
November 25, 2021

Mr. John Mencias
Chief Executive Officer
Belize Electricity Limited
Phillip Goldson Highway
Belize City, Belize

Dear Mr. Mencias,

Re: Cost of Power and Relating Matters for the Month of September 2021

The Public Utilities Commission (“PUC”) writes in relation to the captioned subject matter.

A careful analysis of the data for the month of September 2021, an extract of which is attached as ANNEX 1 for ease of reference, has raised three main concerns for the PUC as follows:

1. There were excessive instances during the period from September 1, 2021 to September 24, 2021 where Belize Electricity Limited (“BEL”) elected to purchase power from BECOL when, in fact, the cost of power from CFE in Mexico was significantly lower;
2. There were contrary instances, particularly in the last week of the reporting period, where BEL elected to purchase power from CFE when, in fact, the cost of purchasing power locally was significantly lower; and
3. Finally, and most critically, as a consequence of the first concern raised above, the water level at the Chalillo Dam has been depleted below the historical levels for this time of the year when Belize begins to actively manage reservoir levels in anticipation of the dry season.

The combined effect of all the above concerns is that the cost of power to the consumer for the month of September 2021 is estimated to be close to BZD\$2,000,000 more than it should have been if BEL had managed the purchase of power in a more prudent way.

Even more far-reaching, though, given the current water level at Chalillo and the bleak forecast for rain in the upcoming months, Belize will find itself with no other option but to continue to purchase power from CFE notwithstanding the cost.

The PUC finds BEL's actions and/or inactions to be very troubling (to say the least) mainly because the consequence of BEL's actions and omissions will adversely impact the cost of power to consumers for the foreseeable future.

The PUC calls on BEL to address the aforementioned issues on or before December 4, 2021 by specifically providing the following:

1. An explanation for BEL's actions and/or inactions in relation to its decisions to purchase or not purchase from CFE;
2. An explanation for BEL's decision to operate the BECOL hydro facilities at or near full output for the period between August 25, 2021 to September 24, 2021, leading to the unusually low reservoir level heading into the dry season;
3. BEL's plans to mitigate the situation as it relates to the Chalillo Dam levels and the anticipated increase in cost of power for the foreseeable future; and
4. BEL's plans to inform the relevant stakeholders about this ominous situation.

Finally, and on a related note, the PUC has discovered several errors while reviewing the September Report. In conducting our own analysis, we have not made any corrections to those errors but relied instead on the summary table as being accurate.

It goes without saying that BEL is expected to review and reconcile its data before submitting same to the PUC. This is in fact the reason why there is a twenty (20) day grace period for the information to be submitted by BEL for each reporting month.

Additionally, the PUC has made numerous requests for BEL to submit copies of actual invoices from IPP's to no avail. Your attention is therefore drawn to these matters.

We await a reply.

Best regards,


Dean Molina
Chairman
PUC Belize

- c. Mr. Andrew Marshalleck SC, Chairman of BEL Board
Director of Electricity, PUC
Director of Tariff, Compliance and Standards

BELIZE ELECTRICITY LIMITED

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December 8th, 2021

Mr. Dean Molina
Chairman
Public Utilities Commission
4 Princess Margaret Drive
Marina Towers
Belize City, Belize

Dear Mr. Molina,

Re: Cost of Power and Related Matters for the Month of September 2021

We write in response to the Public Utilities Commission's (PUC) letter dated November 25, 2021, in which the PUC requests explanations for Belize Electricity Limited's (BEL) power purchase decisions just prior to and during the month of September 2021.

BEL's Dispatching Methodology in relation to CFE and BECOL

BEL's generation dispatch decisions are guided by considerations that seek to minimize cost of power subject to maintaining adequate levels of generation availability and overall system reliability. We source generation for supply to the Grid from a diversified mix of energy providers: BECOL's hydroelectric plants in Cayo, Hydro Maya's hydroelectric plant in Toledo, CFE (Mexico), Belcogen's co-generation plant in Orange Walk, SSEL's bagasse generation plant in Cayo, Bapcol's diesel/HFO-fueled plant in Stann Creek, the JICA solar plant in Belmopan, and our own diesel-fueled gas turbine at Mile 8 George Price Highway in the Belize District. Each of these sources of supply have different characteristics of cost, level and type of capacity, reliability, fuel type, location on the Grid, operations and maintenance requirements, and purchase arrangements with BEL.

In the case of CFE, BEL must agree to the amounts it will purchase (subject to availability) two days ahead of the date of actual dispatch based on estimated prices provided by CFE. The actual price BEL pays for the energy it purchases from CFE is determined the day before the dispatch – which is after the commitment to purchase has been made. Historically, the actual prices have not deviated significantly from estimated prices, though there have been times when the deviation has been substantial. If BEL is unable or unwilling to purchase the full amount agreed to on the date of dispatch, CFE will seek to sell it to some other buyer at the spot market price on the day of the dispatch and BEL pays (or gets credited for) the difference between what it had contracted to pay

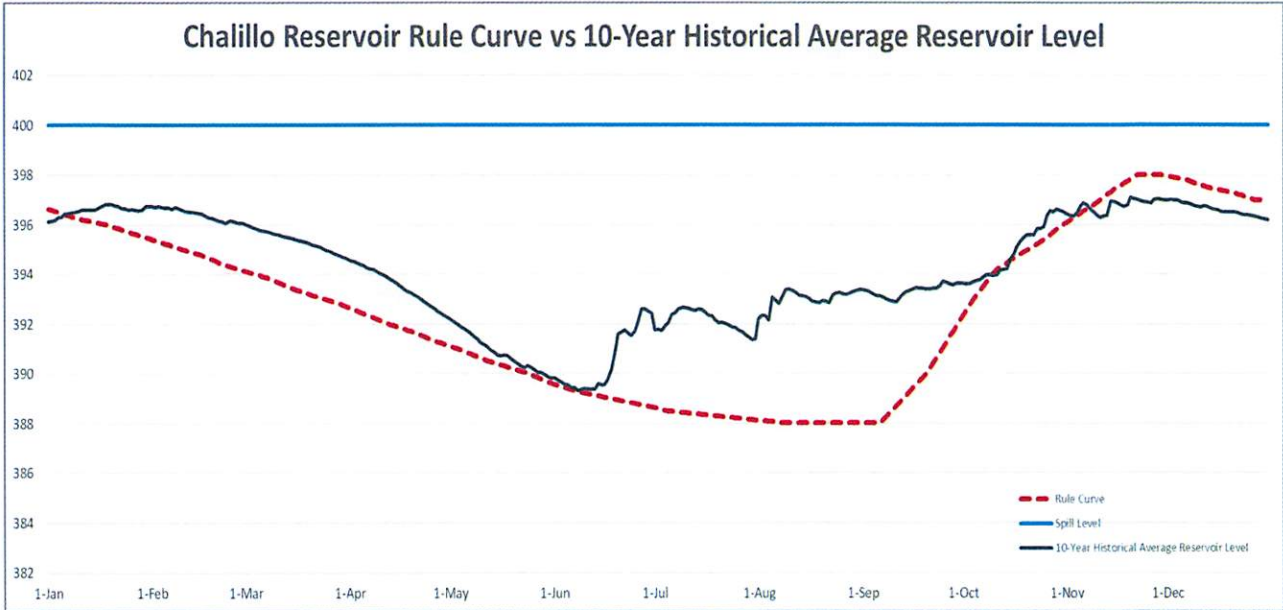
versus what the buyer paid. If BEL takes more than it had contracted to in any hour on the day of dispatch, it will pay the spot price on any additional amounts it purchases.

Under the 'Amended and Restated Power Purchase Agreement' of 2001 between BEL and BECOL, BEL is responsible for controlling the operation of the Mollejon/Chalillo facility (i.e. for dispatching output from the plant), but must ensure that it purchases all energy generated by the facility, otherwise it must pay for energy that it could not take. Except for certain periods of heavy rainfall in the upper Macal River catchment area, the output of the three BECOL hydroelectric plants is largely controlled by the water flow from the Chalillo Reservoir. For a given water flow rate, more energy is produced the higher the level of water in the reservoir; however, the probability of spillage and loss of the opportunity to convert the spilled water to energy is also greater.

The Rule Curve

Consequently, in 2006, BECOL established a Rule Curve for the Chalillo Reservoir to help guide dispatch decisions. The Rule Curve is based on historical river flow and rainfall patterns in the Upper Macal River over the various weeks of the year and prescribes the level at which water in the reservoir should be maintained to get the most (energy) production and the highest available capacity without causing spillage. BEL has, over the years, sought to adopt the operating principle of maintaining the Chalillo dam level at least one meter above the Rule Curve as a means of bolstering overall in-country firm capacity.

