Market Potential 72% Consumer Confiden[illegible] Brand Recognition 82%
3% Energy Efficiency 27% Product Awar[illegible]ss 67% [illegible]stomer

research/into/action inc

Final Report

MARKET ASSESSMENT OF GREEN LIGHT-EMITTING DIODE (LED) TRAFFIC LIGHTS IN THE ENERGY TRUST'S SERVICE TERRITORY

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EXECUTIVE SUMMARY

In April 2002, the Energy Trust of Oregon initiated its Green LED Traffic Light Program. The program sought to replace green incandescent traffic signals with light-emitting diode (LED) lamps in locations in Portland General Electric and Pacific Power service districts statewide.

LED green traffic signals reduce electricity use from about 160 watts to about 15 watts, depending on the lamp manufacturer. LED lamp service life is about seven years, compared with two years for incandescent bulbs. Analysis in support of the program resolution determined that the program would be cost effective.

The program provided a $60 incentive per LED lamp installed. All lamps receiving incentives were to be committed to and installed in 2002. The incentive corresponds to one-third to one-half of the product cost, depending on the type of lamp purchased (hardwired or screw-in).

The initial program scope was for 750 lamps. The scope expanded twice during the year, for a total of 3,000 lamps. The expanded program was estimated to save 0.183 average megawatts for seven years at a cost of $201,950.

The program was implemented by the City of Portland Office of Sustainable Development, under contract to the Trust. The City was responsible for marketing the program, working with applicants and potential applicants, day-to-day program management, and verifying installations. The Trust issued the incentive checks to participants.

Research Into Action, Inc. conducted a market assessment of the program in November and December of 2002. Interviews with the implementation manager, participants, nonparticipants, and representatives of LED manufacturers and distributors provided the data used in the assessment.

The program was launched in mid-May 2002. The first application arrived on May 30. Four months after the program start, 3,000 lamp incentives had been allocated to applicants. Fifteen jurisdictions participated. These fifteen participants include the two jurisdictions in the Trust's service territory (in fact, in the state) with the most incandescent green traffic signals.

Of the nine cities in the service territory with populations greater than 25,000 people and incandescent signals, seven participated. An eighth city—the largest of the nine—submitted an application yet needed to withdraw it due to problems

encountered in obtaining product bids. This city will install green LEDs on its own. It will purchase without an incentive about two-thirds the number it had planned to purchase with an incentive.

In addition to the green LEDs installed through the program, three program participants installed red LEDs at the same time, totaling 260 red LEDs.

The Trust program converted 58% of the green incandescent traffic lights owned by program participants to LEDs. It converted approximately 35% of the green incandescent lights owned by jurisdictions eligible to participate in the program. Through the Trust's program, along with LED programs run by Portland General Electric and Pacific Power prior to the Trust's program, approximately 66% of the green incandescent traffic lights in the Trust's service territory have been converted to LEDs.

Program participants uniformly said that the process was clear and easy. A few participants elaborated that the process under the Trust program was much easier than they had experienced previously under programs offered by the investor-owned utilities. Participants appreciated the program marketing and implementation efforts of the City of Portland Office of Sustainability. No negative feedback was given.

Seven major conclusions flowed from the research:

1. **The Trust's program has succeeded in transforming the market for LEDs.** It did so by reaching the largest jurisdictions and all but one of the eligible medium and large cities. The volume of lamps resulted in a temporary decrease in product price and increase in marketing activity of the distributors. The volume was too small to affect manufacturer's output or prices.

2. **These LED installations likely would not have happened in the absence of the program for the duration of the current economic recession.** Were the economy prosperous, with governmental jurisdictions having adequate funding, perhaps one-third of the LEDs would have been installed without a program. This conclusion is based on experience from red LED purchases (half of the participants with red LEDs had purchased them without a rebate; half had received a rebate) and the comparative prices of red and green LEDs (greens cost an additional 50% to 75% more than reds).

3. **The program size of 3,000 was appropriate to demand.** The program limit did not create dissatisfaction among participants or nonparticipants.

4. **The decision to use the City of Portland Office of Sustainability to market and implement the program contributed to the program's success.** No drawbacks to this approach were identified. The factors leading to the success included the City's experience with traffic signal LEDs, its knowledge of and access to public works staff throughout the service territory, and the manager's timeliness in his actions and his responsiveness to applicants and potential applicants. In addition, the City of Portland had received money from the Northwest Energy Efficiency Alliance to promote the City's efficiency activities throughout the region. The synergy of the Trust's funding, the Alliance's funding, and the City's experience and capabilities contributed to the success of the Green LED program.

5. **The process was easy for participants, which they appreciated.**

6. **Nonparticipants were smaller than participants and had organizational differences that limited their participation.** Many of the nonparticipants had agreements with larger jurisdictions (counties, ODOT—Oregon Department of Transportation) for these larger entities to purchase their traffic lights (in bulk purchases), install and maintain their lights, or both. Due to these agreements, some municipalities were confused whether they should participate or leave it to the larger entity to participate on their behalf. In spite of their small size, the nonparticipants reported more people involved in the participation decision than participants reported. Finally, some of the nonparticipants expressed misinformation about the program process (describing it as too difficult) or lack of information about LEDs (in spite of the information provided by the program manager).

7. **Although the Trust had anticipated that participants would install lamps during routine maintenance, the short program time necessitated that most participants install the lamps through a special project.** Special projects increased participants' costs.

Three major recommendations flow from these conclusions:

1. The Trust should feel free to use the City of Portland Office of Sustainable Development as implementation manager of efficiency programs related to its experience.

2. When equity within the region is important, small jurisdictions should be targeted with tailored marketing and assistance.

3. Provide the market with advance notice of a program so that potential participants can budget for their required expenses.

1. INTRODUCTION

This report describes the results of a process evaluation of the Energy Trust of Oregon's Green LED Traffic Light Program, offered in 2002. The Trust contracted with Research Into Action, Inc. (RIA) to conduct the process evaluation in late fall of 2002.

PROGRAM OVERVIEW

In April 2002, the Energy Trust of Oregon initiated its Green LED Traffic Light Program. The program sought to replace green incandescent traffic signals with light-emitting diode (LED) lamps in locations in Portland General Electric and Pacific Power service districts statewide. Analysis in support of the program resolution determined that the program would be cost effective.[1]

The program provided a $60 incentive per LED lamp installed. All lamps receiving incentives were to be committed to and installed in 2002. The initial program scope was for 750 lamps. The scope expanded twice during the year, with an initial increase of 750 lamps and a final increase of 1,500 lamps, for a total of 3,000 lamps. The expanded program was estimated to save 0.183 average megawatts for seven years at a cost of $201,950.[2]

LED green traffic signals reduce electricity use from about 160 watts to about 15 watts, depending on the lamp manufacturer. LED lamp service life is about seven years, compared with two years for incandescent bulbs. Prices for the lamps vary; hardwired LEDs cost less than screw-in models, but cost more to install. At green LED prices current in spring 2002, the $60 incentive covered about one-half of the equipment cost for a hardwired lamp and about one-third of the cost for a screw-in lamp replaced during normal periodic maintenance activities. The incentives reduce

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1 *Board Decision—Proposed Green LED Traffic Light Program*, Energy Trust of Oregon, Inc., April 3, 2002. The societal benefit/cost ratio was estimated to be 1.1; the utility system benefit/cost ratio was estimated to be 1.3. Average megawatt savings of 0.046 would accrue from 750 lamps. The cost per average megawatt was estimated to be $1.46 million. The program was subsequently expanded to a total a total of 3,000 lamps.

2 Incentives for the program were expanded, while administrative and marketing costs were held constant. This expansion resulted in improved benefit/cost ratios. For the expanded program, the societal benefit/cost ratio was estimated to be 1.46. The cost per average megawatt was estimated to be $1.10 million. Total program cost includes LED incentives, City of Portland implementation activities, and Trust administration. *Board Decision—Proposed Green LED Traffic Light Program Funding Extension,* Energy Trust of Oregon, August 2, 2002.

customer payback on the LEDs to about two years, from three to five years without incentives.

The Energy Trust contracted with City of Portland Office of Sustainability to market and implement the program. The City of Portland had replaced all of its red and green signal lamps with LEDs in 2001; its experience with the installation of LED traffic lamps suited it to the administration of the Trust's program.

The Office of Sustainability was to promote green LED traffic light replacement to the Oregon Department of Transportation (ODOT) and local jurisdictions throughout the Energy Trust's service territory. The LEDs were positioned as appropriate for use during jurisdictions' normal traffic signal maintenance activities. The installations had to conform to ODOT's specifications.

The Trust's Board decision authorizing the program for 750 lamps suggested that, in addition to acquiring cost-effective average megawatts, the program might support market transformation. The decision stated: "This is a very small program. However, it may pave the way for larger green LED purchases in the future, which in turn may help advance manufacturing, increase competition, and thereby lower the price of the green LEDs, leading to market transformation. This is largely what occurred for the red lamps." It noted that a significant number of red LEDs were installed in many locations throughout the state.

The Board's decision authorizing the program expansion included the following rationale: "The program to date is over subscribed and very popular with the municipalities already participating. It is our belief that this next level of prospects is the population of organizations that need assistance the most. The prospects targeted by this next round of incentives will most likely not install LED lamps independently due to a combination of financial constraints and budget cycles. Anecdotal information leads us to believe if incentives are not available to them now, it may be two years until they may have the opportunity to act."

EVALUATION PURPOSE AND METHOD

The Trust contracted with Research Into Action to conduct a process evaluation of the Green LED Traffic Light Program. This evaluation assesses the effectiveness and efficiency of the program's administration, delivery and implementation, and participant response to the program and includes nonparticipant activities. It documents the program's history. The study discusses the market for LED traffic signals in Oregon prior and subsequent to the program, and from this discussion assesses the effect the program has had on the market.

To support the process evaluation, Research Into Action conducted the following data collection activities:

- Reviewed program documentation and program email correspondence.
- Conducted an in-person interview with the Green LED program manager from the City of Portland Office of Sustainable Development.
- Conducted telephone interviews with a total of 21 people involved with seventeen applications to the Green LED program, spanning sixteen traffic jurisdictions (fifteen participants and one that terminated participation after the program limit had been reached). This report covers four different types of traffic jurisdictions: cities or towns, counties, ODOT regions, and one city port (which includes airports and marine terminals). Towns and cities are referred to as "municipalities" throughout the report to distinguish them from other types of jurisdictions.
- Conducted telephone interviews with green traffic light LED manufacturer's representatives (4) and distributors (2).
- Conducted telephone interviews with knowledgeable representatives of ten nonparticipating jurisdictions that had received notification of the program.[3]
- Conducted secondary research (reviewed selected web sites and reports) on traffic signal LEDs.

The in-person interview with the LED program manager lasted about two and one-half hours. The phone interviews with participants averaged 45 minutes in length, while those with manufacturers and distributors averaged about 30 minutes. The interviews with nonparticipants averaged about 30 minutes.

The methodology for nonparticipant interviews differed slightly from the approach used for participant interviews. For participant interviews, when a primary respondent did not have technical information such as the number and brand of incandescent bulbs, rate of incandescent bulb replacement, LED type and brand, and—in two cases—number of signals, we solicited names and contact information

[3] Representatives from sixteen nonparticipating jurisdictions were contacted. Interviews were not conducted with six of these 16 jurisdictions because the contact person indicated that decision-making for their jurisdiction's traffic signals takes place at another agency, ODOT or the county in which the municipality is located.

for second (and in one case third) sources that could fill in the missing information. For nonparticipant interviews, we did not solicit or call any of the secondary sources.

For the sixteen respondents interviewed as participants, five (31%) recommended that we call another party or agency to "fill in the gaps" in the information. With regard to nonparticipants, for some questions none of the ten respondents was able to supply technical information.

REPORT OUTLINE

The following chapter describes the program implementation. It reviews the City of Portland's experience with traffic signal LEDs, other leaders in the Oregon market, program marketing and delivery, and program administration and implementation.

Chapter 3 provides a characterization of the end-user traffic signal market, while Chapter 4 characterizes the LED manufactures and distributors in the market.

Chapter 5 describes the experience of participating end users (the traffic jurisdictions) and the decision-making process for nonparticipants. Chapter 6 presents the experience of manufacturers and distributors.

Chapter 7 provides an assessment of the program's impact on the traffic signal market in Oregon. Conclusions and recommendations are given in Chapter 8.

2. PROGRAM IMPLEMENTATION

The Energy Trust contracted with the City of Portland's Office of Sustainable Development to implement the Green LED Traffic Light Program.

THE CITY OF PORTLAND'S EXPERIENCE WITH LEDS

Curt Nichols, Senior Energy Manager for the City of Portland Office of Sustainable Development, became familiar with LED traffic signal lights in the mid-1990s, when he had researched them as a member of the Urban Consortium's Energy Task Force. As a test of the technology, the City installed red LEDs in flashing signal lights, since these have high loads and high maintenance costs associated with replacing incandescent lamps. Nichols concluded that the lamps were not cost-effective at the electricity and lamp prices then current.

In the midst of the 2001 energy crisis, Nichols turned to a master list of energy efficiency actions that the Office of Sustainability had compiled for the City. Traffic LEDs showed the largest potential savings. Green lamps were now commercially available and the Institute of Transportation Engineers (ITE) had created specifications for them in the previous few years. In addition, Oregon had experience with traffic LEDs because ODOT had installed red ones in all of its roughly 1,000 to 1,200 traffic signals.[4]

The prices of both red and green lamps had fallen dramatically as quantities produced had increased. The two utilities serving the City—Portland General Electric and Pacific Power—offered an incentive for installing the lamps and a bonus for installations completed by December 1, 2001. Finally, by arranging to lease the lamps from Washington Mutual, Inc., a bank, the project was eligible for a 20% tax rebate from the State of Oregon, savings Washington Mutual passed on to the City.

[4] ODOT reported that the number of 3-color traffic signals in all ODOT regions is 1,275 and the number of flashers in the state is 1,100. Almost all discussion of ODOT traffic signals refers to the 1,275 signals in the state. Flashers are mentioned specifically in Chapter 7 under "Interest in Yellow LEDs."

Given all these favorable conditions, the City chose to replace all of its red and green signal lights at one time.[5] To meet the deadline for the incentive bonus, the City hired an installation contractor, a cost that was rolled into the lease. The project totaled two million dollars.

According to Nichol's analysis, the hardwired LED lamps paid for themselves a little sooner than the screw-in lamps; nonetheless, the City chose to go with screw-ins due to their ease of replacement. It used ODOT's specifications. At that time, only one manufacturer produced a screw-in green LED; the City has been satisfied with its choice.

The City's signal lights are served under PGE's Tariff 91. The City reports to the utility the signals operating at each location and the utility calculates a monthly bill based on the wattage of the signals and the monthly hours of operation.[6] Nichols estimates: "We save $335,000 a year on electricity, plus more on maintenance savings. Our annual savings are about $650,000 or so."

Based on its experience installing LED traffic lamps, the City proposed to the Trust that the Trust offer a green LED program and use the City (its Office of Sustainable Development) to implement it.[7] Says Nichols, "We worked with the Oregon Department of Energy to estimate the necessary incentive and conduct cost-effectiveness calculations. We estimated an initial cost of $180 a lamp, so $60 gives reasonable payback." The goal of 750 lamps (the initial program limit) was selected because it seemed achievable.

OTHER LEADERS IN THE OREGON LED TRAFFIC SIGNAL MARKET

The Trust Board decision that led to the establishment of the program identified ODOT as a key end-user in the traffic signal market. Several interrelated factors place ODOT as a key player.

The first and most obvious is ODOT's mission as the state's transportation arm. ODOT sets equipment specifications used by many jurisdictions. It has established

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5 Earlier, the City had determined that its red lights were illuminated, on average, 50% of the time, green 45%, and yellow 5% .

6 This method is also used for calculating the electricity bill for streetlights.

7 This program idea was combined with several others in a single proposal. The Trust decided to pursue the green LEDs.

specifications for red LEDs and, at the time of the program launch, was working on specifications for green ones.

Second, ODOT is one of the two jurisdictions in the state with the largest number of traffic signals (Multnomah County being the other). ODOT's actions both set a precedence for, and constitute a significant proportion of, the market.

Third, ODOT is responsible for maintaining traffic signals owned by some local jurisdictions that are too small to afford their own installation equipment ("bucket trucks").[8] These local jurisdictions pay for the lamps, but ODOT purchases, stores, and installs them. If the jurisdictions serviced by ODOT choose to purchase LEDs, they can combine their orders with those of ODOT, thereby saving the effort of a bid process and receiving the lower prices that result from large-quantity purchases.

Fourth, ODOT had installed red LEDs in nearly all of its traffic signals.

At the outset of the program, therefore, ODOT was both a leader in the Oregon market for traffic signal LEDs and a potential participant in the Green LED Program.

ODOT is organized into five districts. Each district has its own budget and made its own determination with regards to participating in the Green LED Program.

An additional leader in the market was Clackamas County. Like the City of Portland, it had installed red and green LEDs in all of its traffic signals prior to the Trust's program, using an incentive from PGE.

PROGRAM MARKETING AND DELIVERY

Marketing

The program was launched with a public announcement on Friday, May 17, 2002. The following Monday and Tuesday, the program was announced to public works staff in eligible jurisdictions. This announcement—a letter drafted by Nichols and approved by the Trust—was sent via email.

In Oregon, all of the traffic jurisdictions (cities, counties, the state, other entities) belong to a chapter of the (Institute of Traffic Engineers), and its subgroup, the

[8] ODOT is not the only provider of this maintenance and purchasing service. Participants and nonparticipants mentioned Washington and Clackamas counties and the cities of Salem and Bend.

Oregon Traffic Control Devices (OTCD). Nichols presented the Trust's Green LED program at a meeting of the OTCD in mid-May. Next, Nichols emailed the public works staff at most of the cities in the program area. The City is in contact with these staff through the League of Oregon Cities, a statewide association of 238 of Oregon's 240 incorporated cities.

Throughout the duration of the program, Nichols periodically sent follow-up emails to the public works staffs, as well as wrote articles for the newsletters of the Oregon chapter of the American Public Works Association and related organizations.

Nichols quickly contacted efficiency staff at PGE and Pacific Power about the program.

