Final Report

Undergrounding Assessment Phase 2 Report: Undergrounding Case Studies

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Executive Summary

This report presents the results of Phase 2 of a three phase project to investigate the implications of converting overhead electric distribution systems in Florida to underground (referred to as undergrounding). The purpose of Phase 2 is to examine the costs and benefits of actual undergrounding projects that have been completed. The focus is to identify the drivers of each project; discuss the challenges of each project; and to collect data that can serve as a real-world basis for the *ex ante* modeling in Phase 3. A summary of the four case studies examined in Phase 2 is shown in Table A.

Table A. Summary of Case Studies

Project	Utility	Year of Conversion	Circuit Miles of Converted Overhead	Circuit Miles of New Underground
Pensacola Beach	Gulf Power	2006	2.6	6.8
Sand Key	Progress Energy Florida	1996	1.8	1.7
Allison Island	Florida Power & Light	2000	0.5	1.0
County Road 30A	Chelco	2006	0.8	0.8

A review of the case studies reaches the same conclusion reached in the Phase 1 literature review: the initial cost to convert overhead distribution to underground is high, and there is insufficient data to show that this high initial cost is 100% justifiable by quantifiable benefits such as reduced O&M cost savings and reduced hurricane damage. Increased data collection can potentially increase the amount of quantifiable benefits, but it is unlikely that these benefits will 100% justify high initial cost, except potentially in a situation where an undergrounded system is struck by multiple severe hurricanes. For all of these case studies, by far the strongest reason for undergrounding is to improve the aesthetics of the area. Additional observations relating to these case studies include:

- All case studies occurred in coastal areas.
- Two of the four projects were done in conjunction with roadway widening projects.
- More circuit miles of underground are sometimes built than the original overhead amount. This is typically to create an underground loop that increases operational flexibility and the ability to respond to faults.
- Cost per circuit mile figures corresponds to those identified in the Phase 1 literature search.
- Cost per customer varies widely based on both the cost per circuit mile and the amount of high density housing such as high rise condominiums.

Not much data is available on the impact of the case studies on non-storm reliability and hurricane performance. The little data that is available indicates that non-storm reliability is not significantly different after undergrounding, and that hurricane reliability of underground systems is not perfect due to storm surge damage.

For these case studies, there is an extensive amount of project description and project cost data, but limited avoided cost and benefit data. These case studies can certainly be used as an input for an *ex ante* model, but there is not sufficient data to compare the output of the *ex ante* model to historical realized benefits. There is not even enough data to determine upper and lower bounds of potential results. At this point, any *ex ante* model that is developed, such as the one to be developed in Phase 3, must be justified by its model assumptions rather than by its ability to replicate realized benefits from any of these case studies.

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1 Introduction

This report is the Phase 2 deliverable of a project awarded in response to RFP #U-1 issued by the Florida Electric Utilities. RFP #U-1 was a result of Florida Public Service Commission Order No. PSC-06-0351-PAA-EI, which directs each investor-owned electric utility in Florida to establish a plan that increases collaborative research to further the development of storm-resilient electric utility infrastructure and technologies that reduce storm restoration costs and interruptions to customers. Municipal electric and cooperative electric utilities are participating voluntarily. In an effort to comply with this order, the following utilities (referred to collectively as the Project Sponsors) are joint sponsors and are coordinating their efforts through the Public Utility Research Center (PURC) at the University of Florida:

Investor-Owned Utilities

- Florida Power & Light Company
- Progress Energy Florida, Inc.
- Tampa Electric Company
- Gulf Power Company
- Florida Public Utilities Company

Publicly-Owned Entities

- Florida Municipal Electric Association
- Florida Electric Cooperatives Association
- Lee County Electric Cooperative, Inc.

The scope of the overall project is to investigate the implications of converting overhead electric distribution systems in Florida to underground (referred to as undergrounding). The primary focus of the project is the impact of undergrounding on the performance of the electric infrastructure during hurricanes, which is the ability of the local power system to withstand high winds and other damage from hurricanes and to minimize the number and duration of customer interruptions. This study also considers benefits and issues with regard to performance during non-storm situations. The project is divided into three phases. Phase 1 is a meta-analysis of existing research, reports, methodologies, and case studies. The Phase 1 final report was issued on February 28th 2007. Phase 2 examines specific undergrounding project case studies in Florida. Phase 3 develops and tests a methodology to identify and evaluate the costs and benefits of undergrounding specific facilities in Florida. This report presents the results of Phase 2.

Phase 2 develops case studies of recent projects in Florida where significant portions of overhead facilities have been moved underground. This is done by assessing the costs and benefits of four actual undergrounding projects in Florida that have been physically completed. The case studies have been selected by the Steering Committee with input from InfraSource. The geographic locations of the selected case studies are shown in Figure 1-1, and a summary of the selected case studies is shown in Table 1-1. The primary purpose of the case studies is to provide real-word data for testing the Phase 3 modeling.

Figure 1-1. Location of Case Studies

Table 1-1. Summary of Case Studies

Project	Utility	Year of Conversion	Circuit Miles of Converted Overhead	Circuit Miles of New Underground
Pensacola Beach	Gulf Power	2006	2.6	6.8
Sand Key	Progress Energy Florida	1996	1.8	1.7
Allison Island	Florida Power & Light	2000	0.5	1.0
County Road 30A	Chelco	2006	0.8	0.8

To ensure that the results of the studies can be applied in different settings, the projects were selected in an attempt to represent different regions of the state, topography, urbanization (city versus rural), type of utility (investor-owned, co-op, or municipally-owned), and other factors, in an attempt to provide insights into how these variables might affect costs and benefits of undergrounding. An attempt was also made to (1) select cases of sufficient magnitude to give meaningful results, and (2) select a mix of recent projects (so that current practices are considered) and cases where sufficient time has passed that the area was subsequently hit by a hurricane.

The case studies examine the costs and benefits of undergrounding in selected projects, paying particular attention to the drivers of each undergrounding project, the challenges specific to each case, and what the cases had in common. The case studies are not intended to provide general conclusions about the costs and benefits of undergrounding; rather the data collected for these cases will be primarily used to validate the predictive model to be developed in Phase 3.

Before examining the specific cases, it is beneficial to discuss the analytical approach that was agreed upon by the Project Sponsors. This analytical approach is discussed in Section 2. Specific case studies are then examined in Sections 3 through 6. The report ends with a summary analysis of the case study and conclusions.

2 Analytical Approach

The purpose of Phase 2 is to develop case studies of recent projects in Florida where significant portions of overhead facilities have been moved underground. The case studies will examine the costs and benefits of undergrounding in selected projects, with the primary goal of collecting data to serve as a real-world basis for the *ex ante* modeling in Phase 3. Consistent with the findings in Phase 1, the case studies will also attempt to address cost and benefit issues that existing studies have been inadequate in their consideration. The case studies will pay particular attention to the drivers of each undergrounding project, the challenges specific to each case, and what the cases had in common.