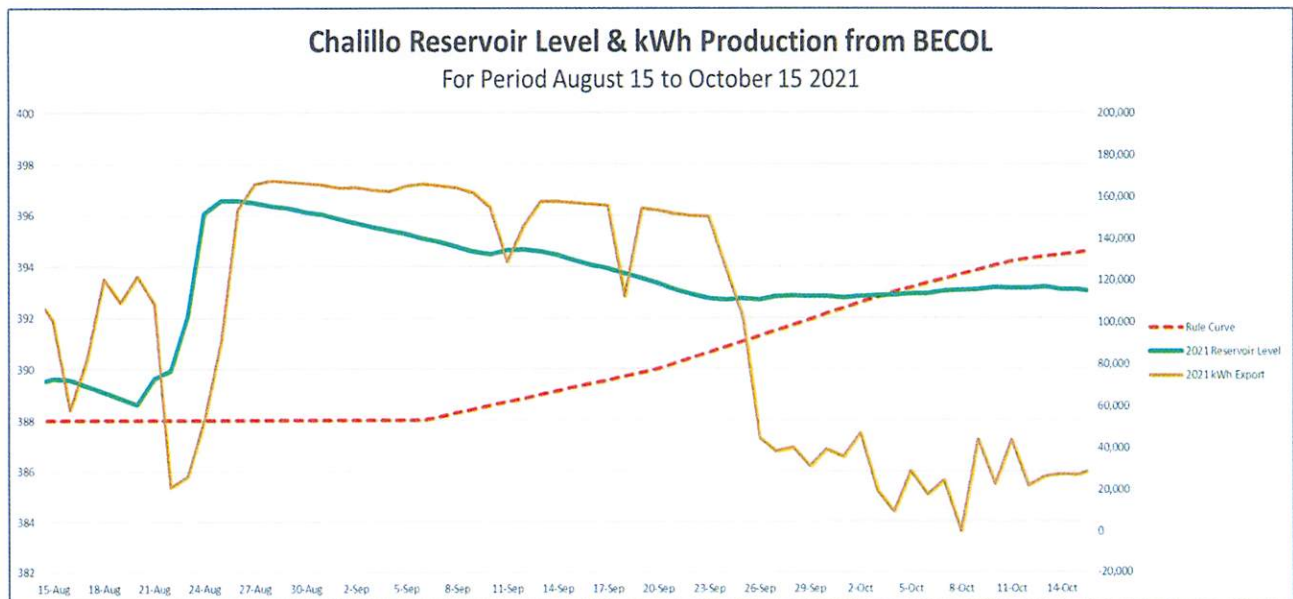
Figure 1



Chalillo Reservoir Level Movement and BECOL Dispatch

Between August 23 to 25, 2021, water levels in the Chalillo Reservoir increased by more than 6 meters from 389.96m to 396.06m, causing the Rule Curve difference indicator to move from 1.96m to 8.06m. Given the fact we were in the middle of the rainy season, and these movements pushed the reservoir levels within 4 meters of the spill point, BEL proceeded to dispatch the BECOL hydroelectric plants to reduce the Chalillo reservoir level and reduce the Rule Curve difference. Despite running the hydro facilities near full output, the reservoir level continued to increase up to August 26, 2021, when it reached a level of 396.57m with a Rule Curve difference of 8.57m. BEL continued to dispatch BECOL at full output for most of the time right through to September 25, 2021, at which point it started to sharply cut back purchases as the reservoir level had by then dropped to 1.69m above the prescribed Rule Curve level. Thereafter, purchases from BECOL were minimal as we sought to maintain water levels at the Rule Curve in light of incoming information that CFE pricing in October could be severely affected by the then emerging natural gas crisis.

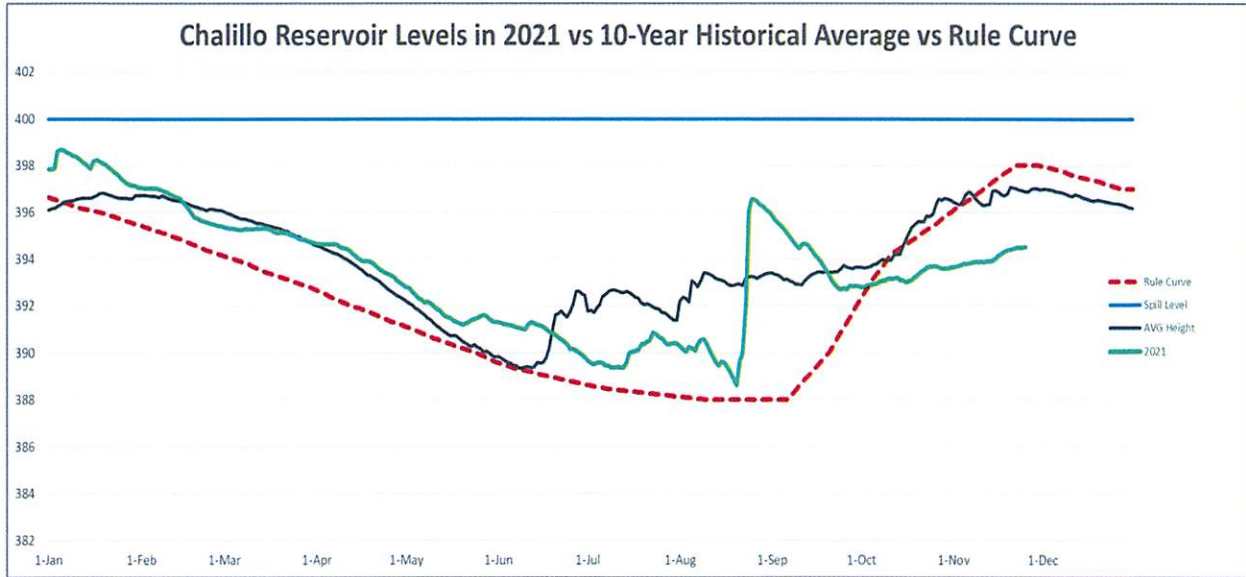
Figure II



Rationale underlying BEL's Dispatching Decisions in September

BEL's decision to run the hydro facilities in the way we did during this period was well in line with how we have usually dispatched the BECOL facilities as shown in Figure III below, and firmly in accordance with prudent utility practice of following the established Rule Curve and avoiding spillage to minimize costs.

Figure III



In the first instance, we sought to mitigate the possibility of spillage which now had a much higher probability of occurring after the sharp rise in reservoir levels culminated at 8 meters above the Rule Curve and just 3.5 meters below the reservoir spillway. It should be noted that, at the time we were making these decisions, the National Meteorological Service had forecasted that the last few months of the rainy season would be 'normal'. *We were therefore convinced that there would be spillage if we did not aggressively reduce the reservoir level (from 3.5 meters below the spillway), and, in any case, we were also convinced that the reservoir levels could build up back to normal levels given the projections for a normal end to the rainy season and lower prices from CFE.* Our follow-up investigation of the 10-year historical data has revealed that in 95% of instances where this reservoir level was reached, there was spillage. In fact, the spillway would have been breached by September 18 had we dispatched BECOL at minimal levels from September 1, assuming water inflows equal to the 10-year historical average.

Our dispatch decisions also took into account the projections of cost of power *over the horizon of the remaining last four months of the year.* Average COP from CFE was forecasted (Business Plan) to be 18 cents in September, 14 cents in October, and 12 cents in November and December. This was based on the fact that CFE prices have historically dropped during the last quarter of the year due to cooler weather and lower demand in Southern Mexico. In fact, average prices during Q4 2020 were 11 cents. Given the high probability of spilling, it made more sense to dispatch BECOL aggressively during September when CFE prices were projected to be higher as opposed to later when CFE prices were projected to be significantly lower. As it turned out, actual CFE prices in September averaged

18.7 cents; they increased (instead of decreased) to 23.6 cents in October, then fell to 14 cents in November. In retrospect, even if we had projected higher CFE prices in October, it still would not have been prudent to increase dispatch of CFE in September at the risk of incurring additional spill charges of 25.8 cents/kWh for Mollejon/Chalillo and 16.9 cents/kWh for Vaca.

