Energy Efficient Cooling in Buildings

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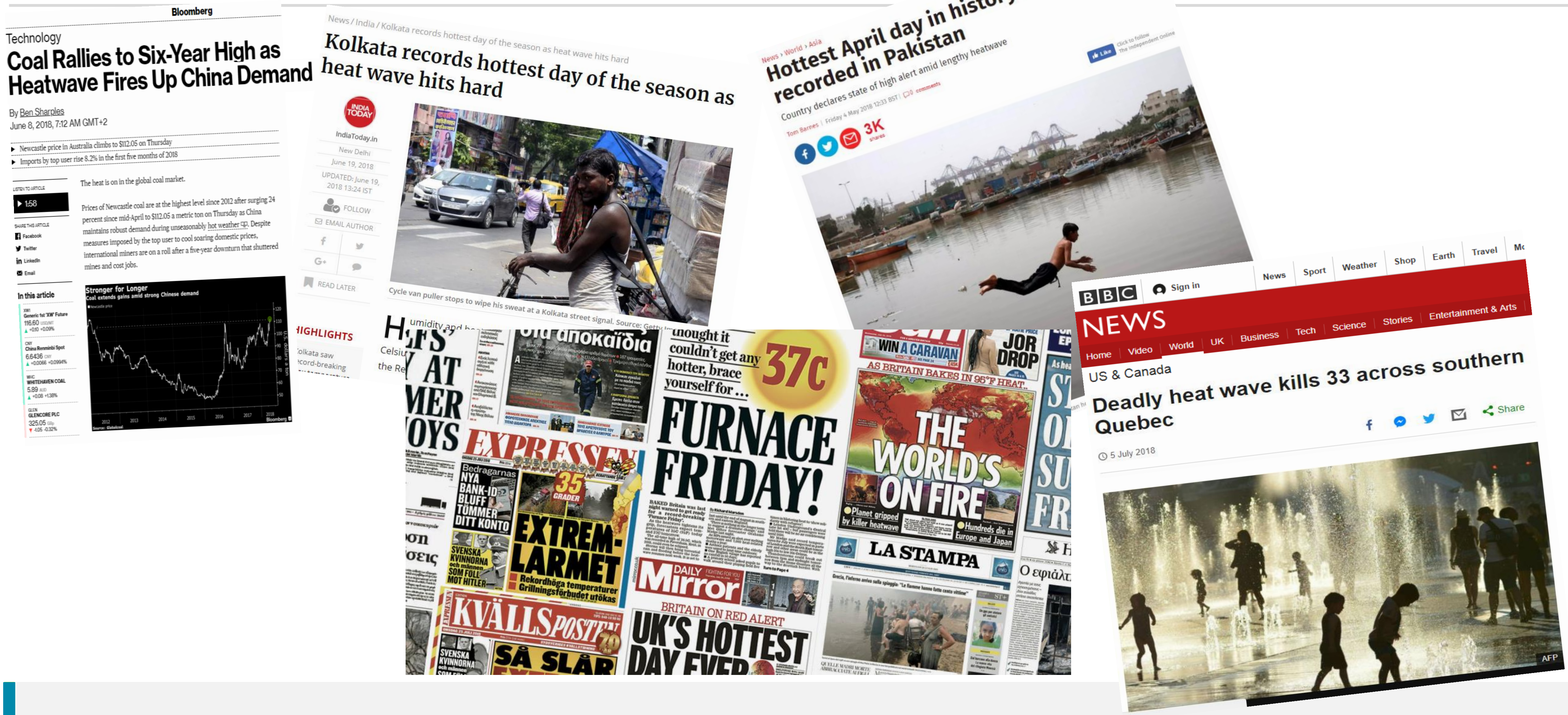
May 23rd, 2019.

Why do we Need Air Conditioning or Comfort Cooling?

The world is getting hotter



The need for cooling is growing – and with it demand for air conditioning.

The need for cooling is driven by:

