Opportunities for the Hydrocarbon Refrigerant Market within CARICOM States

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Outline

- The Energy Situation
- The Climate Change Nexus
- The Caribbean ESCO Experience
- Future Development

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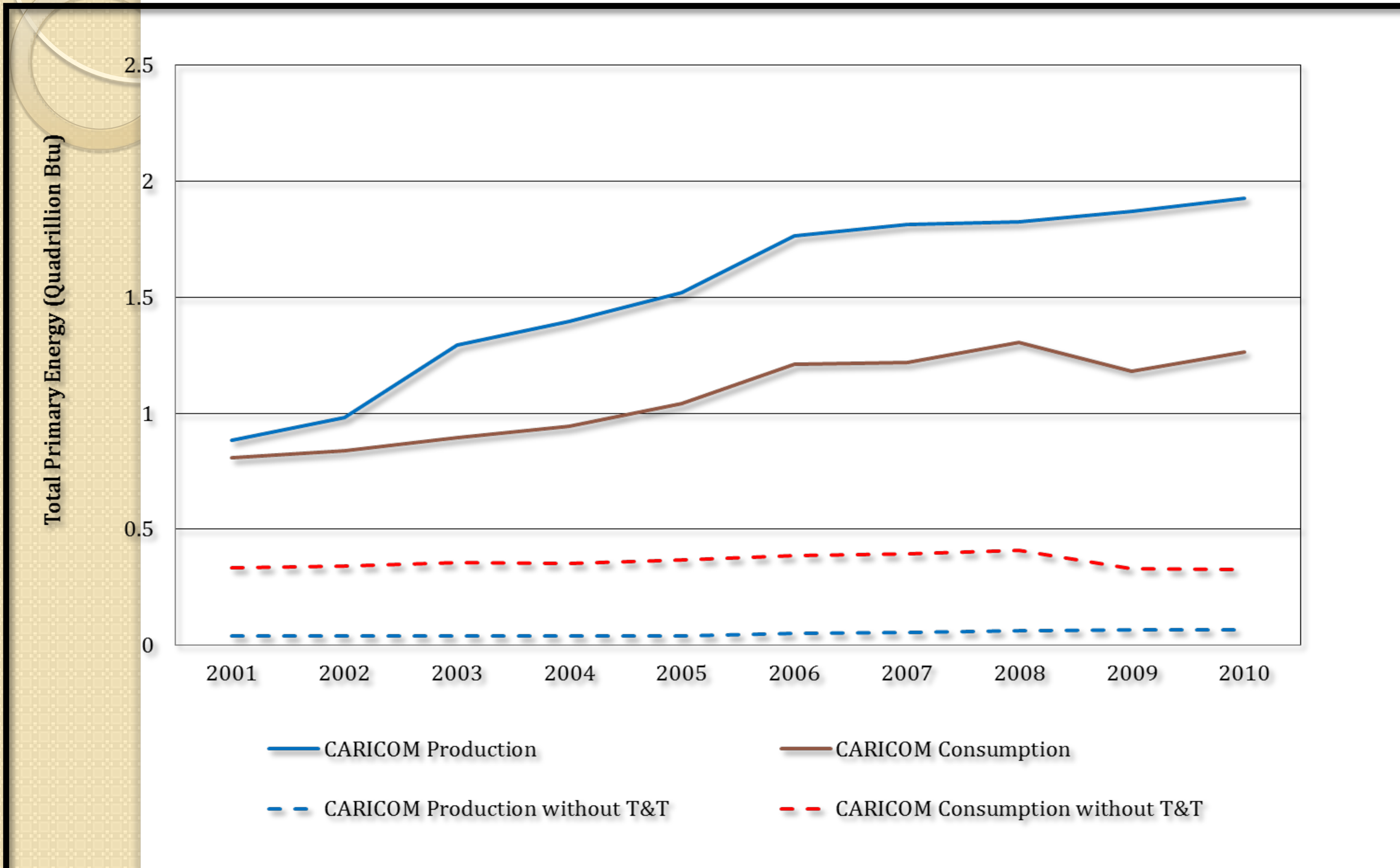
CARICOM Energy Production and Consumption Trends

Source: CARICOM Sustainable Energy Roadmap and Strategy (2013)



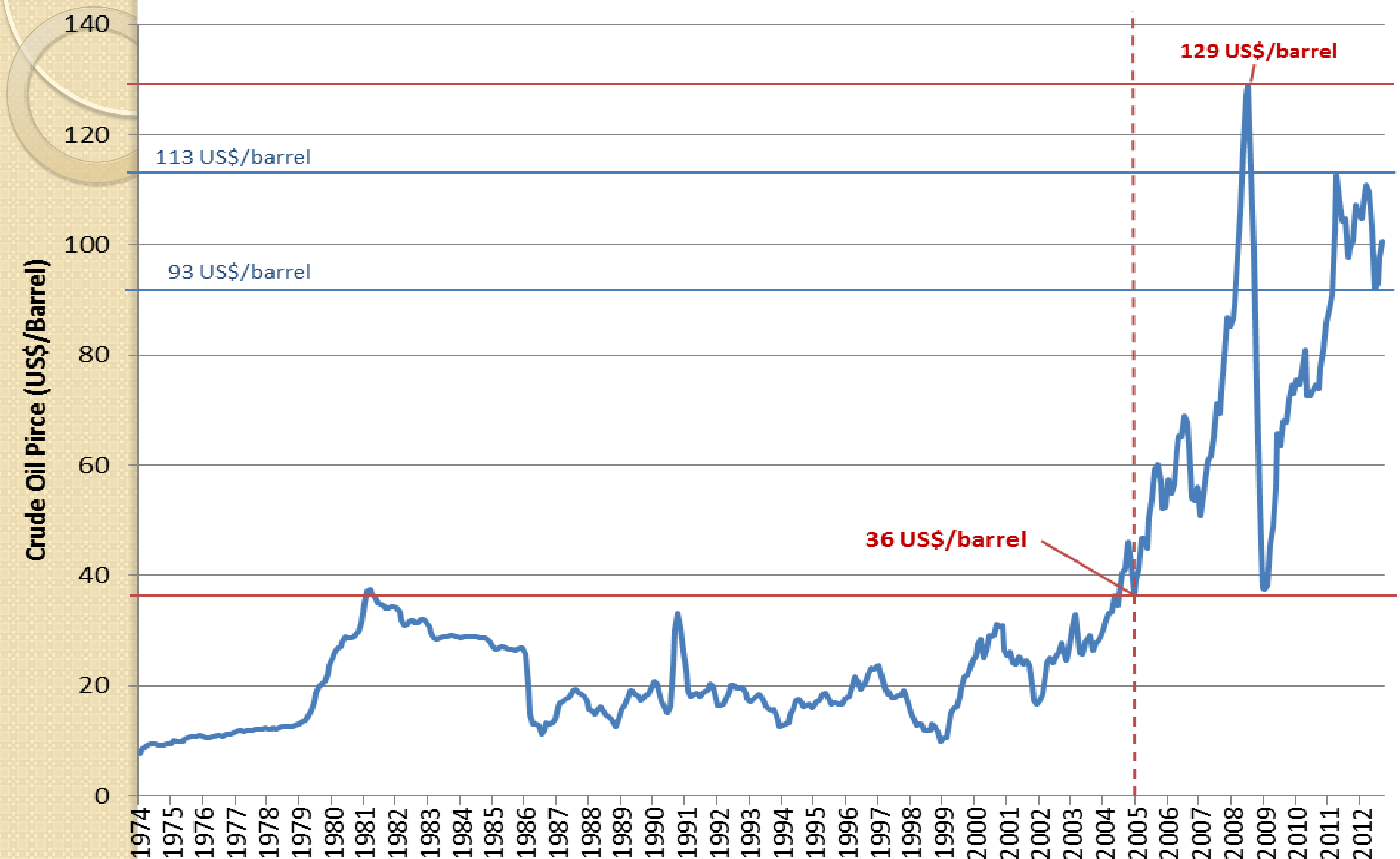
CARICOM (excluding Haiti and Montserrat) Annual Liquid Fuel Consumption (2011)

