Electricity Savings "Soon Come" to Jamaica -- Assessing the Potential for Air Conditioning and Refrigeration End-Use DSM

Thomas Conlon, RLW Analytics, Inc.
Ed Hamzawi, RLW Analytics, Inc.
Volton Campbell, Jamaica Public Service Company

ABSTRACT

With the support of the Inter-American Development Bank, the Global Environment Facility of the World Bank, and the Rockefeller Foundation, the national electric utility in Jamaica (Jamaica Public Service Company) has begun an assessment of the technical, economic, and financial opportunities for achieving demand-side management (DSM) energy savings in the air conditioning and refrigeration end uses. The feasibility and cost effectiveness of specific measures is being assessed for both the residential and commercial segments. While structured as a traditional load-research-based market assessment, the project uses ethnographic data collection and analysis techniques and involves collaboration with local contractors. The skills of local experts are being tapped to identify and interview the key market players, and to develop an understanding of the barriers to and opportunities for energy efficiency present in the evolving equipment markets. The paper outlines methods and presents preliminary case study results for the air conditioning market. We identify major groups of market players and dominant types of equipment, and provide an overview of market dynamics. The volume of sales passing through both formal and informal distribution channels is estimated and market barriers are identified. Based on the findings of the study, recommendations will be made for future program and policy initiatives designed to mitigate selected barriers in each of the supply chains.

Introduction

Jamaica is the largest English speaking island nation in the Caribbean (4,244 square miles; 10,991 km^2). Some 2.5 million people of African, Asian, and European descent enjoy salubrious weather year-round. Traditionally an agrarian society, foreign exchange income comes primarily from minerals (bauxite, alumina, gypsum) tourism, and agricultural products (sugar, rum, bananas, and coffee). In 1996, peak electrical demand reached 431 MW (gross) on December 19th at 6:30 PM.

Background

This project is part of a larger effort underway since 1990 to develop and implement demonstration pilot programs aimed at identifying the costs and benefits of energy savings measures applied to electricity consumption in Jamaica. Targeted sectors include Residential, Small Commercial, and Large Commercial (New and Retrofit) customers. Total project funding is US $12.5 million dollars, and the demonstration project duration is through 1998. A number of consultants from Jamaica, the US, Canada, and elsewhere are engaged in various independent project initiatives. All aspects of the project will build upon the existing institutions in Jamaica and the strengthening of these institutional capabilities is a key component of the program.

Explicit objectives include creating within Jamaica Public Service Company (JPSCo) the capability to design, implement, and evaluate full scale sustainable demand-side management programs, to integrate DSM resources into the system planning process, and to set in place the organizational structures to support ongoing energy conservation programs. Lessons from past development projects in Thailand, the Philippines and elsewhere have shown that in order to realize potential energy savings over the long term, it is essential to provide adequate technical assistance for institutional development, equipment testing, and program design and implementation, and to demonstrate clearly to both the utility and consumers the viability of demand-side management measures.

Scope

The research effort involves two separate but parallel studies of the interrelated air conditioning and refrigeration end-use equipment markets; a freestanding report will result from each study. RLW Analytics, Inc. (RLW), a US-based international energy consulting firm, is providing research design, analytical, and reporting services for both studies. RLW is the prime contractor for the air conditioning market assessment. Two Jamaican firms are also active on the project. Alberga Graham Jamaica (AGJ) is prime contractor for the refrigeration market assessment and, with Winvar Ltd., will be performing on-site and telephone data collection and assisting in the analysis and recommendation tasks for both studies. This collaborative approach enables consistent research design, joint data collection, and comparability in the two analyses. It also maximizes project cost-effectiveness and encourages the bilateral transfer of technical capabilities and local knowledge.

The objectives of the project are to:

1. Characterize the existing condition of the air conditioning and refrigeration markets in the residential and commercial sectors.
2. Assess the sales volume of various types of air conditioning and refrigeration equipment from existing studies and by conducting surveys and interviews.
3. Establish guidelines for categorizing existing and emerging air conditioning and refrigeration units/technologies based on efficiency and local environmental considerations.
4. Establish the technical and economic potential for measures that improve air conditioning and refrigeration equipment efficiency in Jamaica, including estimates of benefit/cost ratios for various technical options to customers, utility, and society.
5. Identify obstacles to the growth of this efficiency market, and solutions that may be provided to eliminate these obstacles.
6. Make recommendations for the implementation of pilot air conditioning and refrigeration efficiency programs.