- Increase income and standards of living

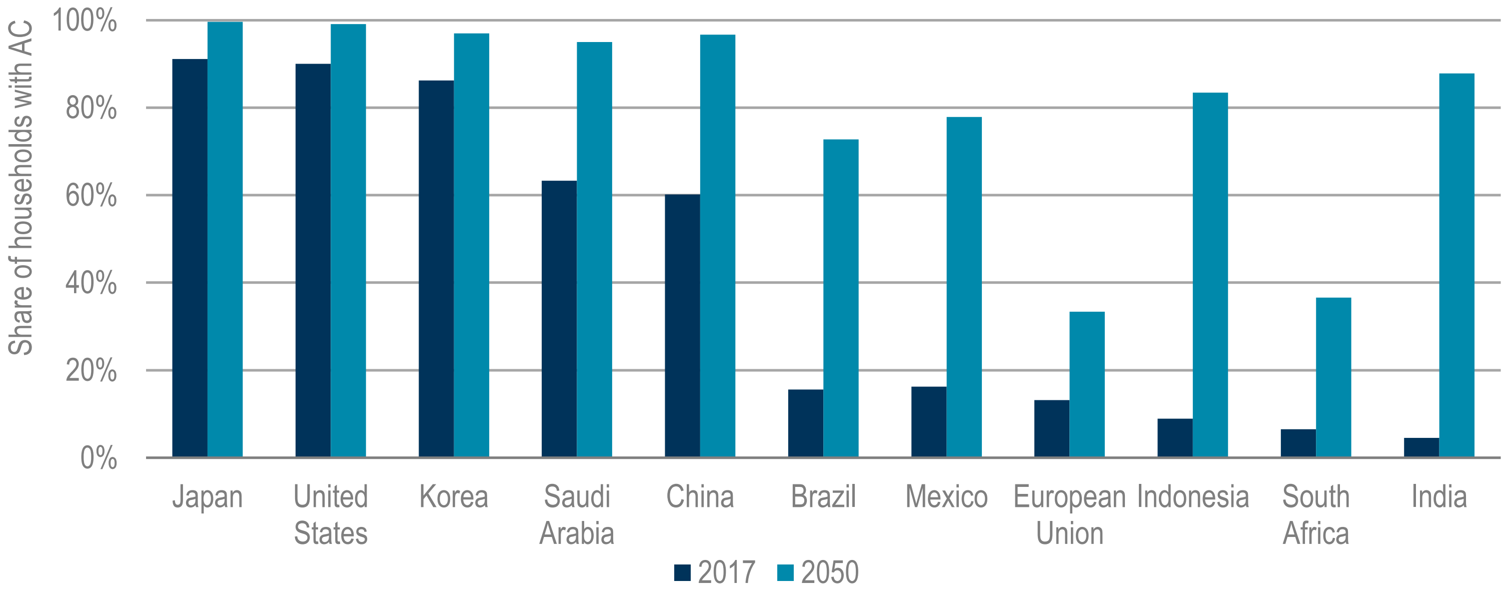
- Increase atmospheric temperatures

- Urbanization and population growth
  - Population growth rate for Grenada 0.42%

Global Air Condition Use

- Only **10%** of households in developing countries have air condition units
- Whereas, **90%** of households in developed countries have an AC
- By 2050, it is expected that 2/3 of households in developing countries would have an AC

Percentage of households that have AC today



Most homes in hot countries have not purchased their first AC.

Air conditioning is highly concentrated in a small number of countries, but AC sales are rising rapidly in emerging economies, especially in Asia.

The 2018 IEA report, "The Future of Cooling" indicates:

- AC use is one of the key drivers of global electricity demand growth
- Global energy demand from ACs is expected to triple by 2050
  - Stocks are expected to grow from 1.6 billion to 5.6 billion
  - An average of 10 new ACs sold every second, for the next 30 years

However, "*...through stringent MEPS and other measures such as labelling, the average Energy Efficiency of stocks of ACs can more than double by now and 2050".*

Estimated Stocks of ACs in Grenada

Sub-sector	Primary data	Secondary data	Reference year
Ductless residential split	4,007		2017
Ductless commercial split	1,679	5,000	2017
Ducted split	73		2017
Rooftop ducted	20		2017
Multi-split, VRF/VRV	314		2017
Air conditioning Chillers	21		2017
Car AC		26,104	2017
Domestic refrigeration		40,472	2015
Stand-alone units	198		2017
Integral units	8		2017
Condensing units	132		2017
Centralized systems for supermarkets	1		2017
Industrial condensing units	15		2017
Centralized systems	3		2017
Refrigerated trucks/trailers		13	2017

