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THINKING TOMORROW

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PRESIDENT'S MESSAGE

Thinking Tomorrow | 01

ON THE GREEN AGENDA

Leveraging new technologies to mitigate climate risks in food production | 03

Financing the energy transition | 10

Understanding commercial solar photovoltaics:
Local success story - Preysal Service Station | 16

NGC upgrades EnergySmarTT mobile app and CariGreen website | 21

Accelerating the shift to a circular economy | 29

PRESIDENT'S MESSAGE

Thinking Tomorrow

In recent years, countless authors and screenwriters have attempted to envision what our world will look like in years to come. Based on the current trajectory of climate change and humanitarian crises, many posit that we are headed toward a dystopian future. However, scientific advancements and breakthrough technologies offer hope that we can change paths and land on a brighter tomorrow.

We at The National Gas Company of Trinidad and Tobago Limited (NGC) are among the hopeful, based on the heartening progress we have seen in our space of operation. The world of energy is rapidly evolving, led by facilitative policies and regulations as well as clean energy technologies. In Trinidad and Tobago, we are seeing more partnerships and initiatives focused on climate action and sustainable development as a whole.

There is growing consciousness in both the public and private sectors of Environmental, Social and Governance (ESG) principles, greater business alignment with the UN Sustainable Development Goals (SDGs), and more public education programmes that seek to bring the population on board with the national sustainable development agenda. We are happy to see such support being galvanised to secure our country's future.

Future-focused

NGC and the wider NGC Group of Companies are similarly thinking of tomorrow, looking for ways to make our own business more sustainable and help our industry achieve the same. Through our subsidiaries, we are exploring renewable energy options, with solar being the most advanced. After successfully

installing a rooftop solar array at the Preysal Service Station, subsidiary National Energy is using project and performance data from that initiative to help guide new projects, such as its work with government towards installation of solar panels on national emergency shelter facilities.

On the education front, we recently expanded our consumer app Energy SmarTT, as well as our online research hub CariGreen, to streamline their functionality and enhance their usefulness to target publics. The rationale is that if we can connect more people with information about the green agenda, we have a greater chance of buy-in and success.
For that same reason, over recent issues of *GASCO News*, we have been leveraging this publication to share more academic articles relevant to the green agenda and sustainability.

In this issue, we are exploring the issue of green financing - options available for companies looking to access funding for clean energy projects. In the interest of promoting more sustainable consumption and production, we are also taking a look at the circular economy, and what can be done in the Caribbean region to transition to that model.

Additionally, we explore a topic of growing importance to us as we partner with local stakeholders in the agriculture industry. The issue of food and nutrition security is one we have incorporated into our CSR agenda, and we have been investigating how we can use technology to build the productivity and resilience of local farming, particularly in the face of climate change.

In short, our hope is that this issue of *GASCO News* leaves our reader better informed about the work we are doing – and indeed the importance of that work – as we help create a safe, healthy and sustainable future for all. ■

Mark Loquan
President

ON THE GREEN AGENDA

Leveraging new technologies to mitigate climate risks in food production

TABLE 1: RANKING OF WORLD PRODUCTION OF MAJOR FOOD CROPS (2020)

	Commodity	Russia Rank	Ukraine Rank
	Sunflower seed or cottonseed oil	2nd	1st
	Wheat or meslin	4th	7th
	Barley	2nd	6th
	Maize	10th	6th
	Fertilisers	4th	18th
	Fuel	3rd	n/a

SOURCE: WORLD INTEGRATED TRADE SOLUTION. WITS (2022)

> As several Caribbean leaders passionately expressed to COP 26 audiences, failure to act swiftly to address climate change will have dire implications for the region

In 2022, on the heels of the COVID-19 pandemic, the war in Ukraine has placed the issue of global food security squarely on the front burner as societies grapple with food supply challenges.

Disruption to important food crop supplies out of Ukraine and Russia has forced producing countries to halt exports to satisfy domestic demand (see Table 1 for Ukraine's and Russia's ranking in world production of major food crops in 2020). This situation has adversely affected net importers of food such as Trinidad and Tobago, leading to inflation of prices for wheat products (as an example) by as much as 33 percent in June 2022.

Notwithstanding the impact of the Russia-Ukraine war, food security is expected to remain a global concern well beyond the conflict, as food systems are increasingly affected by the impacts of climate change.

According to the World Bank: "Climate change is already increasing average temperatures around the globe and, in the future, temperatures are projected to be not only hotter but more volatile too. This, in turn, will alter how much precipitation falls, where and when. Combined, these changes will increase the frequency and intensity of extreme weather events such as hurricanes, floods, heat waves, snowstorms and droughts.

They may cause sea level rise and salinisation, as well as perturbations across entire ecosystems. All of these changes will have profound impacts on agriculture, forestry and fisheries."

In the Caribbean, food security is perennially plagued by systemic issues such as inadequate access to land and land tenure, praedial larceny, lack of infrastructure and irrigation. These issues make farming as a livelihood a risky proposition, and act as a deterrent to prospective 'agripreneurs' who may be considering investing in farming or agriculture.

Climate change adds to this level of uncertainty and risk, further exposing our region's farmers to the prospect of losing their investments and jeopardising their ability to earn a living.

Despite this uncertainty, there is good news for farmers.
Modern technologies linked to Climate Smart Agriculture or CSA, and digital or smart farming, are emerging as important tools in the modern farmer's tool belt to survive and thrive in a hotter, riskier climate change-impacted world.

According to the World Bank Group: "Climate-Smart Agriculture (CSA) is an integrated approach to managing landscapes—cropland, livestock, forests, and fisheries—that addresses the interlinked challenges of food security and accelerating climate change. CSA aims to simultaneously achieve three outcomes:

1. Increased productivity: Produce more and better food to improve nutrition security and boost incomes, especially of 75 percent of the world's poor who live in rural areas and mainly rely on agriculture for their livelihoods.

2. Enhanced resilience: Reduce vulnerability to drought, pests, diseases and other climate-related risks and shocks; and improve capacity to adapt and grow in the face of longer-term stresses like shortened seasons and erratic weather patterns.

3. Reduced emissions: Pursue lower emissions for each calorie or kilo of food produced, avoid deforestation from agriculture and identify ways to absorb carbon out of the atmosphere."

FIGURE 1: AN EXAMPLE OF AN INDOOR VERTICAL FARM IN TRINIDAD AND TOBAGO GROWING A VARIETY OF LEAFY GREEN VEGETABLES AND STRAWBERRIES (IMAGE COURTESY CUBE ROOT FARMS).

While all forms of technology in this space may not be perfectly suited to the Caribbean region due to our smaller scale, several technological applications have the potential to spur a new wave of 'agripreneurs' to meet the region's food and nutritional needs.

1. Indoor Vertical Farms

"Indoor vertical farming can be defined as the practice of growing produce stacked one above another in a closed and controlled environment. By using growing shelves mounted vertically, it significantly reduces the amount of land space needed to grow plants compared to traditional farming methods."[1]

[1] Plugandplaytechcenter.com

Indoor vertical farming has the potential to change how societies view farming. Rather than being limited to rural areas, urban and sub-urban areas can be potentially converted to hubs of food production. Underutilised spaces in institutions such as schools, hospitals, and community centres provide ideal spaces to start vertical indoor farms. Vertical farms typically do not require soil for plants to grow. One acre of vertical farming can produce the equivalent of 10-20 acres of conventional production.

Benefits of indoor vertical farms include:

- **They use less water** – These farms can typically use up to 70-95 percent less water than traditional farms.

- **They are unaffected by adverse weather conditions** - Growing in a fully enclosed and climate-controlled environment completely eradicates the need to rely on - or worry about - the weather.

ON THE GREEN AGENDA

Traditional Farming VS Vertical Farming

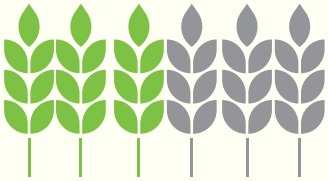
80% arable land already **IN USE**

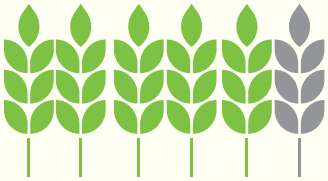
0% LAND

0.4 ha vertical farm

4-8 ha land-based traditional farm depending on crop

50% of crops are **NOT HARVESTED**



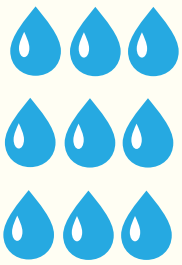


90% of crops are **HARVESTED**

70% GLOBAL

FRESH WATER USED FOR SOIL-BASED FARMING

50-80% of which is lost to evaporation and runoff



70-95% LESS

FRESH WATER USED FOR VERTICAL FARMING

using aquaponics or aeroponics method of farming

FOOD MILES

On average food travels from 1,500 to 2,500 miles on its way to our plate

LOCAL

Reduces the need for long distance transport decreasing the need for fossil fuels and ensuring quality

Leveraging new technologies to mitigate climate risks in food production | CONTINUED

- **Reliable year-round crop production**- Because these systems are not dependent on weather, or seasons, consistent year-round crop production can be achieved. Additionally, precisely controlled environmental conditions eliminate the variability in crop yields to improve consistency and reliability of supply of crops to the market.
- **Improved security** – Producing in a secure indoor environment reduces the risk of praedial larceny and minimises crop losses leading to greater profitability.
- **Reduced carbon emissions** – Using less inputs such as water, fertilisers and pesticides means lower carbon emissions. Additionally, vertical farms located closer to end users and markets lower overall emissions from transportation.

