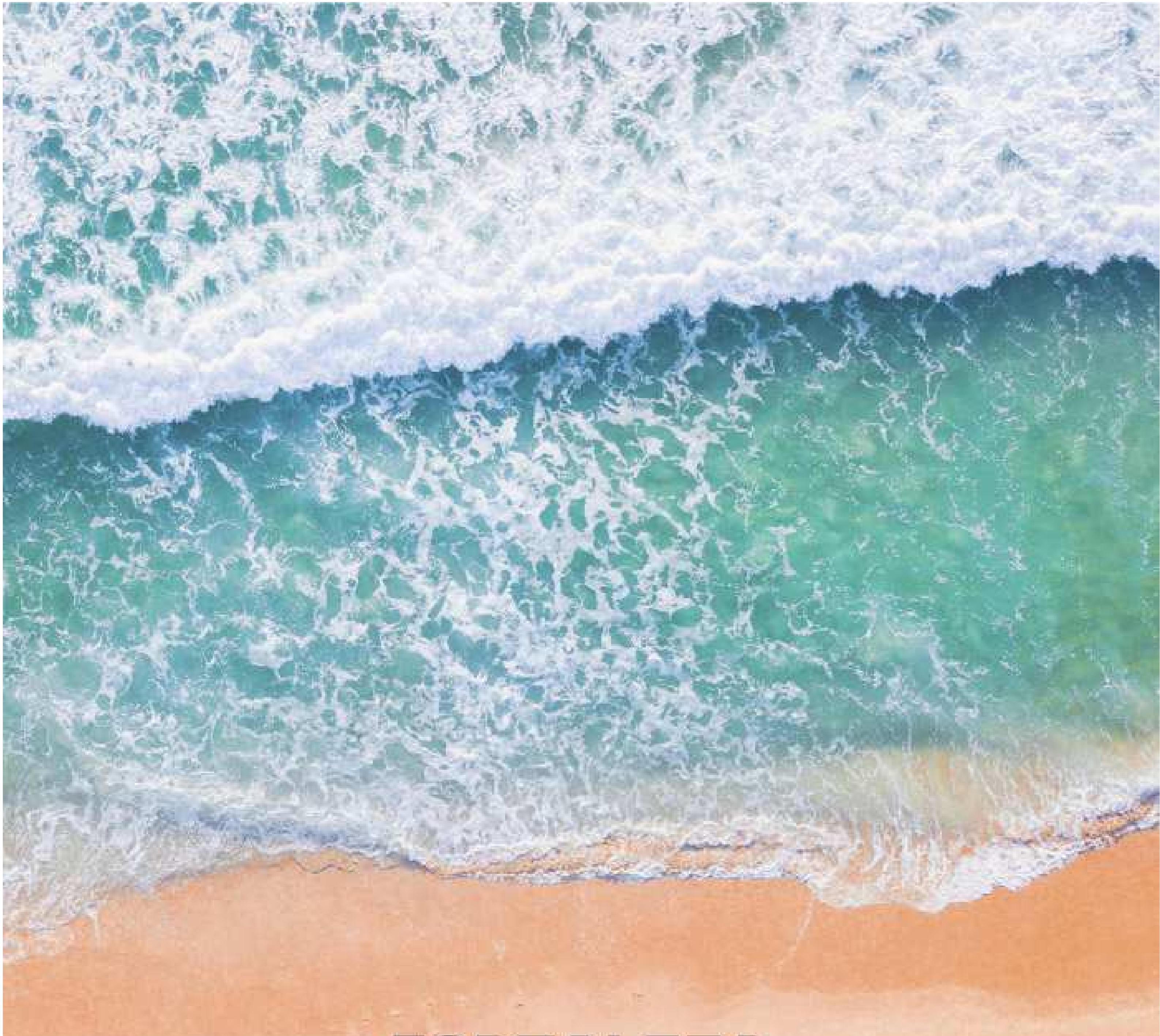

FORTALEZA DESALINATION PLANT

ELECTRICAL DEMAND AND SUPPLY STUDY

SUMMARY

LIST OF TABLES

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Presentation

This material corresponds to the review of Study 5 – Electrical Power Supply and Demand, originally delivered by GS Inima Ltd., the leading company authorized to develop this and the other 14 (fourteen) studies elaborated in the scope of the Public Notice for the Expression of Interest Procedure – PMI 01/2017/CAGECE, whose objective was the Elaboration of Studies for a Sea Water Desalination Plant, for the Fortaleza Metropolitan Region with capacity for 1 m^3/s.

