that. First time it's ever been done in the United States. So we gave our local money to the Canadian government, which allowed them to pay off vendors, which allowed the bus company to start working again.

Everyone in the United States thought we were nuts. It was really done on faith. It was done on our board's faith in Mr. Tanaka and the Canadian government—that they wouldn't let us down. And they had faith in their management team and all the rest of it, so hey, they took the risk and away they go. But remember, I took board members up to Canada on these trips and they knew who the people were and they had met Mr. Tanaka. [Also,] we had a chairman who really met the need of the time. [B]rilliant guy, retired at 50 with a gazillion dollars. He was a real entrepreneur and understood business and was able to sell the board. And the board had faith in his background such that when he said "this is a go," they went along with it.... Crazy. But it's really understanding your asset and educating that asset to where it supports what you're trying to do. You know, you keep that going so they're part of the solution.



## Getting into the Training Business

With the buses on the way, SunLine faced a new problem that pulled the organization forward. They had committed to a fleet of buses that they did not know how to maintain. Moreover, they would not be phasing buses in incrementally. A full fleet of buses would come on line simultaneously.

This generated organizational resistance. "I didn't want to [put all the buses in service at once]," said Earl, who would be responsible for maintaining the fleet. "I went to [Cromwell] and said, 'Can't we, ten at a time, feed them in? New technology, new buses—we don't know what's going on with these things.' And he says, 'No. We're ready, and if we're not we're going to bite the bullet.'" The other mechanics were also skeptical about the new technology. It wasn't what they were used to: the engines weren't the right color, and high-pressure gas presented new technological problems and risks. But at the same time, they would be out of a job if they couldn't adjust.

Because the technology was new, the problem resisted conventional solutions. SunLine couldn't simply hire new personnel. "[In the past], if you couldn't work on the vehicle, well, go away. We'll get a mechanic who can," said Cromwell. But there were no mechanics who understood CNG technology. Nor could SunLine turn to the manufacturers. "Manufacturers aren't in the training business," Cromwell explained. The most they could do was offer to have one of SunLine's mechanics attend an eight-hour class, which SunLine felt was inadequate.

To solve the maintenance problem, SunLine had to "get into the training business." Because the agency had limited expertise in both training and compressed natural gas technology, they had to expand their network and involve other actors. Cromwell thought that the College of the Desert, a local community college, might be able to help train the mechanics and engineers to work on alternative-fuel technology. He asked the manufacturers to provide the college with the necessary technical expertise. "I was able to get the manufacturers to go to the community college," Cromwell said, "to partner with [them] and let them do their area of expertise, which is to develop curricula."

SunLine ultimately developed a 100-hour course with the College of the Desert and the equipment manufacturers. By the time the buses arrived, all of the mechanics had completed the course. They changed the fare boxes

over a weekend, and on Monday morning the new fleet of CNG buses rolled out onto the routes. George Earl asked the Cummins Engine Company, who manufactured the CNG engines, to bring one of their service trucks on site that first day, in case any problems arose. But none did. "From that day on, everything just went smoothly," said Earl.

SunLine also developed a preventative maintenance program, which has been central to the agency's success with the new buses. Earl explained that they developed it, at first, to "honor everybody's warranties," since the warranties required that the equipment be properly maintained. "[W]e found out that [the preventative maintenance program] is a pretty good program," he said. "So we just kept it in force, even after the warranties went away. And this is one of the reasons we're successful.... If you've got a good preventative maintenance program, you're not putting out fires at the end."

SunLine's approach to choosing an alternative-fuel technology and developing a maintenance course also played a big role in their success. It produced commitment throughout the organization to making the new technology work. Earl's description of how he handled the transition with the maintenance staff is illustrative of how it went in the organization as a whole.

[For the m]ost part, people don't like change. If I had 18 years of being a diesel mechanic, why would I all of a sudden have to change my whole way of thinking and the way I do things? So you've got to make them part of the whole thing, and say "Your input is just as critical as that guy's input." And make them part of it, so they feel like they're being more valuable, and they'll come [along] faster.

Now, change and the chance to work with emerging technologies are part of what is attractive about SunLine. This has important practical effects in areas like maintenance, where SunLine has not only maintained performance but also invented new approaches to solving problems and new uses for technologies. Earl explained it this way:

There's two or three of them that don't [like new challenges]. They're here for a paycheck, and they'll learn, [but] they're a little reluctant. But there's guys that like the change. There's guys that like to tackle new stuff. I couldn't do it ...without them, because those are the guys who come up with the ideas, most of the time. [They're like] sponges—they can take a technology and dissect it and come back with better ways of doing things. It's fun watching them.

## Getting Results

Since the switch to CNG buses, SunLine has experienced significant improvements in service and reliability. SunLine is consistently above the national average for distance between “roadcalls”—a reliability measure in the transit industry—by a factor of four to five.<sup>17</sup> Moreover, since the switch, not only pollution but also operating costs have declined. A recent study demonstrates that the operating costs of running a CNG fleet are lower than for diesel.<sup>18</sup> These results run contrary to the expectations and the experience of other transit agencies that have conducted trial programs. The conventional wisdom is that increased costs and decreased dependability have to be tolerated to gain experience with new technologies.

What is more interesting and more significant in the long term is the “cascade” of indirect effects that have been generated by SunLine's efforts. The first, of course, is the involvement with training. SunLine now sees training as a core activity and central to the success of alternative-fuel programs.<sup>19</sup> The program they developed with the College of the Desert was used as the model for DOE's certification program for CNG mechanics. It also led to the establishment of the Energy Technology Training Center at the College of the Desert and the statewide Advanced Transportation Technologies Initiative. SunLine technicians now participate in the ongoing redesign of the training program, and the last eight hours of the 40-hour basic course are conducted in SunLine's shop.<sup>20</sup>

Through their relationships with colleges, equipment manufacturers, and, most recently, DOE and the U.S. Department of Transportation (DOT), SunLine has become involved in an entirely new set of projects. Due to their relationship with equipment manufacturers like Cummins Engine Company and Detroit Diesel, SunLine is now a test site for these companies' innovations in engine technology. For example, SunLine tested

a compressed natural gas generator for Cummins. They are now testing a liquid catalyst for radiators that destroys ground-level ozone as air is processed through the engine. With this technology, buses can actually clean the air as they move down the road. These programs keep SunLine in regular contact with the manufacturers and keep the technicians involved with a constantly developing technological base. Cromwell described the relationship between SunLine staff and the equipment manufacturers, and its effects on the organization, as follows.

There's nobody finer in alternate fuel engine technology in the United States than our staff. [T]hey're doing the beta tests on the stuff that's not even on the market yet. And they take great pride in working with John Deere and Cummins. [W]hat Cummins does is..., at their own plant, they'll put a [project together] similar to what we're doing and we beat 'em every time, and our guys love that. We've got ours in the bus and running long before Cummins Engine gets it done. And now they're not mechanics anymore, they're *technicians*. And...I don't do the tours anymore, they do them. And when experts are wanted to go to Chile to represent the United States, who do they call on? They call on us. [O]ur head trainer [just] went down to Chile on behalf of the [Federal Transit Administration] and did many meetings and met with transit properties [there]. [W]e don't pay the most in the world. [Our technicians] could go to Los Angeles or other places, and are often solicited. But they stay here because...they're not aware of any other transit property that...does the stuff we do. And they like that. They like that pride,...they've got a sense of ownership. I mean they drive this ship and do a heck of a job. It's great.

In this context, the conversion to compressed natural gas has become just a stepping stone. "We think our future will be in fuel cells," Cromwell was quoted as saying, "and going from diesel to natural gas is just the bridge to go to fuel cells."<sup>21</sup> Bruce Finley, a former engineer at SunLine, described the agency's goal of becoming the first zero-emissions transit agency:

That's our goal. It's possible. Right now, we could go to electric vehicles and be 100 percent zero emission [at the] tailpipe. But...obviously somehow you have to produce electricity. That usually generates some sort of emission from

running power production plants. But if we use hydrogen from renewable resources, then the total life cycle of the fuel is zero emissions.<sup>22</sup>

The hydrogen program is a compilation of several overlapping projects that evolved from relationships that began in SunLine's involvement with training and CNG. In partnership with the College of the Desert and the National Automotive Center (a branch of the U.S. Army), SunLine is involved in the 21<sup>st</sup> Century Truck project, which is examining the technical design of an onboard diesel reformer and the maintenance requirements for these vehicles. Their relationship with DOE, which developed through the mutual interest in training CNG technicians, has involved them in a consortium with Clean Air Now and the Schatz Energy Research Center at Humboldt State University to put hydrogen technology into use and, as Cromwell put it, "see if it's ready for prime time." This includes construction of on-site reformers, photovoltaic panels to supply part of the energy, and the fueling station. This emphasis on infrastructure requirements ensures that all newly constructed CNG infrastructure is compatible with hydrogen technology. George Earl and others are part of a committee of the American Public Transit Association that is examining the design and maintenance requirements for fuel cell buses.

These various projects will provide opportunities for everyone at SunLine to become familiar with fuel cell technology. Cromwell explained:

We're developing right now a basic 8<sup>th</sup> grade curriculum [on hydrogen technologies] that I'll put everyone in this agency through, from the fuel hustlers to the receptionists.... Everyone wants to talk about the Hindenburg, [so] let's talk about the Hindenburg. Let's get that over with. Let's talk about the volatility of hydrogen, let's talk about whether it's dangerous or not dangerous, let's talk about what hydrogen's all about.

Every mechanic will go through two weeks of training on the new fuel cell bus. According to Earl, some of the technicians aren't happy about learning yet another technology, but they know they have no choice if they want to keep their jobs. And, he said, some of them welcome the challenge. Bill Clapper, Executive Director of SunLine Services Group, described the learning process that's already gone on.

[The maintenance staff] were a little concerned last year when we started talking about [hydrogen].... But that's because of what they didn't know. As we got smarter, we started giving them information and showing them things. What I think really sold them is last November we had the fuel cell bus.... We popped open the trunk where the engine is, and [they said] "Oh, yeah, there's the air compressor and there's the camshaft, and I recognize that. Oh, by the way what are those two black boxes up there?" "Those are the fuel cells." "Oh, well what do you do with those?" "You just remove and replace." "Oh, OK. Well it's got brakes, it's got lights...."

Thus the hydrogen program and the organizational commitment to becoming a zero-emissions transit agency developed out of the interactions SunLine initiated to solve the training and maintenance problems that arose during the conversion to CNG. The assortment of programs and projects described above and a host of other, less formal, cooperative programs comprise the "cascade" of effects mentioned earlier. This cascade was triggered by the commitment SunLine made and by the way in which they handled the problems that emerged, and out of their interactions with an expanding network of public and private organizations.

Moreover, this is only one part of the story. A similar cascade of effects occurred from SunLine's effort to develop CNG infrastructure. SunLine worked with Pickens Fuel Corporation, a private gas distributor, and Southern California Gas Company to install four public-access fueling stations in the Coachella Valley. Southern California Gas built a \$1.5 million refueling station for SunLine—the second largest such facility in California—as a demonstration project. SunLine agreed to serve as the anchor tenant and to lease stations to Pickens for \$1 per year if Pickens would construct and operate natural gas refueling stations with SunLine's guidance.

These projects expanded the two gas companies' service bases. However, the companies wanted assurance that the demand for natural gas would not be limited to SunLine. SunLine thus worked with the nine Coachella Valley cities and Riverside County to pass resolutions stipulating that the municipalities would first consider natural gas vehicles when expanding their fleets. As a result, public works, fire, and police departments in the Valley now own more than 400 natural gas vehicles. SunLine's operation of

a 60-foot mobile fueling truck that can deliver gas to municipal customers, as well as to stranded SunLine vehicles, helped to bolster the municipalities' commitment. The mobile station bridges the gap between the initial use of natural gas on the part of public or private entities and the development of permanent natural gas infrastructure. Furthermore, SunLine and Pickens have convinced a number of private fleet operators, including Waste Management, Inc. and the U.S. Postal Service, to begin converting their fleets to natural gas. This story makes clear that SunLine's decision to operate CNG buses led to a commitment to working with and supporting Southern California Gas and Pickens, which in turn generated a cascade of unanticipated environmental gains.

Finally, SunLine's move into natural gas-fueled street sweeping, as part of a regional air pollution mitigation program, also supports the natural gas infrastructure. The street sweeping program is run by SunLine's entrepreneurial arm, SunLine Services Group. Through this program, SunLine earns enough money to operate two CNG buses per year, while eliminating the need for street sweeping vehicles that pollute.

## Part II: Assessing SunLine's Experience

*What...spurred it on is, one thing kind of leads to another.*  
(Dick Cromwell)

Is SunLine's experience merely a fortuitous chain of events, or are there lessons to be learned from their story?

Figure A provides a point of access for understanding the "pattern of development," or how the situation evolved. The story began with the interaction between SunLine's management and board regarding the problem of poor service (specifically, on the day two-thirds of the fleet were broken down). This original problem (P1) was transformed when these interactions resulted in the board's commitment to purchase new buses and, in Dick Kelly's words, "make them alternative fuel."

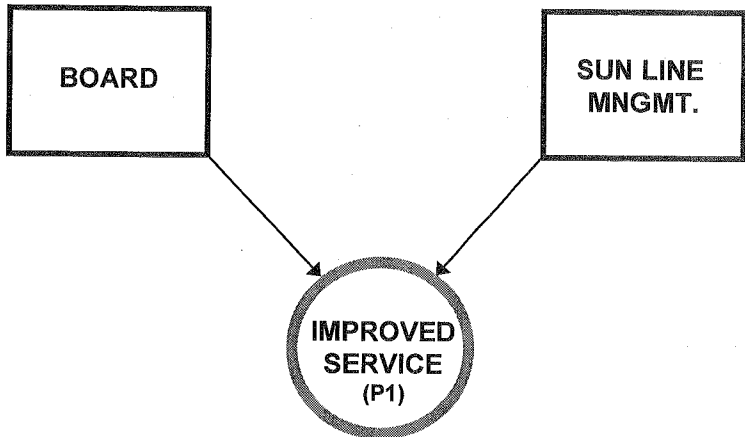
As shown in Figure B, the new problem (P2) was to select an alternative fuel that met SunLine's needs. This new problem engaged management with a new set of actors, drawing in engine manufacturers, bus manufacturers, other transit agencies, and the Southern California Gas Company.

The "product" of these interactions was the choice of compressed natural gas as the alternative-fuel technology and Orion as the bus manufacturer, which in turn, created new problems. These new problems included building the infrastructure to support CNG (P3) and establishing a maintenance program for the buses (P4). In short, SunLine had committed to a technology that it had neither the infrastructure nor the expertise to support, and they had to face the consequences of that commitment.

Figure C traces SunLine's effort to address the infrastructure problem (P3). This involved them with the Southern California Gas Company, which built the on-site refueling stations, and Pickens Fuel Corporation, which shared SunLine's interest in expanding the use of natural gas. To develop a sufficient infrastructure to support CNG, however, the two gas companies needed to expand their customer base beyond SunLine alone (P5). Through SunLine's board, therefore, the core interactions grew to include the local communities as potential customers for Pickens and partners for SunLine.



Through these municipalities, Waste Management Inc., which provided solid waste pickup, became involved as a user. The U.S. Post Office also decided to experiment with CNG vehicles, and they eventually became a major user of the infrastructure. The financing scheme for the construction of refueling stations brought in the Department of Transportation, which allowed SunLine to invest its transit allocation in capital improvements and to generate and keep a return on their investment.

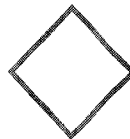


**KEY:** These diagrams describe the development of SunLine's sustainable technology through the interaction of many actors around different problems.

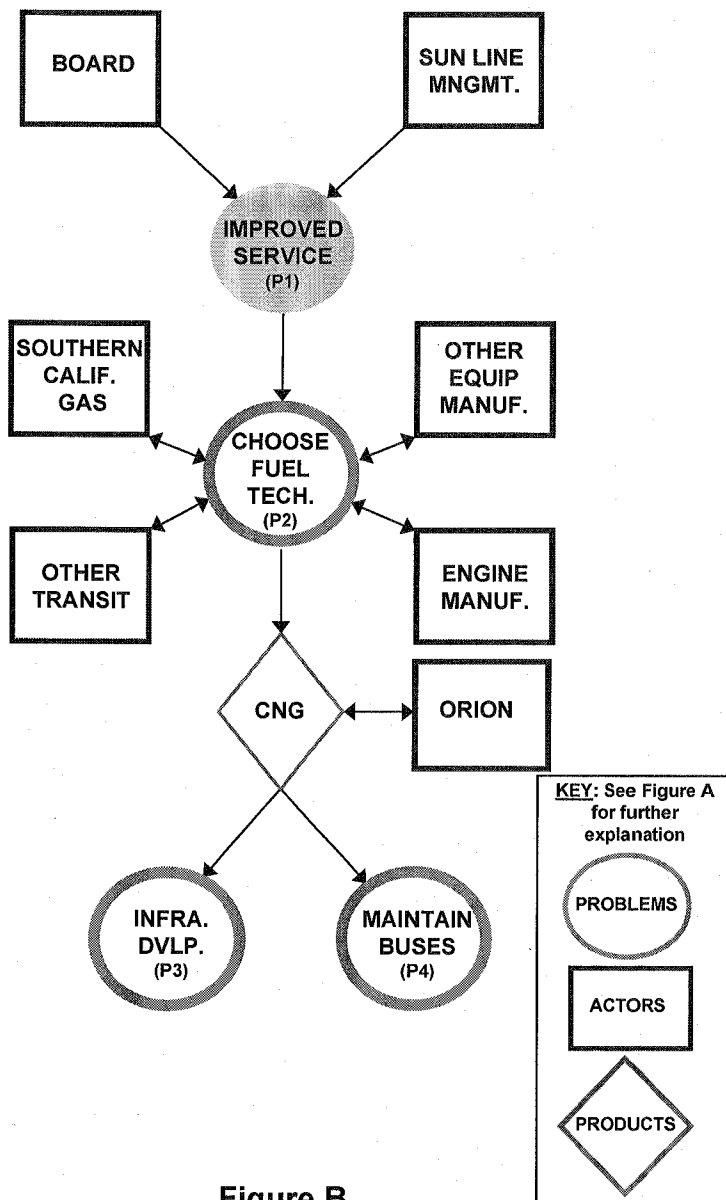
Circles represent the **problems** around which development was framed. Shaded circles represent resolved problems.

Squares represent the **actors** which form networks.

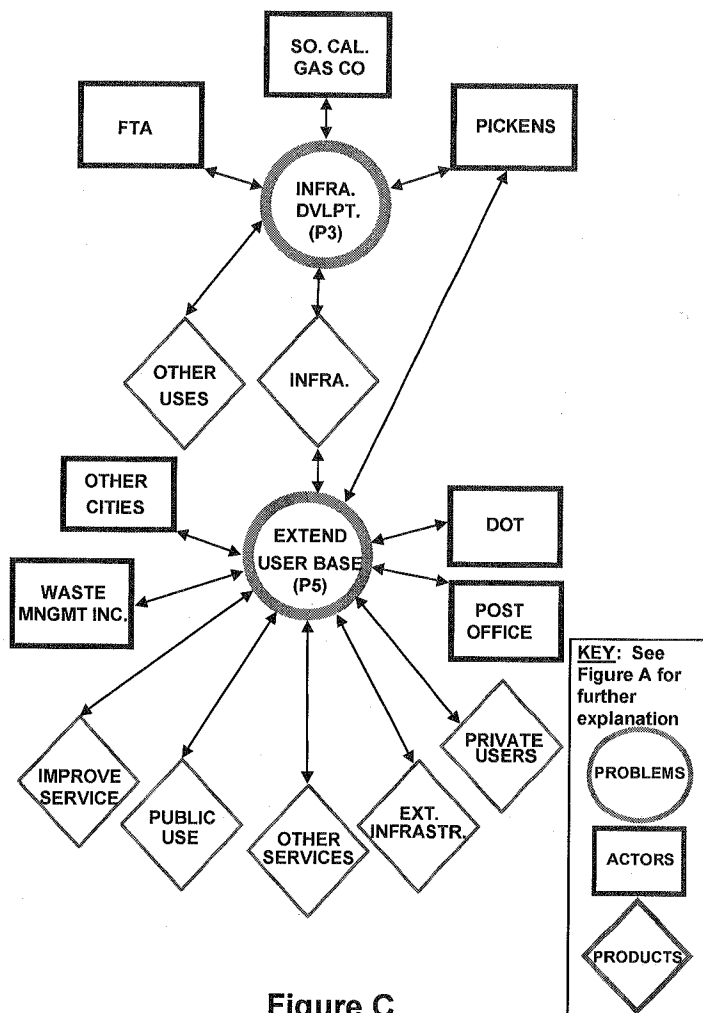
Diamonds represent the **products** which come out of the interaction among networks.



**Figure A**



**Figure B**



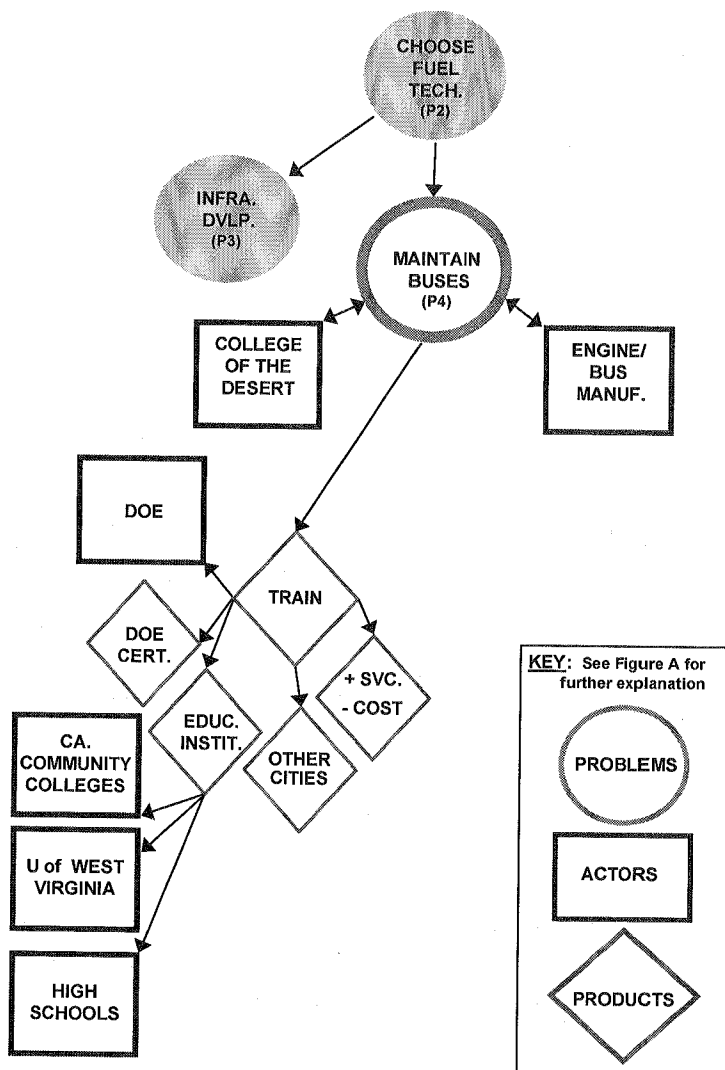
**Figure C**

Figures D, E, F, and G trace the evolution of the maintenance problem (P4) and the development of the network that accompanied it. SunLine found that no training program existed, so they had to put together a group to produce one. (See Figure D.) They selected the College of the Desert and the engine and bus manufacturers. The College of the Desert marketed the training program and found that there was broad interest. Together with SunLine, they have continued to develop and offer the program to a variety of clients. The training program brought the initial group into contact with the Department of Energy, which established training standards for new technologies and used SunLine's program as a model. It also involved them with an extended network of secondary and post-secondary educational institutions that were interested in adopting the SunLine program. These included the community college system of California, the University of West Virginia, and vocational high schools. SunLine's mechanics have also widened the educational network by playing a role in on-the-job training programs across the U.S. and internationally and providing informal consulting to other transit agencies.