Additionally, other studies reporting on experiences with similar issues in other developing countries are being reviewed for their applicability to the Jamaican context. The collected information and resulting recommendations will be used by JPSCo to develop minimum efficiency levels and incentive levels for the implementation of pilot programs.

The sectors and facility type segments to be considered are shown in Table 1. The intention in defining segments *a priori* is to over-sample and focus on those where savings potential is believed to be greatest.

Table 1: Customer Sectors and Facility Type Segments

	Small Commercial	Large Commercial
Commercial	Grocery	Grocery
	Hotel	Hotel
	Office	Office
	Restaurant	Restaurant
	Hospital	Hospital
	—	Other
Residential	(No Subsegments)	

The following section presents our methodology, summarizing the research approach and outlining the specific data collection and analysis methods we have chosen. Next, the results section presents preliminary findings based on the project's first round of data collection, primarily semi-structured interviews with leading air conditioning professionals. This section includes a preliminary characterization of the air conditioning equipment market in Jamaica, identifying perceived barriers to the adoption of energy efficient technologies and business practices. Finally, the conclusion section proposes a list of market barriers that are considered significant and potential targets for future program interventions. At this stage, these preliminary findings are considered working hypotheses, which will be tested after the remaining data collection is complete. Ultimately, they will form the basis for future program design recommendations.

Methodology

Data Collection

Structured as a traditional load-research-based market assessment, the project began with a review of secondary sources. These included a wide range of materials: past JPSCo-sponsored research studies, other perspectives on demand-side planning in Jamaica, and other background demographic and development policy references of relevance to the project (Reid 1995; Watson 1994). Limitations in current JPSCo load and market research were overcome through the use of pre-existing engineering estimates from the US and case studies from other developing countries (World Bank 1996; The Results Center 1994; NEPO 1992). Where necessary, we augmented these sources with new primary data collection: personal interviews of market actors and on-site equipment saturation and operating practices audits.

The market assessment was designed to provide baseline data on a broad scale in order to develop an island-wide perspective on how air conditioning and refrigeration equipment is distributed and utilized within the customer population. For this effort we took two views into consideration: first, the sources and quantity of equipment distributed through existing market channels (the supply side); and second, the penetration of this equipment into specific customer segments (the demand side).

For the supply-side characterization, the study used ethnographic data collection and analysis techniques and relied heavily on collaboration with the local consultants. The skills of local experts

were tapped to identify and schedule interviews with the key market actors, and to develop a richer understanding of the barriers to, and opportunities for, energy efficiency in Jamaica's unique and changing equipment markets. The types and volume of sales passing through both formal and informal distribution channels were also estimated through market actor survey responses. It is not often easy to extract the needed sales data and to unravel the relative roles of market players at various levels of the distribution chain (Harriss 1993; Conlon and Weisbrod 1996). Establishing credibility and rapport — and communicating the promise of confidentiality — were all considered critical to the success of the interviews. This was accomplished through professional presentation (hand-delivered pre-notification letters by utility staff), known personal contact telephone recruiting (through the assistance of the local contractors), and the technical preparation of the personal interviewer.

For the demand-side characterization, commercial on-site audits were deemed necessary to collect equipment saturation and building characteristics data. These were drawn from separately developed samples of large and small commercial customers. Given cost constraints, a residential saturation survey from 1992 was considered a suitable alternative to new residential sector data collection. A recent billing system extract was used as the large commercial sample frame; model-based statistical sampling was used to optimize the statistical precision of the sample sizes used (60 on-site; 100 telephone). An additional 60 small commercial customers were sampled for on-site audits by means of a randomized technique using the Greater Kingston and "Country" telephone directories. [1]

Data Analysis

The project's main analytical tasks are the interpretive assessment of the market actor interview data and the quantitative analysis of the facility audit results. These analyses provide the context for and inputs to the measure potential analyses (technical, economic and financial) upon which the final recommendations will be based. The market characterization was designed to identify the structure, actors, and processes by which the air conditioning and refrigeration markets function. The focus of this assessment was to identify existing barriers to the market allocation of otherwise cost-effective energy efficient goods and services. Most barriers to energy efficient measure adoption found in other market assessments (Eto, Prahl and Schlegal 1996; Conlon and Weisbrod 1998) can be described as belonging to one of the following types:

- Insufficient or inconvenient product availability options (e.g., stocking barriers)
- Insufficient access to investment capital
- Insufficient information to evaluate energy-related alternatives
- Distrust of the credibility of the information source
- Bounded rationality in decision-making, even when presented with credible information
- Organizational limitations that preclude known 'best practices' from being implemented
- Barriers to new market entrants offering competitive products or prices
- Barriers to new product development or product feature disaggregation
- Additional costs internal or external to the price of a good or service that are not included in that price (positive and negative externalities).