Source: SIDS DOCK. Capacity Building Strategy (**2013**)

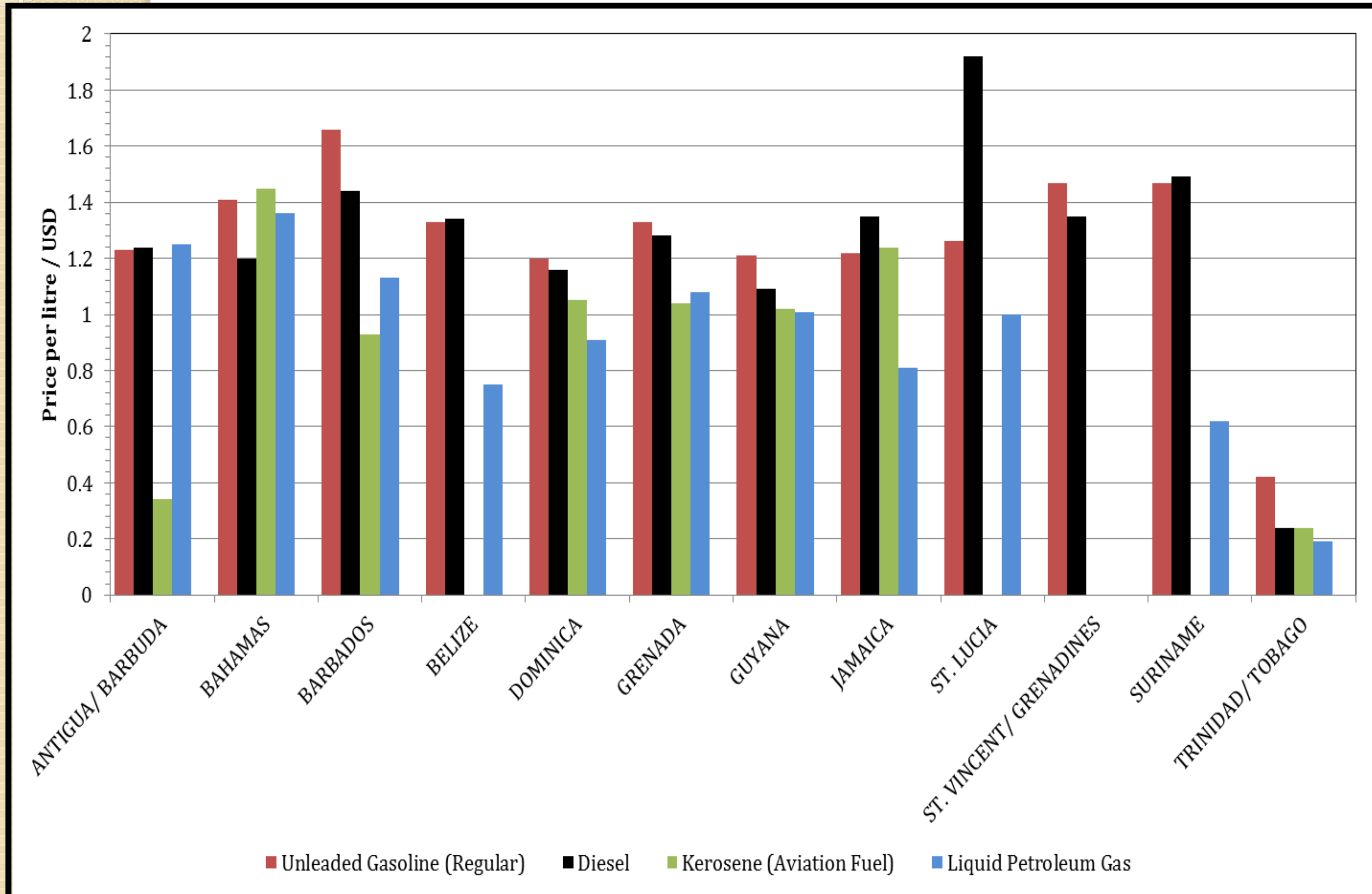
Country	Liquid Fuel Consumption (000's barrels)			
	Total	Power Generation	Transportation	
			Gasoline	Diesel Oil
Antigua and Barbuda	1,251.1	560.2	304.5	386.4
The Bahamas	9,408.2	4,750.2	1,692.0	2,966.0
Barbados	2,726.3	1,241.6	811.7	673.0
Belize	1,148.9	142.9	354.7	651.3
Dominica	328.8	74.9	106.4	147.5
Grenada	647.8	202.5	163.4	281.9
Guyana	3,403.0	744.0	747.5	1,911.5
Jamaica	14,602.9	6,225.9	4,398.0	3,979.0
St. Kitts & Nevis	548.8	187.4	132.1	229.3
St. Lucia	1,390.2	456.4	351.4	582.4
St. Vincent & The Grenadines	666.5	155.6	167.3	343.6
Suriname	2,073.4	493.0	634.6	945.8
Trinidad and Tobago	5,056.6	18.7	3,101.3	1,936.6
Total CARICOM	**43,252.5**	**15,253.3**	**12,964.9**	**15,034.3**

Refiner Acquisition Cost of Crude Oil, Composite (1974-2012)