Nichols got word to the six counties in the state that had incandescent traffic signals—Jackson, Lane, Marion, Deschutes, Multnomah, and Washington — through the Association of Oregon Counties.[9] Nichols also spoke to public works staff in Eugene, Ashland, and other cities that operate municipal utilities and hence were not eligible for the program. He encouraged them to ask their municipal utilities about incentives for green LEDs.

Nichols reported that he spoke with colleagues he knew at the Port of Portland and Washington County about the program. Ultimately, these jurisdictions chose to participate late in the program, when all but 720 of 3,000 lamps had been spoken for. Nichols characterized the process of getting them committed to the program as "hard work".

Within two weeks of the program launch, the City had received its first application—"for a city government to act in two weeks, well, that's *very rapid*", says Nichols—and in one month (by June 19th) jurisdictions had submitted applications for more than 750 lamps. As shown in Table 1, these applications came from seven jurisdictions and so did not represent simply a few large purchases.

When asked why he thought jurisdictions jumped at the program, Nichols responded, "PGE's traffic signal rate is increasing fifty percent." In addition, some jurisdictions had already been considering green LEDs. It is logical to assume that the jurisdictions in Table 1 were those that were considering green LEDs prior to the Trust's program. This validity of this assumption is explored in Chapter 3.

[9] A seventh county—Clackamas—has traffic signals, yet these had already been converted to LEDs.

Table 1

APPLICANTS FOR THE INITIAL 750 LED LAMPS

TRAFFIC JURISDICTION	DATE OF APPLICATION	NUMBER OF LAMPS	CUMULATIVE LAMPS
City of Corvallis	5/30/02	56	56
Multnomah County Bridges	6/4/02	30	86
Multnomah County Streets	6/4/02	150	236
City of Cottage Grove	6/6/02	55	291
City of Salem	6/12/02	260	551
City of Tigard	6/13/02	62	613
City of Medford	6/13/02	250	863

Nichols reported that during the development of the marketing approach he and the Trust had discussions about an optimal distribution of the limited incentive money—such as a distribution between the two utility service territories or between size or type of jurisdiction. One thought was to limit the number of the lamps for which a jurisdiction could receive incentives. After considering the issues, the Trust decided to run the program on a first-come, first-serve basis, with no per-participant limit. Table 2 identifies the applicants for the second set of 750 lamps and Table 3 identifies those for the final set of 1,500 lamps.

Table 2

APPLICANTS FOR THE SECOND 750 LED LAMPS

TRAFFIC JURISDICTION	DATE OF APPLICATION	NUMBER OF LAMPS	CUMULATIVE LAMPS
Total from Applicants for First 750 Lamps	NA	NA	863
Oregon City	6/19/02	149	1,012
City of Lebanon	6/24/02	63	1,075
ODOT Region 1	6/26/02	496	1,571

Table 3

APPLICANTS FOR THE FINAL 1,500 LED LAMPS

TRAFFIC JURISDICTION	DATE OF APPLICATION	NUMBER OF LAMPS	CUMULATIVE LAMPS
Total from Applicants for Second 750 Lamps	NA	NA	1,571
City of Lake Oswego	7/11/02	50	1,621
City of Albany	7/18/02	154	1,775
ODOT Region 1	8/14/02	339	2,114
City of Wilsonville	8/2/02	166	2,280
Port of Portland	9/5/02	21	2,301
Multnomah County	9/9/02	50	2,351
City of Bend	9/10/02	264	2,615
Washington County	9/11/02	385	3,000

Even on a first-come, first-served basis, the LEDs were installed by fifteen jurisdictions.[10] Seventy-one percent of the lamps (2,137) were installed in PGE's service territory and 29% (863) were installed in Pacific Power's service territory.

The cities of Klamath Falls and Hillsboro submitted applications at the end of October and the beginning of November, after the program quota was reached. The two applications totaled 285 lamps. In November, the City of Salem revoked its application[11] and Klamath Falls was accepted as a program participant. Klamath Falls purchased 132 lamps.[12]

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10 The tally of fifteen counts Multnomah County's bridges and streets as separate jurisdictions.

11 Salem experienced difficulties in its bid process and was unable to meet the program requirement of purchasing and installing lamps by the end of 2002.

12 The difference between the 260 lamps reserved by Salem and the 132 that Klamath Falls reserved is 128 lamps. Nichols explained that the rebate money associated with these lamps will be used as a "cushion" for jurisdictions that initially underestimated the number of LEDs they would need. He elaborated, "Bend, for example, wanted to order 44 more LEDs. Several other jurisdictions want five, ten, or fifteen more than they

At the program's outset in May, Nichols notified the LED manufacturers and their representatives about the program and periodically touched based with them as the program progressed. A few manufacturers called Nichols about the program, but these calls mainly sought information to facilitate a customer's purchase through the program. Nichols did not observe manufacturers and distributors responding to the program with special marketing campaigns.[13] He found this lack of apparent response a bit surprising, yet identified possible explanations:

1. The market for LEDs is more specialized—for traffic control—than that for incandescents, which sell into the broader outdoor lighting market. As a consequence, the LED suppliers are in contact with the traffic control staffs in the state. "It's not like they haven't been trying to sell LED traffic lights already."

2. The project was small. "One manufacturer initially formed the impression that each application would be for 750 lamps. When they found out that 750 was the program total, they didn't express much interest."

Delivery

Subsequent to announcing the program and notifying traffic jurisdictions around the state, Nichols assisted interested jurisdictions as needed with such things as helping to assess their opportunity and providing information on manufacturers and on LEDs already in use in the state.

For the first jurisdiction that sought Nichols' help in assessing the savings potential, Nichols created a cost-effectiveness example using utility rates, the Trust's incentive, the State's tax credit, number of lamps, and lamp prices and installation costs based on the City of Portland's experience. He quickly learned that lamp prices had come down since the City's project a year earlier and he adjusted the prices used in the example. For use with subsequent jurisdictions, he recalculated the example with different lamp quantities. Said Nichols, "Several jurisdictions had calculated the cost-effectiveness of LEDs some time ago and decided against them. So it was helpful to do the analysis again at current prices."

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ordered. The extra money allows us to be flexible in how we administer the program. All of the unallocated money at the end will go back into the budget of the Energy Trust."

13 The two distributors described creating special marketing campaigns in Oregon in response to the Green LED program in Chapter 4.

Nichols offered to come and speak to colleagues of the contacts who would be involved in the decision. "But that was not needed. Perhaps the contacts that would have needed an outsider to state the case didn't even pursue the issue."

Nichols reported that staff in jurisdictions that contacted him about the program voiced little in the way of objections to the technology that constituted a barrier to their participation. Contacts would ask him if something they had heard (for example, that one brand of LEDs had high failure rates) was true. "Whatever objections they raised were overcome with information from experience [the City's, ODOT's, Clackamas County's] or from research. For example, someone wanted to know if the LEDs generated enough heat to melt any snow that might blow into the signal head. We checked with the Consortium for Energy Efficiency and the EPA's ENERGY STAR® folks and found no documented problems with this."

For the most part, participants did not need much help in developing bid specifications. "Most jurisdictions," said Nichols, "used ODOT's specifications. Some were already working with a vendor and had negotiated specs. Some folks needed a bit more help. I would say, 'Clackamas County is buying that model' and this sort of endorsement was all that was needed."

When asked about the extent of his communication with the applicants, Nichols responded that it varied widely. The first application received, as well as a few others, came in based on the announcement of the program and perhaps a few phone calls or emails. One small city that might have been expected to make a quick decision took a while to commit to the program.

Nichols elaborated on the process of marketing the program to the five participants that took the most involvement to bring on board.

Multnomah County, which filed the second and third applications, has separate staff responsible for the signals on the streets and on the bridges.[14] Nichols spoke with them and then with the energy manager for the county, who put in two applications for the two domains.

ODOT was a bit difficult because of its five regions. Nichols had multiple communications with central staff and followed up with all of the regional staff to ensure that everyone was informed. Region 1 applied without waiting for the organization to issue specifications governing green LEDs. Region 2 expressed interest but lacked the funds to purchase the lamps. ("We caught them at a bad

[14] Multnomah County also submitted a third application toward the end of the program.

time. We told them in mid-May, when they had already committed their money for the fiscal year ending in June, and already set their budget for the fiscal year starting in July.") Regions 3, 4, and 5 did not express interest in the program.

Bend is served by ODOT and is in Region 4. Regarding marketing the Green LED program to Bend, Nichols says, "The barrier was figuring out who applies, who gets the incentive. They nearly did not participate—perhaps they thought ODOT would purchase the lamps. When there was just a little money left, I called them and they decided to do it."[15] The city paid for the lamps and ODOT crews installed them.

For two other applicants, Nichols had multiple conversations with three different people at each organization with no success. When the end of the incentive money was in sight, he contacted a friend of his in one of the organizations and an energy manager at the other and these people got commitment for the projects.

One city that failed to get an application in on time had waited for the ODOT specifications for green LEDs to be issued before it committed to the project.

PROGRAM ADMINISTRATION AND IMPLEMENTATION

Nichols drafted the program participation forms, which were finalized by the Trust.

Participants completed an initial application form indicating their intention to install green LEDs, the number of lamps they intended to install, the manufacturer and lamp type (screw-in or plug-in, i.e., hardwired), total equipment cost, and projected installation completion date, as well as some other information. This form included an agreement clause stating their eligibility and their understanding that "funding for this program is limited and may be already committed to other applicants." Through this application, the jurisdiction was claiming a share of the incentive money. Applicants submitted this form to Nichols, usually preceded by phone calls verifying that incentive money was still available. Nichols approved the applications (up to the limit of the funds), assigned each applicant an identification number, and tracked total program commitments.

At the conclusion of a jurisdiction's project, participants submitted a form documenting their installations and provided copies of their project invoices. Nichols forwarded these forms to the Trust, who issued the incentive payment.

[15] Bend was the penultimate application received.

The Trust mailed the incentive check to an applicant with a letter expressing the Trust's appreciation. The letter also identified the operating and maintenance cost savings the applicant could expect to reap. Included in the letter was a press release announcing the completion of the project. The Trust sent the press release to the media local to the applicant. The press release contains quotes from the applicant that Nichols sought when he received the final paperwork.

Both the application and installation forms were clear and simple. Although the program information listed the return fax number in two places, "apparently it wasn't readily seen" said Nichols. At any rate, the fax number was not on the actual application and installation documentation forms.

When Nichols reviewed the forms, he found a few errors that he asked applicants to correct. "Three or four cities had included a truck use fee in their stated equipment cost. I could tell it was more than just lamp cost, because I would divide their total equipment cost by the number of lamps. So I would work with them to get the accurate number."

As of the time of the interview with Nichols, he had inspected two completed projects. He is able check the installation of LEDs from their appearance. Since most of the LEDs for a given applicant are clustered in a geographical area, he anticipates being able to check virtually their entire installation. He had asked all participants to notify him of their installation schedule, so that he might visit them during installation. If that does not work out, he will go when the installation is done. He was hoping to travel to the more distant applicants at a time when the trip could be combined with another purpose.

Nichols was asked whether the limit of 3,000 lamps—and the consequent refusal of two applications that came in after the limit was reached—generated any dissatisfaction among the jurisdictions regarding the Trust's actions.[16] He said that he no impression that his contacts responded negatively. He identified the following factors as potentially contributing to the positive outcome:

- One: "Because it was announced in May, the jurisdictions didn't have a chance to budget for the program. If we had announced this in January and they had put LEDs in the budget then found that no incentive was available—well, that might have been a problem. But this program with

[16] This issue was raised in documents and email correspondents about the Green LED Program internal to the Trust that were reviewed in preparation for the interviews conducted for this evaluation. Note that one of the two applicants was subsequently able to participate.

its short time frame—the jurisdictions hadn't planned for this. They adjusted their planned spending, and they didn't have the ability, time, or money to do more."

- Two: "The incremental rollout of quantities (first 750, then 750 more, then 1,500 more) might have all along created the impression of limited amounts. I saw people being judicious. No one tried to reserve a lot for themselves."

It appears that participants and potential participants had expectations in line with the program's ability to serve them. As noted, the application clearly said that funds were limited and Nichols, in all his communication with contacts, reiterated this point.

Nichols reported that his interactions with the Trust on the program went smoothly. The Green LED Program was one of the first offered by the Trust, and it began while the Trust itself was in a start-up phase. Consequently, Nichols worked with one person initially, who handed off the project to another, before it landed with a newly-hired staff person. "There was no problem in any of these transitions. I was simply concerned that I provided the new person enough background without duplicating any debriefing they had received on the project." Regarding his draft letters and applications, and other decisions about the program, "The Trust responded in a timely manner and reasonably."

When asked how he assessed the success of the City of Portland—including his own work—in implementing the Green LED Program, Nichols was thoughtful:

> *"Perhaps half of the applicants would have participated simply as a result of being told that incentive money was available. But half of the applicants joined because I pursued them and worked with them. They are more likely to listen to another city than to the sales rep, or even to the utility rep.*
>
> *"And in the area of transportation, Portland has a good reputation. We had already shown leadership in the region. We have a presence on the technical committees. And our LED experience was invaluable. We had all the details—the prices, the manufacturers, the availability, the cost-effectiveness. Finally, I was aware that some people might assume that the City is bureaucracy in the worst sense of the word, so I made sure I responded quickly."*

Nichols also noted that his prior experience with utility programs also benefited the Trust. He added language to program documents that had been overlooked, but was

essential to protecting the Trust—language on the program end date and that applicants were ineligible for Trust incentives on equipment for which rebates from other programs were received.

Simultaneous to the project with the Trust, the Office of Sustainability had a contract with the Northwest Energy Efficiency Alliance to build on its experience with traffic signal LEDs. This project contributed to the success of the Trust's project. With Alliance funding, the City prepared a four page glossy brochure with the header: *"Energy Efficiency Success Story: LED Traffic Signals = Energy Savings for the City of Portland, Oregon."* The brochure described the project and its cost and benefits, and identified web sites with information on LED traffic signals.

The Alliance also funded the creation of a demonstration traffic signal. Two green signals—one LED and one incandescent—were mounted with a watt meter beneath them. Illuminating the lamps provides a potent demonstration that the LED lamp provides high quality light at a fraction of the electricity usage.

Finally, the Alliance funded Nichols to make some presentations on energy efficiency. These presentations allowed him the opportunity to simultaneously promote the Green LED Program.

Nichols summarized, "So the three resources together—the Trust's program, the City's experience, and the Alliance funding—together were more effective in promoting green LEDs than each would have individually been."[17]

[17] Nichols included the City as a resource in LED promotion because, irrespective of its role as the Trust's program implementation contractor, it has a "good neighbor" policy and responds to other jurisdictions (in the state and around the world) seeking to learn from its experience.

3. MARKET CHARACTERIZATION PRIOR TO PROGRAM: END USERS

SIGNALS, MAINTENANCE PRACTICES, AND SUPPLIERS

The total number of traffic signals among participating jurisdictions ranges from fifty in the smallest jurisdiction to 982 in the Oregon Department of Transportation (ODOT)'s Region 1. Table 4 shows that five out of the sixteen participating jurisdictions have fewer than 100 signals in their municipalities. Participants reporting higher numbers of traffic signals are in cities, counties, or at ODOT. Those with fewer traffic signals are in small cities or towns.

Table 4

NUMBER OF TRAFFIC SIGNALS PER JURISDICTION

NUMBER OF SIGNALS	PARTICIPANTS N=16	NONPARTICIPANTS N=10
Under 20	0	1 (10%)
20 to 49	0	2 (20%)
50 to 99	5 (31%)	2 (20%)
100 to 499	7 (44%)	5 (50%)
500 and Over	4 (25%)	5 (50%)

Five of the ten nonparticipating jurisdictions have 100 or more traffic signals. Two large municipalities and three ODOT regions make up the larger jurisdictions.

The majority of the participants in the Green LED program (13 out of 15 responding to the question) report that their jurisdictions will add six or fewer signals in the coming year (Table 5). Both of the jurisdictions adding more than six estimate they will install ten new signals in the next year. One of the jurisdictions adding ten new signals is large and the other is small.

Table 5

ESTIMATED NUMBER OF NEW SIGNALS TO BE ADDED IN COMING YEAR

NUMBER OF NEW SIGNALS	PARTICIPANTS N=15*	NONPARTICIPANTS N=10
Add One Every Few Years	0	2 (20%)
One	5 (33%)	3 (30%)
Two to Three	4 (27%)	1 (10%)
Four to Six	4 (27%)	0%
Seven to Ten	2 (13%)	1 (10%)
More Than Ten	0	2 (20%)
Not Sure	0	1 (10%)

* *Fifteen respondents answered the question; one respondent did not. Percents do not add to 100% due to rounding.*

Nonparticipants tended to report slow growth in their jurisdictions. Half (5 out of 10) of the nonparticipants reported that their jurisdiction adds one signal a year or one "every few years."

Ten of the sixteen participants reported 100% replacement of incandescent bulbs (both green and red) as a part of the cyclical maintenance on their traffic signals. Nine of the ten replace their incandescent bulbs annually. Multnomah County, with 920 traffic signals, reported that their maintenance technicians replace all of their incandescent bulbs on an 18-month cycle due to the high volume of replacements necessary. Five of the six jurisdictions that replace incandescent bulbs on an "as needed" basis have fewer than 50 signals; one has more than 100 signals.

Four of the twelve nonparticipant jurisdictions replace their incandescent bulbs on a scheduled basis. Of the four that perform scheduled maintenance, three report that they replace 100% of their bulbs and one nonparticipant said that his jurisdiction replaces "some bulbs on a scheduled basis and some on an 'as-needed' basis."

Roughly half of the participants (9 out of 16) do not know how many green incandescent bulbs are kept on hand by their jurisdiction for replacement (Table 6).

Three of the nine say that the maintenance of their traffic signals is handled by another agency and that the bulbs are supplied by that agency.

Table 6

PROPORTION OF GREEN INCANDESCENT BULBS KEPT IN STOCK

PROPORTION OF GREEN BULBS	PARTICIPANTS N=16	NONPARTICIPANTS N=10
100%	6 (38%)	0
20%	1 (6%)	0
Don't Know	9 (56%)	10 (100%)

Six of the participants that know the level of replacement stock said that their municipality keeps a full complement of bulbs—enough to replace bulbs in all of the traffic signal heads. The supervisor from ODOT reported having more than 100% replacement stock on hand, not surprising given that ODOT supplies many jurisdictions with bulbs.