It is beyond the scope of these case studies to reach general conclusions about undergrounding existing overhead facilities. However, the data collected in the Phase 2 case studies will be examined for areas of similarity, differences, and idiosyncrasies. These examinations may also raise questions that can be further investigated in the future, and identify data collection opportunities for future undergrounding projects.

The four case studies examined in this report are a small number of projects and, therefore, caution should be used before drawing general conclusions about the costs and benefits of undergrounding. In fact, there are too few Florida case studies presently available from which general conclusions could be derived. [Note: the Phase 2 data are consistent with the results of studies examined in Phase 1 of this study.]

When deriving the costs and benefits associated with these case studies, care has been taken by InfraSource to ensure that potential bias is avoided if possible or identified if unavoidable. This includes bias that could either make undergrounding seem more attractive or less attractive than is justified on an objective analysis of the costs and benefits, and could result from both project selection and project data. For example, all four case studies examined in this report are near coastal areas (no non-coastal projects were available for examination). Certain characteristics associated with coastal undergrounding projects may make them generally more attractive when compared to inland projects (these project may also be more expensive due to the need for submersible equipment). Therefore, the overall results may not be representative of all possible undergrounding projects. This report attempts to explicitly identify these types of issues so that results can be viewed in proper context.

The proposed analytical approach of Phase 2 is to gather as representative data for each case study in the following categories:

Proposed Data Categories

1. General Project Data
2. Initial Costs
3. Recurring Costs
4. Reliability (non-storm)
5. Tropical Storm Damage
6. Intangibles

The data for each category is generally presented in a manner provided by the associated utility, but is collected in a manner such that it is suitable for comparison in a summary table. The first five data categories are focused primarily on quantifiable information. The last data category (intangibles) is focused on items that are important to underground conversion projects, but are difficult to quantify in either engineering or economic measures (e.g., aesthetic improvement).

The following sections discuss the specific data items that have been identified as desirable to collect for each of the data categories. It is understood that each case study may not have data for a large number of these data fields. Still, these lists are valuable for identifying missing data and for implementing data collection plans for future projects that reduces or eliminates missing data for project evaluation.

General Project Data

General project data captures the high-level perspective on a project. This includes the motivation for the project, the size of the project, the scope of the project, and general design considerations. A list of general data desirable to have for each project is shown in Table 2-1.

Table 2-1. General Project Data

Description	Value
Utility Type	
Voltage	
Customers	
Residential	
Commercial	
Industrial	
Total	
Circuit Miles	
Three Phase	
Two Phase	
One Phase	
Total	
Construction Type	
Level of Urbanization	
Geography	
Primary motivation	

Utility Type: Provides the ownership structure of the utility such as investor-owned, municipal, or co-operative.

Voltage: Lists the primary distribution voltage class associated with the project such 34.5 kV, 24.9 kV, 12.5 kV, and 4.7 kV.

Customers: Reports the total number of customers affected by the project including all customers served directly from the undergrounded sections and all customers served by feeders served directly from the undergrounded sections. Customers affected by the undergrounding project will be divided into residential, commercial, and industrial. Due to data collection methods, the number of customers will be measured at the upstream protecting device. This means that a project on a fused lateral will be associated with all customers on the lateral, even if the entire lateral is not underground. Similarly, a project on a main feeder trunk having no line projection will be associated with all customers on the feeder, since the upstream protection device is the feeder breaker at the substation.

Circuit Miles: Provides the total number of circuit miles that were converted from overhead to underground. This will be further broken down into three-phase conversion, two-phase conversion, and single-phase conversion.

Construction type: Reports the underground construction method used such as direct buried, cable in conduit, manhole and ductbanks, and potentially others.

Level of Urbanization: Describes the zoning, level of development, and surrounding geography for the area affected by the project. Typical descriptors include urban core, suburban, and rural. A description of both customer density (as defined as customers per circuit mile) and the placement of existing right-of-ways will be provided.

Geography: Describes the terrain where underground construction took place. Typical descriptors include urban, mountains, forest, rural (soft ground), rural (rocky ground), swampland, etc. Geographical categories may overlap (such as forest and swampland).

Primary motivation: States the primary driver that resulted in the underground conversion process being initiated and implemented.

Initial Costs

This category of data is focused on capturing the actual cost of converting the overhead distribution system to underground. The goal is to approximate the "turnkey" cost that a utility would have to pay an external contractor to perform all of the work necessary, even though some of the work may have been performed with internal resources. A list of initial cost data desirable to collect for each project is shown in Table 2-2.

Electric Facilities: Engineering & Design represents the cost for developing the construction documents used to build the electrical facilities. This includes all labor (e.g., internal, contracted, and outsourced).

Electric Facilities: Materials represents the procurement costs for electrical-related work done in the project including cable, vaults, manholes, ductbanks, transformers, etc.

Electric Facilities: Internal Overhead represents the amount of internal overhead costs, such as G&A, that are allocated to the project. This does not include any overhead that is already embedded into internal labor rates.

Electric Facilities: Internal Labor represents the total internal labor charges incurred during the process and is generally determined based on the number of construction crew hours charged to the project multiplies by an internal hourly rate for each person. The percentage of cost attributed to overtime will be described separately in the table notes.

Electric Facilities: Contract Labor refers to all bills paid to external contractors minus any material procurement cost (if any). The total will be divided by total man-hours worked to calculate an effective hourly contract labor rate.

Electric Facilities: Other refers to other costs directly associated with conversion of the overhead electrical facilities to underground, but included in other cost categories. This includes costs associated with destruction and repair of infrastructure such as roads and sidewalks.

Table 2-2. Initial Costs

Category	Units	Quantity	$ per Unit	$	$/mi
Electric Facilities					
Engineering & Design					
Materials					
Internal Overhead					
Internal Labor					
Contract Labor					
Other					
Total Cost					
Initial Book Value					
Third-Party Facilities					
Telephone					
Cable TV					
Broadband Fiber					
Other					
Total Third Party Cost					
Customer Facilities					
Service entrance					
Other					
Total Customer Cost					
Miscellaneous					
Landscaping					
Financing					
Other					
Total Miscellaneous					
Total Initial Cost					

Electric Facilities: Initial Book Value reports the initial value of the newly-installed underground equipment as shown in the utility accounting system.

Third-Party Facilities: Telephone represents the incremental cost required to convert telephone cables, if any, from overhead to underground.

Third-Party Facilities: Cable TV represents the incremental cost required to convert cable television cables, if any, from overhead to underground.

Third-Party Facilities: Broadband Fiber represents the incremental cost required to convert broadband fiber cables, if any, from overhead to underground.

Third-Party Facilities: Other represents the incremental cost required to convert any facilities other than telephone, cable, or broadband, from overhead to underground

Customer Facilities: Service entrance represents the total cost spent on customer-owned service entrance equipment to make it acceptable for underground service. [Note: this data may be difficult to obtain since it is not generally the responsibility of the utility to keep track of these costs.]

Customer Facilities: Other represents the total cost spent on customer-owned equipment other than the service entrance to make it acceptable for underground service. For example, this may include the cost of bringing panelboards up to code. [Note: this data may be difficult to obtain since it is not generally the responsibility of the utility to keep track of these costs.]