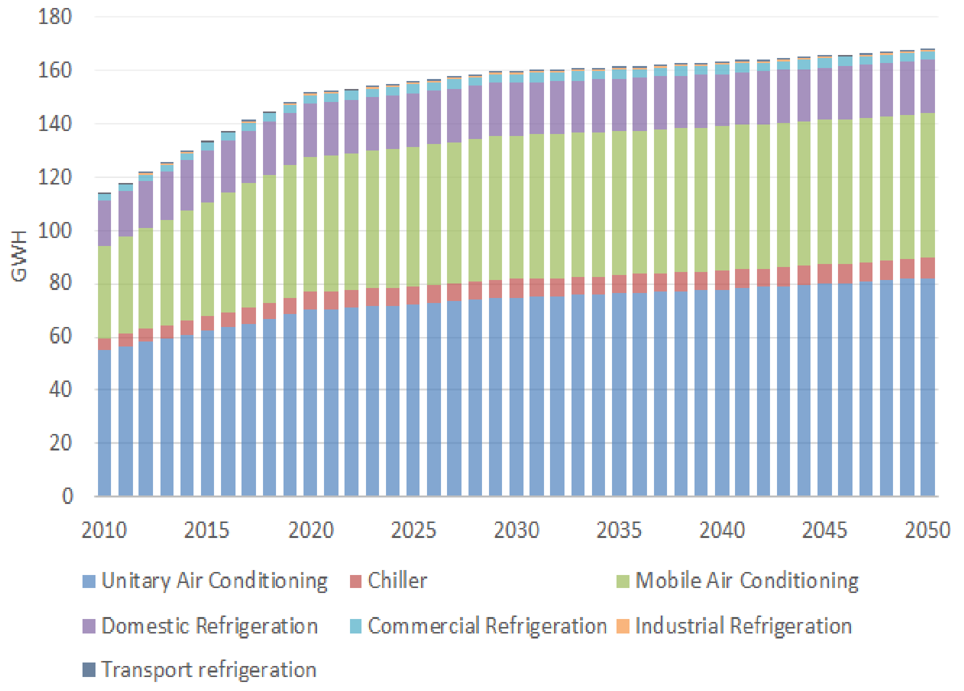
6,114 AC units in buildings

Source: Inventory report of the RAC sector in Grenada

Electricity Used for ACs in Grenada

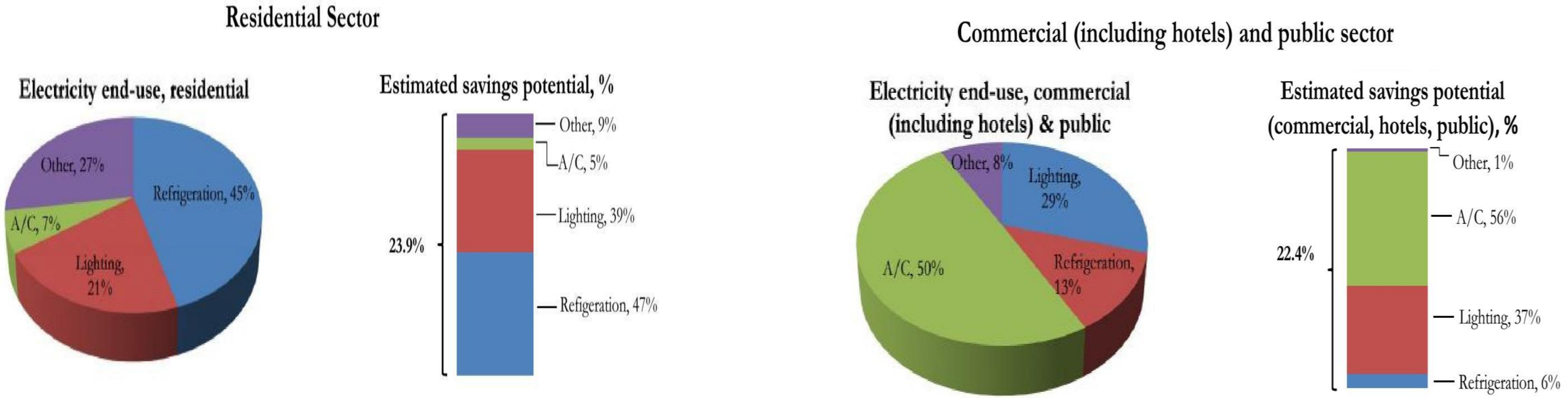
- In Grenada, the RAC sector in 2015 accounted for approximately **49%** of the total national electricity consumption.

- For the same year, unitary AC (UAC) was responsible for 47% of the energy consumption by the total RAC sector