None of the nonparticipants knew how many green incandescent bulbs are kept on hand. Half of the nonparticipants (5 out of 10) reported that another jurisdiction performs the maintenance and purchases equipment for the jurisdiction. Three of the five with maintenance and purchasing agreements are under the aegis of ODOT; one pays the City of Salem for maintenance and one has an arrangement with Washington County.

Half of the participants (8 out of 16) could not name the supplier of their incandescent bulbs. Table 7 shows that seven of the eight report that their jurisdiction gets their bulbs from another agency—the county or ODOT. These respondents did not know the name of their incandescent supplier, nor did a respondent who said that another department—purchasing—handles all of the transactions.

Table 7

SOURCES FOR INCANDESCENT BULBS

SOURCES	PARTICIPANTS N=16	NONPARTICIPANTS N=10
Don't Know	0	3 (30%)
County or ODOT	7 (44%)	4 (40%)
City of Salem	0	2 (20%)
City of Bend	0	1 (10%)
Purchasing Department	1 (6%)	0
Commercial Suppliers:	8 (50%) Total	0
• ***North Coast Electric***	*3 (19%)*	*0*
• ***Platt Electric***	*2 (13%)*	*0*
• ***McCain Electric***	*1 (6%)*	*0*
• ***Taylor***	*1 (6%)*	*0*
• ***Northwest Signals***	*1 (6%)*	*0*

Of the eight participants who could name a commercial supplier, six thought that their supplier did not carry LEDs as a part of their product line. One person expressed uncertainty, speculating that *"if they don't carry LEDs now, they probably will soon."*

None of the nonparticipants could name a commercial supplier as the source of their incandescent bulbs. The five jurisdictions with maintenance and purchasing agreements get bulbs from the agency that performs the service. Two more purchase bulbs from other municipalities. Respondents for three jurisdictions that purchase their own bulbs did not know the supplier.

Seven participants were able to name the manufacturer of their incandescent bulbs (Table 8). While Sylvania is the most often-mentioned brand, several said that that the brand varied depending on which distributor had won the bid for a particular budget cycle. Two participants were able to recall the names of two manufacturer's brands they had used in the past.

Table 8

MANUFACTURERS OF INCANDESCENT BULBS
(Multiple Response)

MANUFACTURER	PARTICIPANTS N=16	NONPARTICIPANTS N=10
Sylvania	4 (25%)	0
General Electric	2 (13%)	0
Philips	2 (13%)	0
Sony	1 (6%)	0
Don't Know	9 (56%)	10 (100%)

None of the nonparticipants was able to name the manufacturer of their incandescent bulbs.

AWARENESS AND PRIOR EXPERIENCE WITH LEDS

By 1996, eleven of the sixteen participants were aware that red LEDs were commercially available for signal lights (Table 9). Two respondents reported that they did not have information about red LEDs until the Trust's Green LED program in 2002. One said he did not know much about LEDs as he was new to his job.

Table 9

YEAR FIRST AWARE THAT RED LEDS COMMERCIALLY AVAILABLE

YEAR AWARE	PARTICIPANTS N=16	NONPARTICIPANTS N=10
Before 1995	5 (31%)	0
1995-1996	6 (38%)	4 (40%)
1997-2000	2 (13%)	3 (30%)
2002	2 (13%)	1 (10%)
Unsure	1 (6%)	2 (20%)

In contrast to the participants, less than half (4 of 10) of the nonparticipants were aware of red LEDs by 1996. Two nonparticipants had recently assumed responsibilities for traffic signals and were not sure when they had become aware of LEDs.

The majority of the participants (10 out of 16) report that their jurisdictions have relamped at least 50% of their red signals with LED lights (Table 10). The seven participants with 100% saturation of red LEDs include ODOT and six municipalities, five with more than 100 signals. Three of the four that had not installed any red LED signals before the Green LED program are installing red LEDs in conjunction with the green LED relamping.

Table 10

PROPORTION OF RED LEDS INSTALLED BEFORE GREEN LED PROGRAM

PROPORTION INSTALLED	PARTICIPANTS			NONPARTICIPANTS		
	WITHOUT REBATES N=6	WITH REBATES N=8*	ALL JURISDICTIONS N=16*	WITHOUT REBATES N= 6	WITH REBATES N=2	ALL JURISDICTIONS N=9**
100%	2 (50%)	5 (63%)	7 (44%)	4 (67%)	2 (100%)	6 (67%)
50%-99%	0	3 (38%)	3 (19%)	1 (17%)	0	1 (11%)
Less than 25%	2 (50%)	0	2 (13%)	0	0	0
None	NA	NA	4 (25%)	NA	NA	1 (11%)
Not Sure	0	0	0	1 (17%)	0	1 (11%)

* *Percents do not add to 100% due to rounding.*

** *Due to respondents' time constraints, only 9 of the 10 nonparticipants were asked about the saturation of their red LED signals.*

Six of the nine nonparticipating jurisdictions had installed red LEDs in all of their signals before the announcement of the Energy Trust Program. Three ODOT regions, one county, and one municipality reported that all of their red signals have been replaced.

Of the ten participants with red LEDs in half or more of their traffic signals, eight report that they had gotten rebates to purchase the LEDs. Two of these participants

went on to purchase additional red LED signals without an incentive. The two jurisdictions that installed all of their red LEDs without rebates are municipalities; one is small and the other is large. One of the two participants with less than 25% of signals converted is a large jurisdiction that used rebates for two years to install LEDs. The respondent continued, saying *"then I bought $20,000 of LEDs a year for three years without rebates."*

Five participants mentioned Portland General Electric (PGE) as the source of their rebate incentive and three mentioned Pacific Power as the funding source.

Only two of the six participants who had purchased LEDs without a rebate could recall the lamp prices: "$65 and $58, depending on size." Both of these municipalities had become aware that red LEDs were commercially available around 1995. Presumably the lower price per lamp was due to a somewhat later adoption date. One of the participants that had purchased red LEDs in 1996 with a rebate recalled the price of the signals as $90, but qualified his recollection, saying, *"That price could be off."*

Two of the nonparticipants that had replaced all of their red LEDs had done so with the aid of rebates. Neither of the two could recall details about the rebate such as the amount of the incentives or the number of years they received incentives. Both recalled that a utility in their jurisdiction had issued the rebate and both had jurisdictions served by more than one utility. Both also reported that their jurisdiction had purchased additional red LEDs without incentives.

Of the twelve participants with previously-installed red LEDs, eleven mentioned saving energy as one of the principal reasons their jurisdiction decided to install red LEDs (Table 11). Lowered maintenance costs and the reliability and performance of the LEDs are mentioned by five of the twelve. These proportions are somewhat similar to findings from a 1998 survey of 31 California municipalities in which 96% of respondents cited energy savings and 26% mentioned lower maintenance costs as principal reasons to install LEDs.[18]

[18] "Light-Emitting Diodes for Visually Critical Applications in Transportation and Architecture," John Bullough, Kun Michelle Huang and Kathryn Conway. Lighting Research Center, School of Architecture, Rensselaer Polytechnic Institute, Troy, NY.

Table 11

REASONS FOR INSTALLING RED LEDS
(Multiple Mentions)

REASON FOR INSTALLING	PARTICIPANTS N=12	NONPARTICIPANTS N=7
Energy Savings	11 (92%)	5 (71%)
Lowered Maintenance Costs	5 (42%)	5 (71%)
Reliability, Performance	5 (42%)	4 (57%)
Rebates	3 (25%)	0
Part of New Signal Replacement or Addition	3 (25%)	1 (14%)
Rising Utility Prices for Power	2 (17%)	0
Public Safety	2 (17%)	4 (57%)
Cost Savings	1 (8%)	0
ODOT Mandate	1 (8%)	0
Acceptance by ITE or Cal Trans	0	2 (29%)

Five of the seven nonparticipants reported the savings in energy costs and lowered maintenance costs as principal reasons for installing red LEDs. The reliability of the LED signals and public safety were cited by four of the seven as additional reasons that their jurisdiction installed LEDs.

We asked participants about their successes and challenges with the red LEDs. Several mentioned the savings they experienced through reduced energy bills and maintenance costs. Two mentioned that installation of the red LEDs reduced their utility bill—one added *"by $1000 a month."* Another remarked that *"saving energy is a feather in my cap."*

Regarding saving maintenance costs, one participant said, *"We've seen quite a maintenance savings since we installed the red LEDs."* Two said that the reliability of the reds has improved public safety—not only because of reduced signal down time, but also because of the reduced need *"to send maintenance equipment and personnel to block off lanes to repair signals."*

Six of the seven nonparticipants also mentioned that they had reduced their energy and maintenance costs after installing the red LEDs. Three said that they noticed that the LED signals were brighter than incandescent lamps. One nonparticipant explained that the red LEDs reduced the risks to public safety because *"I don't have to close a lane to repair a broken signal in an urban area."*

Several participants expressed satisfaction with the reliability and performance of the red LEDs. One explained, *"I've had seventeen reds up and running for six years and I've only had to replace one."* The overall high levels of satisfaction among the participants is represented by the remarks of one person who said, *"We've been so happy with the performance of the reds that we built the specifications for LEDs into our requirements for new traffic signals."* Two nonparticipant noted that if some of the individual diodes in the lamp stop working they *" don't lose the whole light; it still maintains the red image."*

The most common complaint among participants about red LEDs has been that their light output is reduced over time. Table 12 shows that one-third of those with red LEDs (4 out of 12) noted that the lights have "faded" or "dimmed" during the course of their four- to five-year lives to date. Two report that the hardwired system was not satisfactory and that they have retrofitted their systems to screw-based LEDs.

Table 12

PROBLEMS WITH RED LEDS
(Multiple Mentions)

PROBLEM	PARTICIPANTS N=12	NONPARTICIPANTS N=7
Fading, Dimming	4 (25%)	2 (29%)
Hardwired System Not Satisfactory	2 (13%)	0
Units Replaced Under Warranty Are Not Warranted	1 (6%)	0
Technology Changed Since Initial Installation	1 (6%)	0
Lifetime Nearing End, Replacement Costs Prohibitive	1 (6%)	1 (14%)
Nonfunctioning LED Pixels at Time of Purchase	0	2 (29%)
Premature Failure	0	1 (14%)

The engineer for one of the largest participating jurisdictions reported a significant problem. Now that most of the installed red LEDs are nearing the end of their expected lifespan, he must find *"$1 million dollars to replace them all at once. I would have preferred to replace a percentage each year rather than find so much money all at one time."*

Respondents from nonparticipating jurisdictions also reported that their red LEDs had faded or dimmed over time. Two more reported that some of the pixels in the LED array failed over time or were not illuminated upon initial installation. One nonparticipant reported "premature failure," without specifying the nature of the failure.

A participant with one of the largest jurisdictions had purchased green LEDs without rebates for about 10% of his signals before the Trust's Green LED program. None of the other participating jurisdictions reported a bulk purchase of green LEDs. Three participants thought that "one or two" of their new signal heads had come equipped with green LEDs but none mentioned concrete plans to install them. When asked directly about plans for green LEDs prior to the Trust's program, five respondents said that they had been waiting for prices to come down or money to become available to help their jurisdictions afford the more expensive green LED lamps. Of those five, four were early adopters, reporting awareness of red LEDs before 1995. The fifth, a smaller municipality, became aware of red LEDs in 1996.

Two of the ten nonparticipants reported that there were "one or two intersections" with green LEDs in their jurisdictions. One had ordered green LEDs to "try them out," the other said that municipalities within his jurisdiction had "tried them out on their own." Four nonparticipants mentioned concrete plans to install green LEDs.

Three of the sixteen participants were aware of the existence of PGE or PPL rebates for green LEDs. Two of the three are from large jurisdictions. Each said that they "reconsidered" working with PGE when they saw how easy the Energy Trust process would be. The comments of one are representative:

> *"The process of working with PGE was frustrating, trying to get all the accounting done. As soon as Nichols (the City) came up with the money, I quit going through PGE."*

We asked ten participants whether they were aware of LEDs with the ENERGY STAR® label. Eight of the ten were not aware of ENERGY STAR® labeling; two

"thought" the LED manufacturers they had selected (Leotek and Electrotechs) "might" qualify for an ENERGY STAR® label.[19]

All of the participants expected to see a savings on their utility bill after their green LEDs were installed.

[19] Leotek and Dialight, in fact, are both ENERGY STAR® Traffic Signal Partners, according to the US EPA and DOE. Interestingly, this fact was not mentioned by either company's sales representative during the interviews.

3. Market Characterization Prior to Program: End Users

4. MARKET CHARACTERIZATION PRIOR TO PROGRAM: MANUFACTURERS AND DISTRIBUTORS

The four manufacturers with whom we spoke sell their products across the United States. Three of the four also sell their products globally. The two distributors interviewed sell products west of the Rocky Mountains.

Two of the manufacturers' sales representatives said they sell their products directly to their customers—the traffic jurisdictions—and two sell to a distributor that carries the LEDs of only that manufacturer (Table 13).[20]

Table 13

MANUFACTURERS' SALES ARRANGEMENTS

SALES ARRANGEMENTS	MANUFACTURERS (N=4)
Direct Sales to Jurisdictions	2 (50%)
Sales Through a Distributor	2 (50%)

The representatives for the firms that sell directly to the traffic jurisdictions most often named traffic engineers as the primary decision-makers for LED purchases (Table 14). Traffic signal technicians and personnel from a jurisdiction's purchasing department were also cited as decision-makers by half of the companies with direct sales.

[20] One distributor also carries non-LED traffic signal products made by another company. One manufacturer's representative says that his distributor carries "some" incandescent products, although he also asserted *"Everything incandescent is moving to LED."*

Table 14

DECISION-MAKERS FOR TRAFFIC SIGNAL PURCHASES
(Multiple Mentions)

PRIMARY DECISION-MAKER	MANUFACTURERS AND DISTRIBUTORS WITH DIRECT SALES (N=4)
Traffic Engineers	4 (100%)
Traffic Signal Technicians	2 (50%)
Purchasing Department Personnel	2 (50%)
Contractors	1 (25%)
City Manager	1 (25%)
Maintenance Services Director	1 (25%)

The sales representative from the company with the ODOT-approved product reported that that he has "dealt with virtually every ODOT person, from the traffic people to the people who are running the departments." The two distributor's representatives named several different contacts for marketing their products. Says one, *"I may talk to the traffic signal technician or supervisor at a smaller jurisdiction, and the engineer at a larger agency."*

Other Products

Five of the six firms do not track the sales of incandescent products. The one firm that did track sales of an incandescent product was a distributor. This distributor's representative said that his company tracks the sales of incandescent programmable traffic signal heads, which are distinct from standard incandescent traffic signal lamps. None of the six manufacturers' and distributors' representatives considered non-programmable incandescent lamps to be competition for their LEDs.

All of the manufacturers produce LEDs for other applications in addition to traffic signals. Table 15 shows that three of the four say their company makes channel letters (individual illuminated letters, often in the company logotype) and other commercial signage.

Table 15

OTHER LED PRODUCTS MANUFACTURED
(Multiple Mentions)

PRODUCT TYPES	MANUFACTURERS (N=4)
Channel Letters and Other Commercial Signage	3 (75%)
Railroad Signage and Illumination	2 (50%)
Floodlights or Spot Lighting	2 (50%)
Vehicle Lighting (Bus and Automobile)	1 (25%)
Aviation Lighting	1 (25%)
Street Signs	1 (25%)

Three of the four manufacturers make LEDs for other public safety-related applications such as railroad, aviation, or vehicle lighting. One manufacturer also advertises its design capabilities for LED lighting. One of the two distributors carries LEDs for commercial signage and street signs; the other distributor carries no other LED product besides the traffic signals. None of the manufacturers makes non-LED products.

Each of the four manufacturers started producing green LEDs in 1997. Each of the distributors started carrying LED products in 1999.

Table 16 shows the prior and current prices that respondents quoted for a 12-inch green ball. Two manufacturers' representatives gave 1997 prices for a 12-inch green ball LED, and one quoted the 1995 price for a 12-inch ball. The 1995 price of $3,000 was so prohibitively high that the manufacturer did not start offering the units until after the unit price dropped. This manufacturer's representative did not give the 1997 price for their green LEDs.

The sales representatives attributed the decrease in green LED prices to increased competition among LED makers, changes in technology, and changes in the array (display face) of the green balls.

Three of the four manufacturers say that green LED prices are lower in part because there are more companies producing the LED components. In the words of one representative, *"When you're the only one offering a product, you can name*

your price. But the number of providers has tripled since last year. This increased availability drives down the price."

Table 16

PRICE CHANGE FOR 12-INCH GREEN BALL LED FIXTURE

REPRESENTATIVE*	YEAR				PERCENT REDUCTION IN PRICE
	1995	1997	2000	2002	
Manufacturer	$3000	—	—	$161	95%
Manufacturer	—	$375	—	$125	67%
Manufacturer	—	$160	—	$110	31%
Distributor	—	—	$300	$150	50%
Distributor	—	—	$200	$110	45%

* *One manufacturer's representative reported she was unsure of the LED product prices.*

Respondents mentioned two changes in green LED technology that helped reduce the price of green LED signals. One change respondents mentioned was that LED component producers increased the wattage of each individual pixel, or light-producing unit. As the wattage of the pixels increased, traffic signal manufacturers were able to decrease the number of pixels in the array, or display face, of the balls. A second change mentioned was that the manufacturers worked with component producers to modify the way the green light was produced. *"Initially green LED signals had a clear lens and the pixels were green. Now the lens is tinted green and the LEDs are white. We were able to reduce the price and sell more."*

Respondents gave their estimates about the future of green LED pricing. Table 17 shows that three of the six felt the pricing would "level out" at the 2002 rates quoted in Table 16. One said, *"After all there is only so much light that can be produced for the price."* One of the manufacturer's representatives was not sure whether prices would remain the same or continue to drop.

Table 17

ESTIMATES OF FUTURE PRICES FOR GREEN LEDS

ESTIMATE	MANUFACTURERS AND DISTRIBUTORS (N=6)
Level Out	3 (50%)
Continue to Drop	2 (33%)
Unsure	1 (17%)

Two felt the prices would continue to go down. One of the two estimated prices would drop "by 10% a year." Another anticipated that new technological developments would continue to reduce the prices. Although, he added, *"Last year I never would have thought prices could dip this low. Now they are lower than I ever thought they would be."*

Two of the sales representatives say that green LEDs comprise about 65% of their total revenues (Table 18). Three said that green LEDs make up 50-55% of their total revenues.

