ENERGY DYNAMICS Ltd.

DYNAMIC ENERGY EFFICIENT SOLUTIONS

Energy Auditing & Energy Cost Saving Opportunities

+ AGENDA

1.0 INTRODUCTION TO EDL

2.0 ENERGY AND THE CARIBBEAN

3.0 ENERGY AUDITING

- 3.1 ENERGY ACCOUNTING & DISTRIBUTION
- 3.2 ENERGY SAVING OPPORTUNITIES

4.0 BENEFITS OF CONDUCTING ENERGY AUDITS

- 4.1 ISO 50001

5.0 ABSORPTION COOLING & COGENERATION

- What is Absorption Cooling?
- What is Cogeneration?
- Potential Savings in the Caribbean
- Feasibility Studies

6.0 CONCLUSION

1.0 Introduction to Energy Dynamics Ltd

DYNAMIC ENERGY EFFICIENT SOLUTIONS

- Commenced in 2000
- Operates throughout Caribbean
  - Barbados
  - Eastern Caribbean
  - Dominican Republic
  - Jamaica
  - Dutch Caribbean – St. Maarten, Aruba & Curacao
- Provides Energy & Environmentally Friendly Solutions
- Manage US$ 15 M in Projects Annually

EDL's Mission

DYNAMIC ENERGY EFFICIENT SOLUTIONS

Energy Dynamics Limited exists to profitably provide the most economically and environmentally friendly solutions to satisfy our customers.

In support of this we are committed to:

- Developing long term relationships through effective customer service;
- Keeping in the forefront of technology through training and educating our employees and customers;
- Evaluating and selecting appropriate technologies to meet our customer's needs;
- Providing a challenging, profitable and harmonious work environment for our employees;
- Building and maintaining long term and honest relationships with our suppliers.

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+ 1.0 Introduction to Energy Dynamics Ltd

DYNAMIC ENERGY EFFICIENT SOLUTIONS

Energy Dynamics Limited (EDL) is an Energy Services Company (ESCo) based in Trinidad and Tobago but operating throughout the Caribbean for over ten (10) years. The services offered includes: -

- Energy Engineering & Consultancy Services
- Supply of Energy and Water Efficiency Solutions
- Renewable Energy Systems (Solar Thermal & PV)
- Energy Retrofit Projects (ESCo)

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1.0 Introduction to Energy Dynamics Ltd

DYNAMIC ENERGY EFFICIENT SOLUTIONS

- Energy Engineering & Consultancy Services: -
  - Energy Audits
  - Design of Building Energy Efficient Systems
  - Design and Analysis of CCHP / Cogeneration Systems
  - Corporate Utility Management Programs (ISO 50001)

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1.0 Introduction to Energy Dynamics Ltd

DYNAMIC ENERGY EFFICIENT SOLUTIONS

- The engineering team at EDL has performed over 300 energy and water audits for properties, Hospitals, Offices and manufacturing facilities throughout the region, providing Energy Saving Opportunities of Millions of US dollars in energy and water costs annually.

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+ 2.0 Energy and the Caribbean

Country	Population	GDP Per Capita	Cost of energy
		($US)	($US/kWh)
Aruba	109,000	$21,800	$0.22
Bahamas	351,000	$30,900	$0.29
Barbados	275,000	$23,600	$0.35
Guyana	752,940	$7,500	$0.24
Jamaica	2,847,232	$9,000	$0.32
Trinidad and Tobago	1,351,000	$20,300	$0.06
Dominican Republic	10,183,000	$9,300	$0.29
OECS			
Grenada	105,000	$13,300	$0.35
St. Lucia	178,000	$12,900	$0.33
St. Vincent & the Grenadines	109,000	$11,700	$0.36
Dominica	68,000	$10,400	$0.31
St. Kitts/ Nevis	54,000	$16,400	$0.34
Antigua & Barbuda	89,018	$22,100	$0.38

+ Caribbean Electricity Tariffs (2011)

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3.0 Energy Auditing

Types & Equipment Required

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3.0 Energy Auditing

What is an Energy Audit?

- An Energy Audit is the first step to make a facility energy efficient by determining its present state.
- Energy Auditing can be simply defined as a process to evaluate where a building or plant uses energy, and identify opportunities to reduce consumption.
- Results of an energy audit should be used to develop a facility's strategic energy plan.

3.0 Energy Auditing

TYPES OF ENERGY AUDITS

- Before commencing an energy audit it is necessary to have an idea about :
  - Scope of the project
  - Level of effort necessary to meet expectations

  - There are different types of audit levels:
    - Level I : Walk Through Audit
    - Level II: Intermediate Audits
    - Level III : Advanced/ Detailed (Investment Grade) Audits

3.0 Energy Auditing

TYPES OF ENERGY AUDITS

- LEVEL I : WALK THROUGH AUDITS
  - Usually lasts less than one (1) day
  - Involves a brief survey of the building to produce a rough estimate of how efficiently energy is being used in the building.
  - A Level I audit detects the "low-hanging fruit" and suggest options worthy of more study.

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3.0 Energy Auditing

TYPES OF ENERGY AUDITS

- LEVEL II : INTERMEDIATE AUDIT
  - This level involves some system performance testing which provides a break down of how energy is used in the building.
  - It provides a broader range of savings options:
    - Low Cost/ No Cost Energy Saving Opportunities (ESOs)
    - Investment Type ESOs

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3.0 Energy Auditing

TYPES OF ENERGY AUDITS

- LEVEL III: ADVANCED/ DETAILED ENERGY AUDIT:
- LEVEL III audits uses energy modeling software and more detailed analysis:
  - Energy Audit & Accounting
    - Energy Consumption and Cost
    - Electrical Bill Analysis
    - Organizational Analysis
    - Maintenance Effectiveness
  - Carbon Dioxide Emission Analysis
  - Water Audit
  - Solar Energy Performance Analysis
  - Natural Gas Analysis
  - Economic Analysis of all Energy Saving Opportunities
  - Discussion and Recommendations

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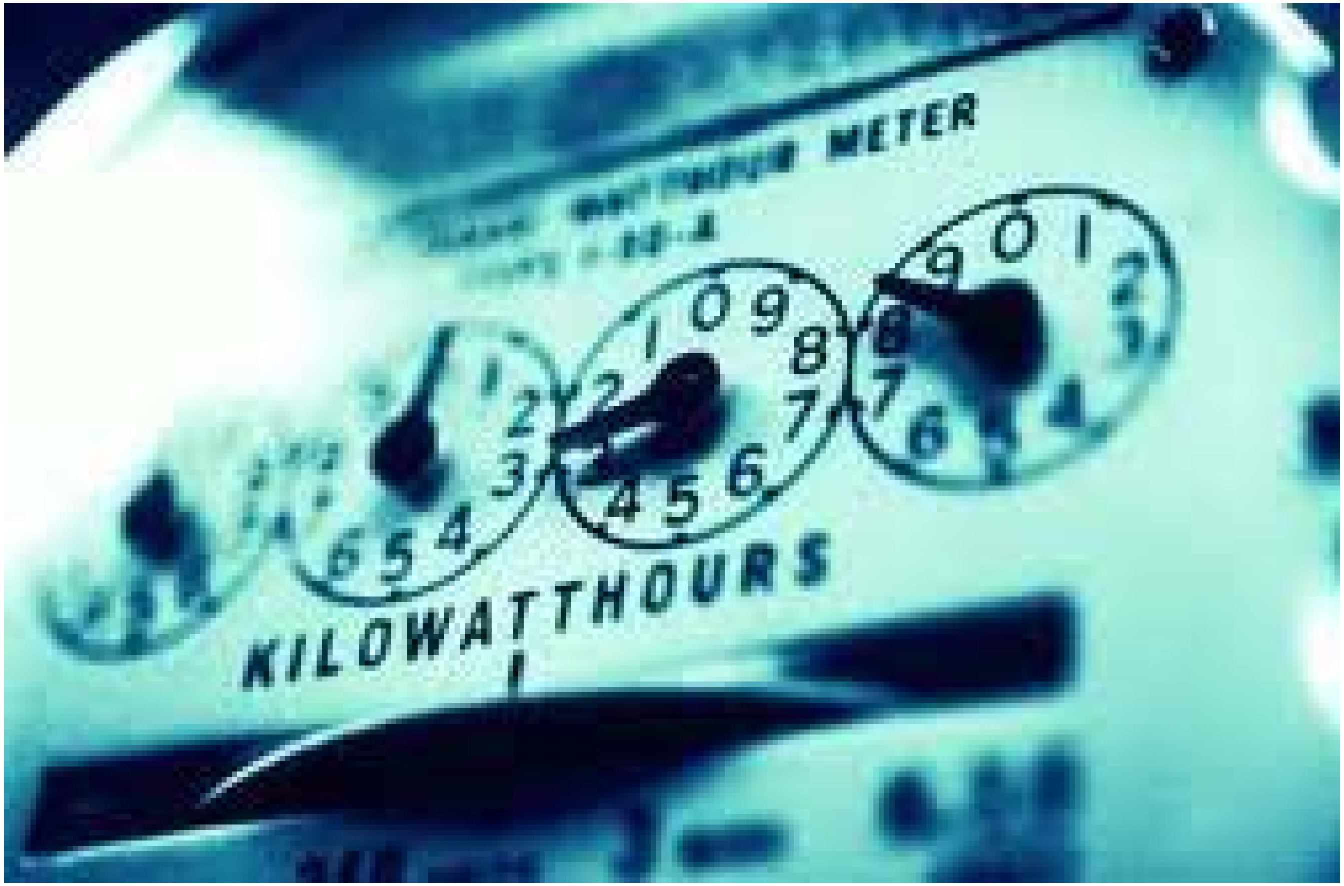

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3.0 Energy Auditing

ENERGY AUDITING EQUIPMENT

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3.0 Energy Auditing

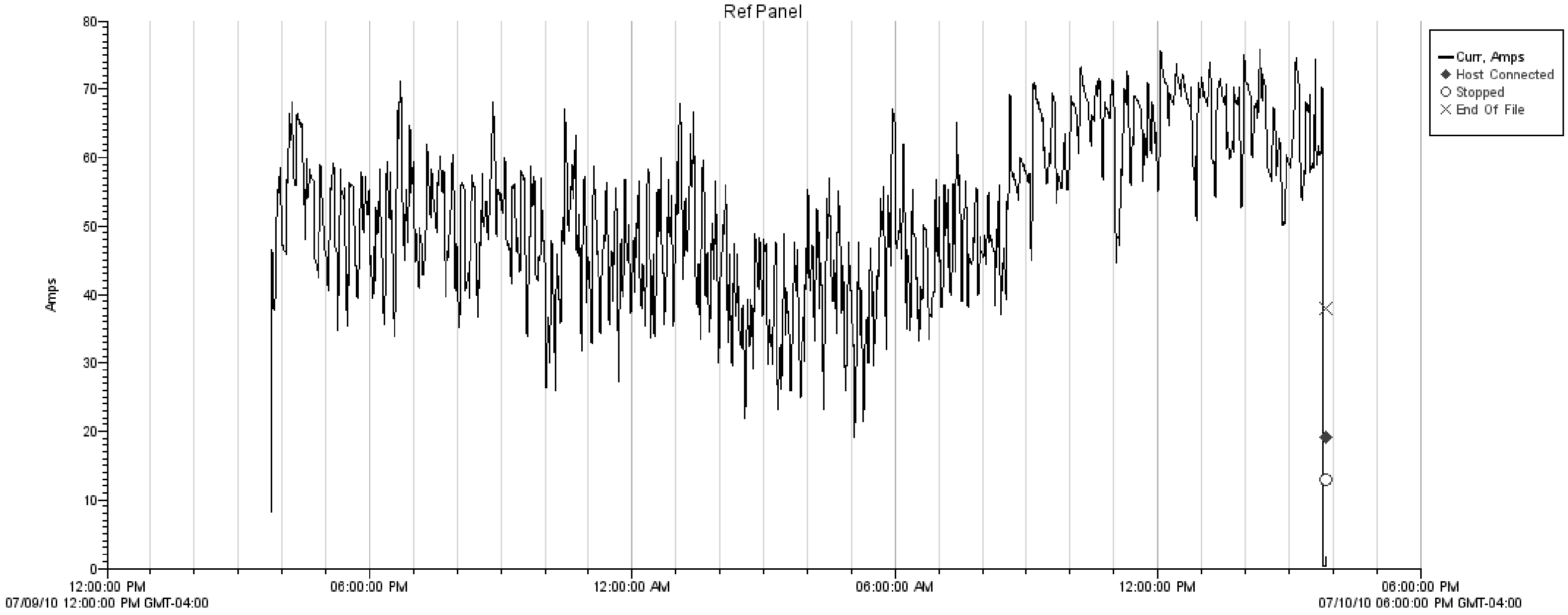
ENERGY AUDITING EQUIPMENT

- Equipment required shall include:
  - Voltmeter /Amp meter
  - Thermometers
  - Light Lumen (foot-candle) meter
  - Data Loggers
  - Energy Meters
  - Thermal Imaging
  - Ultrasonic flow metering (Compressed Air, Water, Gases, Exhaust)
  - Ultrasonic leak detection equipment
  - Combustion Analyzer
  - Air flow meters

3.0 Energy Auditing

ENERGY AUDITING EQUIPMENT

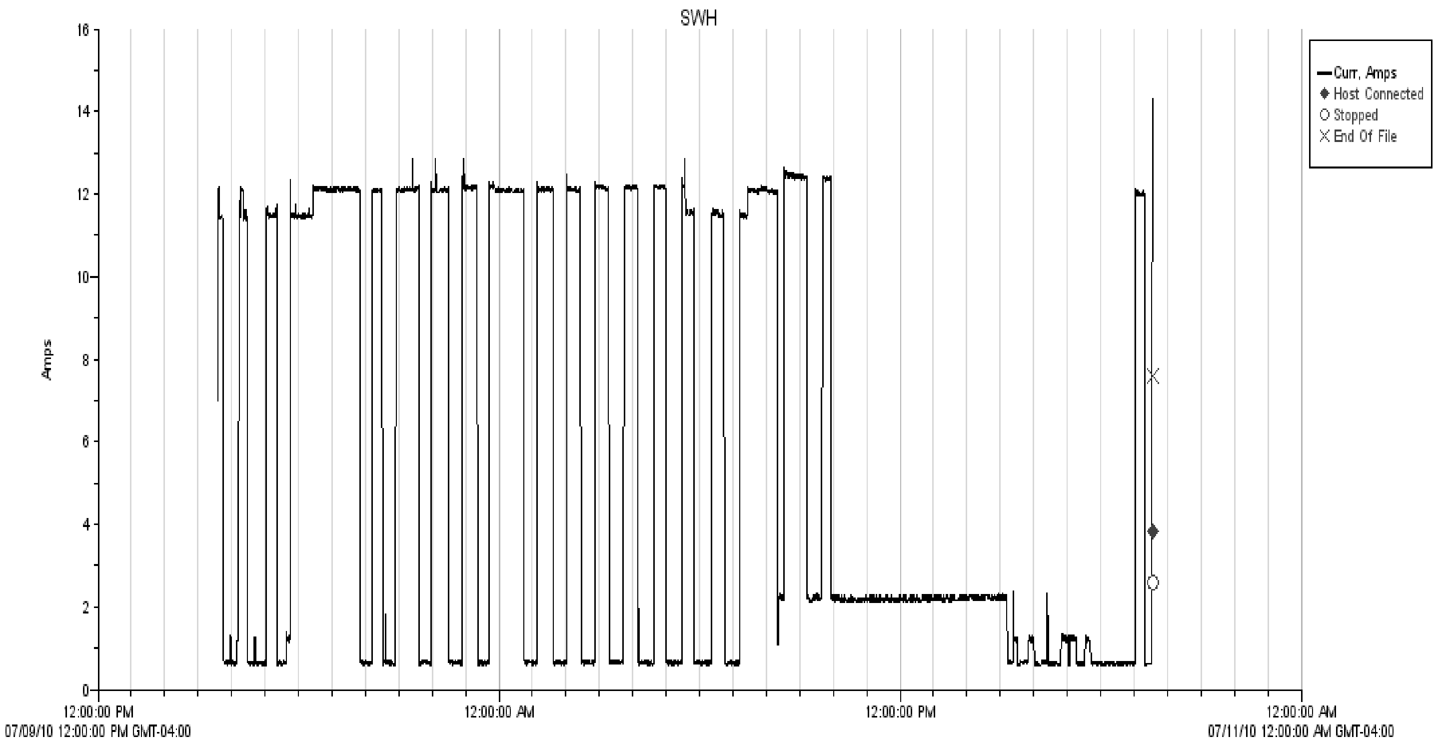
Data Logging



3.0 Energy Auditing

ENERGY AUDITING EQUIPMENT

Data Logging



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3.0 Energy Auditing

ENERGY AUDITING EQUIPMENT

Energy Metering

This type of monitoring gives the following results:

- Kilowatt hours (kWh)
- kVAR
- Voltage
- Power Factor
- Amps
- Harmonics

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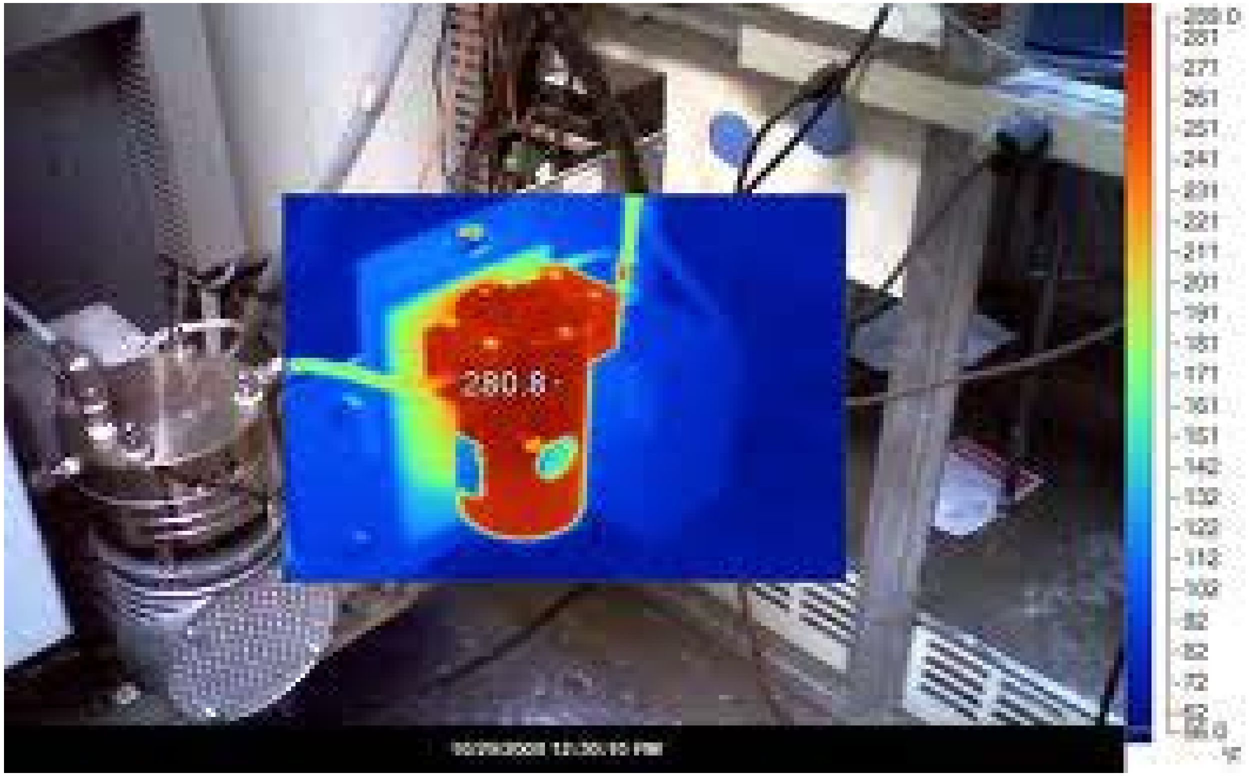
3.0 Energy Auditing

ENERGY AUDITING Equipment

- Thermal Imaging



3.1 Energy Accounting and Distribution

3.1 Energy Accounting and Distribution

ELECTRICAL BILL ANALYSIS

- Each property is required to provide copies of their bills which allows the audit team to determine the Voltage Rating of the facility and all their associated charges on a monthly basis
  - Customer Charge
  - Energy (kWh) Charge
  - Demand (kVA)Charge
  - Fuel Charge
  - Other (Time of day)

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3.1 Energy Accounting and Distribution

3.2 ENERGY BALANCING

- The actual Energy accounting process tabulates all of the following data:

Energy Consumer Description	Power kW	Average Monthly Energy kWh	% Total	Monthly Cost BDS$
Air Conditioning	190	41,576	58%	$22,191
Lighting	23	6,963	10%	$3,766
Guest Rooms	291	3,884	5%	$2,073
General Equipment	35	5,831	8%	$3,112
Kitchen & Bar Equipment	15	3,064	4%	$1,635
Solar Water Heaters	5	641	1%	$342
Pumps	2	1,095	2%	$585
Casino	4	3,106	4%	$1,658
Exhaust Fans	4	2,770	4%	$1,478
Refrigeration	8	3,170	4%	$1,692
Grand Total	568	72,100	100.0%	$38,483

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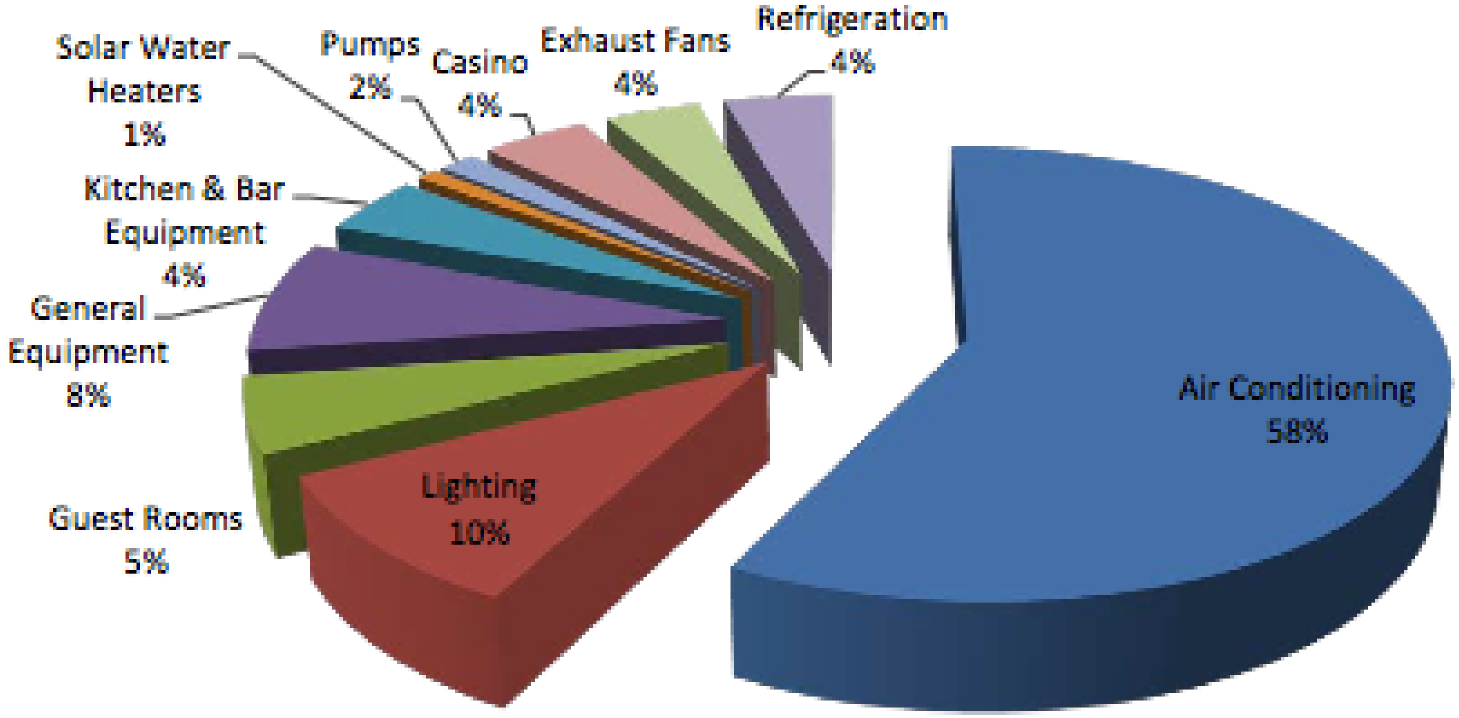
3.1 Energy Accounting and Distribution

ENERGY DISTRIBUTION



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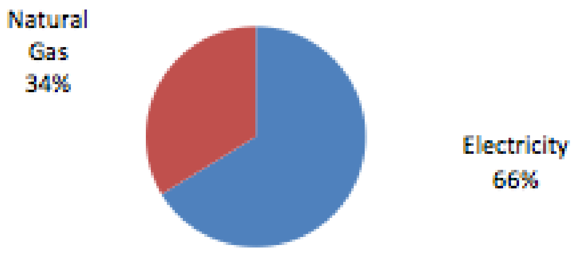
3.1 Energy Accounting and Distribution

ENERGY DISTRIBUTION

- This portion of the report analyses the consumption of the actual facility based on the equipment used.
- Energy Consumption and cost is based on the billing information provided by the property. This is done for Electricity, Water & Natural Gas
- From this information we develop the following data:

	Electricity	Natural Gas	Total Energy
Energy kWh	867,680	441,428	1,309,108
Cost (BDS$)	$421,204	$58,932	$480,135
Energy %	66%	34%	100%
Cost %	88%	12%	100%



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3.1 Energy Accounting and Distribution

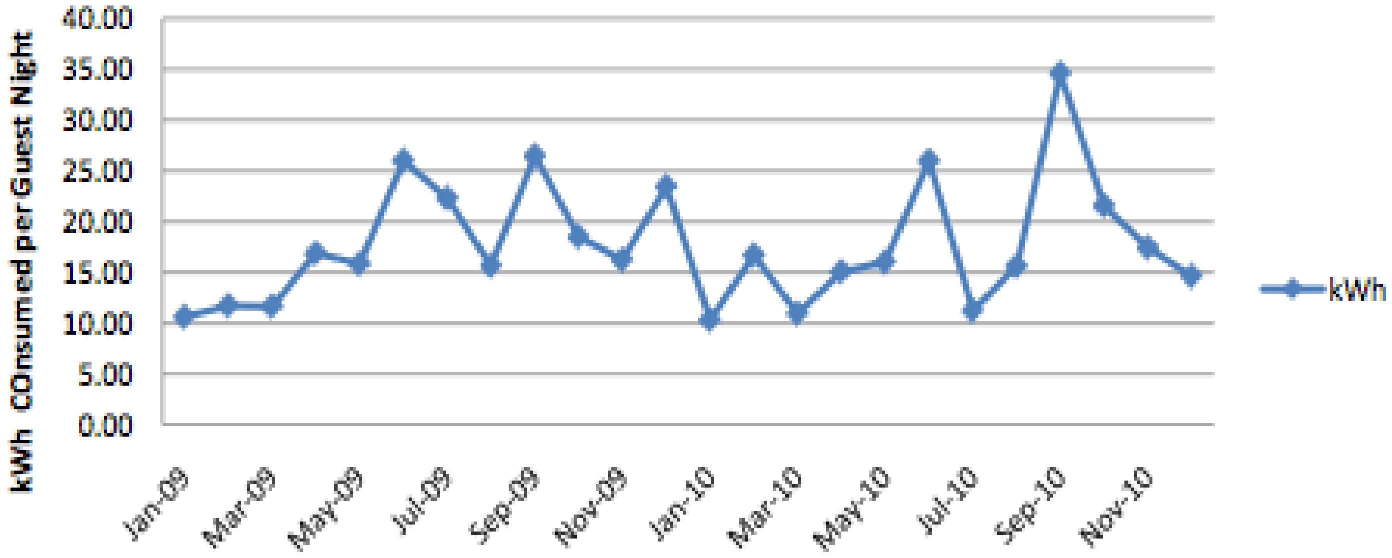
Energy Use Index

- This term refers to a measure of energy consumption in buildings.
- It is derived from the total energy consumed per year, divided by the square foot area of the building.
- The index can also be done per unit/ guest night/ employee. It all depends on what the facility is investigating.
- It represents how concentrated the energy use is within he building.
- Example: **30kWh/m^2; 45kWh/GN.**

3.1 Energy Accounting and Distribution

ENERGY USE INDEX

- The following graph illustrates the property's Energy Index per Guest Night (HOTEL)



3.1 Energy Accounting and Distribution

NATURAL GAS ANALYSIS

- NATURAL GAS ANALYSIS
  - Simply shows the conversion of Natural Gas consumed in m^3 to kWh.
  - The sum of the kWh from Natural Gas and Electricity gives a clearer idea of the total energy consumption of the facility

			NG Gas Index (kWh/RN)				
	NATURAL GAS ENERGY	NG FUEL	NG Fuel	Occupancy	NG Gas Index	Amount Paid	Natural Gas Cost
Item	Month	Used (m3)	Used (kWh)	Guest Nights	kWh/GN	BDS$	BDS$/$m^3$

- This is done for all fuels found on the property.

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3.1 Energy Accounting and Distribution

CARBON DIOXIDE EMISSION ANALYSIS

- This is an analysis of the fuels used at the property and also at the utility to produce the required electricity.
- It impacts the environment due to the Carbon Dioxide emissions that come hand in hand with the use of energy
- This table shows a sample analysis for a property

Annual Carbon Footprint	kWh Consumed	CO2 (Lbs)	CO2 (Tonnes)	CO2/GN (Lbs)
Natural Gas (kWh)	36,815	4,970	2	0.2
Electrical (kWh)	389,950	505,765	229	18.9
Annual Carbon Footprint	426,765	510,735	232	19.1

- The total kWh figure is a sum Electrical Energy from the Utility and Natural Gas Consumed annually.

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3.2 Energy Saving Opportunities & Their Benefits

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3.2 Energy Saving Opportunities (ESO)

- After a complete inspection and analysis of the facility is done ESO's are developed specific to each facility.

- The economic feasibility for each ESO is determined:
  - The annual energy and financial savings
  - Simple Payback Period
  - Tons of Carbon Dioxide Saved annually (i.e. not emitted)
    - All calculations are shown in the Energy Accounting Appendix

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3.2 Energy Saving Opportunities

- At the end of every report the Discussion and Recommendations section lists the most economically feasible projects for the property to undertake.