[1] Large commercial facilities were selected first and screened out of the small commercial sample. Without population data, estimates of statistical precision could not be calculated for the small commercial group.

Once all relevant market barrier data are gathered and collected, the available data on market barriers will be analyzed by customer segment (residential and commercial), new construction versus existing construction, and business type (grocery, office, restaurant, hotel, or other) for commercial customers. Differences between customer groups will dictate the various delivery mechanisms and marketing approaches for various segments through different programs. Complementing the primarily qualitative assessment of measure adoption barriers, the study will also quantitatively assess measure potential for each measure category and market segment. There will be three stages to the assessment of measure potential (Gellings and Chamberlin 1993; EPRI 1991):

- ***Technical Potential***: *Pure* technical potential includes all applications of a measure regardless of cost. In this analysis, we will analyze the more useful definition of *practical* technical potential. For *practical* technical potential, measures are only considered if they meet certain economic criteria, i.e., within reasonable payback and first cost investment limits.

- ***Economic Potential Screening***: For those measures that have a reasonable level of viability from the technical potential perspective, the economic potential will be considered. Economic potential considers whether each measure type can be cost-effective given the expected savings, costs and the utility's avoided costs. At this level, the Total Resource Cost (TRC) test will be applied to determine measure cost-effectiveness. In this analysis, we will ignore the effects of participation rates or base program costs. These effects will be captured in the subsequent financial potential analysis of the various program options.

- ***Financial Potential***: Once measures have passed the economic potential screening, various program options will be considered. This analysis will use varying estimates of participation rates under different program scenarios. The scenarios will differ by measure mix, marketing, promotional and delivery channels and financial assistance (financing or 10% subsidy).

Results

Because the study is still underway, only preliminary findings are available at this time. These fall into two categories: 1) Load research findings, based on our review of existing secondary sources, and 2) A preliminary characterization of the air conditioning equipment market, based on interviews with equipment dealers and consulting engineers. As a result of space limitations, only market characterization findings are presented here.

Market Characterization Overview

A total of 25 industry professionals were interviewed during a two week period in February of 1998. Most interviews were conducted one-on-one, in the offices of the subject. Respondents were sampled using a reputational case selection strategy (Miles and Huberman 1994). Our key informant/collaborators identified the firms and individuals they believed to be the major market players (i.e., those responsible for the greatest share of the respective product markets). These included 17 air conditioning and refrigeration equipment dealer/contractors and 9 consulting

electrical/mechanical engineers.[2] Five of the dealers interviewed sold residential refrigerators and chest freezers. Three of these were active exclusively in this stand-alone appliance market; the other two refrigerator dealers were broadly active in the commercial equipment markets as well. The commercial refrigeration and air conditioning markets were found to be highly inter-related. Of the 17 dealers interviewed, 14 were active in the commercial air conditioning business; of these, 9 were also active in the trade of commercial refrigeration equipment. Four main types of air conditioning systems are common in Jamaica:

- Chilled water systems
- Central DX systems
- Mini-split room air conditioners and
- Window/wall units.

Chilled water systems are found only in the largest buildings, especially office towers, hospitals and large central-plan hotels. New buildings at this scale are built infrequently, and only a limited number of firms have the technical and institutional capabilities to complete such a project. Most new or replacement machines are of the reciprocating type. This is said to be the result of owners' first-cost concerns and their limited appreciation for the operational savings that payback from scroll or screw type machines. Air-cooled condensers are most commonly installed as a result of three main barriers to more efficient water-cooled alternatives: 1) inadequate water supply or water quality, 2) lack of skilled maintenance personnel, and 3) high initial cost. In 1997, approximately 22% of the tonnage installed in commercial applications (3,696 tons) was chiller-based.

Central DX (direct expansion, package and split) systems are common in mid-size buildings and larger sub-metered buildings with multiple tenants (retail malls, leased offices). Different customs duty rates for "components"[3] (15% GCT only) versus complete systems (28% Total) constitute an institutional barrier to the importation of package units so common in the US. A recent increase in package unit sales is attributed to the expansion of fast-food style restaurant and ice cream chains refusing to depart from their template building plans. In 1997, roughly 26% of all commercial tonnage (4,284 tons) involved DX machines.