The objective of this report is to present an analysis of power demand, electricity costs, supply viability and other relevant themes for the electrical power supply for the Desalination Plant currently studied

This report is divided in 08 (eight) chapters, with Chapter 01 (one) – The Electrical System, representing the main characteristics of the electrical system to be implemented in the Desalination Plant. Chapter 02 (two) – Relationship between Expected Loads and Demand, the relation of loads extracted in Study 4 – Project Draft and the power demand in kVA to be considered for the 60kV Substation calculation are presented; in Chapter 03 (three) – Technical Viability Assessment, the works to be performed in the power distribution company system to enable the Desalination Plant are detailed, in accordance with the aforementioned Technical Viability Assessment. In Chapter 04 (four) – Installation Costs, the electrical installation costs for the Substation and other buildings presented in the previous chapter are described. In Chapter 05 (five) – Electricity Costs, the power costs as a Captive, Distributed Generation and Free Power consumer are calculated. Chapter 06 – Conclusion, the conclusion of the best manner to obtain energy is presented. Chapter 07 presents the Attachments and Chapter 8 presents the teams responsible for reviewing, complementing and preparing this Reference Project.

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1. The Electrical System

1.1. Desalination Plant Substation

The Desalination Plant shall obtain its energy supply through a 15 MVA main transformer substation, in a 69kV voltage, that will be lowered to the 13,8 – 6,6 kV level.

A distribution station shall be installed in a medium voltage single bus, from which the voltage transformers will be fed. The transformation centers and electrical equipment shall be planned in the most efficient manner possible, in order to minimize costs with low-voltage material.

An access road shall be built for substation entrance. Its perimeter shall be surrounded by a fence to prevent the access of any outsider into the building site during construction, and later, the facilities. The substation shall be located within its sector in the Desalination Plant.

1.2. Installation Characteristics

The facility shall be prepared to operate with an overall power factor greater than 0,98. For this purpose, a reactive power compensation system will be installed through a self- regulating capacitor bank.

The electrical system frequency is 60 Hz

The following voltage levels will be established for power installations:

✓ Main Substation: High Tension Feeding, 69 kV, three phases.
✓ Medium tension distribution: between 13.8 kV and 6.6 kV, three-phase system, four wires.
✓ Low tension distribution: performed at 380/220 V, with a three-phase system, four or five wires (depending on equipment), with TT grounding system. Installation must comply with IEC 60364, considering that installation will take place in a humid location, as well as Brazilian regulation for electrical installations.
✓ Low and medium voltage control. The voltage level for the control circuits and control of medium voltage cells will be 125 VCC, by battery charger / rectifier.

The requirements for the Harmonic Current Distortion and voltage injected in the network, indicated in IEEE-Std 519-1992 Regulation, and current Brazilian standards shall be met throughout the entire system operating range. The project shall include the equipment necessary for harmonic mitigation.

1.3. Transformers

Transformer capacity shall be calculated without considering the installation of capacitors to improve their performance, but by the level of harmonics they can handle.

Transformer reserve margin shall be of at least 20% on maximum simultaneous demand in normal operation.

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Transformers shall be designed in accordance with IEC 76, IEC 726 or ANSI C57.12 standards. Noise levels shall conform to what is provided in the IEC 551 standard.

Transformers with capacity greater than 4000 kVA will be the oil cooled type; those with lesser or equal capacity shall be the hermetic, dry or oil-filled type (for capacity less than 2500 kVA).

All transformers will be three phase, 60 Hz, Dyn11 connection group. They are suitable for indoor or outdoor operation in saline and tropical environments, providing continuous service at full load.

They shall have 05 (five) voltage regulation sockets covered on the higher voltage side (± 2.5%; ± 5%). Transformers with low voltage output shall have no-load tap changes.

1.4. Other Systems

The following electrical systems shall be included:

- ✓ Medium voltage cells
- ✓ Engine control centers
- ✓ Engines
- ✓ Frequency changers (*Variadores de frequência*)
- ✓ Earthing system
- ✓ Condenser Batteries
- ✓ Direct Current System
- ✓ Safe Direct Current Stimulator System
- ✓ Emergency power system
- ✓ Indoor and outdoor lighting
- ✓ Power sockets
- ✓ Cables
- ✓ Trays and conduits

1.5. Control System

The Process Control System shall work through a Distributed Control System (DCS), in which there will be mixed signal concentration cabinets, with I/O boards distributed throughout the desalination plant, two PCUs with true redundancy, the workstations, associated software and the communication networks between the different elements.