- The following ESO are evaluated:
  - Energy Management / Corporate Utility Management Program
  - Variable Refrigerant Flow (VRF or Inverter) Air Conditioning
  - Insulation of pipes, vessels
  - Building Envelope (glass, radiant barrier for roofs, wall insulation)
  - Steam systems (steam traps, leaks etc.)
  - Compressed Air systems (efficiency, leaks, design)
  - Absorption Cooling & Cogeneration
  - Energy Recovery Systems (air to air, air to water)
  - Improved Maintenance
  - Lighting Retrofits
  - Guest Room Controls & Building Management Systems
  - Timers & Controls
  - Photovoltaic Systems
  - Variable Speed Drives
  - Power Factor Correction

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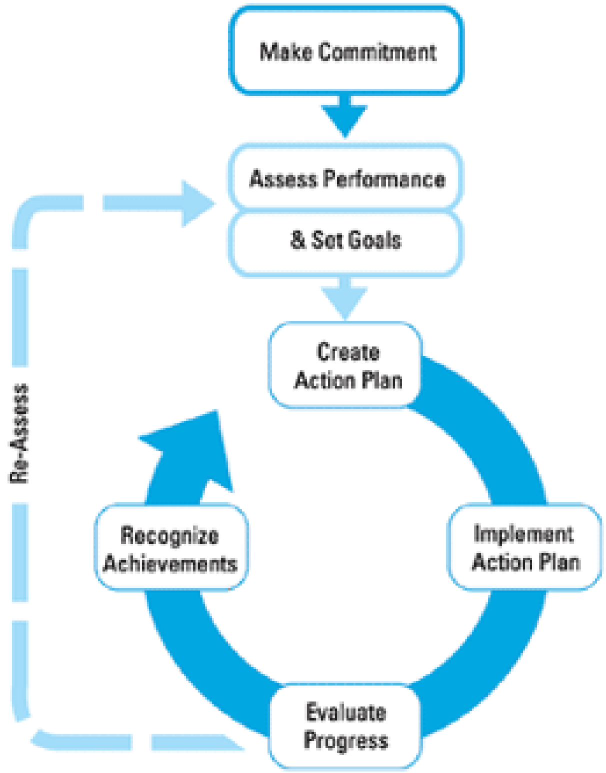
3.2 Energy Saving Opportunities

The Energy Management Process



- Energy Management or Corporate Utility Management Programs (CUMP) have the ability to save facilities as much as 10% on their total utility bill.
- Costs vary according to size:
  - Small TT$24,000-36,000/yr
  - Medium TT$ 42,000/yr
  - Large TT$144,000/yr
  - Payback: 4-5 months
- Increases awareness among staff and users of the need for energy conservation & sustainability.

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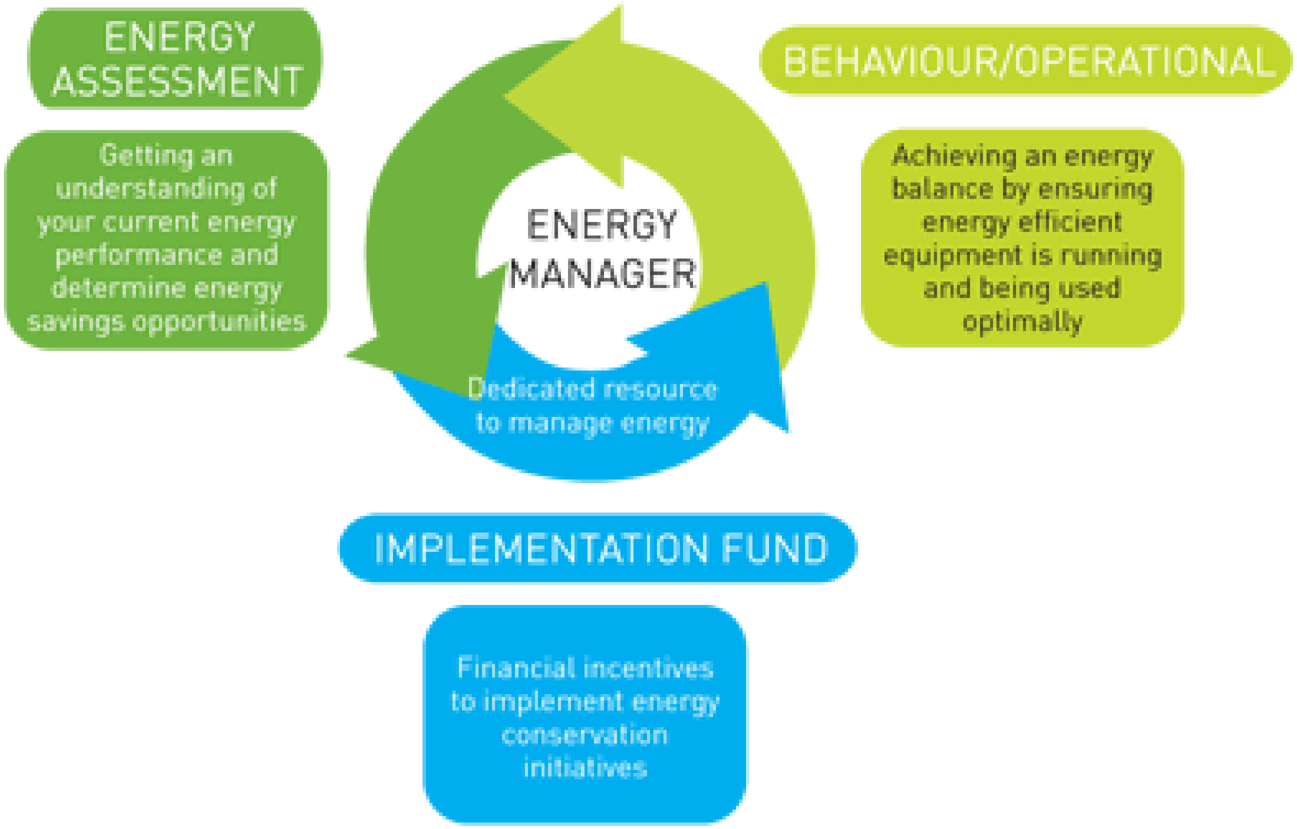
3.2 Energy Saving Opportunities



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CARILEC
An Association Of Electric Utilities

Caribbean Electric Utility Services Corporation

IDB

Certified Energy Manager

22—25 May 2012 **Bay Gardens Hotel** **St. Lucia**

Registration Fee:	**US$500.00 (inclusive of examination fees)**
Seminar Time:	8:30am—5:00pm
Accommodation:	Bay Gardens Hotel Room Rate: US$115.00 (inclusive of breakfast and taxes)
Target group:	Professionals in the Energy Business

Overview

CARILEC will be offering a seminar for persons in the Energy Business who are interested in being a Certified Energy Manager (CEM). The CEM credential is widely accepted and used as a measure of professional accomplishment within the energy management field. This fast-paced, highly focused seminar is designed to provide the specific training and background needed by professionals preparing to sit for the CEM exam. The training will be done over two days with one(1) day put aside for revision of training material, then on the fourth day, participants will write the examination. The seminar will include updates on topics of current importance, such as implementation of the most recent energy legislation, new energy efficiency equipment standards for commercial buildings, building commissioning basics, and critical indoor air quality considerations.

The course will review the technical, economic, and regulatory aspects of effective energy management and the basics of energy efficiency improvement as it relates to electrical, utility, building, and combustion systems. Professionals seeking the CEM designation must meet a CEM board-approved list of pre-qualifications in experience in the field and/or prior educational achievement . This certification helps individuals distinguish themselves and obtain their career objectives .

3.2 Energy Saving Opportunities

- VARIABLE REFRIGERANT FLOW SYSTEMS
  - One condensing unit for multiple indoor fan coil units
  - An additional condenser can be installed as back-up
  - Free hot water producing feature
  - Uses less space than multiple units
  - Can be supplied with occupancy sensors to reset room temperature when guests are not there
  - Consumes less energy per ton when compared to typical splits (0.9kW/ton vs 1.15 kW/ton)
  - Can produce energy savings of up to 30%
  - Payback: 3-5 years

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3.2 Energy Saving Opportunities

- ABSORPTION COOLING
  - Absorption Cooling produces air conditioning for a facility using any of the following fuels:
  - Steam/ Exhaust
  - Natural Gas
  - Diesel
  - LPG
  - Hot Water
  - * there is also a free hot water producing feature

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3.2 Energy Saving Opportunities

- INVERTER AIR CONDITIONING UNITS
  - This technology uses variable speed rotary compressors, This allows the Inverter mini-split unit to speed up and slow down as needed, avoiding the typical on-off-on-off air conditioning cycle that is very wasteful of energy.
  - Typical air conditioners run on an on-off cycle to maintain a room's desired temperature. This actually puts strain on the air conditioner's motor as frequent restarting requires more energy to run.
  - Cost : $800 per ton
  - Payback: 2 years

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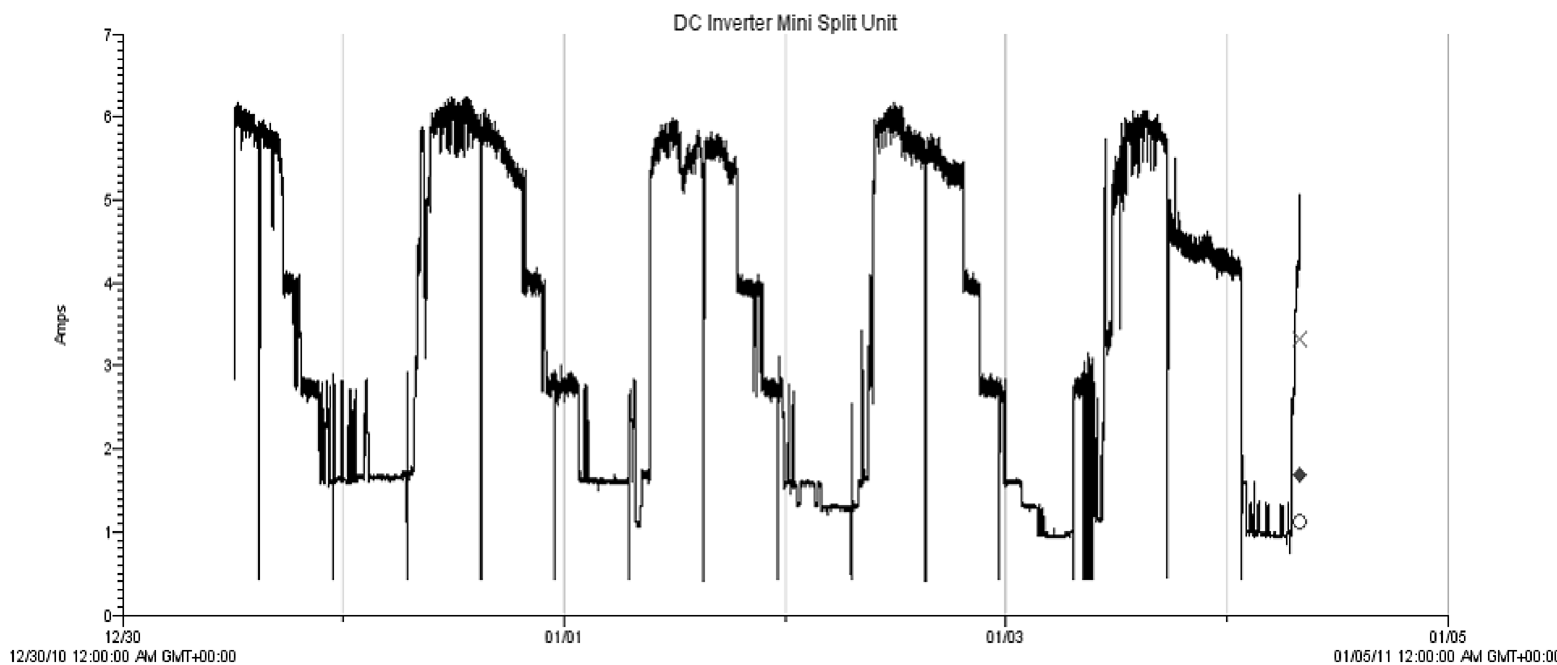
3.2 Energy Saving Opportunities

- INVERTER AIR CONDITIONING UNITS
  - EDL has done testing on this unit as can be seen below.



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3.2 Energy Saving Opportunities

LIGHTING RETROFITS:

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3.2 Energy Saving Opportunities

- LIGHTING RETROFITS:
  - The following are lighting fixtures that can be used for retrofits:
  - L.E.D. Down Lighters (3 Watts)
  - L.E.D. 18W Tubes
  - T5 Florescent Tubes (25 Watts)
  - 11& 13 W Compact Florescent bulbs

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3.2 Energy Saving Opportunities

- GUEST ROOM CONTROLS & BUILDING MANAGEMENT SYSTEMS
  - These systems can save hotels up to 40% on energy costs.
  - Guest Room Controls
    - These can be in the form of : the card key system, thermostats, sensors placed inside of the room to control equipment based on the room's occupancy.

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3.2 Energy Saving Opportunities

- BUILDING MANAGEMENT SYSTEMS (BMS)
  - BMS is a computer based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment. Example: Ventilation, lighting, power systems, fire systems and security systems.
  - A BMS is most common in a large buildings. Its core function is to manage the environment within the building and may control temperature, carbon dioxide levels and humidity within a building.
  - Payback: 2-3 years

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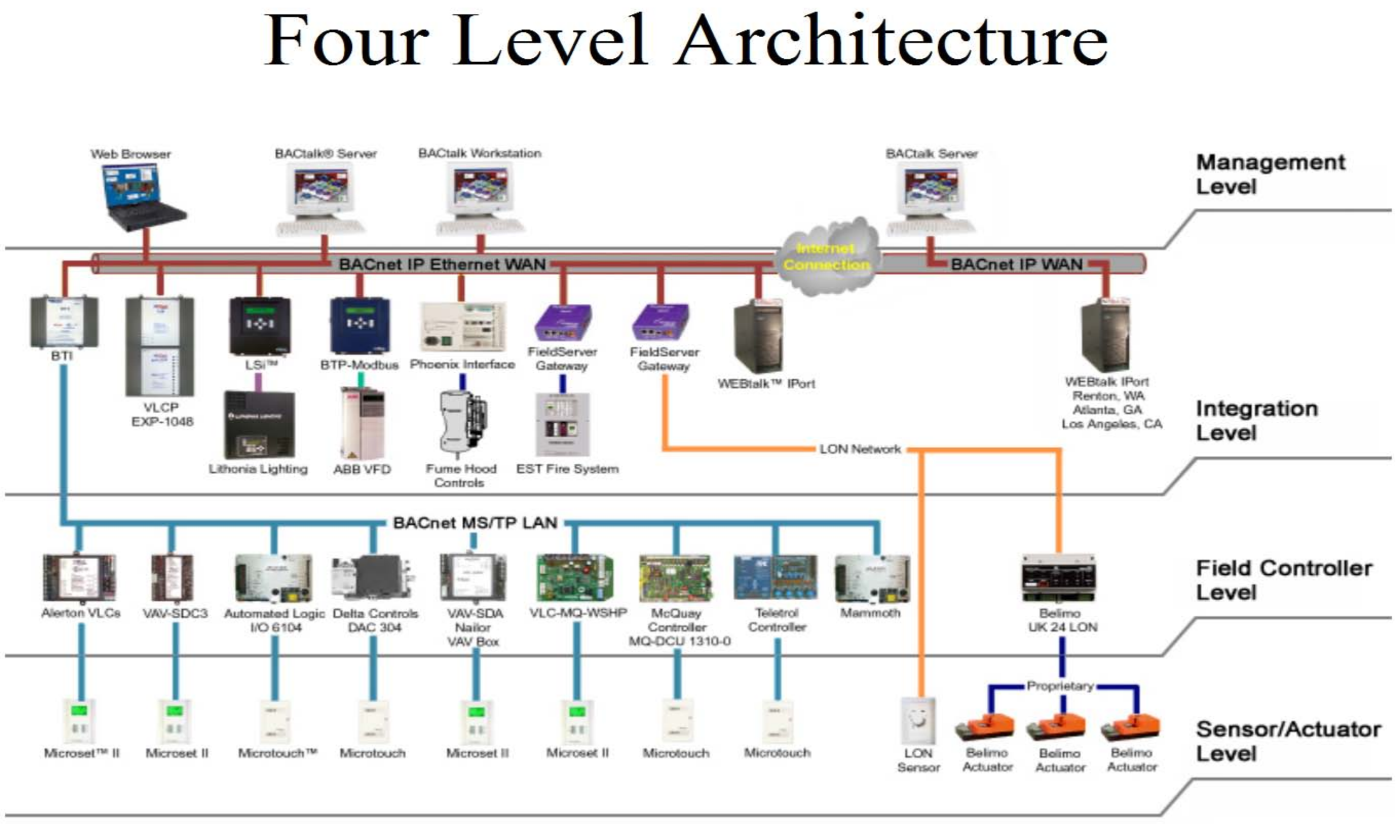
BMS Architecture