In terms of both unit sales and tonnage, mini-split room air conditioners dominate the Jamaican market. These simple systems comprised approximately 47% of the commercial tonnage installed in 1997 (7,746 tons). Split systems conventionally come in trade sizes from 9,000 to 30,000 Btu/h. They consist of a free standing exterior condenser unit coupled with either a high wall-mounted or "cassette" ceiling-mounted interior evaporator. They are installed in a surprising variety of building types, wherever designers decide their low maintenance convenience and modular design flexibility is warranted. Window/wall type air conditioners are less common, comprising only 5% (816 tons) of the commercial market in 1997. The main arguments against their use are security risks, aesthetic concerns, and noise.

Figure 1 is a market structure diagram for the A/C equipment market. Arrows are weighted to indicate the volume and flow of goods. The major categories of market players are introduced below.

---

[2] One "consultant" performed enough installations to justify being counted in both categories.

[3] Experienced importers are careful to have their split system evaporators and condensers shipped in separate lots, thus avoiding the higher duty.

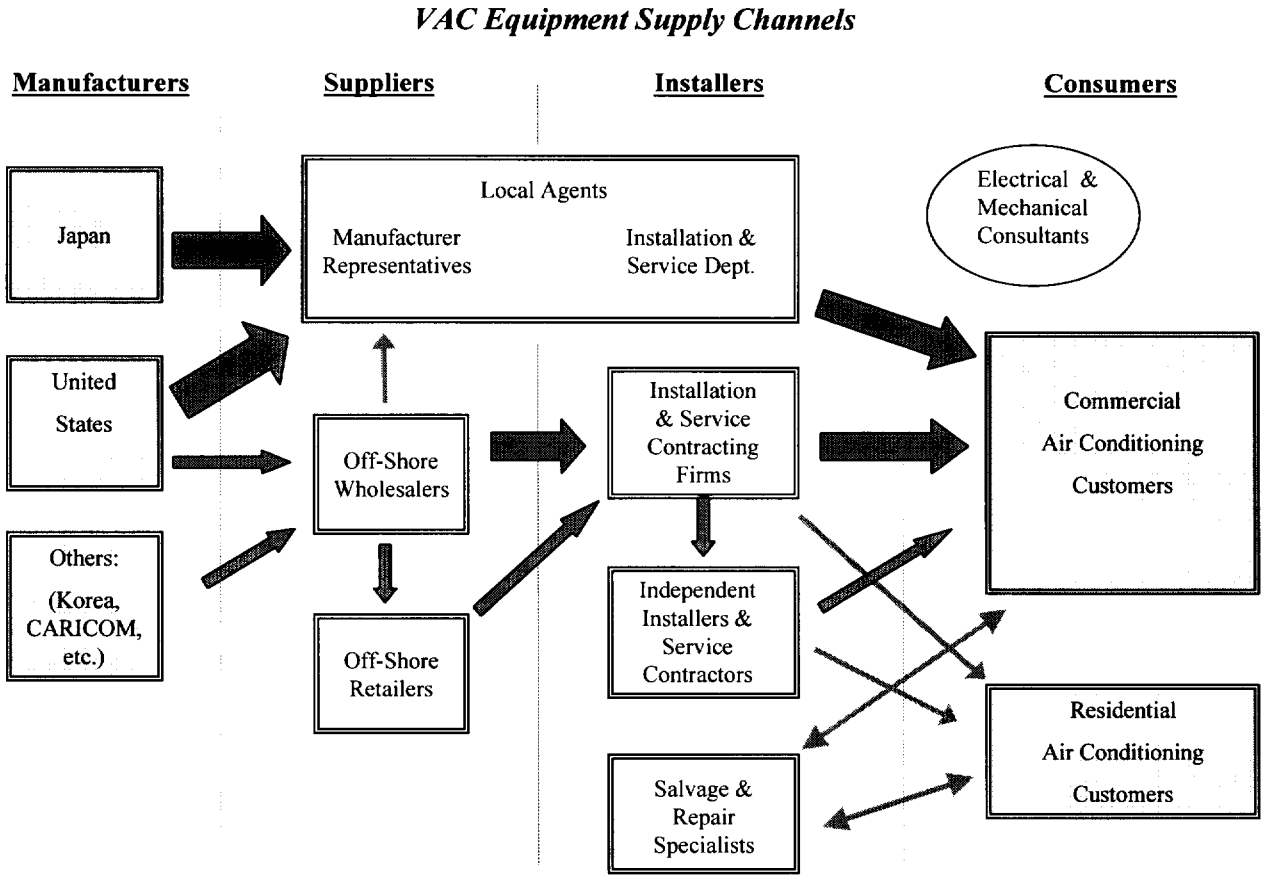

Figure 1. Air Conditioning Equipment Supply Channels

Manufacturers. Jamaica has no indigenous manufacturing of air conditioning or refrigeration system components. A/C equipment comes to Jamaica from many countries, but the major players are headquartered in the United States and Japan. Other countries of manufacture include Korea, Indonesia, Taiwan, Columbia, and Malaysia. Trinidad, one of Jamaica's Caribbean Community and Common Market (CARICOM) trading partners, also manufactures and assembles both air conditioning and refrigeration systems which are sold in Jamaica. European manufacturers generally do not compete in the market, because shipping costs render their products too expensive to be competitive.

Suppliers. Equipment suppliers to Jamaica fall into two main groups: 1) Island-wide distributors, so-called "agents", affiliated with the leading manufacturers, and 2) Off-shore exporters (often wholesale outlets operated directly by the manufacturers). A third and minor source of equipment, off-shore retailers, serves primarily the smallest of Jamaica's independent installation contractors who are venturesome enough to attempt to import equipment on their own. Most of the local agents are well-connected branches of Jamaica's most established business enterprises. They are typically operated by professional managers and technically skilled engineers. Some have represented the major manufacturers for generations while others represent newly arrived brands trying to gain a share of the market.

Installation and Service Contractors. In the air conditioning market, four distinct types of installation and service contractors were found to be placing orders for new equipment: 1) local agents, 2) independent dealer/contractor firms, 3) independent labor contractors, and 4) salvage and repair specialists. Data collection was concentrated within these first two groups. The majority of new and retrofit installation work is performed by a select group of local agents. Agents operate as vertically integrated importer/retailer/installers and often provide maintenance and repair services for existing installations as well. The "independent dealers" (installation and service contracting firms) are a group of