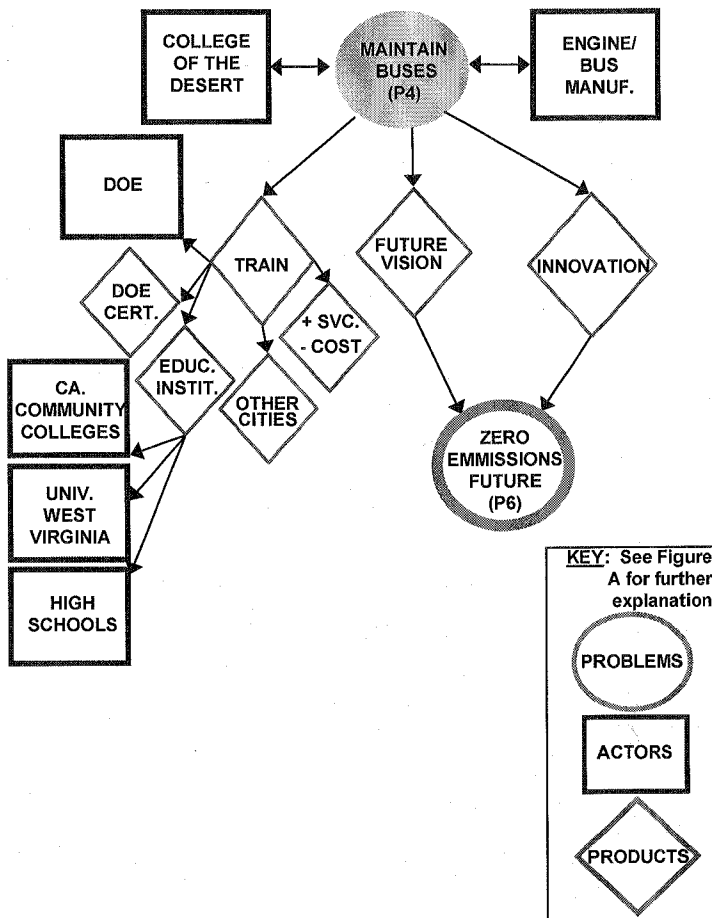
The training program had other consequences as well. It enabled SunLine to improve their service and reduce their costs after converting to CNG. Also, SunLine has partnered with manufacturers to beta test new technologies. This activity helps manufacturers learn how their technologies perform in the field, and it helps SunLine to develop new knowledge and skills and keep their maintenance staff "ahead of the curve."

As Figures E and F show, SunLine's interactions with educational institutions, manufacturers, and government agencies like the DOT and DOE have had a dramatic effect on their organization. SunLine now sees training and technology development as at the core of their transportation services. Furthermore, SunLine began to treat the conversion to CNG as an intermediate step. By solving what are essentially interim problems (the CNG training program and CNG infrastructure), SunLine was led to frame new problems. First, SunLine began to ask what it would take to become a zero-emissions transit company (P6). Life-cycle analysis was naturally incorporated into their practice and this problem was reformulated more specifically (P7): How can SunLine convert to hydrogen fuel cells?

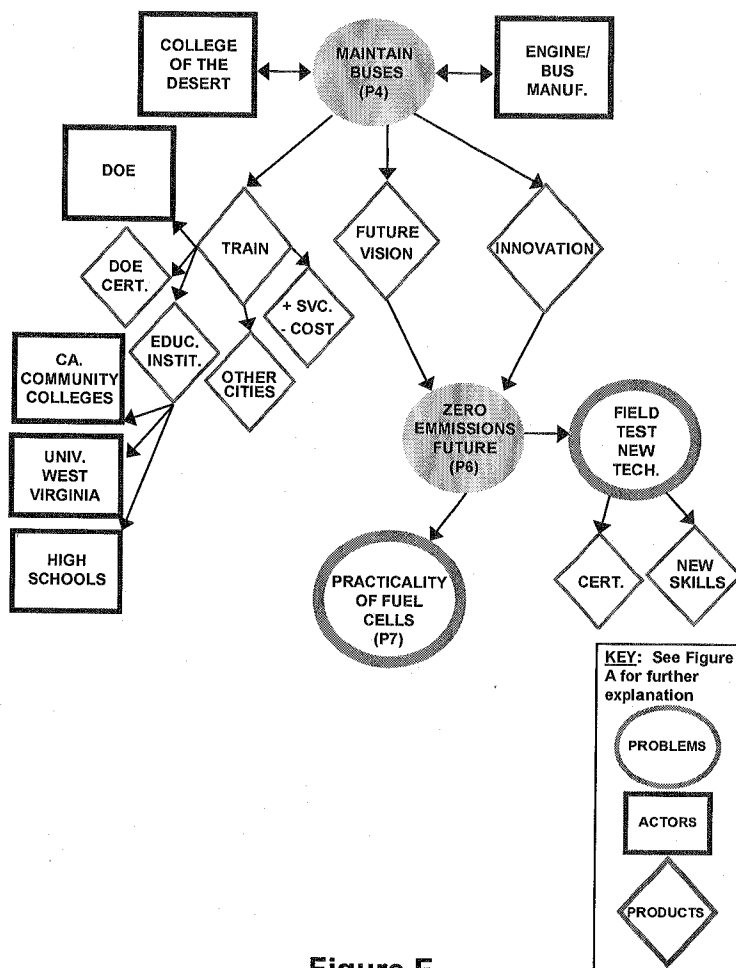
This new problem, illustrated in Figure G, is of interest to a broad group of actors and involves SunLine in an expanded network of interactions. SunLine had already formed relationships with the College of the Desert, DOT, DOE, and equipment manufacturers. Those actors were then joined



**Figure D**

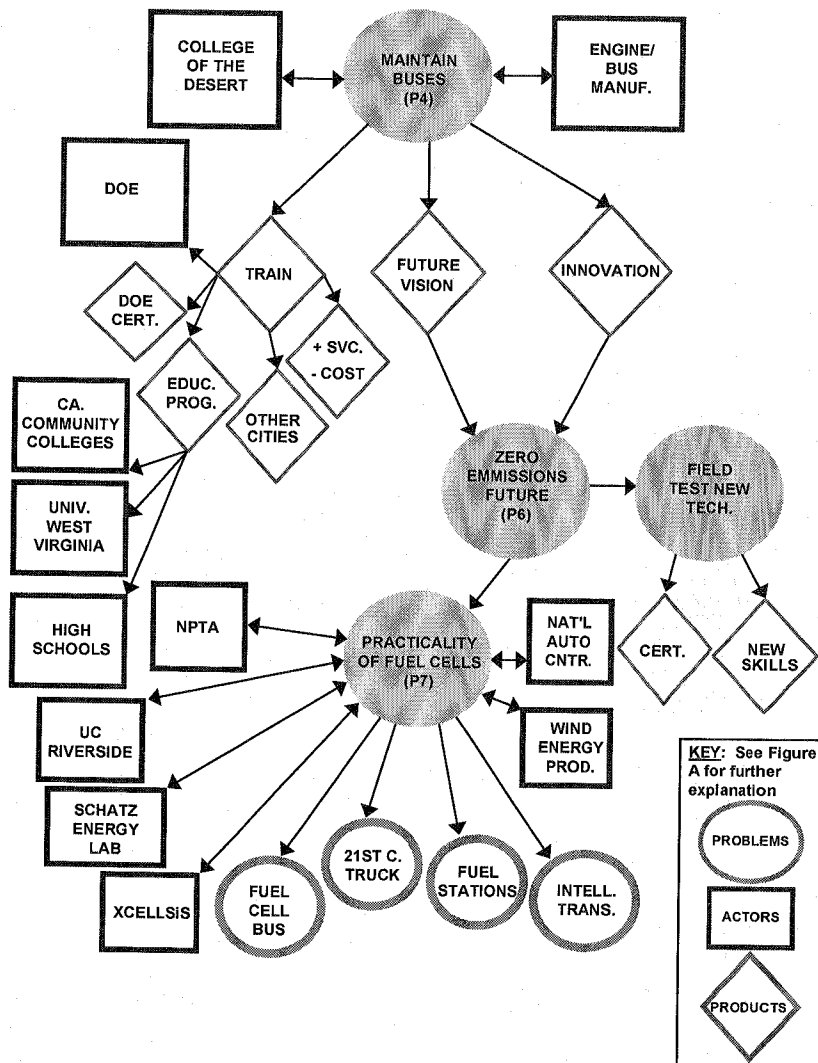


**Figure E**



**Figure F**





**Figure G**

by the Schatz Energy Laboratory at Humboldt State University, the University of California at Riverside, and the National Automotive Center. The fuel cell bus manufacturer XCELLSIS also became involved.

The fuel cell conversion problem is actually a series of problems. The 21st Century Truck program explores the design and maintenance requirements of onboard diesel reformers. The fuel cell bus program puts SunLine as the link between XCELLSIS and the DOE. The on-site reformers, fueling stations, and photovoltaic array extend an ongoing program with the DOE and Schatz Energy Laboratory. An effort is underway to extend this network to wind energy producers. These programs overlap with SunLine's work on the alternative-fuels committee of the American Public Transit Association. Also, both the bus and the 21st Century Truck programs involve questions about maintenance.

## **SunLine's Pattern of Development**

Figures A through G highlight the pattern of development—i.e., the network that evolved and the cascade of effects that resulted from one simple decision to acquire alternative-fuel vehicles. The current goal of this development—the hydrogen program—is emerging from a series of problems. To address these problems, SunLine has had to interact with numerous other actors. The maintenance/training problem is perhaps the best example of this. Everyone involved at the early stage cared strongly about the resolution of this problem. SunLine needed to train its mechanics and improve service. The College of the Desert wanted to expand its educational programs in automotive technology. The engine and bus manufacturers needed to offer training in the new technologies they were beginning to offer commercially. Because the technologies were new, the actors needed to work together to solve the problem. No single actor could do it alone.

This interaction provided a common experience of working together that made it easier, and more likely, for these actors to work together again. For example, SunLine and the College of the Desert continue to provide the training program together and to develop the content to reflect discoveries made in practice. The actors also discovered new problems of common interest. SunLine and the equipment manufacturers, for example, found they would both benefit by having SunLine test new equipment. SunLine gets access to new technology, staying ahead of the curve on maintenance and sustaining the culture of experimentation and learning that developed out of the original training problem. The equipment manufacturers get information

about how these technologies work in practice, which is essential for commercialization.<sup>23</sup>

The persistent involvement with new technology, the educational orientation that was initiated and sustained through SunLine's interaction with the College of the Desert, and questions about the future that were continually raised, if not provoked, in the context of the interactions with the DOE and the California Air Quality Boards, have created an environment in which it is both natural and possible to ask of any problem, "What's next?" The partnership with XCELLSIS and the DOE regarding the fuel cell buses, for instance, drew on SunLine's experience working with government agencies and equipment manufacturers. This enabled SunLine to provide the link between these actors. SunLine staff understood what was important to both organizations and knew how to talk to them and bring them together. The staff also recognized how each organization would benefit. XCELLSIS gets information about field performance and help identifying and solving the problems that arise. DOE gets a different set of data about the commercial use of fuel cells. SunLine gets an opportunity to acquaint its staff with hydrogen fuel cells, address questions about risk, and identify necessary changes in practice. If the past is any predictor, this will lead to the identification of a new problem of common interest.

## **The Central Role of Multi-Party Interactions**

Figures A through G illustrate what was essentially a process of sustainable development. The tangible artifacts that indicate that sustainable development occurred—such as the hydrogen program and the 400 vehicles in the Coachella Valley running on CNG—emerged from a process that did not make them explicit ends. Rather, these artifacts developed out of interactions among multiple actors around problems of common interest. Four things are worth noting about these interactions.

First, by working together, the various actors began to see themselves as united by common interests and complementary competencies. The problems attracted and held actors' attention at first, and then the actors reframed the problems so that they (the actors) continued to be relevant. The "disequilibria" that initially fixed the attention of SunLine, the College of the Desert, the equipment manufacturers, and the DOT also opened an exploration of broader interests that provided the basis for future interactions and sustained these actors' involvement. The actors continued to articulate new problems, and as a result, the organizations present at the beginning

were still involved at later stages.

The actors invested their time and resources in these new problems, in part, because they could see that a core of competence existed (among the other actors) to help resolve them. DOE, which started out looking for a model certification program for CNG mechanics, stayed around to cooperate with SunLine and others on the hydrogen program. Schatz Energy Laboratory got involved when SunLine became interested in hydrogen fuel cells. In addition to these explicit partnerships, the various organizations began to regularly consult with and advise each other on low-level problems.<sup>24</sup> The practices of these actors are joined through interaction around problems at several levels; the density of the interactions contributes to their robustness and fertility.

Second, the identities of these actors changed as a result of the interactions with other organizations. SunLine is the most dramatic case. Training was never a part of their business, but they have now come to view it as a core competency. Training continues to involve SunLine with new partners. Earlier partnerships have blossomed into technology development and beta-testing programs that feature training and maintenance as essential components. Through these experiences, SunLine's identity as an organization has changed. They now see themselves as actively engaged in a process of technology development that is tied to realizing environmental goals. As a result, they educate their staff not just about technology, but about broader issues like air pollution and global climate change.

Third, as the organizations' competence increased as a result of their interactions with others, they became interested in and able to take on larger problems. SunLine again provides a clear example. The problems SunLine is now interested in and able to work on are much more technically involved and have much broader policy implications than the problems they addressed in earlier stages. SunLine's development hinged on the interplay between interest and competence. To restate, an actor's interest in new problems pushes them to become involved with other actors, and through these interactions their capacity to act increases. Actors also see these problems in new and, often broader, ways, and so they are both pushed and made able to engage with a broader and deeper set of problems.<sup>25</sup>

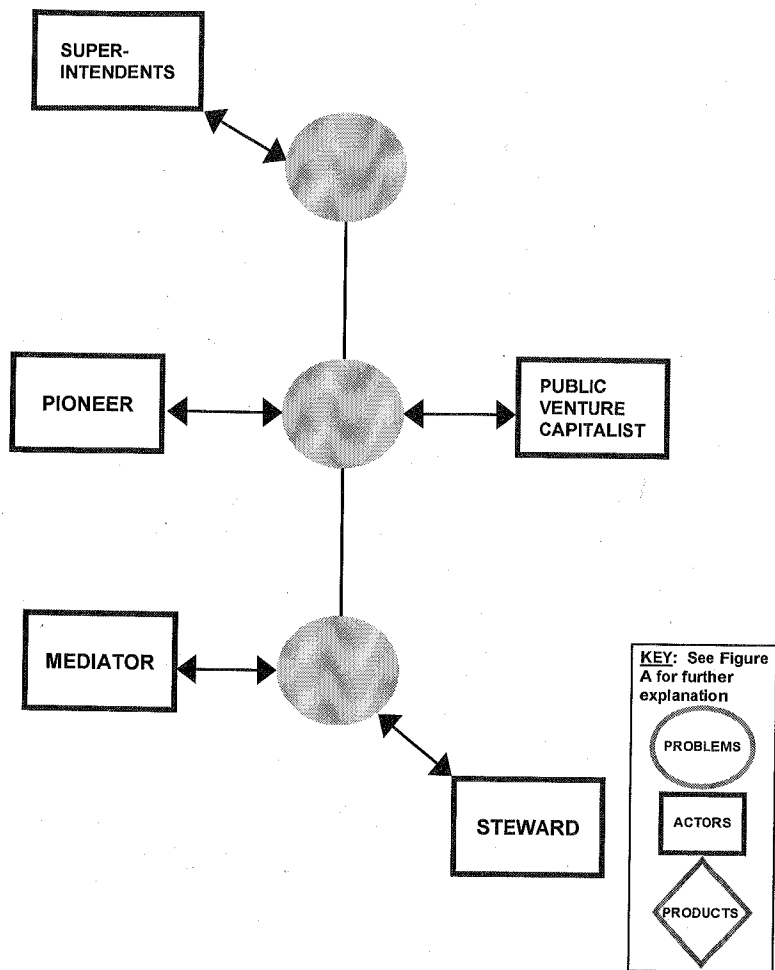
Finally, this pattern of sustainable development did not seem to depend on gaining access to scarce resources. Rather it drew on resources that were either "latent and conditionally available" or made more available by

the effort to use them.<sup>26</sup> The relationship between supply and demand in this case seems much closer to that which characterizes speaking a foreign language—the more you speak it the more you are able to speak it—than in using a natural resource like coal or gas where the supply is fixed.

These interactions still amount to a description, if an increasingly “thick” one, of the pattern of sustainable development. We see, for instance, how the efforts to understand and acquire the “fruits of progress” are joined. The translation of broad ends into tangible goals and the map to reach these goals both emerged from the ongoing effort to “meet and overcome successive obstacles.”<sup>27</sup> The process is “not so much one of finding optimal combinations of resources,” but of “calling forth and enlisting for development purposes resources that are hidden, scattered, or badly utilized.”<sup>28</sup> These obstacles, as the discussion of problems above illustrates, provided the focus for each round of interaction and the basis for successive rounds. Success in earlier rounds makes it more likely that the subject can be brought up again and that others will be interested. The commitment, at each moment, to solving the immediate problem is precisely what allows actors to develop a broader vision and the competence to realize it.

All of this might deepen our interest in the process of sustainable development. It does not, however, provide an adequate explanation of the process—of what keeps the relationships together, gives the actors access to the latent resources, or ensures that actors meet, rather than being overwhelmed by, the successive obstacles. It misses the fragility of the process, and fails to help us understand how agency, resources, competence, and interest came together again and again over time. We need a more acute image of the “binding agent” that keeps this process from flying apart.





**Figure H**

## **Part III:**

# **Understanding the Pattern of Development**

In this section we seek to understand the pattern of SunLine's development in terms of the roles that the various organizations filled at pivotal moments in the story. These roles shed insight on the central questions in all development stories: How was the venture started? How did it develop a distinct identity and set of resources? How did the actors cope with the problems that arose? By looking at the story in terms of roles, we can better discern the pattern of SunLine's development and understand its implications for policy and administrative action.

We focus on the five roles outlined in Figure H: Pioneer, Venture Capitalist, Superintendent, Mediator, and Steward. The combination of these roles accounts for much of SunLine's success. We want to emphasize two aspects of these roles. First, they should be understood as part of a set. That is, their relationships to each other are as important as their individual character. Pioneers are much less likely to emerge without the action of Superintendents, for example, and they are unlikely to succeed without the participation of Venture Capitalists and Mediators. Second, different actors play these roles at different times. In fact, one way to track development is to see how the players move between roles. For example, SunLine's management and board initially played the role of Pioneer, but, as development unfolded, this role was taken on by SunLine's maintenance staff and later by the College of the Desert, Pickens, and local elected officials.



## Pioneer

A big part of the story in this case is SunLine's "entrepreneurial" initiative. SunLine's commitment and determination continually brought new resources into play and enabled the agency to work their way through the succession of problems that expanded the circle of interaction. Their efforts could be summarized by the simple imperative to "Stick with it." However, this statement fails to convey the wide variety of ways SunLine worked to keep things moving. It also fails to acknowledge the pivotal contributions of other actors.

SunLine's story essentially began the moment the agency's board made a commitment to alternative-fuel technology. It is easy, in retrospect, to gloss over the controversial nature of this commitment. SunLine had no track record with alternative-fuel technology, let alone a solid record in public transit. Indeed, it would not have been surprising if SunLine's board looked at their dependability problems and sought a conservative solution based on tried-and-true technologies. Instead, they decided to experiment.

The board's willingness to take on the role of Pioneer came from their general commitment to environmental quality and their interest in alternative fuel technology. The board's decision depended on their close relationship with SunLine's management, and their confidence in management's ability to solve problems. It also hinged on the board's ability to provide management with a limited mandate. If management couldn't get anyone else to support the idea, especially financially, the board would back off. At the same time, the mandate was broad enough to make the use of alternative fuels a realistic possibility.

Whether the board acted as pioneers or as fools is much easier to say in retrospect. In describing the initial commitment to alternative-fuel technology, George Earl remembers that it was "a little scary," because he didn't understand what they were getting involved in. It must have seemed especially scary when they made the commitment to send money to a bankrupt Canadian bus manufacturer. As Dick Cromwell recalled, "Everyone in the United States thought we were nuts." Cromwell remembers it was "done on faith," but the faith was based upon informed judgment.

After their initial success, SunLine faced a series of problems in which their status as Pioneers rather than fools depended on their ability to attract new actors and resources. The ability to attract the right actors and solve these

problems was always in doubt at first. But early successes bred confidence and helped to develop resources and competencies, which have since made that confidence well founded.

The hydrogen program provides a good example of SunLine's willingness to take risks and play the Pioneer role. Many knowledgeable people believe that the time is not yet ripe for hydrogen-powered vehicles. Skeptics say that the energy demands of creating the fuel are too great and the infrastructure demands too burdensome. They might be right, or they might not, but we will never know if no one tries. SunLine is now busy assessing operational needs, addressing public acceptance issues, and working to produce the fuel without significant environmental costs. At the same time, they are building a compatible infrastructure and a base of experience with CNG that contributes directly to their ability to make hydrogen work. Their willingness to take on the role of Pioneer and risk being a fool continues to push the organization forward.

One of the primary effects of SunLine's willingness to make a commitment was to draw in other actors to play Pioneer roles in significant, if less immediately apparent, ways. The Federal Transit Administration (FTA), for example, (a part of the DOT) was willing to commit to new, untested funding arrangements, including the use of grant money to pay the loans on the buses and for capital investments in infrastructure. The College of the Desert pioneered a new training program at a time when the demand for training in alternative-fuels technology was uncertain. The program has turned out to have long-term value, of course. Pickens also took a risk by making joint investments in a new technology with a public agency under uncertain financial arrangements. Since then, Pickens and SunLine have together convinced the Postal Service, municipalities, and commercial users to commit to CNG technology. Thus, one effect of SunLine's efforts has been to lower the barriers and risks associated with using CNG. In this way they have enabled other actors to take on the role of Pioneer.

## Venture Capitalist

*I'm just naturally an entrepreneur, so you begin to just naturally do things entrepreneurially. The board got kind of excited about it and they let me continue.... What makes it exciting is there's lots of rules in government about what you can do entrepreneurially. You can't be in competition. You can't borrow the money the same way, and there are rules and strings for how you can spend it. Part of the challenge is figuring out how to make [it] work within the rules.*

(Dick Cromwell)

The Venture Capitalist (V.C.) is the second essential role. In the private sector, Venture Capitalists seek out and select promising ventures, evaluate and take financial risks, and package financial resources creatively. SunLine sometimes played the V.C. role, while at other times other organizations played this role.

SunLine has consistently taken financial risks and packaged resources creatively to meet project-driven needs. The most striking example was when SunLine used a conventional \$2.5 million grant from Congress to provide the cash flow to get Orion out of bankruptcy and back into bus production. A less creative or more conservative effort might easily have stalled at this stage, disrupting the project's momentum, undermining internal commitment, and propagating other impacts that could have thwarted the program. The commitment to alternative fuels might have been abandoned at this point, for instance, prompting the organization to take a better-traveled and more predictable route like diesel buses. The ability to respond to financial crises that emerge unexpectedly may be central to dealing with a new technology.

The construction of the refueling stations is another case in point. The development of CNG infrastructure was clearly necessary for SunLine's plans to succeed, but the agency lacked the financial (and technical) capacity to undertake this project unilaterally. When SunLine found a partner organization with complementary interests and capacities, it happened to be a private corporation. The joint venture SunLine negotiated with Pickens Fuel Corporation hinged on devising a financial arrangement that worked for both sides. Initially this translated into the need to find sufficient flexibility in the federal grants program to use grant money for a joint capital investment. This was just the first in an ongoing series of problems raised

by the need to work across the public-private boundary. In retrospect, such individual examples may seem like small hurdles. But in the moment, and particularly when they arise in close succession, these kinds of problems could easily erode the commitment of a less creative or less entrepreneurial organization.