Our Direct Responses to the Claims and Statements made in the PUC's Letter of November 25

- 1) The PUC's claim that *"there were excessive instances during the period September 1, 2021 to September 24, 2021 where (BEL) ... elected to purchase power from BECOL when, in fact, the cost of power from CFE in Mexico was significantly lower"* fails to consider the entirety of optimal dispatch considerations. Our dispatch decisions were made in full accordance with prudent utility practice guided by considerations that seek to minimize cost of power subject to maintaining adequate levels of generation availability and overall system reliability. Had we dispatched CFE more than we did, we could have caused an increase in cost of power to consumers in consequence of spilled charges. Given that reservoir levels remained within 6 meters of the spillway through to September 18 despite aggressive dispatching of the Chalillo hydroelectric power plant, it made no sense to risk committing to maximum purchases from CFE on the required two day-ahead basis (during that time) when there was a fairly high probability of a 6-meter spike in water levels in two days (and faster) reoccurring as it did between August 23 and 25. In fact, our calculations show that if BEL had dispatched CFE at all times during September when CFE's prices were lower than BECOL's, as the PUC seems to be advising, BEL would have saved \$1.55 MN in costs from the lower CFE prices but incurred \$2.32 MN in spilled charges, for a net increase in cost of power to consumers of \$0.77 MN.
- 2) The PUC's statement that *"there were contrary instances, particularly in the last week of the reporting period, where BEL elected to purchase power from CFE when, in fact, the cost of purchasing power locally was significantly lower"* is not supported by the facts and the data, and, furthermore, fails to consider the entirety of optimal dispatch considerations. The average cost of power (based on dispatch price) from CFE from September 25 to September 30 was 20 cents/kWh. Belcogen and Hydro Maya were being fully dispatched for the entire period, Santander was already offline for the rest of the year, and energy from both Bapcol and the GT were more costly. The only other option was BECOL. As previously explained, BEL chose to dispatch CFE in greater amounts at that time because we had already brought Chalillo reservoir levels in line with the Rule Curve and were beginning to receive information that CFE pricing in October could be severely affected by the then emerging natural gas supply crisis.
- 3) The PUC's claims that *"the water level at the Chalillo Dam has been depleted below the historical levels for this time of the year when Belize begins to actively manage reservoir levels in*

anticipation of the dry season” because of its initial claim in 1) above and that BEL’s dispatch decisions between August 25 and September 24 led to *“the unusually low reservoir level heading into the dry season”* are also not supported by the facts and the data. Firstly, we have already comprehensively refuted the PUC’s claim in 1) above. Secondly, as shown in Figure II further above, BEL cut back purchases from BECOL to a minimum at the point where the reservoir level was still 1.69m above the prescribed Rule Curve level, and 0.69m above the *Rule Curve + 1 m* point where BEL has sought to maintain the Chalillo reservoir level. This is also less than 1 meter below historical reservoir levels for that day. Had the average historical water inflow into Chalillo for that time of the year occurred as expected, reservoir levels in Chalillo would have risen well above the Rule Curve by mid-October.

- 4) The PUC’s estimation that the *“cost of power to the consumer for the month of September 2021”* was *“close to BZD\$2,000,000 more than it should have been if BEL had managed the purchase of power in a more prudent way”* is likely calculated on the basis of the wrong cost data or fails to take into account the entirety of optimal dispatch considerations. It would be helpful if the PUC could explain to us how it arrived at additional costs to the consumer of close to \$2,000,000 within the context of the reality within which dispatch decisions are made at BEL or by any other electric utility adhering to prudent utility practice. In any case, the evidence provided in the foregoing paragraphs firmly shows that BEL’s actions, taken after due consideration of the information available at the time of the decision and after careful technical analysis, mitigated cost impacts.
- 5) Finally, we unequivocally reject the assertion by the PUC that *“the consequence of BEL’s actions and omissions will adversely impact the cost of power to consumers for the foreseeable future”*. This assertion has no basis in fact and is not supported by the data. On the contrary, the facts and data show that BEL has consistently acted in accordance with Prudent Utility Practice in fulfilment of its mandate to control and minimize cost of power subject to maintaining adequate levels of generation availability and overall system reliability.

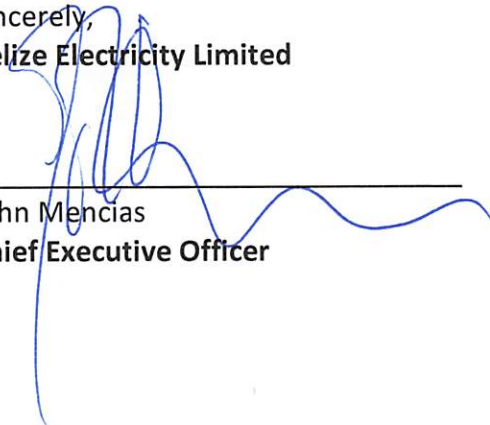
Looking Ahead

We note the PUC’s request for us to share our *“plans to mitigate the situation as it relates to the Chalillo Dam levels and the anticipated increase in cost of power for the foreseeable future”* and *“plans to inform the relevant stakeholders of this ominous situation”*. This request appears to be largely driven by the PUC’s pronouncement that *“Belize will find itself with no other option but to continue to purchase power from CFE notwithstanding the cost”*. It seems to us that the PUC has already arrived at an opinion about the situation it refers to without first receiving BEL’s responses to the concerns it has raised.

We wish to reiterate that any increase in the cost of power to consumers in the foreseeable future would not be because of BEL’s dispatch decisions in the period under review by the PUC: **BEL’s actions mitigated cost of power impacts!** Based on year-to-date results and projections for the rest of the year, unit cost of power for 2021 is expected to average below 22 cents per kWh generated; just over 2 cents higher than in 2020, but 7 cents and 5 cents less than in 2019 and 2018 respectively. The rainfall forecast from the Caribbean Climate Outlook Forum indicates that, for the period December 2021 through to February 2022, Belize should expect “at least as high as usual rainfall totals”, though the Belize Met Service forecasts that a short-term drought may evolve in the southwestern parts of the country. Based on the empirical evidence before us therefore, there would be no reason to characterize “the situation” as “ominous” and we believe our ongoing communications on cost of power management is sufficient to keep customers and other key stakeholders abreast of the complexities involved in energy supply management.

Lastly, on the matter of the errors in the September report you refer to, we would appreciate if you would provide us with a full enumeration of these errors discovered by the PUC for our review and reconciliation: Our goal is to provide complete and accurate data to all our stakeholders, the PUC, as regulator, chief among them. BEL also notes the PUC’s requests for IPP invoices and will work with the PUC liaison to clarify expectations and timelines for standard regulatory reports and submissions.

Sincerely,
Belize Electricity Limited



John Mencias
Chief Executive Officer

Report: Dispatch Outcomes for September 2021 and October 2021

Technical Features of BECOL's Hydroelectric Cascade

Table 1 below briefly describes the key technical attributes of the three-(3) BECOL hydroelectric plants that it owns and operates. In a nutshell, the scheme is rated at 52 MW and in a normal hydrological year would be expected to deliver 240 GWh.

Table 1: Macal River hydroelectric cascade

Belize Electric Company Limited (BECOL)	51.40	
Chalillo	7.20	Plant nameplate rating of 7.2 MW at a design head of 38m; with a normal annual plant production of approximately 32.5 GWh. Prime movers: Vertical Kaplan: 2 x 3.6 MW
Mollejon	25.20	Plant nameplate rating of 25.2 MW at a design head of 112m; with a normal annual plant production of approximately 127.5 GWh. Prime movers: Vertical Francis: 3 x 8.66 MW
Vaca	19.00	Plant nameplate rating of 19.0 MW at a design head of 58m; with a normal annual plant production of approximately 80.0 GWh. Prime movers: Vertical Francis: 2 x 9.375 MW and Horizontal Francis: 1 x 1.065 MW

Storage for the entire scheme is provided by the 35 m Chalillo dam. The attributes for the reservoir is shown in Table 2 below.

Table 2: Key technical parameters of the Chalillo Dam

Reservoir Levels		Drawdown		Live Storage	Potential
Elevation	Volume	Elevation	Volume	Mm3	GWh
400	124	-	-	99.00	65.741
395	85	5.00	39.00	60.00	38.739
390	50	10.00	74.00	25.00	17.952
385	25	15.00	99.00	-	-
380	10.5	20.00	113.50		
375	3	25.00	121.00		
370	0	30.00	124.00		
365	0				

The storage provided by the Chalillo dam represents about ¼ of the expected annual production of the hydroelectric scheme. Hence the rule of thumb wherein “**the Chalillo Dam provides 3 months of storage**”.

When the BECOL hydroelectric cascade is being modeled the following key monthly numbers should be borne in mind.

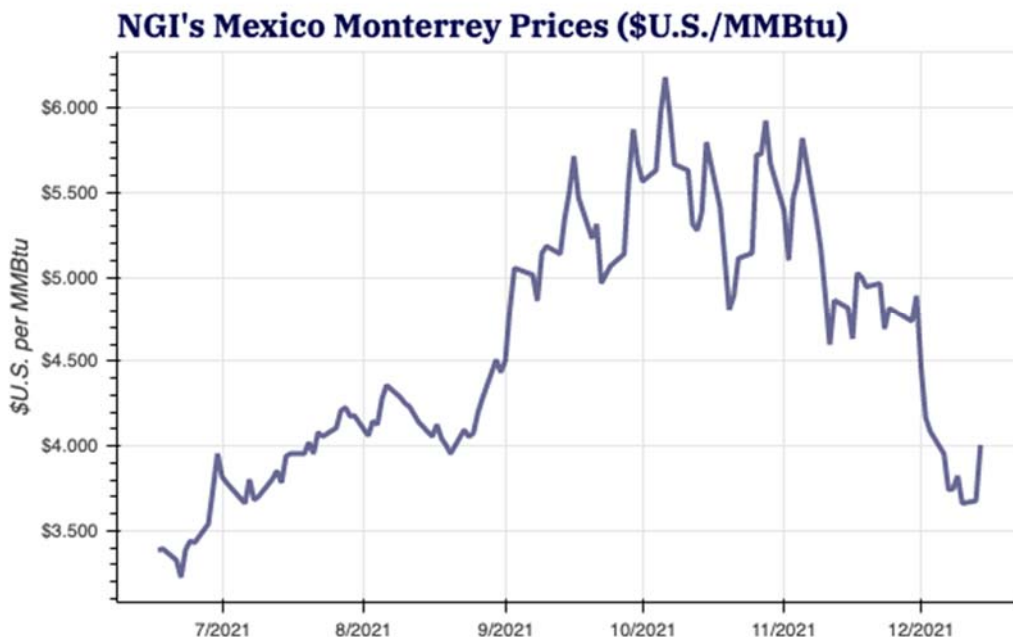
- (i) At the flood the scheme will export some 38 GWh;
- (ii) On average the scheme produces 20 GWh monthly;
- (iii) In extreme dry the expected production approximates to a plant utilization of 15%, being 5.5 GWh.