smaller firms who lack exclusive distribution franchises with specific manufacturers. They operate by purchasing equipment from the local agents at wholesale prices, or by-pass the local agents by purchasing their goods directly from off-shore suppliers. Some members of this group do some limited retail trade as well. This group of firms are run by former agent employees or facility managers, and other entrepreneurial types who are increasingly competing with the established local agents. The independent labor contractors (independent installers and service contractors) are skilled technicians and semi-skilled laborers. When members of this group engage in residential or small commercial projects on their own, they generally purchase small tonnage equipment from the local agents or the independent dealers. Alternatively they hire out their labor to the local agents and independent dealers on a project-by-project basis. Finally, the salvage and repair specialists are primarily engaged in the repair and refurbishment of used systems and components. Some specialize in motor rewinding or in rebuilding compressors, while others simply replace worn out components with new ones. Of the 14 air conditioning dealers/contractors interviewed, 8 reported being agents for specific manufacturers.

Consulting Engineers. Though they do not typically engage in direct sales or installations, consulting engineers play an important role influencing the purchase of equipment. Most are broadly educated and qualified as both electrical and mechanical engineers. Their work tends to be concentrated on larger buildings where systems require the assistance of a design professional. Most are experienced primarily in air conditioning system design. Large refrigeration projects (warehouses and supermarkets) are usually designed either by a limited number of local refrigeration consultants (generally associated with some of the leading agents) or by engineers brought in from outside the country. Given their educational backgrounds, advanced social status, and habit of working on the largest construction projects in the country, consultants tend to be informed and well-connected far beyond the norm for consulting engineers in the United States.

Market Volume Assessment

All 14 air conditioning dealer/contractors responded when asked to summarize how many tons of equipment they had sold in 1997. Their responses totaled 20,973 tons. Because some of the independent dealers interviewed purchase a portion of their equipment from local agents, this quantity presumably counts such sales twice. Therefore the sum of the tonnage sold by just the 8 local agents interviewed is considered a more conservative starting point for estimating the volume of equipment in trade; this amount was 19,088 tons (91% of all sales reported by all those interviewed). Based on this reasoning, total tonnage handled in 1997 by all those surveyed is estimated to be roughly 20,000 tons.[4]

[4] One month (November 1997) of customs import data on whole A/C systems (252 units) was provided by the Statistical Institute of Jamaica. 89% of the records had sufficient data to determine tonnage. Nevertheless only roughly 350 tons were recorded for this purportedly better than average month (i.e., an annualized estimate of 4,300 tons). In contrast with the dealer reports, this data is believed to severely underestimate the total volume of equipment imported. This may be due to the practice of importing systems as "components" or other reasons.