Another example in which SunLine played a V.C. role comes from the audit problems that were generated by SunLine's partnership with Pickens. Cromwell explained the problem, and how they handled it.

[W]e have a public-private partnership with Pickens Fuel Corp., and they're the ones who build our fuel stations. We own these fueling stations together, and we share in the "profit." One of the rules is, when we do our reporting, the federal government wants to see an original invoice for the fuel station. Well, Pickens Fuel bought it from Southern California Gas, so there wasn't an original invoice. So all of a sudden you've got a problem with your audit. My job, of course, is to run to the federal government and explain this problem. And the federal government says, "Well, why do you think we let you be first? You're supposed to ferret this out and we'll figure out how to fix it."

The Federal Transit Administration has also repeatedly played the role of Venture Capitalist, particularly by working with SunLine creatively on financial arrangements. For example, SunLine's partnership with Pickens generates "profits" that SunLine reinvests in their transportation program. These profits run afoul of administrative rules and conventions. The FTA has been willing to experiment with these new financial arrangements so that funding can meet the needs of the venture. They did not guarantee the success of SunLine by backing them with all of the necessary financial resources. They have, however, helped SunLine get access to resources at critical points, and in ways that are sufficiently flexible to meet the needs of the project.

Through these interactions, the different organizations' financial creativity has been closely coupled with an ability to evaluate and a willingness to take risks.<sup>29</sup> SunLine's investment in Orion is the best example, but the infrastructure program, the training, and the new hydrogen programs all involve risky investments of one kind or another. The FTA took a risk by helping SunLine to purchase the buses and by investing in the

CNG infrastructure. These examples demonstrate the central importance of SunLine's ability to address questions about risk and package resources in those cases where risks are worth taking.

## **Superintendent**

*It's very important to get a group of folks that think differently, that come from different backgrounds, that run communities differently.... [They] all [can] come together and are quite supportive. (Dick Cromwell)*

The third essential role is that of Superintendent. The Superintendent is that organization (or individual) that seeks to create and maintain networks of related organizations and individuals and which they (or others) can draw on to solve problems that arise.<sup>30</sup> SunLine Transit, through their efforts to develop and maintain a network infrastructure, has continually played the Superintendent role in this case.

Relationships, institutional ties, and common experience have been consistent and important factors in SunLine's development. (Indeed, SunLine's experience highlights the importance of social as well as financial capital.) In trying to account for the board's initial confidence in him, Cromwell emphasized the overlapping associations that contributed to their confidence.

You have to understand my background. I ran department stores for about 25 years, and then I got into the public arena.... I'm an entrepreneur, basically.... But I was also an elected official. I've been a council person for one of the cities for about five years and I was on a school board for about six years. I was president of the school board.

At every stage in its development, SunLine has drawn on a similar background of relationships. To get backing for the request for congressional seed funding, SunLine drew on the personal and professional relationships of its management and board in the Coachella Valley. The structure of SunLine's board—the fact that it is constituted of the chief elected official in each of the communities SunLine serves—contributes directly to the development and maintenance of such ties.

Beginning with the initial selection of a technology, SunLine has continually drawn on informal relationships with other transit agencies and built relationships with other private actors. Ad hoc relationships have been transformed into durable lines of interaction and partnership. SunLine's relationship with the College of the Desert is an outstanding example. The training partnership has blossomed and been formalized with the establishment of a national training center. SunLine's relationships with other transit agencies, while more diffuse, have also provided a resource that SunLine has consistently drawn upon in order to solve operational problems. Many of the contacts that have been the most instrumental in moving the program forward were forged during part of the training program that takes place in SunLine's shop. Cromwell explained:

That's where this networking develops. That's where the suspicion [of a new technology] goes away, because management's not there. The teachers aren't there. It's just mechanic to mechanic. "Hey Joe, I mean what is this crap? Does this really work?" "Well yeah, let me show you." "Well gosh I'm a little nervous about this thing I learned over there...." "Well fine, here's my e-mail address...."

These relationships are especially important in an area like alternative fuels where the actors are consistently engaged with new problems. A network increases the available basis of experience and reflection. Cromwell explains how, after a maintenance accident, he recognized that SunLine needed a larger network of likeminded individuals and organizations with which to share ideas.

[The accident is what] made me get going on having an alternate fuels committee at the American Public Transit Association (APTA). So we could begin networking and all that. When we started out there were zero buses on natural gas, and now about 25 percent of the buses run on natural gas. And we head up the alternate fuels committee for APTA. [It's] nothing but a big bunch of networks. It's one of the most active committees in APTA. We have 90 people who come to our meeting four times a year.... And it's just exchange and interchange. E-mails back and forth and talking to each other, "I've had this problem," and "What's that mean?" That sort of thing. It's worked very well.

SunLine is now increasingly involved in helping other transit agencies make the conversion to alternative fuels. The network even extends overseas, as Cromwell explained.

We did an article in...1998 and...talked about partnerships and so on. And for some reason that struck a chord, and we've had people come here from all over the world. Holland has been here probably 5 times.... [We've also had visitors from] South America, Mexico, Iran...Egypt. I mean it's all the time. They go through [our facility] and look at it, and go look at the college, and see what we're doing. And now with the hydrogen it's going to be even more dramatic, since this is the only place in the world I'm aware of that this sort of thing [is being done]....

We were asked to go to Taiwan, and [they said,] "By the way, bring a bus." "Bring a bus?" "Yeah, bring a bus." Well, we put a bus under our arm and went to Taiwan. First alternate fuel on the island. We participated in the first alternate fuel conference they had there.... As a result of that they've now bought three or four buses. And they're in constant communication with our people on the issues they're finding and working out. We also had the People's Republic of China here two years ago, my counterpart [in Beijing] and his staff. [In Beijing] they put out 6,000 buses a day and move 6 million people a day. So we gave them a whole day on what we do here, and I took them for a ride on the bus. And before we got back I kicked the driver out and put my counterpart in the seat of the bus and said, "OK, let's go." I mean you talk about the wild ride.... All his guys in the [bus] were... just having a ball. Six months later they sent over 17 technicians, and we put them through a week's training program and they bought 1,500 CNG engines from Cummins Engine Company. Now the Cummins Engine Company has come to us and they want us to take the program to Beijing, so in October we'll be going to Beijing. The goal there is to sell the rest of the engines, to get...all 6,000 [converted to CNG].

It's clear that most of what SunLine has accomplished has drawn on ties and relationships with other actors. The close overlapping ties with the board and among board members are important for the way the board works and has approached transportation. The problems with both maintenance and the development of CNG infrastructure have been solved by drawing other actors into problem-solving networks. In the former case, SunLine's involvement with the College of the Desert and the equipment manufacturers has led to projects that involve the DOT and DOE, the U.S. Army, the University of California at Riverside, and Humboldt State University in California. SunLine is also tied through formal and informal networks to other transit providers, particularly those interested in alternative-fuel technology. SunLine has continually recognized the significance of these relationships and has acted, in the Superintendent's role, to cultivate and sustain them, even if only as byproducts of problem solving.

## Mediator

*At the end of the day, we find a way to make public entrepreneurship work, because it has to work for all the parties, just like in real business. And so you try to identify what is your issue and what is my issue and is there a way I can make that work within this box I have to work within? And then if the box gets too confining, what can I do to make the box move a little bit...together? We've had some pretty good success with all that. (Dick Cromwell)*

For SunLine, the development of networks depended on the ability to sustain momentum and deliver practical benefits to participants. Because each step on the path involved new technologies, new financing schemes, and new organizational arrangements, SunLine had to forge new agreements regarding what sort of practices would be acceptable. There were often no formal rules to follow, and the problems lay outside the scope of informal rules. There was no precedent to guide decision-making. On the one hand, moving forward meant building and sustaining consensus (within the organization and with other affected stakeholders) on goals and direction. On the other hand, it meant intervening to resolve the practical problems that emerged regularly and threatened to block the program. In both cases, SunLine and other actors had to play the role of Mediator.<sup>31</sup>

Many times, SunLine made a persistent effort to "bring everyone together." Their success in getting an appropriation from Congress, in holding the



board together when Orion went bankrupt, and in solving the training program all hinged on their ability to build consensus on goals and direction among a core group of stakeholders. SunLine made progress by informing other actors about its goals and practices and by involving them in addressing problems. They were committed to making progress on terms compatible with the values of openness and respect for others' ability to learn. This contrasts with efforts to restrict access, control problems and information, and centralize authority, which often characterize organizational strategy in uncertain and volatile environments.

In SunLine's organizational vernacular, "selling" involves providing information and reasons that address the buyers' interests, engaging their sense of the future, and dramatizing the mutability of the present. Change, in this program, is learning, and it implies a reciprocal commitment to be open to new possibilities and new information. This certainly was the attitude that characterized the organization's approach to the now-familiar succession of problems. SunLine's management and staff took the board's initial mandate as a commitment to build consensus with them about the organizational implications and technical choices implied by the move to alternative fuels. By interacting with the board on each decision from the outset, Cromwell and his staff demonstrated respect for the board's ability to understand and be engaged in the process. This, in turn, forced the board to demonstrate that they were worthy of this respect by engaging in the complexity of the organization's situation.

SunLine's approach to other problems has been similar. The way they involved the College of the Desert and the equipment manufacturers in developing the training program demonstrates these commitments to learning. The way the training program was handled internally also exemplifies this approach to change. Management treated the concerns of the employees as legitimate and involved them in building consensus about how practice must change, rather than by simply training them to perform tasks. The maintenance staff were treated as individuals who were capable of learning and change. As George Earl was quoted as saying earlier, "You've got to make [the mechanics] part of the whole thing, and say 'your input is just as critical as that guy's input.' And make them part of it, so they feel like they're being more valuable, and they'll come [along] faster."

Most of the staff not only demonstrated that they were capable of change, but found that it made their work more interesting and engaging. Earl has transferred this approach to day-to-day work as well. He encourages

the development of "controversies" about maintenance techniques and procedure and uses these as opportunities to learn. He explained how it works:

We're always coming at each other with, "This ain't working," or "This is working," or "Can we do it this way?" And then...among the supervisor staff we'll get together and say, "Well, what do you think?" And they'll go out to their shift and they'll talk about it out there and then we'll come back and meet again. Once we decide [on a solution], we create a paper that goes in each mechanic's thing that [describes] the new procedure.... Everything is...up for grabs and [can] be revised at any time, as long as we can prove to ourselves that we found an easier and better way of doing something, and we're accomplishing the same thing or making it better.

Since SunLine is always breaking new ground, they face similar challenges when working with the organizations that are affected by their efforts. When the CNG refueling station was installed, for instance, the entities responsible for public safety, such as the fire department, became involved. They were nervous about the new station, and the possibility of a sudden controversy was always imminent. Cromwell and others at SunLine worked hard to involve these actors in decision making and design, and to respond to their questions and concerns. Over time, Cromwell said, they learned to trust SunLine.

[W]e told them what we were going to do [regarding the fueling station], because there were no rules, there were no safety rules, there wasn't anything there. This was 7 years ago. [We were] the first people in the United States to do this. Well you know, all of a sudden you find out the fire guys didn't show up at the meeting anymore. You call them and say, "You weren't at the meeting." They say, "Oh, it's all right, we feel comfortable with what you're doing." Then the safety guys are gone. And then all parties that would have an issue are gone because they felt comfortable.

The benefits of this approach were realized when SunLine experienced a small accident in its maintenance shop. A flare of gas ignited and burned near the ceiling. The fire was put out and the problem that caused it was

quickly fixed. SunLine had already developed relationships with the actors outside the organization who might have disrupted their program over a problem such as this. They were thus able to address the issues raised by the accident directly and without controversy. In fact, SunLine treated the accident as an occasion to further develop consensus that CNG could be handled safely. Instead of minimizing publicity, SunLine actually wrote up information about the accident and submitted it to the FTA, which published it.

SunLine is now working to build acceptance within the organization of its hydrogen program. As Cromwell was quoted as saying earlier, SunLine is developing a curriculum on hydrogen for its employees that provides time to air concerns and fears about using the volatile fuel.

This aspect of SunLine's experience highlights how the effort to build consensus merges into a process of learning and development that occurs through interaction and the re-elaboration of problems and relationships over time. These aren't spontaneous characteristics of change. In SunLine's case, they depended upon efforts to shape actions and settings in ways that treat others with respect, starting from the assumption that their concerns are legitimate and engaging their capacity to learn and to reason. These efforts illustrate the central role of the Mediator in defining organizational practice and meeting the goals of the agency and the broader public.

SunLine is also working to develop broad public understanding of their CNG and hydrogen programs and, with it, interest in the potential of alternative fuels. Percy Byrd, who was recently appointed for a second term as chairman of SunLine's board, started his relationship with SunLine as a critic and opponent. Dick Cromwell and others at SunLine took the time to address his concerns and explain their goals, and Byrd has since become an active promoter of SunLine and alternative fuels. Cromwell describes how Byrd first got involved.

I was at a meeting [in the town of Indian Wells]. One of the ways we help our cities get going is we support them getting [natural gas] vehicles by [delivering] the gas, because it's very expensive to put in your own compressor. So...we'll deliver the gas to you and then when you get 20 vehicles that are on natural gas you can either use the infrastructure we've got in place, or [you can now justify] putting in a compressor. So I was there [encouraging] the council to put

in a manifold system for their two vehicles. Well, Percy didn't quite understand what was going on, so he got up there and raised all kinds of Cain about it: "We don't want a gas station in Indian Wells." So anyway the council went with it because our current chairman was the mayor at the time and he was able to persuade him. [A]s I was leaving I talked to Percy, and I said, "You know, Percy, I think you have a little misunderstanding of what we're trying to do. Why don't you come on out, let me show you what's going on." So I brought him out here and took him on a tour, and we had lunch. And the next thing you know he's all excited about this.... Son of a gun, he [soon] ran for office, he won, and [now] he's on our board. And they just voted him for his second year as chairman.

These efforts helped to avert numerous potential problems and quickly defuse those that did emerge.

The process of involving actors with diverse backgrounds and interests in exploring new terrain also required SunLine to intervene in a much more directed way on a regular basis. The hydrogen program provides a good example. One key element of this program involves using a fuel cell bus in regular commercial operation. The idea is to develop hands-on experience about the operational and maintenance requirements of this technology, and also to provide a focal point for discussions about hydrogen. SunLine currently has one bus from XCELLSIS, and next year will exchange this bus for two more.

The program that first led SunLine to deploy hydrogen buses brought SunLine into a partnership with XCELLSIS and the U.S. Department of Energy. These actors were both contributing resources, but had interests that initially seemed incompatible. The DOE was interested in hydrogen as a future fuel source and wanted to get information on the operation of the bus in exchange for its investment in the program. XCELLSIS, by contrast, saw itself as involved in a competitive product-development business. They did not want to release information to the DOE that they viewed as proprietary. This disagreement threatened the whole venture.

SunLine, however, understood enough about both parties to see that the DOE wanted access to information that did not in fact threaten XCELLSIS's competitiveness. SunLine intervened and played the role of Mediator to help both parties understand and consider their real interests and stakes.

In the end, both parties came to see that the points of contention were not as significant as the benefits the partnership would yield. Without SunLine's active involvement, however, the entire program could easily have foundered on the details of this particular dispute.

## **Steward of the common good**

The final role is that of Steward. From the outset, SunLine has played the role of Steward by espousing recognized public goals and ensuring that its activities contribute to the achievement of these goals. The conversion to CNG originated in the board's commitment to environmental goals, for example.

SunLine's partners in this project have also filled the role of Steward at times. The commitment of the Southern California Gas Company, one of SunLine's earliest partners, derived partially from their desire to expand their market and partially from a sense of responsibility to further the development of alternative fuels. Warren Mitchell, President of the gas company, highlighted this sense of duty when he described why he committed to the partnership with SunLine.

The thing about natural gas vehicles is there's a chicken and the egg situation that occurs. You have to have vehicles on the road to get refueling infrastructure and you have to have refueling infrastructure to get vehicles on the road. So we feel a *responsibility* to help kick start the market and make that happen. (emphasis added)

SunLine has continued to develop its association with public goals and to glean benefits from this association. SunLine brought together a group of 100 stakeholders in the Coachella Valley to participate in the DOE's Clean Cities Program. SunLine's efforts have been recognized with awards by the DOE, the American Public Transit Association, and the Federal Highway and Transit Administrations, among others. These efforts have tangible benefits as well as reputation effects. In 1997, SunLine received the "Rain Maker" award from the DOE in recognition of all the funds they have leveraged from these efforts. SunLine also maintains a strong connection to other public goals associated with public transit. They are committed, for instance, to providing a high level of service to the disabled and other groups with special needs.

These activities and the pattern of formal cooperation and informal interaction they involve have contributed to a regional identification with the alternative-fuels program. The Coachella Valley now advertises itself as an "International Center of Alternate Fuel Vehicles." More than this, alternative-fuel technologies provide the thread that organizes many residents' views about the direction development should take in the Valley. Consider the following quotes:

I think for the Valley, it just puts us way out ahead of innovations throughout the country. We pride ourselves here on our natural environment, and by switching from diesel fuel to natural gas, we're going to preserve that environment not only for our children but for many generations to come. (Julie Bornstien, Assemblymember, 80<sup>th</sup> district, California State Assembly)

The entire Coachella Valley has embraced this project. All nine cities have committed to fleets. The infrastructure is being supported by the Southern California Gas Company. What has happened is that the entire Coachella Valley has become a regional demonstration of how an entire geographical area can make a conversion to cleaner fuels by being supported by municipalities, by public education, and by the private sector. (Terry Green, Dean of Community Education and Resource Development, College of the Desert)

I think the Coachella Valley is a very unique area. And the people here, they're innovators. I think that this is a fantastic place to create a model for CNG development. Working with SunLine Transit..., the College of the Desert, and the other partners, we were able to accomplish something in a very short period of time at reduced costs for everyone involved, including our ratepayers, our company, and the taxpayers of this area. (Vern Keener, District Manager, The Southern California Gas Company)

I think you can see that we have nine cities in the county that are really excited that they produced something that is evolutionary. In fact, we are kind of part of an evolution. Here in the Coachella Valley we kind of see ourselves as a

biosphere of doing demonstrations and things that are on the cutting edge. All the questions on moving from a traditional fuel to an alternate fuel are answered by natural gas. (Dick Cromwell, SunLine Transit)

There you have it. Out of the practical interactions that took place over issues like training, vehicle maintenance, and infrastructure development, a vision of community has emerged with technology development at its core. This vision ties together past, present, and future, and links economic activity and environmental goals in an open-ended relationship. In doing so, this vision gives expression to a notion of sustainability that is tangible and robust. Much of the strength of this vision derives from its emergent, open-ended character.

This rendering highlights a generative aspect of stewardship that is significant in the context of sustainability. Stewardship does not have to be understood as husbanding a fixed pool of commitments and beliefs that secure the legitimacy of projects, practices, and institutions. It extends to synthetic notions of generating, or transforming notions of the common good, through interaction around practical problems. Community, in this sense, can be understood not solely as the source of goals for policy making, and thereby the touchstone of legitimacy, but also as an outcome, an end of policy making. In this sense, the process of making and implementing sustainable development policy can be understood as a practice in which community—democratic political community—is made. This also enhances our understanding of sustainability as a political problem, perhaps one of a limited set of problems, that generates attention and interest sufficiently broad and deep to become a basis for the renewal of political community.

## **Part IV:**

# **The Relevance and Implications of the Developmental Roles**

In this section, we examine the broader relevance and implications of the five roles—Pioneer, Venture Capitalist, Superintendent, Mediator, and Steward—that we drew on to understand and explain the pattern of development in the SunLine case. For each role, we examine whether and how it can be found in other cases, comment on its internal organization, and review how it might fit in a policy program focused on sustainable development. The goal is to test the plausibility of these roles as the foundation for a more general explanation of patterns of development and a set of policy prescriptions. We demonstrate that they are not unique to the SunLine case, but have a broader explanatory value and a more general resonance for sustainable development policy.

### **Pioneers**

Two essential elements of entrepreneurship are the ability to read opportunity in the everyday, and the ability to make commitments that create action. Both elements involve taking action before there is clear evidence that success will follow.

In the SunLine story, success was tied to the board's ability to both recognize the potential for radical change inherent in the acquisition of a new fleet, and to commit to alternative fuels before they had proof that this approach would (or even could) succeed. The protagonists in this drama agree that a provisional commitment at this stage—to buy, say, three or four alternative-fuel buses rather than a whole fleet—would likely have failed. Only the full commitment to an entire fleet of alternative-fuel buses was sufficient to establish the conditions for success.

The board was only the first to play the role of Pioneer, however. Their success and wisdom depended on securing commitments from SunLine's management and maintenance staff, Pickens Fuel, the College of the Desert, and the Department of Transportation. While the pioneering actions of these other organizations may not have been as dramatic, they were also done



“on faith,” without the assurance of success, and were ultimately integral to success. Commitments continue to be important and relevant in SunLine’s hydrogen program.

The term “Pioneer” signifies the studied faith that is essential to functioning in uncertain, open-ended environments. As we pointed out previously, the vision of the Pioneer is often difficult to differentiate from the fantasy of the fool at the outset. In fact, the Pioneer’s origins are in the willingness to take on this role of the “visible fool.” This willingness is essential for ventures like SunLine’s to get off the ground and develop.

The importance of Pioneers is not unique to the SunLine case. In 1997, for instance, Greenpeace made a commitment that might have appeared foolish to more experienced hands in the photovoltaic (PV) industry. Greenpeace felt PV cells offered a much more immediate potential than was being realized. In order to break through the stalemate that was preventing higher production, Greenpeace decided to take direct action that would put solar panels on the roofs of homes and offices. They thereby hoped to generate an “action vector” that would draw together purchasing and production commitments and make panels cheaper, more accessible, and more commonly discussed by consumers and citizens. This, in turn, would help to moderate climate change and promote environmental sustainability.

Greenpeace dubbed the project “Solaris,” and committed to the ambitious goal of placing 20,000 solar panels on Dutch roofs within two years. Their strategy was to use the organization’s visibility and legitimacy with the public to appeal directly to citizens and get them to contract to purchase solar panels. These contracts would then be assembled into a purchasing block that would interest producers and help to break the volume/price standoff that was keeping production levels low.<sup>32</sup> Because Greenpeace lacked the financial resources, market understanding, or production capabilities to pursue this strategy unilaterally, they assembled a network of actors to meet their ambitious target.

Greenpeace brought in the consulting firm Ecofys to conduct the market study that would set the panels’ target price and shape the technical design. Ecofys identified three primary consumer rationales for purchasing solar panels: the excitement of being the first to use a new technology, a desire to help the environment, and the independence that comes with producing one’s own electricity. The product design merged these insights with Greenpeace’s direct marketing strategy. The do-it-yourself kit could

be sold directly to consumers and assembled at home without professional assistance or exotic tools. The panels could be mounted on a roof with the hardware contained in the kit, and plugged directly into a household electrical outlet.

RaboBank committed to help with the financial arrangements, and Stork, another consulting firm, committed to manage the supply chain and assemble the packages. Ecostream, a spin-off from Ecofys, agreed to manage the marketing for the kits. Because Greenpeace had collected customer contracts, any number of industrial producers, including Shell, were willing to produce the photovoltaic panels for the kits.

Ecofys's market study revealed that consumers would be willing to pay NLG 1000 for a PV kit.<sup>33</sup> To bring the market price down to this target, the government and utilities would need to provide a package of subsidies. With the contracts from consumers in hand, Greenpeace was able to persuade NOVEM, a quasi-government entity, to redirect funds to the project, enough to subsidize 5,300 PV panels. However, NOVEM was only permitted to give subsidies to commercial enterprises. Greenpeace and the others worked out a scheme in which the funds were given to Rabobank, which then leased the panels to the consumers. This brought the price down to the targeted level.