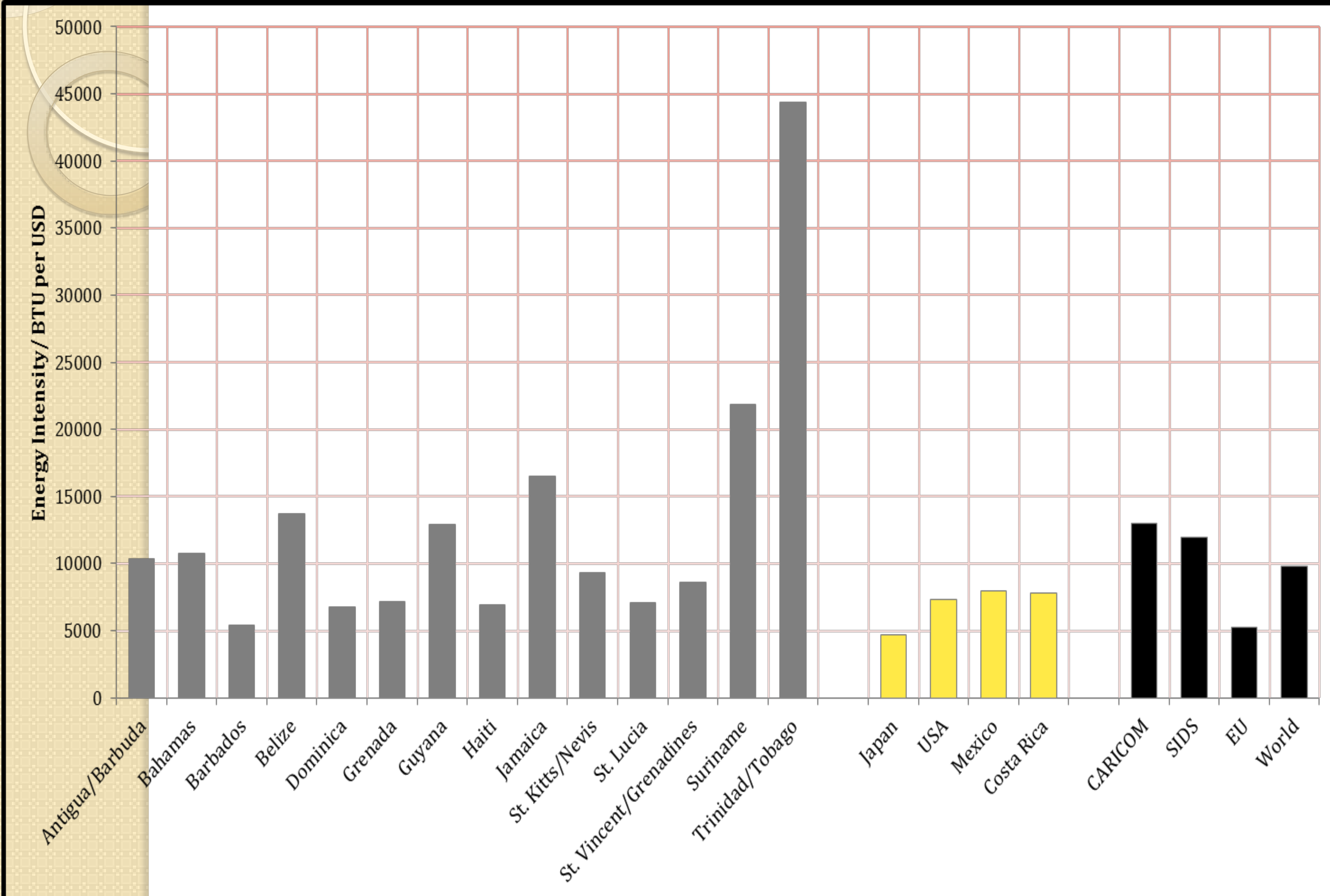
Source: U.S. Energy Information Administration, Energy Review (December 2012)



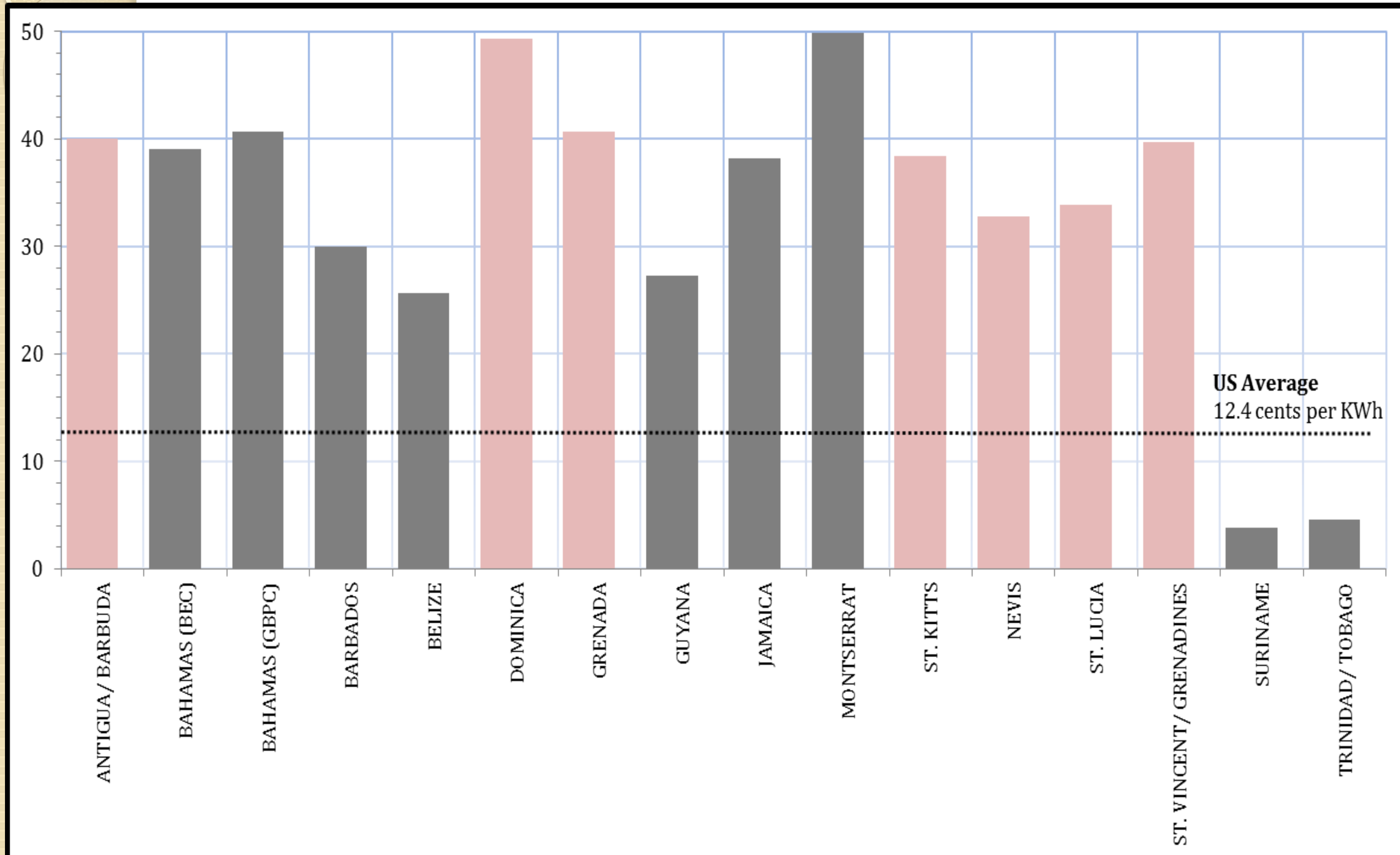
Retail Prices for Petroleum-derived Liquid Fuels (USD per litre), February 2013



Energy Intensity, CARICOM States (2012)
Source: UN Statistics Database



Average Retail Prices for Electricity (US cents per kWh), 2012



CARICOM Energy Sector

Technical

- Isolated grid networks
- Small overall generation capacity
- Inability to meet existing and future demand
- Outdated equipment
- Low efficiency

Socioeconomic

- High electricity tariffs
- Vulnerability to rising, volatile fuel prices
- Missed opportunities for domestic investment and jobs
- Energy poverty

Environmental

- Local air, freshwater and ocean pollution
- Deforestation
- Degradation and depletion of natural habitats, ecosystems and resources
- Global climate change

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What do we know?

- **1896:** Fossil fuels such as coal, would add CO_2 to the Earth's atmosphere & raise the planet's average temperature.