The equipment must meet all requirements in IEC 61000-4-2, 61000-4-3, and 61000-4-4 electromagnetic compatibility standards.

The proposed supervision and control system consist of the following levels of control:

- ✓ Level zero, or data acquisition and local control level. This level would correspond to instrumentation and field control.
- ✓ First level or sequential control, that corresponds to the plant controllers (PLCs). Its functions are:

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- Data acquisition (analysis of analog variables and equipment status);
- Events and alarms creator (depending on process inputs and measured analog variables);
- Surveillance of interlocks and operation sequences (generating alarms in non-compatible situations);
- Start/stop, open/close equipment, with interlock surveillance. These commands can be executed according to the PLC's internal program or depending on a central supervision system order.
- Control adjustment loops

This level works in an autonomous manner, that is, even without communication, making its own programmed decisions.
The remaining zone controllers would be installed as close as possible to the signal transmission elements. The central controller and the periphery of the distributed zone shall communicate via Ethernet, through a fiber optic ring network.
✓ The Second level, or SUPERVISION, is performed in the control room on supervision PCs, where supervisory software is located in the Windows operating system. From this level on, one can:

- View all field elements (status, analog values, etc.);
- View historical data (trends, alarms, etc.);
- Data changes, slogans or process parameters;
- Make miscellaneous request to field staff
- Create reports
- Access equipment and information systems (electrical diagrams, incident report sheets, etc.), through a link to the management application.

The facility will have its own control room, where the operating and engineering stations and servers will be installed.

In the Operation and Engineering stations, a human-machine interface (HMI) shall be made available. It was created based on specific programs for this purpose, for data visualization, commands, alarms, process control, events, installation conservation, elaboration of operation reports and maintenance.

The screens will be interactive, menu-based and hierarchically structured, presenting the overall Plant level until and to the amount of points.

Two (02) redundant servers will be included for real time data and history data storage, as well as 01 (one) operating station and 01 (one) engineering station. Each workstation shall consist of 02 (two) 27" monitors, an optical mouse, keyboard and PC with the latest technology high performance hardware and Windows operating system. Communications will be made via Industrial Ethernet.

The supply shall include all software and licenses required for the proper functioning of each workstation, including: Windows operating system, Microsoft Office (Word, Excel and Access), antivirus programs, etc.

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Ethernet is planned for the process communication network between PLC controllers and operating stations, with fiber optic cables as support. Data transmission shall be done by baseband, with 15 Mbits per second minimum speed. The network protocol will be TCP / IP.

Communication between the main controller and remote I/O enclosures shall happen via PROFIBUS Fiber Optic Fieldbus (DP and PA) or Foundation Fieldbus. The fieldbus will allow transmission speeds of up to 12 Mbit per second.

1.6. Communication Network

There will be a telephone exchange and an internal telephone network that shall allow communication between the different rooms and areas of the desalination plant. Internal phones shall be installed in the control room, offices, etc. Considering the noise level of each area, the respective ringtone will be louder. Considering the extension of the embedded facility, several phones shall be distributed along to facilitate communication.

1.7. Video Surveillance Network

A perimeter video surveillance network with recording capacity (DVR) shall be installed on the Desalination Plant premises and its interior. The main access door shall also have an intercom with a control room and automatic door.

The installation of a perimeter security system on the outside to prevents intruders is also included.

2. Relationship Between Expected Loads and Demand

In accordance with the Fortaleza desalination system description, many electrical equipment items shall be required. The equipment is presented on the Table below:

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Table 1- List of Expected Loads