As of June 2000, participants in Solaris had leased 3,100 panels. The partnership between Ecofys/Ecostream, RaboBank, and Stork will continue until all 5,300 panels subsidized by NOVEM have been sold. After that point, Ecostream, as project manager, plans to continue Solaris, but some of the other partners may decide to leave. Ecostream has learned lessons through cooperative work on Solaris about how different types of organizations contribute to joint ventures, and may replace certain partners. Greenpeace's involvement in Solaris, after initiating the project, chiefly involved mailing information to Greenpeace members and allowing the partnership to use the Greenpeace logo on informational materials. After fulfilling these responsibilities, Greenpeace discontinued its active role.

Overall, the results of the project are mixed. The number of panels leased falls far short of expectations. However, Solaris did introduce thousands of people to photovoltaic technology, and the learning gained in the process was of significant value. For example, some consumers became frustrated that they could not determine how much electricity they were saving by using the panels. In response to that frustration, a meter was developed

that consumers could purchase to measure energy production. This design modification was an important contribution, because it recognized and addressed a likely barrier to the technology's future dissemination that would not have been identified through continued research and development work. Ecostream and NOVEM also learned much about customers' desires through a formal study and an informal follow-up. Ecostream has decided to apply the lessons it learned from Solaris to another project that offers hot water systems to private consumers.

Greenpeace also proved its point that action can push technologies forward. Solaris brought together a network of actors, connected ideas, resources, and expertise, and contributed to the development of social capital. Moreover, it enabled these actors to learn about consumer demand and response to certain design elements, marketing and financing strategies, and a host of other factors that will be critical for this product's and other products' future success.

Unlike the SunLine story, Greenpeace did not face an explicit crisis like the August day when 24 of SunLine's 37 buses broke down. The catalyst in the Solaris case was Greenpeace's decision to commit its organizational resources to a project that would put photovoltaic panels on roofs.

Two doctors from the Dortmund Institute for Public Health in Germany, Dr. Rosin and Dr. Preisendanz, made a similar commitment in 1989. They needed a new cold storage room for their institute, but all the units on the market posed threats to ozone or contributed to global climate change. This discovery motivated the doctors to commit time and resources to an effort to develop an environmentally friendly cooling technology. After developing this "Greenfreeze" technology, the doctors joined with Greenpeace and a refrigerator manufacturer to introduce the Greenfreeze refrigerator to the market. The new technology caught on very quickly; there are now approximately 40 million Greenfreeze refrigerators worldwide.

Firms can also play the role of Pioneer. Intergamma, for example, a Dutch company that sells wood products, decided to sell only certified sustainable wood. This case also illustrates the way an individual's commitment can be amplified when it is embraced by an entire organization. Intergamma's director served as Pioneer initially. He was committed to selling certified sustainable wood before it was certain that such a thing was feasible. Since making that decision, the director has institutionalized it in corporate policy and practice, and has transformed his decision into a corporate commitment,

which makes it more likely to succeed. This commitment has enhanced the firm's reputation as socially responsible, which in turn has broadened and deepened the organization's commitment to the goal. Intergamma's new reputation makes it easier for management to work with government and environmental advocates, and has simplified work for branch managers by eliminating embarrassing environmental protest activities directed at certain stores. In this and other cases, the Pioneer's solid reputation and position of influence within his or her organization has seemed important in achieving organizational commitment.

Pioneers provide an initial spark that can ignite entrepreneurial activity that serves public goals. In fact, Pioneers help to generalize across organizational and sectoral boundaries, even into private firms, such as Intergamma. This practical idealism is an important background for entrepreneurs' willingness to assume the risk involved in launching initiatives. In other words, to be willing to assume that risk, the Pioneer must believe that his or her idea can make a difference.

Other examples of Pioneers abound. Environmental organizations in Flanders, for example, partnered with small firms to pioneer the use of small-scale water purification technology as an alternative to conventional wastewater systems. The use of wind energy was similarly pioneered in the Netherlands by cooperatives founded by citizens.

Environmental and citizen organizations sometimes expend effort and resources for public goals rather than a financial return, which enables them to effect change where private industry will not. The German chemical industry, for example, had researched environmentally friendly cooling technology, but never identified the mixture that the Dortmund doctors found because they were only looking for formulas that could be patented and used for a profit. Dr. Rosin and Dr. Preisendanz did not benefit financially from patents on the Greenfreeze technology, because the cooling agent was simply a particular combination of natural gases.

The examples of the Dortmund doctors, Greenpeace, and the director of Intergamma, as well as the SunLine board, show that the role of Pioneer can be played by private citizens, people in environmental organizations, governmental agencies, and/or private firms. Because the combination of conditions needed for a pioneering initiative does not arise every day, and because entrepreneurial initiatives require significant support to succeed, government should be poised to identify and support public-

spirited Pioneers. A publicized governmental program to support Pioneers could play an important role in encouraging people who are unsure about whether to pursue an entrepreneurial venture to become Pioneers.

## Public Venture Capitalist

In the United States, and increasingly in Europe, venture capital is an important engine for the development of new ventures in the private sector. V.C. investment supports private entrepreneurship by providing funding, advice, and connections in the early stages of development, when the high levels of uncertainty deter other investors. In the SunLine story, influxes of flexible capital were pivotal in getting the buses manufactured and developing the fueling infrastructure. Indeed, financial inventiveness and the ability to engage risk, both of which characterize venture capital, were at least as important as technical invention and organization adaptation in the program's success. In order to better understand how *public* venture capital might work in the context of public entrepreneurship, we turn to look at how *private* venture capital functions.

In the private sector, venture capital is thriving. In the United States, venture capital investment reached an all-time high in the first quarter of 2000, with \$12.5 billion put towards startup financing. The V.C. industry in Europe is less developed, in part because of greater risk-capital market fragmentation. Investor networks are also not as developed in Europe. Moreover, restrictions on investment (even among European Financial Union members) make it difficult for fund managers to invest in foreign ventures that are not publicly traded. V.C. also carries a greater perception of risk in the E.U. and, as a result, institutional investors (e.g., pension fund managers) rarely invest in venture capital. V.C. is growing in the E.U., however. Global Finance predicts V.C. investment will double or triple in the next few years, especially as more European consumers make use of the internet—the technology that fueled the United States' V.C. boom.

The high returns venture capital has earned recently (an average of 146.2 percent in the U.S. in 1999) are certainly a substantial factor in its current popularity. An institutional analysis of the V.C. industry, however, reveals a reliance on formal and informal networks and historical experience that create a kind tipping effect, in which each round of investment makes it more likely that future rounds will follow. The surge in internet investing, for instance, can also be explained by the spread of investor networks and the development of historical experience that provides a basis for decision

making. This institutional analysis suggests that if investment, interest, networks, and experience can be attracted to green technology sectors, this will build a momentum that will, in turn, attract more attention and investment.

In the private sector, a typical venture begins with an innovative concept or technology that a Pioneer has developed on his or her own time. If the initial research is promising, the Pioneer will seek resources to support further development. At this stage, Pioneers usually turn to business "angels." Angels are wealthy individuals with business knowledge; many are successful entrepreneurs themselves. They meet Pioneers through networks of personal ties to businesses, university researchers, and other investors. Angels rely on their personal experience to evaluate the ventures they find through these ties. If a project looks promising, they lend seed money and help the young firm develop a business plan and make contacts with other investors. In return, the angel receives equity in the new company; this has the effect of securing the angel's commitment to the project.

If the product and business plan progress, angels expect their protégés to seek additional private investment. "V.C. shops" provide the larger investment needed in this second stage of development to gear up for production or launch a product. V.C. shops are usually private partnerships of investors. Their average investment in a start-up is \$5 million, a large enough outlay to secure their commitment. Like angels, V.C. shops monitor the ventures' progress closely (some Pioneers might say too closely) and provide financial and strategic advice along with their dollars. They may rewrite the business plan, help develop a corporate board, select a C.E.O., and bring in other second-round investors.

Start-ups generally go through several rounds of financing while their products are being developed, test-marketed, and sold. From the V.C. financing stage, successful companies either go public with a sale of stock, or sell their operations to a larger firm. This is the stage at which the angels and V.C. shops receive their payoff.

Five characteristics distinguish Venture Capitalists from other investors and lend the V.C. industry its distinctive character. V.C. investors are not only tolerant of risk, but used to working with it. V.C. investors are patient through the long holding periods that separate investment from return. V.C. investors work to actively influence the future of their investments. V.C. investors rely extensively on networks. Finally, V.C. investors' decisions are

shaped by heuristics that develop out of their own experience and interaction with other investors. We will now address each of these characteristics in more detail.

Risk tolerance is the major quality that distinguishes venture capital from other sources of investment. Banks are bound by legal codes of ethics and internal standard operating procedures to avoid investments in which exposure is high and risk is difficult to characterize. Bankers must be ready to justify their decisions with respect to established rules and standards of practice. V.C. firms, on the other hand, are organized around the idea of risk. Even in a generous economy, most new businesses fail. In the U.S., only between one in three and one in five start-ups succeed. V.C. investors thus expect that they will lose on 66 percent to 80 percent of their investment picks. Moreover, each pick represents an investment of several million dollars that may return little or nothing. This enormous risk is balanced by the fact that the return on successful investments is potentially spectacular. The ability to function in this kind of high stakes, boom-or-bust environment is one of the features that characterizes venture capital investing.

The second quality that distinguishes V.C. investing is the long holding periods that separate investment from return. While stock market investments are highly liquid, ownership in start-up firms is not tradable, and the firm may take from three to ten years to be purchased by another company or offer stock that can be traded publicly. During that time, investors must wait. The average holding period for a V.C. investment is just over four years—a long time in financial terms. Thus investors must be patient and willing to let projects develop (even if they help them along).

A third quality of Venture Capitalists is their extensive use of networks. V.C. investors use networks to solicit winning business concepts, to evaluate the concepts they receive, and to support the concepts they capitalize as firms. The networks employed by the V.C. industry include wealthy individual investors, business and industry groups, and even university contacts and other interest groups primarily outside the business community. Within the V.C. “industry,” networks have been institutionalized as “investment clubs” and “forums” that provide networking opportunities.

Unlike stock market investors, V.C.s are not passive. They use their personal knowledge and network of connections to actively promote the success of the firms that they back. Angels and the principals in V.C. shops act as consultants, give advice from their own experience, promote their firms

among their personal and professional friends, even call in personal favors on behalf of the companies they support. The role investment plays in securing commitment and sustaining attention and, in turn, in gaining access to the resources necessary to meet challenges, cannot be overemphasized. Venture capital investment links start-ups into networks that make it increasingly likely that they will get access to the resources they need.

Finally, the decision-making processes of V.C. firms are heuristic. Most V.C. investors—both partners in V.C. firms and individual angels—are experienced entrepreneurs who have founded companies. They keep close tabs on the industries in which they invest, tracking profits, losses, and new investment. However, they also rely on a less-quantifiable “pulse” of the industry. V.C. investors make their decisions based on trial-and-error experience and by comparing the new venture with other firms in the industry. They use these comparisons to try to assess the potential of technologies and the competence of management. This calculation often turns on intangibles like whether the leadership is creative and committed enough to succeed or, if they succeed, how the new technology will transform the industry. Venture capitalists themselves characterize this process as “intuitive.”

These traits add up to the distinctive institutional character that weds investment to commitment and decisions to experience, that builds the formal and informal ties that shape the evaluation of prospects and the development of projects, and that unites a taste for risk with the prospect of big payoffs. Venture capitalists are also characterized by the patience to wait through the stages of a project’s development and the resourcefulness to put together the resources needed to push a project over any bumps that crop up. The distinctive character of these traits raises questions about whether a public equivalent of a venture capital could be developed, what challenges it would need to overcome, and what it would look like in the end.

The Small Business Administration (SBA) in the U.S. provides one view of how risk capital might be organized and operate in a public context. The SBA, an independent federal agency, sometimes plays the role of angel, giving start-up firms \$100,000 grants to investigate the technical merit and feasibility of an idea or technology. If this initial stage goes well, the SBA will renew the award for up to \$750,000 over two years to develop the project’s commercialization potential. The SBA has developed in-house expertise in evaluating technical feasibility at this stage, so it makes these angel grants directly. It also functions like an angel by providing free advice



and finding mentors from a pool of retired executive volunteers. After two years, the SBA expects the small business to move on to private capital. For many firms, the initial federal grant is essential for developing their project to the point where it can attract private investment.

The SBA also provides stage-two financing on the scale supplied by V.C. shops. In this context, the SBA does not invest directly but uses a matching program. This ensures that there is substantive private interest and, in effect, creates a partnership with private V.C. shops. The private shops make the initial assessment, and only after they demonstrate that they are willing to commit funds does the SBA consider following suit. This form of organization ensures that start-ups have access to the expertise, coaching, and connections that V.C.s provide. The matching is done at a three-to-one ratio, so V.C. firms can leverage a substantial supply of capital. Five million dollars in private capital, for instance, can leverage \$15 million in low-interest loans from the SBA, creating a sufficient pool to launch ventures even in R&D-heavy businesses.

The SBA has developed a tolerance for failure, which is so necessary for functioning in a start-up environment. They lose money on many of the ventures they finance, particularly when they invest at an early stage. Their tolerance is tied to their ability to count indirect effects in calculating the benefits of investment and so see the full "return." For example, the SBA includes tax revenue and job creation in their assessment of the benefits accrued from successful investment. This creates the equivalent of the big payoffs that attract private venture capitalists.

Sustainability creates new opportunities and challenges in accounting for these benefits and tying them back to investments. The SunLine case clearly illustrates the cascade of benefits that can flow from successful ventures. Better bus service and environmental performance are the most obvious benefits, but these are augmented by improved maintenance practices, the development of training programs, the testing of new technologies, and the development potential raised by the concentration of alternative-fuel activities in the Coachella Valley.

Likewise, the benefits of the Solaris project are not limited to the profits generated or the solar panels that were produced. The participants themselves cite the importance of learning about production and financial arrangements, their improved understanding of how environmental technologies play in the do-it-yourself market, the relationships that developed, and the symbolic

value of their effort. Louis Mauricio of Stork summarized this with his observation that “experiences never make one any poorer, only richer.”<sup>34</sup>

The Greenfreeze project has also had large spillover effects. In particular, Greenfreeze has provided a focus for cooperation between Europe and developing countries. For example, German refrigerator technicians conducted a technical seminar in China on hydrocarbon technology, and Greenpeace formed a partnership to promote the use of Greenfreeze technology in Chinese refrigerators.<sup>35</sup> Another example of cooperation is a program under which the Netherlands converts 200,000 second-hand refrigerators to propane each year for use in West Africa.<sup>36</sup>

These projects also contribute to the development of expertise and practices that create the potential for financing sustainable technology development projects. The significance of these developments is highlighted by comments like the following by Daan Dijk of RaboBank, in reference to Solaris:

[The] most important weakness in the Solaris Project was the intricate financial situation. In the Netherlands, the arrangement to finance these kinds of consumer-oriented projects for sustainability doesn't exist as yet.<sup>37</sup>

Developments are underway in a number of sectors that will directly influence the kind of financing arrangements that are available for sustainable technology projects. The regional banks in Germany, for instance, have been leaders in incorporating sustainability principles into their operations and lending practices.<sup>38</sup> The DSGV, the umbrella association of these banks, has sponsored sustainability audits in banks and, following the 1996 Hanover Convention of the German Saving Banks (Hannoveraner Sparkassentag), the members of the DSGV adopted sustainability as a core part of their mission, developed a mission paper, and began planning for implementation.<sup>39</sup> Firms often demonstrate significant variability in the way they treat sustainability in internal decisions about capitalization. In the automobile industry, for instance, firms like Toyota and Honda that are leading in alternative-fuel technology are willing to subsidize the production and sale of hybrid cars for the U.S. market and electric cars for the domestic market with internal investment.

The organization of sources of public venture capital along the SBA model could contribute to this pattern of development by making investments in sustainable technology more attractive and amplifying the effect of "socially responsible" capital funds. As we noted above, the institutional effects of these changes can be significant. Given the way venture capital works, the development of ties and experience has significant effects on the potential for future investment. The challenge is to organize programs in a way that does not interfere with the ability to engage risk and tolerate failure that are essential to functioning in a start-up environment. The structure of the SBA program, in particular the partnerships with private V.C. shops, offers some interesting insights in this regard.

## **Superintendent**

The first step in innovation—in the sustainable technology arena or any other field—is to turn a sense of "what is known" into a curiosity about "what is possible." To find out what is possible, actors must interact with each other, and sufficient trust and cooperation must exist for ideas and information to be shared. In SunLine's history, for example, many potentially "dead-end" moments were transformed when the sense of "what is possible" shifted, and new alternatives and insights were generated by interacting with other organizations and individuals. In this section, we want to make the case for the importance of these interactions—and the networks that develop from them—in sustainable technology development. We also want to point out that these networks do not arise naturally or accidentally. Actors devote time and attention to cultivating networks in the hope of reaping benefits over time. The resources they dedicate to these pursuits give some sense of how much they value them.

The way in which networks affect the sense of what is possible can be understood by drawing an analogy between sustainable technology development and product development. In industries like semiconductor fabrication that are marked by rapid change in technology and design requirements, the future is uncertain. Linear processes, in which goals are carefully set before action is taken, cannot keep pace with the innovations nor respond to uncertainties about the future. Production goals are continuously revised as innovations open up new possibilities. Likewise, in sustainable development innovations in "green" technology constantly change the sense of what is possible. Concrete goals are difficult to set. Action often shifts the boundary of what is possible, extending it in some cases and restricting it in others. Some innovations shift the context dramatically and require a more

radical reorientation of the heuristic standards.

Firms succeed in these dynamic environments by comparing current practice with best practice and persistently striving to revise their standards and practices in light of each other. For example, a firm that is developing a new semiconductor might start from their understanding of where best practice currently stands in the industry. This survey of "what is known" becomes a starting point for their own investigation and a benchmark for evaluating their own progress. Because these benchmarks are revised as innovations occur, the effect of successive comparisons over time is to "ratchet-up" performance.<sup>40</sup>

The prerequisite for this pattern of development over time is the existence of networks in which an actors can exchange information. The rise of technology "clusters," whereby firms within the same industry locate near one another, suggests the importance of these ties. Silicon Valley, California and Bangalore, India are almost proverbial examples for the computer industry, as is Stockholm for telecommunications. The proximity of firms at these clusters fosters interaction among them. This interaction in turn leads to the development of networks across which information and expertise can be exchanged. The way a company gets ahead is to be part of this exchange rather than isolating itself, despite the fact that participating implies giving information about plans and practices. Michael Porter notes the aggregate effect of these clusters on innovation:

[T]he proximity of firms and institutions ensures certain forms of commonality and increases the frequency of interactions. Well functioning clusters...become lattices of numerous overlapping and fluid connections among individuals, firms, and institutions.... Modest changes in the pattern of relationship within a cluster may have significant consequences for productivity and the direction of innovation.<sup>41</sup>

These insights from product development have to be adapted for sustainable technology development, but in both contexts the goal is an environment in which each generation of change shapes the opportunities available in the next. Moreover, examples in public policy suggest that the analogy is apt. A good example in the area of economic development is the Manufacturing Innovation Networks (MAIN) project that took place in the late 1980s in Pennsylvania. The program was designed to spur innovation

and development in declining industries like garment manufacturing and foundries. As a first step, the program asked firms to evaluate their operations and define their needs for support and resources. The next step required these firms to consider how they might organize this support by cooperating with other firms within their industry. The hope, and outcome, was that "[b]y 'studying' their industries jointly...the [firms] would...discover new sources of vitality which could serve as models for collective reorganization...[and] tip the balance in favour of trust...".<sup>42</sup> Through financial support for the generation and implementation of redevelopment plans, the strategy deliberately cultivated the development of inter-firm networks in industries characterized by fierce competition for a declining pool of business. Through these networks, the participants reconceptualized their goals, discovered shared interests, and organized joint actions that, in aggregate, opened new opportunities that none of the firms had been able to discern or act on in isolation.

The MAIN experience is one of many examples that highlight how interaction within a network can foster trust among actors. Trust, at least in a "studied" sense, is necessary for the kind of information sharing and collective action that is often critical to moving innovations forward.<sup>43</sup> Actors who take on the role of Superintendent typically have a keen awareness of and concern for the conditions under which such exchange, understanding, trust, and joint actions can develop.

We see this concern for fostering and sustaining a network of relationships in other situations in environmental policy and green technology development. The Massachusetts Toxics Use Reduction Act (TURA) is an interesting and important example. This program applies to all companies in Massachusetts that produce or use (above a modest threshold) any of more than 650 listed toxic chemicals. The diversity of production processes employed by these firms makes regulation through across-the-board standards almost impossible. Thus the program focuses on promoting development and innovation within firms. To accomplish this, TURA requires each firm to prepare and submit plans every other year for reducing the use and generation of toxics in their operations. Firms are permitted to apply a standard of economic feasibility in deciding whether or not to pursue the recommendations in the plans, and so are not bound in any effective way by their analysis.

TURA's planning requirements exploit two insights simultaneously. First, firms that are forced to evaluate their own performance will find economically and environmentally attractive ways to improve their operations. This demonstrates that the public goal of toxics reduction can be compatible with internal goals such as improving efficiency, cutting costs, and creating innovative and better-quality products. Second, the planning process instills in firms a habit of innovation and learning that is oriented toward public environmental goals.

In addition to the planning requirements, the TURA program has created networks that support the immediate goal of producing good plans and the more diffuse goal of cultivating a climate of interchange in which innovation becomes a natural part of business. For example, the state developed training and certification programs for the "toxics use reduction planners"—the individuals in each firm who prepare the plans. These "TURPs" undergo training together, and are required to attend activities organized by the state to maintain their certification. These common experiences create ties across firms that planners often draw on when they have questions or confront particularly difficult design and operational problems. The training programs and annual conferences also facilitate interchange across the public-private boundary, by creating a group of actors who can understand both the goals of policy and the experience of the firm.

The activities and resources established by TURA also promote innovation more directly. A state Office of Technical Assistance (OTA) provides information about current practices and techniques, which are especially important to smaller firms. The OTA also acts as a liaison to other public and private resources such as technical expertise, grants, and credit. A research institute at the University of Massachusetts at Lowell undertakes directed research, often targeted by requests or comments from firms. For example, firms involved in semiconductor fabrication might see potential to move to nontoxic cleaning solvents, but because of tight margins and production schedules, they may not have the resources or organizational slack to experiment in production lines or research facilities. They are unlikely to make the commitment to substitute without direct evidence of a new chemical's commercial viability. Research can help bring in Pioneer firms, which, in turn, can reshape perceptions in the industry through the kind of benchmarking of practice outlined above. By filling the gaps in this chain that are beyond the capacity of firms tied to production schedules, TURA engages and amplifies the potential for innovation that resides (often latent) within firms.

In our terms, the offices and programs of TURA collectively fill the role of Superintendent. They act as a liaison between firms and outside resources, provide a network for sharing information, create a forum in which it becomes natural for firms to ask "what is possible?", and provide firms the information and other resources to act on this curiosity. This inquiry is driven by the cycle of benchmarking that is initiated and sustained through the development of networks that span firms and the public-private divide. TURA's success has been remarkable, leading to a 20 percent production-adjusted drop in toxics use, and a 30 percent drop in toxics generation from 1990 to 1995. More telling still is that 86 percent of the affected firms said that they would continue the toxics reduction process, even if they were no longer bound by law to submit plans under TURA.

Two recent cases in the Netherlands—the Solaris project and the Sol Alamos effort—provide additional examples of the role of Superintendent. These cases have not only reshaped the sense of what is possible in photovoltaics, but have produced the inter-organizational partnerships that bring this potential within the scope of action. These developments emerged out of a diffuse background of interactions among a group of actors involved and concerned with the potential of photovoltaics to change the energy profile in the Netherlands. The combination of informal connections and workshops created a level of interaction that resembles the industrial clusters described above.