- **1930's:** Callendar insisted that anthropogenic climate change was responsible for North Atlantic temperature rise.

- **1991:** Mann first published the "hockey stick" graph.

- **2001:** IPCC-AR3 stated that anthropogenic climate change was "real".

- **2007:** IPCC-AR4 stated states unequivocally that **Caribbean SIDS are among the most vulnerable to the projected impacts of climate change.**

- **2013:** IPCC-AR5 states that **human influence on the climate system is clear**: since the 1950s, many of the observed changes are unprecedented over previous decades to millennia.

Climate Change Concerns

- Climate change is an ***energy-related issue*** as an estimated 80% of Greenhouse gases (GHG) are generated by the energy sector.

- Climate change is really "the dark side of fossil fuel"; **the world is facing a great challenge to significantly *decouple fossil fuels from their energy economies*.**

- A number of refrigerant gases have very high Global Warming Potential (GWP); if left unchecked, HFC emissions in 2050 are predicted to represent 9-19 per cent of global GHG emissions [IEA].

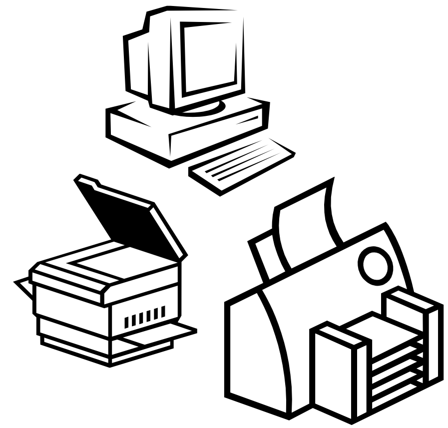
- **USD 86 billion per year will be required to support adaptation activities in developing countries [UNDP].** The majority of these countries are already stressed economically due to the *volume of GDP and foreign exchange resources* that are being spent to pay for energy imports; these monies could have otherwise been directed to adaptation to climate change, alleviating poverty, and other critical social interventions.

Within the Caribbean

- Hotter temperatures, sea-level rise and increased hurricane intensity.
- **Caribbean population is largely concentrated in coastal areas.**
- More frequent and longer droughts.
- Coral reef habitats are stressed by warmer waters.
- Accelerated erosion of coastal beaches, land and protective mangroves.
- Increased hurricane damages, loss of tourism revenue, and infrastructure damages.
- **Estimated cost under BAU is US$22 billion annually by 2050 and US $46 billion by 2100, i.e. 10 per cent and 22 per cent of GDP respectively**

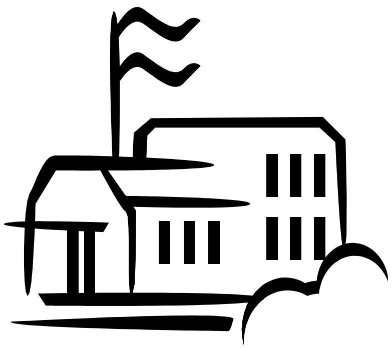
Crude Oil Price (US$)	Percentage of Petroleum Import Reduction for CARICOM SIDS (using 40 million barrels as a base)					
	Base Case Annual Expenditure by SIDS (Millions US$)	Resulting Level of Savings From 10 % Reduction (Millions of US$)	Resulting Level of Savings From 20 % Reduction (Millions of US$)	Resulting Level of Savings From 30 % Reduction (Millions of US$)	Resulting Level of Savings From 50 % Reduction (Millions of US$)	Resulting Level of Savings From 60 % Reduction (Millions of US$)
70	2,800	280	560	840	1,400	1,680
80	3,200	320	640	960	1,600	1,920
90	**3,600**	**360**	**720**	**1,080**	**1,800**	**2,160**
100	4,000	400	800	1,200	2,000	2,400
110	4,400	440	880	1,320	2,200	2,640
120	4,800	480	960	1,440	2,400	2,880
130	5,200	520	1,040	1,560	2,600	3,120
140	5,600	560	1,120	1,680	2,800	3,360
150	6,000	600	1,200	1,800	3,000	3,600