Table 18

LED REVENUES BY COLOR

PERCENT OF REVENUES FROM LED PRODUCTS	COLOR OF LED		MANUFACTURERS AND DISTRIBUTOR (N=6)**
	GREEN LEDS	RED LEDS	
100%	65%	35%	2 (33%)
100%	55%	40%*	1 (17%)
100%	50%	50%	1 (17%)
90%	30% (27% of total sales)	70% (63% of total sales)	1 (17%)
Unknown	50%	50%	1 (17%)

* *Respondent says remaining 5% of sales are yellow LEDs.*

** *Percents do not add to 100% due to rounding.*

Three of the respondents were careful to distinguish that the number of green LEDs sold is lower than the number of red units. However, because the price of the green LEDs is higher than the red LEDs, the proportion of their revenue from greens is greater. One distributor's representative emphasized the difference by saying that their green LEDs are twice as expensive as red LEDs (implying that, although their revenues were split evenly, their company sells twice as many red as green LEDs).[21]

Table 19 shows that sales representatives from the five companies reporting green LED growth attribute some of the increase in sales to the 2001 energy crisis. One representative said, *"Demand was insane in California in 2001 because of the energy crisis."* He implied that the demand in California would continue regardless of a change in price, *"Now the jurisdictions say 'we need them.' If our price is lower, that's great, but the need is the same."*

Table 19

REASONS FOR GROWTH IN GREEN LED SALES IN CALIFORNIA AND OREGON

REASON FOR GROWTH	MANUFACTURERS AND DISTRIBUTORS WITH GROWTH IN GREEN LED SALES (N=5)
Energy Crisis	5 (100%)
Incentive Programs	4 (80%)
Changes in Technology	4 (80%)
Reductions in Price	3 (60%)
Shorter Lead Time Than Competitors	1 (20%)

Four respondents said that incentive programs have boosted the market for green LEDs. One representative said that the dollar amount for the green LED incentive

[21] One distributor that sells LEDs and other traffic signals reported that the company had "*not experienced a lot of growth in green LEDs in the last year.*" This respondent, then, was not asked questions about the reasons for growth in the green LED market.

made the price of the green lamp comparable to the price for red LEDs: *"Part of all of the activity in California is because a utility stepped up to the plate and said, 'For every green LED we'll give a jurisdiction $50.' This kind of incentive for large quantities makes the green LED price comparable to the price I quote the state department of transportation for reds."*

Respondents also said that the changes in green LED technology discussed above drove down the price for the LEDs and created favorable market conditions for growth.

Three of the six manufacturers' and distributors' were able to give estimates of the market saturation for green LEDs in the United States and in California. Table 20 shows that, for the nation, two of the three estimate that there is less than 25% saturation. Two respondents estimated the saturation of green LEDs in California to be 85% or greater. None of the respondents could give estimates about the level of market saturation in Oregon.

Table 20

ESTIMATED 2002 MARKET SATURATION FOR GREEN LEDS (Multiple Mentions)

ESTIMATED 2002 MARKET SATURATION	MANUFACTURERS AND DISTRIBUTOR (N=3)
UNITED STATES	
20%-25%	2 (66%)
50%	1 (33%)
CALIFORNIA	
85%	1 (33%)
100%	1 (33%)

All six of the manufacturers' and distributors' representatives said that California has experienced the greatest rate of growth in LED sales in the country (Table 21). Two said that Oregon's growth rate is "lower," but neither was able to estimate the growth of LED sales in Oregon.

Table 21

STATES OR REGIONS IN THE US WITH THE HIGHEST GROWTH OF LED SALES (Multiple Mentions)

STATES OR REGIONS WITH MOST GROWTH	MANUFACTURERS AND DISTRIBUTOR (N=6)
California	6 (100%)
Southeastern States (North Carolina, Florida, Georgia)	4 (66%)
Northeastern States	2 (33%)
Texas	1 (17%)

The manufacturers' and distributors' representatives shared their growth estimates for the upcoming year. None of the respondents would predict what the market might do beyond the upcoming twelve months. Table 22 shows that two of the six predict between 25% and 30% growth in their industry in the upcoming one year, one predicts "fast growth," and two predict "steady growth" without revealing details.

Table 22

PREDICTED GROWTH IN LED SALES AND MANUFACTURING IN UPCOMING YEAR

PREDICTED GROWTH	MANUFACTURERS AND DISTRIBUTOR (N=6)
25%-30%	2 (33%)
Fast Growth	1 (17%)
Steady Growth	2 (33%)
Growth Leveling Off	1 (17%)

Three respondents say the pattern of adoption of LED traffic signals is somewhat sporadic, with one large order accompanied by several small orders in a region. In the words of one respondent:

"The smaller towns follow the state or a city. The city will do a big project then the smaller towns will purchase LEDs….After a jurisdiction has done their initial changeover, they buy for replacements or new intersections."

5. PARTICIPATION IN PROGRAM: END USERS

DECISION-MAKING

The decision to participate in the Green LED program was characterized as a as an easy one by all sixteen of the program participants. As noted in Chapter 3, five said that their jurisdictions had been considering purchasing green LEDs but were waiting for the unit prices to come down.

Three participants said that the notification of the Energy Trust program came to them from a superior in their department who encouraged them to participate. When we asked who besides themselves was involved in making the decision, participants most often mentioned "managers" in their department, such as the division manager or operations manager (Table 23).

Table 23

DECISION-MAKERS INVOLVED IN DECISION TO PARTICIPATE IN TRUST PROGRAM (Multiple Mentions)

DECISION-MAKERS	PARTICIPANTS N=9*	NONPARTICIPANTS (N=10)
Division Manager, Operations Manager, Other Manager	5 (56%)	3 (30%)
Public Works Director	4 (44%)	0
Traffic Jurisdiction Contracted to do Maintenance	3 (33%)	3 (30%)
City Council	2 (22%)	3 (30%)
City Engineer	2 (22%)	1 (10%)
Finance Director	2 (22%)	1 (10%)
Electrical Crew Supervisor	0	4 (40%)
City Attorney	1 (11%)	0

* *Nine of the sixteen were asked this question.*

Four of the ten nonparticipants mentioned making the decision not to participate with feedback from their electrical crew supervisor. Like the participants, however, nonparticipants also reported that they had consulted with managers, staff from the jurisdiction that provides maintenance, or a representative from their city council.

Table24 shows that respondents from participating jurisdictions most often reported consulting with one additional decision-maker when deciding whether to participate in the Energy Trust program (5 out of 7). In contrast, nonparticipants most frequently reported consulting with two or three additional decision-makers.

Table 24

NUMBER OF ADDITIONAL DECISION-MAKERS CONSULTED

ADDITIONAL DECISION-MAKERS	PARTICIPANTS N=9*	NONPARTICIPANTS N=10
None	0	1 (10%)
One	5 (56%)	1 (10%)
Two	2 (22%)	4 (40%)
Three	2 (22%)	4 (40%)

* *Percents do not add to 100 due to rounding.*

Eleven of the sixteen participants said that they conducted a financial analysis to determine the payback period for the green LEDs (Table 25). Two more participants said that while they were not required to meet a specific financial criterion, they analyzed the return on investment informally, or had "penciled out the costs and benefits."

Of the five participants who said they did not do a payback analysis, two emphasized that the energy savings of LEDs is of primary importance, but did not directly equate the energy savings with a long-term savings. The following remarks are typical: *"We don't have a payback; the City wanted to do this because of the energy savings."* The two largest jurisdictions (with around 900 signals) did not report having to meet any specific financial criteria. In the words of the engineer at one large jurisdiction: *"The green LED installation is part of a general endorsement*

by my jurisdiction for doing energy-saving and environmentally responsible actions."

Table 25

FINANCIAL CRITERIA NECESSARY

FINANCIAL CRITERIA	PARTICIPANTS N=16*	NONPARTICIPANTS N=10
Formal	11 (69%)	3 (30%)
Informal	2 (13%)	4 (40%)
None	3 (19%)	3 (30%)

* *Percents do not add to 100% due to rounding.*

Four of the seven participating jurisdictions with 100% saturation of red LEDs reported that they had not done a financial analysis for the green LEDs. Several remarked that the cost-effectiveness of LEDs had already been proven through their experience with the red LEDs. One engineer had conducted a payback analysis and found that the green LEDs had a *"three to five year payback but no one in his jurisdiction asked for the analysis this time."* The remarks of another are typical for the group with installed red LEDs:

> *"We have to show a good cost-benefit ratio for the City to pursue the project. The reliability, savings in energy and savings maintenance hours of the red LEDs leave no doubt that there's a cost benefit. Therefore, going forward with the green LEDs was an easy idea to sell."*

One participant in a large jurisdiction remarked that he was able to calculate the return on investment based solely on the potential savings in maintenance costs. Most of the traffic signals in his jurisdiction are governed by a flat usage rate rather than metered. He explained that when he analyzed the potential savings in maintenance costs, he realized that, even without a reduction in his electricity bill, his jurisdictions would still benefit from installing LEDs. He elaborated:

> *"We had to show that we could recoup the costs on the maintenance savings. The Office of Sustainable Development gave me the*

information I needed. The savings in maintenance costs is the reason we decided to join."

Another participant also emphasized that, while energy savings were important, the potential savings in maintenance costs was persuasive:

Portland told us that maintenance costs the City of Portland $200 every time a signal is out. We hadn't considered that and it was part of our decision to participate.

The majority of nonparticipants (7 out of 10) had also done either a formal or an informal payback analysis. Three small municipalities of the seven had been required to do a formal payback analysis. Two of the three nonparticipants who said they did not need to meet financial criteria elaborated that they anticipated savings from the green LEDs based on their experience with red LEDs. Both of these large jurisdictions declined to participate for other reasons.[22]

Table 26 shows that all but one of the participants spontaneously mentioned the Energy Trust's rebate as a primary reason to install green LEDs at the current time. One-fourth (4 out of 16) mentioned ODOT's recent approval of green LEDs for purchase as a motivator.[23]

Several mentioned that their jurisdictions had been experiencing budget constraints and that the Energy Trust incentive reduced the costs sufficiently to make the project possible. The comments that follow are representative.

"Principally, the rebate offer was attractive enough that it helped us rationalize doing greens. It was enough to kick us into doing greens."

"We never saw a down side to installing green LEDs except the up-front dollars. But the rebates took a lot of the sting out of the initial cost."

"Budgets have been tight. The green LED purchase would have created a bump in the budget even though it has the potential for a payback.

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22 One of the two did not participate because his jurisdiction is primarily served by utilities other than PGE and PPL. The other jurisdiction did not participate because his budget had already been allocated to other purposes.

23 One participant mentioned that, while ODOT had approved green LEDs for purchase, at the time of the program green LEDs had not been tested for use. Although this participant has purchased and received his order of green LEDs, he is waiting to hear the results of the ODOT testing before he will install them in his jurisdiction.

We wouldn't have gotten support for the purchase without the extra funds from the incentive."

"The rebate was the key. I don't know if I could have pulled this off in this year's budget without the rebate."

Table 26

FACTORS CONSIDERED IN DECISION TO INSTALL GREEN LEDS AT CURRENT TIME (Multiple Mentions)

FACTORS CONSIDERED	PARTICIPANTS (N=16)
Energy Trust Rebate	15 (94%)
Recently Approved by ODOT	4 (25%)
Green Installed in New Signals	3 (19%)
Availability of Green LEDs	2 (13%)
Potential Savings in Maintenance Costs	2 (13%)
Other Jurisdictions Have Installed Green LEDs	2 (13%)
Lower Prices for Green LEDs	1 (6%)
Expected Lifetime of Green LEDs	1 (6%)
Favorable Experience with Red LEDs	1 (6%)
To Evaluate Green LEDs	1 (6%)

Six of the ten nonparticipants mentioned either budget constraints or limited time as barriers to participating in the Green LED program (Table 27). Many of those that mentioned budget constraints said that, while the rebate offer was attractive, their own municipality's lack of capital or operating funds meant that they could not "match" the rebate money with funds of their own. Several of the nonparticipants that mentioned time as a barrier to participation said that the rebate process for the Green LED program appeared to be time-consuming. In the words of a typical nonparticipant:

"Doing the paperwork to apply for the rebate seemed like a big time investment…I'm basing this opinion on my previous experience with grant programs."

Table 27

BARRIERS TO PARTICIPATION IN ENERGY TRUST PROGRAM
(Multiple Mentions)

BARRIERS	NONPARTICIPANTS N=10
Budget Constraints	6 (60%)
Limited Staff Time to Devote to Rebate Process	6 (60%)
Another Jurisdiction Purchases Traffic Equipment	3 (30%)
Initial Cost Too Large, Payoff Too Long	3 (30%)
Traffic Signal Power Supply Not Metered	3 (30%)
No Product Warranty	1 (10%)
Not In Qualifying Utility District	1 (10%)

One nonparticipant said that getting a rebate was not an advantage for his large jurisdiction. He said he decided not to participate in part because the bureaucracy in his jurisdiction prevents him from returning the rebated funds to the same budget line-item:

"When we take money out of the operating budget and get reimbursed, it's never easy. With all the bureaucracy of government, we can't be reassured that the rebate will come back to our operating budget."

We asked the nonparticipants what it would take to convince decision-makers in their jurisdiction that LEDs are a good investment. Table 28 shows that "money in the budget" was the response given most often. This supports the finding in Table 27 that budget constraints are a barrier for several jurisdictions.

Table 28

CONDITIONS NECESSARY TO CONVINCE DECISION-MAKERS (Multiple Mentions)

CONDITIONS	NONPARTICIPANTS N=10
Money in budget	4 (40%)
Information on payback period	2 (20%)
Shorter payback period	2 (20%)
Needs analysis	2 (20%)
Reduced bureaucracy	1 (10%)

CONTACT WITH THE CITY

None of the respondents had worked on a project with Curt Nichols or the City of Portland prior to the Green LED Program. One participant said that his municipality had "talked in the past" with the City of Portland about group purchases of utility services and trading information about best practices. He reported that this previous contact positively affected his willingness to participate in the LED project. He said *"Curt and his folks have better technical knowledge and I was looking for leadership."*

Table 29 shows that five of the sixteen participants said that Curt Nichols provided them with new information about green LEDs. Three participants recalled that Curt provided the names of vendors, contacts in other traffic jurisdictions, and other resources for further investigation.

Nonparticipants were less likely to recall the information they had received from Curt. The remarks of one are representative: *"I don't remember what Curt emailed to me, but I know he gave me adequate information with which to make a decision about the program."*

We also asked participants if Curt was helpful in their municipality's process of decision-making about the type or brand of LED. All sixteen respondents were emphatic that Curt provided information that helped them make a decision, often

responding with comments such as, *"Curt was definitely helpful." "Absolutely, I found Curt's information helpful."*

Table 29

INFORMATION FROM CURT NICHOLS ON GREEN LED PROJECT

INFORMATION	PARTICIPANTS N=16	NONPARTICIPANTS N=10
New Information About Green LEDs	5 (31%)	0
Names of Vendors and Other Contacts for Information	3 (19%)	0
Energy Savings Potential	1 (6%)	1 (10%)
Availability of Green LEDs	1 (6%)	1 (10%)
Viability of Green LEDs	1 (6%)	0
Tax Credit Information	0	1 (10%)
Don't Recall	5 (31%)	7 (70%)

Five of the sixteen participants were careful to distinguish between what they perceived as help in making a decision and influence upon the decision itself. Each of the five who made the distinction either stated or implied that, while Curt informed their process, he did not exert influence on it. The remarks of one participant are typical:

> *"Curt was helpful in giving me places to go for technical information and suggestions for manufacturers, but he did not really recommend any one vendor—he just gave suggestions about places to get information."*

Ten of the sixteen participants said that Curt was readily available for them via email and the telephone. Five related that Curt had repeatedly advised them of the availability of funds, their own jurisdiction's application status, and sent timely reminders about the program deadlines.

In fact, fifteen jurisdictions initiated the purchasing process during the original program time frame. In the course of the bidding and purchasing process, however,

one of the initial fifteen jurisdictions dropped out of the process and was unable to participate in the program. Curt Nichols had maintained communication with a contact at a sixteenth municipality that had sent in its program application a day after the program limit had been reached. When the one jurisdiction dropped out, Curt activated the application of the sixteenth applicant and extended the installation deadline by a month. In the words of the late-coming participant: *"I really appreciated getting the call from Curt saying that we could participate."*[24]

All sixteen implicitly expressed satisfaction with their communication with Curt in their comments. The following three remarks are representative:

> *"Curt has been very good at providing updated information, telling us how the numbers work. He has been good about emailing our status when the committee met and when the money was available. He provided the launch pad to get the program started."*
>
> *"Curt spelled out the application process very well. It was an easy application process."*
>
> *"He would call or email us with a heads up: 'Here's an opportunity' and what the timelines were. He provided us with enlightenment."*

We asked participants to relate the steps once they realized the rebate was available. Table 30 shows the process steps that participants followed. Most mention that they gathered information and filled out an application for the program. Seven of the fifteen had requested and received guidance from Curt on the application process or conducting the payback analysis (one received assistance with both). At the time of the interviews, three participants had already submitted paperwork for the verification of the installation to the City of Portland and had received their rebate check. A fourth person was preparing to submit the documentation.

Most of the participants described the application process as "straightforward" or "simple." Ten of the sixteen volunteered that the program process steps were "easy."

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24 At the time of the participant interviews, data was gathered from the original fifteen participants. During the nonparticipant interviews (which occurred three weeks after participant interviews), participant data was gathered from the sixteenth participant. For the purposes of robust analysis, the data are analyzed on the basis of sixteen responses wherever appropriate.

Table 30

PROGRAM PROCESS STEPS MENTIONED VOLUNTARILY BY PARTICIPANTS

STEPS MENTIONED	PARTICIPANTS (N=15)
Contacted Program Administrator for Q&A Session	1 (6%)
Sought Guidance with Application Process	5 (31%)
Sought Guidance for Payback Analysis	4 (25%)
Researched Wattage for Existing Lights, Contacted Utility about Power Usage	3 (19%)
Searched Internet for Information	1 (6%)
Gathered Bids for LED Purchase	3 (19%)
Reallocated Budget Funds to LED Purchase	3 (19%)
Missed Deadline, then Notified that More Funds or Extended Deadline Available	2 (13%)
Submitted Paperwork for Verification of Installation	4 (25%)

Few jurisdictions reported difficulties with the process of applying to the program or ordering the LEDs. Three participants said that their jurisdiction had to reallocate budget funds in order to take advantage of the incentive. One of the three reported that more than one meeting was necessary to reallocate the funds and two others reported that a manager or division leader helped to procure extra funding so that the municipality could purchase the green LEDs.