The Solaris project, which was described in detail in a previous section, had very immediate objectives of disrupting fixed conceptions about what was possible in the near term in photovoltaics and breaking the chicken-and-egg dilemma that was constraining production. What Greenpeace did was to bring together other actors that could develop and meet production targets. They drew in the consulting firm Ecofys, which contributed to an assessment of the market and the product design, a group of manufacturers committed to organizing an initial production run, and RaboBank to help organize financing. NOVEM and the power companies provided subsidies that lowered the cost to consumers.<sup>44</sup> The development of this partnership drew on network ties and relationships. Daan Dijk of Rabobank described the way the partnership came together: "Greenpeace came up with the idea of promoting solar energy on a consumer market, but RaboBank was already part of a network, including Ecofys and Stork, [so] partners found each other quite naturally." RaboBank, Ecofys and Stork are all leaders in their fields and share a special interest in sustainable development.

While Solaris has not been a dramatic financial success to date, it has created and enhanced relationships and pushed the benchmarking of "what is possible" forward in several ways. First, it provided experience with the potential of the do-it-yourself market that is relevant not only to photovoltaics but other green products. Second, it pushed thinking about the role of government in promoting the adoption of a technology and of new financial arrangements. It also pushed institutional horizons by demonstrating both the potential and difficulties of working across the boundaries between civil society, the private sector, and government. Perhaps most dramatically, Solaris established a new benchmark for jumpstarting a stalled technology. It is difficult to take this condition as fixed after the Solaris project. The project has provided a list of useful steps and enhanced a set of nascent relationships by providing a grounded base for interaction.

Sol Alamos provides a second example. Sol Alamos is an inter-organizational partnership driven by Sunergy, an alternative energy firm in Rotterdam. Like Solaris, Sol Alamos seeks to alter the production environment to trigger a dramatic change in the photovoltaic market in a short period of time. Sol Alamos developed out of formal and informal interactions among a network of public and private actors and NGOs concerned with the future of solar power. Through a process of benchmarking, the various actors together identified changes in automation and scale that could change wafer production, as facilities like Shell's new wafer plant come online. Benchmarking these nascent developments demonstrated how correlative developments in materials production and business practice could transform into a dramatic shift in photovoltaics.

The partners involved in Sol Alamos have drawn on this benchmarking analysis to set a new goal of reducing costs by a factor of four. They are now seeking to address the correlative changes that are required to meet this goal. They are focusing, for example, on the availability of a dedicated source of solar grade silicone and the need for cooperative development work. Sol Alamos has directly addressed the institutional demands created by the "spider's web" (as they have called it) of issues constraining the development of photovoltaics, such as material and wafer production, technology and application development, and financing schemes and organization models. The partnership is an institutional invention that has built strong ties between actors and created networks with industry, government, and environmental groups, thereby enabling them to meet the demands of the various parts of the "spider's web."



These examples, as well as research in management and economic sociology, point to the critical role of networks in facilitating the innovation of technology, and the joint action needed for implementation. Furthermore, we see from each case that a government entity, NGO, or private firm has understood the power of such a network and actively cultivated one. In this sense, the Superintendent role is analogous to that of a "cultivator," who establishes the fertile conditions needed for ideas to be explored and be pushed forward. Although the role of the Superintendent may be played by different actors at different times in a project, or involve efforts as diverse as informal networking and setting up a newsletter to exchange information, the role is essential for promoting green technologies.

## **Mediator**

Problems often develop in the course of entrepreneurial ventures that threaten to block their progress. In the SunLine case, the DOE and the bus manufacturer XCELLSIS came to an impasse over issues relating to proprietary information, and the problem threatened to derail part of SunLine's fuel cell program. SunLine had already built consensus with the two organizations on the need and appropriate direction for the program, however, which helped to lay the groundwork for a resolution of this dispute. And SunLine was able to understand the interests of both sides and help them resolve the problem. As in this case, the Mediator role typically includes both building consensus and resolving disputes.

The innovators, organizers, and supporters of a sustainable technology project may not always be able to fill this Mediator role themselves. Because they control resources and expertise, these actors may not be perceived as fair arbiters of a dispute or problem. If an innovation does not benefit everyone, for example, those who stand to lose, or perceive that they may lose, may seek to block the initiative to protect their interests.

In Bologna, protests threatened the implementation of an innovative information system that controlled access to the city center. Called "SIRIO," the system limited access to permit holders, taxis, public transportation, and emergency services. A manual system that had been in place for some time gave access to 82,000 permit holders. Under SIRIO, the quota of permits was just 46,000.<sup>45</sup>

The technical features of the system worked smoothly, but the implementation has been very difficult. The negative response from residents threatened to derail the project at several points. Local businesses and trade unions feared that limiting access would also mean limiting business. Car owners who did not receive permits were upset. The protests of these groups were joined by right-wing parties that opposed the new quota. Several firms went to court to increase their access.

The organizers failed to anticipate the variety of interests that would be affected by SIRIO, particularly those who would lose out. They also failed to see that addressing the interests of these "losers" was essential to the success of the program. By not engaging these parties before implementation, or, better yet, involving them in the design of the implementation plan, SIRIO's organizers missed opportunities that may not only have avoided opposition but improved the project. A system of monitoring that analyzed the effect of limiting traffic on economic activity, for instance, might have both addressed the interests of the businesses and trade unions and contributed to the broader public value of the project. The organizers also missed the opportunity to reconcile what seemed to be conflicting demands. The lack of a Mediator in this case threatened the implementation of the project and certainly compromised its legitimacy and value. A more effective effort to build consensus and to address interests that are threatened by innovation could have contributed to a smoother implementation and a more thoughtful project design.

Innovations can also stall when new technologies and practices do not fit neatly into existing administrative categories, and regulators are unable or unwilling to find latitude within the regulatory framework to allow the initiative to move ahead. SunLine confronted this on several occasions in the development of financial arrangements. Only their perseverance and the resourcefulness of DOE and DOT staff permitted them to move forward at these critical points. A bit less on either side might have produced a conflict that was beyond the capacity of the parties to resolve.

When the German manufacturer Foron was developing the Greenfreeze refrigeration technology, they faced potential regulatory snags over issues of efficiency and fire threat, which they were eventually able to resolve by tweaking the design. Likewise, the Solaris projects was threatened at two points by the mismatch between administrative categories and project characteristics. First, the subsidies available from NOVEM were intended to support research and development and did not fit Solaris's

effort to promote photovoltaics through the do-it-yourself market. Second, immediately following NOVEM's decision to grant the subsidies, the Solaris partners found that the money could only be given to commercial enterprises, not consumers. Here RaboBank filled the Mediator role. They designed a purchase and lease system that met NOVEM's administrative demands and allowed the benefits of the subsidies to be transferred to the consumers.

Regulatory requirements are also complicating the introduction of alternative-fuel vehicles in California. The existing air-quality requirements set by the California Air Resources Board (and driven by air-quality concerns) mandate that 10 per cent of the vehicles sold in the state must meet a standard of either zero emission (4 percent) or extremely low emission (6 percent) by 2003. The regulatory situation has gotten quite confusing, however, as the Air Resources Board has also created designations such as "ultra low-emissions vehicle" and "super-ultra low-emissions vehicle." It's difficult to determine what cars fit into which categories, as well as how cars in these latter categories are figured into the 10 percent goal. The California Air Resources Board recently appeared to uphold a strict mandate for manufacturers to introduce electric cars. This ruling, if it stands, will provide limited or no credit for natural gas, fuel cell, or hybrid vehicles. This, in turn, may disrupt vehicle and infrastructure development oriented in this direction, such as SunLine's efforts. The debate over this issue involved lobbying and quasi-judicial proceedings, both of which encourage actors to express their interests as strident, fixed demands. Protests, disputes, and litigation are likely to follow the ruling, particularly from carmakers and other groups who feel they are on the losing side. As with the Bologna case, a confrontational approach to the budding controversy may have excluded alternatives that might meet the interests of all parties and serve environmental goals more effectively.

The indirect effects of this kind of conflict can be equally devastating. Confrontation is antagonistic to the development of the kind of associative environment that, as noted above, is conducive to innovation, entrepreneurship, and the search for strategies that might take advantage of the differences in technology to create a program of technological change with greater environmental impact. Zoning and other land use regulations will likely engender similar disputes if and when alternate fuels like hydrogen are introduced into commercial use.

The inter-organizational relationships that characterize public entrepreneurship naturally create the potential for conflict and the need for mediation or something like it. The mismatch between the needs of innovative ventures and administrative categories is only one way this tension can arise. Partnerships and joint ventures also bring together actors who have diverse goals and organizational identities, and who work under very different incentives. These differences can raise tensions and make cooperation difficult.

The Solaris project, for example, was a joint venture that brought together Greenpeace—an NGO with a history of advocacy and direct action and an identity as an independent watchdog—with two consulting firms and a bank. These actors had diverse competencies, which benefited the joint venture, but they also had different goals and expectations regarding timing. All parties were interested in learning about the do-it-yourself market and photovoltaics, but they had different expectations about the kinds of “returns” that would be available, the relative significance of these returns, and the time horizon in which they would become available. The proponents at Greenpeace, for instance, were not interested in profits and were even willing to subsidize their involvement in the project. The private actors had divergent views about what sort of balance between economic return and learning would justify their involvement. The actors also had different ways of working and different views about the meaning and implications of agreements, which raised tensions and required adaptation as the venture developed.

These organizational patterns and tensions are not unique to Solaris. SunLine’s program brought together administrative agencies, local government, utilities, equipment manufacturers, and educational institutions. Sol Alamos is based on an inter-organizational web of private firms, banks, environmental groups, and government agencies. The development of the Greenfreeze refrigerator required cooperation between the inventors, Greenpeace, and the appliance manufacturer Foron. We have shown that this institutional diversity is essential to the development of these ventures and to achieving public goals. It can also create tension, however, and disputes that must be resolved. These tensions and disputes cannot be treated as incidental but must be seen as inherent in the pattern of development and pivotal in achieving public goals.

Mediation provides a model of consensus building and problem-focused intervention that responds to these demands. Where public entrepreneurship has flourished, the parties involved have found a way to fill the Mediator role. Where it has been stunted or withered, it is often because parties were unable to resolve problems raised by the "losers" in a dispute or inter-organizational tensions. Mediation is attractive in the context of public entrepreneurship because it draws on and enhances the resources and interests of participants. It is compatible with the current position of administrative agencies that are concerned with getting problems solved while working within organizational boundaries. Moreover, these agencies increasingly cannot (and probably do not want to) impose solutions. By playing the mediative role, public agencies can facilitate solutions that reduce the impacts or risks for groups that stand to lose or that find latitude for discretion within existing regulations, without compromising their status or legitimacy. Public agencies may increase their "clout" as Mediators and expand the pool of available solutions by bringing resources to the table and by gaining access to specialized forms of expertise.

## **Steward of the common good**

*We had a dual intention in the Solaris Project: to promote sustainability and 'to make a living.'* Mr. Daan Dijk,  
Manager of Sustainable Energy Projects, RaboBank.

Public entrepreneurship may seem at first blush to be of a family with proposals to reinvent government by organizing the delivery of public "services" along the lean and efficient lines that mark firms disciplined by the market. The rise in these privatization policies coincides with the "triumph" of market economies over centralized planning.<sup>46</sup> In this historical light the emphasis public entrepreneurship places on entrepreneurial initiative and access to capital, for example, seem to fit neatly in this picture of the triumph of the market as the exemplary form of social organization.

Such a reading misses the point, however. First, it neglects the regard for public goals that characterizes the participation of actors in public entrepreneurship networks. Second, it misinterprets the relationship between public entrepreneurship and entrepreneurial patterns of development in the private sector. The latter error results from misplaced emphasis on the private status of entrepreneurship and its association with market activities. Entrepreneurship can also be understood as a pattern of inter-organizational action that is characterized by horizontal ties, flat structures,

and heightened perceptions of interdependence. This rendering highlights the similarities between entrepreneurship and the pattern of organization that are increasingly common in private production. These symmetries have broad implications for relationships that are developing among public agencies, civic organizations, and firms.<sup>47</sup> In this light, public entrepreneurship becomes a counter-example that accents the enduring importance of public concerns as well as the challenges raised by new patterns of organization and coordination.

The first point-- the association between public goals and participation in public entrepreneurship networks--is evident across the cases we have discussed. Public agencies, civic organizations, and even firms, participate in public entrepreneurship networks in part because of such ties. SunLine's activities reflect the importance of this link from the initial motivation of the Board, to their efforts to gain access to funding, to the involvement of actors from the College of the Desert to the Southern California Gas Company to the Department of Energy. Where entrepreneurial zeal has pushed the scope of the agency's services into areas like street sweeping and cleaning graffiti where the association with public goals is thinner, SunLine has come under heightened scrutiny and censure and has had to justify these activities as appropriately public.

Other projects also reveal this association between participation and public goals. In the Solaris project, Greenpeace's involvement created a public character and significance that attracted and sustained the attention of its partners. Stork, Ecofys, and RaboBank knew each other and Greenpeace precisely because of their shared interest in sustainability. This brought them into contact with each other and provided the focus for the interactions that launched the Solaris project. The partners each had their private interests--publicizing the issue, making profit, securing market share--but the common point of reference was the public goals of promoting sustainable technology. Greenpeace's public reputation helped further the program by interesting members, supporters, and interested parties who came, collectively, to constitute the level of demand that interested producers in producing photovoltaic panels at a lower price and government in subsidizing the sale of panels. In commenting on the success of Solaris as an organizational experiment--"a perfect way to take on new products and developments"--Mr. Dan Dijk of RaboBank highlighted the fact that often "these partnerships are concerned with some sort of public good."

In the Greenfreeze case, the this rationale, which underwrote the commitment of Doctors Posin and Preisendanz and the involvement of Greenpeace was the development refrigeration technology that would be less environmentally harmful than the available HCFC and HFC cooling technology. Without this motivation the project would never have gotten off the ground or made it through critical stages of development. For civic organizations, the partnerships and alliances that mark participation in public entrepreneurship networks provide a practical strategy for achieving their goals.

The participation of private firms also highlights the importance of an association with public goals. Their partners describe this in terms of the importance of public reputation and the ongoing search for opportunities for "ethical entrepreneurship." The people who represent these firms cite the sense of public responsibility that motivates them. Shell's reorganization in the wake of the Brent Spar and Nigerian controversies is a good example of the way public goals are being internalized in firms. What practical effect Shell's new "triple bottom line" and emphasis on environmental business units will have, remains to be seen. The more useful question may be how the broader context of inter-organizational interaction will shape the expression of this commitment in the firm. The efforts of Sunergy and its partners in Sol Alamos provide another good example of progressive private organizations working to square the circle that headlines this section and promote social goals while earning a living."

The second characteristic we highlighted above is the status of public entrepreneurship networks as a form of inter-organizational activity. Public entrepreneurship networks exhibit much of the flat decentralized structures that characterize reorganized firms and production networks in the private sector.<sup>48</sup> In public entrepreneurship, these networks also span the boundary between public and private and highlight the ambiguity and interdependence that characterize this boundary. These networks provide the structures through which organizations coordinate action and frame the problems that require coordination.

Networks also provide an institutional forum for the joint monitoring of experience and for deliberation about the significance of this experience. In the Good Wood foundation InterGamma, a private firm, is involved in ongoing interaction with WNF<sup>49</sup>, Novib<sup>50</sup>, VMD<sup>51</sup>, and Staatsbosbeheer<sup>52</sup> over how to promote sustainable forestry. Through these interactions the organizations involved have each extended their understanding of the how wood is produced and marketed around the world. As part of their

interaction, Intergamma, WNF, Novib, VMD, and Staatsbosbeheer have collectively engaged in "governmental" activities like setting targets--25% certified sustainable wood sales in the Netherlands by 2002--and establishing standards for certifying wood. In Sol Alamos, interactions among the members of the public entrepreneurship network provided the basis for articulation of the goals for reducing the production price of photovoltaics.

These interactions provide the kind of mutual close observation of practice that can contribute to learning and to the deepening of trust relations among the parties. Civic organizations like Milieu Defense and Greenpeace get regular information about the practices of their collaborators (much more detailed than the kind of information that commonly results from monitoring programs). Firms get information about the goals and activities of their public and civic partners and the effects of different actions and strategies. This pattern of close interaction helps to clarify commitments, hold parties to these commitments, and confirm compliance when partners follow through. Such dense patterns of interaction help partners act in ways that demonstrate they are deserving of trust. As trust develops through these interactions new forms of collective action become possible.<sup>53</sup> These aggregate influence of effects will be especially significant in cases where the practical meaning of organizational commitments is contingent. The practical force of Shell's commitments to sustainability, for instance, will undoubtedly depend on the context of relationships in which the organization interprets and acts on these goals.

These dense patterns of interaction can also be understood as an associational environment that has implications for modern democracies. Here the democratic significance of these patterns becomes clear. Community, solidarity, and even coordination are increasingly difficult to legislate in a decentralized and pluralistic society. Institutions no longer retain their legitimacy as such, but must generate it through action and interaction. The problems at the heart of these public entrepreneurship networks cut wide enough and deep enough in many cases for to contribute to a sense of political community. This has begun to happen in the Coachella Valley. Pursuing these possibilities demands the kind of deliberative understanding of the tie between democratic legitimacy and collective decision-making that has recently emerged in political theory and the institutional imagination to see practically oriented interactions as potential platform for creating political community.<sup>54</sup>



These activities as a group constitute the role of the steward. Organizations act on this regard for the common good when they embrace sustainability organizationally and when they participate in inter-organizational partnerships that take public goals as the common point of orientation. Government agencies and other actors also play the role of steward when they take steps to ensure that the tie between action and public goals is understood and accepted as legitimate. Stewardship in the broadest sense involves an effort to generate understanding, trust, an awareness of interdependence, and, out of the kind of interaction around practical problems that takes place in public entrepreneurship networks, a sense of political community. The suite of activities that comprises stewardship is likely to gain in significance as the decentralized patterns of development and action that are evident in public entrepreneurship networks become more prevalent. Administrative agencies retain prominent ties to the role of Steward in this environment, but their exclusive charter is gone and the patterns of practice that are effective in promoting understanding and legitimacy are changing.

## **Part V:**

# **Implications for Practice**

We have identified a distinctive pattern of development that draws on durable changes in the institutional landscape and provides a way to think about what it means to manage a social transition process. Our analysis isolates an approach to fostering development that also generates a set of relationships in which it is possible to ask if the development makes sense. This provides a way to conceptualize sustainable development as a transition process in which the need to act in the present is always balanced against asking what actions imply for the future.

Situating entrepreneurship in a network underscores the multiple roles that contribute to the success of a venture. This set of roles (pioneer, public venture capitalist, superintendent, mediator, and steward of the common good) highlights the dynamically articulated relationships that characterize success in public entrepreneurship networks. It is this inter-organizational "ecology," rather than the prominence of any single role, that enhances the capacity of these networks to develop and deliver public benefits. These same patterns of interaction can provide the basis for public deliberation on policy goals.

To prosper, these public entrepreneurship networks require the participation and support of public administrators, executives, managers, environmental advocates, and other actors who want to promote sustainable development. Articulating the set of roles is the first step in translating analysis into practice. The next step will require careful reflection on organizational goals and capacity and the demands that participation in PENs places on different kinds of organizations.

In this concluding section, we start this translation process by describing some ways that practice in administrative agencies can respond to the opportunities for development highlighted by our analysis of public entrepreneurship networks. We summarize our recommendations around three questions that the civil servants who have the responsibility for managing this transition process face:

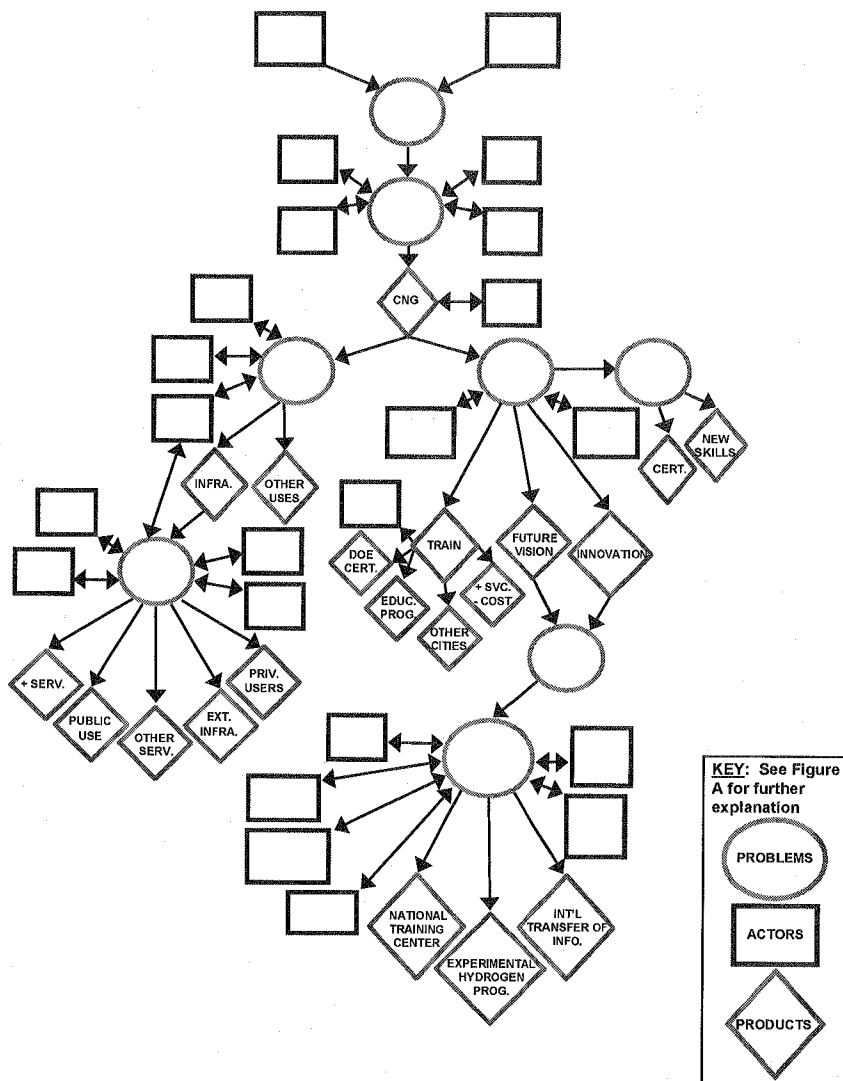
- What can we do to help "green" projects get off the ground?
- What kinds of assistance would keep these ventures moving forward?
- How can we make sure locally initiated projects stay oriented to public goals?

## **What can we do to help "green" projects get off the ground?**

Public entrepreneurship networks are galvanized by the action and commitment of pioneers. When Greenpeace declares it will get solar panels on twenty thousand Dutch roofs, when two doctors in Dortmund begin working at night in their basement to perfect a new refrigeration technology, or when SunLine's board tells the management team, "While you're at it, make the new buses alternative fuel," they start a process of development.

The central thread in this process is the emergence of the ties that link organizations in a network that provides access to resources and to the expertise needed to solve problems. As Figure I illustrates, these ties bind the framework from which policy-relevant products "hang." Thus even before the problem of commitment, comes the question, "Where do the ties come from that actors draw on as public entrepreneurship networks develop?" In any single case the source of these ties is apt to look fragile. Wolfgang Lohbeck *happened* to see an article about Dr. Preisendanz in a little known journal and invited him to a conference on refrigeration technology. Dick Kelly happened to see an alternative fuel bus at a public transit conference. This kind of serendipity provides an unexpected foundation for policy in an important arena like sustainable development.

Yet consider the implications if (as the evidence suggests) these are exactly the moments in which change is possible. Then worries about fragile origins translate into concerns for how these ties can be cultivated to ensure that ventures get started and prosper. Good management means finding ways to raise the odds that the necessary connections will be available by creating ties among individuals and organizations. The goal is to create the pattern of overlapping ties that characterizes thriving regional centers of innovation like Stockholm and Silicon Valley.



**Figure I**

*Enhance relationships* – The first step is to build ties by creating events that bring actors together and get them to interact. As *superintendents*, public administrators can take a number of practical steps in this direction. Organizing conferences and workshops, publishing newsletters and a host of other activities can bring actors with overlapping interests together in a way that builds ties. These activities can function like the cocktail parties in the Silicon Valley where everyone has an eye out for the next deal and a hand on the non-disclosure agreement in their back pocket.<sup>55</sup> Or they may provide opportunities for informal conversation. The trick is to hold the parties regularly, get a good turnout, and make sure the conversation is engaging.