Drawbacks of vertical farming:

- **High capital cost** - Establishing a vertical farm requires access to a facility, and capital for equipment, inventory, software, marketing, advertising and overheads. According to StarterStory.com the average start-up cost is estimated at around US$20,000.
- **Training and expertise** – Establishing a vertical farm has no room for guesswork. Operators need to be properly trained in all aspects of the business well before start-up.
- **A limited number of crops can be grown economically** - A vertical farm can be customised to support the growth of many plant species, however, only a limited number can be grown economically. In the global vertical farming industry, leafy greens and herbs remain the primary crops due to their rapid growth cycle, high cost, and short shelf life.

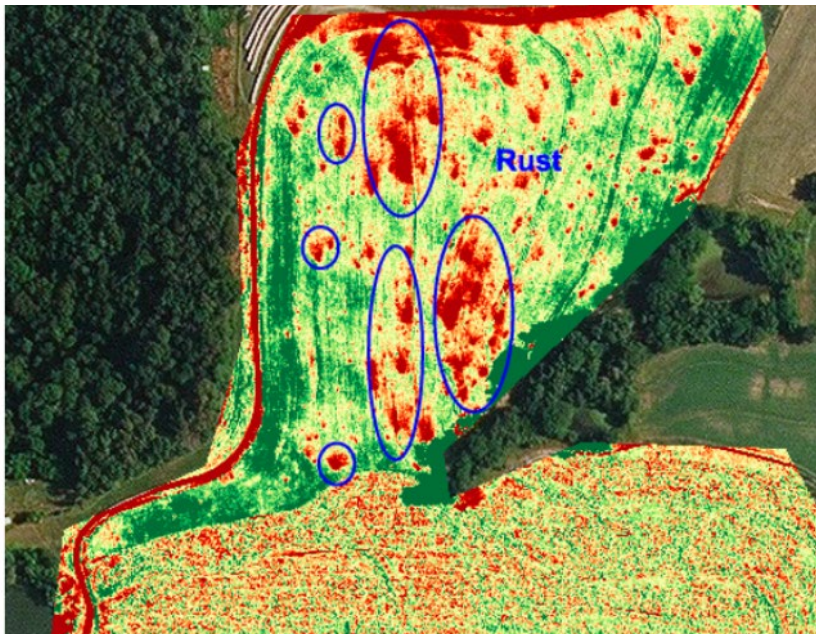


FIGURE 2: BUILT-IN PLANT HEALTH TOOLS IN DRONE MAPPING SOFTWARE ALLOW FOR QUICK IDENTIFICATION OF PROBLEMS THAT ARE NOT DETECTED BY THE NAKED EYE. AREAS IN RED INDICATE PLANT HEAT STRESS IN A FIELD.

2. Drones in Precision Agriculture

Drones or Unmanned Aerial Vehicles (UAVs) are powerful tools that farmers can use to take the guesswork out of field production. With a drone not much bigger than the size of one's palm, along with mapping software, a farmer can gain invaluable insights in minutes to help eliminate risks, improve productivity, and reduce costs.

Here are some ways that drones are helping farmers become more productive:

- **Early detection and timely prevention of plant health problems** - In the world of agriculture, timing is everything. Diseases and invasive species spread fast. Drones can provide a high-resolution map of a field in a matter of minutes. Powerful plant health monitoring tools built directly into mapping software allow users to visualise issues and make decisions on the spot.
- **An aerial view of fields** - Drones provide high-resolution, low-cost aerial maps that allow farmers to make quick informed decisions about where to plant. Drones can also perform automated crop counts in minutes compared to manual counts which can take hours to do.
- **Assess damage to crops** - High-resolution imagery from drones can help farmers quickly and accurately assess damage to crops after adverse weather events. This information can be used to document and support claims to insurance companies or to government authorities for compensation.
- **Monitor livestock** - Drones with thermal or night-vision cameras can quickly scout a farm from above to monitor livestock or detect potential predators or intruders.

Potential drawbacks of using drone technology in farming:

- **Expensive** - Drones and the associated software are expensive and may be out of reach of the typical farmer. Exploring shared-service models such as purchasing and deploying drone technology through agricultural societies or co-operatives may be required to reduce the cost of acquiring the technology.

- **Local regulations and safety** - Drones are regulated by the local Civil Aviation Authorities. 'No-fly' zones such as close to airports, industrial and military facilities usually restrict the use of drones. Exemptions typically require special permits supported by liability insurance, manufacturer training, and having a legally registered company.

- **Impact on labour requirements** - Drones usually automate tasks that are traditionally done manually. This could lead to reductions in the number of jobs in the agricultural sector.

- **Weather-dependent** – Drones cannot be deployed in rainy or windy conditions, which limits the number of productive days per year in the Caribbean region due to the rainy seasons.

3. Digital or Smart Agriculture Monitoring

IBM predicts that through the Internet of Things (IOT) and Smart Agriculture, by 2050, farmers will be able to increase their production rates by 70 percent. Digital or Smart Agriculture includes a range of technologies that allow farmers to precisely monitor and control key activities and inputs such as planting, watering, harvesting and pest control.

Some examples of the potential applications of Digital or Smart Agriculture include:

- **Soil condition monitoring** - Soil condition is key to deciding on the optimal times for planting and harvesting. Using sensors, farmers can get instant alerts on soil conditions and metrics such as temperature, moisture levels, and salinity, all critical to successful crop management.

- **Crop monitoring systems** - "As crops grow and ripen, so many things can go wrong: diseases, infestations with pests, or adverse environmental conditions can potentially cause irrevocable harm before farmers even notice. Applied in crop monitoring, smart sensing technology collects metrics about the state of the crops (temperature, humidity, health indicators)."[2] This enables farmers to take timely measures should anything go wrong.

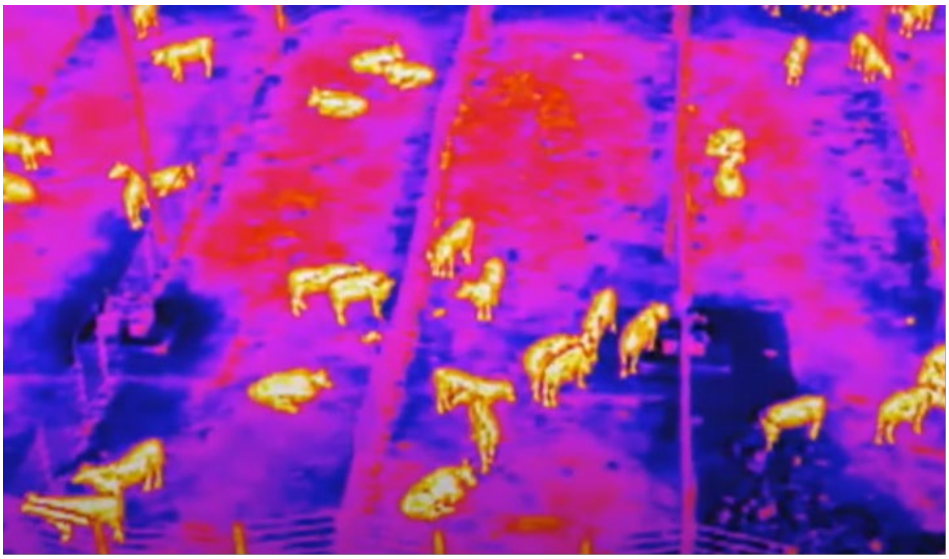


FIGURE 3: SCREENSHOT FROM A DRONE BEING USED AT NIGHT TO MONITOR CATTLE.

NGC's Role in Supporting Food and Nutrition Security

In June 2022, NGC and global fertiliser producer Nutrien announced the intention to collaborate to explore opportunities to improve Trinidad and Tobago's food and nutrition security. The partnership will explore the promotion and adoption of CSA and associated digital technologies as pathways to improve adaptation of our food systems to the impacts of climate change. Both companies will work closely with stakeholders along the local food value chain to identify opportunities in five main areas.

Some of these opportunities have been discussed above:

1. **Praedial Larceny**: to improve detection and intervention through the deployment of shared remote sensing technologies such as closed-circuit cameras, sensors, and UAVs.

2. **Precision Agriculture**: to introduce, test and deploy precision agriculture methods through UAVs and satellite technology. This model will aim to improve plant health monitoring efficiency and sustainability in the use of agricultural inputs.