One city reported considerable difficulty with the bidding process. As described in Chapter 5, this municipality's attempt to combine two sets of specifications created problems in the first round of bidding. At the time of the interview, the purchasing officer was waiting to receive the results of a second round of bids. Nevertheless, he characterized the problem as *"our own, not a problem of the Trust's."* This municipality subsequently dropped out of the Green LED program and was replaced with a municipality that had submitted its application one day after the program limit had been reached.

Most participants expressed a high level of satisfaction with the performance of the City of Portland as a program administrator. Thirteen of the fifteen participants

said that the City of Portland did an "excellent job," a "great job," or a "good job" in administering the program. Other comments included:

> *"It was nice to have a local administrator; the process went very smoothly."*
>
> *"It made sense to have one point of contact for the program."*
>
> *"Having the City of Portland administer the program has been absolutely perfect. I don't know how they could have done better. We've gotten all the information we needed and then some."*

The two participants who had refrained from praising the City of Portland did not have negative comments. Both were unsure of how to evaluate the City's performance. Says one, *"I just don't know, I don't have a basis for comparison."*

Feedback Regarding Green LED Program Process

Participants provided feedback on what worked well and what difficulties they encountered during the course of the program. Seven participants found the program process and communication to be easy (Table 31). Two of the seven emphasized that they found the Trust program to be "much easier" than the process they had experienced getting rebates from Portland General Electric.

Four participants suggested that the principal actions the Trust could take to improve the program would be to provide more money for bigger incentives, to provide incentives for more lamps, or fund the program for more than one year. Three also suggested that jurisdictions get more advanced notice about the program. Specifically, participants suggested that participant candidates receive notice about the program one year in advance of implementation of the program. Those who made this recommendation said a "12-month lead time" would give them time to allocate funds in the budget for the LED purchase.

Table 31

FEEDBACK ON GREEN LED PROGRAM
(Multiple Mentions)

FEEDBACK	PARTICIPANTS (N=16)
PROGRAM MERITS	
Communication Was Easy	4 (25%)
Program was Simple and Easy	3 (19%)
Program Administration Staff Had Technical Expertise	1 (6%)
Local Administration Was Appropriate	1 (6%)
SUGGESTIONS FOR IMPROVEMENT	
Increase Funding	4 (25%)
Provide Longer Lead Times	3 (19%)
Provide a Demonstration of LEDs	1 (6%)
Publicize the Program Through the Local Government Commission Web Site	1 (6%)
Provide Help with the Press Release	1 (6%)
Clarify the Roles and Relationships of the City of Portland and the Energy Trust of Oregon	1 (6%)

Nonparticipants also had a chance to make spontaneous comments directed toward the Trust. Two of the respondents made remarks that reflect their perception that the rebate process is complicated. Two expressed concerns about the length of the payback period. Another requested information about future repair and replacement of LEDs. The list of remarks is below:

- *We would participate if the process were not complicated.*
- *The grant process needs to be easier.*
- *We need to recoup our costs within the same year.*
- *We need more data on the payback for green LEDs.*

- *We need information on repair and replacement of LEDs.*
- *If the program were multi-year we would stagger our purchases. We'd like to know whether it would continue for several years or not.*
- *If all of the utilities and the Energy Trust of Oregon could coordinate their rebate programs, it would be easier.*
- *The Trust should open up the program to other utilities.*
- *We appreciate the opportunity to participate but our budget is stretched so thin.*
- *We would consider participating another year.*

TECHNOLOGY AND MANUFACTURERS

Research

We asked participants to tell us how they had selected the manufacturer from which they bought their green LEDs: they reported relying on information from other jurisdictions more than any other source. Table 32 shows that fourteen out of fifteen of the participants have spoken with or visited another jurisdiction to get information on the green LEDs. The indented list in the table shows the breakdown of jurisdictions regarded as sources of information by program participants.[25]

ODOT and Clackamas County are named as sources of information in equal measure by respondents. Three of the four who say they got their information from ODOT were also purchasing their LEDs through ODOT's state contract—an arrangement similar to the group purchasing arrangement for incandescent bulbs. A fourth said, *"We bought our green LEDs from the same manufacturer as the red LEDs. We found out about this manufacturer from ODOT because [ODOT] had done research on LEDs. They worked directly with the manufacturer."*

[25] Data was gathered from fourteen original participants and the one late-entering participant for a total of fifteen participants for the analysis of decision-making around the LED technology and manufacturer selected.

Table 32

SOURCES OF INFORMATION FOR RESEARCH ON GREEN LEDS (Multiple Mentions)

SOURCES OF INFORMATION	PARTICIPANTS (N=15)
Other Jurisdictions (Total)	14 (93%)
• ***ODOT***	*4 (27%)*
• ***Clackamas County***	*4 (27%)*
• ***Unspecified***	*4 (27%)*
• ***City of Portland***	*1 (6%)*
• ***Lebanon***	*1 (6%)*
Manufacturers (Samples and Information)	7 (46%)
Professional Organizations, Trade Shows*	3 (20%)
Testing (Field and Lab)	2 (13%)

* *Each of the three respondents named a different professional organization: the American Public Works Association (APWA), the International Municipal Signal Association (IMSA), and the Institute of Transportation Engineers (ITE).*

It is interesting to note that ODOT's engineer named Clackamas County as a source for information on green LEDs.

> *"I communicated with Clackamas County and they had been on it a while. ODOT has an approved products list with only one manufacturer approved. I am pushing to get some other, cheaper LEDs approved. With the information I got from Clackamas County, I knew a bit about what was available."*

Similarly, another participant in a smaller jurisdiction indicated that he had considered the LEDs installed by the City of Portland and those installed in Clackamas County. He says of his final decision, "*I did not go with the City's manufacturer. I talked to people at Clackamas County who used a different manufacturer; they were happy. They put in a fairly significant number of signals.*"

Specifications

None of the participating jurisdictions had specifications that exceeded the requirements for LED lamps set by the Institute of Transportation Engineers (ITE). One person said that ODOT's standards are based on ITE standards, *"So we know that when they've been approved by ODOT, they meet the specifications of ITE."*

Four participants mentioned that their jurisdictions use the specifications set by the California Department of Transportation (Caltrans). One participant in a large jurisdiction said, *"If all of California is willing to go with a specific manufacturer then it's a jurisdictional preference [and we don't' need to wait for ODOT approval]"* to use another specification. The participant from ODOT speculated that Oregon's specifications may be "more stringent than those issued by Caltrans" in part because Caltrans qualified green and amber LEDs for use more rapidly than ODOT.

The respondent whose jurisdiction dropped out said that his jurisdiction's effort to combine the Caltrans specification for green LEDs with ODOT's approved specification for red LEDs made it difficult to find three manufacturers (the minimum number required for a successful bid) whose products met the specifications. *"We used a minimum LED count for the heads from one set of specifications and the wattage requirements from another set of specifications conflicted with this, so we had to throw out our original set of bids and start all over again."*

Most of the nine participants who had worked with a distributor said that they had had good communication with the sales representative. Five of the nine said that the distributor had provided them with samples and information regarding a screw-in product. Another participant said that he had considered (and eventually chose) a hardwired bulb based on the strength of his distributor's recommendation. The participant had purchased non-LED products from the distributor in the past. He said, *"This distributor has a very good reputation for dealing in good products. They don't try to market products they think people will have problems with."*

Selection of LEDs by Type of Bulb and Manufacturer

We asked participants questions about the type of bulb and manufacturer's brand they selected for their signals. Table 33 shows that one-third of the participants (5 out of 15) chose Electro-Techs LEDs for their jurisdiction and one-third purchased Leotech LEDs. Leotech was the only manufacturer of screw-in LED bulbs represented by a distributor in the Pacific Northwest. All five of those that purchased Leotech signals did so through Western Pacific Signal. One of the three

participants that purchased Dialight bulbs named *Advanced Traffic Signals* as the distributor for this region.

Table 33

LED SELECTION BY TYPE OF BULB, MANUFACTURER, AND DISTRIBUTOR

MANUFACTURER (BRAND)	DISTRIBUTOR	PARTICIPANTS SELECTING BRAND (N=15)*
Electro-Techs (Screw-In)	**None**	5 (33%)
Leotech (Screw-In)	**Western Pacific Signal**	5 (33%)
Dialight (Hardwired)	**Advanced Traffic Signals**	3 (20%)
Electro-Techs and Dialight	**None**	1 (6%)
Electro-Techs and Leotech	**Western Pacific (for Leotech)**	1 (6%)

* *Percents do not add to 100% due to rounding.*

Although fewer participants chose Dialight LEDs (3 out of 15), those who did included the two largest jurisdictions and one county. One of the large jurisdictions bought Dialight green LEDs exclusively; another bought mostly Electro-Techs and purchased a few Dialight signals to test the performance of the hardwired Dialights.

Six of the fourteen participants did not know or were unsure of the bulb type or brand of LED purchased. For these six jurisdictions, follow-up interviews were conducted with other personnel (a lead electrician, signal technician, or head of the maintenance agency). In four of the six cases, conflicting information was gathered.

Table 34 shows that for three of the four cases, information about bulb type and manufacturer was supplied by larger agencies that performed maintenance and coordinated group purchasing arrangements for several municipalities. A second, short, follow-up interview was conducted with the county that supplied information about two participating jurisdictions to confirm bulb type and manufacturer. The fourth jurisdiction did not require a follow-up interview but the participant was unable to supply some details about the purchase of both the incandescent and the LED signals in his jurisdiction.

Table 34

SOURCES OF INFORMATION FOR INACCURATE REPORTING OF BULB TYPE ACCORDING TO MANUFACTURER REPORTED

SOURCE OF INFORMATION	NUMBER
County Performing Maintenance for Smaller Jurisdictions	2
ODOT Performing Maintenance for Smaller Jurisdiction	1
Purchasing Department in Same Jurisdiction	1
Total	4

In all four cases, interview subjects referred to paper files to answer questions about the purchasing process. For three of the cases, the maintaining agency dealt with traffic signals in its own jurisdiction as well as traffic signals in several municipalities. It is reasonable to assume that for the three agencies performing maintenance, the larger agencies were not able to supply accurate information about bulb type for a particular jurisdiction.

Table 35 shows that about half of the participants (8 out of 15) said that their choice of LED was based on ease of installation, replacement, or conversion. One-third (5 out of 15) based their decisions on the unit price alone, or price in conjunction with other factors. Another four of the fifteen said they follow the lead of ODOT, either by purchasing only "ODOT-approved" LEDs or by joining ODOT in a group purchasing arrangement.

Although participants were not unanimous in choosing one manufacturer for ease of installation and another manufacturer based on price, some patterns emerge. Ease of installation and ODOT approval are the two most often-given reasons that participants purchased Electro-Techs LEDs. Four out of five of the participants who purchased Electro-Techs say they did so for one or both of these reasons. Participants from all four of the jurisdictions that ordered Leotechs named price as a primary consideration in their purchasing decision.[26]

[26] This reasoning is supported by the distributor's sales representative who said that his company aggressively marketed Leotechs in Oregon by lowering the price in conjunction with the Energy Trust rebate.

Table 35

REASONS GIVEN FOR CHOICE OF MANUFACTURER OR TYPE
(Multiple Mentions)

REASON	PARTICIPANTS (N=15)
Ease of Installation, Replacement, or Conversion	8 (53%)
Price	5 (33%)
ODOT Approved of LED or Provided Group Purchasing Arrangement	4 (27%)
Maintenance Agency or Department Suggested	2 (13%)
Other Affordable Brands Not Available in Time to Qualify for Rebate	2 (13%)
Experiment to Test Second Brand	2 (13%)
Used Same Vendor as for Red LEDs	1 (6%)
Flexibility of Screw-In	1 (6%)
Compatible with Existing System	1 (6%)
Hardwired Unit Less Likely to Fail	1 (6%)
Long Run Savings for Hardwired	1 (6%)

The following comments reflect participants' decisions.

> *"At the time that we first purchased the red LEDs hardwired fixtures were our only option. But the screw-in base is same as changing a light bulb. We paid to retrofit back to the old style screw-in socket. We kept all of the old shields and sockets so it was easy to do that."*

> *"The screw-ins are fast to install."*

> *"We got the screw-base style. They are easy to replace."*

> *"Screw-ins. The county prefers those and they do our maintenance."*

> *"The county wanted screw-in not hardwired because they do the maintenance."*

"Screw-in because my guys say that what works. For ease of installation."

"My traffic signal technicians preferred the screw-ins."

"The county that does our maintenance said they had had some trouble with the screw-ins. They recommended the hardwired."

"We got the hardwired. They are a little bit more time to install but connectors are already made up. Removing the socket from the fixture eliminates a possible source of maintenance and failure."

"The screw-in units are more expensive. The availability and cost were in favor of the hardwired."

PURCHASE AND INSTALLATION PROCESS

The majority of participants (12 out of 15) say that the purchase of green LEDs was funded through their jurisdiction's operating expenses (Table 36).

Table 36

SOURCE OF FUNDING FOR LED PURCHASES

FUNDING SOURCE	PARTICIPANTS	
	CURRENT PURCHASE (N=15)	FUTURE PURCHASES (N=15)
Operating Expenses	12 (80%)	4 (27%)
Capital Expenses	2 (13%)	3 (29%)*
Not Sure	1 (6%)	8 (27%)

* *One participant reported that his jurisdiction used operating funds to meet the program deadline but would use capital funds in the future: "The funds came out of the operating budget but we didn't have much notice this year. If we had more notice we would have tried to budget it as a capital item."*

Most respondents did not know whether future purchases would be handled as operating or capital expenses. Those who indicated a future source were almost equally divided between operating and capital funds.[27]

Fourteen of the fifteen participants said the number of lamps they were able to purchase with Energy Trust incentives met their needs. Although the two large jurisdictions still have some lamps to buy, neither wants to purchase all of the lamps at once. Explained one, *"We want to try staggering them. I'd like to buy and install 20% of the total number of signals each year. It makes better budgeting sense and it makes sense from a labor standpoint."*

All of the fifteen participants ordered all of the lamps they had reserved. At the time of the initial round of interviews, a sixteenth municipality had requested a second round of bids and had not ordered any lamps. This participant subsequently dropped out of the program and reported that his jurisdiction would use the same amount of internal funding to buy 100 fewer lamps.

One jurisdiction went on to buy 75 green LEDs for intersections not covered by the Energy Trust incentive. He describes, *"I had a highway to finish and I wanted all of the signals to be the same so I bought them on my own."*

Four of the municipalities reported that their green LEDs were installed by the time of the interview (Table 37).

Table 37

INSTALLATION STATUS

INSTALLATION STATUS	PARTICIPANTS (N=15)
Installation Complete	4 (27%)
Installation Not Begun	10 (67%)
Installation Not Complete	1 (7%)

[27] Although seven jurisdictions are slated to replace all of their green signals with LEDs, three participants envisioned adding new signals in the future that would be funded through capital expenditures.

One jurisdiction had installed about half of its green LEDs and was waiting for the other half, which were back-ordered. Ten municipalities had not begun to install the green LEDs at the time of the interview.[28]

Table 38 shows that nine of the eleven jurisdictions that had not begun or completed their green LED installation were waiting for a shipment of LEDs. One participant knew that his LEDs were *"sitting on a dock somewhere in California, thanks to the dockworkers' strike."* Several were waiting for a shipment from their group purchase with ODOT or another agency. One such participant said, *"We're expecting them from ODOT but they haven't received the order. It has taken quite a while for delivery.*

Table 38
REASON INSTALLATION NOT COMPLETED

REASON	PARTICIPANTS WITH INCOMPLETE INSTALLATION (N=11)
Waiting for Full Shipment	8 (73%)
Waiting for Partial Shipment	1 (9%)
Received; Waiting for ODOT Test Results	1 (9%)
Joined Program After Deadline	1 (9%)

Another municipality reported that the LEDs had been received and were "in the warehouse," but that *"ODOT has not approved green LEDs for installation, only for purchase, so we're waiting for the results of ODOT tests to begin to install ours."*

Of the four jurisdictions that had completed the green LED installation, three purchased screw-type bulbs. The jurisdiction with half of its green LEDs installed also purchased screw-in LEDs. All four with some or all of its screw-in bulbs installed report that the screw configuration made it easy to do the installation. Each one emphasized the ease of installation:

[28] The interviews took place from October 30th to November 8th.

> *"The screw-in LEDs don't require any wiring changes. We are not electricians, so for future replacement, they will be easy to work with."*
>
> *"It was not hard to install the screw-in LEDs because anybody can change a light bulb."*

The participant that had experience with both hardwired and screw-in LEDs noted that the installation time for screw-ins compared favorably to the time to re-wire a signal for hardwired LEDs: *"The installation time for the screw-in LEDs is two minutes, compared to twenty minutes for the hardwired units."*

One of the participants that had installed hardwired units acknowledged that *"It takes a little longer to change to hardwired LEDs, but,"* he added, *"the initial cost of the screw-in units is higher and the labor costs of changing to hardwired LEDs do not add up for the higher cost of the screw-in units."*

Participants who had installed all or some of the LEDs characterized the process as "easy" and "fast." Two reported that the process took "about two weeks" and was "simple." One of the jurisdictions that installed the LEDs in two weeks replaced seventeen signals, the other had installed 104 LEDs. One participant reported that he is waiting for more labor to become available in order to install the LEDs. He explained, *"I would have started this week but we are still doing asphalt and painting because of the favorable weather."*

We asked fourteen of the participants how their jurisdiction had planned or had executed the installation of the LEDs. Ten of the thirteen said that installation had been or will be done by special project. Table 39 shows that three of the four municipalities with LEDs installed before the interview period had done so through their routine maintenance schedule. In contrast, all of the jurisdictions with no green LEDs installed will install the LEDs through a special project.