Based on these realities a **Dispatch Model** of the Macal River cascade can be parameterized that has the following operating conditions in order of increasing water utilization:

- (i) **Extreme Water Conservation** – in this mode water may be held back at Chalillo Dam for up to 6 hours in a day, otherwise environmental flows during non-baseload periods and plant utilization may ramp up to 75% during peak. Expected monthly output is **7.5 ± 2 GWh**;
- (ii) **Conserve Water** – in this mode water release is limited to environmental minimum during non-baseload periods and plant utilization may ramp up to 75% during peak. Expected monthly output is **12.0 ± 2 GWh**;
- (iii) **Neutral Water Utilization**– in this mode plant utilization is typically at least 20% during non-baseload periods and plant utilization may ramp up to 90% during peak. Expected monthly output is **20.5 ± 2 GWh**;
- (iv) **High Water Utilization**– is a wet season water release mode intended to forestall future spills. Plant utilization is 20-50% during non-baseload periods and plant utilization may ramp up to 95% during peak periods. Expected monthly output is **27.5 ± 2 GWh**;
- (v) **Flood**– is a water release mode when the Chalillo Dam is at spill stage. Plant utilization is more than 80% during non-baseload periods and plant utilization may ramp up beyond 100% during peak periods. Expected monthly output is **36.5 ± 2 GWh**.

What occurred over the period September to October 2021

Prices in the Mercado Eléctrico Mayorista (MEM)



A confluence of events created a natural gas price shock as shown in the figure above - prospect of early start of winter in the Northern Hemisphere, supply chain difficulties during the COVID-19 pandemic and geopolitics particularly in Europe, which started in late September and carried over into November.

The Yucatan peninsula is heavily dependent on combined cycles generation units fired with natural gas, consequently electricity prices surged by more than 50 percent in October.

Drought Outlook

August 2021 Update

The Caribbean Hydro-Met Service publishes a monthly Drought Outlook. The bulletin breaks down time periods into Current, Short-term (within 3 months), and long-term (3-6 months). The pertinent bulletin is the August 2021 Update, which concluded in respect of the Upper Macal river watershed that:

- No current drought situation (up until June 2021);
- Shorter term drought situation is evolving in Belize (up until November 2021); and

- Longer term drought is not a concern (December 2021 through to February 2022).

September 2021 Update

The next bulletin issued September 2021 concluded in respect of the Upper Macal river watershed that:

- No current drought situation (up to August 2021);
- No Short term drought concerns, and
- Longer term drought is a concern and warned that a Drought Watch may be advisable by the end of November 2021.

Taken as a whole, these bulletins expressed concerns that the wet season would likely be shorter than is normal and thereby create a situation where long term drought occurs as a consequence of large reservoirs, large rivers and ground water not being sufficiently recharged to carry into the 2022 dry season.

September 2021

Recharge of the reservoir in August meant that a less restrictive water management modality more typical of the wet season could be contemplated. The following observations are worth noting (see Table 3 below).

- CFE prices in general were less than BZ\$0.145/kWh early in the mornings and for extended periods through Saturday and Sunday.
- Dispatch of BECOL does not appear to modulate strongly with CFE prices, output being 29 ± 3 MW in the early mornings and 39 ± 4 MW the rest of the time. BECOL purchases by BEL were 26.6 GWh for the month.
- The average CFE prices reported for June 2021 was BZ\$0.1833/kWh. For context, the median CFE price being BZ\$0.145/kWh. CFE purchases by BEL were 19.9 GWh for the month.
- COP reported was BZ\$0.2363/kWh

Table 3: Dispatch of BECOL for September 2021

Hours	CFE Prices							Hours	BECOL						
	Week Days								Week Days						
	1	2	3	4	5	6	7		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0	0.1436	0.1522	0.1663	0.1487	0.1499	0.1517	0.1340	0	32,582	33,183	34,555	33,869	39,546	34,091	35,344
1	0.1366	0.1416	0.1466	0.1409	0.1382	0.1479	0.1334	1	27,990	31,117	30,684	31,307	38,048	31,811	33,553
2	0.1337	0.1368	0.1428	0.1398	0.1373	0.1409	0.1326	2	28,090	30,522	30,084	31,500	36,869	31,140	33,057
3	0.1310	0.1334	0.1376	0.1358	0.1357	0.1375	0.1303	3	27,606	28,526	28,951	31,146	36,884	29,914	32,849
4	0.1287	0.1332	0.1373	0.1338	0.1345	0.1358	0.1270	4	26,604	27,132	28,970	30,896	36,870	29,066	32,856
5	0.1326	0.1336	0.1379	0.1349	0.1348	0.1370	0.1292	5	27,293	27,154	28,964	30,887	36,161	28,243	32,885
6	0.1370	0.1536	0.1407	0.1351	0.1571	0.1338	0.1283	6	27,609	27,395	28,916	30,291	28,825	27,125	32,384
7	0.1390	0.1669	0.1383	0.8156	0.1418	0.1331	0.1195	7	31,998	30,318	31,234	34,529	28,848	27,027	32,383
8	0.1445	0.1646	0.1479	0.9727	0.1401	0.1332	0.1140	8	39,499	33,001	37,526	37,885	40,154	29,236	32,382
9	0.1515	0.1547	0.1517	0.5661	0.1535	0.1379	0.1147	9	41,610	35,497	39,413	38,660	43,353	32,867	33,668
10	0.1478	0.1642	0.1514	0.5572	0.1412	0.1412	0.1166	10	42,205	35,961	40,804	38,424	43,597	34,786	34,701
11	0.1532	0.1798	0.1501	0.5559	0.1475	0.1419	0.1192	11	42,772	36,100	41,796	38,759	44,053	35,109	36,187
12	0.1478	0.1826	0.1641	0.5873	0.1743	0.1399	0.1226	12	42,425	35,704	41,238	39,448	43,612	35,739	37,004
13	0.1584	0.2131	0.1572	0.2700	0.1678	0.1393	0.1235	13	43,023	37,101	41,364	38,004	43,345	36,481	38,616
14	0.1468	0.2262	0.1675	0.1591	0.1698	0.1422	0.2981	14	43,020	38,692	41,505	39,507	42,396	36,397	40,060
15	0.1528	0.1769	0.2035	0.1635	0.2831	0.1411	0.3345	15	41,688	37,398	41,980	40,336	42,636	36,745	39,241
16	0.1532	0.1720	0.1951	0.1587	0.1733	0.1548	0.1416	16	40,324	36,084	40,640	38,905	41,837	37,585	39,556
17	0.1508	0.1653	0.1840	0.1668	0.1726	0.1552	0.1515	17	39,299	34,877	38,909	36,246	41,005	37,626	39,403
18	0.1639	0.1706	0.1717	0.1611	0.1796	0.1406	0.1432	18	41,255	39,317	39,800	37,677	43,411	42,851	42,743
19	0.1781	0.2972	0.1860	0.1830	0.2022	0.1356	0.1659	19	43,286	42,445	40,910	39,462	44,195	44,529	44,290
20	0.2748	0.2493	0.2375	0.2077	0.1633	0.1378	0.1449	20	42,815	41,843	41,106	40,040	42,636	44,359	43,598
21	0.3104	0.2763	0.2169	0.2091	0.1462	0.1420	0.1623	21	41,551	41,387	40,545	40,475	41,833	44,412	43,812
22	0.2929	0.2501	0.2128	0.1858	0.1445	0.1456	0.1409	22	41,223	41,394	40,227	39,479	41,619	43,548	42,365
23	0.1746	0.1738	0.1709	0.1914	0.1433	0.1636	0.1514	23	38,339	37,343	37,337	37,944	40,425	42,333	38,875

October 2021

BEL having doubled down on a high water utilization strategy in September, BEL found itself with insufficient water resources to adequately modulate CFE high prices. The following observations are worth noting (see Table 4 below).