Item	Load Description	Loads		Unit Power (KW)	Total Power (kW)	FP	Total Power (kVA)
		Operation	CV	Consumed			
1	Raw Water Pumps	4	750	552	2208	0,88	2509,09
2	Treated Water Pumps	4	400	294,4	1177,6	0,88	1338,18
3	APB Feed Booster Pump	4	376	276,82	1107,28	0,88	1258,27
4	High Pressure Motor Pump	4	2275	1.674,62	6698,48	0,9	7442,76
5	Recirculation Pump	4	373	274,29	1097,16	0,88	1246,77
6	Filter Backwash Motor Pump	2	209	153,61	307,22	0,87	353,13
7	Filter Backwashing Blower	2	66	48,36	96,72	0,86	112,47
8	Chemical Cleaning Pump	2	180	132,13	264,26	0,87	303,75
9	Chemical Cleaning Agitating Pump	2	18	12,94	25,88	0,83	31,18
10	Displacement Pump	1	180	132,13	132,13	0,87	151,87
11	Hydrocompressor	1	4	2,66	2,66	0,83	3,20
12	Pretreatment Dosing Pump	10	1	0,37	3,7	0,77	4,81
13	Posttreatment Dosing Pump	6	1	0,37	2,22	0,77	2,88
14	Other Dosing Pumps	4	1	0,37	1,48	0,77	1,92
15	Dosing Pump Positioner	20	1	0,55	11	0,79	13,92
16	Powder Dosing Screw Conveyor	1	0	0	0	0,77	0,00
17	Chemical Cleaning Neutralizing Pump	2	150	110,62	221,24	0,87	254,30
18	Agitators and Transport	1	22	16,33	16,33	0,88	18,56
19	Electrical Resistance Heating for Chemical Cleaning	1	282	207,85	207,85	0,88	236,19
20	Overhead Crane	1	13	9,5	9,5	0,83	11,45
21	Motor Valves	28	3	1,85	51,8	0,87	59,54
22	Suction Blower	2	1	1,1	2,2	0,81	2,72
23	Control Panel and Electric Valves	1	-	45	45	0,88	51,14
24	Lighting	1	-	30	30	0,95	31,58
25	Air conditioning	1	-	70	70	0,8	87,50
Total				**3495,87**	**13789,71**		**15527,17**
Monthly Consumption (MWh)					**8640,00**		
Off-peak Monthly Consumption (MWh)					**7560,00**		
Peak Monthly Consumption (MWh)					**1080,00**		
Calculated Demand (kW)					**12000**		
Contracted Demand (kW)					**14000**		

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3. Technical Viability Assessment

Given that Praia do Futuro became the option of choice, a Technical Viability Assessment (*AVT – Avaliação de Viabilidade Técnica*) was requested by ENEL for this location.

The *AVT* pointed the need for supporting works, listed below:

✓ HIGH VOLTAGE AIR CIRCUIT CONSTRUCTION - in Elgin 315 mm² - CAL cable, approximately 3 km long, from the Papicu substation to the customer substation.

✓ 72,5 KV LINE OUTPUT MODULE INSTALLATION

✓ MODULE 72.5 KV SWITCHGEAR INSTALLATION - at the Papicu substation with automatic disjunction and automation.

The respective document is attached.

4. Installation Costs

The installation and connection costs for the Desalination Plant feeding substation consist of the supporting works, connection to the electrical system and construction of the substation itself.

✓ Approximate cost of a 15 MVA substation → R$ 8,000,000.00.

✓ Cost of connection to the electrical system (According to AVT ENEL):

- HIGH-VOLTAGE AIR CIRCUIT CONSTRUCTION in Elgin 315mm2 - CAL cable, with approximate length of 3km → R$ 1,950,000.00
- MODULE 72.5 KV SWITCHGEAR INSTALLATION at SE PAP with automatic disjunction and automation → R$ 910,000.00

Therefore, the ESTIMATED costs for substation installation will be approximately R$ 10.860.000,00.

Therefore, the ESTIMATED costs for the installation of the substation will be approximately R $ 10,860,000.00., Which was updated based on the INCC, becoming R$ 11,007,696.00.

Network reinforcement installation may be performed by the contractor or directly by ENEL-CE, with cost-effectiveness analysis when deciding which company will perform the services.

5. Electricity Costs

The Desalination Plant will be classified as a subgroup A3 consumer (high voltage serviced consumer, around 69kV). Estimated consumption is approximately 8,640 MWh, with a contracted demand of 14,000 kW.

5.1. Captive Consumer

This tariff modality requires a specific contract with the power distribution company, in which both

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the demand amount expected by the consumer in peak hours (peak contracted demand) and the value expected outside of peak hours (contracted off-peak demand) are agreed upon. The electricity bill for these consumers is composed by the sum of installments referring to consumption, demand and overriding (if any). Due to the installed capacity, the Desalination Plant will be framed in the blue hourly-seasonal tariff which can be seen in the Table below.