3.2 Energy Saving Opportunities

- PROGRAMMABLE TIMERS & CONTROLS
  - These simple devices can ensure equipment is shut of during hours of inactivity
  - Example shutting off of:
    - Pumps
    - Exhaust Fans
    - Lighting
    - Payback: 5 months

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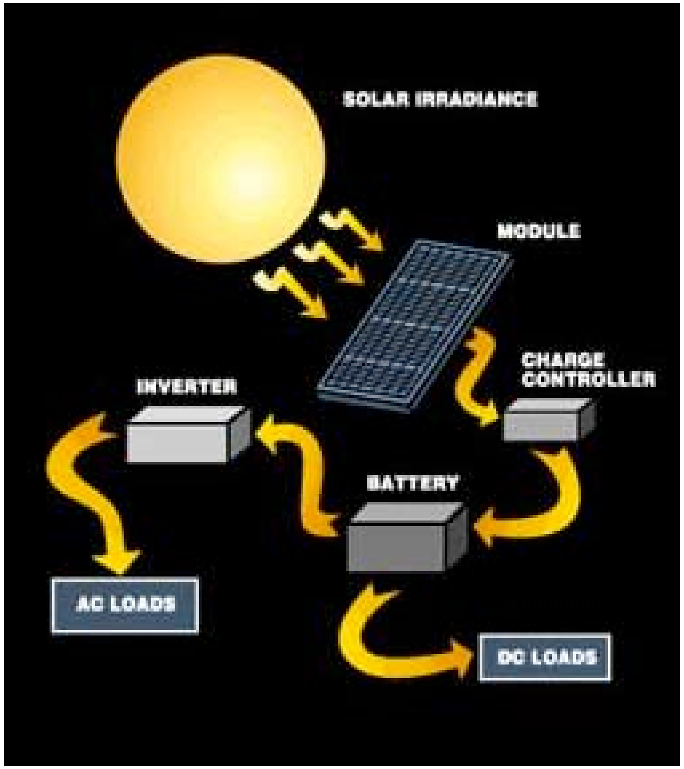
3.2 Energy Saving Opportunities



- PHOTOVOLTAIC (PV) SYSTEMS
  - These systems are a large financial investment
  - Once funding is available facilities should take advantage to install a PV system which is more sustainable for the facility in the long run.
  - Payback: 5-10 years

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3.2 Energy Saving Opportunities

- **VARIABLE SPEED DRIVES (VSD)**
  - Energy savings are attained by using VSD because they basically control speed.
  - That means if an application only needs 80 percent load, pump will run at 80 percent of rated speed and only requires 50 percent of rated power. In other words, the VSD is reducing speed by 20 percent and requires only 50 percent of the power.
  - For many pump and fan applications expenditure is often recouped in less than a year and costs $1000/kW with a payback of 1-2 years

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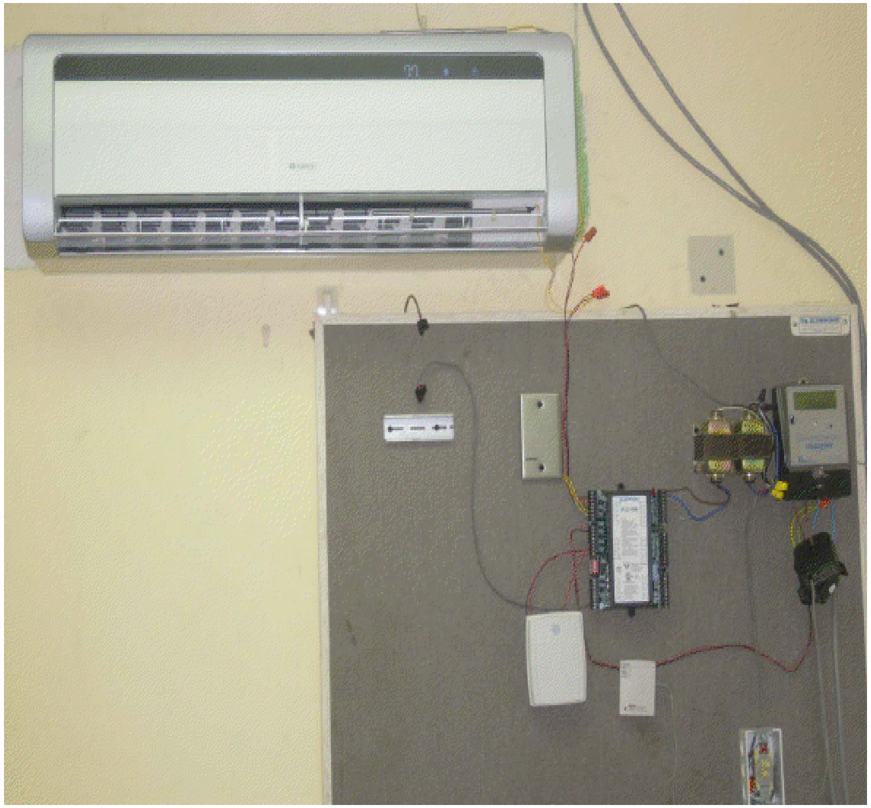
3.2 Energy Saving Opportunities

Product Testing

- EDL ensures tests these energy efficient equipment before recommending in reports to ensure accuracy.
- Testing needs to be done on equipment, facilites can work together to determine what works best for them.



4.0 ESO's based on facility type and activity

- Facility energy distribution patterns are not the same. As a result the energy management focus will fall different areas based on facility type/ activity.
- Petrochemical : Refining Equipment
- Mechanical Plant: Mechanical equipment (Compressors, pumps, blowers)
- Commercial Buildings : Air Conditioning, Ventilation & Lighting

Manufacturing Plant ESO's

- Energy Recovery: Use of exhaust gas in an Absorption chiller

- Use of exhaust gas : Free hot water production

- Cogeneration

Petrochemical Plant ESO's

Process heating, distillation, evaporation, absorption and cooling are typical processing operations in the petrochemical industry.

Energy efficiency improvements in this sector begin with the following applications:

- Good housekeeping, process management, optimized steam network, process integration, heat cascading, mechanical vapor recompression, heat exchangers, adjustable speed drives, high-temperature heat recovery, and low-temperature heat recovery.

Petrochemical Plant ESO's

Investment Type ESO's can include:

- Broad Heat Pumps
- Cogeneration
- District Cooling

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Commercial Building ESO's

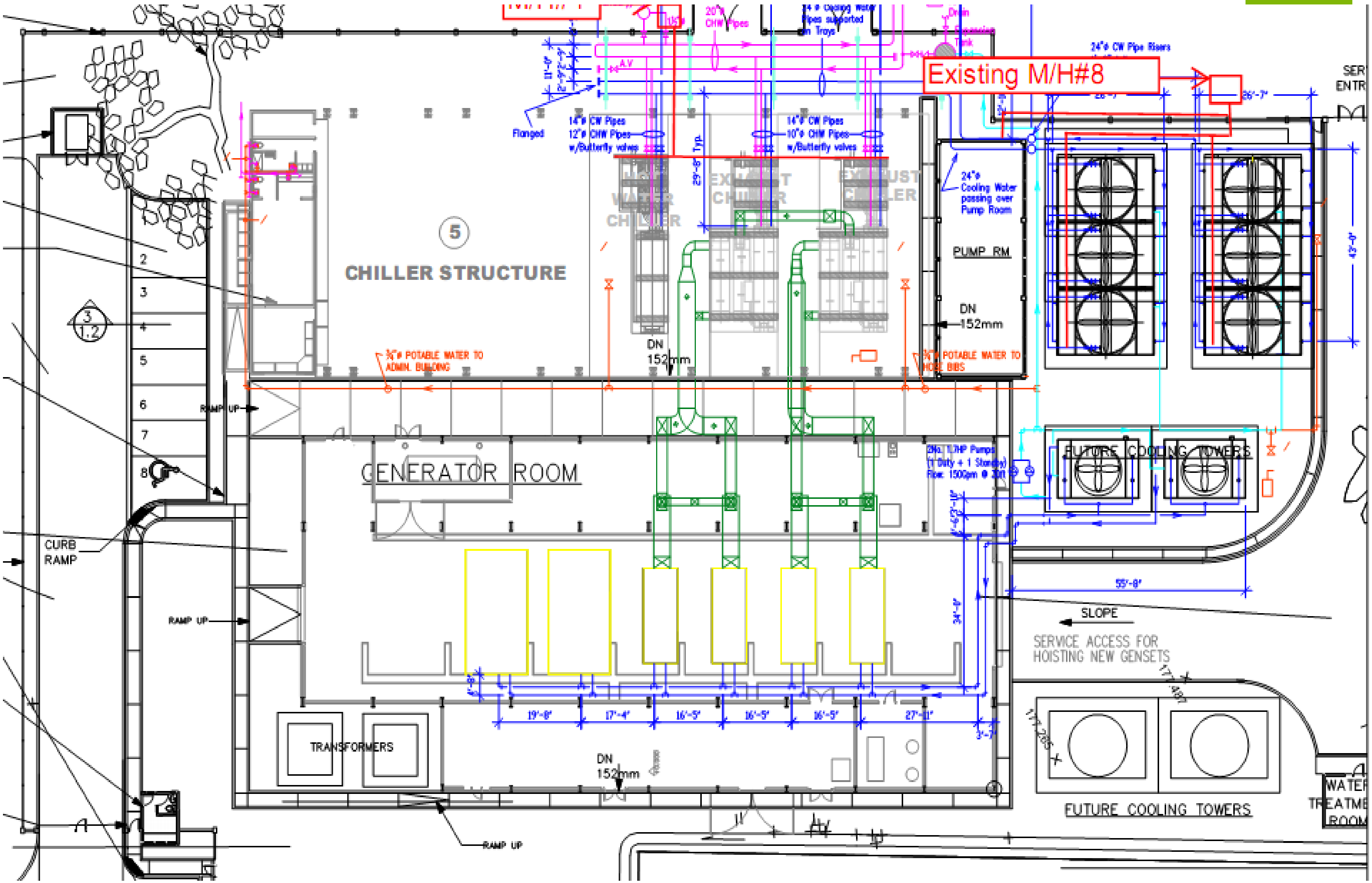
Investment Type ESO's include:

- Direct Fired Absorption and Cogeneration.
- Energy Recovery (SEMCO)

Commercial Building ESO's

Investment Type ESO's include:

- Direct Fired Absorption and Cogeneration.
- This is currently being installed at the UWI Mona Campus. 2,400Rt



Existing M/H#8
CHILLER STRUCTURE
PUMP RM
GENERATOR ROOM
TRANSFORMERS
FUTURE COOLING TOWERS
SERVICE ACCESS FOR
HOISTING NEW GENSETS
SLOPE
CURB
RAMP
RAMP UP
DN
152mm
24"ø Cooling Water passing over Pump Room
24"ø CW Pipe Risers
14"ø CW Pipes
12"ø CHW Pipes
w/Butterfly valves
10"ø CHW Pipes
¾"ø POTABLE WATER TO ADMIN. BUILDING
¾"ø POTABLE WATER TO HOSE BIBS
FUTURE COOLING TOWERS
WATER TREATMENT ROOM

Utility ESO's

- Investment Type ESO's include:
- Turbine Inlet cooling
- Use of exhaust gas for District cooling via Absorption
- Cogeneration

Utility District Cooling

Dominican Republic – 7,000 Rt.

Solar Cooling – Digicel Jamaica

4.1 ISO 50001 : Energy Management

- ISO 50001 is an Energy management systems standard- Requirements with guidelines for use developed by the international organization for standardization ISO 50001 provide the framework of what an energy management system should contain, but not how to implement it or detail on the contents.

- **The objective is to achieve continual improvement of energy performance.**

- More specifically it encourages to:
  - Set a Corporate Energy Performance Policy
  - Develop a baseline of energy use;
  - Actively manage energy use and costs;
  - Reduce emissions without negative effect on operations;
  - Continue to improve energy use/product output over time;
  - Document savings for internal and external use (e.g. emission credits)

4.1 ISO 50001: Energy Management

Why Industry are not Energy Efficient?

- The business of industry is not energy efficiency
- Data on energy use of systems is very limited
- Difficult to assess performance or evaluate performance improvements
- Opportunities for more energy efficiency are overlooked
- Budgets are separate for equipment purchases and operating costs
- Facility engineers typically do not become CEO or CFOs

4.1 What is the goal of ISO: 50001

- To develop an international standard for Energy Management Systems Specifies core requirements for ENMS.
- To incorporate the ENMS into the overall management system of a company.
- To co-ordinate corporate functions such as planning activities, responsibilities, practices, procedures, processes and resources.
- To develop, implement, achieve, review and maintain the energy policy and objectives.
- Designed to facilitate auditing of ENMS core elements.

+ 5.0 Absorption Cooling & Cogeneration

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What is Absorption?

- Uses the absorption cooling process to achieve the refrigeration effect necessary to produce chilled water;
- No mechanical compression of refrigerant is done as in the vapor compression type chiller;
- Therefore, very little electricity is needed for the absorption cooling system when compared to the vapor compression system.
- Two liquids inside:
  - Lithium Bromide (LiBr) – absorbent
    - Diluted; or
    - Concentrated
  - Water – refrigerant
    - Liquid; or
    - Vapor

Absorption Cooling Cycle

High Temperature Generator

- Dilute LiBr solution is boiled – water vapor escapes, LiBr concentrated

Condenser

- Water vapor condenses to water

Evaporator

- Water vaporizes at low temperature under vacuum conditions

Absorber

- Water vapor condenses on cooling water tubes and LiBr becomes diluted

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BROAD Absorption Chillers

- Inputs
  - Heat – natural gas, town gas , biogas, diesel, recycled oil
  - Lithium Bromide salt solution (non toxic, has a high affinity for water)
  - Cooling water (30°C)
- Outputs (dedicatedly or simultaneously)
  - Chilled water (>5°C)
  - Heating water (<95°C)
  - Hot water (80°C)

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BROAD Absorption Chillers

- Features
  - Dual fuel – gas/oil, gas/waste heat, multi energy
  - Waste heat from power generation or industrial waste heat streams (steam, hot water, exhaust, etc.)