- CFE prices in general were less than BZ\$0.180/kWh early in the mornings and for extended periods through Saturday and Sunday.
- Dispatch of BECOL appears to modulate strongly with CFE prices, output being less than 8 MW in the early mornings, Saturdays and Sundays, but supplying 18 ± 4 MW weekdays during late afternoons and nights. BECOL purchases by BEL plummeted to 6.6 GWh for the month.
- The average CFE prices reported for October 2021 was BZ\$0.2354/kWh. For context, the median CFE price being BZ\$0.175/kWh, a BZ\$0.06/kWh difference. CFE purchases by BEL were 36.9 GWh for the month.
- The COP realized by BEL was BZ\$0.2690/kWh

Table 4: Dispatch of BECOL for September 2021

Hours	CFE Prices							Hours	BECOL Dispatch						
	Week Days								Week Days						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7	
0	0.1608	0.3467	0.1905	0.2520	0.2054	0.1818	0.1620	0	1,555	3,695	4,663	6,188	2,814	1,546	2,876
1	0.1723	0.2266	0.1833	0.2212	0.1795	0.1768	0.1562	1	1,341	972	1,428	3,747	2,440	954	2,747
2	0.1506	0.1633	0.1702	0.2165	0.1817	0.1662	0.1534	2	1,340	971	1,355	3,161	1,432	951	2,747
3	0.1482	0.1558	0.1692	0.2005	0.1764	0.1631	0.1537	3	1,335	975	1,360	2,531	1,263	951	2,743
4	0.1487	0.1616	0.1668	0.2014	0.1698	0.1662	0.1550	4	1,338	970	1,357	2,013	1,264	949	2,648
5	0.1646	0.1725	0.1964	0.2187	0.1785	0.1680	0.1517	5	1,337	974	1,352	2,008	1,262	950	2,404
6	0.1662	0.1798	0.2021	0.2221	0.1833	0.1753	0.1507	6	1,340	4,222	1,346	1,996	1,337	1,271	5,355
7	0.2057	0.1960	0.1900	0.2387	0.9899	0.1671	0.1391	7	3,442	7,226	3,422	3,909	6,503	2,297	5,784
8	0.2490	0.2229	0.5067	0.2050	0.7905	0.1865	0.1168	8	8,835	13,077	12,412	9,316	10,950	4,115	7,237
9	0.2762	0.2517	0.1896	0.2238	1.1352	0.2371	0.1152	9	10,225	16,661	10,840	11,554	15,896	5,599	8,434
10	0.3745	0.3055	0.1812	0.1987	0.7448	0.2094	0.1149	10	12,045	19,141	10,512	12,871	14,878	7,489	8,690
11	0.3616	0.3183	0.1785	0.1923	0.8514	0.2098	0.1157	11	14,316	20,739	11,922	10,844	19,708	8,190	8,808
12	0.3736	0.3230	0.1935	0.2046	1.1393	0.2127	0.1193	12	15,229	20,280	11,267	10,317	22,055	8,123	9,217
13	0.4810	0.2622	0.2401	0.2301	0.2828	0.2201	0.1178	13	19,295	18,267	11,942	11,539	17,990	7,762	9,216
14	0.3905	0.3820	0.2351	0.3569	0.2851	0.2462	0.1449	14	22,054	19,348	12,855	16,439	17,750	7,577	7,329
15	0.3640	1.4112	0.2522	0.4083	0.3701	0.2814	0.1450	15	22,411	20,193	12,298	17,699	16,993	6,918	2,657
16	0.6425	0.9892	0.2635	0.4988	0.3141	0.1742	0.1451	16	20,047	19,639	9,373	15,547	14,090	5,739	2,657
17	0.2863	0.2002	0.2098	0.2995	0.3350	0.1723	0.1509	17	14,604	12,707	7,857	14,110	10,915	5,149	3,790
18	0.1919	0.4133	0.2580	0.3223	0.2202	0.1856	0.1719	18	11,600	19,401	10,546	14,496	10,640	7,352	7,547
19	0.3941	0.7746	0.3411	0.4305	0.2460	0.2281	0.1904	19	16,432	23,255	15,466	16,169	11,299	7,671	7,179
20	0.2938	1.5995	0.4217	0.3763	0.2713	0.2441	0.1915	20	17,695	26,454	20,332	13,265	9,723	8,769	6,684
21	0.3840	1.9392	0.4782	0.3918	0.3179	0.2370	0.1956	21	17,874	26,444	22,341	17,453	10,489	7,511	6,107
22	0.3982	1.1595	0.3994	0.3883	0.2781	0.2207	0.1650	22	13,439	23,793	23,172	15,555	7,774	6,590	3,985
23	0.4631	0.2677	0.2559	0.2106	0.1997	0.1775	0.1994	23	9,875	11,682	11,351	7,041	4,605	3,301	1,970

Modeling September and October 2021

Rationale for the values used for BECOL and Mexican supplies in Dispatch Model

The top half of table 5 describes the CFE parameters. Four operational modes are defined - when CFE prices are less than BZ\$0.20/kWh the full 55 MW is made available, between BZ\$0.20 /kWh and BZ\$0.30/kWh a buffer of 2.75 MW is subtracted, between BZ\$0.30 /kWh and BZ\$0.50/kWh only ½ of the CFE transfer capacity is contemplated to be utilized, and above BZ\$0.50/kWh the CFE take is curtailed to 3 MW,

The price points in the **dispatch model** reflect current estimates of relative costs for the supply options. So below the BZ\$0.20/kWh cheap CFE, environmental flows of BECOL is prioritized, below BZ\$0.30/kWh CFE low mid-merit and BECOL are prioritized, below BZ\$0.50/kWh CFE high mid-merit, BECOL and BAPCOL are prioritized, above BZ\$0.50/kWh the Mile 8 power plant must respond to severely limit CFE purchases.

Table 5: Inputs for Deterministic Model of BEL's System

CFE DISPATCH PARAMETERS							
Maximize		Maximize		Mid-Merit [High]		Minimize	
Price	Max. Load	Price	Max. Load	Price	Max. Load	Price	Max. Load
\$ 0.2000	55,000	\$ 0.3000	52,250	\$ 0.5000	27,500		3,135
MACAL RIVER HYDROELECTRIC CASCADE							
Dry {low utilization}		Median {average utilization}		Wet {high utilization}		Max {Extra utilization}	
Cha	1,080	Cha	2,160	Cha	4,321	Cha	5,401
Mol	3,844	Mol	7,749	Mol	15,683	Mol	19,988
Vaca	2,197	Vaca	5,114	Vaca	11,187	Vaca	14,982
	15.0%		30.0%		60.0%		75.00%
	7,121		15,023		31,190		40,370

The bottom half of table 5 describes the BECOL parameters. For harmony there are also four operational modes. When CFE prices are less than BZ\$0.20/kWh BECOL shall be in extreme conservation mode wherein plant utilization is cut to 15% and during the hours of 01:00 and 06:00 the hydro-plants may be shut down; between BZ\$0.20 /kWh and BZ\$0.30/kWh plant utilization is doubled (*30% plant utilization*), between BZ\$0.30 /kWh and BZ\$0.50/kWh plant utilization is doubled again (*60% plant utilization*). The Maximal operating mode is a special case assumed to be 15% plant utilization higher than the normal high utilization. It would likely mean operating Chalillo while building up the reservoirs for Mollejon and VACA to have enough water for mitigating extreme CFE price peaks.

Important Note: The BECOL parameters for the Neutral Water Utilization mode is 20%, 40%, 75% and 90% respectively.

Application of Dispatch Model to September and October 2021

September 2021

The top half of table 6 shows the actual dispatch and production costings for September 2021. The BECOL purchases were 26.6 GWh, the CFE purchases were 19.9 GWh at an average rate of BZ\$0.1833/kWh. This resulted in a cost of power of BZ\$0.2363/kWh.

The bottom half of table 6 shows the simulated dispatch and production costings for September 2021, wherein the Neutral Water Utilization mode is implemented. The BECOL purchases are 11.3 GWh, the CFE purchases are 35.2 GWh at an average rate of BZ\$0.1554/kWh; which would have resulted in a cost of power of BZ\$0.2028/kWh.

Sep-21	DISPATCH SUMMARY of Daily Averages											Total
Hours	Week Days											Total
	Chalillo/Mollejon	Vaca	Hydro Maya	Solar	BelCoGen	SSEL	CFE	BAPCOL	GT	BEL Diesels		
	18,449,840	8,128,187	2,147,559	57,066	6,149,154	-	19,924,233	1,083,679	110,976	799,535		56,850,229
	\$ 4,879,415	\$ 1,834,825	\$ 299,845	\$ 7,481	\$ 1,336,117	\$ -	\$ 3,651,875	\$ 870,496	\$ 153,965	\$ 397,523		\$ 13,431,543
	\$ 0.2645	\$ 0.2257	\$ 0.1396	\$ 0.1311	\$ 0.2173	#DIV/0!	\$ 0.1833	\$ 0.8033	\$ 1.3874	\$ 0.4972		\$ 0.2363
Sep-21	OPTIMIZE BECOL and CFE Only											Total
Hours	Week Days											Total
	Chalillo/Mollejon	Vaca	Hydro Maya	Solar	BelCoGen	SSEL	CFE	BAPCOL	GT	BEL Diesels		
	6,789,442	4,526,295	2,147,559	57,066	6,149,154	-	35,186,523	1,083,679	110,976	799,535		56,850,229
	- 11,660,398	- 3,601,893	-	-	-	-	15,262,290	-	-	-		
	\$ 1,795,598	\$ 1,218,998	\$ 299,845	\$ 7,481	\$ 1,336,117	\$ -	\$ 5,466,691	\$ 843,292	\$ 161,952	\$ 397,523		\$ 11,527,499
	\$ 0.2645	\$ 0.2693	\$ 0.1396	\$ 0.1311	\$ 0.2173	#DIV/0!	\$ 0.1554	\$ 0.7782	\$ 1.4593	\$ 0.4972		\$ 0.2028
												\$ 1,904,044

Table 6: Comparison of Actuals and Modeled dispatch and productions costings for September 2021

The model confirms what the high level key performance indicators indicate that if the average CFE rate is within BZ\$0.01/kWh of the median CFE price (BZ\$0.145/kWh), it is likely a well-executed dispatch in terms of modulation of the CFE supply through proper management of the BECOL facilities.