Dealer/contractors and consultants were also asked to estimate what share of total product volume (in tons) they believed to be "by-passing conventional market channels", i.e. by-passing the local Jamaican agents through off-shore purchases.[5] All but one of the dealer estimates varied within the reasonably tight range of between 5% and 20% (10% mean), depending on the perspective and personal experience of the respondent. The one outlier response came from a mid-sized independent dealer who estimated that 60% of all equipment came in through such channels. Presumably this estimate was influenced by his personal experience. The four consultants who responded returned higher estimates of local agent bypass (15–50%, 34% mean), but were generally less confident of their ability to make such an estimate.

For this reason the dealers' more conservative estimates are considered more reliable. Given our confidence that our survey included the majority of major market actors, we estimate the volume of the air conditioning units entering Jamaica in 1997 to be approximately 23,000 tons. Table 2 documents the assumptions behind this estimate.

Table 2. Estimated Annual Air Conditioning Equipment Market Volume

The 8 agents surveyed represent approximately 90% of the volume handled by all agents	19,088 tons
Any remaining agents not surveyed represent approximately 10% of volume handled by all agents	1,909 tons
The volume of equipment by-passing local agents represents approximately 10% of all agents volume	1,909 tons
Estimated total volume of air conditioning equipment entering Jamaica in 1997	22,906 tons

Based on these data, we estimate most of this equipment (16,542 tons, 72%) is installed in commercial applications; the remaining 6,364 tons (28%) is going to residential applications. Despite a downturn in commercial construction activity in 1997 (discussed later), this finding suggests that the residential air conditioning sector has seen significant growth in the past six years. This interpretation is further supported by the continuing influx of new mini-split system brands into the market, and prominent outdoor advertising campaigns. A 1992 residential appliance saturation survey suggested that the percentage of households with air conditioning was only 1%.

While island-wide, the per household saturation of air conditioning no doubt continues to remain low, the residential sector's share of the this end use can no longer be considered insignificant.

[5] This form of by-pass is considered by those interviewed to be much more common than any true "informal sector" activity which "violates some law, official regulation, or generally accepted standards and/or codes of business behavior" (Witter and Kirton, 1990). While our respondents generally acknowledged that some small-scale operators may evade business registration, taxation (duty and/or GCT), or other formal sector norms (Anderson 1996), such marginal players are believed to constitute only a small and insignificant portion of the overall tonnage of air conditioning equipment currently imported into Jamaica. In contrast, the market for residential refrigerators involves much more of the aforementioned informal sector trade.

Market Dynamics

Of the 10 dealers who ventured an opinion on the agent by-pass trend over the past five years, 7 said it was increasing, 2 decreasing, and 1 said it was remaining constant. All 3 consultants believe this trend is increasing. Respondents' explanations of the factors influencing this trend provide insight into the market forces that are changing Jamaica's air conditioning industry.

Depressed Economy. By most accounts, 1997 was a poor year for Jamaica's new construction industry, particularly for the large scale projects that require more advanced technical and managerial skills to complete. Nearly all of the mechanical and electrical consultants and several of the suppliers of chilled water systems described sharply reduced revenue in 1997. These conditions led to staff downsizing and the pursuit of alternative business ventures. However not all members of the industry have been negatively affected. Tougher times were cited by many as driving greater competition between local suppliers, and encouraging enterprising independent dealers to seek out alternative sources, primarily through export wholesalers in Miami.

Historically the insularity and small scale of Jamaica's markets have limited the entry of new competitors, and led to higher margins for the relatively small number of dominant suppliers. According to one consultant, "What I notice is that the swing in the price of equipment is rising. Maybe now because the market is tight all this [market power of dominant suppliers] is breaking down". This encouraging finding suggests that market functioning may be improving.