Table 2 – Hourly and Seasonal Blue Tariff with ICMS PIS/COFINS. ENEL Table Aug/19

BLUE HOURLY-SEASONAL TARIFF			
SUBGROUP/VOLTAGE LEVEL			
A3 - 69,0 kV (Water, Sewage and Sanitation)			
DEMAND			
kW Pt	kW TPF	Overuse TP	Overuse TPF
16,08	8,06	32,17	16,12
GREEN			
kWh Pt	kWh TPF	KWh (hr)	
0,5863	0,3681	0	
YELLOW			
kWh Pt	kWh TPF	KWh (hr)	
0,6092	0,3910	0	
RED			
kWh Pt	kWh TPF	KWh (hr)	
0,6474	0,4292	0	

Considering the electricity costs and demand amounts previously presented, we have arrived at the values displayed in the following Table:

Table 3 – Captive Energy Market Costs

RESULT SUMMARY WITH TAXES	
Green Band	
Captive Monthly Average (R$)	3.754.088,56
Yellow Band	
Captive Monthly Average (R$)	3.951.981,37
Red Band	
Captive Monthly Average (R$)	4.281.802,71

5.2. Distributed Generation Usage Viability

Distributed generation is considered any electricity production from power distribution companies, permission bearing or authorized agents directly connected to the buyer's electrical distribution system. According to ANEEL Normative Resolution 482/2012, responsible for constituting the regulatory conditions for the insertion of distributed generation in the Brazilian energy matrix, the following definitions are presented:

Micro distributed generation: Renewable power generation or qualified cogeneration systems connected to the grid with power up to 75 kW;

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Mini distributed generation: Renewable power generation or qualified cogeneration systems connected to the grid with power exceeding 75 kW, but inferior to 5 MW.

Under RN 482, the generating consumer, after deducting his own consumption, receives a credit to his account for the positive balance of energy generated and inserted in the grid (energy compensation system).

Whenever this positive balance exists, the consumer receives an energy credit (in kWh) on the next bill and will have up to 60 months to use it. However, consumers cannot market the excess amount of energy generated.

The available power grid shall be used as a backup when locally generated power is not sufficient to meet the consumer-generator demand, which is often the case for the use of intermittent power sources, such as solar or wind power.

To calculate the feasibility of using distributed generation, a 5 MWp (distributed generation limit) photovoltaic power plant will be chosen, along with the following information:

- ✓ Annual energy generation per kWp * = 1658 kWh / kWp * year;
- ✓ Average cost of a large distributed generation solar plant = R$ 4000 / kWp;
- ✓ Annual maintenance cost of a large distributed generation solar plant = 1.5% / year;
- ✓ Loss of power generation efficiency over time (according to solar generator data) = 0.7% / year
- ✓ Useful plant life = 35 years.

Therefore, we shall have the following total expenses, amounting to the present value:

- ✓ Plant amount = R$ 20.000.000,00;
- ✓ Total maintenance costs throughout useful plant life = R$ 10.500.000,00.

With this information in hand, it is possible to obtain a general kWh value for the generation itself distributed over time. This value shall be approximately R$ 0.15 / kWh, which would be ideal for the system, but since there is no possibility of self generation for the entire installation, distributed generation would only be able to supply 8% of energy requirements. It also requires a high initial investment and an area of approximately 40,000 m².

Even with the division of the system into more 5 MWp plants installed elsewhere, it would still be necessary to consider electrical grid and connection costs.

Since system limitation lies in the power and not in the generation level or project cost, we can conclude that we shall reach the same limitation for wind generation, making distributed generation impossible.

5.3. Free Energy Market Consumption Viability

Free consumers purchase energy directly from generators or traders, through bilateral contracts with

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freely negotiated conditions, such as price, term, volume, etc. Each consumer unit pays a distribution service bill to the local power utility (a regulated tariff) and one or more energy purchase bills (negotiated contract price).

For Free Energy Market feasibility analysis, a preliminary study comparing free and captive tariffs was performed for year 2019. It is emphasized that free market prices change daily.