Furthermore, the seasonally moderate prices from CFE results in BECOL’s output stagnating around 12 GWh monthly output. For context, during the summer months CFE median price may rise above BZ\$0.20/kWh and in such a case the Neutral Water Utilization mode would induce purchases from BECOL in the 20 GWh monthly output.

A reasonable system dispatcher would have operated September 2021 in Neutral Water Utilization as regards the BECOL facilities and thereby have saved ratepayers \$1.9 million if that strategy was efficiently executed. Precipitation forecasts were indicative of abnormally low rainfall for the south-west areas of Belize thru the rest of 2021, hence the caution. In fact, what BEL did in September 2021 was to pursue an aggressive water release strategy. Table 7 captures the expected impact of that strategy.

Table 7: Modeled dispatch and productions costings for September 2021 when BECOL exports 26.5 GWh

SUMMARY OF DISPATCH OUTCOMES					
MERIT ORDER		SECURITY OF SUPPLY		SUBTOTALS	ECO-SUPPLY
BECOL	8,646,603	BECOL	17,862,537	26,509,141	9,229,637
CFE	34,953,350	CFE	- 14,960,232	19,993,119	38,006,815
Totals	43,599,954	Totals	2,902,306	46,502,259	47,236,452
As Produced				10,347,969	
				56,850,229	\$ 12,568,671
					\$ 0.2211

The model estimates that pursuit of “let’s run BECOL” in the range of 26.5 GWh would have resulted in a cost of power pf BZ\$0.2211/kWh if such a strategy was efficiently executed. The second column shows that the loss is about 14.9 GWh of more economical CFE energy being replaced by BECOL energy.

The other takeaway is that BEL’s execution of “let’s run BECOL” turned out to be a flawed strategy. BEL pursued a high utilization of BECOL when CFE prices were relatively lower in the first twenty-four days of the month; and thereafter made a drastic shift to a conserve water mode, just as CFE prices took off. Accordingly, our model is pricing BEL’s “let’s run BECOL” dispatch as poorly executed estimated as \$0.8 million.

According to our **Dispatch Model**, pursuit of the “most economic dispatch” would have resulted in a cost of power in the range of BZ\$0.2005/kWh, being \$2.0 million lower than actual dispatch outcomes.

Table 8: Modeled dispatch and productions costings for September 2021 – CFE + BECOL + Thermals

SUMMARY OF DISPATCH OUTCOMES					
MERIT ORDER		SECURITY OF SUPPLY		SUBTOTALS	ECO-SUPPLY
BECOL	8,678,407	BECOL	3,083,978	11,762,385	8,691,024
CFE	35,094,884	CFE	3,443	35,098,327	38,083,375
BAPCOL	687,203	BAPCOL	-	687,203	708,750
LM2500	148,999	LM2500	-	148,999	323,000
Totals	44,609,494	Totals	3,087,420	47,696,914	47,806,149
As Produced				9,153,314	
				56,850,229	\$ 11,400,278
					\$ 0.2005

The difference in estimated COP between tables 7 and 8 speaks to the role and impact of thermal generation sources – BAPCOL and the LM2500 at Mile 8. Table 7 has the modeled results for the modulation **between BECOL**

and CFE only. While table 8 looks at the **optimal mix between CFE, BECOL, BACOL and the LM2500.** In a nutshell, the **Dispatch Model** is saying than in September 2021, wherein CFE prices were moderate and BECOL had adequate water resources the contribution of the thermal sources was not significant to either the supply of electric capacity or the provisioning of electric energy. In fact according to table 8, there was no economic need to operate the LM2500 unit at Mile 8, and the efficient interaction of BAPCOL had the potential to lower COP by a minor \$0.1 million.

October 2021

The top half of table 9 below shows the actual dispatch and production costings for October 2021. The BECOL purchases were 6.6 GWh, the CFE purchases were 36.9 GWh at an average rate of BZ\$0.2354/kWh. This resulted in a cost of power of BZ\$0.2690/kWh.

The bottom half of table 9 shows the simulated dispatch and production costings for October 2021, wherein the Extreme Water Conservation mode is implemented. The BECOL purchases are estimated at 10.1 GWh, the CFE purchases being 33.4 GWh at an average rate of BZ\$0.2053/kWh; which would have resulted in a cost of power of BZ\$0.2582kWh; a savings of around \$0.6 million.

Table 9: Comparison of Actuals and Modeled dispatch and productions costings for October 2021

Oct-21 DISPATCH SUMMARY of Daily Averages												
Hours	Week Days											Total
	Chalillo/Mollejon	Vaca	Hydro Maya	Solar	BelCoGen	SSEL	CFE	BAPCOL	GT	BEL Diesels		
	3,946,377	2,699,133	1,885,426	47,994	0	-	36,896,760	10,576,696	1,131,899	800,992		57,985,277
	\$ 1,045,633	\$ 906,602	\$ 263,246	\$ 6,294	\$ 0	\$ -	\$ 8,685,920	\$ 3,718,236	\$ 584,409	\$ 386,397		\$ 15,596,736
	\$ 0.2650	\$ 0.3359	\$ 0.1396	\$ 0.1311	\$ 0.2172	#DIV/0!	\$ 0.2354	\$ 0.3515	\$ 0.5163	\$ 0.4824		\$ 0.2690
Oct-21 OPTIMIZE BECOL and CFE Only												
Hours	Week Days											Total
	Chalillo/Mollejon	Vaca	Hydro Maya	Solar	BelCoGen	SSEL	CFE	BAPCOL	GT	BEL Diesels		
	6,717,359	3,445,060	1,885,426	47,994	0	-	33,379,851	10,576,696	1,131,899	800,992		57,985,277
	2,770,982	745,927	-	-	-	-	3,516,909	-	-	-		
	\$ 1,776,535	\$ 1,034,136	\$ 263,246	\$ 6,292	\$ 0	\$ -	\$ 6,852,587	\$ 4,048,408	\$ 592,371	\$ 396,180		\$ 14,969,754
	\$ 0.2645	\$ 0.3002	\$ 0.1396	\$ 0.1311	\$ 0.2173	#DIV/0!	\$ 0.2053	\$ 0.3828	\$ 0.5233	\$ 0.4946		\$ 0.2582
												\$ 626,982

The model is suggesting that at these really high prices the average CFE rate should be within BZ\$0.03/kWh of the median CFE price (BZ\$0.175/kWh), for a well-executed dispatch in terms of modulation of the CFE supply through proper management of the BECOL facilities.

It is possible to extract from the model additional useful information shown in table 10 below. Of note, the high prices from CFE would cause BECOL’s monthly output to exceed 10 GWh on an economic basis – wherein median prices during weekdays exceeded \$0.20/kWh, but in the mid-teens on weekends. So any offtake of BECOL below these levels would indicate a sub-optimal dispatch.

Table 10: Modeled dispatch and productions costings for October 2021 under Extreme Water Conservation

SUMMARY OF DISPATCH OUTCOMES					
MERIT ORDER		SECURITY OF SUPPLY		SUBTOTALS	ECO-SUPPLY
BECOL	9,487,250	BECOL	675,169	10,162,418	10,529,243
CFE	32,514,387	CFE	865,465	33,379,851	34,696,310
Totals	42,001,637	Totals	1,540,633	43,542,270	45,225,553
As Produced				14,443,007	

The fact that BEL dispatched the BECOL facilities in such a manner so that output was less than 7 GWh meant that BAPCOL had to be dispatched to replace expensive CFE power. And because BEL made a conscious decision to not run 2 of 2 Chalillo turbines often enough some expensive CFE power were procured. The model

estimates that these two aspects added about \$0.9 million. That is, these causations account for most of the variance observed between the model simulation and actual COP outcomes.

According to our **Dispatch Model**, pursuit of the "*most economic dispatch*" would have resulted in a cost of power in the range of BZ\$0.2457/kWh, being \$1.3 million lower than actual dispatch (*see table 11 below*).