3. **Food Waste:** to identify opportunities to reduce food waste. This will support the country's efforts to reduce carbon emissions and help the most vulnerable to meet their daily nutritional needs.

4. **Community Climate Smart Agriculture:** promote food production at the community level using CSA.

[2] Chalimov, 2019

FIGURE 4: IAN WALCOTT MANAGING, DIRECTOR OF NUTRIEN TRINIDAD, AND MARK LOQUAN, PRESIDENT OF NGC SIGN A PARTNERSHIP AGREEMENT IN JUNE 2022 TO COLLABORATE ON FOOD AND NUTRITION SECURITY IN TRINIDAD AND TOBAGO.

5. **Food, Health, and Nutritional Awareness:** build public awareness regarding the health benefits of boosting the production and consumption of fresh, locally produced foods, especially those with a high plant-based content.

Conclusion

Climate change is expected to continue impacting the ability of our global food systems to meet the growing demand for readily available, affordable, and nutritious food for the rapidly increasing world population. Climate Smart Agriculture and technologies that allow farmers to become more productive while reducing their exposure to risk are critical to success.

Technologies such as indoor vertical farms, precision agriculture tools such as drones, and smart monitoring devices that provide real-time and accurate data about crop conditions are likely to be commonplace in the farm of the future.

NGC and its partner Nutrien will explore how these technologies, along with greater public awareness on issues such as food waste, could be implemented to help the country build resilience against the threats posed to food and nutrition security by climate change.■

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ON THE GREEN AGENDA

Financing the energy transition

ON THE GREEN AGENDA

> Over the next 35 years or so, hydrocarbon energy sources are expected to be phased out and replaced by renewables and non-carbon energy sources.

The Paris Agreement was signed in 2015 by 196 countries, including Trinidad and Tobago. In the landmark document, countries pledged to reduce their greenhouse gas (GHG) emissions to limit global warming to below 2° Celsius relative to pre-industrial levels. The execution of this legally binding document marked a significant turning point in the global fight against climate change and effectively ushered in the energy transition. Over the next 35 years or so, hydrocarbon energy sources are expected to be phased out and replaced by renewables and non-carbon energy sources.

The Paris Agreement acknowledges three key elements that are critical to ensuring a just transition that supports less-resourced and vulnerable countries – finance, technology, and capacity building. Finance is needed immediately to enable mitigation, to reduce GHG emissions, and adaptation, to reduce the impacts of climate change. Finance underpins technology and capacity building as all aspects of the energy transition come at a cost.

Countries, corporations, financial institutions, intermediaries as well as non-profit organisations in the public and private spheres, are responding to the increasing requirement for green financing. This response is driven by consumer demands in tandem with organisations' thrust towards sustainability. Numerous financial options are now available to organisations involved in energy efficiency, renewables, clean transportation, and clean technology.

There are myriad ways to invest in green projects and companies, as sustainable financing – the incorporation of environmental, social and governance (ESG) principles into business and investment decisions - is becoming progressively more mainstream.

Green and sustainable financing options

Non-profit and community-based organisations in Trinidad and Tobago can access financing for green projects from the country's Green Fund. Organisations can also access grant support from international organisations such as the Inter-American Development Bank (IDB). From 2015 to 2020, the IDB's Infrastructure and Climate Change and Sustainable Development Sectors invested US$813.23 million in green and green-grey infrastructure projects. Green-grey infrastructure development is a hybrid approach that employs traditional engineering methods such as revetment walls and dams, as well as green methods including mangroves and forests.

At COP 26, the IDB announced its target of US$24 billion of green financing including biodiversity financing. In the United States, most government departments offer funding for green projects, such as the Environmental Protection Agency (EPA) which has provided a wide range of grants for green infrastructure projects. The UK government has made over £5 billion available to help businesses become greener.

Green bonds, social bonds, sustainability bonds and sustainability-linked bonds (SLBs) are rapidly emerging as popular forms of sustainable financing. Green bonds evolved from the Climate Awareness Bond introduced by the European Investment Fund in 2007 and the World Bank in 2008. Green bonds are fixed income securities used to fund environmental and climate projects. Green bonds usually have long maturity periods and offer tax incentives to investors. The National University of Singapore (NUS) in 2019 launched its first net-zero energy building, which was financed by a green bond. Similarly, blue bonds are debt instruments which are issued to support investments in healthy oceans and blue economies.

The African nation of the Seychelles in 2016 issued a sovereign blue bond to raise funds for marine protection projects. By 2020, the Seychelles had been able to use the proceeds from the issuance of the blue bond to help reduce its national debt and protect marine areas which form a critical part of the nation's economy.

Social bonds are similar to green bonds but are geared toward development of social projects.

Sustainability bonds seek to raise funds for both social and environmental initiatives. Regarding SLBs however, funding is usually linked to specific sustainability targets established by the issuer that can impact the entire organisation.

There are usually premiums or penalties to be paid if the issuer does not meet its sustainability targets. In 2021, Singapore's Surbana Jurong Group – an infrastructure and project development consulting firm - issued the first public SLB in Southeast Asia. The bond was oversubscribed more than six times, highlighting the appetite among investors for sustainable investment opportunities.

Funding can also be accessed through commercial banks and other international and regional funding agencies such as the World Bank and the Caribbean Development Bank.

Risks associated with sustainable finance

The sustainable financing industry is not without risks, not least of which is the threat of 'greenwashing'. This happens when bond issuers mislead investors by overstating the environmental benefits of their activities.

ON THE GREEN AGENDA

There is also a risk related to a reliance on ESG ratings in which companies are ranked based on their ESG performance. These scores are widely inconsistent, since performance can be measured based on the potential impacts of ESG factors on the issuer, rather than the impact the issuing company can have on the environment and people.

Sustainable financing comes with inherent investment risks that projected returns may not be realised. These risks are exacerbated by the fact that sustainable financing is a relatively new field and investment periods are generally long. Targets are set with imperfect information and in some cases, may prove to be unrealistic and unachievable.

One of the most serious risk elements associated with sustainable financing is that the industry is essentially unregulated. The International Capital Market Association (ICMA) has issued guidelines for green bonds, social bonds, sustainability bonds, and SLBs. The guidelines are built on four principles:

- **Use of proceeds** – It is imperative that the proceeds of green bonds be used for green projects that provide clear and quantifiable environmental benefits. Projects can involve renewable energy, energy efficiency, prevention of pollution, biodiversity on land and in the water, clean transportation, wastewater management, climate change adaptation, circular economy products, technology and processes, or green buildings.

- **Process for project evaluation and selection** – The issuer should clearly state the objectives of the project and the processes by which projects will be identified as well as the selection and exclusion criteria.

- **Management of proceeds** – As long as the green bond is outstanding, the issuer should disclose periodically, how the green account is being reconciled against project expenditures. Unallocated balances should also be disclosed.

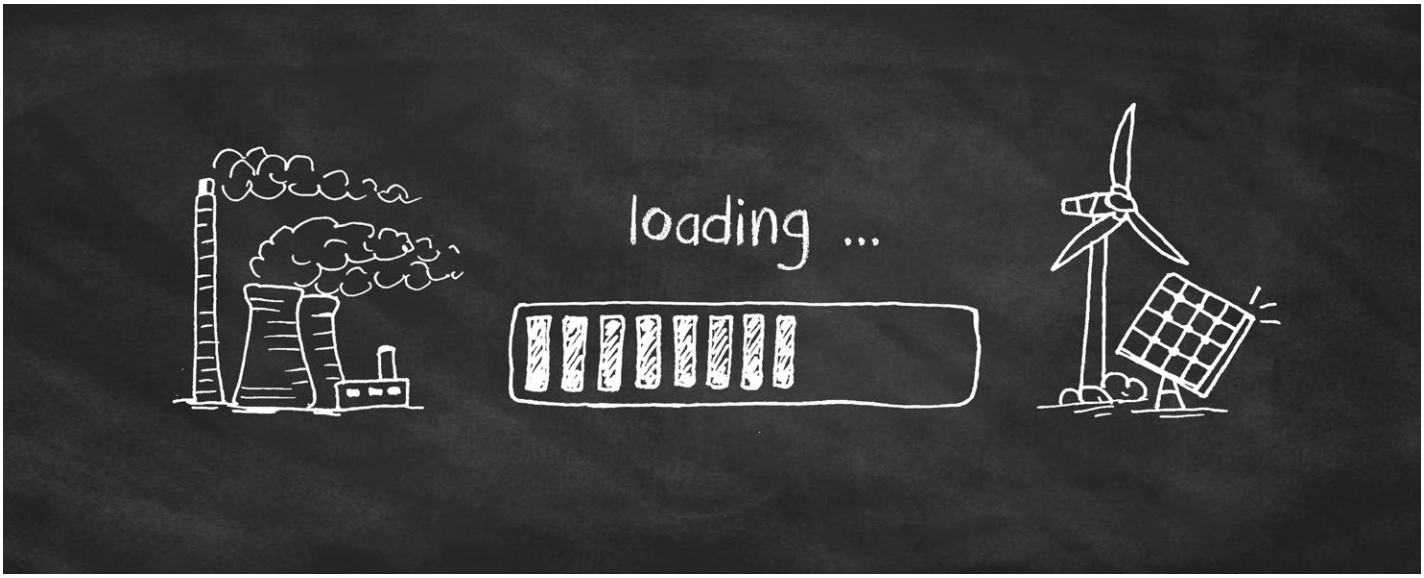
- **Reporting** – Issuers are to report annually on the amounts allocated and the performance of eligible projects using both qualitative and quantitative metrics.