Miscellaneous: Landscaping refers to the cost, if any, spent on landscaping over and around the location of the new underground facilities.

Miscellaneous: Financing reports the total initial cost of project financing such as fees.

Miscellaneous: Other reports costs not associated with any other category.

Recurring Costs

Recurring costs are costs that will be incurred periodically over the life of the overhead or underground facilities, and will typically be described in terms of expected cost per year. Ideally this will be the average annual costs over a period of three to five years, but data limitations may require the use of a single year. The approach is to describe costs both before and after the conversion. In this manner, incremental increases and decreased in annual spending categories can be determined. A list of recurring cost data desirable to collect for each project is shown in Table 2-3.

Table 2-3. Recurring Costs

Category	Units	Quantity Before	Quantity After	$/yr per Unit	$/yr Savings	$/yr per mile
Inspection & Maintenance						
Unscheduled Maintenance						
Vegetation Management						
Lost Electricity Sales						
Vehicular Accidents						
Employee Accidents						
Live Wire Contacts						
Dig-in Contacts						
Pole Attachment Revenue						
Underground Locates						
Interest Payments						
Total Recurring Costs						

Inspections & Maintenance refers to the costs associated with regular scheduled inspections and normal maintenance items. This category does not include vegetation management, which is treated as a separate item.

Unscheduled Maintenance refers to the cost of fixing unplanned problems such as equipment failures. This category does not include those due to any of the other categories listed in the section (i.e., no double counting).

Vegetation Management reports all costs associated with maintaining vegetation-related clearances such as tree trimming, tree removal, tree replacement, herbicides, growth retardant, and mowing.

Lost Electricity Sales refers to all lost electricity sales due to scheduled and unscheduled outages that lead to customer interruptions. This category does not include lost electricity sales that occurred during major weather events such as hurricanes.

Vehicular Accidents refers to the number of motor vehicles striking utility equipment. Costs for these accidents include all legal and settlement costs.

Employee Accidents refers to the number of OSHA-recordable events. Costs for these events are based on paid-out workers compensation and any related direct costs.

Live Wire Contacts refers to the number of people touching energized conductors. Costs for these accidents include all legal and settlement costs.

Dig-in Contacts refers to all events where excavating equipment contacts buried electrical equipment and results in damage. Typically the costs for this category will appear in unscheduled maintenance. However, if there are any costs associated with the dig-in that are not related to equipment repair, they are recorded under this field.

Pole Attachment Revenue reports the annual fees paid by third parties to the electric utility. Typically revenue will be positive before the project, and zero after the project.

Underground Locates reports the number of times that the utility needed to identify the location of its underground facilities at construction sites, and the associated costs.

Interest Payments refers to any interest payments on loans that are specifically linked to the undergrounding project.

Reliability (non-storm)

This category of data is focused on actual outages and interruptions that occurred both before and after the project. It will also estimate the financial impact of interruptions to customers through the Customer Cost of Reliability section. A list of reliability data desirable to collect for each project is shown in Table 2-4.

Table 2-4. Reliability (non-storm)

Measure	Before	After
MAIFIe (/yr)		
SAIFI (/yr)		
SAIDI (min/yr)		
CAIDI (min/event)		
Customer cost of reliability		
Expected useful life		
High Profile Events		

MAIFIe (/yr) refers to the Momentary Average Interruption Frequency Index (events). It is the average number of momentary interruptions experienced by a customer in a given year. A momentary event consists of one-or-more customer interruptions that occur during a one-minute time period (this is the threshold used by the Florida Public Service Commission). Ideally this number will reflect actually momentary events experienced by customers. If utilities only track reclosing information at the substation breaker, this will be used as an approximation.

SAIFI (/yr) refers to the System Average Interruption Frequency Index. It is the average number of sustained interruptions experienced by a customer in a given year. A sustained interruption occurs when a customer loses power for more than one minute.

SAIDI (min/yr) refers to the System Average Interruption Duration Index. It is the average number of interruption minutes experienced by a customer in a given year.

CAIDI (min/event) refers to the Customer Average Interruption Duration Index. It is the average number of interruption minutes per outage event.

Customer Cost of Reliability is the estimated amount that all customers would have been willing to pay to have avoided all interruption that contributed to MAIFIe, SAIFI, and SAIDI. This amount will not be calculated directly. Rather, it will be estimated based on customer cost surveys and the specific customer mix in area affected by the project. This measure will be bounded from above as the cost of installing back-up generation at the residence or business.

Expected Useful Life refers to the estimated useful life of the equipment. At the end of the useful life for a piece of equipment, it has about a 50% chance of either having to have been replaced or is in a situation that it should be replaced.

High Profile Events is a list of events that resulted in unwanted and significant public exposure. An example of a high profile event might be a set of cable failures leaving a large portion of a central business district without power. Another example might be an explosion in a manhole that launches a manhole cover and results in a damaged window or vehicle.

Tropical Storm Damage

This category of data is focused on actual tropical storms and hurricanes that affected the project area. Ideally there is data for storms that occurred both before and after the project. It is not possible to perfectly compute the damage from an actual hurricane assuming either (1) a replaced overhead system was still in place instead of converted underground, or (2) a potential underground system was in place instead of existing overhead. Regardless, a listing of hurricane performance is useful despite these limitations. A list of tropical storm data desirable to collect for each project is shown in Table 2-5.

Table 2-5. Tropical Storm Damage

Description	Value
Description of storm	
Before or after undergrounding?	
Customers interrupted	
Customer interruption hours	
Days to 100% restoration (project area)	
Days to 100% restoration (entire system)	
Cost of Restoration ($M, project area)	
Cost of Restoration ($M, entire system)	

Description of storm describes the basic characteristics of the storm such as its name, its category when passing through the affected area, and the maximum wind speeds recorded in the area. Anecdotal data about the storm will also be gathered such as the type of damage that was primarily incurred.

Before or after undergrounding indicates whether the storm occurred before or after the project.

Customers interrupted reports the total number of customers interrupted in the area impacted by the project.

Customer interruption hours is the total number of customers hours service was unavailable in the area impacted by the project, and will consider staged restoration.

Days to 100% restoration refers to the number of days elapsed before all customers are restored. This will be recorded both for the customers in the project area and for the entire system. For example, all customers in the project area might have been restored in 5 days, but the entire system was restored in 10 days.

Cost of Restoration ($M) refers to the cost of restoration efforts including staging area, internal crews, external crews, materials, and so forth. This will be recorded both for the restoration cost of the project area and for the entire system. For example, the total restoration cost for a particular hurricane might be $200 million, but the cost to restore the project area might be $10 million. The cost to restore the project area does not include any staging area costs, only labor and materials.

Cost breakdowns between overhead and underground are usually allocated as a percentage of damage or ticket volume between overhead and underground. One problem with this is that some underground tickets are codified as underground are for underground risers which have overhead damage. Accuracy also depends on the type of storm (wet versus dry). In dry storm there is very little or no underground damage except for areas damaged by storm surge in strong hurricanes.