Some Opportunities for Efficient Energy-use



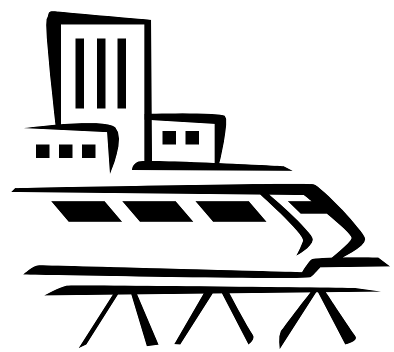
Office equipment,
up to 35%

- Computers, printers, etc.
- Photocopiers
- Energy management systems

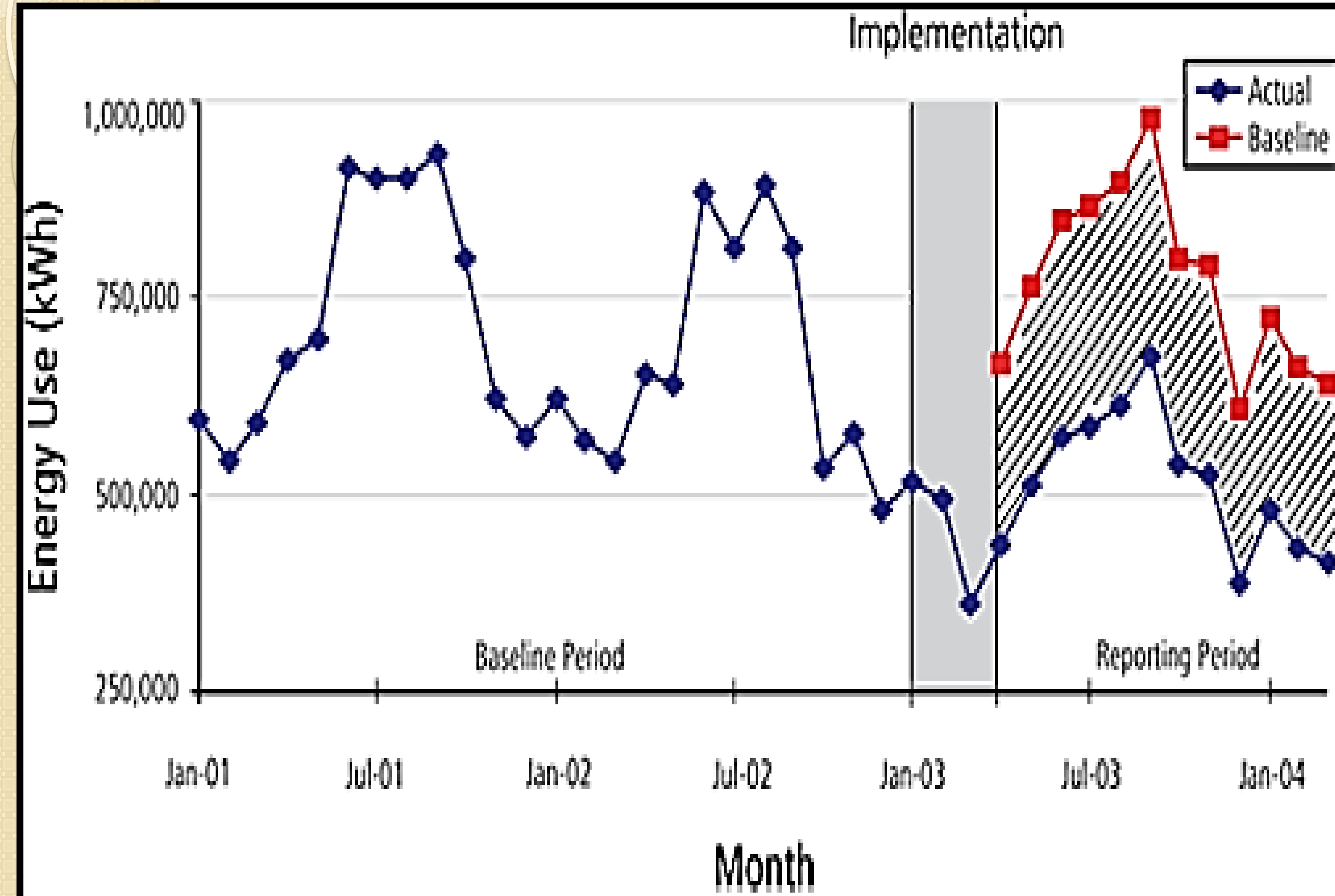


Buildings,
up to 30%

- Building envelope
- Lighting efficiency
- HVAC efficiency



Transport,
up to 20%



Reduction in demand due to EE

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- In December 2004, a pilot shipment of approximately 100 kg of hydrocarbon refrigerant blends, to be used as “drop-in” replacements for refrigerants R12, R134a and R22, was imported into Jamaica.

- This was done with the Ozone Unit of the National Environment Protection Agency (NEPA), in which they implemented a National Training Programme for a number of technicians.

- More than three hundred technicians were trained across the island, based on the code of practice developed by NEPA in July 2004.

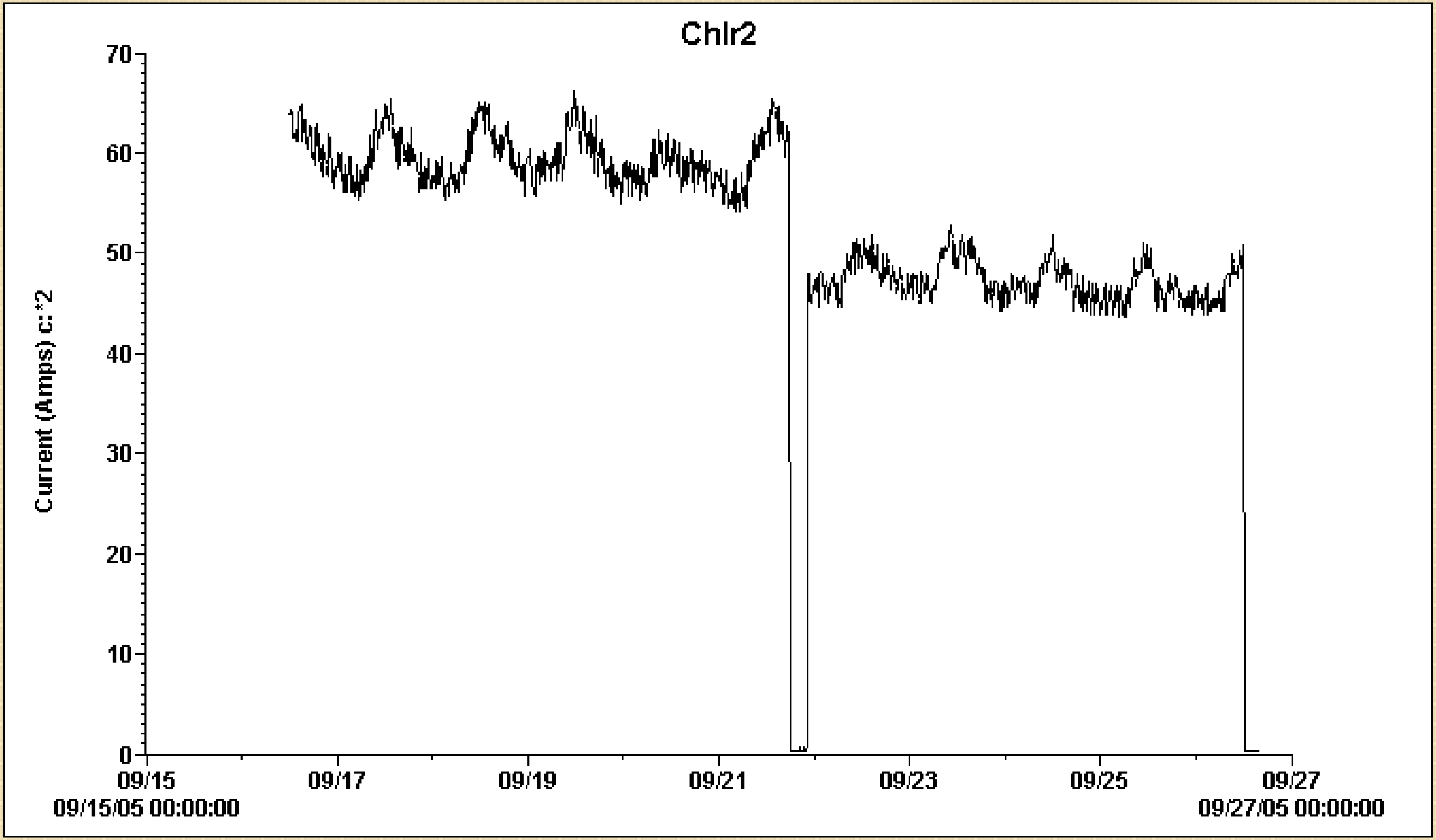
- We observed reduced electricity consumption in local appliances in which hydrocarbon refrigerants were used as a drop in replacement

- **THEIR PERFORMANCE EFFCIENCY OF THE HC REFRIGERANTS WERE SUPERIOR TO THE F-TYPE REFRIGERANTS DUE TO THE CHARGE WEIGHT OF THE FORMER BEING APPROXIMATELY 60% LESS THAN THAT OF THE LATTER**

- The results showed a general savings of up to 40% in energy-use and electricity cost; there were also additional savings due to improved maintenance cost benefits and extended equipment life

DURING THE CHANGE OUT EXERCISES, "BEFORE AND AFTER" PERFORMANCE DATA WERE COLLECTED FROM THE EQUIPMENT THAT WERE RETROFITTED.