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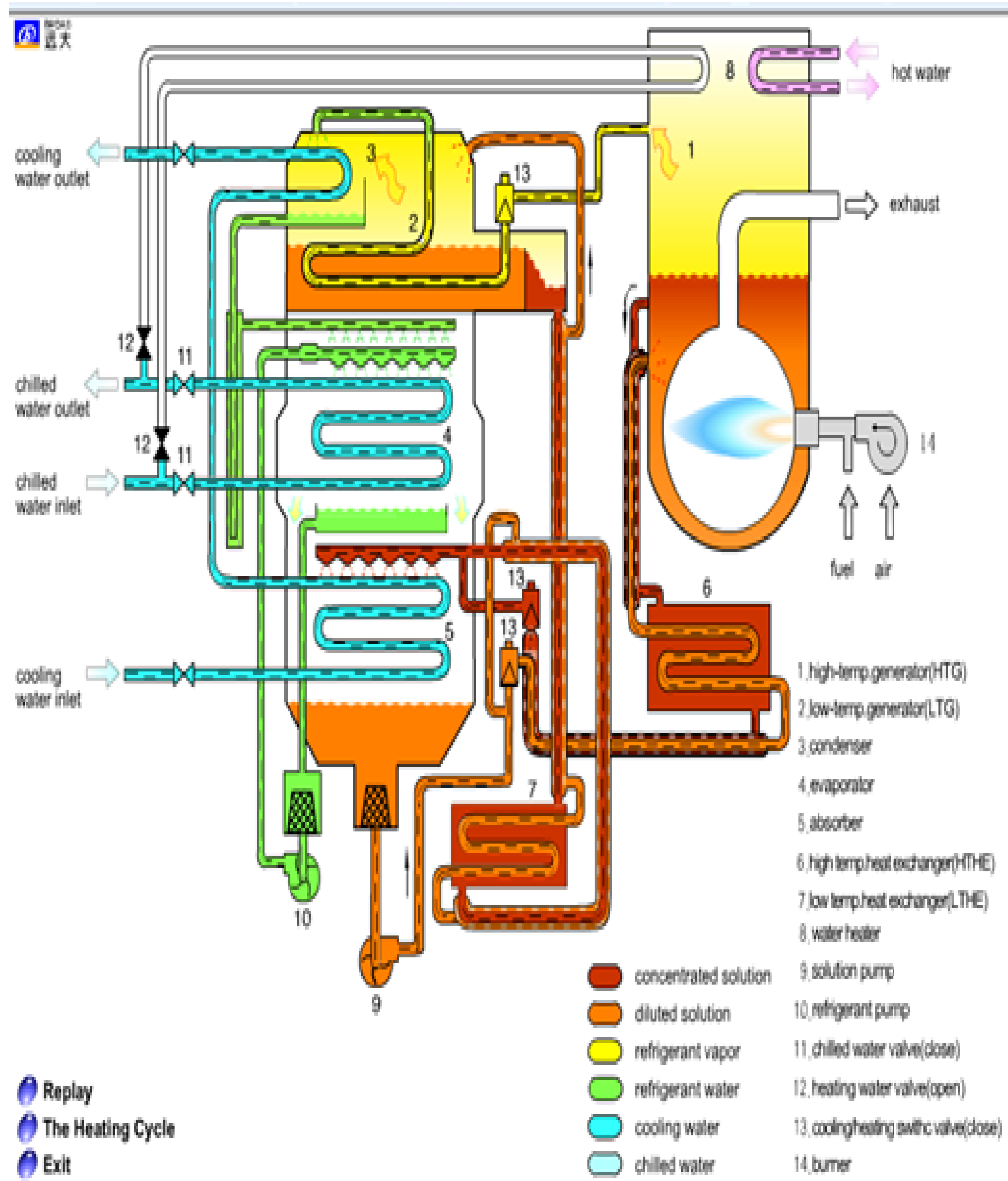
How the BROAD Chiller works

Dilute LiBr solution is heated in the *High Temperature Generator (HTG) and causes water* vapour (refrigerant vapour) to leave and enter the *Low Temperature Generator (LTG)* where it is used to heat up some more dilute LiBr solution.



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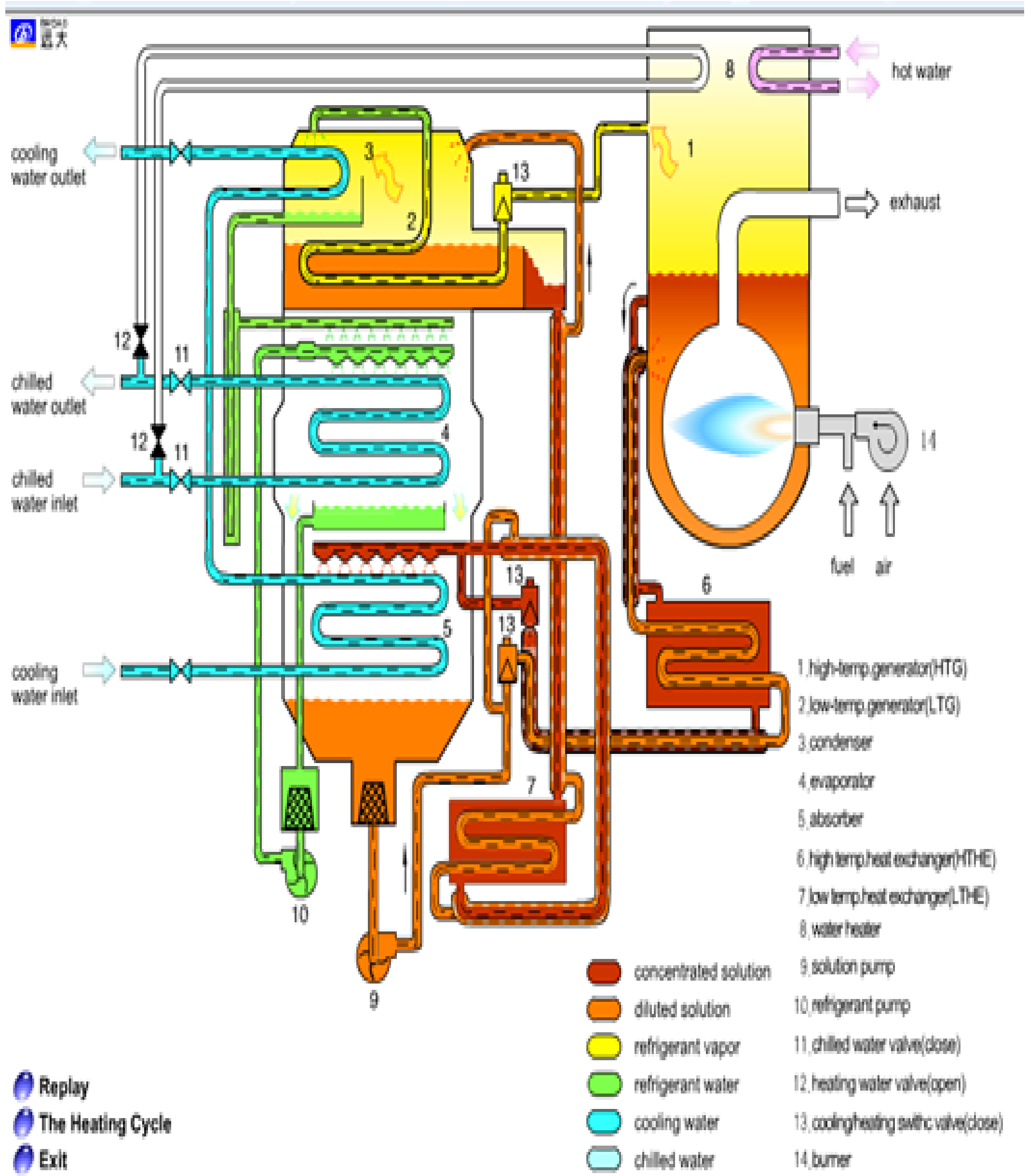
How the BROAD Chiller works

Refrigerant vapour passes on to the *Condenser* where the water vapour condenses on the cooling water tubes to liquid water, forming refrigerant water.



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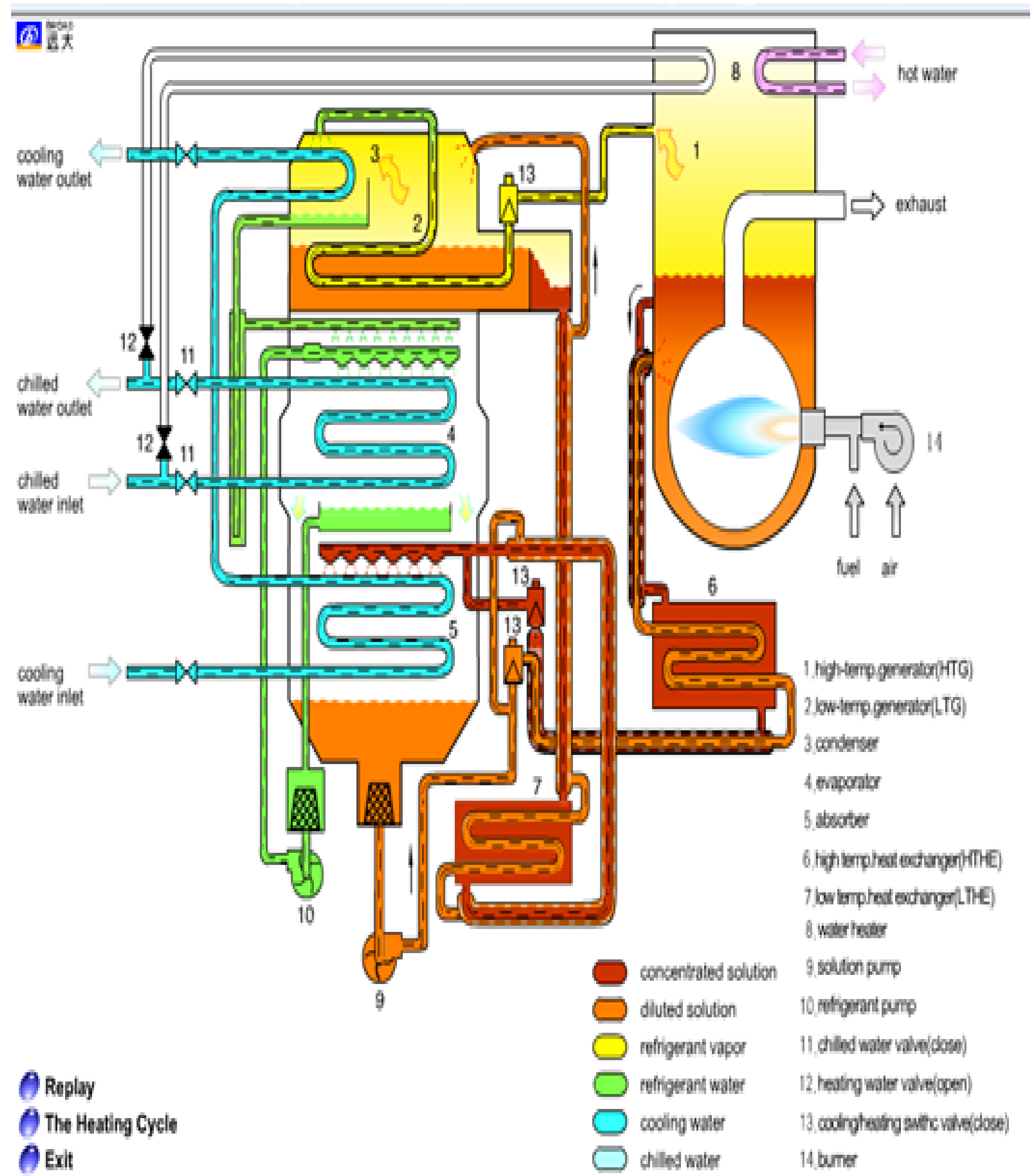
How the BROAD Chiller works

The refrigerant water is then sprayed on the tubes in the *Evaporator*. These tubes contain the chilled water that is circulated for cooling.



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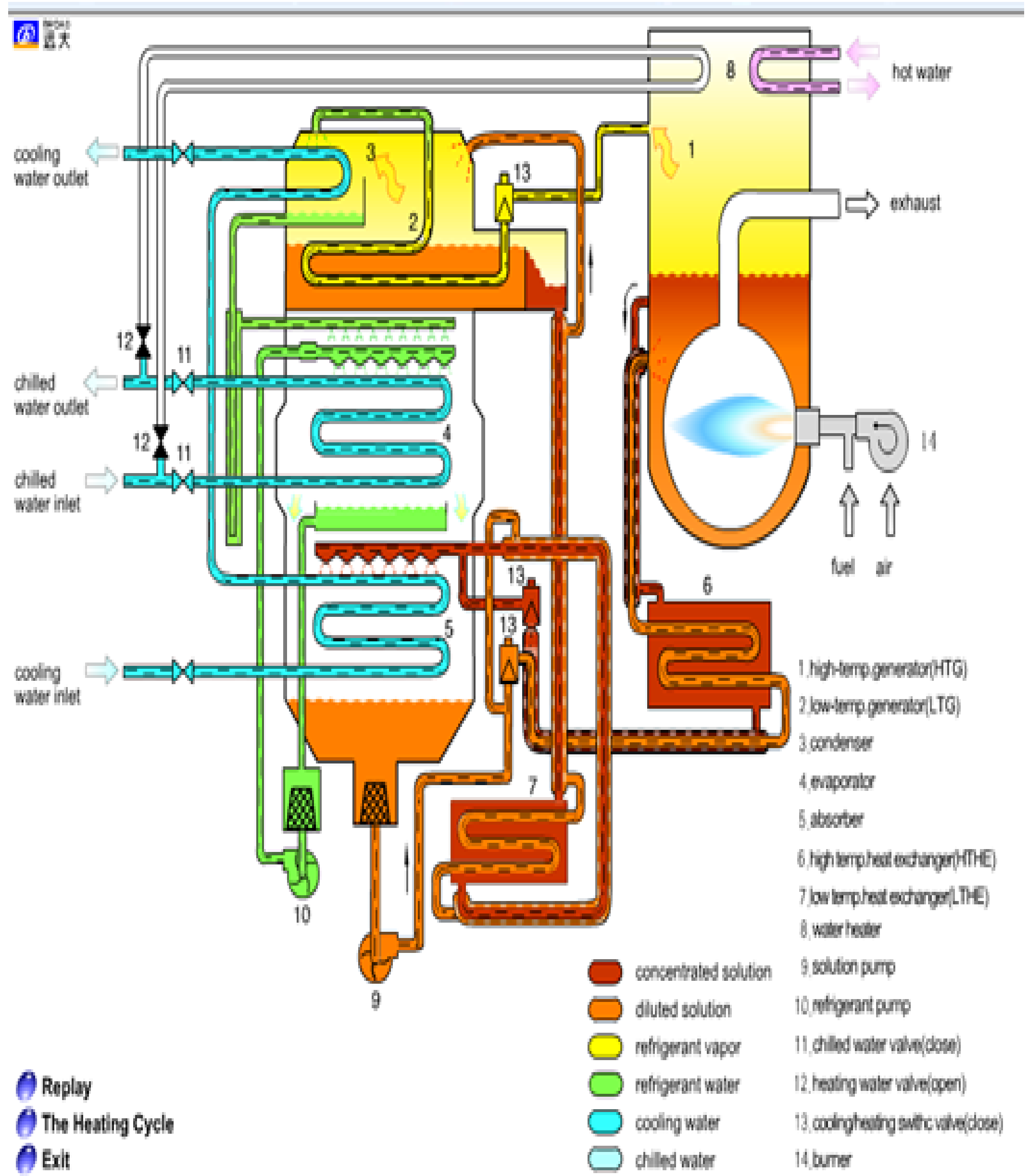
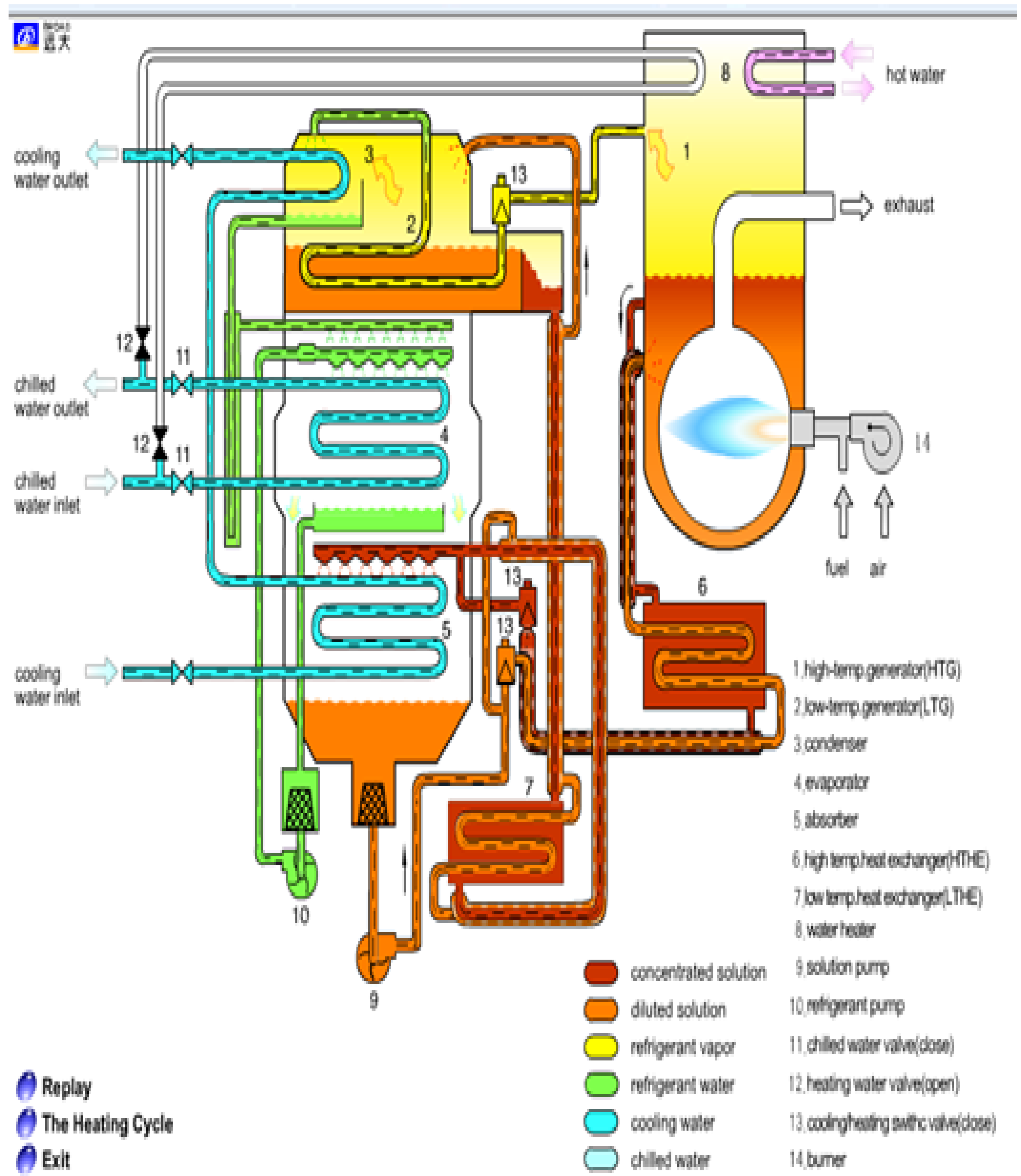
How the BROAD Chiller works

The evaporator is under vacuum condition which causes the water to vaporize at very low temperatures. The energy for vaporization is drawn from the water and so it becomes chilled water.