Intangibles

This category of data is focused on potentially important issues that are difficult to quantify in engineering or economic terms. A list of intangible information desirable to collect for each project is shown in Table 2-6.

Table 2-6. Intangibles

Category	Comments
Aesthetics	
Improved Property Values	
Sidewalks	
Environmental impact	
Business impact	
Operational Flexibility	

Aesthetics refers to the aesthetic benefits associated with the project. In addition to the elimination of overhead facilities, this category will also discuss any improved landscaping made possible by the project. This category refers to qualitative aesthetic benefits only, and does not refer to any of the associated costs (e.g., landscaping costs).

Improved Property Values is an attempt to quantify property sale prices before and after this project to see if there was any noticeable impact on property values. If yes, the total amount of property value improvement will be estimated.

Sidewalks will note whether sidewalk conditions improved as a result of the project.

Environmental Impact will describe any environmental damage that was incurred during project construction such as tree root damage, erosion, and habitat disruption.

Business Impact will describe generally the impact of the project to businesses in the area.

Operational Flexibility will describe any operational benefits or difficulties that resulted from the project. For example, the utility may have found it more difficult to perform system expansion projects on an underground system, or may have found it more difficult to implement a distribution automation scheme.

3 Allison Island (Florida Power & Light)

Allison Island is a man-made peninsula in Biscayne Bay, which is located in the City of Miami Beach (City). It is about five city blocks long by one city block wide, and contains 45 high-value residential homes in the $1 million to $1.5 million range (the median Dade County home is in the $400,000 to $500,000 range). In October of 1994 the City manager contacted Florida Power & Light Company (FPL) to determine the firm costs associated with converting the entire distribution system from overhead to underground (including overhead primary, overhead secondary, and service drops). FPL provided the firm cost to convert the entire island to an underground system in July of 1995. The final design called for the underground facilities to be located in the median where a previous existing utility easement existed. An aerial picture of Allison Island with circuit locations is shown in Figure 3-1.

During negotiations, many homeowners did not want to incur the cost of bringing their customer-owned equipment up to current codes, which would be required before converting their service drop from overhead to underground. In the end, FPL and the City agreed to install service poles and overhead service drops for these customers so that they would not have to incur these costs (the undergrounding agreement transferred all future relocation risk to the municipality). Subsequently, all of these overhead service drops have been converted to underground.

The underground conversion for Allison Island was completed in November of 2000, about five years after the initial request. This has been the only conversion project that has been completed of the dozens of requests that FPL has received. Underground conversions are normally very difficult to execute because of finding the necessary space to fit the necessary underground equipment. Allison Island's geography provided an ideal situation for conversion to take place by allowing all the necessary equipment to be installed in the street median (see Figures 3-2 and 3-3).

General project data for Allison Island is shown in Table 3-1. Allison Island used to be served by a 0.5 mile-long two-phase radial tap from a primary main trunk. The new underground system loops to the end of Allison Island and back, and is therefore 1.0 miles in length.

Table 3-1. General Project Data for Allison Island

Description	Value
Utility Type	Investor-owned
Voltage	13.2 kV
Customers	45 (all residential)
Old Overhead Circuit Miles	0.5
New Underground Circuit Miles	1.0 (two phase)
Construction Type	URD cable in direct buried duct with single phase pad-mounted transformers. Cable and transformers placed in existing easement in center median.
Level of Urbanization	Dense urban area with ultra-expensive single-family homes.
Geography	Man-made peninsula in Biscayne Bay.
Primary motivation	Aesthetics

Figure 3-1. Allison Island Geography and Circuit Routing

A detailed breakdown of the initial cost of the underground conversion was not available. However, the final bill amount consisted of the following (cost per mile is based on the amount of overhead circuit miles that were converted):

Construction cost	$ 207,401
Cost per circuit mile	$ 414,802
Cost per customer	$ 4,609

The construction cost includes service drops, but does not include the cost to bring customer-owned equipment up to current codes.

In accordance with the FPSC ratemaking tariff at the time of the project (Florida State Laws 366.03 - 366.05), the customers paid for the incremental cost of underground conversion above the cost of new overhead construction. In addition, customers must pay for the remaining book value of old system. Therefore, the cost to the City was the following:

Construction cost	207,401
Remaining book value[1]	19,415
New overhead cost[2]	(101,353)
Cost to the City	$ 125,463

1. The remaining book value could be considered a "stranded cost" since it represents assets that are no longer able to directly recover their costs. The stranded cost is not a function of the costs and benefits of doing the project but an accounting result. The remaining book value is allowed to be recovered by the utility and will add to the customer cost burden.
2. The new overhead cost is the cost that it would take to replace the existing older overhead system with brand new equipment.

And so, the direct cost to the city for the conversion of Allison Island to underground was $125,463, which amounts to about $2,788 per resident affected.

Figure 3-2. Underground equipment in the median of Allison Island.

Figure 3-3. Underground equipment in the median of Allison Island.

4 Sand Key (Progress Energy Florida)

Sand Key is a coastal part of the City of Clearwater. It consists mostly of high-density residential properties, but also contains some limited single family properties, small commercial properties, two resort hotels, and a County Park. An aerial view of Sand Key is shown in Figure 4-1.

The underground project for Sand Key converted all overhead electric and CATV facilities on Sand Key from the southerly City of Clearwater city limits to the Clearwater Pass Bridge at the north end of Sand Key. This involved approximately 9,500 circuit feet of 795 AAC overhead three phase feeder and associated equipment. Parallel runs of 6"conduit were installed, resulting in about 18,000 feet of 6" underground conduit. One run (9,000 feet) is used for the three phase main feeder cable and the other run (also 9,000 feet) is a spare.

The undergrounding of the facilities was requested by the citizens of Sand Key and was financed by the City of Clearwater by an additional property tax levy.

The trigger for the project was Pinellas County's upcoming project to reconstruct Gulf Boulevard from the Clearwater City Limits to the Sand Key Bridge, which was under construction at the time. The design of the project was started in late 1995 with the undergrounding project going to construction in 1996 to coordinate with the proposed roadway construction. Pinellas County postponed the proposed Gulf Boulevard reconstruction project due to financial constraints until 1999. However the City of Clearwater began collecting the additional property taxes with the 1996 assessment cycle. This caused the undergrounding project to go to construction 3 years ahead of the roadway construction project which increased the need for accurate survey and as-built information to prevent future damage to the system by the roadway construction.

The new system is comprised of 1000 kcmil cable for the main feeder trunk, padmounted switch-gear, and 1/0 cable loops feeding the required transformers. Construction was accomplished by a combination of open trench and directional bore technologies. A summary of the equipment comprising new underground system is the following (taken from construction estimates):

- 1.5" conduit 10,000'
- 2.5" conduit 1,000'
- 4" conduit 30,000'
- 6" conduit 18,000'
- Pull boxes 17
- Junction boxes 35
- Switch boxes 14
- Splice boxes 42
- Transformer pads 17

A summary of general information for Sand Key is provided in Table 4-1.