The World Bank has issued similar guidelines. However, these guidelines are voluntary and not legally binding. Governments are becoming increasingly involved in regulating green bond markets. The US Securities and Exchange Commission in May 2022 proposed new regulations aimed at ensuring ESG funds accurately describe their investments. In Germany, it was alleged that Deutsche Bank AG's fund unit overstated its ESG capabilities to investors, and the authorities were forced to become involved. In Europe, the Sustainable Finance Disclosure Regulations were introduced, requiring investments to be labelled 'light green' or 'dark green' based on the level of sustainability integration.

Is sustainable financing worth the risk?

At NGC we believe that the opportunities far outweigh the risks. Within sustainable financing there is the opportunity for introducing standards to govern sustainable financing, eliminating the practice of greenwashing, making a real impact on the economy, society, and the environment, and of course, doing it all profitably.

In 2021, NGC made its first venture into the sustainable financing arena with the introduction of our Sustainable Investment Initiative. Under the initiative, the company is diversifying its investment portfolio to include investment in green funds. The company is currently assessing opportunities to expand the initiative through direct investments in environmental projects.



In the absence of industry standards, NGC analyses potential sustainability investments with the same degree of rigour with which the company evaluates all its investments. Relevant best practices are applied.

The energy transition is no longer approaching. It is here. While NGC continues to grow its core business built on the transition fuel of natural gas, the company is investing in its own future and that of Trinidad and Tobago. We acknowledge the challenges that the energy transition will bring, and we are pivoting and positioning ourselves to overcome those challenges. ■

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ON THE
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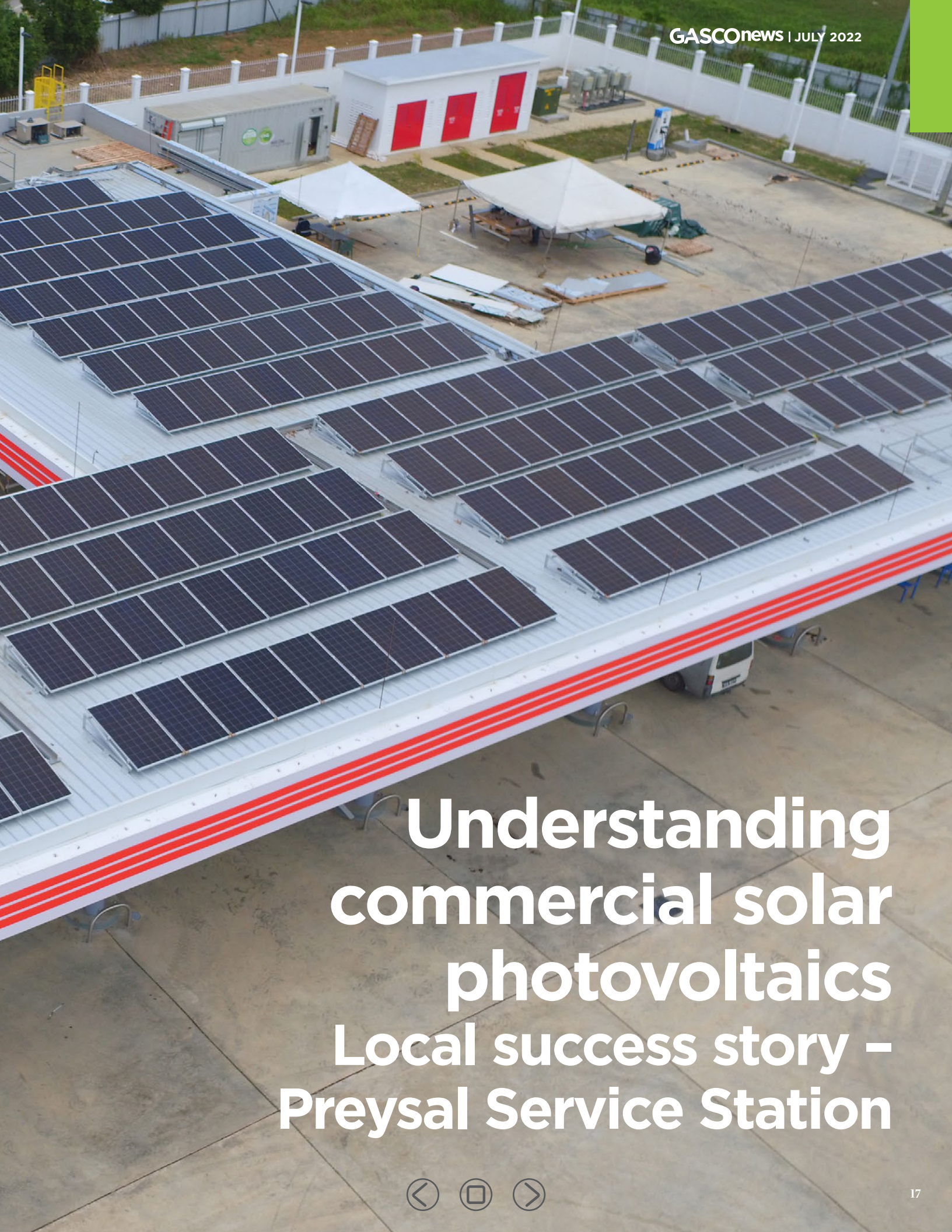


Understanding commercial solar photovoltaics

Local success story – Preysal Service Station

FIGURE 1: 320 SOUTH FACING SOLAR PANELS AT THE PREYSAL SERVICE STATION WHICH FORM PART OF THE PV SYSTEM.

> Indeed, National Energy is currently working with the Government towards the future installation of rooftop solar photovoltaic (PV) systems at schools and community centres that are used as emergency shelters.

In 2021, National Energy successfully oversaw the installation of a 100 kW rooftop commercial solar photovoltaic (PV) system at the new Preysal Service Station.

This project showcases the Government of Trinidad and Tobago's commitment to incorporating renewable energy technologies into the national mix. Indeed, National Energy is currently working with the Government towards the future installation of rooftop solar photovoltaic (PV) systems at schools and community centres that are used as emergency shelters.

As such projects unfold, the Preysal Service Station is a model that allows for the collection and analysis of critical solar data. Some of this data is profiled below.

PROJECT DATA - CONSIDERATIONS FOR MAXIMUM PERFORMANCE OF A SOLAR PV INSTALLATION

Prior to installation of the solar array at Preysal, several factors needed to be assessed. These factors should inform any project seeking to harness maximum solar energy.

Shading

In conducting the technical assessment of using a commercial solar PV system, issues of shading, roof orientation and the structural and space requirements must be analysed and optimised. Conducting a shading analysis refers to looking at the effects of sunlight blockage on the solar array cell. Any form of blockage/shading reduces the power out of the solar PV system. Objects such as trees, other buildings and fixtures can cause shading issues on the solar array cell at different times during daylight hours.

Roof orientation

Roof orientation deals with the slope of the roof on which the solar PV system will be mounted and how this will impact the configuration of the system. Roofs are classified as either low-sloped or sloped, where the incline of a low-sloped roof ranges from 0 to 24 degrees.

Azimuth & Tilt Angle
Two additional factors to be considered in the configuration of the solar array are the azimuth and tilt angle of the array. The azimuth refers to the angle at which the array is positioned. The azimuth angle is the clockwise angle from true north that describes the array's orientation. A south-facing array has an azimuth angle of 180 degrees, whereas a north-facing array has an azimuth angle of zero (0) degrees.

The default azimuth angle for locations in the northern hemisphere is 180° (south-facing) and 0° (north-facing) for locations in the southern hemisphere. However, the specific azimuth used at the location must be determined based on the orientation of the roof, to optimise spacing and layout.

The tilt angle refers to the angle of the PV modules in the array which is measured in degrees from the horizontal. The tilt angle of a fixed array is its angle from horizontal, where 0° equals horizontal and 90° equals vertical. Figure 3 shows the relationship between azimuth and tilt angle. To optimize the system's total electricity production across the year, a popular rule of thumb for fixed arrays is to adjust the tilt angle to the latitude of the system's position. However, on flat roofs the system may employ a tilt angle that is less than ideal for the given latitude. Flat or zero-tilt arrays are sometimes utilised on low-slope roofs because they provide a significant amount of energy per square foot of roof area and reduce wind loads.

The solar PV system at the Preysal Service Station was installed well in line with industry standards for Trinidad's location (see Figure 2).