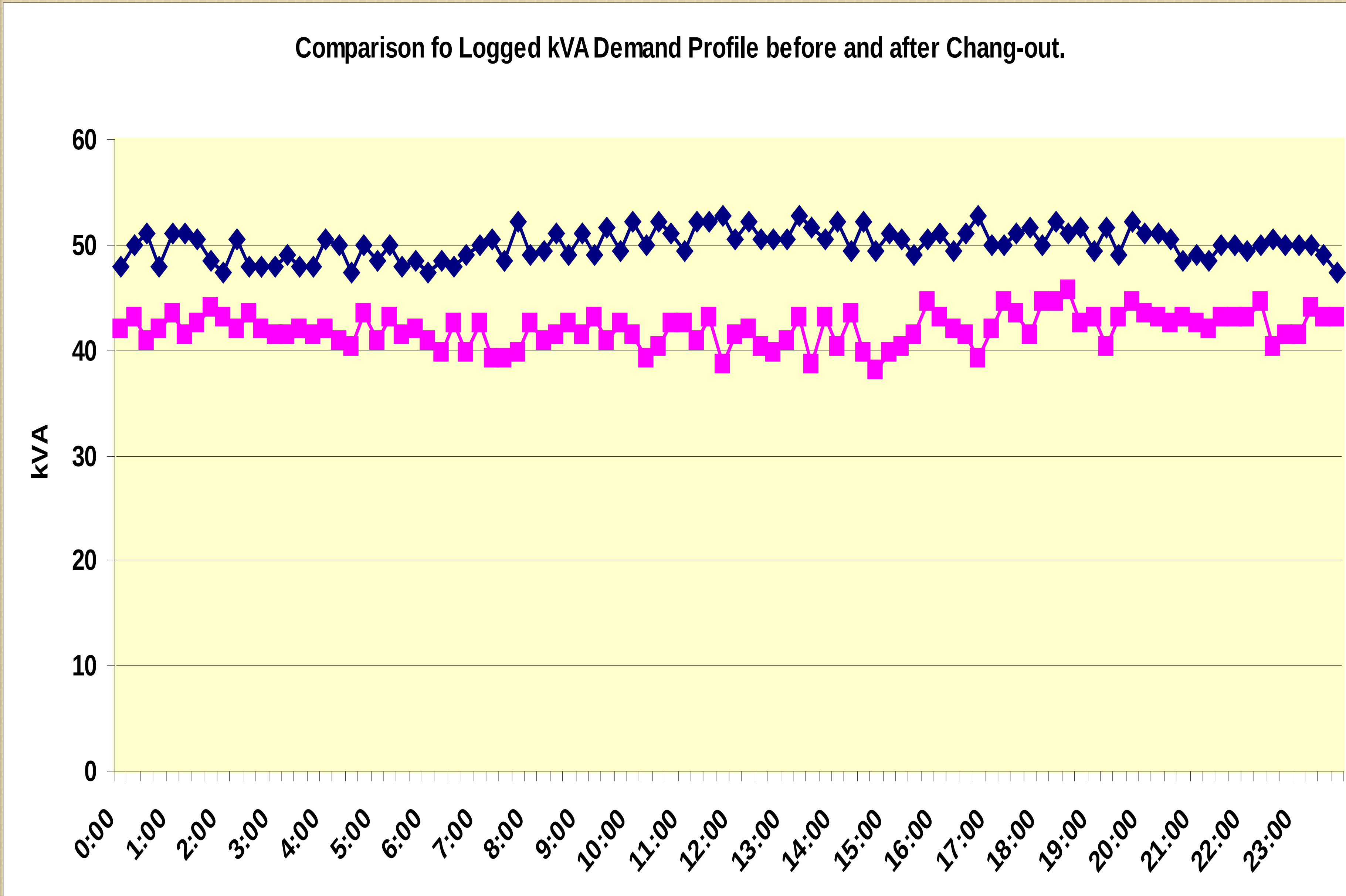
THE GRAPH BELOW SHOWS THE DIFFERENCE IN CURRENT DRAW BY A CHILLER COMPRESSOR BEFORE AND AFTER THE R22A RETROFIT.



THE TABLE BELOW PROVIDES A BREAK-DOWN OF THE PREVIOUS GRAPH AND CLEARLY SHOWS 28 PER CENT IN ENERGY SAVINGS.

DESCRIPTION							
UNIT TYPE & MODEL #		REF. CHARGE (lb)	VOLTS	AMPS	INPUT POWER (kVA)	Head Pressure	Suction Pressure
	BEFORI	105	400	72	50	360	70
	AFTER	42	400	60	42	260	60
	DIFF.			12	8.3	100	10
Chiller #3 Comp #2 .	% Diff.,			17%	17%	28%	14%

COMPARISON OF KVA DEMAND ON A TYPICAL DAY BEFORE AND AFTER HC RETROFIT



TECHNICAL AND FINANCIAL ANALYSIS OF A RETROFIT EXCERCISE

Breezes Runaway Bay

JPSCo Service rate	50
Demand Rate ($/kW)	$12.00
Energy Rate ($/kWh)	$0.13

ECO # 1: Chiller with Duracool Refrigerant

BASE EQUIPMENT INSTALLED (LOGGED): 1 of 2 X 50-ton circuits with R-22

Type	Quan	Capacity	Compressor	kVA/ton	Average	Op., hrs	Energy	Demand	Energy	Operating Cost
		tons	EER		kVA	hrs/yr.	kWh	kVA	kWh/yr	US$/yr
Trane Chiller # 3	1	50	12	1	50	8500	425,000	50	425,000	62,450
Total Existing		**50**						**50**	**425,000**	**62,450**

REVISED EQUIPMENT: Recover R-22 and Recharge with Duracool R22a

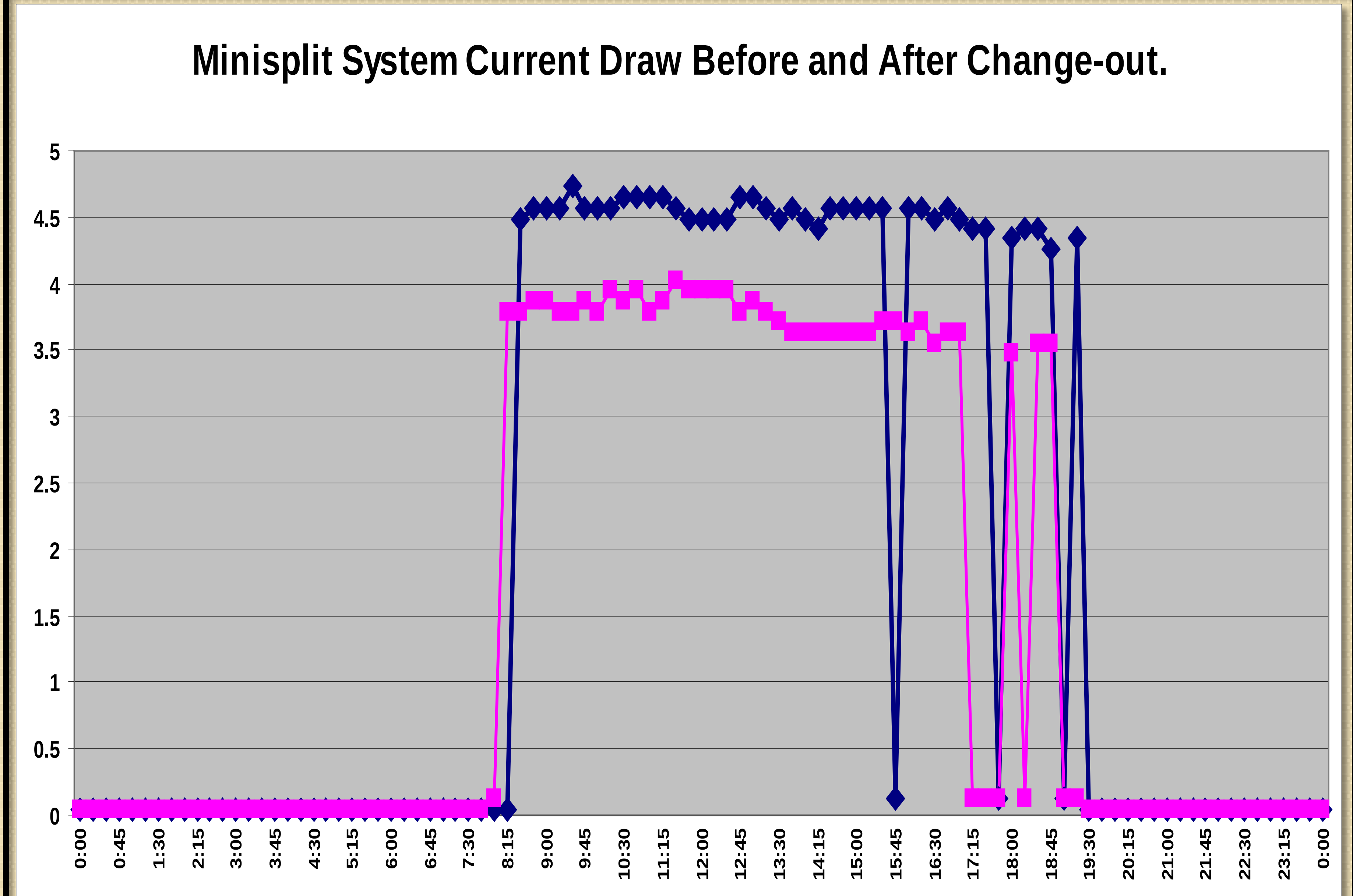
Type	Quan	Capacity	EER	kVA/ton	kVA	Op., hrs	Energy	Demand	Energy	Operating Cost
Trane Chiller # 3	1	50	14	0.8	42	8500	357,000	42	357,000	52,458
Total Projected								**42**	**357,000**	**52,458**