Figure 4-1. Sand Key

Table 4-1. Sand Key General Project Data

Description	Value
Utility Type	IOU
Voltage	12.47 kV
Customers	
Residential	3,191
Commercial	184
Industrial	0
Total	3,375
Circuit Feet (three phase overhead)	9,500 (1.8 miles)
Circuit Feet (three phase underground)	9,000 (1.7 miles)
Construction Type	6” parallel CIC conduit (1 is a spare) via directional bore and trenching. 4” conduit in parallel used to connect from switchgear to transformers (i.e. 200 amp loops).
Level of Urbanization	High density urban
Geography	Beachfront
Primary motivation	Aesthetic. Home owner association initiated the project by a majority vote. The City of Clearwater paid CIAC to Progress Energy. It then initiated a property tax assessment of residents spread over 10 years.

Progress Energy Florida has kept detailed cost information related to this project. This cost information is summarized in Tables 4-2 through 4-5. Costs are separated into labor and material, and are placed into the same defined categories for each major activity. A guide to the information contained in each table is:

Table 4-2	Removal of Overhead Feeder;	Installation of Streetlights
Table 4-3	Installation of Cable;	Installation of Transformers and Padmounts
Table 4-4	Locate and Verify;	Installation of Conduit
Table 4-5	Survey work;	Totals

In addition to the costs reflected in Tables 4-2 through 4-5. Additional miscellaneous costs associated with the project are shown in Table 4-6.

Table 4-2. Sand Key Initial Cost Data (1)

	Remove Overhead Feeder			Install Streetlights		
	Labor	Material	Total	Labor	Material	Total
Construction	$575.20	$5,210.22	$5,785.42	$6,225.94	$50,288.34	$56,514.28
Miscellaneous Costs			$0.00			$0.00
Subtotal			$5,785.42			$56,514.28
Truck & Loading (3% of Subtotal)			$173.56			$1,695.43
Eng & Sup (15% of subtotal + above)			$893.85			$8,731.46
Work Order Esti-mate			$6,852.83			$66,941.16
CIAC			$0.00			-$5,816.03
Work Order Cost			$6,852.83			$61,125.13
Transformer Cost	$0.00	-$22,664.92	-$22,664.92	$0.00	$0.00	$0.00
Meter Cost			$0.00			$0.00
O&M Cost	$1,068.21	$0.00	$1,068.21	$0.00	$0.00	$0.00
Removal Cost	$25,746.74	$0.00	$25,746.74	$0.00	$0.00	$0.00
"Other" Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Related Costs			$0.00			$0.00
Service Cost			$0.00			$0.00
Service Credits			$0.00			-$7,573.82
Salvage		-$66,065.57	-$66,065.57		$0.00	$0.00
Reimbursements			$0.00			$0.00
Net Project Cost	$27,390.15	-$83,520.27	-$55,062.71	$6,225.94	$50,288.34	$53,551.31

Note: negative values indicate costs that offset the underground conversion cost. For example, the negative transformer cost represents overhead transformers that can be re-used in other parts of the system or sold.

Table 4-3. Sand Key Initial Cost Data (2)

	Install Cable			Transformers and Padmounts		
	Labor	Material	Total	Labor	Material	Total
Construction	$43,122.95	$607,494.03	$650,616.98	$919.44	$3,216.64	$4,136.08
Miscellaneous Costs			$0.00			$0.00
Subtotal			$650,616.98			$4,136.08
Truck & Loading (3% of Subtotal)			$19,518.51			$124.08
Eng & Sup (15% of subtotal + above)			$100,520.32			$639.02
Work Order Esti-mate			$770,655.81			$4,899.19
CIAC						
Work Order Cost			$770,655.81			$4,899.19
Transformer Cost	$675.87	$78,850.91	$79,526.78	$0.00	$0.00	$0.00
Meter Cost			$0.00			$0.00
O&M Cost	$2,731.03	$0.00	$2,731.03	$41.94	$0.00	$41.94
Removal Cost	$140.01	$0.00	$140.01	$113.99	$0.00	$113.99
"Other" Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Related Costs			$0.00			$0.00
Service Cost			$0.00			$0.00
Service Credits			$0.00			$0.00
Salvage		-$462.87	-$462.87		-$127.25	-$127.25
Reimbursements			$0.00			$0.00
Net Project Cost	$46,669.86	$685,882.07	$852,590.76	$1,075.37	$3,089.39	$4,927.87

Table 4-4. Sand Key Initial Cost Data (3)

	Locate & Verify			Install Conduit		
	Labor	Material	Total	Labor	Material	Total
Construction	$0.00	$0.00	$0.00	$0.00	$189,303.83	$189,303.83
Miscellaneous Costs			$6,125.00			$0.00
Subtotal			$6,125.00			$189,303.83
Truck & Loading (3% of Subtotal)			$183.75			$5,679.11
Eng & Sup (15% of subtotal + above)			$946.31			$29,247.44
Work Order Esti-mate			$7,255.06			$224,230.39
CIAC						
Work Order Cost			$7,255.06			$224,230.39
Transformer Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Meter Cost			$0.00			$0.00
O&M Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Removal Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
"Other" Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Related Costs			$0.00			$359,138.00
Service Cost			$0.00			$0.00
Service Credits			$0.00			$0.00
Salvage	$0.00	$0.00	$0.00		$0.00	$0.00
Reimbursements						$0.00
Net Project Cost	$0.00	$0.00	$7,255.06	$0.00	$189,303.83	$583,368.39

Table 4-5. Sand Key Initial Cost Data (4)

	Survey Work			Totals			
	Labor	Materials	Total	Labor	Materials	Other	Total
Construction	$0.00	$0.00	$0.00	$50,844	$855,513		$906,357
Miscellaneous Costs			$37,060	$0.00	$0.00	$43,185	$43,185.00
Subtotal			$37,060				$949,542
Truck & Loading (3% of Subtotal)			$1,112	$0.00	$0.00	$28,486	$28,486
Eng & Sup (15% of subtotal + above)			$5,726	$0.00	$0.00	$146,704	$146,704
Work Order Estimate			$43,898				$1,124,732
CIAC				$0.00	$0.00	-$5,816	-$5,816
Work Order Cost			$43,898				$1,118,916
Transformer Cost	$0.00	$0.00	$0.00	$676	$56,186		$56,862
Meter Cost			$0.00	$0.00	$0.00	$0.00	$0.00
O&M Cost	$0.00	$0.00	$0.00	$3,841	$0.00		$3,841
Removal Cost	$0.00	$0.00	$0.00	$26,001	$0.00		$26,001
"Other" Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Related Costs				$0.00	$0.00	$359,138	$359,138
Service Cost				$0.00	$0.00	$0.00	$0.00
Service Credits				$0.00	$0.00	-$7,574	-$7,574
Salvage		$0.00	$0.00	$0.00	-$66,656		-$66,656
Reimbursements				$0.00	$0.00	$0.00	$0.00
Net Project Cost	$0.00	$0.00	$43,898	$81,361	$845,043	$564,124	$1,490,528

Table 4-6. Sand Key Initial Cost Data (Misc)

Sidewalk Fix	$560.00
Locates	$1,575.00
Survey	$951.72
Bores	$159,291.60
Hand Trench	$36,125.60
Machine Trench	$16,893.70
Total Misc. Costs	$215,397.62

The total initial cost for Sand Key is the net project cost of $1,490,528 plus the associated miscellaneous costs of $215,397 for a total initial cost of $1,649,065. With 3,375 customers, this corresponds to $489 per customer. It must be emphasized that the vast majority of these customers live in large multi-dwelling units. With the original 1.8 circuit miles of overhead feeder, the conversion cost corresponds to $917,532 per mile.