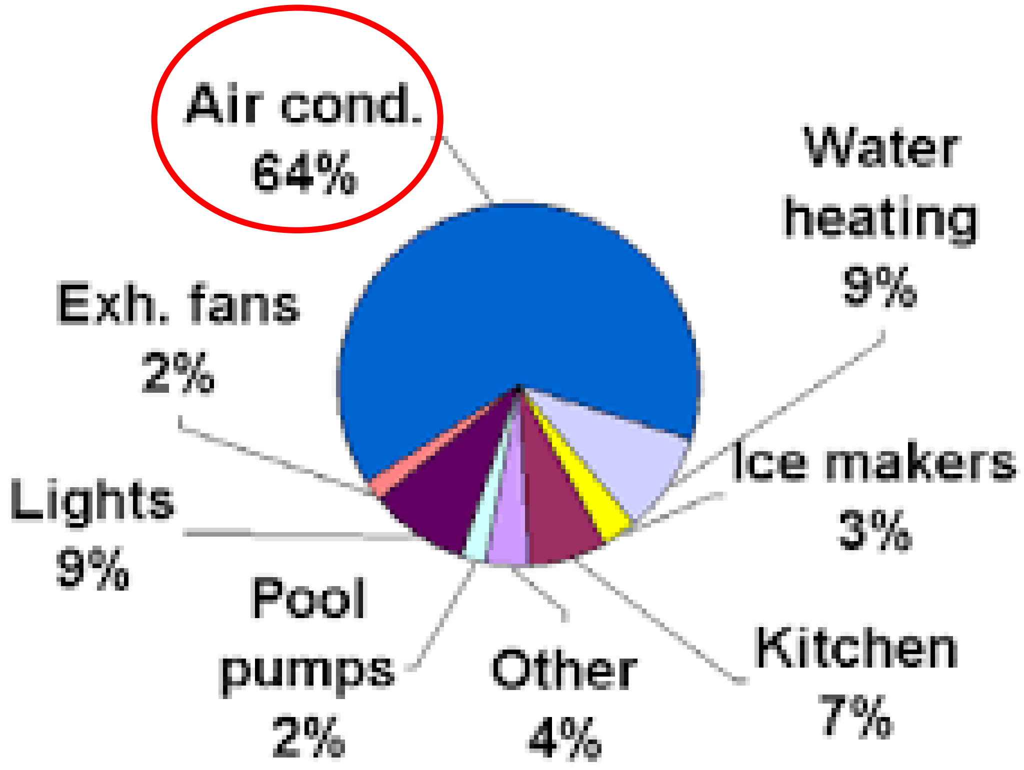


Projected BAU energy consumption in the RAC sector for the years 2010-2050

Typical Energy Use in Caribbean Buildings



Breakdown of Small Hotel Energy Use by Application (CHTA)



60%-70% of electricity consumed in commercial buildings in hot countries is used for Air Conditioning (Austin Energy)

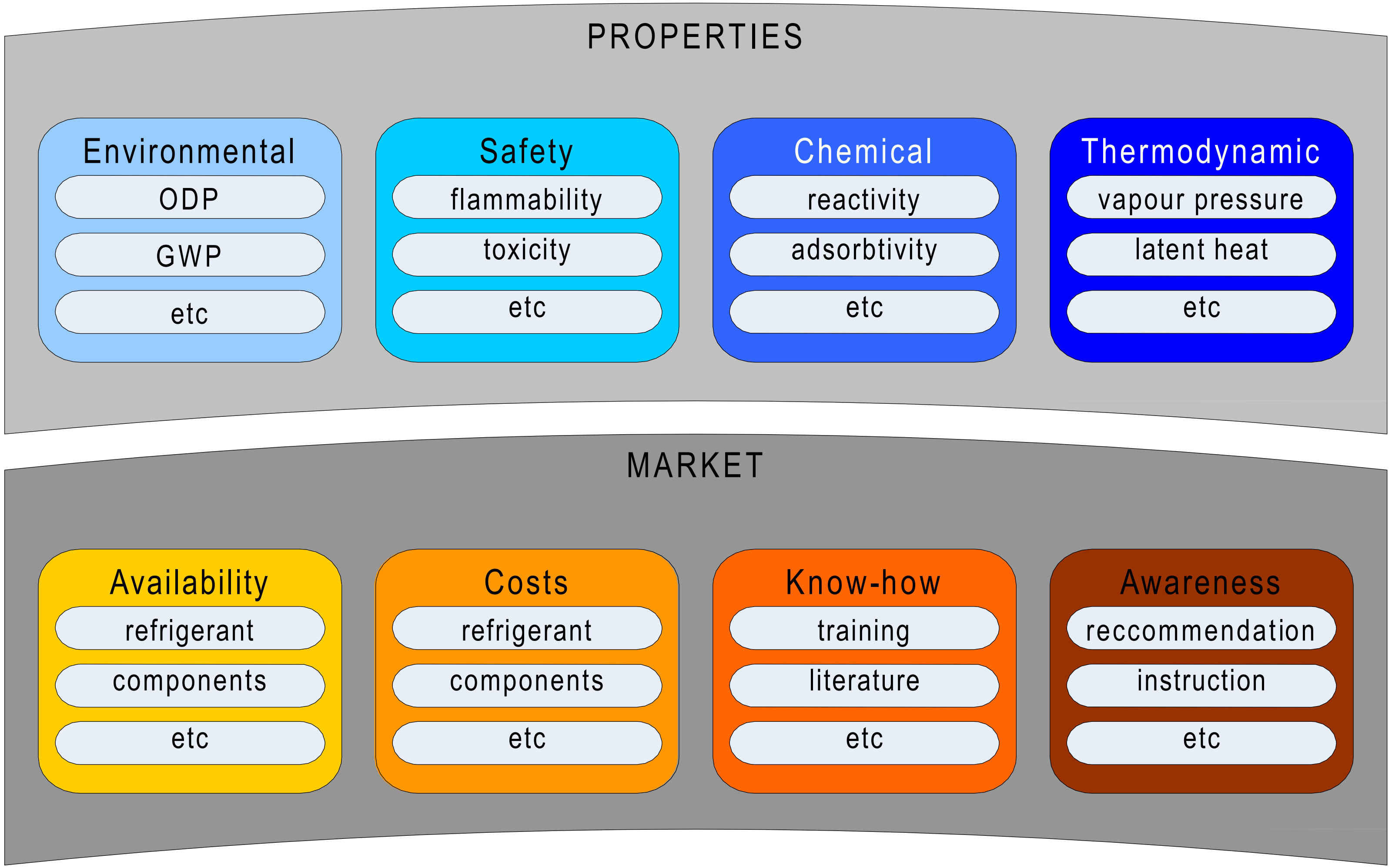
What Determines the type of AC that is purchased?