As large office tower (e.g., banking, insurance, and governmental offices) and large hotel projects have become more scarce over the past year, mid-size commercial buildings (primarily smaller offices, retail, and chain fast-food restaurants) have gained a larger share of the overall market for air conditioning. The split and packaged DX air conditioning equipment most common in such mid-size buildings are said to be the types that are most likely to by-pass the local agents. Projects calling for larger chilled water systems usually involve clients that are more risk averse and prefer to pay a bit more to receive a guarantee from the local agent that the equipment will be properly specified and installed. Nevertheless some of the more technically sophisticated independents are bringing in some chiller system components directly. The popular mini-split room air conditioners are said to rarely if ever by-pass local agents, since the market has filled with competing brands in the last five years.

Proximity to the US Market. Jamaica's economy remains greatly influenced by that of the United States, less than two hours away by air. Miami in particular functions as the regional center of Caribbean commerce, and all the major manufacturers of large scale equipment have wholesale warehouses there. But Jamaica's relatively unique electricity infrastructure presents a continuing barrier to greater integration with the North and Central American equipment markets.

Jamaica's electricity distribution system operates at a frequency of 50Hz (110V single-phase; 220V three-phase; 415V three-phase). All equipment manufactured for the US market is designed to run at 60Hz. As a result, most suppliers in Miami don't routinely stock the 50Hz equipment suitable for the small Jamaica, Trinidad, and Barbados markets. Instead Jamaican importers (either agents or independents) have two alternatives: 1) wait a minimum of 4-6 weeks (and often as much as 16

weeks) to special order 50Hz equipment, or 2) purchase 60 Hz equipment, usually off-the-shelf and at a lower price.

Frequency matching problems occur most often with the mid-size DX equipment. Smaller mini-split systems generally come from Japanese manufacturers and are already optimized for Japan's 50Hz system. Larger built-up systems usually are installed in projects where the long lead times can be anticipated. Consultants uniformly reported specifying 50 Hz equipment and manufacturers warned that warranties become void when equipment is installed where electrical conditions fail to meet design specifications. But the dealer/contractors explained the practical limitations they must face.

As a result, it appears that well over half of the DX systems installed in Jamaica are fundamentally designed to operate at 60Hz. Some argue that almost none of these systems are truly optimized for 50Hz operation. Firm estimates are hard to determine since a number of methods for retrofitting 60 Hz equipment were described:

1. No change whatsoever, US rated equipment installed at US rated capacity
2. Simply change the nameplate (de-rating capacity by an estimated factor of 50/60)
3. Oversize equipment (10% – 20% reported) to account for capacity degradation
4. Replace motors with 50Hz motors and/or install larger fan coils to increase capacity
5. Install transformers to boost voltage (208 to 220V; 415 to 480V) to meet motor tolerances
6. Replace starter controls with 50 Hz rated equipment

Some manufacturers apply nameplates bearing a "50/60" frequency rating. Some contractors said they respond to this situation by letting a consultant or the equipment supplier determine the capacity of such a machine when operating at 50 Hz. Others assume the motors are optimized for 55 Hz and de-rate accordingly. Most reputable dealers take steps to ensure that such equipment is properly modified as necessary to prevent premature failure, burdensome callbacks, and to uphold their reputations. Several however stressed that a person buying from abroad is typically less technically sophisticated. Looking for what they think is a bargain, these independent dealers may not install all the components needed to protect the equipment from overloading, phase loss, or premature starter control or motor burnout.

A wide range of opinions exist on the magnitude of the effect these frequency-related issues have on overall system efficiency. Some assume that current DX installation practices are inherently inefficient "just eating up kW for nothing" with a penalty of approximately 15%. Others argue that through proper mitigation measures (starters, transformers, over-sizing, etc.) the efficiency penalty can be cut to almost nothing (1½ %). This is an area where further empirical testing is clearly needed.

Some dealers seemed hopeful that this situation may be improving somewhat. As US manufacturers increase their attempts to penetrate the Japanese (50 Hz) market, more alternatives should become available and lead times for "true" 50 Hz equipment should go down. Another dealer described a trend toward bringing in more European equipment where 50 Hz equipment is more common, but given the distance, lead times tend to be no better.