One of the participants who said that his jurisdiction will install the LEDs by special project directed the interviewer to the county for more details on the installation process because the county performs all of the maintenance on his jurisdiction's signals. The contact from the county reported that, while he is aware that the municipality ordered green LEDs, he had not seen a work order for the installation. He expressed concern that county maintenance workers would not be available to install the city's LEDs before the deadline: *"They haven't asked us to do anything. I think this is a failure in communication. The jurisdiction may be assuming that we'll include them in our work without a request."* The county representative was concerned about the lack of a formal work order and mentioned it several times during the interview.

Table 39

METHOD FOR GREEN LED INSTALLATION

METHOD OF INSTALLATION	PARTICIPANT STATUS	
	ALREADY INSTALLED (N=4)	YET TO BE INSTALLED (N=10)*
Special Project	1 (25%)	10 (100%)
Routine Maintenance	3 (75%)	0

* *For the purposes of this analysis, the municipality with half of its LEDs installed and half back-ordered is grouped with others that have yet to begin installation.*

Nearly all of the participants had a high awareness of the program deadlines and the need to complete the installation by December 20th. Two participants were typical in explaining that the program deadline necessitated initiating a special project to install the LEDs:

> *"Because of the deadline, this will be a special project."*
>
> *"The special project will be a pretty quick process; they need to be installed by 20th of December."*

Participants from the four municipalities that had completed the LED installation said that the City of Portland has called or emailed them to check on the status of the installation.

Nine of the fifteen participants reported that their jurisdiction had already publicized the green LED installation or would publicize the new LEDs once the installation was complete. Table 40 shows the methods of publicizing reported by the municipalities. Four participants said they would publish a press release once the rebate check has been received. Two participants had already publicized the green LEDs through their city's "Friday Update," a listing of municipal events and news that is circulated among city departments, to the city council, and chamber of commerce.

Table 40

METHOD OF PUBLICIZING

METHOD OF PUBLICIZING	PARTICIPANTS THAT WILL PUBLICIZE (N=9)*
Press Release	4 (44%)
Friday Update	2 (22%)
Photograph in Newspaper	1 (11%)
Presentation to City Commissioners	1 (11%)
Web Site Mention	1 (11%)

* *Percents do not add to 100% due to rounding.*

Several noted that publicity tied to the rebates helps the constituents in their jurisdiction understand that not all of the money for new signals comes from taxes. In the words of one participant:

> *"It's a good thing for the media to share with public that we are getting money to offset the costs to the local taxpayer."*

6. PARTICIPATION IN PROGRAM: MANUFACTURERS AND DISTRIBUTORS

The two distributors' representatives with whom we spoke were aware of the Green LED incentives. None of the manufacturers' sales representatives were aware of the program. The two distributors that are aware handle the sales of two of the manufacturers that were not aware and do not market directly to traffic jurisdictions.

Both distributors' representatives said that they have been involved with marketing the Energy Trust program to their customers. One described sending out a mailer, and encouraging his existing customers to "spread the word" to other jurisdictions. He mentioned that his customer *"Clackamas County helped jump-start the smaller municipalities."* In addition, his company conducted a designated marketing campaign and offered special prices in conjunction with the rebates.

This distributor's representative mentioned one municipality that is conducting a second round of bidding. He related that his company "*won the first bid, until we noticed the specification regarding the array of LEDs in a 12-inch green ball. We couldn't provide that level of LEDs and, the way the spec was written, it could not be a fair, competitive bid. Basically, they were writing the spec around one product."* The representative related that he pointed this out to his contact at the municipality and, *"They rewrote their specifications."*

The other distributor's representative expressed frustration with the process of trying to market his product in Oregon. In his words, *"I've done my time with this program. I've offered a lot [by reducing the profit margin] for people to get off their horses and get their LEDs installed."* In his view, a competing LED manufacturer had offered "ridiculous prices" for a product with performance problems. He continues, *"I've told people that it's not the most dependable product out there but the people in purchasing and procurement don't care about quality. They award the bid on price, the product ends up in the hands of signal maintenance staff and they get bad signals."* The representative continued, *"If the selling period were longer, I'm confident I could get more sales."*[29]

[29] This distributor was named by a program participant at a large jurisdiction as having a "very good reputation for dealing in good products."

All six manufacturers' and distributors' representatives volunteered that they thought the Energy Trust rebate was "great." Table 41 shows that the two distributors' representatives were aware that rebates offered by California utilities were higher. One said that, in some cases, the California Energy Commission awarded money to offset the labor costs of installation in addition to reducing the lamp prices. Says one, *"I don't know exactly how much the Pacific Gas and Electric rebate was last year, but it was enough to get the attention of the whole state."*

Table 41

COMPARISON OF ENERGY TRUST REBATE TO OTHER INCENTIVES

COMPARISON TO OTHER INCENTIVE PROGRAMS IN THE U.S.	MANUFACTURERS AND DISTRIBUTORS (N=6)
California Rebate is Higher	2 (33%)
Trust Rebate is "Huge"	1 (17%)
Not Sure	3 (50%)

7. ASSESSMENT OF PROGRAM EFFECTS

SATURATION OF GREEN LEDS AFTER THE TRUST PROGRAM

Table 42 shows the number of jurisdictions contacted by size/type and the proportion of each type of jurisdiction that participated in the Green LED program. Nearly all of the small cities (cities with populations of between 25,000 and 100,000 people) participated in the Trust program.

Table 42

TYPE OF JURISDICTION CONTACTED AND PROPORTION OF PARTICIPATION

TYPE OF JURISDICTION*	NUMBER	NUMBER PARTICIPATED	PROPORTION OF TYPE THAT PARTICIPATED
Large Cities	1	NA**	NA
Small Cities	8	7	88% (n=8)
Large Municipalities	17	4	24% (n=17)
Small Municipalities	3	1	33% (n=3)
Counties	6	2	33% (n=6)
ODOT Regions	5	1	20% (n=5)

* *Large cities are classified as those with a population of more than 100,000, small cities are those with a population of between 25,000 and 100,00, large municipalities are those with a population of 10,000 to 24,999 (and this includes one jurisdiction with no population per se but 50 traffic signals), and small municipalities are classified as those with a population below 9,999.*[30]

** *This large city attempted to participate and was initially interviewed as a participant. The city dropped out in November, 2002, due to unresolved complications with the bidding process*

[30] Populations of incorporated Oregon cities provided by the League of Oregon Cities, based on Portland State Population Estimates for the year 2000 from the 2000 Census.

Through the Trust's program, 58% of participants' green signals have been converted to green LEDs (Table 43). Through the program, green LEDs have been installed in 38% of the green signals owned by eligible jurisdictions. At the conclusion of the program, 68% of the green signals in the Trust's territory have green LEDs, due to the actions of the Trust, utility LED programs preceding the Trust, and early LED adopters.

In addition to the green LEDs installed through the Trust's program, three participants who had not previously installed any red LEDs are installing a total of 260 of them in conjunction with the green relamping:

- Lake Oswego—installing 50 red LEDs, or 25% of its signals,
- Lebanon—installing 61 red LEDs, or 100% of its signals, and
- Oregon City—installing 149 LEDs, or 100% of its signals.

INFLUENCE OF THE TRUST'S PROGRAM ON LED PURCHASES

Based on the responses of participants and nonparticipants given in Chapter 5, it is unlikely that any of the green LEDs installed through this program would have been installed in the absence of this program. It is doubtful that any green LEDs will be installed without rebates in the state until the current economic downturn and crisis in governmental budgets abate.

Here, we give a brief review of the findings bearing on this issue.

Plans to install green LEDs:

- Two of sixteen participants indicated that they had planned to install green LEDs as part of a "broad effort to conserve energy," but they did not state a timeframe.
- Fourteen of sixteen participants said that prior to the program they had "no plans to install," or "no plans to install until either prices fall or funds become available," or "yes plans to install but are waiting for either prices to fall or funds to become available."
- Three of ten nonparticipants said they have plans to install when prices fall, three have plans to install "over the next three years" or in an unspecified timeframe, and two have plans for new signal heads (for replacement or system expansion) to be LED.

Table 43

SATURATION OF GREEN LEDS AFTER THE PROGRAM

JURISDICTIONS	NUMBER PER JURISDICTION		CUMULATIVE ACROSS JURISDICTIONS		
	GREEN LED LAMPS	GREEN SIGNALS	GREEN LED LAMPS	GREEN SIGNALS	LEDS AS PERCENT OF SIGNALS
Participants with 100% Green LEDs[a]	832	832	832	832	100%
Corvallis	56	75	888	907	98%
Bend	264	296	1,152	1,203	96%
ODOT Region 1	835	982	1,987	2,185	91%
Washington County	385	770	2,372	2,955	80%
Medford	250	840	2,622	3,795	69%
Lake Oswego	50	216	2,672	4,011	67%
Multnomah County	180	920	2,852	4,931	58%
Estimated Penetration of Green LEDs in Participants' Jurisdictions					58%
Interviewed Nonparticipants	0	1,162	2,852	6,093	47%
Noninterviewed ODOT Regionts (2-5)	0	293	2,852	6,386	45%
Noninterviewed Municipalities (Large and Small)[b]	0	729	2,852	7,115	40%
Noninterviewed Counties [c]	0	450	2,852	7,565	38%
Estimated Penetration of Green LEDs among Eligible Jurisdictions					38%
Jurisdictions with Green LEDs Installed Prior to the Program[d]	7,390	7,390	10,242	14,955	68%
Estimated Penetration of Green LEDs in Oregon Regions Served by the Trust					68%

[a] *Albany, Cottage Grove, Klamath Falls, Lebanon, Oregon City, Port of Portland, Tigard, and Wilsonville*

[b] *Number of signals estimated by calculating the average number of people per signal in a jurisdiction based on census data on populations and number of signals reported by interviewed participants and nonparticipants.*

[c] *Assumed to be an average of 150 signals each for Deschutes, Jackson, and Marion Counties. Derived from Lane County—an interviewed nonparticipant—which has approximately 180 signals.*

[d] City of Portland (6,400 signals), Multnomah County (10% of its stock), Clackamas County (about 900).

Requirements for green LED purchases:

- Fifteen of sixteen participants said that they purchased the LEDs at this time because of the rebate.
- Thirteen of sixteen participants and seven of ten nonparticipants said an LED lamp purchase needs (or needed) to be supported by a favorable financial analysis (formal or informal).
- Six of ten nonparticipants said that the price of LEDs and/or their budget constraints prevented them from purchasing LEDs through the Trust's program.

We conclude that no green LED purchases were "in the pipeline." Most jurisdictions were waiting for events beyond their control to change before they would purchase green LED lamps.

PARTICIPANT SATISFACTION WITH AND EXPECTATIONS FOR LEDS

Of the four participants that had installed their green LEDs at the time of the interview, two related their positive experiences. Both observed a change in the on-site electric meter, and one compared differences in the brightness between the LEDs and incandescent bulbs.

> *"As soon as we started putting up the LEDs, I noticed a change. We went from 10-15 amps for the incandescents down to 3 per signal for LEDs. That represents a big chunk of savings."*

> *"As we installed the LED, I stood back and looked at the electric meter. It slowed down quite a bit….Also, the difference between the brightness of the LED and incandescents is amazing. The LED is brighter, more uniform, and you get a full ball of green. I was impressed."*

None of the participants from jurisdictions that had installed green LEDs was able to give an evaluation of the performance of their signals. Each participant said he or she had not had enough time to judge whether the green LEDs were performing as expected.

We asked fourteen participants that had already purchased green LEDs how long they thought their green signals would last. Table 44 shows that the minimum life expectancy is three years and the maximum is ten.

Table 44

EXPECTATION FOR GREEN LED LIFETIME

LIFETIME EXPECTATION IN YEARS	BASED ON EXPERIENCE WITH RED LEDS*	PARTICIPANTS PURCHASING LEDS (N=14)
Three to Five	No	1 (7%)
Five	No	2 (14%)
Five to Seven	Yes	2 (14%)
Five to Ten	Yes	1 (7%)
At Least Six	No	1 (7%)
Seven	Yes	2 (14%)
Seven to Ten	Yes	2 (14%)
Don't Know	No	3 (21%)

* *Each "Yes" answer represents one participant.*

Four participants volunteered that their estimate is based on their experience with red LEDs. All of those who based their estimates on experience with red LEDs assumed that their green LEDs would last between five and ten years, and eight of the fourteen estimates fall within this range. If the green LEDs perform similarly to red LEDs, then the five- to ten-year lifetime estimate may be a reasonable one.

Participants from three jurisdictions expressed some concern about the replacement schedule for their green LEDs. One of the three is anticipating replacing nearly 1,000 red LEDs purchased at nearly the same time five years ago. Another participant remarked, *"We have to be sure we budget for replacement at end of the expected life of the LEDs so we are not hit all at once with unplanned costs. Fortunately, we did not replace the whole system at once."*

FUTURE LED PURCHASES PLANNED

Seven of the eight participants with less than 100% of their signals converted to green LEDs reported that their goal is to convert all of their green signals to LED. Two of the seven said that they would convert all of their reds and greens but none of their existing yellow signals, as the potential energy savings from yellow lights is small.

Two participants from large jurisdictions said that they planned to evaluate each intersection in their jurisdiction to determine where the red and green LEDs would provide the greatest energy savings. Each participant described an analysis that takes into account traffic flow, type of signal (e.g., 12-inch ball, 8-inch ball, arrows, etc.), the age of existing signals, and duty cycle as factors in their decision-making about how to proceed with purchasing LEDs in the future.

Seven of the nonparticipants reported that they planned to convert all of their green signals to LEDs "eventually."

Interest in Future LED Rebate Program

Eleven of the fifteen participants said that they would purchase more green LEDs if the Energy Trust continued the program (Table 45). Three jurisdictions indicated they would purchase 500 or more lamps.

Table 45

ESTIMATES OF GREEN LEDS RESPONDENT WOULD PURCHASE IF OFFERED REBATES

ESTIMATES OF GREEN LEDS	PARTICIPANTS WILLING TO PURCHASE MORE GREEN LEDS (N=11)	NONPARTICIPANTS WILLING TO PURCHASE MORE GREEN LEDS (N= 10)
49 or Fewer	4 (36%)	0
50-100	3 (27%)	0
100-500	1 (9%)	0
500 or More	3 (27%)	0
Unspecified	0	6 (60%)

The participant from the largest jurisdiction quantified the number he would need for one sub-region of his jurisdiction and then added that he anticipated "additional funding in 2004" for LED retrofitting in another large sub-region in his jurisdiction. He added, *"Through the statewide traffic improvement program, I've asked for $250,000 but think we will get at least $180,000 to replace red LEDs and purchase greens."* He did not divide this dollar amount into the number of red or green LEDs he planned to purchase nor did he mention how much would be allocated for labor.

Table 46 shows that five of the eleven respondents who are willing to purchase more green LEDs were the Trust to continue to offer rebates will have converted 100% of their signals to LEDs at the conclusion of the current program. These respondents, then, would be purchasing replacement lamps. The four jurisdictions with less than 50% saturation of green LEDs at the conclusion of the program are large, including the two largest participants.

Table 46

SATURATION OF GREEN LEDS AMONG PARTICIPANTS WILLING TO PURCHASE MORE REBATED LEDS

PROPORTION OF GREEN LEDS INSTALLED AT CONCLUSION OF TRUST PROGRAM	PARTICIPANTS (N=11)
Less than 25%	3 (27%)
50%	1 (9%)
75%	1 (9%)
85%	1 (9%)
100%	5 (45%)

Six of the ten nonparticipants said they would consider purchasing green LEDs in the future with an incentive such as the Energy Trust's Green LED program. None of the six named a quantity they thought they would purchase.

Participants were enthusiastic about the idea of purchasing red LEDs were the Trust to offer an incentive program. Table 47 shows that few were able to provide estimates of the number of red LEDs they would buy, in part because of uncertainty

about purchasing requirements for the red LEDs. Several stipulated that if a future red LED purchasing program included replacements, they would buy "some."

Table 47

ESTIMATES OF RED LEDS RESPONDENTS WOULD PURCHASE IF OFFERED REBATES

ESTIMATE OF RED LEDS	PARTICIPANTS (N=15)	NONPARTICIPANTS (N=10)
Unspecified	11 (73%)	3 (30%)
10 or Fewer	2 (13%)	0
30	1 (6%)	0
75	1 (6%)	0
Not Sure If Would Purchase	0	7 (70%)

Three of the nonparticipants said they would purchase red LEDs if the Trust were to offer an incentive. None of the three was able to quantify the number of red LEDs they would purchase.

All of the participants who said they would buy either red or green LEDs in the future if an incentive were available said that a multi-year program was more desirable than a one- or two-year program. Participants from the large jurisdictions (where smaller proportions of the total number of signals have been converted) would prefer to have a multi-year incentive program to help them achieve their goal of converting 100% of their signals to LEDs. The comments of two participants from large jurisdictions follow:

> *"It would be easier for my jurisdiction to schedule our funding if the Energy Trust program were a multi-year program. Over the next two to three years our funding will be limited but if we had a way of reducing costs for scheduled purchases (as opposed to a one-time large purchase), it would be to our budget advantage."*

> *"It would give us greater confidence if we knew an Energy Trust program was going to be a multi-year program. If we knew a program would continue for more than one year we might allocate enough*

money for 100 new retrofits and save other funds for 50 replacement units. If we thought the money would only available for one year, maybe we would do all 150 as new retrofits and then deal with replacements on a crisis basis. By having a one-year program there is no assurance that the funding will continue. We could be in a situation where we are pushing the life of old units beyond where we should."

Nonparticipants also favored a multi-year program, especially those in larger jurisdictions with more signals to convert.