Table 11: Modeled dispatch and productions costings for October 2021 – CFE + BECOL + Thermals

SUMMARY OF DISPATCH OUTCOMES					
MERIT ORDER		SECURITY OF SUPPLY		SUBTOTALS	ECO-SUPPLY
BECOL	8,940,402	BECOL	3,758,905	12,699,307	9,944,501
CFE	34,535,050	CFE	887,561	35,422,611	35,032,250
BAPCOL	3,057,750	BAPCOL	3,057,153	6,114,903	3,057,750
LM2500	884,345	LM2500	-	884,345	952,000
Totals	<u>47,417,548</u>	Totals	<u>7,703,618</u>	<u>55,121,166</u>	<u>48,986,501</u>
As Produced				2,734,412	
				<u>57,855,578</u>	\$ 14,213,374
					\$ 0.2457

Conclusion

Sub-optimal modulation of CFE prices come in three flavors'

- (i) Where BEL prioritizes the offtake of energy from domestic suppliers, which in almost all cases is BECOL, at a time when CFE prices are low. As can be seen in table 8, even sustained pricing below \$0.15/kWh did not alter BEL's actions;
- (ii) Where BEL prioritizes the offtake of energy from CFE, despite CFE prices being well above the producer prices for domestic suppliers.

Of these first two shortcomings *(i) and (ii) above*, the failure to take cheap Mexico, is usually the costlier.

- (iii) Where BEL prioritizes energy production from BECOL, despite the very low likelihood of a major recharge event occurring that would cause water to spill.

The third shortcoming (iii), actually imposes causation (i) in the month it happens, and causation (ii) in future months.

September and October 2021 are case studies on sub-optimal dispatch. Simulations using the Dispatch **Model** estimates that in total BEL incurred excess input power costs in the region of BZ\$3.0 million over the two month period. September being twice as bad because BEL substituted quite a bit of cheap Mexican energy with more expensive BECOL. The other takeaway being the challenging capacity situation brought about by limited water resources at the Chalillo Dam. What this means is rather than BECOL and CFE providing the bulk of the capacity for the system, BAPCOL moves higher up the merit order stack behind CFE. This obviously imposes additional costs on the system.

The root cause of sub-optimal modulation of CFE prices using BECOL and domestic thermal generation sources appears to be.

- (i) **Water resource management** – everything starts with the prevailing reservoir conditions, the rate of runoff from the watershed, the short-term forecasts for water inflows, and the seasonal outlook for precipitation and associated runoff. Specifically,
 - ✓ Short-term and Seasonal Outlooks give BEL the foresight to respond in a deliberate way in selecting the right operational modes for the Chalillo reservoir: whether conserve water, average water release or accelerated water release; Wild swings in operational modes tend to result in sub-optimal economic outcomes.

- ✓ BEL has provided no evidence that the utility in planning its system dispatch for September and October 2021 used the relevant climatological tools to define the prudent water management strategies to pursue.
- (ii) **Minimizing the inputs costs of the Mexican supply** – the philosophy is simple enough, take as much cheap Mexican power within acceptable technical constraints and curtail offtake when Mexican prices rise above domestic producers. Specifically,
- ✓ BEL has to manage the risks inherent in anticipating CFE prices one and two days ahead. The lowest Mexican prices in a week are known with a high degree of certainty, because it is fundamentally on account of low overall demand – early mornings and Sundays. Severely limiting BECOL’s energy output during periods of cheap Mexico has to be the highest priority;
 - ✓ Clearly, understanding the pattern of electricity demand and monitoring supply constraints on the peninsula – gas supply and prices, power plants out of service, congestion on the network informs price movements. Otherwise, high Mexico prices may come and bite the utility. Again BEL has not provided any evidence that it conducts the necessary surveillance that a prudent utility would undertake.
- (iii) **Using a forward-looking system dispatch model** – Models are an important tool in forward planning and evaluating dispatching outcomes. Specifically,
- ✓ Modeled elements shall include *inter alia* load curve, CFE and BECOL parameters, domestic thermal power plants and parameterization of other renewable energy resources;
 - ✓ BEL has not shared with the PUC the tools and associated operating philosophy it utilizes for making detailed monthly dispatch plans
- (iv) **Competent Planning and Execution** – The value proposition of dispatch models is paring down all the possible futures to a handful of well understood possibilities. In addition, model outputs are only as good as the inputs provided. A competent person still needs to sieve through the weather data, reservoir conditions, electric market price signals and narrowed options outputted from dispatch models.
- ✓ It would not be surprising if a competent person can often refine the modeled outputs to get a slightly better outcome;
 - ✓ Always - The monthly and day-ahead plans require prevailing conditions be evaluated and plans thereby updated.
 - ✓ Periodically - On a monthly basis, or if a threshold event occurs, the 12-month plan needs to be updated.

CariCOF Drought Outlook

By the end of November 2021

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Dr. Cédric J. Van Meerbeeck - Climatologist
Dr. Teddy Allen – Assistant Climatologist
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Participating territories

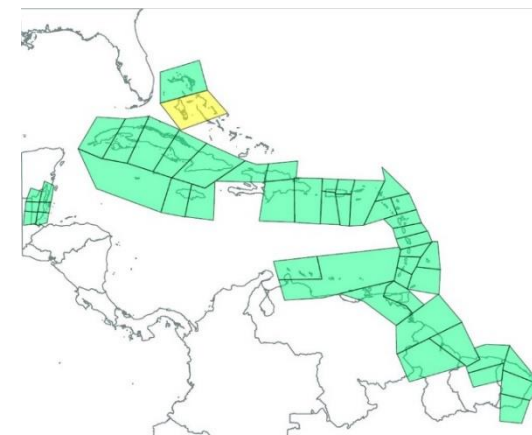
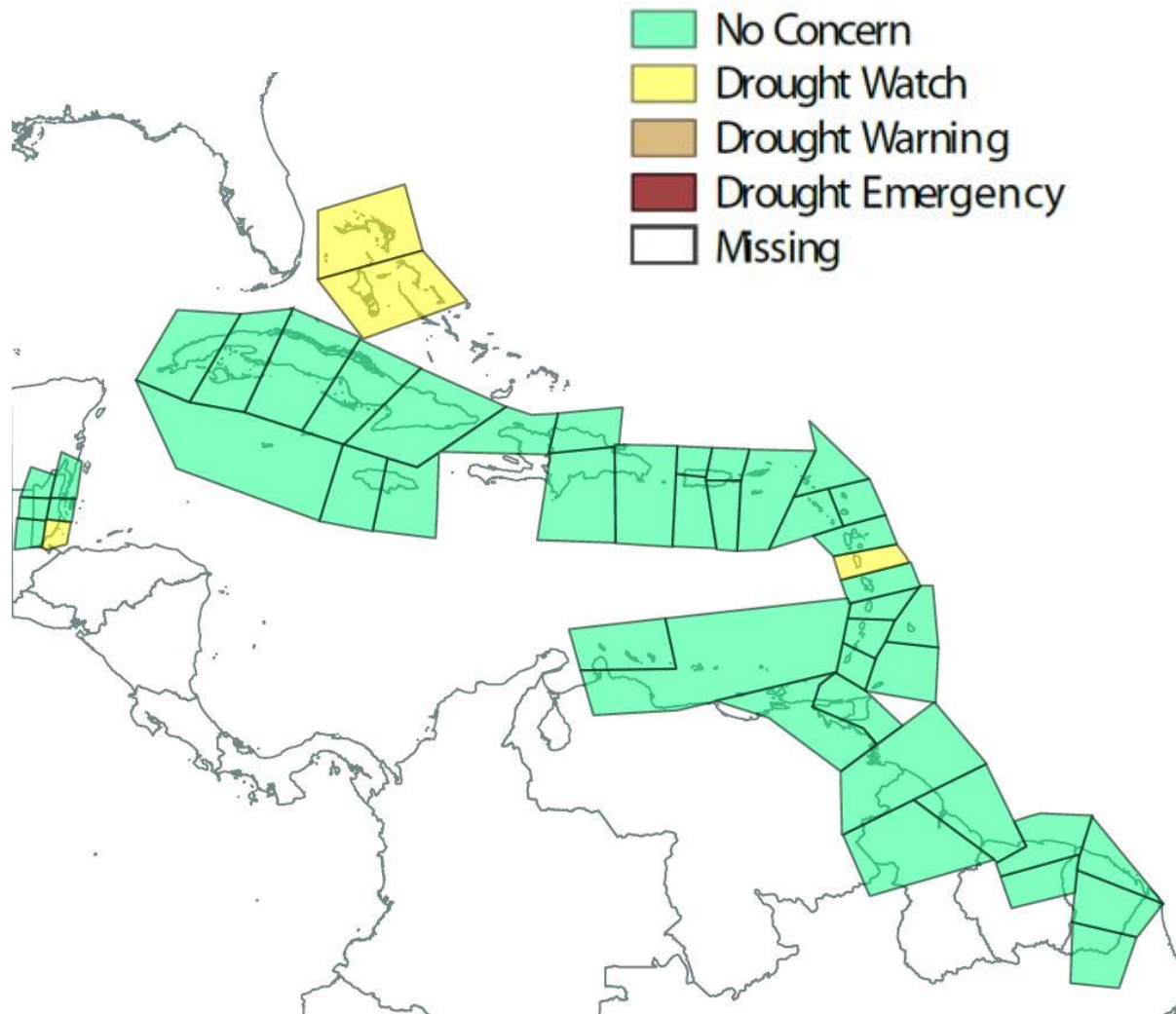
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What is the predicted short term drought concern by the end of November 2021?