Established programs like DTO (a Dutch sustainable technology development program) may already contribute to creating the lines of association that actors can draw on when needs arise. Pilot programs can be treated as occasions for interaction that develop the relationships that lead to further development. From the perspective of public entrepreneurship, these activities should be extended and organized with the explicit attention to creating the ties and highlighting the common interests around which networks coalesce. This will mean ensuring that a suite of activities is available that covers the spectrum from focused events that build strong ties around common interests and shared problems to general interest events that build the weak ties whose significance will emerge at some pivotal moment in the future. The goal should be to provide a rich second track of policy interaction that builds relationships and creates common vocabularies and visions.<sup>56</sup>

Benchmarking can give these events a practical edge. The Sol Alamos project demonstrates the value this edge can have. Benchmarking production practices in the photovoltaic industry led participants to articulate a goal (factor four reduction in costs) and identify a program of steps that would reach it. The network of organizations that constitutes Sol Alamos grew out of these interactions and has the capacity to act on the program. A practical edge also made Greenfreeze, Solaris, and SunLine attractive. The commitment to put solar panels on twenty thousand roofs was just far enough ahead of the curve to be interesting and down to earth enough to be practical; the combination attracted partners.

Finally, advances in information technology provide new opportunities to enhance conventional forums. They must be organized with the goal of building ties in mind to be effective, however. The DOME project at

Massachusetts Institute of Technology suggests how a well designed effort might tap the potential of information technology to enhance interaction. DOME (Distributed Object-based Modeling and Evaluation) provides a virtual platform and infrastructure for teams of researchers to dynamically explore complex problems. Dome "fosters collaboration between experts working on discrete aspects of a larger design problem" by providing a decentralized non-hierarchical architecture that permits independent modules to interact with one another over the web. In DOME these modules actually influence each other. An international research group is currently using DOME to facilitate technical and political interactions in the Tokyo Half Project (a research program that is trying to reduce greenhouse gas emissions in Tokyo by half). DOME highlights the potential of virtual systems to provide environments for interaction that enhance ties among actors working on similar problems. Public administrators can enhance the continuity of relationships by designing and managing rich virtual environments for interaction.

*Facilitate access to capital* - From the perspective of a *public venture capitalist*, ministries can contribute to getting projects off the ground in two ways. They can take the role of the "angel" investors who figure prominently in the early stages of private ventures. These angels provide working capital and expertise and help attract investment. An effort to create an *angel fund* would build on programs like Ecology, Environment, and Technology to create a pool of public resources that can be managed like private capital. This fund would require a high degree of flexibility and discretion and have to be managed with a high tolerance for risk. Moreover, not only would the funds have to be unencumbered, but the staff responsible for administering them would need substantial autonomy if they were to really fill the role angels play in the private sector. These conditions may be difficult to create given the standards of justification that government programs face. The experience of the Small Business Administration in the U.S. suggests that it is possible to find a way around these problems.

Venture capitalists also promote development in the private sector by helping pioneers conduct their due diligence and get access to capital. This aspect of the venture capitalist role is more easily extended to government. An *inter-ministerial task force* of "*development specialists*" could enhance the efforts of pioneers seeking to get green projects off the ground. This task force would hold key expertise and could provide valuable services. Members could provide a sort of policy-risk analysis that would supplement traditional financial, technical, and market analyses. Will this green venture

fly given the current shape and direction of policy? Where will it run into problems? If there will be problems, is this for a good reason, or because of a rule or commitment that should be changed? What can be done? What approach is most likely to succeed?

The members of this task force could become internal advocates for promising green innovations. As a group they would have a thorough understanding of the policy landscape. Their collective capacity would include an understanding of the different programs set up by government to promote more sustainable and socially desirable development. They could help pioneers navigate this complex terrain and get access to programs that are appropriate. Because public entrepreneurship and green projects touch both public and private interests, the services of this task force would be relevant and valuable in most cases. The members of such a task force may also be able to provide a liaison to actors outside government who have resources or expertise that is needed.

*Organize experiments* – Administrators may also choose to act directly and organize experiments with new technologies and practices in key sectors. By taking the initial step as pioneers, administrators can focus attention and draw out potential partners. Their participation can lend credibility to projects that may make it easier for other actors to commit to experiment with new technologies or with trying to change the way they do things.

From the perspective of PEN, these experiments should be understood and organized as development networks. These initial steps should be taken in a way that makes it more likely that additional steps will follow. Thus, in addition to technological promise, sectors and regions considered for experiments should demonstrate potential for developing the relationships that will allow these experiments to mature into ventures. This means identifying potential partners who can fill the different roles in the network. In particular, there should be an identifiable local sponsor who can take over the pioneer role early in the experiment. Effective use of stakeholder involvement to design these experiments will help create the ties that make it likely that a venture may acquire a life of its own.

## **What kinds of assistance would keep these ventures moving forward?**

Public entrepreneurship networks that prosper share three characteristics. They continue to engage the curiosity, interest, and commitment of participants, they succeed in getting access to capital at different stages in their development, and they find ways to address barriers that threaten progress. Environmental ministries can help public entrepreneurship networks develop by taking steps that enhance these attributes of successful networks.

*Sustain vitality* - Successful networks retain their vitality. SunLine's maintenance staff provides a vivid image of this goal. The members of the staff are engaged in an ongoing effort to reinvent the way they solve problems. They are consistently confronted with new information and, through their role in the training program, with new questions. Joint projects with equipment manufacturers keep them engaged with new technologies. The internal organizational environment supports and enhances these ties by encouraging interaction, debate, and by treating standards as benchmarks that are always in the process of being revised.

Administrators can enhance networks in each of these ways. They are in a favorable position to circulate information about new technologies and innovations in practice. They can ensure that this information is expressed in terms that will be meaningful to potential users. When they participate in networks, administrators can use their position to raise the kinds of questions about the future the DTO program has shown can be effective in disrupting inertia. In the context of helping with financing or designing a regulatory covenant, they can ask, "If this is the first step, what is the second and the third?" "What will your organization look like in the future?" How will the needs you address be met in the future?" The patterns of close interaction that characterize PENs provide multiple opportunities to raise these questions and help think about answers.

*Bridge gaps* - The second characteristic that marks successful networks is continuity in access to capital. In the cases we reviewed the financial packages were complex. Putting these packages together was a central problem for participants in the venture. This is partly because public entrepreneurship networks draw on a mix of sources of capital that often includes public subsidies, guarantees, or even assistance. The available mix is constantly changing as well. Private sources of "green" capital are



proliferating and conventional investors have shown increased interest in green projects.

Because public entrepreneurship networks depend on different sources of capital, they are vulnerable to gaps in the sequence. These coordination problems draw attention to how different programs of public support fit in the sequence of capital investment available to green innovations. Administrators can facilitate development by identifying gaps and proposing ways to reconfigure programs to bridge these gaps. This is just the kind of analysis that an interagency task force like the one described in the preceding section would have the expertise to provide. Their responsibilities would put them in constant communication with new and established ventures and provide real time information about how public programs fit in the sequence of capital that is available at any time.

*Overcome barriers* - Finally, public entrepreneurship ventures can be disrupted by controversy and regulatory barriers. The benefits of any moves toward more sustainable development will be unevenly distributed -- gains to one group in society almost always involve short-term losses or costs to another. Thus, some will favor maintaining the status quo as others push for greater sustainability. Those who stand to lose will often have effective ways of intervening to halt or slow the process of development. Controversies arise when those who stand to lose or who distrust change intercede to derail projects.

Civil servants can mitigate these problems by enhancing the capacity of ventures to build consensus among stakeholders who will be impacted by green innovations and to resolve disputes constructively when they arise. The best way to increase the capacity of PENs to handle these problems may be to provide access to the assistance of professional neutrals who can help design and manage stakeholder involvement in design and dispute resolution. This will entail providing support for training, a referral service, and financial support for the neutrals. Training may need to be extended to the pioneers and public venture capitalists who are the potential clients for these services, so that they understand how the services can help them.

The second barrier to the development of public entrepreneurship networks is the thicket of rules, standards, and regulations that green innovations often get stuck in. Sustainable development projects are susceptible to these barriers because they involve new technologies and practices and cut across traditional administrative boundaries. Stories where a rule or regulation

has stopped a promising project are not uncommon. The ease with which they circulate underscores the importance of finding constructive ways to address these problems. It is unlikely that a comprehensive review of regulations can eliminate these barriers. Because innovation is by nature unpredictable, new projects will almost always surface new problems.

One proposal that responds to the systemic character of the problem is to create the office of a *sustainability ombudsman*. This would provide a clear destination for pioneers who run into conflicting regulations or other institutional barriers. An ombudsman could work between ministries and between national and municipal government to find scope to allow promising projects to move ahead. Such an office would build on the problem solving capacity that effective administrators already display. Because surfacing regulatory conflicts is a hallmark of successful transition projects, the capacity to respond to these problems should not be left to the ad hoc efforts of civil servants with competing responsibilities and mandates.

A successful program of dispute resolution will deliver additional benefits. It will contribute to a climate in which organizations and individuals are willing to experiment. As much as stories of derailed projects corrode initiative, examples of success contribute directly to creating and sustaining a climate of innovation.

## **How can we make sure locally initiated projects stay oriented to public goals?**

One way to understand the trick of managing a transition process is sustaining a tension between action in the present and a vivid image of a desirable future. For public administrators this aligns with the need to tie action to publicly endorsed policy goals. This need is particularly high in cases like PEN, where the pattern of development is likely to be diffuse. A central challenge is to find practical ways to keep these ventures oriented to each other and to policy goals. The more a PEN approach succeeds the worse this problem seems to get.

The strategy we suggest draws on the relational character of PENs to foster reflection in the process of development, to organize opportunities for learning, and to facilitate public deliberation on policy goals. We review three examples of this approach that address prominent responsibilities of public administrators. These examples highlight a central characteristic

of PENs. The relationships that participants build to meet the demands of development also make it possible to ask if the pattern of development makes sense. Here we see that efforts to promote sustainable development can also promote democracy.

*Hold actors accountable* – When public resources are used to promote development there are bound to be demands for accountability. Traditional mechanisms for accountability rely on technological or behavioral standards that interfere with innovation. A new set of regulatory approaches that builds on the covenants model is emerging which provide forms of monitoring and reporting that can actually promote innovation.

The Toxics Use Reduction Program (TURA) in Massachusetts is a good example of this approach. TURA requires firms to analyze and report on their production practices. The primary report is a plan that identifies steps that would make production practices more sustainable. By identifying and reporting on these steps, the firms do not commit to take them. Many do so however, because in the planning process they demonstrate to themselves that the steps make sense.

Other cases suggest that the “transformative” power of self-reporting is enhanced when the data are public.<sup>57</sup> Public data facilitates comparisons and can generate pressure on laggards.<sup>58</sup> Public entrepreneurship networks provide an organizational structure in which this kind of joint monitoring of practice occurs naturally. How strategies worked, how funds were spent, and what results have been achieved are all subject to discussion in the network. Because PENs cut across lines between public, private, and civic a form of public monitoring is built into the structure of these ventures.

Administrators can enhance the monitoring capacity of these networks by creating reporting regimes that set protocols and pool data to facilitate analysis. It may be possible to enhance reporting by tying access to subsidies to willingness to report. Another approach would be to require organizations in these networks to jointly set goals and then report on their performance with respect to these goals.<sup>59</sup> In cases where reporting cannot be required, it may be useful to ensure that data is collected either by paying organizations to report or hiring someone to collect data. Planning and reporting requirement can encourage reflection on practice and provide the data for comparison across ventures.

*Organize opportunities for learning* – The development experience is rich and offers frequent opportunities for learning. The actors involved often lack the time and resources to take advantage of these opportunities, however. Acting in the role of the superintendent, administrators are in a good position to organize participants to reflect on experience and to capture and communicate the insights and lessons that these efforts generate. Because they hinge on interaction, PENs naturally lend themselves to this sort of process. Yet without this kind of explicit effort to organize reflection and capture the insights, the potential will go unrealized. Public administrators are in a good position to organize these processes.

If the first set of recommendations suggest a national clearinghouse for data on entrepreneurial practices and performance, this set might be understood as the branch of that center that is concerned with organized reflection on the development experience in PENs. A small example may help. In the Solaris project, Ecofys, Greenpeace, and Stork discovered that consumers really wanted a device that would tell them that their photovoltaic panels were working.<sup>60</sup> The mechanisms that provided this feedback in the current design were unsatisfactory. Stories circulated about families turning off all electricity and gathering around to watch their electric meter run backwards. This provided clear information about the consumers who were willing to buy the panels that was important for the next round of design. Solaris had no mechanism to capture this insight however, and it only exists in the ad hoc stories that the participants tell about the project.

Lost lessons are never mourned, but simply forgotten. Yet even small examples like this suggest the unrealized potential for learning that resides in PENs. In addition they offer great potential to learn about these new forms of inter-organizational collaboration. Administrators can enhance the learning capacity of the system by taking responsibility for organizing opportunities for the actors involved in PENs to reflect together on their experience and by capturing and circulating the insights that are gained.

*Deliberate about goals* – Finally, administrators are in a unique position to organize deliberative forums that relate experience to policy goals. In the context of deliberative arrangements, action can provide the basis for learning about goals. These deliberative forums may be considered as part of a program of nested opportunities for reflection that starts with reporting on practice and includes efforts to engage the actors involved in public entrepreneurship networks in an organized effort to learn from experience.

An initial step would be to organize forums across cases in which participants could examine what it means to work together in a public entrepreneurship network. What does experience tell us about the demands and tensions that are involved in working across sectoral and organizational boundaries? What does it mean for an NGO to work with a private firm and vice versa? What steps can be taken to enhance these working relationships? As much as the actors involved in PENs might benefit from asking these questions, it is unlikely that they will have the time to do this in an organized way or to follow through and capture the results. The potential of these PENs to generate public benefits creates a rationale for the use of public resources to organize opportunities for reflection that will enhance their capacity to act.

This kind of interaction can be extended to reflect directly on the goals of policy. What do we learn about the world from our efforts to change it? What do we learn about the meaning and value of sustainable development from trying to act on it? By organizing and managing these forums agencies can create a vital connection between action and goals and between the present and the future.

This approach to maintaining orientation has numerous benefits. It contributes directly to the legitimacy of policy goals and PENs as legitimate processes for realizing these goals. It builds association between goals and practical steps that advance them. It creates a level of commitment that is robust because it is tied to a broad understanding of goals. It creates relationships that make it easier to coordinate action and resolve disputes down the road. It offers a way to act on environmental goals that is attractive from the perspective of democracy. The challenges that are entailed in organizing these forums and the commitment of resources that is necessary should not be underestimated. Efforts that lack sufficient resources or are incomplete can actually do harm.

Participation in these deliberative forums can create the kind of tangible understanding of goals that leads people to act in local settings. Commitment can emerge for efforts to build understanding. Public entrepreneurship can be understood as a cycle in this sense. The efforts of the steward to organize deliberation on public goals and the common good also foster the kind of commitment that distinguishes pioneers and leads to the creation of new public entrepreneurship networks.

## Next steps

These recommendations for action are consistent with our findings. They represent our best assessment of steps public officials can take to enhance the performance of public entrepreneurship networks. Some central characteristics of these networks still need to be understood, however. By acting on these steps public officials begin to engage in an experiment. There are two aspects of these networks where such light is especially needed.

First we need a better understanding of the dynamics of the public entrepreneurship network. The five roles we have described provide an initial portrait of how development unfolds. What we have not been able to describe in detail are the relationships among these roles. We conceive of them as related in a loose "ecology." Just as one role in a game assumes another—if there is a goalie, there must be a striker—pioneers need and assume public venture capitalists, superintendents, and mediators. Stewards draw on the patterns of interaction generated through these roles to build community.

But the notion of ecology also implies that these roles are related dynamically. What remains opaque is what rules, if any, shape the relationships among these roles. Must pioneers come first, or can they emerge out of networks established by superintendents? How important is the practical focus that pioneers' commitments provide in attracting and sustaining the attention of other actors? How do the efforts of other actors contribute to the cohesion of networks? Is it possible to "seed" networks to trigger the moments when pioneers make commitments, or is policy restricted to indirect methods of cultivation? Is it possible to speed up development? What is put at risk when public agencies or other actors try to control the development of public entrepreneurship networks?

A second set of questions concerns what roles different organizations can take on at different times. From an organizational perspective, the five roles constitute a *role set*.<sup>61</sup> This does not say what kind of organizations can actually play each of these roles. Are the roles of pioneer, public venture capitalist, superintendent, mediator, and steward open to all actors? In particular, what roles can government play, and under what conditions? Are subsidiary relationships significant in analyzing government's capacity to play these roles? Are some roles open to local public agencies but not to federal agencies? It would be hard to imagine the U.S. Department of

Transportation playing the role SunLine did, for instance. How does this fact frame and limit the efforts of federal environmental agencies to promote sustainable development? The notion of a role set also raises concerns about organizational capacity and development.

Finally, we might ask how an organization's public entrepreneurship roles relate to the conventional roles it plays in policy making. For example, how do the internal demands of enforcing environmental regulations fit with an agency's participation in a public entrepreneurship network? What does it mean for government to become involved as an investor, or to play the role of mediator? What happens when advocacy organizations become involved with firms through public entrepreneurship networks? What happens when firms make commitments as pioneers or try to play the role of public steward? The historical experience of environmental agencies suggests that these roles conflict and create tensions inside organizations. Our research suggests their experience is not unique. Civic organizations and private firms experience similar tensions when they participate in public entrepreneurship networks. Advocacy groups and firms may find that their expectations about participation in a network are different. To sustain collaboration in a network, individuals may find themselves at odds with other members of their own organization. How these organizational tensions arise and how actors address them is an important area of inquiry.

The best vehicle for accomplishing the inquiry suggested by our recommendations is the organization of a series of action experiments. These experiments should be organized in areas where the potential for direct gains is high because of a promising pool of technologies and local interest. They could be organized either geographically or by sector. They should be conceived of as institutional experiments as much as experiments with new technologies. By carefully tracking progress and structuring the kind of opportunities for reflection discussed in the preceding section, these experiments could yield insight into the dynamics of public entrepreneurship networks, the relationships among roles, and the organizational tensions raised by participation in these new forms of inter-organizational cooperation. These experiments could be organized around instances of green technology implementation in the United States, Holland, and elsewhere. These experiments could provide direct benefits in changes in practice. Even more valuable is the understanding these experiments could yield about how public entrepreneurship networks function and how they can be enhanced to help make the transition to a more sustainable society.

# Appendix:

## Summary of Cases

The cases in this appendix provide further examples of the developmental process detailed by PEN. Each of the cases highlights the developmental roles played by the stakeholders involved in order to underscore the importance of these relationships to innovation. The following matrix summarizes the main points of each case.

<b>The Greenfreeze Refrigerator</b>	<ul style="list-style-type: none"> <li>▪ Traces the development and successful marketing of green refrigeration technology by two German doctors with assistance from Greenpeace</li> <li>▪ Highlights the importance of the venture capitalist, superintendent, and mediator roles played by Greenpeace in nurturing the pioneering efforts of the scientists</li> </ul>
<b>The Solaris Project</b>	<ul style="list-style-type: none"> <li>▪ Discusses the marketing of photovoltaic panels in the Netherlands through the partnership of Rabobank, the Dutch government, the management consultancy Ecofys, and Greenpeace</li> <li>▪ Underscores the importance of the superintendent role played by Greenpeace in nurturing cooperation between the financial sector and environmental organizations</li> </ul>
<b>Mobility CarSharing Switzerland</b>	<ul style="list-style-type: none"> <li>▪ Maps the merger of two major car sharing companies in Switzerland with the assistance of the Swiss government in order to provide a better integrated and more extensive service</li> <li>▪ Emphasizes the importance of the Swiss government providing venture capital to induce greater technological innovation in car sharing and acting as a superintendent in order to build relationships between Mobility and transit providers</li> </ul>
<b>Windmill Cooperatives in the Netherlands</b>	<ul style="list-style-type: none"> <li>▪ Focuses on farming cooperatives in the Netherlands that finance windmill development and market the resulting electricity for profit</li> <li>▪ Points out the ability of pioneers to generate create solutions for sustainable technology and finance them collectively through venture capital</li> </ul>
<b>National Energy Policy Simulation (NEPS)/ National Energy Consensus Experiment (NECE)</b>	<ul style="list-style-type: none"> <li>▪ Explains a two-part consensus-building program designed to encourage stakeholders in the United States to develop a national energy policy</li> <li>▪ Highlights the superintendent role played by the program sponsors in building communication and common understanding between traditionally opposed groups in the energy policy</li> </ul>



<b>Massachusetts Toxics Use Reduction Act (TURA)</b>	<ul style="list-style-type: none"> <li>▪ Discusses a Massachusetts program that encourages toxics use reduction by creating new forums for interaction among firms that use chemicals in production processes</li> <li>▪ Calls attention to the government's role as a superintendent in promoting communication between companies and promoting learning through interaction</li> </ul>
<b>Flanders Small-Scale Wastewater Treatment</b>	<ul style="list-style-type: none"> <li>▪ Details the development of new environmentally friendly wastewater treatment facilities through community opposition to the government's wastewater system construction plans</li> <li>▪ Accentuates the role of environmental and community organizations as stewards capable of reframing conflicts and defending public goals</li> </ul>
<b>The Coventry Electric Vehicle Project (CEVP)</b>	<ul style="list-style-type: none"> <li>▪ Discusses the deployment of electric vehicles in several government fleets and technological innovation that resulted from monitoring the test program</li> <li>▪ Draws attention to the importance of the relationships formed between the project sponsors and Peugeot in leading to the production of new electric vehicles</li> </ul>
<b>Connecticut Corridor</b>	<ul style="list-style-type: none"> <li>▪ Focuses on the failure of the Connecticut government to resolve conflicts between community groups and the Department of Transportation over improving transit service in a major highway corridor in the eastern United States</li> </ul>
<b>Praxitèle Electric Vehicles</b>	<ul style="list-style-type: none"> <li>▪ Discusses the first program to test electric vehicles with consumers, which was developed through a partnership with Renault, the French electricity board, a public transit agency, and several research institutes</li> <li>▪ Emphasizes the importance of venture capital to testing pioneering technologies on consumers and generating new collaboration between the public and private sector over automobile innovation</li> </ul>
<b>La Rochelle Electric Vehicles</b>	<ul style="list-style-type: none"> <li>▪ Details another French electric vehicle test program designed through a partnership between PSA Peugeot Citroen and the French electricity board that used consumers to generate information about market demand for Evs</li> <li>▪ Points out that the relationships formed by the program led to the production of two new electric vehicles and helped to generate new research partnerships based on EV research</li> </ul>
<b>Good Wood Foundation/Intergamma</b>	<ul style="list-style-type: none"> <li>▪ Discusses an organization that seeks to build relationships between wood vendors and environmental advocates over forestry issues and market strategies</li> <li>▪ Highlights the role of the superintendent in building relationships between divergent groups in order to share experience and expertise, and provide for common understanding regarding forestry issues</li> </ul>
<b>Station Car Demonstration in San Francisco Bay Area</b>	<ul style="list-style-type: none"> <li>▪ Traces the development of a station car program in the northern California through the collaboration of the Bay Area Transit Authority (BART), utility companies, and other private sector partners such as Bank of America.</li> <li>▪ Emphasizes the importance of public venture capital in recognizing innovations and providing the resources necessary to test them publicly</li> </ul>

## The Greenfreeze Refrigerator

The development of Greenfreeze refrigerators would not have occurred without the *pioneering* initiative of two doctors working in the Dortmund Institute of Hygiene. Motivated by an unsuccessful search for a new environmentally friendly cold storage unit for their institute, the doctors began researching new cooling technologies that would be less environmentally harmful than available HCFC and HFC cooling technologies. The doctors developed a new hydrocarbon-based technology and joined with other partners to introduce the Greenfreeze refrigerator on the market. Although the chemical industry had previously tried to develop an environmentally friendly cooling mechanism after CFCs were phased out, the companies gave up when they failed to find a profitable technology. Motivated by public goals rather than profit, the doctors represented *stewards of public interest*; their civic regard represented the essential catalyst for the discovery and introduction of Greenfreeze technology.