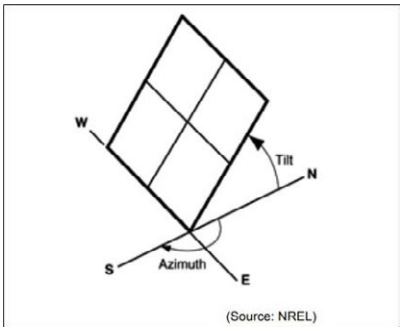


FIGURE 2: PREYSAL SERVICE STATION PV SYSTEM CONFIGURATION

Preysal Service Station PV System Configuration

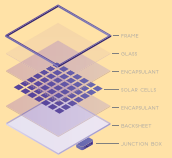
PV System: Medium size commercial
Azimuth of PV panels: 186°
Tilt of PV panels: 11°
Installed capacity: 100kW

Structural and Spacing Requirements

The structural integrity of the commercial facility must be evaluated before the solar PV system is placed on the rooftop. The roof must be able to support the weight of the solar PV system while still dealing with environmental conditions such as rain and debris as well as the weight of service personnel who will have to conduct routine maintenance and checks on the solar PV system. Understanding the pressures applied to the racking system and roof from static and dynamic loads is critical.

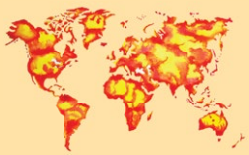
Depending on the type of solar PV module utilised and the system's architecture, the array's footprint will vary significantly. When evaluating potential roof space for a solar PV system, it is important to consider the placement and size of current or future rooftop equipment such as heating, ventilation, and air conditioning (HVAC) systems.

FIGURE 3: CONSIDERATIONS FOR SOLAR PV INSTALLATIONS



PV System Components

- **Major components: mounting system, PV array, inverter, switches, circuit breaker and meters**
- **Mounting systems attach the PV modules to the roof**
- **Mounting system must securely support the PV array and its attached components under conditions such as strong wind and heavy rainfall**
- **PV arrays are composed of PV modules and their material impacts operating characteristics and efficiency**



Meteorological Data

- **The amount of solar radiation and time of sunshine hours**
- **Wind velocity and wind direction of the location**
- **The wind direction and wind velocity of the location must be accounted for to minimise damage during adverse weather conditions**
- **Geographical latitude and longitude positioning determines the amount of solar radiation available**

Other Factors

- **Energy load/demand**
- **Regulations**
- **Transmission and interconnection requirements**
- **Accessibility**

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OPERATIONAL DATA FROM THE PREYSAL SERVICE STATION

Emissions Savings

During the period January – April 2022, the solar PV system dispatched 31,484.2 kW of power, resulting in 5,788.99 kg of CO_2 emissions savings. This makes it clear that distributive, rooftop or commercial solar PV installations can open an avenue for Trinidad and Tobago to achieve its Paris Agreement targets.

February Blackout vs Preysal Solar Panels

Security of supply and resilience of infrastructure were critical in the design of the Preysal Service Station. The use of a solar PV system as the primary source of power was part of a strategic effort to improve business continuity for the station's operations, during such events as the nationwide power disruption which occurred on February 16th, 2022.

There are 320 solar PV panels installed on a purpose-built canopy and a battery bank with a total voltage of 729.6 VdC which provides 510.72 kWh. During the power outage on February 16th, the battery bank provided power for the:

- liquid fuel pumps
- internal and external lighting in the convenience store
- in-store cashier booths.

Combined, the abovementioned factors facilitated increased customer purchases at the pumps and traffic through the convenience store. The station was able to remain online and continue providing full service to its customers. At the time of power restoration, the state of charge of the battery was 78%.

National Energy continues to work with stakeholders to expand the use of solar energy as a power source in Trinidad and Tobago. As the solar PV installation atop the Preysal Service Station continues to support operations, more data and learnings will be collected to help guide future projects. ■

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Accelerating the shift to a circular economy

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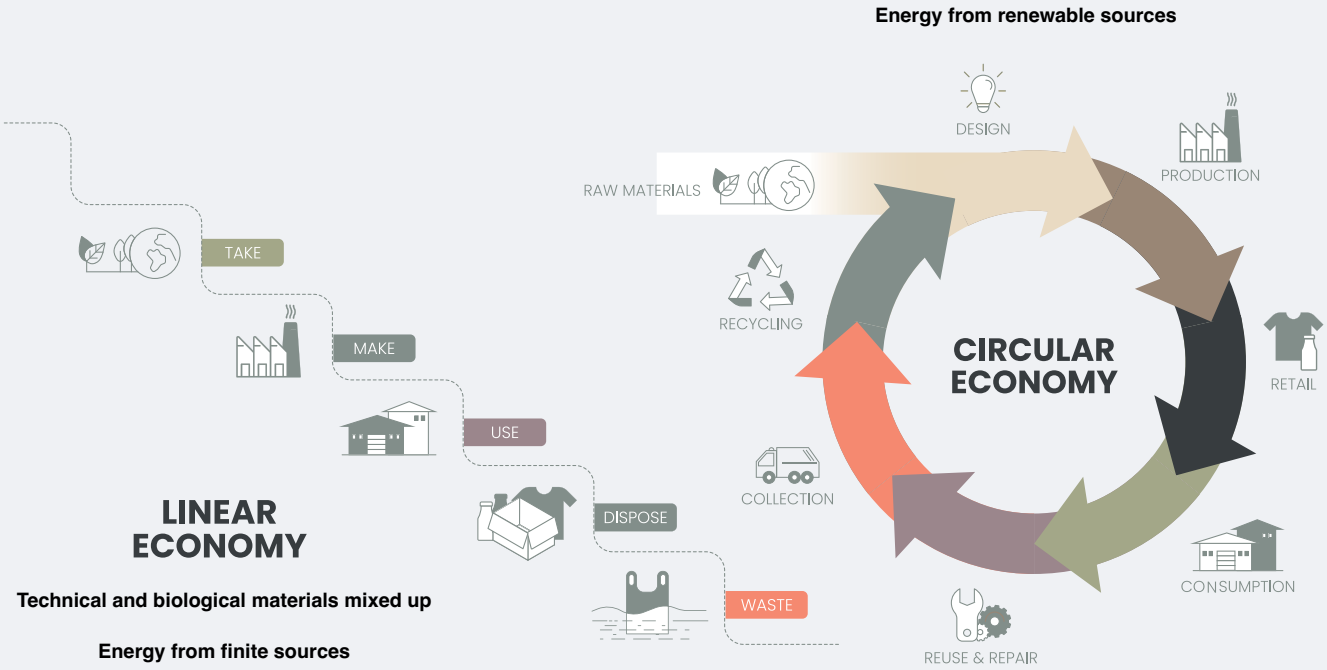

SOURCE: HTTPS://ENVIRONMENT.GOVT.NZ/WHAT-GOVERNMENT-IS-DOING/AREAS-OF-WORK/WASTE/OHANGA-AMIOMIO-CIRCULAR-ECONOMY/

> The circular economy is a method of economic production and use that minimises disposal and waste by maximising recycling, repurposing, reusing, lending, leasing, sharing, repairing, and refurbishing existing products for as long as is feasible.

Gains from the industrial revolution of the 18th and early 19th centuries, as well as the green revolution of the 20th century, are responsible for growing global prosperity and increased product and food availability over the last hundred years. These generational improvements in the standard of living have come about due to the creation of the linear economy.

We have a "take, make and dispose" economy. We take natural resources, make things, and dispose of them in landfills and elsewhere. One component of the linear economy is planned obsolescence, when a product has been designed to have a limited lifespan to encourage consumers to buy the product again. This method of production and consumption encourages wastage, excess consumption, and the pursuit of monopoly profits.

In recent years, we have reluctantly come to the realisation that this economic archetype has hard limits, in terms of the ability of the planet to provide materials, cheap energy or a method for disposing of waste. Indeed, the quadruple crises of the COVID-19 pandemic, ongoing climate change, pollution, and biodiversity loss point to the high cost of maintaining unsustainable means of production. As we rebuild from the pandemic, we have an ideal opportunity to reset.

Enter the circular economy

The circular economy is a method of economic production and use that minimises disposal and waste by maximising recycling, repurposing, reusing, lending, leasing, sharing, repairing, and refurbishing existing products as long as is feasible.

The appeal of the circular economy is that it is far more holistic than the linear economy, as it incorporates not only the realm of economics and business, but also involves social and environmental factors and policies.

The circular economy gives us the tools and ability to tackle both climate change and the loss of biodiversity, while addressing important social needs. It has the potential to increase prosperity and jobs, while reducing greenhouse gases, pollution, and waste. The circular economy can also be key to economic recovery and development that is aligned with the Sustainable Development Goals (SDGs), by supporting wellbeing, prosperity and ecosystem regeneration. More importantly, while the concept is new, the learnings are not. The circular economy is unique in that it draws from both new knowledge and technologies as well as on traditional and indigenous worldviews and expertise.