For most persons, it is the (upfront) cost of the equipment

For others, it maybe the ENERGY EFFICIENCY or Cost to Operate.

There are several other factors to consider……….

Here are some factors that determines the choice of AC



Some factors affecting the performance and efficiency of ACs

The inefficient use of an air conditioning system can be caused by the following reasons:

- A poorly maintained air conditioning unit may cause one or a combination of these problems:
  - Thermostat problems:
  - Refrigerant leaks:
  - Clogged air filter:
- Poor insulation of the room:
- Incorrect choice and sizing of the air conditioning unit.
- Building type, usage and design
- Behavioral use

The Need for New and more efficient air conditioners

- There are now several alternatives to the traditional air conditioning systems:
  - Direct Current (DC) inverter air conditioners with variable speed compressors,
  - Solar Thermal air conditioners and
  - Solar Powered air conditioners.

	Traditional Air Con	DC Inverter	Solar Thermal	Solar Powered
9000 BTU	500W	30-60%	20-40%	100%
12000 BTU	1100W	30-60%	20-40%	100%
15000 BTU	1400W	30-60%	20-40%	100%
18000 BTU	1600W	30-60%	20-40%	100%
22000 BTU	2000W	30-60%	20-40%	100%
24000 BTU	2600W	30-60%	20-40%	100%

Air Conditioner efficiency comparison
Source: BREA Energy Efficiency Consumer Guide, brea.bb
NB the percentage saving is relative to the amount of electricity used by a standard air conditional unit.

Improvements in system performance is primarily due to two factors:

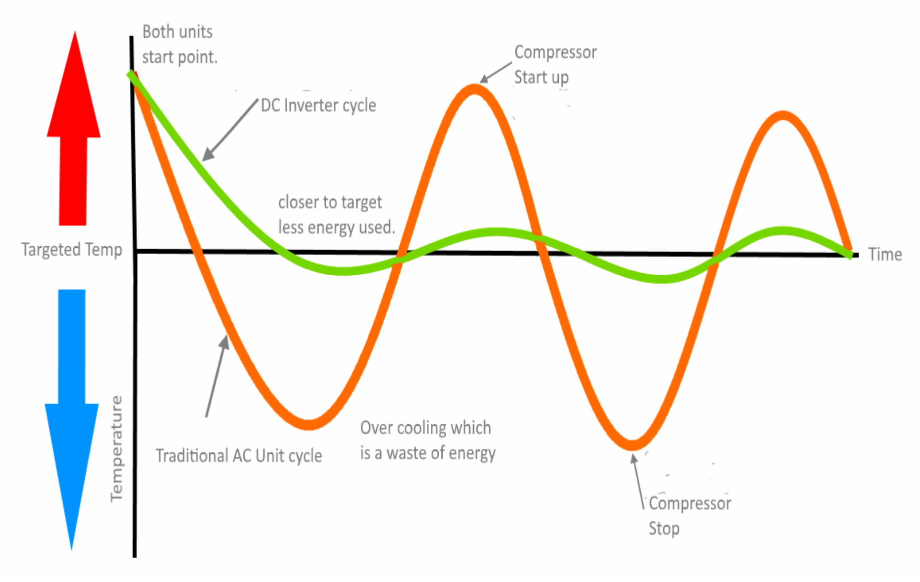
- Technology
  - Design
  - System components
    - •variable speed inverter-driven compressors, which adjust to the required cooling load;
    - •improved evaporator or compressor heat exchangers;
    - •variable auxiliary components such as pumps and fans;
    - •sensor-linked controllers with smart adjustment functions and better insulation systems to lower the required cooling loads.