How the BROAD Chiller works

The water vapour travels over to the *Absorber* where it condenses on the cooling water tubes. Concentrated solution, which has a high affinity for water, is sprayed over these tubes as well and absorbs the water, thus it becomes diluted solution that is returned to the *High Temperature Generator (HTG)* and the Low Temperature Generator (LTG)



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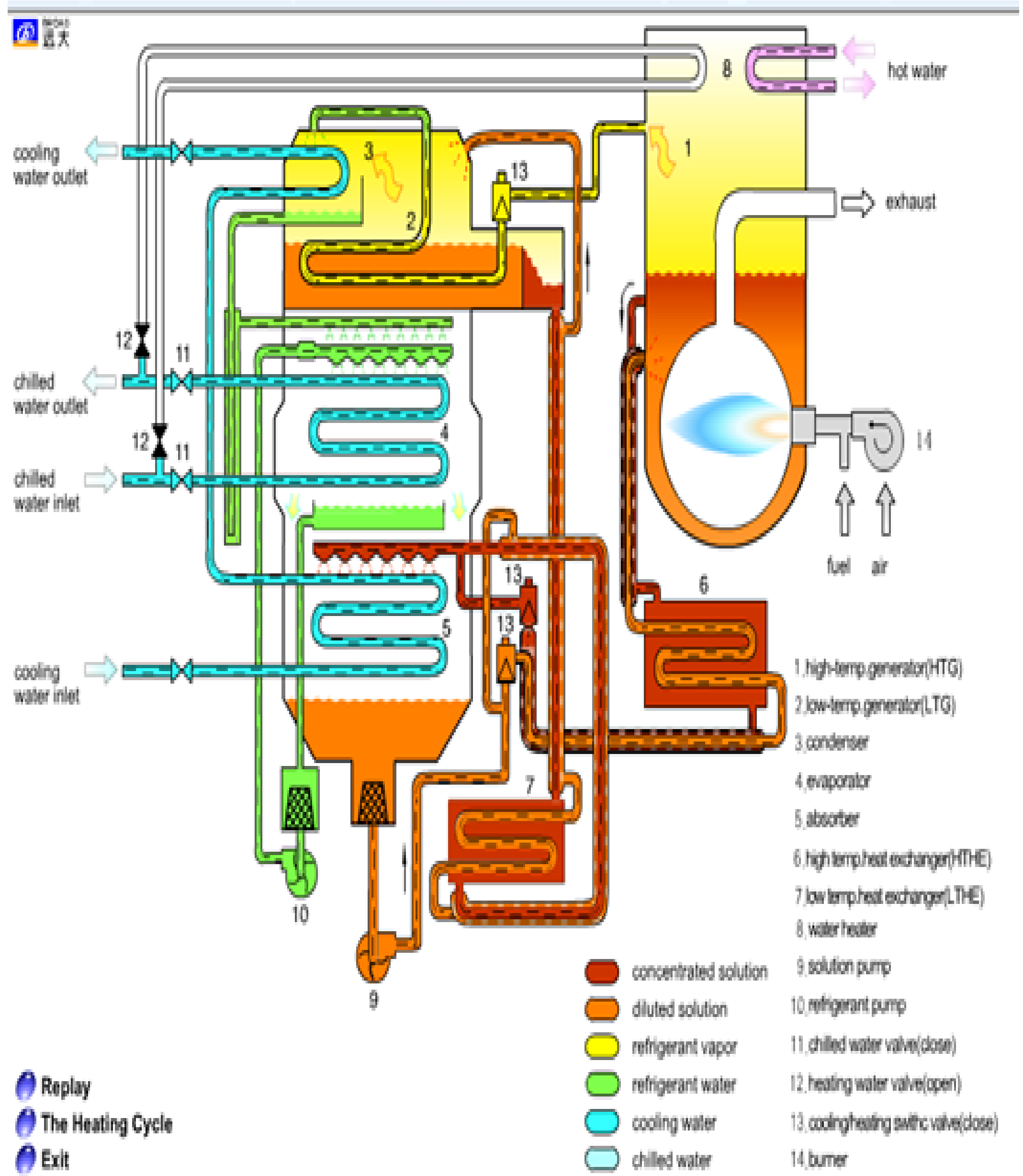
How the BROAD Chiller works

Dilute solution from the absorber is preheated using concentrated solution in the *High Temperature Heat Exchanger (HTHE*) and in the *Low Temperature Heat Exchanger (LTHE)* before it is returned to the *High Temperature Generator (HTG). and the Low Temperature Generator (LTG) respectively.*



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BROAD BCT Chiller

Available Capacities:

6.6 - 33 RT

Includes water cooled condenser

Fuels: Natural gas, LPG, Town gas, Light Oil

NG consumption: 10kWh/m^3

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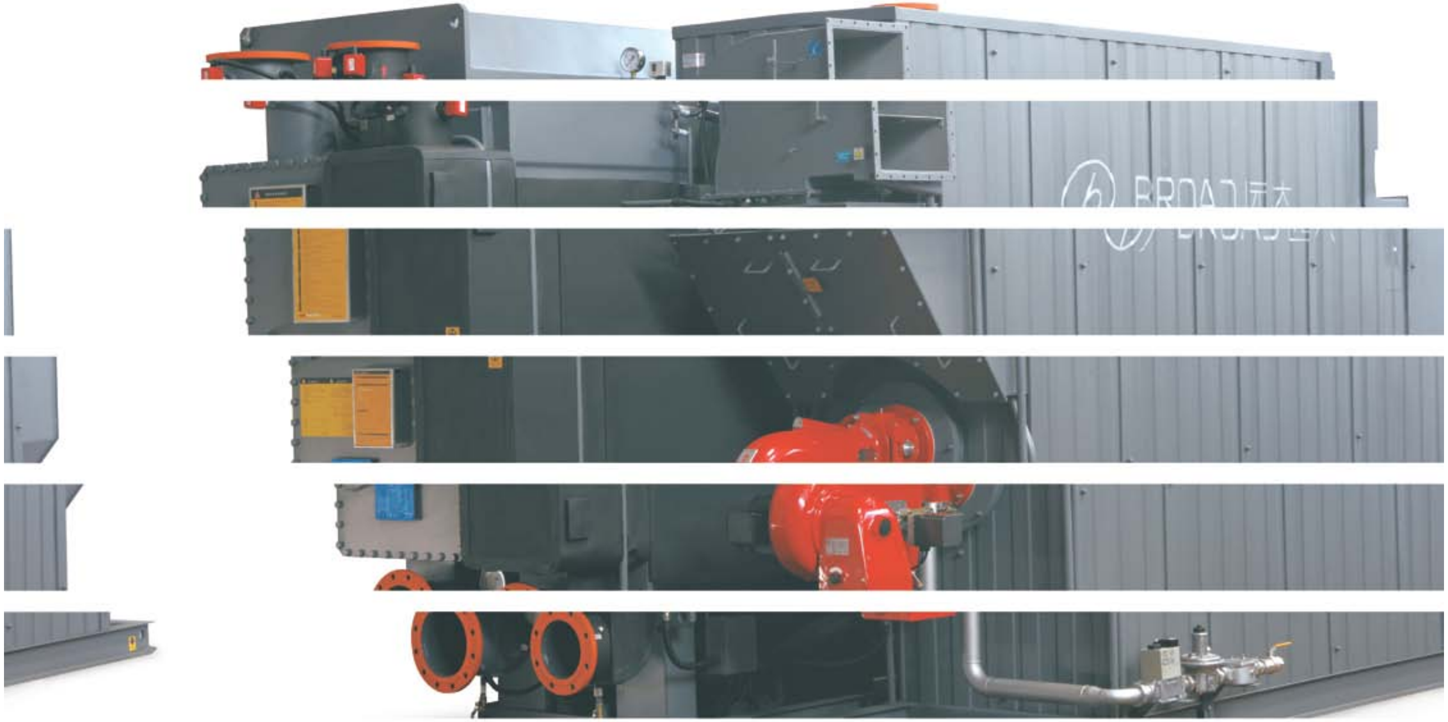
BROAD Direct Fired Absorption Chiller

BZ



BROAD Steam Absorption Chiller

BS

BROAD Packaged Chiller

Central Air Conditioning Industrialization

Space Saving

The BROAD Packaged Chiller includes chilled water pumps and cooling water pumps on a single skid.

It may also be totally enclosed in a container to protect the components from weathering and to make installation easy.

BROAD Packaged Chiller

Central Air Conditioning Industrialization

Energy Saving

50% less water resistance from large check valves means less pumping energy required.

Two pump system – Inverter controlled. Water is pi

+

BROAD Packaged Chiller

Central Air Conditioning Industrialization

Water Softener

Water treatment chemicals are included to deposit in the cooling water circuit.

BY

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Some BROAD Chiller Installations in the Caribbean

Customer	Location	Chiller Quantity	Chiller capacity (Rt)	Total capacity (Rt)	Year of commissioning
Hospital	Trinidad	2	66	132	2003
Commercial Building	Trinidad	3	20	60	2004
Commercial Building	Trinidad	2	33	66	2005
NGC Warehouse	Trinidad	2	100	200	2005
Hospital	Trinidad	1	66	66	2005
Accra Beach Resort	Barbados	3	66	198	2006
The Crane Resort	Barbados	2	248	496	2007
OWP Apartment Complex	Trinidad	2	1300	2600	2008
Commercial Building	Trinidad	1	66	66	2009
Financial Complex	Trinidad	1	413	413	2009
Commercial Office	Dominican Republic	1	20	20	

BROAD Chiller Installations in the Caribbean

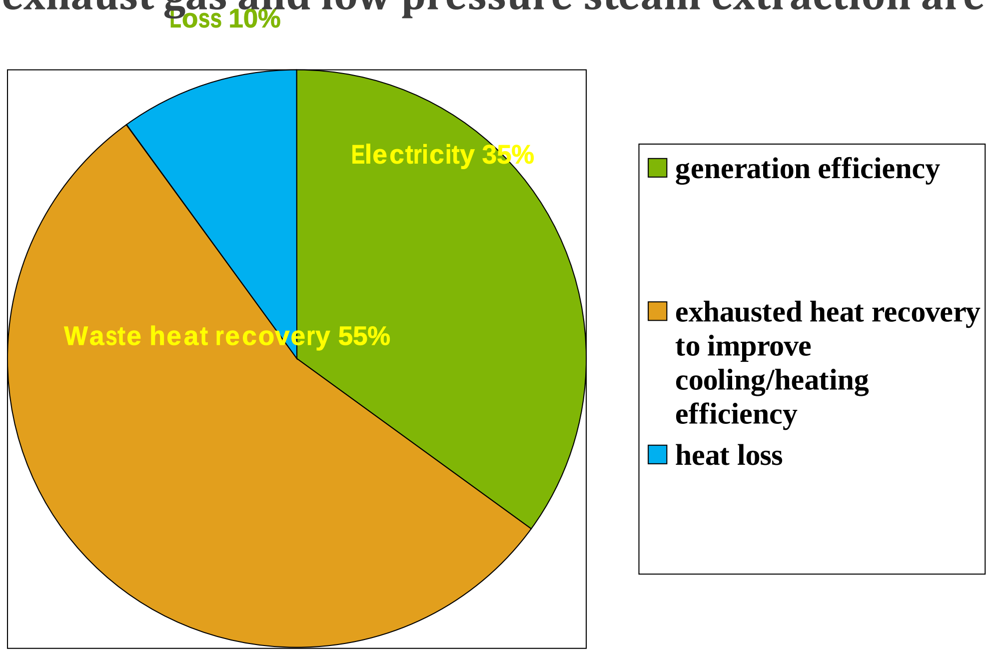
Customer	Location	Chiller Quantity	Chiller capacity (Rt)	Total capacity (Rt)	Year of commissioning
Secondary School	Trinidad	1	66	66	2010
Secondary School	Trinidad	2	165	330	2010
Chemical Laboratory	Trinidad	3	331	993	2011
Commercial Building	Trinidad	3	250	750	TBC
Hotel	Dominican Republic	1	661	661	TBC
Secondary School	Trinidad	3	2 *165 + 66	396	2011
Secondary School	Trinidad	3	2 *165 + 66	396	TBC
Secondary School	Trinidad	3	2 *165 + 66	396	TBC
University of Trinidad & Tobago	Trinidad	2	1300	2600	TBC
University	Jamaica	3	800	2,400	TBC

CCHP systems

Distributed Energy System /Combined Cooling, Heating and Power is a system that apply power, cooling and heating to customers in one district at the same time to achieve high-efficiency through integration and application of primary energy conversion.

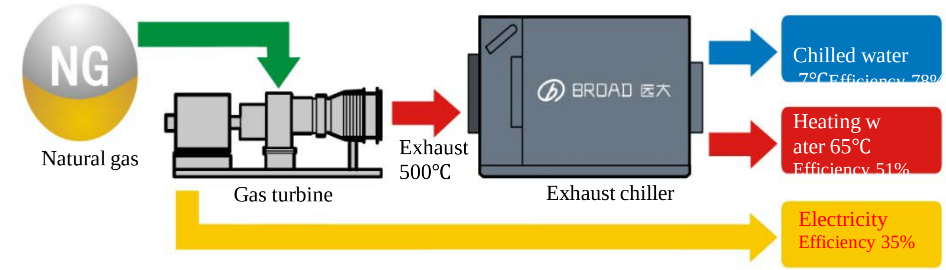
CCHP: Cogeneration Systems

With using natural gas as its primary energy, the DES/CCHP system is usually use gas turbine or combustion engine to generate first， then high-temp exhaust gas to generate more power through exhaust heat boiler-steam turbine；the low grade heat like low-temp exhaust gas and low pressure steam extraction are used for cooling and heating.