When electric refrigeration was introduced in the 1920s and 1930s, a number of the units used isobutene (a hydrocarbon) as a cooling agent.<sup>62</sup> However, in the 1930s chlorofluorocarbons (CFCs), hailed as the new “miracle compounds,” replaced hydrocarbon technology in most refrigerators. After scientists discovered that CFCs were largely responsible for the growing ozone hole, international treaties mandated the phase-out of CFCs in refrigerators in the late 1980s. During this period, German refrigerator manufacturers cooperatively decided (with encouragement from the chemical industry) to use HFC 134a as a replacement for CFCs, while refrigerator manufacturers in many other countries decided to replace CFCs with HCFCs. Environmental groups pointed out that these changes in refrigeration technology were far from ideal, because HCFCs deplete ozone (although at a slower rate than CFCs) and both HCFCs and HFCs are global warming gases.<sup>63</sup>

Enter Dr. Harry Rosin, Director of the Dortmund (Germany) Institute of Hygiene, and Dr. Hans Preisendanz, scientific assistant to Dr. Rosin. When the institute needed to install a new cold storage room in March 1989, the doctors decided that using any of the HFC-based refrigerators on the German market was unacceptable due to their impacts on climate change.<sup>64</sup> The team, led by Dr. Preisendanz, started experimenting with new refrigeration technology and developed a new cooling system that uses a special combination of naturally occurring hydrocarbons (propane

and butane, specifically) for cooling. Price competitive with HFCs and produced routinely as a byproduct of the oil industry,<sup>65</sup> these gases contain no ozone-depleting or global warming substances.<sup>66</sup>

While the doctors' research was still ongoing, the Dortmund city leaders ordered that the doctors cease their refrigeration study and return to "public health" work.<sup>67</sup> (This argument could be made that the refrigeration research aimed at reducing use of HFC chemicals had a direct link to Dortmund public health, in fact, because a German chemical company was at that time setting up a new plant in the city).<sup>68</sup> The doctors' work shifted to their own houses and they abandoned their prototype refrigerator in the institute basement.<sup>69</sup>

Meanwhile, Greenpeace campaigner Wolfgang Lohbeck was searching for the least environmentally damaging solution to refrigeration problems.<sup>70</sup> Lohbeck noticed a short article in a little-known journal that reported that the German environmental ministry, Umweltbundesamt, had honored Dr. Preisendanz with an award for his research.<sup>71</sup> Lohbeck established contact with Dr. Preisendanz, and Dr. Preisendanz introduced Greenpeace to the possibility of using hydrocarbons in refrigeration.<sup>72</sup> Acting as a *superintendent*, Lohbeck brought Dr. Preisendanz to a conference in March 1992 organized by the chemical industry in order to convince detractors of 134a that it represented a good solution.<sup>73</sup> Participants included representatives of the German environmental ministry, chemical manufacturers, technical universities, and refrigerator producers.<sup>74</sup> According to Lohbeck, the conference served as important opportunity for increasing communication between groups; in particular, Dr. Preisendanz successfully defended 134a and presented a convincing argument about the unsuitability of HFCs.<sup>75</sup>

Next, Greenpeace and the doctors sought to discover a refrigerator manufacturer that would produce a hydrocarbon-based refrigerator. The team contacted major German refrigerator manufacturers to persuade them to use the new technology, but none of the firms responded with interest. The major manufacturers had already invested heavily in HFC technology, had close ties to the West German chemical industry, and had voiced serious doubts about the feasibility and safety of hydrocarbon use.<sup>76</sup>

Greenpeace next made contact with DKK Scharfenstein (subsequently renamed Foron), a former East German refrigerator manufacturer that was suffering from severe financial problems.<sup>77</sup> Foron seemed to be the ideal partner for the project for several reasons: the firm was willing to experiment with new technologies because it had little presence in the market, represented the only firm to make its own compressors (this eliminated the insurmountable difficulty of forming agreements with subcontractors on isobutane prototype production), and was the only manufacturer not to use CFC-based insulation.<sup>78</sup> Although the firm was in the hands of the Treuhand, an agency set up to rejuvenate dying East German industries, its chief liquidator was reportedly traveling from Berlin to Saxony to close down the firm.<sup>79</sup> However, Foron staved off liquidation by agreeing to develop 10 prototypes of refrigerators cooled by hydrocarbons, which were funded using *public venture capital* provided by Greenpeace.<sup>80</sup> Although the firm did not see any technical problems with creating the hydrocarbon refrigerators,<sup>81</sup> Treuhand initially opposed the manufacturing plan. The funding provided by Greenpeace however demonstrated a strong level of support and Treuhand eventually responded with additional funding.<sup>82</sup> Greenpeace then launched a cheap publicity campaign to promote the new refrigerators, and 50,000 advance orders were placed within a month.<sup>83</sup> This demonstration of market demand represented an essential component in securing the extra capital investment necessary to launch the Greenfreeze refrigerator.<sup>84</sup>

In the course of developing the Greenfreeze refrigerator, Foron met objections to the hydrocarbon technology by using extra insulation and by showing that there was a negligible fire risk. Because of these features, the German safety and standards institution Technischer Ueberwachungsverein (TUEV) approved the new 'Greenfreeze' Models as "safe and tested" (a designation valid throughout the European Community).<sup>85</sup> Through the assistance of Greenpeace as a *mediator*, Foron has successfully surmounted the obstacles to producing the refrigerators and proving that the technology was environmentally friendly and safe.

Underscoring the success of the new product, Foron gained 5% of the refrigeration market share with its new Greenfreeze units within a year. After witnessing this initial success, Foron decided solely use hydrocarbons as coolants in its refrigerators. Other German refrigerator manufacturers initially criticized the new technology, but also decided to abandon use of HFC 134a after observing Foron's accomplishment. Within two years of the first hydrocarbon refrigerator, German-made refrigerators almost

exclusively used hydrocarbons for cooling. Today almost every major European refrigerator manufacturer is marketing refrigerators based on Greenfreeze technology.<sup>85</sup>

The popularity of Greenfreeze refrigerators has consistently increased in recent years; there are now approximately 40 million units sold worldwide, in over 100 different models.<sup>87</sup> Most notably, China's two largest refrigerator manufacturers have switched to Greenfreeze technology, highlighting the popularity of the technology in developing countries.<sup>88</sup> Greenpeace has continued to assist this development by using *public venture capital* to campaign extensively for the introduction of hydrocarbon refrigerators in Japan, Latin America, and China.<sup>89</sup> Greenpeace has also continued its role as a *superintendent* in increasing communication between various refrigeration stakeholders; the organization participated in one technical seminar, for example, that brought German refrigerator manufacturers to China to discuss hydrocarbon technology.<sup>90</sup> There has also been a good deal of cooperation between other European firms and institutions and developing countries. For example, the Netherlands now converts 200,000 second-hand refrigerators a year to propane for use in West Africa.<sup>91</sup>

Refinement of Greenfreeze technology continues. Some Greenfreeze refrigerators with isobutane now use up to 38 percent less energy than their identical counterparts with HFC-134a.<sup>92</sup> Moreover, Greenfreeze technology developers have not limited themselves to traditional refrigeration; models of interior and vehicle air conditioning also have been developed.<sup>93</sup>

It is clear that the Greenfreeze project was very successful in that it resulted in the market replacement of an environmentally hazardous product with a more environmentally friendly product. But the project was also successful in that it led to learning on the part of industry, the public, and Greenpeace in several ways. First, the campaign made the public aware of both the dangers posed by the old refrigerator design and the availability of environmentally friendly technology. Second, the market push by Foron forced other refrigerator companies to reexamine their original assumptions about hydrocarbon cooling technology. The project also caused Greenpeace to reexamine its role in defending the environment. For example, Wolfgang Lohbeck, the campaigner who first worked on spreading Greenfreeze technology, says that the organization learned that it could enjoy more fruitful relationships with industry as a partner in a collaborative effort: "What really surprised me was that we could suddenly talk quite differently with industry...[n]ow we were seen as partners in dialogue."<sup>94</sup> Furthermore,

the organization "could talk to the public quite differently from when [it was] just saying 'no' to using CFCs."<sup>55</sup>

The case also demonstrates the power of network formation. The doctors obviously lacked the resources to penetrate and dominate the refrigerator market themselves, but the team formed by Greenpeace and Foron succeeded in disseminating the technology because of the combination of skills and resources they brought to the project. Part of the success of the publicity campaign can be attributed to Greenpeace's position as an organization committed to *serving public goals*; their position lent legitimacy to the new refrigerator's claims to environmental friendliness.

Although the Greenfreeze story is one of success, the case highlights several obstacles that could have brought the project to a halt. These barriers further underscore the importance of the six public entrepreneurship roles. The failure of the local government to support Dr. Rosin's and Dr. Preisendanz's research represents one of these obstacles. Had the doctors not met with Greenpeace during this crucial period, the Greenfreeze technology might never have been introduced. The assumption of a *mediating* role by some unit of government could have provided a sort of safety net for the process, because the government could have worked to remove obstacles from the project's path. Similarly, the absence of regulations that could generate liability for refrigerator manufacturers for kitchen fires is one reason that the Greenfreeze refrigerator was able to penetrate the refrigerator market.<sup>56</sup> In countries with more strict liability regulations, the government could play a *mediating* role in order to provide a fair opportunity for the technology.

In this case also we see that non-governmental actors may have a vision or understanding that enable them to better serve as a *steward* of the public interest than the government. Government policymakers, because of their generally limited understanding of refrigeration technology, did not possess the technical vision to undertake a project to make refrigerators more environmentally friendly. Because of economic investments and industry ties, the major refrigerator manufacturers had no interest in developing a new technology. The doctors' *pioneering* vision was the crucial catalyst for the Greenfreeze project, and non-governmental actors may need to offer such a vision in many similar cases. While in some cases private firms may have the initiative and ideas necessary to launch new green technologies, in this case Dr. Rosin and Dr. Preisendanz simply came up with the right mixture of gases – an example of innovation that cannot be patented.<sup>57</sup> The chemical industry had earlier searched for a substitute for CFCs, but since

it was only interested in ideas that could be patented, the industry never seized upon the mixture of butane and propane that the doctors identified.<sup>8</sup> Research infused with a degree of public spirit, then, was essential for the launch of the Greenfreeze technology.

## **The Solaris Project**

In 1997, Greenpeace set out to prove a point. They felt photovoltaic technology offered a much more immediate potential than was being realized. The way to break through the stalemate was to take direct action that would put solar panels on the roofs of homes and offices. By generating this 'action vector' they would also contribute to making panels cheaper, more accessible, and more commonly discussed by consumers and citizens.

Greenpeace set the ambitious goal of placing 20,000 solar panels on Dutch roofs within two years. They sought to use the organization's visibility and legitimacy with the public to appeal directly to citizens to purchase solar panels. These contracts could then be assembled into a purchasing block that would interest producers and help to break the volume/price standoff that was keeping production levels low.<sup>9</sup> Because Greenpeace lacked the financial resources, market understanding, and production capabilities to pursue this strategy unilaterally, they immediately began to put together the network of actors necessary to meet their ambitious target.

Greenpeace contracted the consulting firm Ecofys to perform a market study that would help set a target price for the panels and inform the design of the product. The study found that consumers would purchase solar panels for three main reasons: the excitement of being the first to use a new technology, a desire to help the environment, and the independence that comes with producing one's own electricity. The product design merged Greenpeace's direct marketing strategy with information Ecofys had gleaned from its study and from other pilot research. The team designed a do-it-yourself kit that consumers could purchase and assemble at home without professional assistance or exotic tools. The panels could be mounted on a roof with the hardware contained in the kit, and plugged directly into a household electrical outlet.

Rabobank and its subsidiary De Lage Landen joined the group to help with the financial arrangements and Stork, a firm which already was installing Shell solar panels in the Netherlands, joined to help with supply chain

management and final assembly of packages. Ecostream, a spin-off from Ecofys, managed the marketing for the kits. The partners in the project signed a statement of intent in 1998.

The price per panel, however, remained higher than the target of NLG 1000. Acting as a *mediator*, Greenpeace lobbied for a package of government subsidies and tax breaks that would reduce the market price to this target. The available subsidies were focused on research and development rather than production, however. With customer contracts in hand, Greenpeace eventually persuaded NOVEM to redirect funds to the project for the first 5300 solar panels. With the help of Rabobank they created an operational lease construction to get around the restriction that limited the subsidies to commercial enterprises. In the end the panels were leased to the consumers, which increased access to the subsidy and reduced the price to the targeted level of NLG 1000.

Participants in Solaris had leased 3100 panels by June 2000, although Rabobank, Ecofys, and Stork had hoped to lease a greater number of panels by this time. However, the partnership between Ecofys/Ecostream, Rabobank, and Stork will continue until all 5300 subsidized panels have been sold. At that point, Ecostream plans to continue Solaris, but the other partners will have the option to leave the partnership. Ecostream has learned lessons through cooperative work on Solaris about how different organizations contribute to joint ventures, and may replace certain partners. Greenpeace's involvement in Solaris after initiating the project chiefly involved mailing project information to its members and allowing the partnership to use its logo on informational materials; after fulfilling these responsibilities early on, Greenpeace discontinued its active role in the partnership.

Some critics of the Solaris project argue that Greenpeace undermined the success of the project by collaborating with other solar panel suppliers. Certain partners were disappointed that Greenpeace violated the terms of the statement of intent by allowing other suppliers to use the Solaris and Greenpeace name and logo on their materials. We can view Greenpeace's nonobservance of business mores as an unsurprising misstep in making a transition into a new forum for environmental action. Other Solaris partners believe that Greenpeace's involvement in the project was critical. Not only did Greenpeace provide the invaluable spark for Solaris; they also gave the partnership legitimacy in promoting Solaris to the government and the public. Ecofys has expressed disappointment that the public character that



Greenpeace brought to Solaris as an organization committed to serving environmental goals is now missing.

The Solaris partners also encountered significant difficulties in developing and implementing the operational lease system. Some project partners claim that delays in getting government subsidies for the lease construction represented the principal reason for the project's slow start. The lessons learned through the experience of developing these financial arrangements may serve as the foundation for the use of similar creative mechanisms in the future.

Overall, the results of the project were mixed. The level of panel leasing fell far short of expectations. However, numerous benefits are clear. Solaris introduced thousands of people to the technology and the learning gained by the project was of less obvious, but no less significant value. Because of some consumers' frustrations about not being able to determine how much electricity they were saving by using the panels, a meter was developed that consumers could purchase to measure energy production. This specific design modification represented an important contribution because it recognized and addressed a likely barrier to the technology's future dissemination that would not have been identified through continued research and development work. Ecostream and NOVEM also learned a great deal about customer desires through formal research and informal follow-up with customers. Most importantly, they learned that many customers would like to be able to purchase the panels, have panels installed for them, or purchase a larger number of panels than were available to each participant in Solaris. Another success of the program was the use of an operational lease construction for financing the project, because this introduced to the Netherlands a new means for securing favorable tax regulations on alternative energy systems.

Greenpeace did show that action can push technologies forward. Action to introduce the technology brought together a network of actors, connected ideas, resources, and expertise, and contributed to the development of "social capital." Moreover, it raised the potential for learning about consumer demand and response to certain design elements, marketing and financing strategies, and a host of other factors that will be critical for the product's and other products' future success. A sign of Solaris's value is that Ecostream has been able to apply lessons learned from Solaris to the SOL\*id project, which offers solar hot water systems to private consumers; Ecostream now combines promotion of these two projects.

Solaris, then, has created partnerships and lessons that persist despite the loss of Greenpeace, the original entrepreneur.

## **Mobility CarSharing Switzerland<sup>100</sup>**

Mobility CarSharing began in 1997 when two independent car sharing organizations merged with the assistance of the Swiss government. The government decided to provide *venture capital* to these *pioneering* companies after a 1992 study showed the car sharing customers drove less and consumed less energy. Identifying the potential public benefit derived from innovations in transportation, the Federal Office of Energy decided to conduct the study in order to justify government support for the companies. Officials contracted the LINK institute to conduct a survey of former, existing, and potential car sharing users to evaluate future demand for the service, and investigate the influence of car sharing on mobility behavior and energy use. Seeking to provide a catalyst for product and market development, the government also used the survey to understand what improvements could be made to the service to increase customer satisfaction and use of the service.

Recognizing the potential public benefit of car sharing, the government also exhibited a *superintendent* role in cultivating relationships between transportation providers in order to increase the ease of car sharing. The combination of the two car sharing companies (ShareCom, a technology-oriented grassroots cooperative, and ATG-AutoTeilet Schweiz, a national and client-oriented enterprise) represented the first of these developmental relationships encouraged by the government. Although car sharing companies had existed in Switzerland since the late 1980s, the government sought to create a standardized nation-wide service that would provide greater integration and increased accessibility to car sharing. Mobility now provides greatly expanded service, with over 900 vehicles available in 300 municipalities and at over 200 rail stations. Membership is currently 20,000 and continues to rise at the rate of more than 50% annually.

The government also sought to develop partnerships between Mobility and existing transit service providers. Hoping to better integrate car sharing into existing transportation services, the government in 1998 helped to create a national combined service for railway users and drivers by forming an alliance between Swiss Federal Railways and Mobility. The resultant "Züri Mobil" program (offered by Verkehrsbetriebe Zürich, Mobility, Europcar, and the government's Energy 2000 program) allows bearers of passes of

the Zurich public transportation system or Swiss Federal Railways general season tickets to use Mobility CarSharing services at favorable conditions, fall back on rental cars at special rates, and use "free companion tickets" on Zurich public transportation.

The *public venture capitalist* role played by the government had an important part in encouraging technological innovation in car sharing, and increasing the professionalism of the service. Potential customer service improvements identified through the LINK survey have been implemented such as allowing reservations by telephone or computer. Public venture capital has provided resources to equip cars with on-board computers that simplify coordination with public transit and facilitate the reservation and accounting processes. Mobility envisions further professionalizing its services by providing individual mobility consultations with users and offering smart card passes that give customers access to all means of transportation.

## **Windmill Cooperatives in the Netherlands<sup>101</sup>**

Citizen groups in the Netherlands opposed to nuclear power have acted as stewards of public interest by forming a number of windmill cooperatives. The members make loans to the cooperative in order to acquire and operate wind turbines that are connected to the electricity grid. The electric companies pay the cooperatives for the energy produced, which is used to refund the members of the cooperative. The cooperative also has shown struggling farmers that purchasing windmills is an effective way to supplement their income, thereby enlarging supply of wind energy. This case also shows citizens acting as venture capitalists by devising creative funding strategies to promote the public goal of sustainability.

## **National Energy Policy Simulation (NEPS)/ National Energy Consensus Experiment (NECE)<sup>102</sup>**

The MIT-Harvard public disputes program in association with the American Energy Assurance Council (AEAC) conducted a two-part consensus-building program aimed at developing national energy policy between 1988 and 1990. The first phase, called the National Energy Policy Simulation (NEPS), was a simulation involving various energy policy stakeholders. The NEPS did not seek to directly outline a new energy consensus. Rather,

the program placed the stakeholders in a simulation of a fictional national energy crisis, which sought to highlight the fact that the stakeholders would probably be unable to reach consensus on a new policy in such a situation. Organizers of the simulation therefore hoped to impel the stakeholders to work towards such consensus before crisis periods. Moreover, the program provided a means to analyze patterns of interaction and stakeholders' ability to reach quick agreement during a crisis.

The second part of the consensus-building effort built on the heightened interest in forming an energy strategy created by NEPS. AEAC sponsored the second phase, entitled the National Energy Consensus Experiment (NECE), in 1990. Bringing together similar stakeholder groups, the effort sought to outline the major interests of these groups, build understanding across them, and attempt to shape a general energy strategy that all participants could support. Although the Board of Directors later sent President Bush's administration a report highlighting the agreements reached in the negotiations, the administration never acted on the report (a high-level official who disagreed with the findings failed to pass the report on to the President). This final phase of the project represented poor *mediating* on the part of government.

NEPS/NECE played a *superintendent* role by bringing together stakeholders in the energy policy debate. By introducing these actors to one another and encouraging interaction, the experiments formed a basis of understanding between different parties. Through negotiation, the different stakeholders formed a more realistic understanding of each other's interests, learned to cooperate and trust each other, and found that they shared previously undiscovered goals. This learning and trust formed the basis for more fruitful real-world interactions and partnerships between the groups. Mediation in the NEPS/NECE clearly made an important step toward breaking the deadlock on national energy policy.

## **Massachusetts Toxics Use Reduction Act (TURA)<sup>103</sup>**

TURA encouraged toxics use reduction by creating new forums for interaction among firms that use chemicals. The Toxics Use Reduction Institute, an office of technical assistance, and an administrative council all facilitated the development of relationships among firms by providing new means for sharing strategies and ideas. Moreover, the presence of industry, environmental groups, and health organizations on the advisory board of the

administrative council built networks between firms and other stakeholders. This is an example of government adopting the role of *superintendent*.

TURA was specifically designed to facilitate learning about toxics use reduction in Massachusetts firms that use chemicals. The act encouraged learning in several ways. First, the requirements for reporting chemical use and toxics use reduction strategies made possible monitoring and the development of an understanding of best practices. Next, TURA created a Toxics Use Reduction Institute and an office of technical assistance that collected information and ideas, partly by way of engaging in research about solving specific toxics use problems. These institutions disseminated knowledge to firms through workshops, panels, and newsletters, among other programs. Finally, the act directed firms to learn about toxics use in facilities by assembling cross-functional teams and by soliciting from all employees suggestions for reducing toxics use; this contributed to an understanding of production processes and potential for process change in a way that facilitated learning among a wide variety of branches of firms.

## **Flanders Small-Scale Wastewater Treatment<sup>a</sup>**

In Flanders, the government invested in a wastewater system that required a great number of wastewater collectors and treatment plants. The government delegated responsibility to these plans to Aquafin, a 51% government-owned body. Environmental organizations, however, objected to Aquafin's plans to construct sewage tubes along natural streams and rivers, because they believed that this strategy would damage natural water management in the waterways. These organizations provided an alternative to the Aquafin plan by cooperating with a number of small firms to develop small-scale biological water purification technology.

The case highlights a divergence of governmental and public views about the common good. The environmental organizations played the role of *steward of the public interest* by introducing a public concern that government actors concerned with other priorities, such as efficiency, had not identified. It seems that in this case that the government (Aquafin) passed up an opportunity to gain expertise, technical designs, and political support from the network of environmental organizations and small firms. The government could have seized this opportunity to organize and provide capital for the implementation of the small-scale treatment system.

## **The Coventry Electric Vehicle Project (CEVP)<sup>105</sup>**

The Coventry Electric Vehicle Project (CEVP) replaced existing traditional vehicles with electric vehicles in several fleets, most noticeably that of the postal delivery service Royal Mail Midlands. Royal Mail Midlands was very motivated to experiment with alternative vehicles because of its concern about future vehicle use restrictions in certain areas. After implementing the electric vehicles, Royal Mail established an extensive monitoring program to assess their use. Royal Mail shared its assessment of its experience with the electric vehicles with Peugeot and suggested developing a larger capacity volume van. Peugeot followed the suggestion and found that the van increased the diversity and commercial potential for its vehicle line. In this case, technology users' formal analysis of the experiment and feedback to experiment organizers led to learning and then to forward-looking technology modifications.

## **Connecticut Corridor<sup>106</sup>**

The Coastal Corridor Coalition (CCC), which is made up of business, civic, and environmental organizations, advocates significant traffic reductions along the I-95 highway. Prompted by the coalition, the Connecticut legislature mandated that the Department of Transportation (DOT) reduce congestion on I-95 by 5 percent within 5 years, with the objective of improving transit service and meeting Clean Air Standards. The coalition formed in reaction to the DOT-initiated stakeholder group ICDC, which has promoted proposals to expand the highway. The coalition suggested developing high-occupancy lanes, transit and ride share improvements, and a transit incentive package, which DOT has refused to acknowledge. In the absence of backing from DOT, limited resources and lack of public capital, little has been achieved in terms of making available alternative modes of transit for I-95. The government could have stepped into the process in a number of roles, including that of *venture capitalist*, *mediator*, and *steward* of the public interest.