Table 4-7. Sand Key Recurring Costs

Category	Units	Quantity Before	Quantity After	$/yr per Unit	$/yr Savings (cost)	$/yr per mile
Vegetation Management	Miles	1.7	0	1,233	2,097	1,233
Pole Attachment Revenue	#	101	0	($4.38)	(442.47)	(260.27)
Underground Locates	#	0	396	(9.00)	(306.00)	(180.00)

Notes for Table 4-7
1. Numbers are based on 2006 costs
2. Vegetation management is for tree trimming only (does not include costs associated with tree-related outages)
3. 396 locate requests from 1996 through 2007; average of 34 per year; $9 per locate. Based on 1.7 miles.

Table 4-8. Reliability (non-storm)

Measure	Before	After
SAIFI (/yr)	0.005	0.005
SAIDI (min/yr)	0.290	0.283
CAIDI (min/event)	62.9	52.736
Customer cost of reliability	NA	NA
Expected useful life	NA	NA
High Profile Events	none	none

Notes for Table 4-8
1. Before data is average reliability from 1989-1995
2. After data is average reliability from 1996-2006
3. The removed overhead facilities were installed around 1960

Table 4-9. Tropical Storm Damage

Description	Value
Description of storm	Spring 1997 storm
Before or after undergrounding?	After
Impact of storm	Tidal surge destroyed 2 switchgear, 1 padmounted capacitor bank, and 2 padmounted transformers.

Note: This storm is not reflected in the Progress Energy outage records. At that time, major events were not recorded through its OMS system.

Table 4-10. Intangibles

Category	Comments
Aesthetics	Main reason for conversion. Street Lights were installed as part of project.
Improved Property Values	n/a
Sidewalks	No sidewalks at time of project; were installed couple years later as part of the DOT road project.
Environmental impact	Minimal – directional bore in easement beside road ROW.
Business impact	Little or no disruption – no lane closures or any significant “cutover” outages.
Operational Flexibility	No reduction in system flexibility. Area was already “built-out”, design provided for spare conduit for feeder addition if needed.

Figure 4-2. Overhead Construction Similar to that Used for Sand Key before Undergrounding (this is system is close, but not in Sand Key proper)

Figure 4-3. Sand Key After Undergrounding

Figure 4-4. Pad Mounted Equipment on the Side of the Road in Sand Key

5 Pensacola Beach (Gulf Power)

In 2003, the Santa Rosa Island Authority contacted Gulf Power Company regarding undergrounding the main corridor of Pensacola Beach. A portion of the business core area (2,500 ft) was converted to underground in 1994 and 1995. The original request and plan by the authority was to convert the remaining portion of the two main roads, Ft. Pickens and Via de Luna in 2004. Due to hurricanes Ivan and Dennis, the project was delayed and some funding was reallocated. The final decision by the authority was to complete all of the 2.2 miles. This included the conversion of facilities on Ft. Pickens Road going west in conjunction with putting 48 road crossings underground along the majority of Via de Luna going east. A map of Pensacola Beach showing the routing of the underground constriction is shown in Figure 5-1.

In June of 2005, Gulf Power was authorized to start engineering. A contractor was selected by bid process and construction work started in February of 2006 and construction was completed in December of 2006. It is important to note that this underground conversion project was in conjunction with major road improvement, drainage, and streetscaping, which is challenging to coordinate across different contractors. BellSouth telephone cables and MediaCom television cables were also placed underground as part of this project.

Gulf Power considered this project to be both technically challenging and state of the art. The beach environment is harsh on equipment and water tables are high. Ft. Pickens Road is designed as a loop system for reliability and all main switches are housed in heavy concrete vaults flush mounted with the beach. The feeders are placed in a concrete duct bank below existing grade. Expectations are that storm surges will flow over the enclosed switchgear and duct banks in most areas. Some equipment was placed behind a large sand dune to take advantage of a natural barrier. Experience from hurricanes Opal, Ivan, and Dennis, however, shows that any beach area is susceptible to damage and washout depending on local elevations and contours.