Interest in Yellow LEDs and Other Applications

Most of the fifteen participants were not interested in purchasing traffic signals with yellow balls (Table 48). Two of those who did not want to purchase a signal with a yellow ball explained that, due to the short run time of the yellow, its average load is too small to justify converting it to an LED. Said one, *"We can't justify paying for them because they're only on for three seconds."*

Table 48

INTEREST IN PURCHASING TRAFFIC SIGNALS WITH YELLOW LEDS

INTEREST IN TRAFFIC SIGNALS WITH YELLOW LEDS	PARTICIPANTS (N=15)	NONPARTICIPANTS (N=6)*
Yes	3 (20%)	2 (33%)
No	12 (80%)	4 (67%)

* *Due to time constraints, not all nonparticipants were asked about their interest in yellow signals.*

We asked six nonparticipants about their interest in yellow signals. Four of the six doubted that a payback analysis performed on yellow LEDs would indicate that they were worth the investment. Two jurisdictions, with large rural areas, however, were willing to consider yellow LEDs in their flashing signals. One explained that the reduced maintenance requirements of a yellow LED bulb made it attractive because it reduced the amount of time an electrical crew had to spend simply driving to the signal to change the bulb. He elaborated:

> *"We are waiting for the amber LEDs to be on qualified product list. We find they last longer. Ambers are on overhead flashers in rural sections. It can take a crew two hours to drive to one of the flashers, then replace a bulb and drive two hours back."*

Six of the participants said that they have converted their pedestrian "orange hand 'Don't Walk'" signals to LED bulbs (Table 49). Five have plans to convert their "Don't Walk" signals to LEDs, but say that the timing of the project is "a matter of priorities and dollars." One participant said that the "old style hand" in his pedestrian signals was not configured for LEDs; he continued, "*About two years ago I bought retrofit kits for them.*"

Table 49

STATUS OF LED PEDESTRIAN SIGNAL LIGHTS INSTALLED

STATUS OF LED PEDESTRIAN SIGNALS INSTALLED	PARTICIPANTS (N=14)*	NONPARTICIPANTS (N=6)**
Have Converted All or Most Signals	6 (40%)	2 (33%)
Plan to Convert All Signals	5 (33%)	1 (17%)
Will Not Convert Signals	3 (21%)	0
Not Sure	0	3 (50%)

* *One jurisdiction does not have any pedestrian signals.*

** *Due to time constraints, not all nonparticipants were asked about other applications.*

As is the case with yellow balls, some participants said that the duty cycle of the "Walking Man" signal is too short to consider replacing the incandescent bulbs with LEDs. All of the participants said that lighted rail applications are not in their jurisdiction.[31]

[31] This is supported by the manufacturers' sales representatives who make a distinction between the LEDs they sell to traffic jurisdictions and those they sell to the rail industry. (See Table 49.)

Two of the nonparticipants say that "all" or "most" of their pedestrian "Don't Walk" signals have been converted to LEDs. A nonparticipant from a small jurisdiction said that his department "would consider" installing LEDs in pedestrian signals.

One of the nonparticipants was interested in LEDs for applications other than traffic and pedestrian signals. This nonparticipant said that he had already installed LEDs in *"hard to reach places such as on top of bridges, in aviation signals, and in river navigation channels."* He said he would be interested in LEDs for replacement purposes.

8. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The Trust solicited this evaluation to answer a number of questions, which it expressed in the project initiation meeting. In addition, some assessment questions were inferred from a review of program documents.

1. Did the Trust's Green LED Program Promote Market Transformation?

At the conclusion of the program, approximately two-thirds of the green traffic signals in the Trust's service territory are LEDs. This level of efficient-product saturation is considered within the efficiency profession to indicate a transformed market.

Although the LEDs of the City of Portland—which acted prior to the Trust's program—constitute over 60% of all installed LEDs, it is only through the actions of the Trust that LEDs have spread throughout its service territory. The Trust reached the largest ODOT region, which is responsible for 77% of ODOT's green traffic signals. It reached seven of eight eligible cities, two of six eligible counties, and 25% of the smaller eligible jurisdictions.

Thus, LED installations are primed for the rest of the service territory. One manufacturer's representative described the pattern of LED adoption in a region: "The smaller towns follow the state or city. The city will do a big project and then smaller towns will purchase them."

The document authorizing the program suggested that the program might further market transformation by increasing the demand for LEDs and thereby lowering the price. The program quantity was too small, however, to influence manufacturer's output and prices. The program did induce one distributor to lower its prices and both distributors to aggressively market their products during the program period.

2. Would Program Participants Have Purchased LEDs in the Absence of the Program?

We found no evidence to suggest that participants would have purchased LEDs without the incentive in 2002, nor as long as the recession and public funding crisis persists.

Had the program been operating at a time of economic prosperity, it is likely that some jurisdictions would have purchased green LEDs on their own. About half of the jurisdictions with red LEDs had purchased them without a rebate. However, the price for green LEDs continues to be higher than the price for red. We extrapolate from these facts that fewer than half of the participants would have acted on their own during prosperous times at today's green LED prices.

The Trust document authorizing the expansion of the program hypothesized that participants in the latter months of the program might be more in need of incentives than those in the first month. The unstated assumption appears to be jurisdictions that acted quickly likely were planning to purchase LEDs on their own. We found no differences between early and later participants; we believe neither group would have purchased the LEDs in the absence of the program.

3. How Appropriate Was the Program Size?

The final program size of 3,000 is well suited to the market. Nearly all of the jurisdictions in the service territory that were in a position to act received rebates. One jurisdiction submitted its application the day after the funds were exhausted, and another jurisdiction needed to withdraw its application. The latter jurisdiction will purchase green LEDs on its own. It will purchase the number of lamps equivalent to its intended outlay under the program (i.e., fewer than its program request).

Three of ten interviewed nonparticipants indicated that they had installed or ordered a few green LEDs to try them out. Thus, they will obtain experience without the Trust's intervention. One participant said that a rebate was not an advantage for his large jurisdiction, as the rebate check would be deposited into a general fund and would not offset his costs.

4. Did the Program's Size Limit Generate Dissatisfaction Among Jurisdictions?

We found no indication that jurisdictions were dissatisfied with the program's size limit.

5. Did Using the City of Portland Office of Sustainability to Implement the Program Enhance Its Operations? Were There Any Drawbacks?

Participants reported that the program process and communication was clear and easy. They reported that program implementation manager kept them well informed about the program progress and provided them with information useful in making their decisions regarding participation and lamp purchase. They respected his experience and judged him to be responsive to their needs. Several participants said that it was the repeated, friendly prompting by the program manager that resulted in their application. No participants or nonparticipants voiced any concerns or criticism of the City's role.

The City of Portland had also received money from the Northwest Energy Efficiency Alliance to promote the City's efficiency activities throughout the region. The synergy of the Trust's funding, the Alliance's funding, and the City's experience and capabilities contributed to the success of the Green LED program.

6. Was the Process Easy for Participants?

Participants expressed the view that it was very easy to participate in the program. Two large jurisdictions said that they had known that PGE was offering incentives for LED traffic lights and they had considered applying for them. They "reconsidered," however, when they saw how easy the Trust process would be. They emphasized that they found the program to be "much easier" than the processes they had previously experienced in getting rebates from PGE.

7. Why Didn't Nonparticipants Participate?

The general reason for nonparticipation appears to be the decision-making process in these jurisdictions and the job responsibilities of the public works staff that the program manager informed about the program. Whereas most participants consulted with one other staff person about the program, most nonparticipants consulted with two or three other staff members. Whereas five of sixteen participants were not able to answer some of the technical questions we posed for the evaluation (and thus referred us to another staff person), none of the ten nonparticipants were able to answer these questions. Half of the nonparticipants reported that another jurisdiction performs the maintenance and purchases equipment for their jurisdiction.

Six of ten interviewed nonparticipants said that they lacked the money necessary to pay for LED lamps at this time, even at the reduced price that resulted from the rebate.

Some nonparticipants seemed to have formed a misunderstanding of the program. Two nonparticipants said that the process needed to be easier. Given the experiences of the participants, we interpret these comments as those made after the fact by respondents trying to reconstruct the reasons for their nonparticipation.

Two nonparticipants said that they would need more data on the payback, repair, and replacement of LEDs before they would purchase any. We assume that either these respondents overlooked information that the implementation manager provided, or they did not take the initiative and ask the manager for additional information, as many participants did.

Four nonparticipants said that they had made the decision not to participate after having obtained the advice of their electrical crew supervisors. Unfortunately, we did not probe whether the advice turned on such things as the timing, staff resources available, and so on or whether the crew supervisors did not like the LED technology.

We conclude that their organizational structures, their arrangements with other traffic jurisdictions, their misunderstanding or lack of understanding of LEDs or the Trust's program, and/or their budgets make their purchase of LED lamps unlikely.

8. Were the Lamps Installed As Part of Routine Maintenance?

Most respondents were installing the LEDs through a special project. It appears that the lack of advance notice about the program and the short program duration made it difficult for participants to coordinate LED installation with their standard maintenance schedule. Thus, the timing of the program led to higher participant costs (higher installation costs) than anticipated.

RECOMMENDATIONS

1. The Trust should feel free to use the City of Portland Office of Sustainable Development as implementation manager of efficiency programs related to its experience.

Participants' had only positive things to say about the implementation manager and the program process. The City's experience with LEDs and as a participant in efficiency programs was an asset to the LED program implementation.

2. When equity within the region is important, small jurisdictions should be targeted with tailored marketing and assistance.

While one might expect their decision process to be simpler, it appeared that smaller jurisdictions had a more complex decision process than larger ones. More people were brought into the decision, technical information was scattered among people, lack of information or misunderstanding existed, and multiple agencies were involved. To reach small jurisdictions, the Trust should consider direct, in-person contact with all of the decision makers, where everyone's questions could be addressed.

3. Provide the market with advance notice of a program so that potential participants can budget for their required expenses.

Large programs should run for more than one year, to assist participants in budgeting and to allow for staggered purchases.

4. The Trust should be aware that small discrepancies were found in this evaluation between lamp purchases and reported numbers of traffic signals.

This evaluation found no evidence of any misuse of program funds. However, as part of this evaluation, we asked participants the number of green traffic signals they have and the proportion of signals that will have LEDs at the conclusion of the program. To this we added information on quantity purchased through the program by each participant. Despite our attempts at clarity, there appeared to be some confusion in the data as to whether a reported number was the number of signals or the number of intersections. Using our best judgments, there remained some small discrepancies among total signals, purchased lamps, and proportion of signals

converted. While there is no cause for alarm or indeed any concern of wrongdoing, the Trust might want to consider investigating this issue further.

APPENDIX

Survey Instruments

Appendix

GREEN LED SIGNAL LIGHTS PROGRAM EVALUATION
PARTICIPANT SURVEY

REVISION 10/29/02

We would like to talk with you about your experience with green LED signal lights and the incentive program offered by the Energy Trust of Oregon and administered by the City of Portland's Office of Sustainability.

Questions about Signal Lamp Stock and Flow

1. Do you have an estimate of about how many traffic signals you have?

2. About what proportion of your total green signals will have LED lamps when the ETO installation is complete? *[Try to get a proportion, but OK to accept "a lot" or "a little" if that's as close as they can estimate]*

3. About how many new signals do you add each year, or expect to add in the coming year?

4. How many green incandescent lamps do you replace in an average year *[what proportion, %]*?

5. Do you do replace these on a schedule or as they burn out?

6. What backlog of lamps do you keep?

   How many months of installations can you do from your storehouse?

7. When do you purchase replacement lamps (e.g., tied to budget cycle or equipment lifetime)?

8. What distributor do you currently use for your incandescent lamps?

   Does this distributor offer LED lamps?

   Do you know the manufacturer of your incandescent lamps? Who?

   Does this manufacturer offer LED lamps?

Questions about Awareness of and Prior Experience with LEDs

Our next questions concern your experience with LED signal lights prior to participating in the Energy Trust's program.

1. When did you first become aware that LED lamps were commercially available for signal lights? *[Probe: red LEDs, green LEDs]*

   [If "Curt"-> skip to next section]

2. Does your jurisdiction have any red LED signal lamps purchased or installed? *[Do not read, but note: red signal retrofits are being done as part of the green signal relamping projects in Oregon City and Lebanon.] [If no, skip to Q3]*

   [If yes:]

   When did you first purchase red LEDs?

   Did you receive an incentive for installing them?

   [If yes:]

   Who offered the rebate?

   Have you gone on to purchase any others without an incentive?

   [If yes:]

   Do you recall the approximate price per lamp?

   [If no:]

   What led you to decide to install the red LEDs?

Have you had any problems with the red LEDs?

3. Have you purchased or installed any green LED signal lights prior to the program with the Energy Trust?

   [If yes:]

   When did you first purchase green LEDs?

   Did you receive an incentive for installing them?

   [If yes:]

   Who offered the rebate?

   [If no:]

   What led you to install the green LEDs?

4. What were your thoughts about getting LEDs for your jurisdiction—what did you see as the pros and cons? *[For those who have not purchased]*

5. Prior to your contact with Curt about the LED program, what sort of plans did you have for LEDs—were you planning on trying them out, waiting for some slack in the budget, or…

   [If not mentioned:]

   Were you aware that PGE/PPL offered rebates for LED lamps?

   [If yes:]

   Were you planning on participating in the utility program?

6. Before participating in this program had you installed or did you have plans to install LEDs in any other applications? *(exs: pedestrian crossing, RR crossing, message sings, fire stations, truck scales, loading docks)*

7. Do you expect to see a savings on you utility bill for traffic lights?

Questions about Contact with the City

1. So what did Curt tell you about the green LEDs—anything you didn't already know? *[Drop the last phrase if they first learned of LEDs from Curt]*

2. What things did you consider in making your decision to participate in the program?

   Were there any objections to or concerns about the LEDs?

   How did you overcome these objections?

   Why did you decide to go ahead at this time?

3. Were others besides yourself involved in your decision-making?

   Who?

4. Was Curt helpful in your decision-making?

   What contact did you have with Curt after he first spoke to you about the program?

5. Can you describe for me the steps you had to go through to participate in the program, and comment on any difficulties you encountered or questions you had about the process? *[Do not read: initial application completion; submittal of installation documentation; submittal of invoices; receipt of incentive check; general paperwork and process]*

   Was a press release issued?

   Who prepared the press release?

6. Have you worked with Curt or the City of Portland on any other energy projects?

   [If yes:]

   Did that affect your willingness to participate in the LED project?

7. [If not clear:]

   Did you get a rebate from PGE/PPL for other LED lamp purchases?

   [If yes:]

   Did Curt direct you to their program?

   What types of lamps did you get rebates for?

   How many lamps?

Questions about the Technology and Manufacturer

1. Did you have requirements for the lamps that went beyond the specifications set by the Institute of Transportation Engineers?

   What were they?

2. What manufacturer did you go with? *[get contact name and phone number if possible]*

3. How did you select the manufacturer you wanted to purchase from?

   Did that manufacture's product fully meet your specifications, or did you need to revise your thinking about what you needed?

4. Did you work with a distributor, separate from the manufacturer?

   [If yes:]

   Who? *[get contact name and phone number is possible]*

   How did you find and select the distributor?

5. Was the distributor/manufacturer able to fill your order right away, or was it back-ordered?

6. Did you purchase screw-in or hardwired lamps?

   What was your thinking behind that decision?

7. Was Curt involved in your process to select the lamp or the manufacturer (or the distributor)?

8. Have the lamps met your expectations?

   Any problems with lamp performance?

9. Are you aware of any LEDs with the ENERGY STAR® label ?

Questions about Purchase and Installation Process

1. Do the LED purchases come out of capital or operating expenses?

2. When did you install the LEDs you purchased through the program—during routine maintenance on the incandescent lights? by special project? To replace burned out incandescents? Or into new signal lights?

3. Do you have a schedule by which you routinely replace the incandescents toward the end of their expected life?

   [If yes:]

   How often is that?

4. Have you encountered any difficulties in installing the lamps?

   Was any training needed for your staff to install them?

   Are the installation costs what you anticipated?

   Has lack of labor availability slowed your plans to install them?

5. Have you ordered all of the lamps that you reserved through the Trust?

   [If not:]

   Why not?

   How many have you purchased?

   Will you complete the total number you requested in your initial application?

   When?

6. Have you installed all of the lamps that you purchased?

   [If not:]

   Why not?

   How many have you installed?

   Will you complete the total number you requested in your initial application?

   When?

7. Has Curt or anyone else representing the program called to check on your progress with the installations?

   To your knowledge, has anyone from the program checked on the installations themselves?

8. How long do you think the green LEDs will last?

   What replacement schedule do you have planned?

Plans

1. Do you have plans for installing additional green LED signal lamps?

   How many?

   For installing red LED lamps?

   How many?

   Do you have any interest in installing the 3-color LED signals?

   [If yes to any of the above]

   At what rate do you plan to install the lamps?

   Will they be used as the replacement lamps when you need to replace existing incandescents [after using up current inventory], or will you go more slowly than that [still plan to purchase incandescents] or more quickly than this?

   Do you have a goal for the proportion of the signal lamps that you would like to convert?

2. Do you have plans to install LED walk lights?

3. Does any one else at your agency need to be convinced in order to continue adding LED lamps?

   What will it take to convince them it's a good investment?

   What other conditions will have to be met?

   Would the purchases come out of operating or capital budgets?

   Is there a pay-back criterion or other financial criteria to be met?

4. If the Energy Trust continued to offer incentives for green lamps, would you purchase more?

   [If yes:]

   About how many more?

   Would you purchase some each year, if the Trust ran a multi-year program?

5. How about if the Trust offered incentives for red lamps?

   [If yes:]

   About how many more?

   Would you purchase some each year, if the Trust ran a multi-year program?

6. This year, did you want to buy more lamps than the Trust was able to fund with incentives?

   [If yes:]

   Did the Trust's limit on the program size create any problems for you?

   Did you go ahead and buy any lamps without an incentive?

   How many?

7. Now that you've installed the green light LEDs, are you considering installing LEDs in any other applications? *(exs: pedestrian crossing, RR crossing, message signs, fire stations, truck scales, loading docks)*

Closing Feedback

1. What overall feedback can you provide about the program to the Energy Trust?

   What worked well about the program?

   Were there any problems?

2. Were there any advantages that you saw to having the City of Portland administer the project?

   Were there any disadvantages?

   How well do you think the City did its job on this?

3. Are there any changes you would like to see for future programs (for signal lamps or for any technology)?

GREEN LED SIGNAL LIGHTS PROGRAM EVALUATION
NONPARTICIPANT INTERVIEW

REVISION 11/9/02

I have been hired by the Energy Trust of Oregon. We would like to talk with you about your experience with green LED traffic signal lights and the incentive program offered by the Energy Trust of Oregon. I understand Curt Nichols of the City of Portland's Office of Sustainability contacted you about this program last May. [or this past summer].

Questions about Signal Lamp Stock and Flow

1. Do you have an estimate of about how many traffic signals you have?

2. About how many new signals do you add each year, or expect to add in the coming year?

3. How many green incandescent lamps do you replace in an average year *[what proportion, %]*?

4. Do you do replace these on a schedule or as they burn out?

5. What backlog of lamps do you keep?

   How many months of installations can you do from your storehouse?