- **CCHP system can achieve 90% of the total thermal energy use efficiency**
- **. According to the data from US department of commerce: average energy saving ratio of CCHP system can reach 46%.**

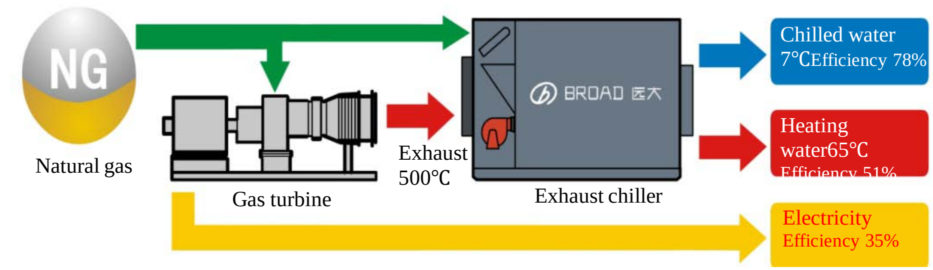
Typical application and solution of CCHP system



Mode 1: Exhaust type

Energy efficiency: Electricity + cooling 113%

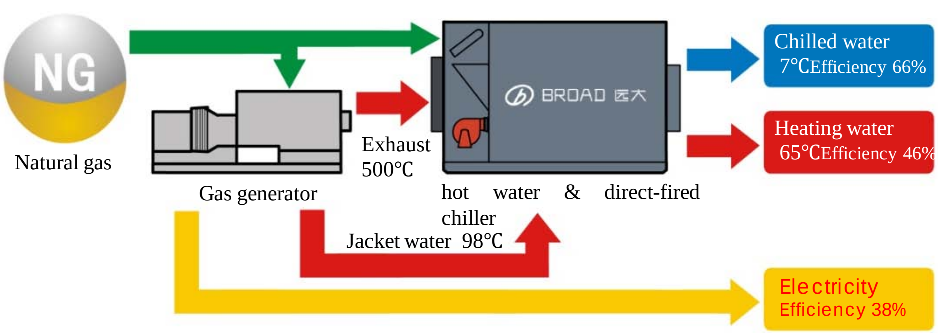
Electricity + heating 86%



Mode 2: Exhaust & direct-fired type

Energy efficiency: Electricity + cooling 113%

Electricity + heating 86%



Mode 3: Exhaust, hot water & direct-fired type

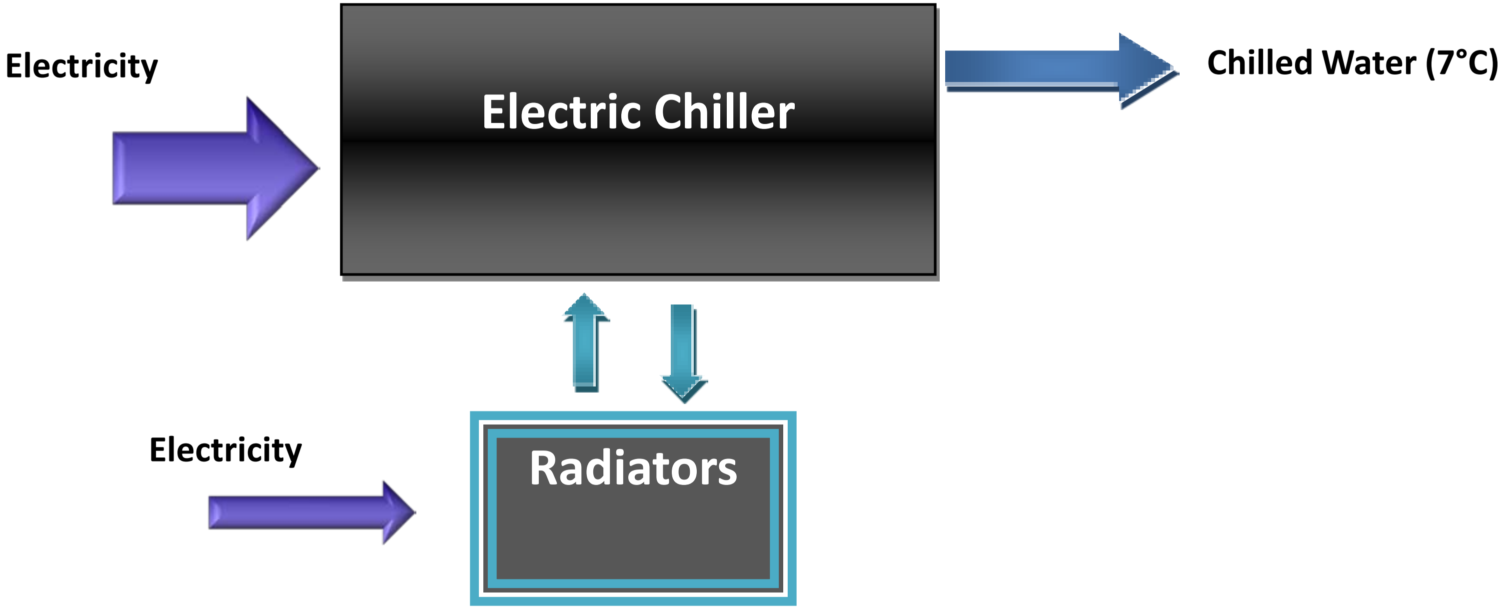
Energy efficiency: Electricity + cooling 104%

Electricity + heating 84%

BROAD Packaged Direct Fired Absorption Chiller System
vs. Electric Chiller System

Feasibility Study

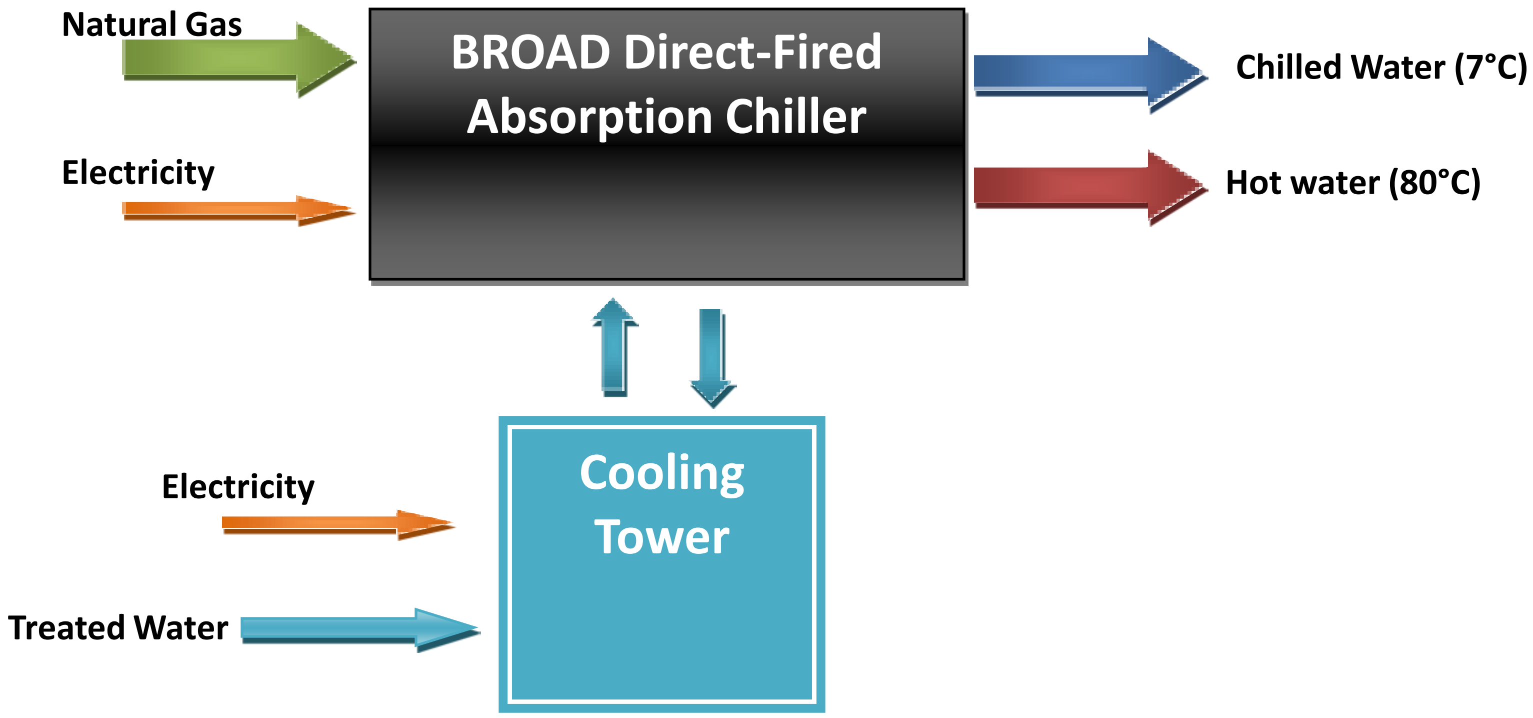
#1 Air Cooled Electric Chiller



Existing System: Electric Chiller

- Existing: UTT, Pt. Lisas
  - 2 x 200 Ton Air Cooled Electric Chillers together with chilled water pumps and radiator fans running 16 hours per day at full load, 365 days per year
  - Electricity consumption cost: 7.75 US$/kVA and 0.03 US$/kWh
  - Power factor: 90%
  - Power demand: 900 kW (1.2 kW/Ton)
  - Total electrical energy consumption: 9565 MMBtu/yr

BROAD Absorption Chiller



Retrofit: BROAD Absorption Chiller

- Retrofit:
  - 2 x 248 Ton BROAD Packaged Direct Fired Absorption Chiller running 12 hours per day at 81% load, 365 days per year (includes pumps and cooling towers)
    - COP = 1.57 at 81% load
  - Electricity consumption cost: 7.75 US$/kVA and 0.03 US$/kWh
  - Natural gas cost : 1.91 US$/MMBTU
  - Power factor: 90%
  - Power demand: 140kW (0.19kW/Ton)
  - Total electrical energy consumption: 1514 MMBtu/yr
  - Total fuel energy consumption: 17866 MMBtu/yr

Auxiliary Infrastructure

- Gas Infrastructure (US$10,000)
- Electrical Infrastructure (US$3,000)
- Water infrastructure (US$1.00/gallon)
  - Make up water (US$1.00/$m^3$)
  - Water Treatment (US$0.006)

Chiller Installation Costs

- Air Cooled Electric Chiller System
  - US$480,000
- BROAD Packaged NG Direct Fired Chiller System (BZY)
  - US$725,000

- Additional investment
  - US$725,000-US$480,000

  = **US$245,000**

Operational Costs

OPERATIONAL COMPONENT	ABSORPTION CHILLER SYSTEM OPERATIONAL COST	ELECTRIC CHILLER SYSTEM OPERATIONAL COST (US$)
Annual Electricity Consumption	$15,001	$94,744
Annual Electricity Demand	$9,721	$49,612
Annual Maintenance	$15,000	$19,200
Annual Fuel Consumption	$34,124	$0
Annual Water & Sewerage	$12,429	$0
Annual Water Treatment	$10,667	$0
TOTAL	**$96,942**	**$163,556**

Save $US66,614 annually

40% annual cost savings!

Feasibility Study Results

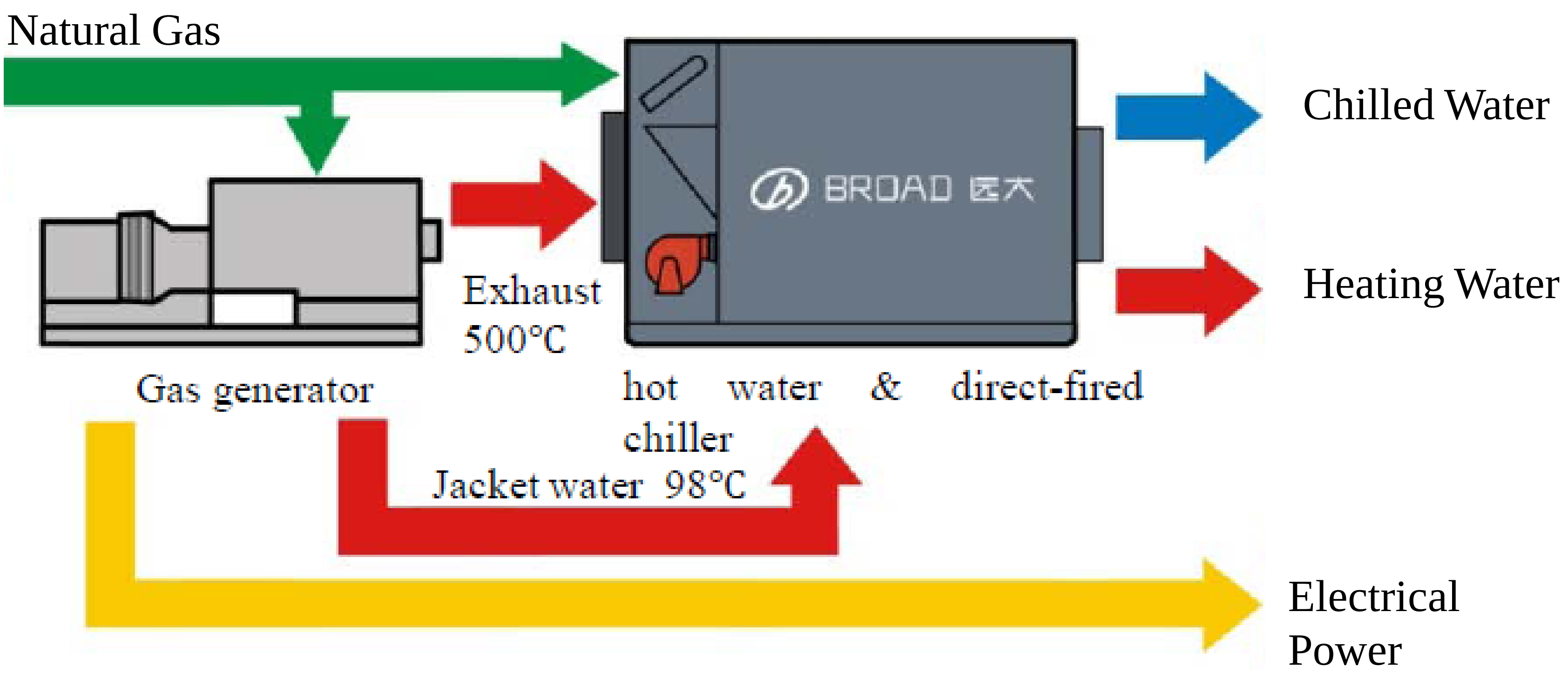
FEASIBILITY STUDY SUMMARY	BROAD vs Air Cooled
Initial Cost Difference ($US)	$245,000
Annual Cost Savings ($US)	$66,614
Payback (years)	3.68
Lifetime (years)	20.00
Interest factor/Discount rate (%)	10%
Present Worth ($US)	$441,973
Future Worth ($US)	$2,713,794
Annual Electrical Energy Savings (kWh)	8050
Annual CO_2 Savings (Tons/yr)	330
Annual CO_2 Savings (Pounds/yr)	727670

Invest US$245,000 to save $US66,614 annually
Payback in 3.68 years!