Measure Costs

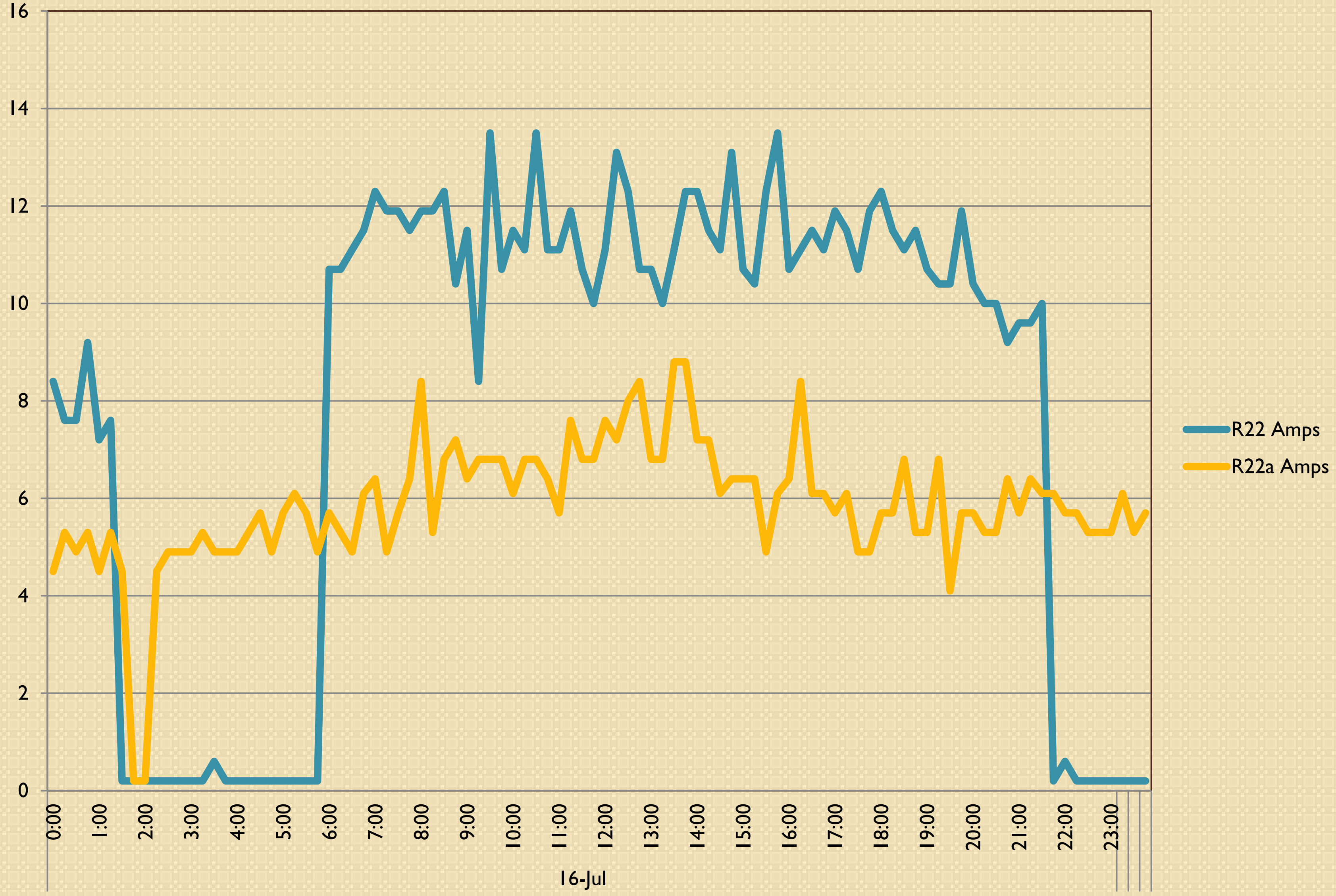
	Unit Cost	Total tons	Cost
Recherge with HC Refrigerant.			
Service, refrigerant leak test and changeout.	100.00	50	5,000
Maintenance savings			$ (500)
Total first year cost			$ 4,500

Project Cost			**$ 5,000**	**J$310,000.00**
Measure Savings				
Demand	**Energy**	**Cost**	**Payback**	
kVA	**kWh/yr**	**US$/yr**	**yr.**	
9	**68,000**	**$9,992**	**0.5**	
19%	**16%**	**J$ 619,504**		

THE FOLLOWING GRAPH AND TABLES REPRESENT A TYPICAL MINI-SPLIT AT AN EDUCATIONAL INSTITUTION SHOWING THE CURRENT MEASUREMENT BEFORE AND AFTER HC REFRIGERANT CHANGE OUT.



COMPARISON OF A TYPICAL CURRENT DRAW OF TWO SIMILAR A/C UNITS SERVING A SINGLE SPACE, ONE UNIT CHARGED WITH HC AND ONE WITHOUT.