- Refrigerant Choice
  - Natural refrigerants (hydrocarbons, ammonia, carbon dioxide)
  - Blends with improved thermodynamic properties – most with high-GWP

Inverter type ACs

Key benefits of a DC inverter air conditioning system:

- At least 30% - 60% cheaper to run as it consumes less power
- Far quicker to achieve desired temperature
- The startup time and energy used is reduced by 30%
- Much quieter
- No temperature fluctuations, maximizing comfort level
- No voltage peaks from compressor
- The DC inverter never turns off, it just slows down and speeds up when the temperature drops below the targeted point



Refrigerant Choice in AC makes a big difference

- The two most commonly used refrigerants in Grenada today are:
  - R-22
  - R-410A
    - *Projections are that R-410 would be the dominant refrigerant in 2019*

Refrigerant Type	ODP	GWP	Energy Efficiency Ratio (EER)
R-22	0.055	1810	4.23
R-410A	0	2088	3.96
R-32	0	675	3.98
R-290 - hydrocarbon	0	2	4.28

Hydrocarbon in Air-conditioning Equipment
R-290 (PROPANE)

Advantages of R-290

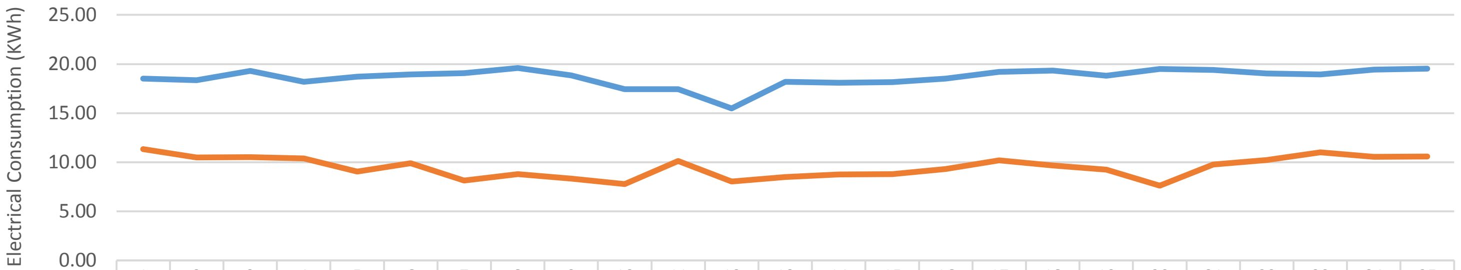
- Environmentally Safe: (zero ODP, <3 GWP)
- Very Energy Efficient
- No changes in the system are required
- Excellent heat transfer properties
- Less refrigerant charge is required (40 % less)
- Operate at lower discharge pressures (extends the life of the compressor)
- Much quieter operation

Hydrocarbon Demonstration Project

Thirty (30) R-290 AC Units (18,000 BTU X20 and 12,000BTU X 10) procured from Godrej

Demo sites included
- Govt offices
- Police stations
- Customs Dept
- Schools
- Health centres
- Private sector

Line 1 (blue), shows the electrical consumption of previously installed AC unit (18,000 BTU, R 410 A) and Line 2 (red), the replacement R-290 AC units, over a twenty-five day period (excluding weekends and holidays)



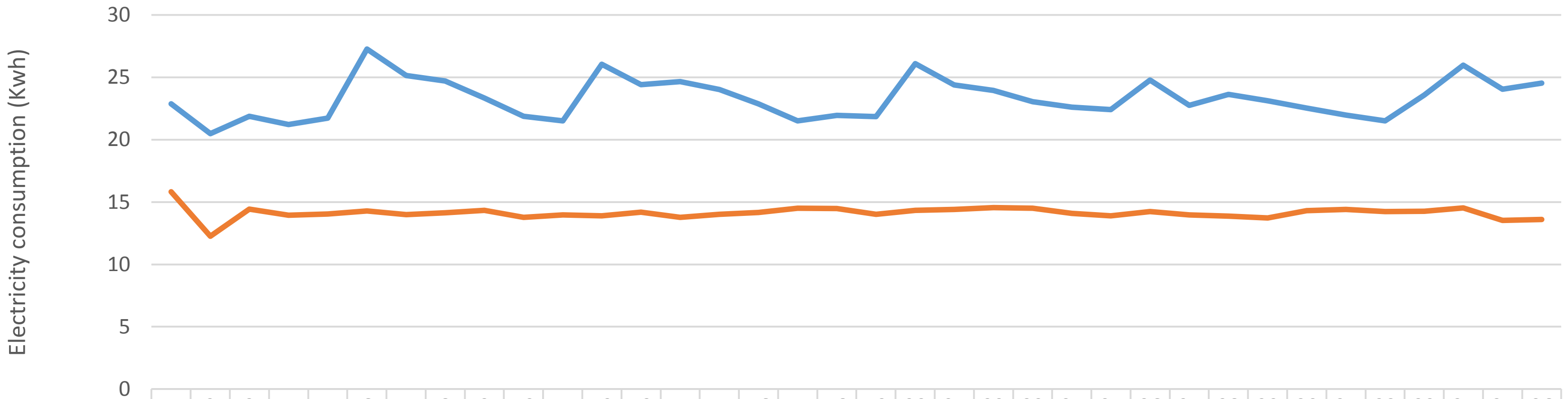
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Previous AC	18.51	18.36	19.31	18.20	18.72	18.96	19.06	19.60	18.83	17.44	17.43	15.47	18.18	18.09	18.15	18.52	19.21	19.32	18.81	19.51	19.40	19.05	18.96	19.45	19.54
R-290 AC	11.34	10.48	10.51	10.39	9.07	9.90	8.13	8.78	8.34	7.78	10.14	8.03	8.49	8.76	8.79	9.32	10.20	9.66	9.24	7.61	9.78	10.24	11.00	10.55	10.58