Conclusions

At this stage of the project some tentative conclusions can be drawn to identify several barriers impeding the potential for high efficiency equipment market penetration. These are:

- Water supply and water quality management barriers constraining consultants from specifying high efficiency water-cooled condensers
- Limited technical training of maintenance and service personnel, leading to diminished operating efficiencies over time and the reluctance of consultants to specify high efficiency equipment that requires more skilled and fastidious attention to maintenance
- Lack of understanding and trust on the part of most owners in the net present value benefits of high efficiency equipment investments
- Lack of ready and hassle free availability of high efficiency model alternatives
- JPSCo's 50 Hz system frequency which leads to a large number of units operating outside their design conditions and which encourages systematic over-sizing practices
- Lack of availability of 3 phase power and high voltage service in many areas leading to high capacity equipment operating at sub-optimal electrical conditions
- High market finance rates, which constrain the ability of actors at all levels of the market to invest in incrementally more expensive high efficiency goods and services
- Customs duties which distort the demand for package vs. split equipment and yet apparently provide no incentives for energy efficient, CFC-free, or other public policy objectives
- Lack of awareness of Jamaica's Energy Efficient Building Code, leading to missed opportunities to achieve long term energy savings at the time of lowest initial cost
- Market power of established large firms and their ability to wield competitive advantage against new market entrants throughout the small and interrelated network of Jamaican commerce.

These barriers and others will be explored in the subsequent stages of the study. Ultimately some of these may become the targets of future JPSCo program interventions.

Acknowledgements

The authors wish to thank all the very helpful people who filled our data requests, answered our tireless questions, and made this paper possible. In particular we appreciate the candor and efforts of the members of Jamaica's air conditioning and refrigeration industry, the Demand-Side Management Unit and Load Research Department of Jamaica Public Service, Alberga Graham Jamaica, Winvar, Ltd., the Jamaica Bureau of Standards, and the Jamaica Air Conditioning, Refrigeration, and Ventilation Association, and the Statistical Institute of Jamaica. Finally we wish to acknowledge the financial and technical support of the Inter-American Development Bank, the Global Environment Facility of the World Bank, and the Rockefeller Foundation; without their support this project would not have been possible.

References

Anderson, P. 1996. *Out of the Shadows: The Institutional Framework and Small-Scale Manufacturing Enterprises in Jamaica*, in Tokman and Klein 1996. Regulation and the Informal Economy: Microenterprises in Chile, Ecuador and Jamaica. Lynn Rienner Publishers, London.

Conlon, T., and G. Weisbrod, 1996. *Market Transformation Studies are Only as Good as the Data They are Built On: Evaluating the Long Term Impacts of a Builder Rebate Program.* in Proceedings: 4th National Energy Efficient New Construction Conference, ADM, Vancouver BC.

Conlon, T. and G. Weisbrod, 1998. *Southern California Edison Hydraulic Services Program market Effects Study Final Report.* Sonoma CA: RLW Analytics, Inc.

Eto, J., R. Prahl, and J. Schlegel, 1996. *A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs.* Ernest Orlando Lawrence Berkeley National Laboratory.

EPRI 1991. End-Use Technical Assessment Guide. Palo Alto, CA: Electric Power Research Institute.

Gellings, C., and Chamberlin, J. 1993. *Demand-Side Management Planning.* Fairmont Press, Inc.

Harriss, B. 1993. 'Talking to Traders About Trade'. In S. Devereux and J. Hoddinott (eds.). *Fieldwork in Developing Countries,* Boulder, CO and London, UK: Lynne Rienner Publishers, Inc.

Miles, M., and M. Huberman 1994. *Qualitative Data Analysis: An Expanded Sourcebook,* Second Edition. Thousand Oaks CA: Sage Publications.

National Energy Policy Office-Thailand (NEPO) 1992. *Energy Conservation Promotion Strategy For Thailand: Discussion Paper* (Prepared by B.C. Hydro/Power Smart Inc. in association with Monenco Consultants Ltd., Canadian International Development Agency Technical Assistance Project #906/14299.) Bangkok, Thailand.

Reid, G. 1995. *Shocks and Strategies: Jamaica and the Caribbean Development Bank.* Ottawa Canada: The North South Institute.

The Results Center 1994. *The Philippines Residential AirCon Standards & Labeling Profile #117.* Aspen CO: The Results Center IRT Environment, Inc.

Watson, H.A. 1994, *The Caribbean in the Global Political Economy,* Boulder & London: Lynne Rienner Publishers, Kingston: Ian Randle Publishers.

Witter, M., and C. Kirton, 1990. *The Informal Economy in Jamaica: Some Empirical Exercises*, Working Paper #36. Institute of Social and Economic Research, Univ. of West Indies, Kingston.

World Bank 1996. Thailand - Promotion of Electricity Energy Efficiency, Mid-Term Review, GEF Grant No. TH-28637 (prepared by Infrastructure Operations Division, County Department 1, East Asia and Pacific Regional Office, and Asia Alternative Energy Unit, Asia Technical Department).