6. When do you purchase replacement lamps (e.g., tied to budget cycle or equipment lifetime)?

7. What distributor do you currently use for your incandescent lamps?

   To your knowledge, does this distributor offer LED lamps?

   Do you know the manufacturer of your incandescent lamps?

      Who?

   To your knowledge, does this manufacturer offer LED lamps?

Questions about Awareness of and Experience with LEDs

1. When did you first become aware that LED lamps were commercially available for signal lights? *[Probe: red LEDs, green LEDs]*

2. Does your jurisdiction have any red LED signal lamps purchased or installed?

   [If no, skip to Q3]

   [If yes:]

      How many (or what proportion)?

3. When did you first purchase red LEDs?

   Did you receive an incentive for installing them?

      [If yes:]

         Who offered the rebate?

         Have you gone on to purchase any others without an incentive?

            [If yes:]

               Do you recall the approximate price per lamp?

      [If no:]

         What led you to decide to install the red LEDs?

Have you had any problems with the red LEDs?

4. Have you purchased or installed any green LED signal lights?

   [If yes:]

   How many?

   When did you first purchase green LEDs?

   Did you receive an incentive for installing them?

   [If yes:]

   Who offered the rebate?

   Have you gone on to purchase any others without an incentive?

   [If yes:]

   Do you recall the approximate price per lamp?

   [If no:]

   What led you to install the green LEDs

5. What were your thoughts about getting LEDs for your jurisdiction—what did you see as the pros and cons?

6. Do you expect to see a savings on you utility bill for LED traffic lights?

[For those who have not purchased]

7. Have you had any plans to purchase or install LEDs—are you planning to try them out, waiting for some slack in the budget, or...

   [If not mentioned:]

   Were you aware that PGE/PPL offered rebates for LED lamps?

8. Do you have plans to install LEDs in any other applications? *(exs: pedestrian crossing, RR crossing, message sings, fire stations, truck scales, loading docks)*

Questions about Contact with the City

1. So, what information did Curt Nichols give you about the Green LED Program?

2. What things did you consider in making the decision whether to participate in the program?

   Were there any objections to or concerns about the LEDs?

   Was anyone besides yourself involved in the decision-making?

3. Why did you decide not to go ahead at this time?

4. Were there any questions you had about the process, or any challenges you saw that difficult to participate?

5. Have you worked with Curt or the City of Portland on any other energy projects?

   [If yes:]

   Did that affect your willingness to participate in the LED project?

Plans

1. Do you have plans for installing [additional] green LED signal lamps?

   [If yes:]

   How many?

   For installing red LED lamps?

[If yes:]

How many?

Do you have any interest in installing the 3-color LED signals?

[If yes to any of the above]

At what rate do you plan to install the lamps?

Will they be used as the replacement lamps when you need to replace existing incandescents (after using up current inventory), or will you go more slowly than that (still plan to purchase incandescents) or more quickly than this?

Do you have a goal for the proportion of the signal lamps that you would like to convert?

2. Do you have plans to install LED walk lights?

3. Does any one else at your agency need to be convinced in order to continue adding LED lamps?

   What will it take to convince them it's a good investment?

   What other conditions will have to be met?

   Would the purchases come out of operating or capital budgets?

   Is there a pay-back criterion or other financial criteria to be met?

4. If the Energy Trust continued to offer incentives for green lamps, would you purchase more?

   [If yes:]

   About how many more?

   Would you purchase some each year, if the Trust ran a multi-year program?

5. How about if the Trust offered incentives for red lamps?

   [If yes:]

   About how many more?

   Would you purchase some each year, if the Trust ran a multi-year program?

6. Would you like to offer any closing comments on the program that might be useful to the Trust?

GREEN LED SIGNAL LIGHTS PROGRAM EVALUATION
LED DISTRIBUTOR SURVEY

REVISION //02

1. What manufacturer's LEDs do you carry?

   Do you distribute products for any other manufacturers?

   Do you supply incandescent lights for traffic signals?

   Who do you typically deal with most directly in your sale of LEDs traffic signals: purchasing departments or the traffic jurisdictions themselves?

   What geographic area do you serve?

      Are you part of a national company?

2. What other LED products do you carry?

   Of your LED products, what proportion of your revenues comes from green LED traffic signals?

   Do you manufacturer non-LED products?

      [If yes:]

         What proportion of your revenues are from LED products?

3. When did you first start carrying LED traffic signals (presumably red)?

   How about green?

   How rapidly have you expanded the number of green traffic LEDs that you hold in stock or purchase from the manufacturer*? [Perhaps some look at volume by year]*

To what do you attribute the expansion in volume?

--Changes in price

--Changes in demand

--West Coast energy crisis

--Some other energy issue

Do you foresee any similar conditions (whatever respondent named) affecting production levels in the next 2 years or so?

4. Demand:

In which states or areas of the country has demand for green traffic LEDs increased (the most)?

What factors are driving demand?

What role have utility and energy agency incentive programs for green LEDs played in increasing demand?

What rate of growth do you project for green traffic signal LEDs (in the nation)?

Do you have any thoughts about how the current output capacity of the industry compares with projected demands?

Do you think you will encounter any periods where you can't get enough to fill your orders?

5. Prices:

What were your average prices for green LEDs (for traffic signals) when you first offered them?

What are your average prices now?

What has led to the price decreases?

What do you predict for prices over the next 2 years?

Will they continue to fall?

When will they level out?

Any prediction of price at that point?

6. Market Saturation:

   Do you track sales of traffic signal incandescents?

   Do you have any estimates of the saturation of green LEDs = the proportion of the signal market that LEDs sell to?

   --Nationally

   --California

   --Oregon

   How about the saturation of red traffic signal LEDs?

7. Are you aware that the Energy Trust of Oregon offered $60 incentives per green LED installed this past year?

   What do you think about the level of incentive offered?

   [If the firm does business outside of Oregon]

   Do you have any sense of how the incentive compares with those given by utilities and energy agencies elsewhere?

   How does the size of the program (3,000 lamps for metropolitan Portland and surrounds) compare with those given by utilities and energy agencies elsewhere?

   That is, is such a program even on your "radar screen"?

8. Involvement with the Program:

   Did you respond to the program in Oregon in any way (what)?

   --Increasing your marketing efforts in Oregon

   --By calling contacts, etc.

   Did you help customers to figure out their needs?

   --Number/type of lamps

   --Estimating the savings, etc.

   Were you prepared to meet the demand generated by the program?

   --Have access to all the stock you needed?

   How did the demand of 3,000 lamps in about 6 months (the last half of 2002) compare with the rest of your sales of green LEDs during that period?

   What effect do you expect that the Energy Trust's program will have on the market for green LEDs in Oregon?

9. Do you think that jurisdictions that install LEDs through an incentive program will continue to install them after the program ends?

   --Continue to convert their incandescent stock

   --Replace LEDs with LEDs at the end of their life

10. How long do you think it will take until the most of the green traffic signals sold in the Oregon will be LED?

    What needs to happen to get the market to that point—that most signals are LED?

GREEN LED SIGNAL LIGHTS PROGRAM EVALUATION
LED MANUFACTURER SURVEY

REVISION //02

1. Do any distributors in Oregon or Washington carry your green LEDs?

   Who?

   Do those distributors carry your products exclusively, or carry the products of a number of manufacturers?

   [If many manufacturers:]

   > Do you know if your distributors carry LED products, or are they also carrying incandescents?

   Do you sell green LEDs directly to traffic jurisdictions?

2. What other LED products do you manufacture?

   Of your LED products, what proportion of your revenues comes from green LED traffic signals?

   Do you manufacturer non-LED products?

   > [If yes:]
   >
   > > What proportion of your revenues is from LED products?

3. When did you first start manufacturing green LED traffic signals?

   How rapidly has production expanded since then? *[Perhaps some look at volume by year]*

To what do you attribute the expansion in volume produced?

--Changes in production process/ changes in green traffic signal technology

--Changes in price

--Changes in demand

--West Coast energy crisis

--Some other energy issue

Do you foresee any similar conditions (whatever respondent named) affecting production levels in the next 2 years or so?

4. Demand:

In which states or areas of the country has demand increased (the most)?

What factors are driving demand?

What role have utility and energy agency incentive programs for green LEDs played in increasing demand?

What rate of growth do you project for green traffic signal LEDs (in the nation)?

How does the current output capacity of the industry compare with projected demands?

5. Prices:

What were your average prices for green LEDs (for traffic signals) when you first offered them?

What are your average prices now?

What has led to the price decreases?

What do you predict for prices over the next 2 years?

Will they continue to fall?

When will they level out?

Any prediction of price at that point?

6. Market Saturation:

   Do you track sales of traffic signal incandescents?

   Do you have any estimates of the saturation of green LEDs = the proportion of the signal market that LEDs sell to?

   --Nationally

   --California

   --Oregon

   How about the saturation of red traffic signal LEDs?

7. Are you aware that the Energy Trust of Oregon offered $60 incentives per green LED installed this past year?

   What do you think about the level of incentive offered?

   How does the incentive compare with those given by utilities and energy agencies elsewhere?

   How does the size of the program (3,000 lamps for metropolitan Portland and surrounds) compare with those given by utilities and energy agencies elsewhere? That is, is such a program even on your "radar screen"?

8. Involvement with the Program:

   Did you respond to the program in Oregon in any way (what)?

   --Increasing your marketing efforts in Oregon

   --By calling contacts, etc.

Did you help customers to figure out their needs?

--Number/type of lamps

--Estimating the savings, etc.

Did your distributors contact you for more stock?

Were you prepared to meet the demand generated by the program?

--Need to backorder stock?

How did the demand of 3,000 lamps in about 6 months (the last half of 2002) compare with the rest of your sales during that period?

What effect do you expect that the Energy Trust's program will have on the market for green LEDs in Oregon?

9. Do you think that jurisdictions that install LEDs through an incentive program will continue to install them after the program ends?

--Continue to convert their incandescent stock

--Replace LEDs with LEDs at the end of their life

How long do you think it will take until the most of the green traffic signals sold in the Northwest will be LED?

What needs to happen to get the market to that point—that most signals are LED?

GREEN LED SIGNAL LIGHTS PROGRAM EVALUATION
LED IMPLEMENTATION SURVEY

REVISION 10/23/02

Questions about City's Experience with Traffic LEDs

1. Can you briefly recap for us the City of Portland's experience with LED traffic signals—both red and green?

   When were reds first installed?

   When green?

   What proportion of the City's signals have been done?

   Were they installed during scheduled maintenance, or as a retrofit?

   What type were installed—screw-in or hard wired?

   What manufacturers and distributors were used?

   Did the City set its own specifications for the LEDs?

   Did the City encounter any difficulties?

   Did the City receive an incentive for the LEDs from PGE/Pacific?

   Is the energy used by the signals metered and billed to the City, or is there a flat fee per signal or some other type of billing arrangement?

   Did you have any involvement with the LED installation?

   Did you draw on the City's experience in your work as program implementer?

2. How did it happen that the City came to be the implementation contractor for the Energy Trust for the green LED program?

   Who initiated contact?

Did you submit a formal proposal?

Questions about City's Experience with State's Traffic Agencies

1. Prior to implementing the green LED program, what contact had you or the City had with the people who are responsible for traffic lights in the various locales and agencies?

   How did you go about finding the right contact person?

   How did you initiate contact with them—what was your first contact with them regarding the program?

2. Were there some agencies that were immediately interested in the program?

   Why do you suppose they were so ready to take advantage of the program?

3. Are there some agencies that have never expressed interest?

   Why do you suppose the program has not interested them?

   What needs to happen for them to be interested in LEDs?

Questions about Program Implementation Activities

1. In proposing to implement the program for the Trust, what did you anticipate would be the necessary activities?

2. Have these, in fact, been the activities you conducted?

   Have you done anything that you didn't anticipate—or didn't anticipate how long it would take?

   Have you not needed to do something you had thought would be necessary—or needed less time?

Let's go through the steps/activities:

3. What type of contact have you had with potential participants and participants?

   What sort of information did potential participants need?

   What were the objections raised to LEDs or to participating in the program at this time?

   What information/arguments did they find most persuasive?

   How much contact have you typically had with agencies to get someone to agree to participate?

   How does the type/amount of contact compare with what you had anticipated?

4. How have the utility LED programs dovetailed with the Trust's program?

   [Curt directed the agencies to the place to go to get the most rebate. The utils were told by ETO not to market their LED pgm, b/c ETO did not have money to fund it. Utils were told to be in a "full responsive mode"—to respond to customers but not promote to them.]

   Did the City receive funding from other sources [NEEA]? How was that money used?

   [The City got NEEA money for LEDs as well. Curt said this money paid for marketing to groups and the ETO money paid for one-on-one and closing the deal]

5. Has ODOT been a significant player in this program?

   Did you target ODOT for any special marketing/contact?

   How successful have you been in getting ODOT's participation?

   Have other jurisdictions been influenced by the fact that ODOT has participated?

   Has ODOT set technical specifications for green signal LEDs?

6. What type of technical support have you provided to participants?

   --Help selecting a manufacturer and distributor

   --Finding an internal funding source or making an internal proposal

   --Determining the locations/numbers of LEDs they wanted to install—focus on replacements made during normal maintenance activities

   --Understanding the Trust's program and PGE/PPL's programs

   Have you had any direct contact with manufacturers or distributors?

   About what?

   Typically, how much time has this taken?

   Is this support/time what you had anticipated?

7. Have any of the agencies developed their own specifications for the LEDs?

   Have they used specifications developed by the City of Portland or ODOT [if there were any]?

   Have they relied simply on the ITE specs?

8. What type of support and how much support has been required to help participants submit applications, documentation, and invoices?

   What types of problems arose?

   Is this type/quantity of support what you had anticipated?

9. Have you conducted any spot inspections?

   Where? *[2-3 largest jurisdictions]*

   What have they involved?

10. What type of contact and how much contact have you had with the Energy Trust?

    How did this compare with what you had anticipated?

    Did you get the support that you needed from the Trust? Were they responsive to your requests?

    Was their direction clear?

11. What's your own perception about the success of the City as the program implementer?

    In what ways was the City's involvement an asset?

    Did you encounter any situations in which it was a liability?

12. What was the contract amount for implementation?

    [The documentation I saw was unclear. Appeared to be $21,950 for admin in initial Trust budget, plus $45,000 in first extension, for a total of $66,950. Yet Curt spent 65 hrs to date out of admin contract of 260 hrs (25%). 260 x $75 = $19,500]

    How much do you anticipate that you will spend by the end of the year?

    Has implementing the program been easier than you expected?

        Why do you think this is so?

Questions About the Program Size

1. Do you perceive that agencies had difficulty accepting the program limit of 2,250 LEDs?

   Did you hear any complaints?

   Do you think people understood why there was a limit—rather than an unlimited program?

Do you think the Trust ended up looking bad or with egg on its face when demand outstripped the budget?

2. What characterized the folks who acted right away, and got in on the first 750 rebates budgeted?

   In what ways, if any, do the folks who came in the next 1,500 differ from the first group of folks?

   Is everyone installing the LEDs as part of routine maintenance?

   Do you know whether they are using operating budgets or capital budgets to buy the LEDs?

   How have the LED purchases fit into their budget cycles?

   [Probe: theory behind the extension: "it is our belief that this next level of prospects [after the first 750] are the population of organizations that need assistance the most. The prospects targeted by this next round of incentives will most likely not install LED lamps independently due to a combination of financial constraints and budget cycles. Anecdotal information leads us to believe if incentives are not available to them now, it may be two years until they may have the opportunity to act."]

3. How many LEDs in total do you think jurisdictions would have committed to this year if there had not been a limit?

   When would they have installed these?

   This year, or next?

   If the Trust were to offer the program next year, how many green LEDs do you think might be purchased?

   [From correspondence Kurt to Steve: Now have semi-firm indications for an additional 315 green LED (above the 1,500 limit). The only firm application is the ODOT Region 1 with its 75 LEDs above our limit. The semi-firms are: City of Albany (130), City of Lake Oswego (50), City of Tigard (phase II) (60). "With others who expressed initial interest that I haven't spoken with recently, it could double the 300" I think a reasonable estimate might be 1,500 more (over the existing 1,500).]

4. Was there any thought to the distribution of the lamps among the possible takers, or has it been first-come first-served? A market transformation strategy might suggest reaching more folks w fewer bulbs, perhaps, or reaching the bigger players, or...

Questions about Program Effect and LED Potential

1. For the jurisdictions that took part in the program, do you have any sense of what proportion of their signals will have green LEDs installed (or of total signals)?

   Red LEDs?

   Do you think the program had the effect of encouraging the installation of red LEDs? Or were they already planning on any reds that they did?

   ["From the 10 applications we've received, we know that they have more than 6,800 green signals and over 3,000 ped crossing signals that won't be retrofit by year end. And that's only a portion of what's left to do in the state."]

2. Do you know the number of jurisdictions that did not take part in the program?

   Do you have any sense of their total size (of signals) in comparison with the total size of those that participated in the program?

3. Do you think the participating jurisdictions will continue to install LEDs after the program ends?

   [The theory is that the program may pave the way for larger green LED purchases in the future, -->incr'd production, lower prices, -->mkt tranformation.]

   Have they had any problems with the LEDs?

   Is the simple screw-in now well accepted?

   Will they install them in current incandescent signals?

   Will they install them when the LEDs burn out?

4. Do you think any nonparticipants have been inspired and might install LEDs without an incentive?

5. Did you talk with program participants about other applications for LEDs (e.g., Pedestrian LEDs)?

   Do you know of any plans to install LEDs in these other applications?

   What would it take for these jurisdictions to do this?

   What are the barriers?

   What are the opportunities?

6. The prices for LEDs are falling. Have you seen any change in prices since you've been involved with the program?

   Are prices now at a point that jurisdictions will buy LEDs without incentives?

   Do you think if the Trust were to offer the program in the future, it could offer a lower incentive and still attract participants?

7. What do you think it will take to get the laggards to install LEDs?

   [ACEEE says market for incandescent greens is collapsing; yet local jurisdictions are strapped for cash and buy cheapest alternative]

8. If you were to gauge the effect of the program in terms of how much it accelerated LED installation, would you say that participants have installed them a year sooner than they would have? Or...

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