CLIENT SAVINGS

		Unit Cost	Total tons	Cost
Refrigerant				
Total Capacity		70.00	1,350	94,500
Annual maintenance savings		15.00	1,550	(23,250)
Total first year cost				$ 71,250
	Project Cost			$ 94,500
	Measure Savings			
	Demand	Energy	Cost	Payback
	kVA	kWh/yr	US$/yr	yr.
	381	648,000	$118,584	0.6
	24%	20%		

DATA COLLECTED FROM A MINI-SPLIT A/C SYSTEM BEFORE AND AFTER HC RETROFIT

UNIVERSITY OF THE WEST INDIES

AIR CONDITIONER REFRIGERANT RETROFITTING REPORT

LOCATION: ELECTRICAL MAINTENANCE DEPARTMENT

DATE:23/02/05

UNIT TYPE								CONDENSER TEMPERATURE ^{0}	
PANASONIC 24000Btu DUAL ZONE MINISPLIT UNIT		VOLTAGE	AMPERAGE	DISCHARGE PRESSURE	SUCTION PRESSURE	INPUT POWER (K.W)	EER	ENTERING	LEAVING
UPPER UNIT CIRCUIT	BEFORE		6.12	125	65	1.11	11	120	105
	AFTER		3.68	70	35	0.69	17	105	93
			40%	44%	46%	38%		13%	11%
LOWER UNIT CIRCUIT	BEFORE		5.6	113	63	1.07	11	121	107
	AFTER		3.09	62.5	36	0.74	16	106	86
			45%	45%	43%	31%	-45%	12%	20%

SUMMARY OF RESULTS OF A MAJOR HC RETROFIT PROJECT

November 6, 2006	No. of units	Total Cooling Capacity (Tons)	% Reduction in Power (Kilowatts)	Estimated Annual Savings (KwH)
1 Administration & Special Agencies	116	291.4	23.3%	49,235
2 Department of Life Sciences	101	184.3	16.5%	53,754
3 Faculty of Social Science	219	368.9	22.4%	101,050
4 Faculty of Pure & Applied Science	67	302.0	27.4%	67,767
5 Humanities and Education	143	266.2	27.1%	78,233

Total number of units	646
Total Cooling Capacity changed (Tons)	1413
Weighted Average Reduction in Power	23.8%
Total Reduction in Power (Kilowatts)	350.0
Annual Reduction in Energy (Kilowatt-Hours)	350,039
Value of Power Savings	J$2,671,496
Value of Energy Savings	J$5,600,621
Total Annual Savings	J$8,272,117
Cost of Project @ US$70 per ton	J$6,507,548
Payback Period (Years)	0.8

Note: Estimated Savings assum (1) 1000 hours operation for each A/C unit
(2) Electricity cost of J$16 per Kilowatt-hour
(3) Demand charge of J$636 / KVA per month

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Some Tangible Facts

- HC refrigerants can replace CFC, HCFC and HFC refrigerants through direct substitution with minor equipment modification.

- **Projects in which F refrigerants are substituted with HC refrigerants typically realize a payback period of 6 – 8 months**

- Equipment maintenance costs are also by HC due to a lowering of the discharge pressures

Electricity Consumption by End-use for OECS, Commercial and Residential Sector

Source: ECELP/GIZ (2013)

END-USE	**CONSUMPTION/ %**
Refrigeration	19.6
Air conditioning	29.1
Water Heaters	2.6
Electric Stoves and Ovens	3.4
Lighting	30.8
Other	14.6

Energy Hierarchy

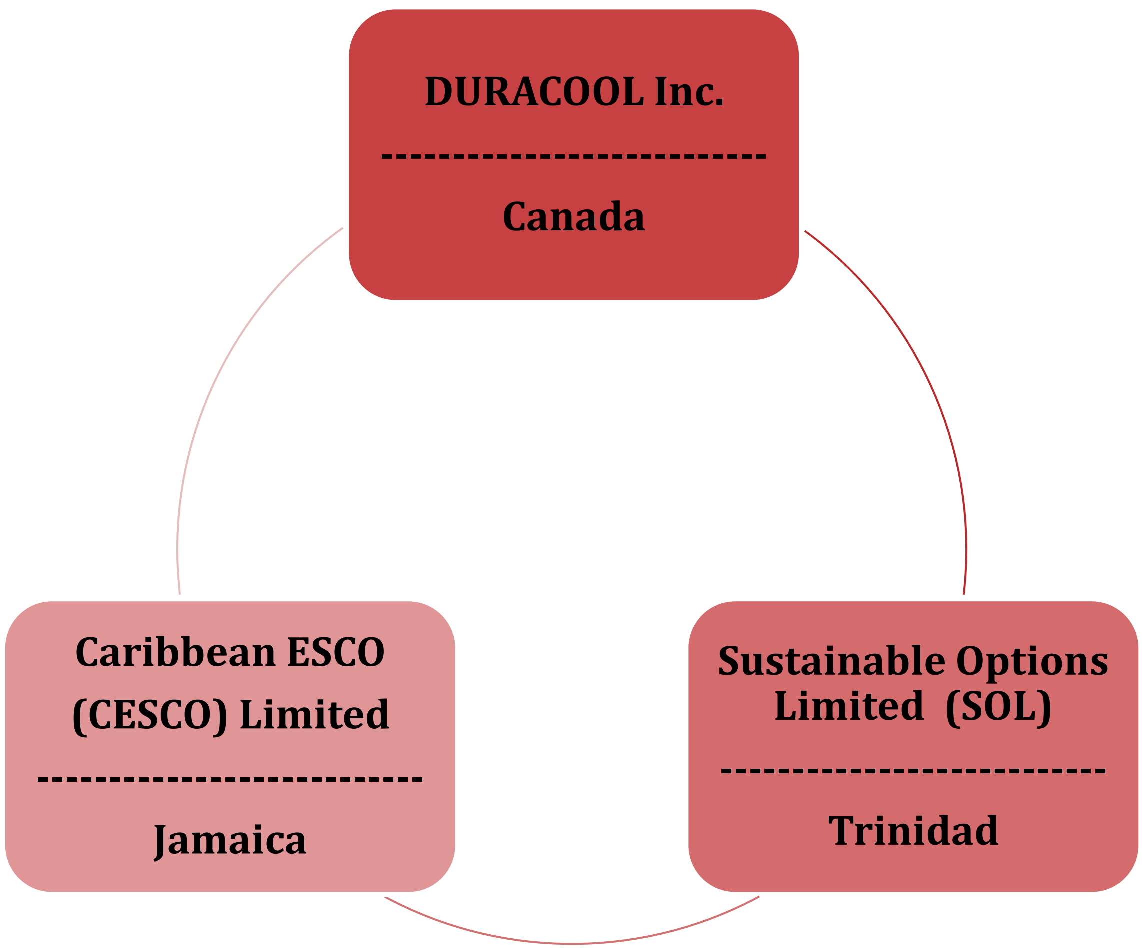
Avoiding Unnecessary Energy Use
Re-organise systems so that energy use can be reduced to the minimum, for example by designing buildings to be warmed by the sun, using natural light and ventilation, or enabling people to get access to the amenities they want with fewer and shorter car journeys.

Use Energy more Efficiently
Finding ways of getting more benefit per unit of energy, for example by using higher efficiency appliances, generating heat and power together or insulating buildings better to retain heat.

Use Renewable Energy
Switch to less damaging low-carbon energy sources, especially renewables, for example solar and wind power, energy crops or hydro.

- **DURACOOL® 12a is marketed and sold as a replacement for ozone-depleting CFC R-12 Substitutes and global-warming HFC R-134a refrigerant.**
- **Duracool® 22a is marketed and sold worldwide as a replacement for R22**
- **The Caribbean can reduce electricity use in the residential and commercial sectors by 10%, through the *direct replacement* of F refrigerants by HCs**

Hydrocarbon Refrigerant Supply Chain



"For the things we have to learn
before we can do them,
we learn by doing them."

-Aristotle

THANKS FOR YOUR ATTENTION!

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