Assessing conditions for the circular economy

The potential for successful implementation of the circular economy, however, needs to be assessed based on location. How relevant is it to this part of the world?

Caribbean economies are characterised by the following:

Small and open. Countries have small land spaces and are open, permitting access to their economies and domestic markets. On the other hand, many of the small land economies have extensive ocean resources available, presenting potential for long-term sustainability if properly utilised.

High dependence on imported fossil energy. Apart from Trinidad and Tobago, Suriname and more recently, Guyana, the Caribbean does not possess significant hydrocarbon resources. Most countries are net energy importers. However, there is considerable potential for the generation of power from renewable resources in the form of solar, wind and geothermal energy.

Heavily dependent on imported goods and services. This is consistent with economies initially established to provide unprocessed raw materials to the metropole. In most such economies, high dependence on energy imports and scale limitations of small markets stymied the efficient development of other sectors such as manufacturing.

Highly dependent on tourism services to drive their economies. Eleven Caribbean countries are in the top 20 most tourism-dependent economies in the world.[1]

[1] Mooney and Zegarra (2020) 'Extreme Outlier: The Pandemics Unprecedented Shock to Tourism in Latin America and the Caribbean'. Inter-American Development Bank. Available at: https://publications.iadb.org/publications/english/document/Extreme-Outlier-The-PandemicsUnprecedented-Shock-to-Tourism-in-LatinAmerica-and-the-Caribbean.pdf

The circular economy gives us the tools and ability to tackle both climate change and the loss of biodiversity, while addressing important social needs.

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Highly vulnerable to natural hazards. This is evidenced by annual occurrences of flooding and seismic activity throughout the region, frequent occurrence of major hurricanes, and, less frequently, significant earthquakes and volcanic eruptions. Between 2017 and 2021, countries in the Caribbean were hit by several devastating hurricanes[2] and one major volcanic eruption.[3]

High level of biodiversity per unit of area. The Caribbean has a high percentage of endemic species relative to land area, high values of ecosystem services per capita, and generally pristine nature. This flora and fauna, however, are exceptionally vulnerable to the effects of climate change and invasive species.

Susceptible to the effects of climate change[4]. Despite the differences among Caribbean nations, climate change poses a serious threat to them all. According to the IPCC, average temperatures in the region have increased by 0.1° to 0.2°C per decade over the past three decades. Rainfall patterns have shifted in the region, with the number of consecutive dry days expected to increase. Additionally, sea level rise has occurred at a rate of about two to four centimetres per decade over the past 33 years, a trend which presents risks to the region's freshwater resources and to its coastal population, largely dependent on tourism and agriculture. Even if all pledges made by governments and companies are fulfilled, global temperatures may still rise beyond 1.5 degrees. Such a temperature rise is predicted to result in catastrophic warming, which could make several regions, including the Caribbean, unliveable.

The traditional linear economic model, modified by colonisation, slavery, and in some cases indentureship, have not served the region well. This is evidenced by enduring challenges of low economic growth throughout the region, ongoing and recurrent significant fiscal and current account deficits, high total debt[5], limited economic diversification and monoculture. Former sugar economies became tourism economies. Commodity exporters, by and large, remained commodity exporters, even if the leading commodity changed. This would imply that economies within the Caribbean, such as Trinidad and Tobago, would be prime candidates for an accelerated shift to the circular economy.

Transitioning to a circular economy
For the transition to take place, a combination of economic, social, and environmental policies must be put in place, with recommendations considering the area's unique characteristics.

Desired environmental outcomes of a shift to a circular economy include the reduction of raw materials for production/excess material for consumption, reduced and/or optimised energy use and reduced waste emissions. Desired economic outcomes include the reduction of raw material and energy costs as well as waste and other emissions costs, lower risks, and the fostering of innovative new product designs and business opportunities. Social outcomes would involve changes in individual and group behaviour, and evolving a "sharing economy" with greater joint social decision-making and more cooperative use of capital.

In this case, one size does not fit all. The Caribbean and Trinidad and Tobago have unique challenges to overcome in facilitating interventions to aid the shift to a circular economy. In most cases, options for reorienting economies through reuse and reduction of materials and energy remain limited, due to limited size and small scale of potential inputs.

Moreover, since the successful provision of tourism services (a mainstay of most Caribbean economies) is so intimately linked to the preservation of the natural environment, a circular economy strategy which seeks to minimise material and energy use is prudent. Trinidad and Tobago, as an oil, gas and commodity petrochemical exporter has different challenges, as it has to balance existing production with long-term sustainability imperatives without impacting existing incomes and standards of living or impacting social stability. For the Caribbean, interventions to facilitate the shift to the circular economy (considering its unique characteristics) would need to centre around the following:

[2] https://publications.iadb.org/en/assessment-of-the-effects-and-impacts-caused-by-hurricane-irma-the-bahamas-2017; https://reliefweb.int/disaster/tc-2017-000136-atg; https://reliefweb.int/report/bahamas/facts-hurricane-dorian-s-devastating-effect-bahamas

[3] https://reliefweb.int/sites/reliefweb.int/files/resources/Executive%20Summary%20SVG%20PDNA%20Volcanic%20Eruption.pdf

[4] https://www.iadb.org/en/ove/climate-change-caribbean-small-island-states#:~:text=Additionally%2C%20sea%20level%20rise%20has,dependent%20on%20tourism%20and%20agriculture.

[5] Reliefweb. "Survival mode on as pandemic ramps up Caribbean debt" (2021) Available at https://reliefweb.int/report/world/survival-mode-pandemic-ramps-caribbean-debt.

TABLE 1: CARIBBEAN INTERVENTIONS TO ACCELERATE THE SHIFT TO THE CIRCULAR ECONOMY

SECTOR	INTERVENTION	NOTES RE. TRINIDAD AND TOBAGO
Energy	Promote renewable energy development	In train, though prices of gas-generated electricity remain low
	Retrofitting buildings for energy efficiency/cooling	Significant scope exists for building retrofitting, given climate trends
Transportation	Develop efficient land-based transportation	
	Implement vigorous policies for promoting public transportation, while discouraging individual vehicle ownership	Mass transit initiatives have not been successful for non-economic reasons
Green Taxes	Implement green taxes	Possibly the most widely recognised in the Caribbean is the Green Fund Levy which is implemented in Trinidad and Tobago
	Establish green and blue investment bonds Credit terms are specified to direct financial resources towards promoting healthy environments, low carbon development and more sustainable use of the natural resource base. Green bonds help to finance these developments on land, while blue bonds support the sustainable use of the ocean space.	Scope exists for utilising both green and blue bonds
	Broader use of green taxes for funding environmental amelioration activities such as tree planting and coastal clean-ups	Difficulties in applying for Green Levy funds due to criteria. Changes in the process of being made
Green Investments	Investment in public goods and services to obviate environmental impacts from production and consumption.	Done for private goods and services. Not done by the State recently

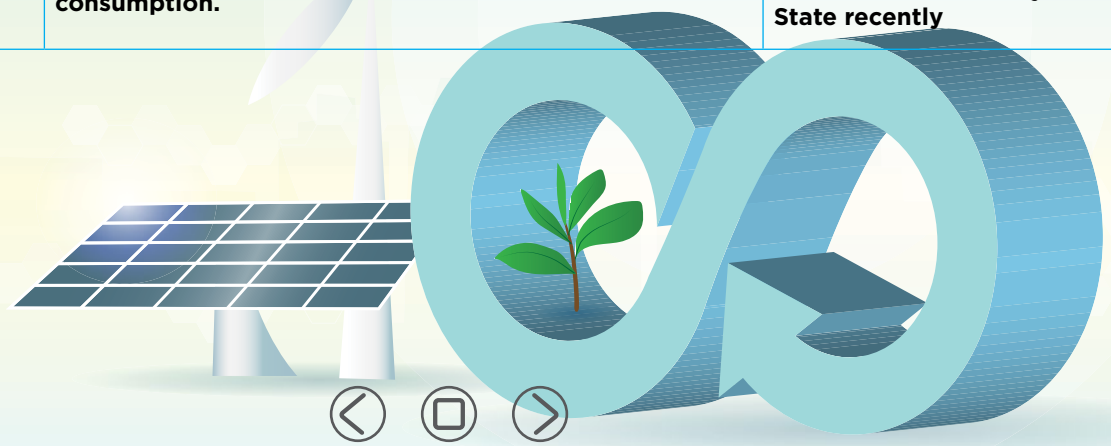

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TABLE 2: CARIBBEAN ENVIRONMENTAL INTERVENTIONS TO ACCELERATE THE SHIFT TO THE CIRCULAR ECONOMY

SECTOR	INTERVENTION	NOTES RE. TRINIDAD AND TOBAGO
Waste Management	Promote efficient waste minimisation	Initiatives at embryonic stage
	Community level investment in municipal waste management such as community composting	Scope for initiative exists
Water Management	Promote efficient water pricing and regulation	Significant institutional changes needed; ageing infrastructure remains a challenge
Environmental	Implement performance bonds for public/ cultural events	Bonds used, but not necessarily environmental
Capacity limits	Set optimal carrying capacity limits for the natural resource base - depend on a determination of the optimal long-run social cost for the use of its natural resource base	Not currently done for Trinidad and Tobago