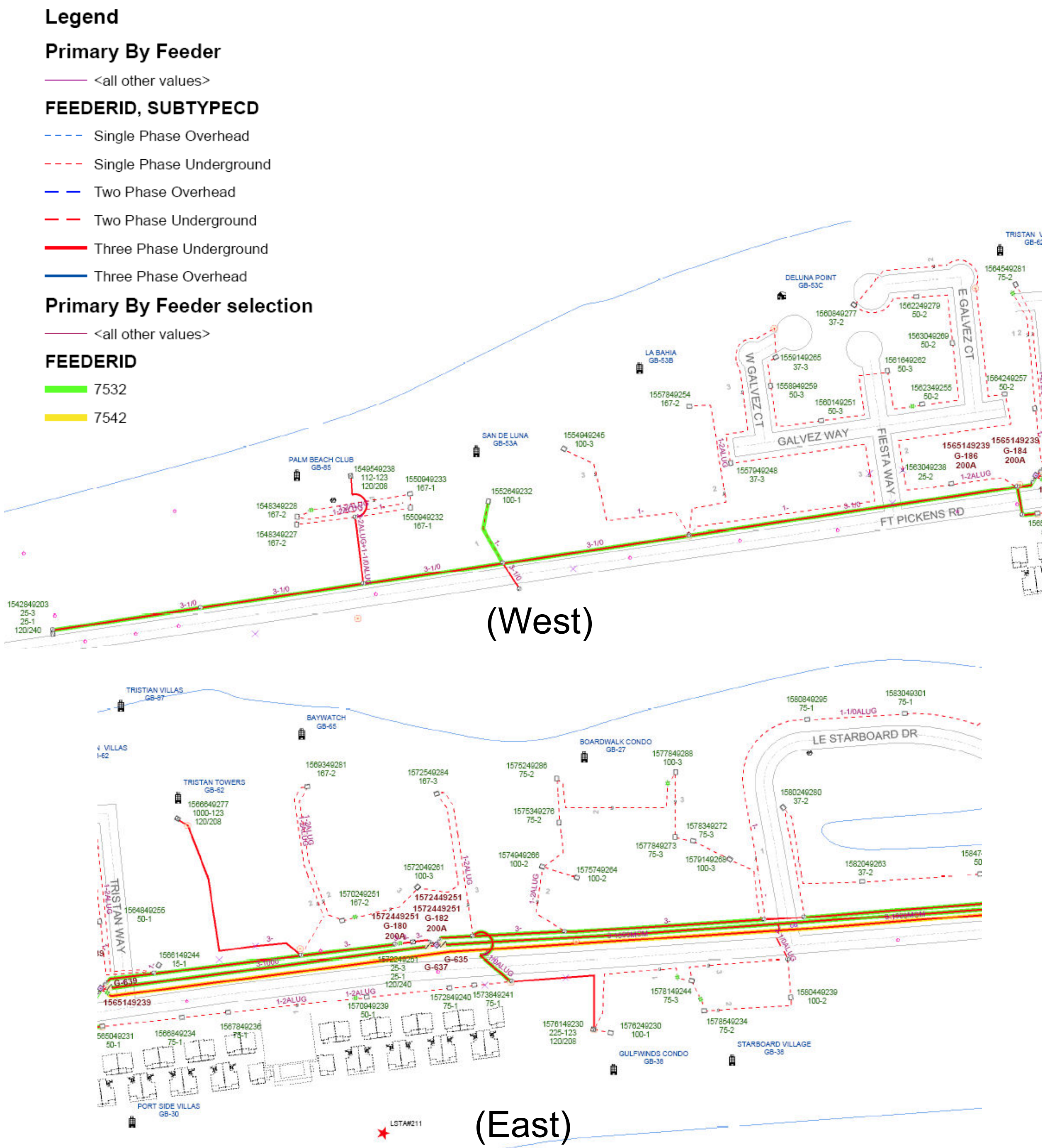

Figure 5-1. Pensacola Beach

Table 5-1. Pensacola Beach General Project Data

Description	Value
Utility Type	IOU
Voltage	12.47 kV
Customers	
Residential	849
Commercial	402
Industrial	0
Total	1,251
Circuit Miles (old three phase)[1]	2.29 + 0.26 = 2.55
Circuit Miles (new)[2]	
Three Phase	3.39 + 3.17 = 6.56
Two Phase	0.00 + 0.04 = 0.04
One Phase	0.04 + 0.02 = 0.06
Total	3.43 +3.41 = 6.84
Main Line	2.20 + 2.05 = 4.25
Lateral	1.23 + 1.36 = 2.59
Construction Type	Concrete ductbank with below grade submersible switchgear in vaults. All other cabinets, transformers and regulators are pad mounted above grade.
Level of Urbanization	High density urban with high rise condos, residential and commercial mix. Typical beachfront usage.
Geography	Barrier island, very sandy beachfront with low dunes and high water table.
Primary motivation	Aesthetics

1. Two circuits were affected. This corresponds to the two numbers for the circuit mile fields.
2. New underground circuits were looped to provide for future growth, operational flexibility and additional reliability.

Initial Cost. At this time Gulf Power is still in the process of compiling detailed internal cost data. The total internal initial cost for the project is $4.3 million. With 1,251 customers, this amounts to $3,437 per customer. With the initial amount of 2.55 miles of overhead, this corresponds to $1,686,275 per mile of overhead conversion.

Customer Facilities. An electrical contractor was hired by the Santa Rosa Island Authority to convert a total of nine service entrances to underground for a cost of $17,365. This amount included at least two large commercial services and was not a part of Gulf Power Company's scope of work.

Miscellaneous Cost. An addendum to the project requested that Gulf Power provide service to customer-owned lighting along the conversion path. The total for this addendum was $105,274.

Table 5-2. Reliability before Undergrounding (non-storm)

Measure	Reliability in 2006
MAIFIe (/yr)	2.24
SAIFI (/yr)	0.0034
SAIDI (min/yr)	0.4394
CAIDI (min/event)	129
High Profile Events	none

Notes:

1. All data provided is at the substation breaker level and is for two feeders, #1 and #2 which served the project area.
2. The project was not completed until December 2006. A full year of data will not be available until January 2008.

Table 5-3. Tropical Storm Damage

Description	Value
Hurricane Dennis in 2005	Category 3 with sustained winds exceeding 100 mph
Before or after undergrounding?	Before
Impact	About 1/3 of the poles failed

In 2007, the actual lost revenue for the Ft. Pickens project on Pensacola Beach is based on 90 Joint Use poles with Cox Cable attached at $6.20 per pole, for a total of $558.

Prior to Hurricane Ivan, both Cox Cable and Bellsouth were attached to an estimated 90 poles on Ft. Pickens Road. Had the storm not occurred, the billing for Joint Use for both Cox Cable and Bellsouth would have been estimated at $9,871. This is based on a prior joint use contract of 90 Joint Use poles with Cox Cable attached paying per contract $3,654 and a prior joint use contract of 90 Joint Use Poles with Bellsouth attached paying per contract $6,217. When BellSouth rebuilt after Ivan, they converted to underground and did not re-attach to the poles.

6 County Road 30A (Chelco)

In July of 2006, Chelco completed a year long project of converting 4,400 feet of overhead three phase feeder to underground along County Road 30A. County Road 30A is the road that runs along the Gulf of Mexico through Seaside, Watercolor, Grayton Beach, Santa Rosa Beach, and Blue Mountain Beach in Chelco service territory. The line converted to underground is a portion of a main feeder line between two substations.

The project was performed at the request of a local developer to improve the appearance of his development. The project began with engineering and design of the conversion. Chelco obtained the required permits from Walton County and the Department of Environmental Protection (DEP), which were needed for a portion of the construction. Easements from the developer and others were also required. This project required the coordination of two contractors and Chelco personnel.

Chelco informed the local cable television company at the time of the request, and included the cable television conversion costs in its estimate to the developer. The cable television company chose to take no action at the time, and remained aerial for a time, but is now is in the process of conversion. The developer paid the entire engineering and construction costs for both the Chelco conversion and the MediaCom conversion.

One of the challenges Chelco faced in this project was to convert the line to underground while still maintaining the reliability for all Chelco members in the area. Additional switchgear is needed when a line is converted to underground. Several other developments were in construction within the scope of this project, which made the engineering slightly more difficult. Chelco also hydro seeded the disturbed ground (once all digging was complete) to help restore the land back to its original landscaping.

General information for this project is summarized in Table 6-1.

Table 6-1. County Road 30A General Project Data

Description	Value
Utility Type	Cooperative
Voltage	12.5 kV
Customers	1200
Overhead Circuit Miles (three phase)	0.8 miles
Underground Circuit Miles (three phase)	0.8 miles
Construction Type	Cable in Conduit
Level of Urbanization	Suburban
Geography	Sand
Primary motivation	Developer requested

Table 6-2. Initial Costs

Category	$	$/mi
Electric Facilities		
Engineering & Design	7,000	8,750
Materials	460,052	575,065
Chelco Overhead	18,538	23,173
Chelco Labor	64,693	80,866
Contract Labor	108,883	136,104
Total Cost	659,166	823,958
CIAC	661,766	827,208
Cable TV Conversion	45,000	56,250
Landscaping	2,600	3,250
Total Initial Cost	706,776	883,469

Initial costs for this project are summarized in Table 6-2, reflecting a total initial cost of $706,776. With 1,200 customers, this corresponds to $589 per customer.