## **Praxitèle Electric Vehicles**<sup>107</sup>

The Praxitèle experiment is the first experiment to offer electric vehicles to customers on a self-service basis. The project was initiated in 1993 in the French town of Saint-Quentin-en-Yvelines by a partnership of research institutes and industries, including Renault (a French car manufacturer), Electricité de France (France's electricity board), and CGFTE (a public transit operator), INRETS (a research institute specializing in transport technology), and INRIA (which specializes in computer science).

The partnership sought to provide electric vehicles in areas where mass transportation lacked flexibility or frequency, providing fifty electric vehicles and five special parking facilities. By 1998, 520 people had made use of the vehicles. The Praxitèle project experimented with a number of sophisticated technologies, including smart-cards that allow clients to open and operate the vehicles, electronic tow-bars for moving the cars, induction recharging, and automatic parking. The partnership evaluated the use of these innovations in order to develop future projects, including similar endeavors in several other cities.

## **La Rochelle Electric Vehicles**<sup>108</sup>

From 1993 to 1995, private users and companies in La Rochelle, France tested a fleet of electric vehicles (EVs) in order to learn about their driving habits and willingness to buy EVs. A variety of *public venture capitalists* provided the resources necessary to implement the test. The city of La Rochelle developed parking systems, PSA Peugeot Citroen supplied the automobiles and maintenance, and Electricité de France installed recharging infrastructure. The fact that, at the conclusion of the project, half of the users of the EVs decided to purchase the EVs they had tested underscored the success of the program. After demonstrating the market demand for EVs, automakers were impelled to introduce two new EV models for production. The experiment generated a cascade of new activity near La Rochelle, such as the citing of an Environmental Defense Fund center responsible for maintenance of re-charging infrastructure, and the development of a research center for electric vehicles. The project led to many new partnerships between these institutions and other universities and businesses involved in EV research and development.

## **Good Wood Foundation/ Intergamma**

The Good Wood Foundation acts as a *superintendent* by creating a forum in which environmental advocates and wood vendors can share their expertise and experiences.<sup>109</sup> Because each group provides its own expertise based on experience (dealers provide information about the market while environmental groups understand issues regarding tropical forests), a “cross-fertilization” of ideas takes place.<sup>110</sup> The foundation also brings together customers who want to purchase sustainable wood with appropriate retailers through their website search engine. Therefore, the networks generated by Good Wood lead to information sharing as well as some joint strategic decisions.

The timber vendor Intergamma joined the Good Wood Foundation as a result of a decision that was “impulsively taken by the general director,” according to E.J. Schippers. The decision represented a *pioneering* decision among major vendors, and the company supported and sustained that initial decision by making the policy “well institutionalized” in corporate policy and philosophy. The reputation garnered through association with the foundation has helped the company to attract new customers and sustain their commitment to selling certified wood.

## **Station Car Demonstration in San Francisco Bay Area**

Founded in 1993, the National Station Car Association sought to test and commercialize the station car concept. Founded through collaboration with Bay Area Rapid Transit (BART), the American Public Transit Association (APTA), the Station Car Task Force, and the Transportation Program of Electric Power Research Institute, the Association developed a station car demonstration project at BART stations. Acting as *public venture capitalists*, a variety of utility providers and private companies funded the effort, including Pacific Gas & Electric Company (PG&E), the California Energy Commission, Defense Research via CALSTART, Bank of America, and Sybase.

The demonstration not only catalyzed interest in electric vehicles and electric vehicle infrastructure, but also demonstrated the feasibility of multiple-use, non-dedicated vehicles and car sharing. The test allowed for customer surveys and market research into participants’ utility for the vehicle and their willingness to pay for the service. The Association’s role



as a *superintendent* in fostering relationships among different energy and financial service companies also underscored the importance of forming alliances for pooling resources. As a result of the project, a number of station car pilot projects are in the pipeline in San Francisco Bay Area with funding from public and private sources.

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## Endnotes

- <sup>1</sup> We are grateful to our colleague Dave Wallace for this direct statement.
- <sup>2</sup> Only 2,400 electric vehicles have been sold in California since their introduction in 1996.
- <sup>3</sup> Johan Schot and Arie Rip, "The Past and Future of Constructive Technology Assessment," Technology Forecasting and Social Change 54 (1996): 251-268
- <sup>4</sup> John O'Dell, "Gas Vehicles Top Rakings on 2001 'Green Book'," Los Angeles Times 14 February, 2001: G1.
- <sup>5</sup> Nicholas Ashford, C. Ayers, et al., "Using Regulation to Change the Market for Innovation," The Harvard Environmental Law Review 9(2): (1985): 419-466.
- <sup>6</sup> Vicki Norberg-Bohm, "Stimulating "Green" Technological Innovations: An Analysis of Alternative Policy Mechanisms," Environmental Technology and Public Policy Program Working Paper. Department of Urban Studies and Planning, Massachusetts Institute of Technology.
- <sup>7</sup> Gerard Keijzers, "The Changing Ecological Arena: The Evolution of Dutch Environmental Policy from 1970-2000 (and Beyond)," ETP99-05, Environmental Technology and Public Policy Program Working Paper. Department of Urban Studies and Planning, Massachusetts Institute of Technology.
- <sup>8</sup> See Schot and Rip, 1996, for an insightful summary of the history of these approaches and a thoughtful perspective on their future.
- <sup>9</sup> *Ibid.*, p. 256.
- <sup>10</sup> All of the quotes by Dick Cromwell in this report were gathered in an interview conducted on August 3, 2000.
- <sup>11</sup> All of the quotes by George Earl in this report were gathered in an interview conducted on August 3, 2000.
- <sup>12</sup> David Laws and Ginette Chapman visited SunLine's headquarters in August 2000.
- <sup>13</sup> Most of the Coachella Valley residents we interviewed professed a regard for environmental quality in one way or another. In fact, environmental quality was frequently cited as one of the reasons residents choose to move to the desert. More than one described in visceral terms driving across the line of smog that sometimes encroaches on the Valley from Los Angeles. This regard for environmental quality is also manifested in local regulations. For example, exterior lighting must be directed downward and shielded to preserve the view of the night sky.
- <sup>14</sup> Interview with Dick Kelly, August 28, 2000.

<sup>15</sup> Interview with John Pena and Percy Byrd, Board of Directors, SunLine Transit, August 2, 2000.

<sup>16</sup> In Dick Cromwell's words: "To make it work you have to go get the money. So they had a built-in check and balance. If I wasn't able to get the money, they're safe, and if I was able to get the money, we'll take that step as we go."

<sup>17</sup> Roadcall is a measure of the average distance traveled between episodes where a bus breaks down while in use, interrupting service and requiring roadside service. The national average is less than 8,000 miles. SunLine's average is between 30,000 and 40,000 miles.

<sup>18</sup> Sacramento Regional Transit District and SunLine Transit Agency, *Three Year Comparison of Natural Gas and Diesel Transit Buses*, revised August 1999. According to this study, in 1997 SunLine's CNG buses saved more than \$200,000. Specifically, "SunLine saved approximately \$0.142 per mile over 1.5 million miles with 34 buses." The study concludes that although the incremental capital costs of CNG buses are between \$35,000 and \$50,000 more per bus, the "payback appears to be realized in approximately six to eight years or 250,000 to 350,000 [miles] per bus." These savings result from "thorough mechanic training and some CNG life-cycle cost reduction because of reduced engine wear." Furthermore, "the CNG engines at both agencies show no signs of needing a mid-life rebuild as usually done with diesel engines at approximately 250,000 miles."

<sup>19</sup> Earl said, "[O]ne of the nice luxuries is that it's almost unquestionable that you'll even question why you need this training.... When I came to work here under a different regime, I and one other guy were the only guys that ever got sent to training anywhere. And we got sent to an air conditioning school in Arizona.... And we had to room together and everything. Now we don't hesitate, we bring trainers in.... We do training as well." SunLine also employs a person to oversee special projects training.

<sup>20</sup> Cromwell explained: "[The involvement of SunLine's mechanics in the design and redesign of the training program] was very, very critical. When they walked me through the community college and I saw what they did over there, I was fascinated with a piece of equipment. I said, 'Gosh, that's an interesting piece of equipment,' and Denny, who was our chief mechanic at the time said, 'Oh yeah, that's a so and so, and it does such and such, but we don't use it very often.' 'You don't use it very often?' He said, 'No...., that's something you send the thing out to do. You don't do that in a shop. [But] everybody [is trained to use] the thing so they know how to do that.' 'Wait a minute, there's a disconnect here. Why are you training someone to do that machine, [even though] when it gets to us we're going to send it out to a shop to be done?' So...I said, [our mechanics] have to be part of

the team..., because there is a natural disconnect from the [academic] to the practical. I don't mean that in a bad sense. But there really is."

<sup>21</sup> Dick Cromwell, quoted in J. Galligan, "SunLine Likes the Alternative," Light and Medium Truck May, 2000.

<sup>22</sup> J. Duffy, "Transit's Brave New World," Mass Transit May/June 1999.

<sup>23</sup> Dick Cromwell explained: "We see ourselves as sort of a beta-test site,... for working with Cummins Engine Co. and John Deere and Detroit Diesel and the like. [T]hey bring in their latest engine, we put it in a bus and we see what happens in real life before it's turned over to the market. [F]rom the manufacturer's point of view, what a great opportunity, because [it may work in the laboratory], but what happens when real people have to work with it? [With] weather conditions like we have, and an everyday, 19-hour operation with several shifts and different levels of education working on that engine, what happens then? We provide an ideal opportunity to [explore] that."

<sup>24</sup> As an example, Dick Cromwell told of a time when DOE called SunLine about "a little funding issue that seemed so miniscule in the world of things." He was a bit startled that they bothered to call at all. "But I think we're going to be able to solve the problem," he said, "and I suppose that's why they called us."

<sup>25</sup> Cromwell described one of their more complex projects: "What we're doing is we're taking diesel, we're reforming it to hydrogen and we're making it work for a tank. We're doing that here with partnerships with [the University of California at Riverside] and College of the Desert."

<sup>26</sup> See Hirschman, Strategy of Economic Development, 6-7.

<sup>27</sup> *Ibid.*, 9-10 (quoted at the beginning of this paper).

<sup>28</sup> *Ibid.*, 5.

<sup>29</sup> Dick Cromwell described the risk SunLine was forced to take by committing to a *fleet* of buses as a key to their success. "I've realized that the way to get this movement to continue to go, elected officials need to find a way to let their person in the trench have a safety net. And the safety net is to have a board say, 'Go do this.' One of the reasons I think the clean air movement is as slow as it is is that people like me don't want to take the risk, because what happens? I go to alternate fuel. I'm kind of afraid of it, I don't know too much about it, but my board wants me to do it, [so,] OK, I'll go do it. I'll put in three buses. Well, if your job is putting out 500 buses a day, where do you think the resource is? It's in those 497 buses, there's not much resource put into the three, and sure enough they don't work. So now it's your turn and you've heard from me that they really don't work. Well you don't know enough to ask: Do you give it the same resources you do your other 497 buses? And you now [think] it doesn't work. So your elected

official comes to you and now you're really nervous, because gosh, it's not going to work, and what's going to happen is the constituents..., the bus isn't going to be there on time or it's not going to be there at all, and they're going to call my elected official and my elected official is going to call me and I'm going to be in trouble. So what do I do? I fight it. I don't care about global warming. And what do I know about balance of trade, and what do I know about energy dependency? All I know is I'm supposed to have that bus out there at 5:37, and with a diesel bus for a hundred years I've been doing it and it works just fine and Joe over here told me it doesn't work [with his three buses]. And it doesn't."

<sup>30</sup> The term "Superintendent" is drawn from the literature on common pool resources. It is typical in successful management programs to have a superintendent who oversees the maintenance of the system. This actor derives his or her authority from the regulated parties and ensures that they follow through on their commitments to sustain the system. The analogy is inexact, but the systemic focus of the concerns is reminiscent.

<sup>31</sup> See Hirschman, Strategy of Economic Development.

<sup>32</sup> In other words, prices cannot be lowered without investing in new production technologies. But firms are reluctant to make such investments when demand is low, and the high prices ensure that demand stays low.

<sup>33</sup> NLG stands for Netherlands Guilder, the Netherlands' monetary unit.

<sup>34</sup> Interview with Louis Mauricio, Project Coordinator, Large Central Projects Department, Stork Infratechniek, August 11, 2000.

<sup>35</sup> Interview with Wolfgang Lohbeck, Greenpeace. See also  
<[http://www.greenpeace.org/~ozone/unep\\_ods/8greenfreeze.html](http://www.greenpeace.org/~ozone/unep_ods/8greenfreeze.html)>

<sup>36</sup> <<http://www.ourplanet.com/imgversn/75/silva.html>>

<sup>37</sup> All of the quotes by Daan Dijk, manager of sustainable energy projects at rabobank, were gathered in an interview conducted on August 10, 2000.

<sup>38</sup> The savings banks (Sparkasse) and regional banks (Landesbanken) are the largest group of banks in Germany. Currently, there are approximately 600 savings banks and 12 regional banks with a composite balance sheet total of about 3.5 billion Deutschmarks and a market share of close to 40 percent in terms of business volume. These banks are also the largest employer in the financial services sector with more than 375,000 employees. The banks are distributed across Germany and most are owned by communities, counties (Landkreise), and states. All banks in this sector are actively involved in giving credit to small and medium-sized firms, whereas the regional banks (not involved in the subsequent survey but involved in the inner association decision making and considered big players) act also on an international level. The German savings banks and regional banks are organized in an umbrella group called the Deutsche Sparkassen- und Giroverband (DSGV)

(German Savings Banks' and Giro Association). Some of these banks have developed "green funds" subsidized by their members and themselves that offer financing at lower rates to green projects.

<sup>39</sup> The mission paper on sustainability reads: "The business policy of the German savings bank association integrates successful business practices with responsible behavior oriented towards public wealth (Gemeinwohl). The objective is a sustainable development, which permits an enduring, sound, economic, ecological and social development. The members of the savings bank association commit themselves to an environmentally compatible form of business. They perform in particular locally and take the role of the partner of the people, of the enterprises, of the communities in their region. They act locally to improve the quality of the regional infrastructure and thereby also support the sustainable development on a global basis." (Translated by Professor Roland Scholz, ETH, Zurich.)

<sup>40</sup> See, for example, Charles Sabel, Dara O'Rourke, and Archon Fung, "Ratcheting Labor Standards: Regulation for Continuous Improvement in the Global Workplace," Unpublished paper. 2 May, 2000.

<sup>41</sup> Michael Porter, On Competition (Boston: Harvard Business School Publishing, 1998) 22.

<sup>42</sup> Sabel, "Studied Trust."

<sup>43</sup> The dearth of cooperation that is often noted in Western economies is explained through various forms of game theory, such as the prisoners' dilemma. Although the benefits of cooperation are clear to the game's participants, the worst outcome for any actor occurs when he agrees to cooperate, while all of his peers do not. This makes firms and other actors reluctant to "go out on a limb" and take on the risks of initiating cooperation. However, faith in the other actors' commitment to cooperate is a way out of the dilemma, and is therefore a powerful tool for furthering the possibilities of innovation.

<sup>44</sup> Daan Dijk of RaboBank explained how the financial set-up worked: "The financial construction which was designed to create the desired price of HFL 1000 consisted of a subsidy from NOVEM for [NLG] 400 and from the power companies for HFL 300. The rest of the difference between production and market price was covered by a special lease-construction, which was designed by the RaboBank. Lage Landen, a RaboBank subsidiary, actually bought the panels and leased them to the consumers. In this way, the project could profit from two government tax breaks: EIA (Energie investeringsaftrek, or energy investment tax break) and VAMIL (Vervroegde afschrijving milieuinvesteringen, or advanced depreciation of environmental investments), which exist exclusively for

corporate use. 90 percent of the tax break was used to lower the price of the panels for consumers."

<sup>45</sup> SIRIO used "roadside stations (at the entry gates), 'transponders' on board vehicles, optical car license plate readers and a central computer...to establish the identity of vehicles passing through any given entry gate and verify vehicle authorization." The first entry gates were installed in 1994, and by 1997 the system was in full operation. Matthias Wever, Recmo Hoogma, Ben Lane, and Johan Schot, "Experimenting with Sustainable Transport Innovations: A Workbook for Strategic Niche Management," Unversiteit Twente, 1999. Our discussion of this case draws on their analysis and the comments of Johan Schot in a meeting at the University of Eindhoven in January, 2000.

<sup>46</sup> This point and others in this introductory section are informed by Charles Sabel's analysis in "Design, Deliberation, and Democracy: On the New Pragmatism of Firms and Public Institutions." Paper presented to the conference on Liberal Institutions, Economic Constitutional Rights, and the Role of Organizations, European University Institute, Florence, December 15-16, 1995

<sup>47</sup> "In historical retrospect the reorganization of manufacturing and service firms worldwide is likely to be seen as one of the signal events of this century, and as enduring and perturbing in its legacy as the victory of the market economies over the centrally planned ones. Today of course this view outlandishly confuses the immediate significance of events. The victory of the market economies suggests the conclusive validation of universal and timeless principles of efficient economic coordination; the reorganization of firms, however disruptive and costly, seems but an example of the continuing adjustment to changed circumstances enabled by -- indeed, providing the final confirmation of -- those very principles of efficiency. At its grandest this victory suggests the triumph of those freedoms authenticated as indispensable to economic exchange and well being over those founded on other, political, principles. Thus privatization becomes the omnibus program of reform not only of the former plan[ned] economies but of the representative democracies, with their apparently sclerotic social welfare administrations and regulatory agencies, as well.

What this valuation overlooks is the possibility that the new firms operate by principles of **decentralized coordination** so different from those of the preceding epoch of large-scale organizations, and so disruptive of the institutional connections to the administrative state, that the "market economy" and "representative democracy" of the coming decades will look as different from the timeless victors of today as the latter now seem from their mid-nineteenth century, small-scale predecessors." Sabel, 1995 p.1



<sup>48</sup> Sabel 1995

<sup>49</sup> WNF = Wereld Natuur Fonds; Dutch branch of WWF (World Wildlife Fund)

<sup>50</sup> Novib = Nederlandse Organisatie voor Internationale Ontwikkelingssamenwerking; Netherlands Organization for International Development

<sup>51</sup> VMD = Vereniging Milieudefensie, Friends of the Earth Netherlands

<sup>52</sup> Staatsbosbeheer = National Forestry Service

<sup>53</sup> See Charles Sabel, "Studied Trust: Building new forms of cooperation in a volatile economy," Industrial Districts and Local Economic Generation, F. Pyke and W. Sengenberger, eds. (Geneva, Switzerland: Institute for Labour Studies), and Robert Putnam, Making Democracy Work (Princeton: Princeton University Press, 1993.)

<sup>54</sup> See Joshua Cohen, "Deliberation and Democratic Legitimacy," The Good Polity, Alan Hamlin and Philip Petit, eds. (Oxford: Basil Blackwell, 1989), and Joshua Cohen and Joel Rogers, "Secondary Associations and Democratic Governments," Politics and Society December 1992, Vol. No. 20, p.4.

<sup>55</sup> The metaphor of a cocktail party is Michael Piore's.

<sup>56</sup> The analogy to Track II diplomacy in international relations helps capture the goal.

<sup>57</sup> Charles Sabel, Archon Fung and Bradley Karkainen, "After Backyard Environmentalism: Toward a Performance-Based Regime of Environmental Regulation," American Behavioral Scientist 44 (December 2000): 4.

<sup>58</sup> Charles Sabel, Archon Fung and Dara O'Rourke, "Ratcheting Labor Standards," World Bank Social Protection Discussion Paper No. 0011, May 2000

<sup>59</sup> See Sabel, Fung and Karkainen note 57 for a discussion of how such a reporting can be organized effectively.

<sup>60</sup> Personal interview with Sander van Egmond, Greenpeace. 21 February 2000.

<sup>61</sup> A role set is simply the set of roles that social actors play. An individual, for instance, might be a father, a professional, a husband, a son, and a friend. He is all of these things and none of them summarizes him. At times these roles may place conflicting demands on him. Organizations can be understood in similar terms.

<sup>62</sup> <[http://www.ac.upc.es/homes/montse/gf\\_eng.html](http://www.ac.upc.es/homes/montse/gf_eng.html)>

<sup>63</sup> <<http://www.ourplanet.com/imgversn/75/silva.html>>

<sup>64</sup> Vidal, John, "The Big Chill," The Guardian 19 November, 1992, p. 2.

<sup>65</sup> *Ibid.*, p.2.

<sup>66</sup> <[http://www.ac.upc.es/homes/montse/gf\\_eng.html](http://www.ac.upc.es/homes/montse/gf_eng.html)>

- <sup>67</sup> *Ibid.*
- <sup>68</sup> *Ibid.*
- <sup>69</sup> *Ibid.*
- <sup>70</sup> Lohbeck, Wolfgang, personal communication.
- <sup>71</sup> *Ibid.*
- <sup>72</sup> *Ibid.*
- <sup>73</sup> *Ibid.*
- <sup>74</sup> *Ibid.*
- <sup>75</sup> *Ibid.*
- <sup>76</sup> Verheul, Hugo and Philip Vergragt, "Social Experiments in the Development of Environmental Technology: A Bottom-up Perspective," Technology Analysis and Strategic Management 7 (1995): 315-326; Vidal, John, "The Big Chill," The Guardian 19 November, 1992, p. 2.
- <sup>77</sup> *Ibid.*
- <sup>78</sup> Lohbeck, Wolfgang, personal communication.
- <sup>79</sup> Vidal, John, "The Big Chill," The Guardian 19 November, 1992, p.2.
- <sup>80</sup> *Ibid.*
- <sup>81</sup> *Ibid.*
- <sup>82</sup> Lohbeck, Wolfgang, personal communication.
- <sup>83</sup> <<http://www.ourplanet.com/imgversn/75/silva.html>>
- <sup>84</sup> <[http://www.greenpeace.org/~ozone/unep\\_ods/8greenfreeze.html](http://www.greenpeace.org/~ozone/unep_ods/8greenfreeze.html)>
- <sup>85</sup> <[http://www.ac.upc.es/homes/montse/gf\\_eng.html](http://www.ac.upc.es/homes/montse/gf_eng.html)>
- <sup>86</sup> <<http://www.ourplanet.com/imgversn/75/silva.html>>
- <sup>87</sup> Lohbeck, Wolfgang, personal communication.
- <sup>88</sup> *Ibid.*
- <sup>89</sup> *Ibid.*
- <sup>90</sup> *Ibid.*
- <sup>91</sup> *Ibid.*
- <sup>92</sup> <[http://www.ac.upc.es/homes/montse/gf\\_eng.html](http://www.ac.upc.es/homes/montse/gf_eng.html)>
- <sup>93</sup> <<http://www.ourplanet.com/imgversn/75/silva.html>>
- <sup>94</sup> *Ibid.*
- <sup>95</sup> *Ibid.*
- <sup>96</sup> <<http://www.sdearthtimes.com/et0298/et0298s10.html>>
- <sup>97</sup> <<http://www.ourplanet.com/imgversn/75/silva.html>>
- <sup>98</sup> *Ibid.*
- <sup>99</sup> i.e. prices cannot be lowered without investing in new production technologies. Firms are reluctant to make such investments when demand is low and the high prices ensure that demand stays low.
- <sup>100</sup> Mobility Car Sharing Switzerland. "About Us." 27 July, 2000. <<http://www.mobility.ch/e/index.htm>>

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- <sup>103</sup> For more information, see Massachusetts Toxic Use Reduction Program, "Evaluating Progress: A Report on the Findings of the Massachusetts Toxic Use Reduction Program Evaluation" March 1997.
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