SOURCE: DERIVED FROM UNECLAC (2021). 'CONCEPTUALISING A CIRCULAR ECONOMY IN THE CARIBBEAN: PERSPECTIVES AND POSSIBILITIES.' AVAILABLE AT: HTTPS://REPOSITORIO.CEPAL.ORG/BITSTREAM/HANDLE/11362/47604/1/LCCAR2021_07_EN.PDF

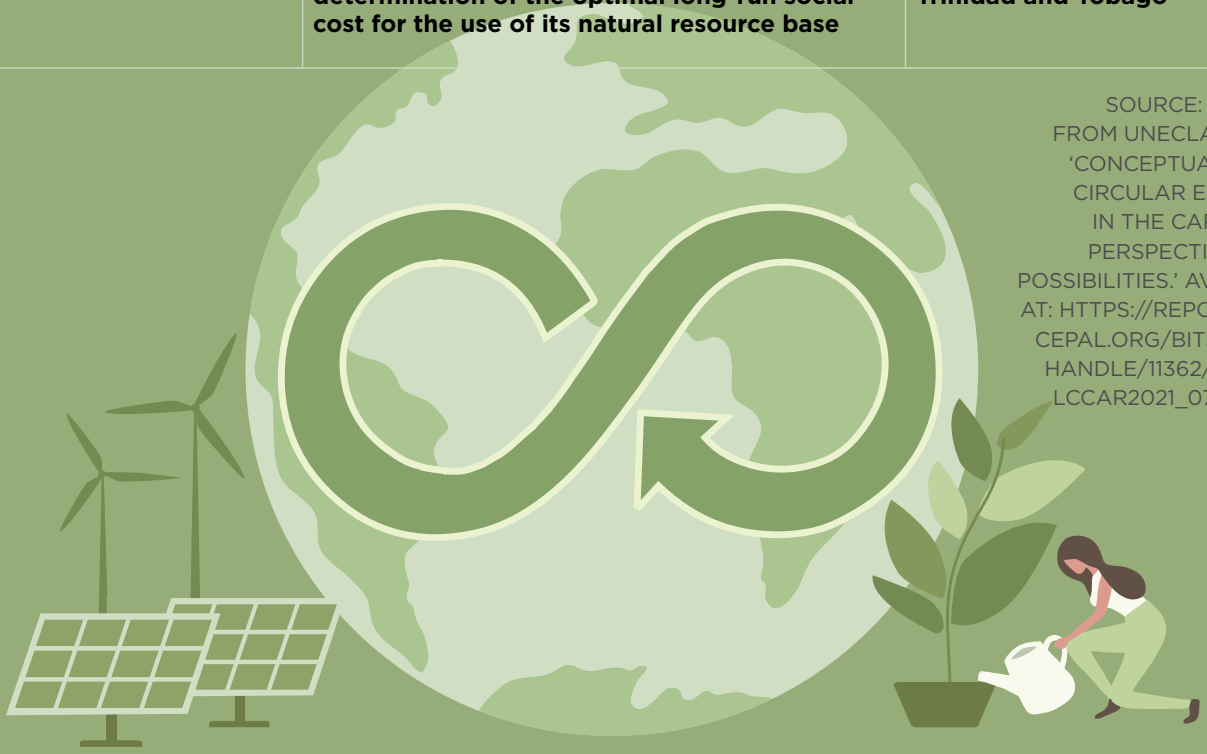

TABLE 3: CARIBBEAN SOCIAL INTERVENTIONS TO ACCELERATE THE SHIFT TO THE CIRCULAR ECONOMY

SECTOR	INTERVENTION	NOTES RE. TRINIDAD AND TOBAGO
Promote Elements of a Shared Economy	**Mitigating negative externalities will change economic cost structures, which will in turn result in new regimes of gainers and losers. Reduced use of materials and energy also implies differences with respect to the use of capital, property rights in terms of the level of public versus private goods and access to and use of the environmental commons**	
Social Reorientation	**Social interventions for Caribbean economies across several spheres (energy, waste management, green taxes)**	
	Promotion of joint community ownership of social services such as transportation, gardening services, and even home repairs. In this way, the value of materials and energy are cycled through the economy for longer periods, before diminishing to the level of disposal	
Use of Private Sector Shared Services	**Capital sharing may be employed at the corporate level – shared services**	**Done for some petrochemical companies in the Point Lisas Industrial Estate. Can plausibly be extended to other sectors without State intervention**

SOURCE: DERIVED FROM UNECLAC (2021). 'CONCEPTUALISING A CIRCULAR ECONOMY IN THE CARIBBEAN: PERSPECTIVES AND POSSIBILITIES.' AVAILABLE AT: HTTPS://REPOSITORIO.CEPAL.ORG/BITSTREAM/HANDLE/11362/47604/1/LCCAR2021_07_EN.PDF

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The recommendations are generally feasible, though not without disruption to the existing organisation of the economy. The reality remains: for Caribbean countries, the shift to a circular economy, though necessary for long-term sustainability and viability, represents a significant disruption for a series of economies that have been historically built to benefit from the linear economy, not to mention the influence of entrenched economic and other interests in the status quo. Smaller islands may be closer to implementing these recommendations since, being in a much more parlous economic state post-COVID, any overall shift may be less jarring.

For Trinidad and Tobago, the economic pain point which would make a general transition to a circular economy feasible is much further away. Though elements that would facilitate the transition exist in the SDGs and country commitments under the Paris Accord, they are not present as a series of overall policies. What is lacking is an explicit circular economy framework, and a means to evaluate and monitor the progress to the circular economy. ■

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NGC upgrades EnergySmarTT mobile app and CariGreen website

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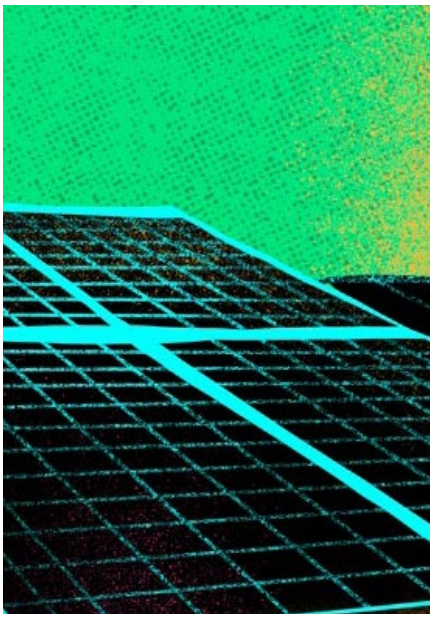


> The National Gas Company of Trinidad and Tobago Limited (NGC) has been working to build national capacity and consciousness around energy efficiency and renewable energy (EE/RE).

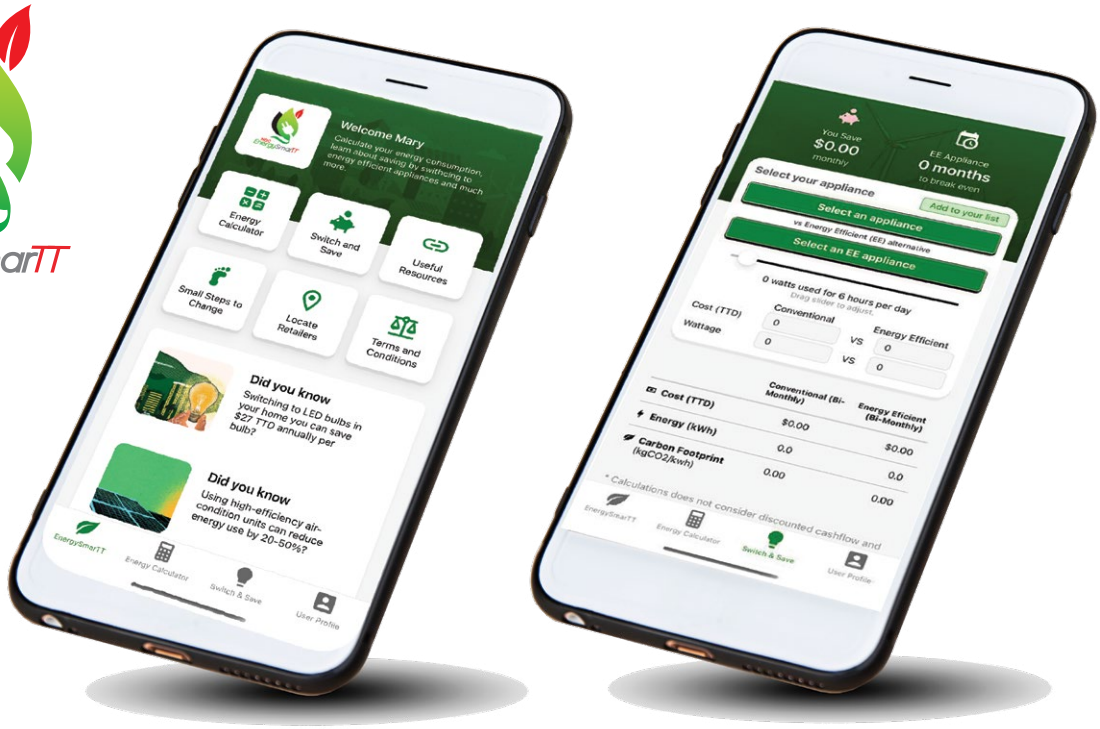
In an effort to support national emissions reduction targets and broader global climate goals, The National Gas Company of Trinidad and Tobago Limited (NGC) has been working to build national capacity and consciousness around energy efficiency and renewable energy (EE/RE). In the past two years, the Company developed and launched two resources geared toward green energy education.