Time (Days)

AC Units	Total Energy consumption (KWh/25 days)	CO2 eq. emissions (Kg)	Running cost (XCD)
Previously installed (R-410a)	466.08	293.63	$442.78
R-290	237.11	149.38	$225.25
Savings	**228.97 (49.13%)**	**144.25**	**$217.52**

Note: 24 hour Operation - SSU

Line 1 (blue) shows electricity consumption of previously installed Ac unit (12,000 BTU) using R-22
Line 2 (red) shows the electricity consumption of the replacement R-290 AC Unit over a 36 day period.



Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Existing	23	20	22	21	22	27	25	25	23	22	22	26	24	25	24	23	22	22
NR	16	12	14	14	14	14	14	14	14	14	14	14	14	14	14	14	15	14

Day	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Existing	22	26	24	24	23	23	22	25	23	24	23	23	22	22	24	26	24	25
NR	14	14	14	15	15	14	14	14	14	14	14	14	14	14	14	15	14	14

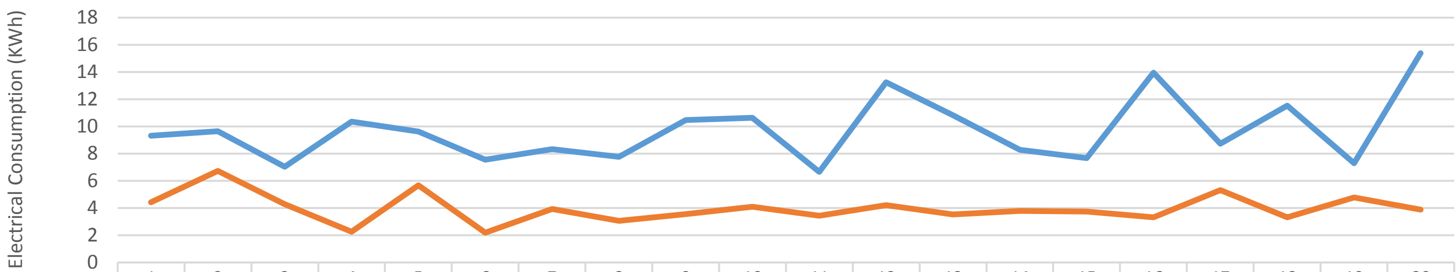
Time (days)

Existing NR

AC Units	Total Energy consumption (KWh/20 days)	CO2 eq. emissions (Kg)	Running cost (XCD)
Previously installed (R-22)	840.37	529.43	$798.35
R-290	508.56	320.39	$483.13
Savings	**331.81(39.5%)**	**209.04**	**$315.22**

Note: 24 hour operation - Prisons

Line 1 (blue), shows the electrical consumption of previously installed AC unit (18,000 BTU , R 410A) and Line 2 (red), the replacement R-290 AC units, over a twenty day period (excluding weekends and holidays)