Current update (August 2021):

- We are currently in the wet season.
- A **drought watch** should be considered for The Bahamas, southeast Belize and Dominica.



Previous update (July): short term drought alert levels at the end of October 2021

Short term drought alert levels at the end of November 2021

(updated August 2021 – based on a 6-month SPI for June to November 2021)

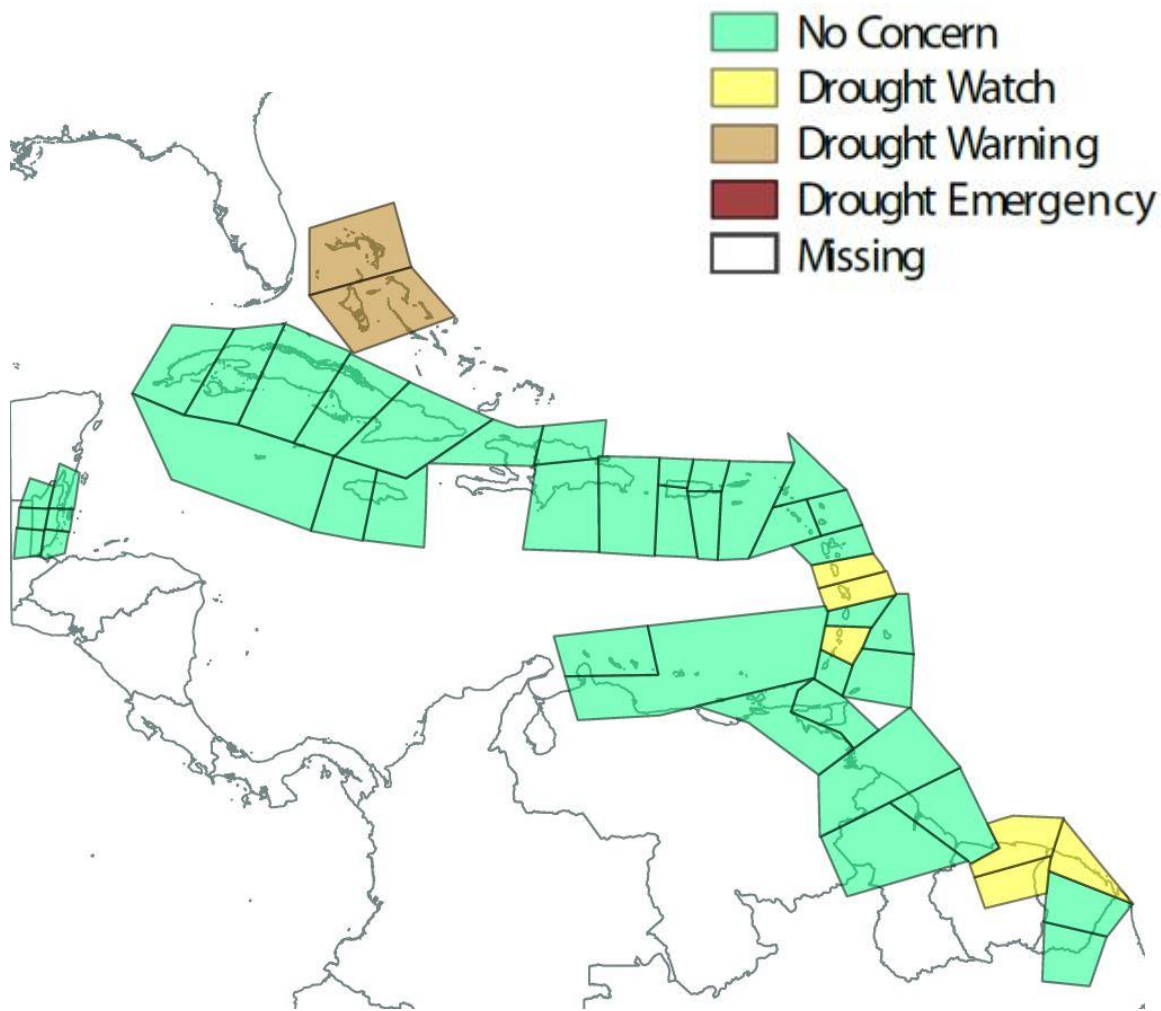
caricof@cimh.edu.bb

For climate information specific to your country, please consult with your national meteorological service. *CariCOF outlooks speak to recent and expected climate trends across the Caribbean in general.*

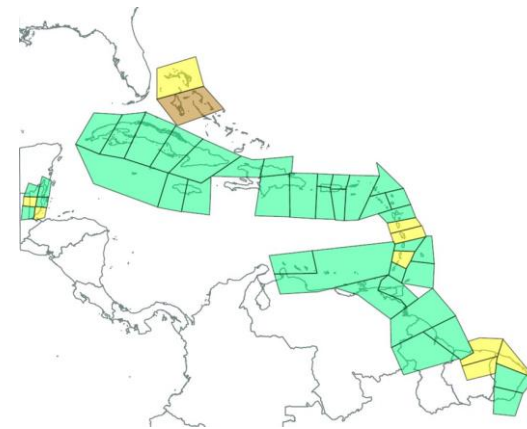


CARICOF
CARIBBEAN CLIMATE OUTLOOK FORUM

What is the predicted long term drought concern at the end of November 2021?



- This 12-month SPI-based drought outlook uses observations through July 2021, with potential impacts on large surface water reservoirs and groundwater. In general, impacts are expected if the 12-month SPI is ≤ -0.8 (*moderately dry or worse* – ref.: CDPMN).
- A **drought warning** should be considered for The Bahamas.
- A **drought watch** should be considered for Dominica, coastal French Guiana, Martinique, St. Vincent and parts of Suriname.



Previous update (July): long term drought alert levels by the end of Nov 2021

Long term drought alert levels at the end of November 2021

(updated August 2021 – based on a 12-month SPI for Dec 2020 to Nov 2021)

For climate information specific to your country, please consult with your national meteorological service. CariCOF outlooks speak to recent and expected climate trends across the Caribbean in general.

Drought outlook – shorter-/longer-term concern?

- Current drought situation (up to the end of June 2021): *(more information [here](#))*
 - Severe (or worse) short term drought has developed in Antigua, the northwestern Bahamas and northwest Martinique.
 - Severe long term drought has developed in northwest Martinique and St. Croix.
- Shorter term drought situation (by the end of November 2021):
 - Shorter term drought might possibly develop or continue in the northern Bahamas, southeast Belize, and Dominica.
- Long term drought situation (by the end of November 2021):
 - Long term drought is evolving in The Bahamas.
 - Long term drought might possibly develop or continue in Dominica, coastal French Guiana, Martinique, St. Vincent and parts of Suriname.
 - Areas ending up in long term drought by the end of November may experience lower than usual water levels in large reservoirs, large rivers and groundwater, which would become a concern for the 2021-'22 dry season.

** We advise all stakeholders to keep monitoring drought and look for our monthly updates.**

**CONTINUE TO MONITOR &
CONSERVE WATER !!**

ALERT LEVEL	MEANING	ACTION LEVEL
NO CONCERN	No drought concern	<ul style="list-style-type: none"> ✓ monitor resources ✓ update and ratify management plans ✓ public awareness campaigns ✓ upgrade infrastructure
DROUGHT WATCH	Drought possible	<ul style="list-style-type: none"> ✓ keep updated ✓ protect resources and conserve water ✓ implement management plans ✓ response training ✓ monitor and repair infrastructure
DROUGHT WARNING	Drought evolving	<ul style="list-style-type: none"> ✓ protect resources ✓ conserve and recycle water ✓ implement management plans ✓ release public service announcements ✓ last minute infrastructural repairs and upgrades ✓ report impacts
DROUGHT EMERGENCY	Drought of immediate concern	<ul style="list-style-type: none"> ✓ release public service announcements ✓ implement management and response plans ✓ enforce water restrictions and recycling ✓ enforce resource protection ✓ repair infrastructure ✓ report impacts

THRESHOLDS

Drought	
Alert Levels	Probabilities
No Concern	< 33.3333
Drought Watch	33.3334 – 50
Drought Warning	50 – 83.3333
Drought Emergency	≥ 83.3334

ROC	
Discrimination	Thresholds
No	< 0.5
Poor	0.5 - 0.6
Moderate	0.6 – 0.7
Fair	0.7 -0.8
Good	0.8 – 0.95
Very Good	> 0.95

Goodness Index	
Skill	Thresholds
Negative Skill	< 0
Very Limited	0 – 0.1
Limited	0.1 – 0.2
Moderate	0.2 – 0.25
Fair	0.25 -0.3
Good	> 0.3



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