The first was the country's first mobile app around energy efficiency and conservation (EE&C) - EnergySmarTT. This app, available for free download by the public, aims to change behaviours and attitudes toward energy consumption - particularly at the domestic level - and increase awareness about the big picture environmental impact of personal choices. At the time of its launch in 2020, it was the first local energy education mobile application in Trinidad and Tobago and allowed anyone with an Android or Apple device to gain customised insights into his or her individual carbon footprint.

The second, launched in 2021, was the CariGreen website. NGC created CariGreen to be a repository for authoritative, updated information on Caribbean clean energy, to make it easier for investors, academics and citizens to conduct research in this area. The ultimate aim was to help expedite investment decisions and clean energy project development in the region.

Following the successful deployment of these resources, NGC decided to undertake expansion of both the app and website in 2022, to include more features that increase their value and streamline their functionality. These upgrades, executed in June 2022, are highlighted on the following page.

NGC upgrades EnergySmarTT mobile app and CariGreen website | CONTINUED



EnergySmarTT 2.0
Building on the strengths of the original app, the second iteration of EnergySmarTT boasts several useful features:

1. The 'My Consumption' feature has been renamed 'Energy Calculator' and allows users to calculate their estimated electricity cost and carbon footprint on a daily, monthly or yearly basis. Users can select an appliance from the list, input their usage pattern and get an estimate of what they pay to power that appliance over the specified period.

   In addition, users can now input their desired expenditure on power for any given appliance, and the app reveals what duration of usage corresponds to that figure – i.e. how many hours per day/week/month one would be able to use that appliance in order to limit its power cost to the stipulated amount.

   Additional upgrades under this feature will soon include a field for users to find out estimated T&TEC rebates, and an expanded appliance listing with commercial grade equipment used by small businesses and Light Industrial and Commercial (LIC) customers.

2. The 'Switch and Save' feature helps users understand the cost of purchasing an EE product. The app calculates the estimated payback period, over which the purchase cost of an EE product would be amortised - i.e. how long consumers would have to wait before realising savings on their energy bills because of that purchase. Calculations illustrate the simple payback, monthly savings, and an estimated carbon savings breakdown per day/month/year.

   Additionally, the listing of products from which app users can select has been expanded to include more renewable energy products.

3. Energy Saving Tips are included to highlight the simple measures users can implement to reduce their consumption habits for common household appliances and products. The app is now also linked to NGC's CariGreen website, which allows users to learn about efficiency and conservation within the broader context of global climate action. This will help sensitise them to the big picture impact of managing their personal energy consumption.

4. The EnergySmarTT app has a unique feature which uses location-based services linked to mobile devices to highlight where EE products can be purchased within Trinidad and Tobago.

   NGC has upgraded this feature to make it easier for businesses selling these products to get the requisite approvals to be featured on the app.

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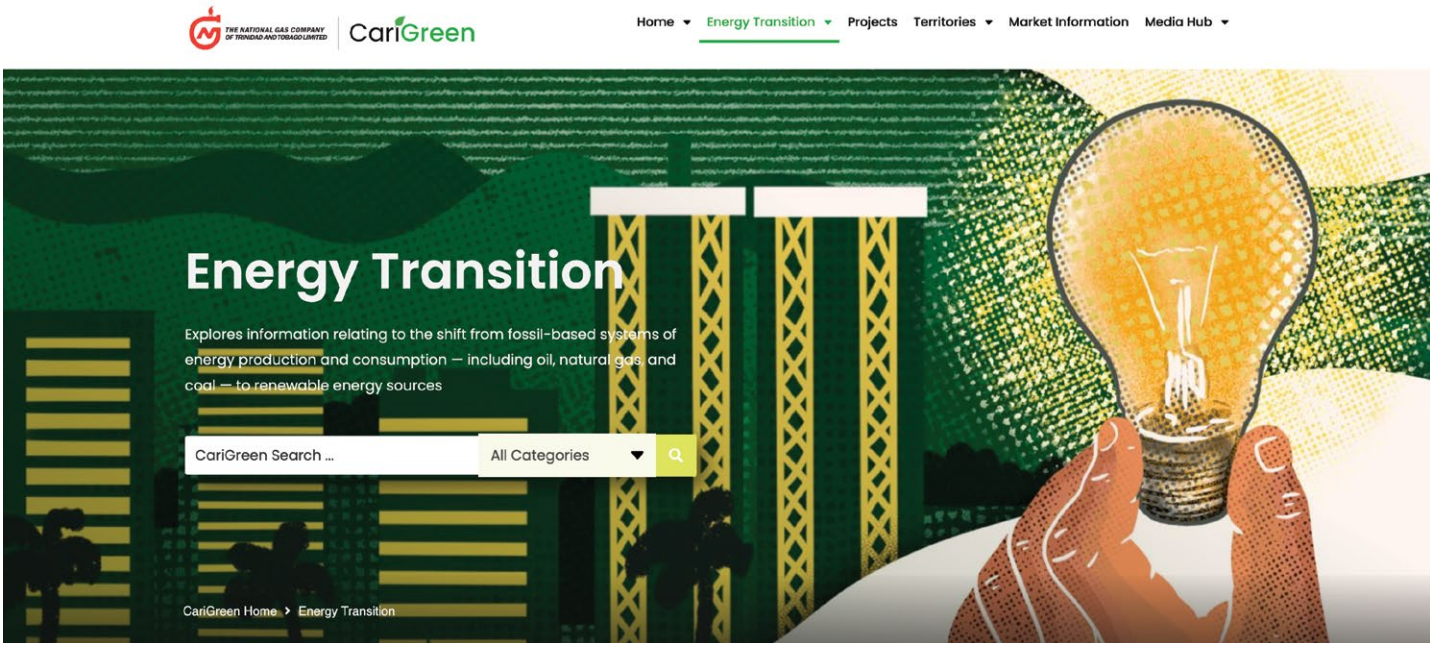

It is envisioned that streamlining this process will attract more businesses to the platform and enrich the directory for app users.

Additionally, users are now able to search within a particular radius for stores that sell EE products, which further enhances their accessibility and improves likelihood of purchase.

An expanded CariGreen

Through the CariGreen website, NGC and its subsidiaries aim to:

- Provide a platform that will bring together datasets, information products, economic data and climate change strategies from different sources into one central location to provide users with complete, timely and trusted information;
- Drive engagement, collaboration and conversation with stakeholders through integration of social media tools and development of energy reports; and
- Build the necessary relationships between the Caribbean and international energy information organisations to sensitise and inform citizens on matters related to green energy.

At its launch, the website's content was divided into:

- Project background and partner information
- Energy transition topics: renewable energy, energy efficiency, alternative fuels, carbon capture and sequestration
- Market information: research reports, funding agencies/ mechanisms
- Caribbean territories: country-specific data from CARICOM and non-CARICOM members around energy transition projects and strategies

In 2022, NGC added a new category to house information about specific renewable energy projects in the region. Included here are specifications of over 100 wind, solar, geothermal, biomass, hydrogen and hydropower facilities and projects across Latin America and the Caribbean. The site profiles the capacity and location of these facilities, and links visitors to the respective facility websites for further information. This upgrade now makes it easier for site visitors to survey the landscape of regional clean energy.

Building stronger

As NGC intensifies its lobby for climate action at the industry, community and household levels, the Company will seek to introduce further innovations across all its energy education platforms, in an effort to amplify the reach and resonance of its messages. Users of the EnergySmarTT app and CariGreen website can therefore expect to see further enhancements and features in future.

NGC encourages all citizens to download the free EnergySmarTT app from their respective mobile application stores, and to visit the CariGreen website at **www.carigreen.ngc.co.tt ,** to learn more about the movement to lower our collective carbon footprint. Action is urgently needed, and the personal choices we make today will determine what kind of planet we leave for our children. ■

TO REFLECT ON THE BEAUTY THAT SURROUNDS US HERE IN TRINIDAD AND TOBAGO

Large mangroves grow at this sandy spit along the eastern coast of Trinidad.

Photo by Shaun Rambaran