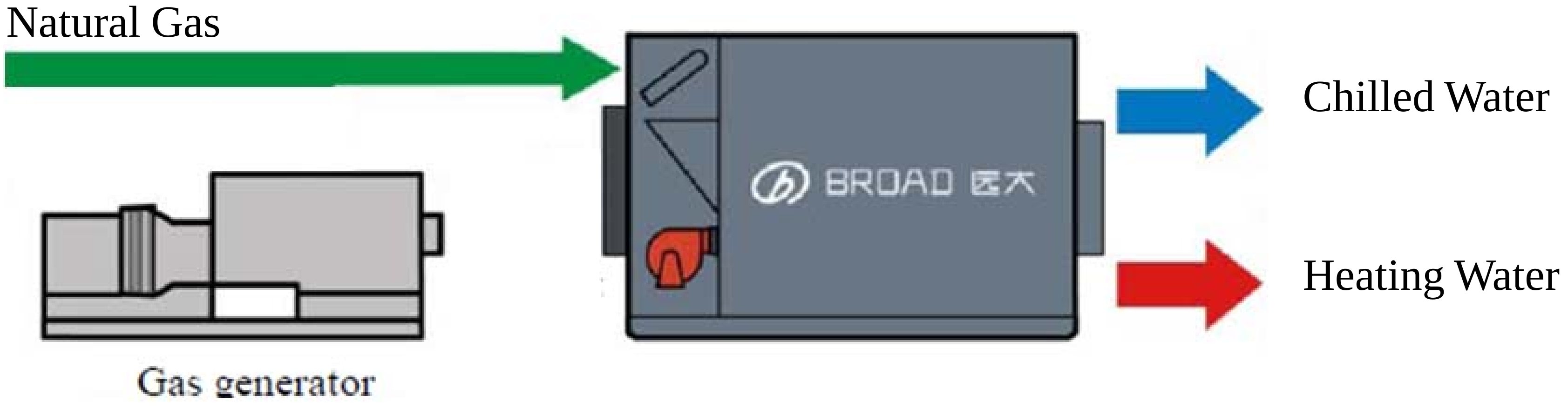
#3 Cogeneration with Absorption Cooling

Feasibility Study

Natural Gas + Exhaust + Hot Water



Reliability of Cogeneration



Chiller Installation Costs

- Air Cooled Electric Chiller System
  - US$480,000
- BROAD Packaged Exhaust and Hot Water Fired Chiller System (BHE)
  - US$832,000
- Additional investment
  - US$832,000-US$480,000

  = **US$352,000**

Operational Costs

OPERATIONAL COMPONENT	ABSORPTION CHILLER SYSTEM OPERATIONAL COST	ELECTRICCHILLER SYSTEM OPERATIONAL COST (US$)
Annual Electricity Consumption	$15,001	$94,744
Annual Electricity Demand	$9,721	$49,612
Annual Maintenance	$15,000	$19,200
Annual Fuel Consumption	$0	$0
Annual Water & Sewerage	$12,429	$0
Annual Water Treatment	$10,667	$0
TOTAL	**$62,818**	**$163,556**

Save $US100,738 annually

62% annual cost savings!

Feasibility Study Results

FEASIBILITY STUDY SUMMARY	BROAD vs Air Cooled
Initial Cost Difference ($US)	$352,000
Annual Cost Savings ($US)	$100,738
Payback (years)	3.5
Lifetime (years)	20.00
Interest factor/Discount rate (%)	10%
Present Worth ($US)	$732,495
Future Worth ($US)	$4,497,645
Annual Electrical Energy Savings (kWh)	8050
Annual CO_2 Savings (Tons/yr)	330
Annual CO_2 Savings (Pounds/yr)	727670

Invest US$352,000 more to save $US100,738 annually
Payback in 3.5 years!

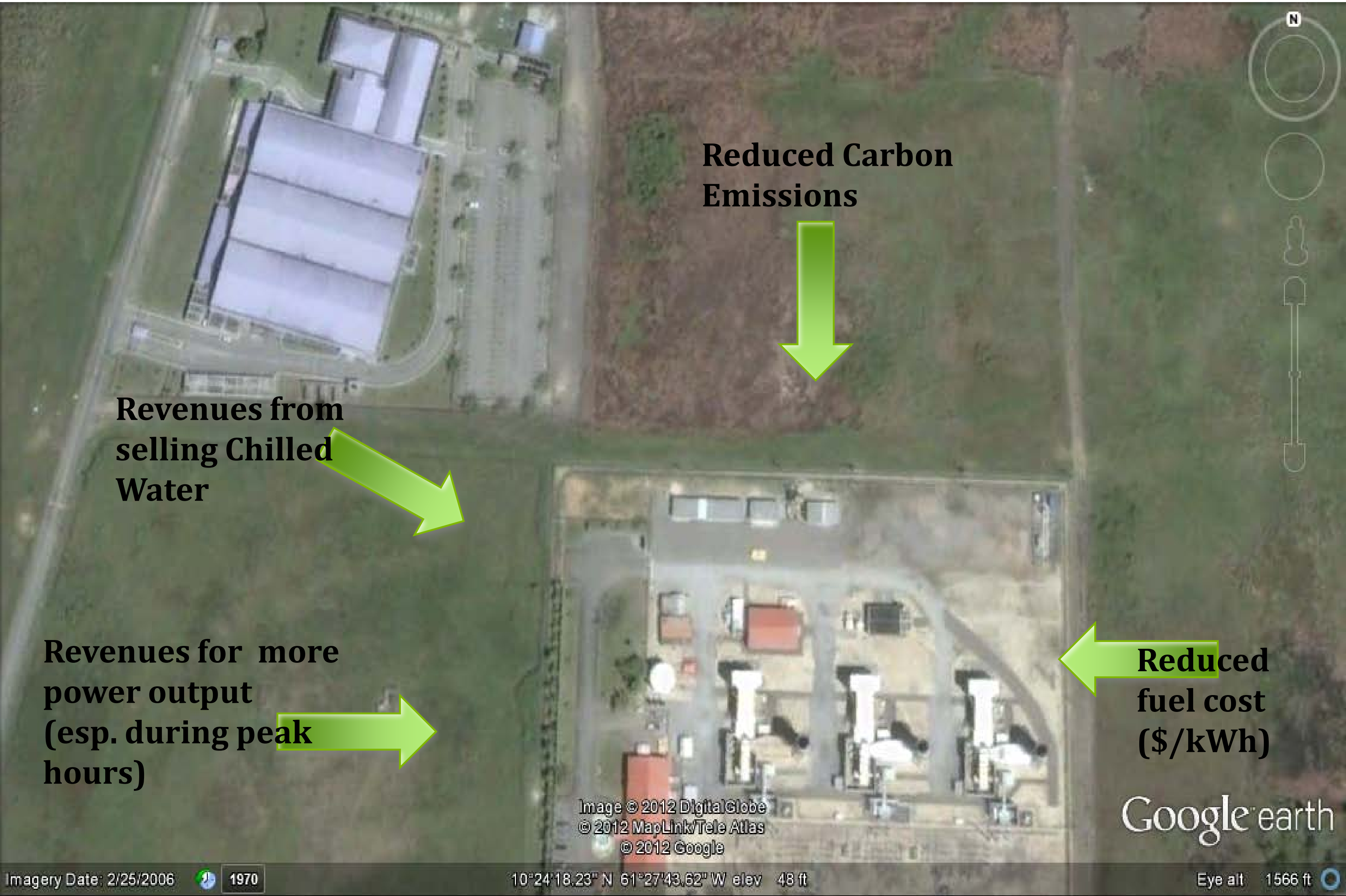
Cogeneration in Trinidad & Tobago

UTT Campus and Trinity Power Pt. Lisas

Solution: Turbine Inlet Cooling (TIC) and Cogeneration using BROAD Exhaust Chiller

Most power is demanded from utilities during the hottest hours of the day.
This is a great opportunity for savings .

Chilled Water
BROAD
Exhaust Chiller
Exhaust
Image © 2012 DigitalGlobe
© 2012 MapLink/Tele Atlas
© 2012 Google
Google earth
Imagery Date: 2/25/2006
1970
10°24'18.23" N 61°27'43.62" W elev 48 ft
Eye alt 1566 ft


Reduced Carbon
Emissions
Revenues from
selling Chilled
Water
Revenues for more
power output
(esp. during peak
hours)
Reduced
fuel cost
($/kWh)
Image © 2012 DigitalGlobe
© 2012 MapLink/Tele Atlas
© 2012 Google
Google earth
Imagery Date: 2/25/2006
1970
10°24'18.23" N 61°27'43.62" W elev 48 ft
Eye alt 1566 ft


No need for additional space to increase peaking capacity
Better turbine performance
No need to install new chillers. Purchase Chilled Water from the utility.
Image © 2012 DigitalGlobe
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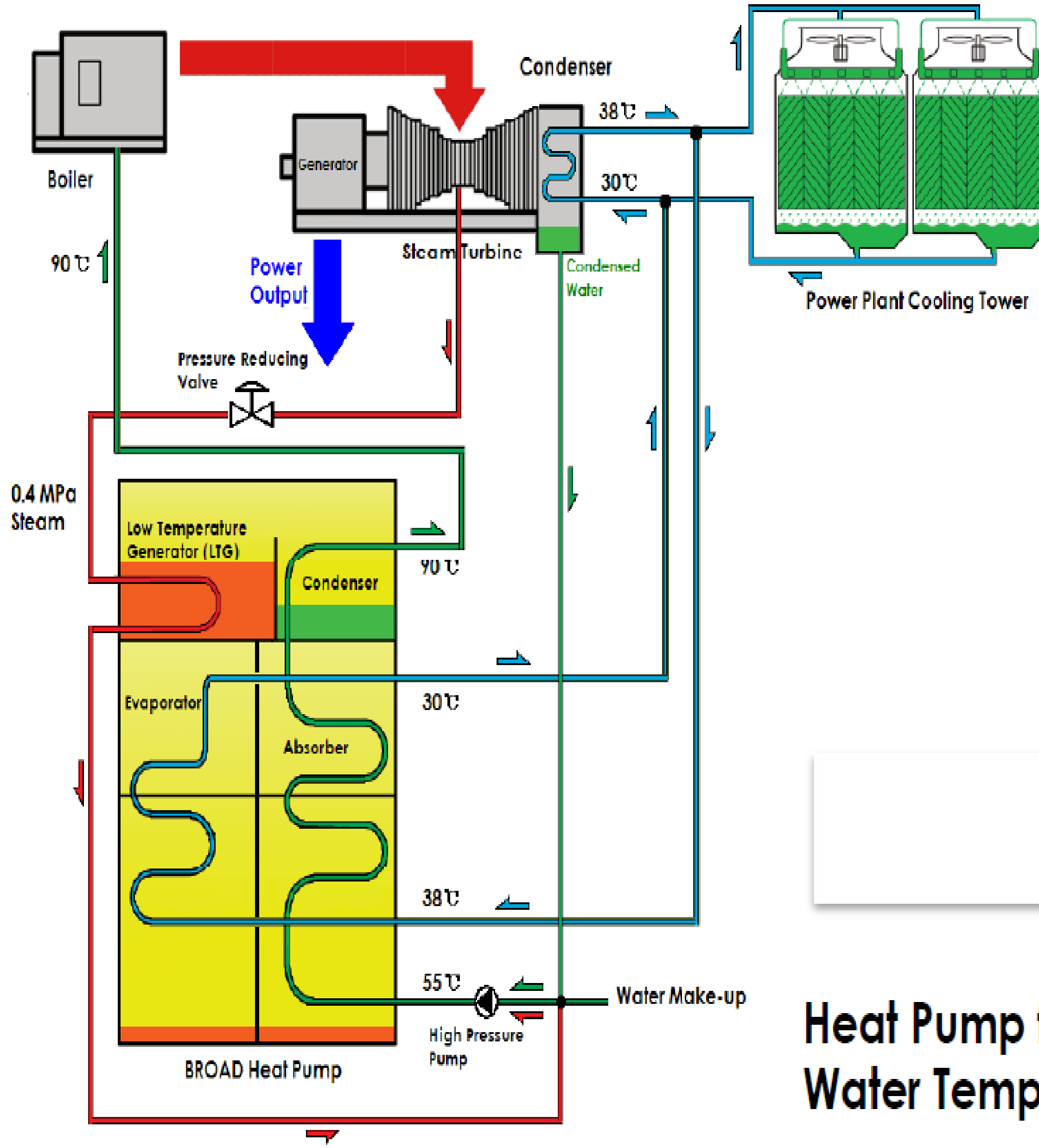
© 2012 Google
Google earth
Imagery Date: 2/25/2006
1970
10°24'18.23" N 61°27'43.62" W elev 48 ft
Eye alt 1566 ft

BROAD Heat Pump

Possible Applications:

-Methanol plants

-Ammonia plants



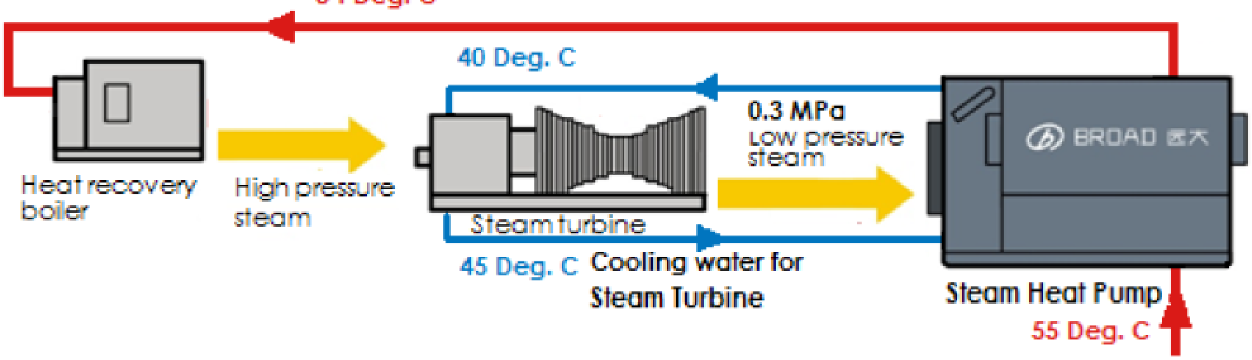
Heat Pump f

Water Temp.

Seoul Ilsan Plant, South Korea

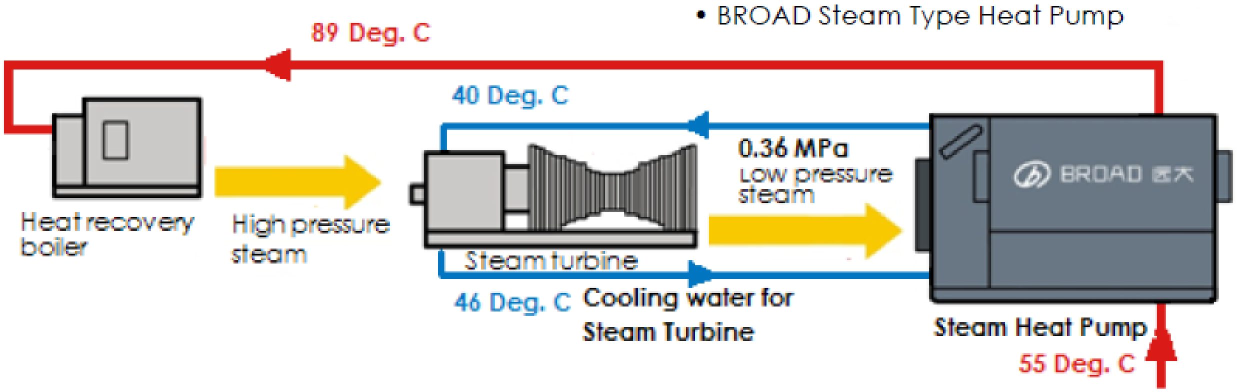
Model:	BDS800 * 2 units;
Heating Capacity per unit:	12MW / 3,453RT
Heat Input:	0.3MPa waste steam
	46 Deg C hot water
Heating water in/out temp.:	55 Deg C/ 84 Deg C

- BROAD Steam Type Heat Pump



Seoul Bundang Plant, South Korea

Model:	BDS1000 * 2 units;
Heating Capacity per unit:	15.5MW / 4,418RT
Heat Input:	0.36MPa waste steam
	46.4 Deg C hot water
Heating water in/out temp.:	55 Deg C/ 89 Deg C



Conclusion

- Although the cost of energy in Trinidad and Tobago is relatively low in comparison to other islands there is still a benefit for energy management and efficiency.
- There are many energy saving opportunities available which can suit different facility types. Energy audits determine which of these are the most energy efficient and economically feasible.
- GOTT has incentives for Energy Audits and Retrofits
- ISO50001 is now available for Energy Responsible organizations
- CCHP using Absorption Waste Energy Chillers provide great potential in Caribbean region.

ENERGY DYNAMICS Ltd.
DYNAMIC ENERGY EFFICIENT SOLUTIONS

The End

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