Table 6-3. Recurring Costs

Category	Units	Quantity Before	Quantity After	$/yr per Unit	$/yr Savings (cost)	$/yr per mile
Vegetation Management	miles	0.8	0	500	400	500
Pole Attachment Revenue	#	16	0	17.50	(280)	(336)

Table 6-4. Reliability (non-storm)

Measure	Before*	After*
SAIDI (min/yr)	0.12	0.27
Expected useful life (years)	30 - 40+	40 - 50 +
High Profile Events	0	0

* SAIDI for "Before" was calculated from data from January, 2005 to June 2006. SAIDI for "After" was calculated from data from July 2006 to February 2007. Raw data has been proportionally scaled to reflect a twelve month time period. Since reliability can be seasonal, comparisons between the before and after values should be made with caution.

Figure 6-1. The residential development on County Road 30A.
The owner of this development initiated and paid for the project.

Figure 6-2. Overhead construction on a road crossing County Road 30A
(similar to what existed on Country Road 30A before the undergrounding project).

7 Conclusions

A summary of the underground conversion case studies is shown in Table 7-1. This table primarily includes information from the "general data" category, but also supplies some targeted cost and performance results.

Table 7-1. Underground Conversion Case Study Summary Table

Description	Allison Island	Sand Key	Pensacola Beach	County Road 30A
Year of Conversion	2000	1996	2006	2006
Utility	Florida Power & Light (IOU)	Progress Energy Florida (IOU)	Gulf Power (IOU)	Chelco (cooperative)
Voltage	13.2 kV	12.47 kV	12.47 kV	12.5 kV
Customers				
Residential	45	3,191	849	1,200
Commercial	0	184	402	0
Total	45	3,375	1,251	1200
Old OH Circuit Miles	0.5	1.8	2.55	0.8
New UG Circuit Miles				
Three Phase	0.0	1.7	6.56	0.8
Two Phase	1.0	0.0	0.04	0.0
One Phase	0.0	0.0	0.06	0.0
Total	1.0	1.7	6.84	0.8
Construction Type	Direct buried duct	Cable in conduit	Concrete ductbank	Cable in conduit
Level of Urbanization	High density urban (expensive housed)	High density urban with mostly high rise condos	High density urban with condos, houses, and commercial mix	Suburban
Geography	Coastal	Coastal	Coastal	Coastal
Primary Motivation	Aesthetics	Aesthetics	Aesthetics	Aesthetics
Road widening involved	No	Yes	Yes	No
Initial UG cost[1]	$207,401	$1,490,528	$4,300,000	$706,776
O&M cost savings	(not available)	$1,349 per year	(not available)	$120 per year
Initial Cost per Mile[1,2]	$414,802	$917,532	$1,686,275	$883,470
Initial Cost per Customer[1]	$4,609	$489	$3,437	$589
Hurricane performance	Not known	1997 storm caused surge damage to new system	2005 storm caused 1/3 of poles to fail	Too early to tell
SAIDI Impact	Not known	No change	Too early to tell	Too early to tell

Notes
1. Initial cost includes all available initial cost data, which includes different items for the different cases
2. Initial cost per mile is based on the original amount of overhead circuit miles

A review of Table7-1 brings one to the same conclusion reached in the Phase 1 literature review: the initial cost to convert overhead distribution to underground is high, and there is insufficient data to show that this high initial cost is 100% justifiable by quantifiable benefits such as reduced O&M cost savings and reduced hurricane damage. Increased data collection can potentially increase the amount of quantifiable benefits, but it is unlikely that these benefits will 100% justify high initial cost, except potentially in a situation where an undergrounded system is struck by multiple severe hurricanes. For all of these case studies, by far the strongest reason for undergrounding is to improve the aesthetics of the area.

A summary of observations about the similarities and differences of the four case studies is now provided:

Observations

1. All case studies occurred in coastal areas.
2. All case studies were motivated primarily by aesthetic considerations.
3. More circuit miles of underground are sometimes built than the original overhead amount. This is typically to create an underground loop that increases operational flexibility and the ability to respond to faults.
4. No industrial customers were affected by any of the case studies.
5. The two larger case studies in terms of circuit miles were done in conjunction with roadway widening projects. The two smaller projects were not.
6. Cost per circuit mile varies widely based on a variety of factors, including the ratio of initial overhead circuit miles to new underground circuit miles. Cost per mile figures are consistent with those identified in the Phase 1 literature search.
7. Cost per customer varies widely based on both the cost per circuit mile and the amount of high density housing such as high rise condominiums.

Not much data is available on the impact of the case studies on non-storm reliability and hurricane performance. The little data that is available indicates that non-storm reliability is not significantly different after undergrounding, and that hurricane reliability of underground systems is not perfect due to storm surge damage.

The primary goal for Phase 2 is to collect data suitable for use in Phase 3. A review of the case studies shows that there is an extensive amount of project description and project cost data, but limited avoided cost and benefit data. These case studies can certainly be used as an input for an *ex ante* model, but there is not sufficient data to compare the output of the *ex ante* model to historical realized benefits. There is not even enough data to determine upper and lower bounds of potential results. At this point, any *ex ante* model that is developed, such as the one to be developed in Phase 3, must be justified by its model assumptions rather than by its ability to replicate realized benefits from any of these case studies.

Glossary

AAC. All aluminum conductor.

CAIDI. Customer Average Interruption Duration Index. This is the average number of interruption minutes per outage event.

CATV. Cable television.

CIAC. Contribution in aid of construction.

CIC. Cable in conduit.

Cooperative. A utility owned by its customers.

DEP. Department of Environmental Protection

DOT. Department of Transportation

FPL. Florida Power & Light

FPSC. Florida Public Service Commission

G&A. General and Administrative. This typically refers to a category of cost.

IOU. Investor owned utility. This is a utility that has common stock that is publicly traded.

Kcmil. Thousands of circular mils. This is a measure of the cross-sectional area of a conductor.

kV. Kilovolt.

MAIFI. Momentary Average Interruption Frequency Index. The average number of momentary interruptions experienced by a customer in a given year. A momentary event consists of a single customer interruption lasting less than one-minute (this is the threshold used by the Florida Public Service Commission).

MAIFIe. Momentary Event Average Interruption Frequency Index. The average number of momentary interruption events experienced by a customer in a given year. A momentary event consists of one-or-more customer interruptions that occur during a one-minute time period (this is the threshold used by the Florida Public Service Commission).

OSHA. Occupational Safety and Health Administration

OH. Overhead. This refers to electrical equipment that is mounted on poles or towers.

O&M. Operations and maintenance. This typically refers to a category of cost

OMS. Outage management system. This is a computer software system that track outages and interruptions. OMS data is often used to compute reliability indices.

PURC. Public Utility Research Center

RFP. Request for proposal.

SAIDI. System Average Interruption Duration Index. This is the average number of interruption minutes experienced by a customer in a given year.

SAIFI. System Average Interruption Frequency Index. This is the average number of sustained interruptions experienced by a customer in a given year. A sustained interruption occurs when a customer loses power for more than one minute.

UG. Underground. This refers to electrical equipment that is located either below the surface or on concrete pads.

URD. Underground residential distribution. This typically refers to a type of underground electric distribution construction.