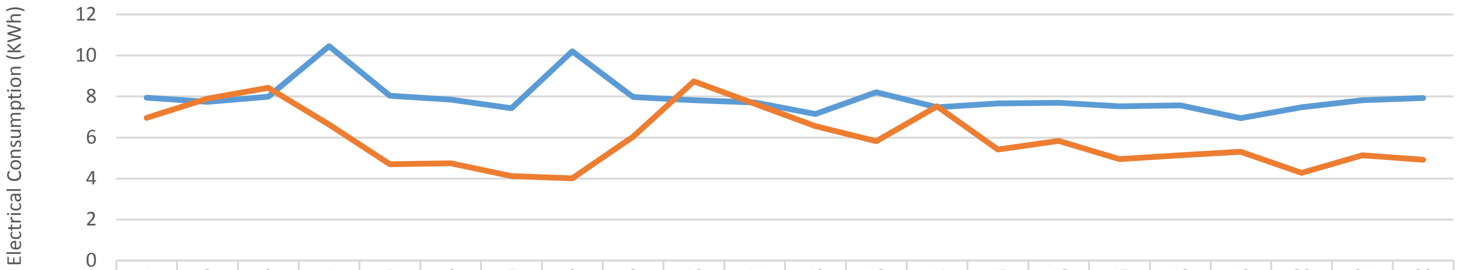
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Previous AC	9.31	9.65	7.04	10.36	9.62	7.55	8.32	7.76	10.48	10.63	6.65	13.25	10.82	8.29	7.67	13.95	8.72	11.53	7.29	15.39
R-290 AC	4.42	6.74	4.28	2.27	5.66	2.18	3.93	3.06	3.55	4.10	3.44	4.21	3.53	3.79	3.75	3.31	5.31	3.31	4.77	3.89

Time (Days)

AC Units	Total Energy consumption (KWh/20 days)	CO2 eq. emissions (Kg)	Running cost (XCD)
Previously installed (R-410a)	194.28	122.40	$184.57
R-290	79.50	50.09	$75.53
Savings	**114.78 (59.08%)**	**72.31**	**$109.04**

Note: 8:00 – 4:00 hour Operation - Customs

Line 1 (blue), shows the electrical consumption of previously installed AC unit (12,000 BTU, R 410A) and Line 2 (red), the replacement R-290 AC units, over a twenty-five day period (excluding weekends and holidays



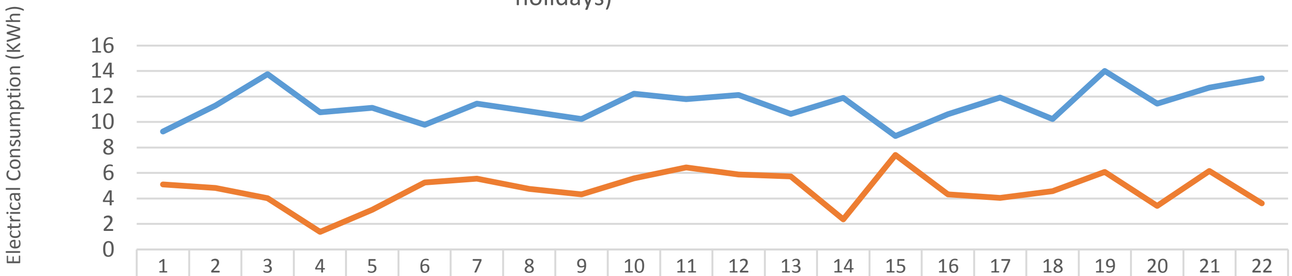
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Previous AC	7.94	7.74	7.99	10.45	8.04	7.85	7.42	10.2	7.97	7.82	7.71	7.15	8.21	7.47	7.66	7.69	7.52	7.57	6.95	7.48	7.82	7.92
R-290 AC	6.96	7.9	8.42	6.63	4.7	4.75	4.12	4.01	6.04	8.74	7.64	6.56	5.82	7.52	5.42	5.84	4.95	5.14	5.31	4.28	5.13	4.91

Time (Days)

AC Units	Total Energy consumption (KWh/22 days)	CO2 eq. emissions (Kg)	Running cost (XCD)
Previously installed (R-410a)	174.57	109.98	$165.84
R-290	130.79	82.40	$124.25
Savings	43.78 (25.08%)	27.58	$41.59

Note: 8:00 – 4:00 hour Operation. Relatively New AC replaced. MBIA

Line 1 (blue), shows the electrical consumption of previously installed AC unit (18,00 BTU Retrofitted R290) and Line 2 (red), the replacement R-290 AC units, over a twenty-two day period (excluding weekends and holidays)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Previously Installed Unit	9.24	11.28	13.75	10.77	11.11	9.78	11.43	10.84	10.22	12.23	11.79	12.12	10.63	11.89	8.89	10.6	11.91	10.22	14	11.45	12.7	13.44
R-290 Unit	5.1	4.81	4.02	1.38	3.1	5.25	5.56	4.75	4.31	5.57	6.43	5.89	5.74	2.35	7.41	4.32	4.05	4.57	6.07	3.42	6.16	3.62

Time (Days)

AC Units	Total Energy consumption (KWh/20 days)	CO_2 eq. emissions (Kg)	Running cost (XCD)
Previously installed (R-290)	250.29	157.68	$237.78
R-290	103.88	65.44	$98.69
Savings	**146.41(58.5%)**	**92.24**	**$139.09**

Note 8:00 – 4:00 hour Operation – Retrofitted R-22 to R-290 AC - SNJ Electrical

Look for the Sticker that says........