Table 4 - Free Power Market Energy Cost Calculation

CONSUMPTION (CONTRACT)	MWh	Tariff	Amount
	8640,00	R$ 246,58	R$ 2.130.410,96

TUSD (Tariff over Use of Distribution Services)		Tariff	Amount
Peak Demand – kW	14000	R$ 14,98	R$ 209.721,73
Off-peak Demand – kW	14000	R$ 7,51	R$ 105.123,67
Peak Charges – MWh	864,00	R$ 39,56	R$ 34.179,01
Off-peak Charges – MWh	7776,00	R$ 39,56	R$ 307.611,10
TOTAL			**R$ 656.635,51**
Other Expenses *CCEE* (Electricity Commerce Chamber)			R$ 41.712,83
Management Costs			R$ 3.122,10
Total monthly electricity cost (CONSUMPTION + TUSD)			**R$ 2.831.881,40**

Below is a comparative table that summarizes the free electricity market use opportunity, also considering cost variations from green to red band:

Table 5 – Comparison Between Free x Captive Energy Markets

RESULT SUMMARY WITH TAXES	
Green Band	
Captive Market Monthly Average (R$)	3.754.088,56
Free Market Monthly Average (R$)	2.831.881,40
Monthly Average Saving Difference (R$)	922.207,16
Savings (%)	0,245654076
Yellow Band	
Captive Market Monthly Average (R$)	3.951.981,37
Free Market Monthly Average (R$)	2.831.881,40
Monthly Average Saving Difference (R$)	1.120.099,96
Savings (%)	0,283427441
Red Band	
Captive Market Monthly Average (R$)	4.281.802,71
Free Market Monthly Average (R$)	2.831.881,40
Monthly Average Saving Difference (R$)	1.449.921,31
Savings (%)	0,338624035

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6. Conclusion (Costs Including Electricity)

After analyzing the alternatives, it was observed that the free power market is the cheapest option to reduce electricity costs, leading to savings that ranged from 25% to 35% per month.

Despite being the most affordable fare option, before choosing this model, a plant operation profile analysis should be made to confirm its feasibility.

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7. Attachments

7.1. Technical Viability Assessment

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coelce Companhia Energética do Ceará	*ATESTADO DE VIABILIDADE TÉCNICA DE FORNECIMENTO DE ENERGIA ELÉTRICA*	Nº AVT: **594/2019** Data: 14/09/2019 Página: 1/2

IDENTIFICAÇÃO DO SOLICITANTE

Nome: COMPANHIA DE AGUA E ESGOTO DO CEARA *Fone:* 31011789

Endereço: RUA RAIMUNDO ESTEVES, S/N *Município:* FORTALEZA

IDENTIFICAÇÃO DO EMPREENDIMENTO

Nome:	DESSALINIZADORA
Localização:	RUA RAIMUNDO ESTEVES, S/N
Ramo de Atividade:	CAPTACAO, TRATAMENTO E DISTRIBUICAO DE AGUA
Capacidade Instalada (kVA):	15000
Demanda Prevista (kW):	14000
Extensão de rede MT (km):	0
Extensão de rede BT (km):	0
Regime de Operação:	Tipico
Inicio de Operação:	01/07/2022
Documento apresentado:	Oficio/Carta

SISTEMA ELÉTRICO RESPONSÁVEL PELO ATENDIMENTO

Subestação: PAPICU

Circuito: 01F4

Ponto de Conexão: LIGAÇÃO NOVA

Código Estrutura *Anterior:* 86E0386 *Posterior:* 60E1764

RESULTADO DA AVALIAÇÃO TÉCNICA:

Necessidade de Obras de Suporte: **SIM** (ver página 2/2)

OBSERVAÇÕES

1) A extensão da linha de AT é aproximada, devendo ser confirmada o total necessário após o projeto executivo. 2) A subestação do cliente deverá constar em seu projeto a inclusão de traformador de força com LTC (Tap com comutação sob carga) em 69,0 kV.

VALIDADE: **Este AVT é valido até 08/03/2020**

Elaborado:	*Visto:*	*Aprovo:*
Anibal Queiroz Braga	B Santanelli	
ANIBAL QUEIROZ BRAGA Engenheiro	BRUNO BARBOSA SANTANELLI Engenheiro	PAULO PETRONIO G L DE F VERAS Chefe Departamento

IDENTIFICAÇÃO DO SOLICITANTE

Nome: COMPANHIA DE AGUA E ESGOTO DO CEARA *Fone:* 31011789

Endereço: RUA RAIMUNDO ESTEVES, S/N *Município:* FORTALEZA

OBRAS DE SUPORTE NECESSÁRIAS

1. Obras para Melhoria da Qualidade do Fornecimento

2. Obras diretamente vinculadas ao Atendimento da Carga da Unidade Consumidora

CONSTRUÇÃO CIRCUITO ALTA TENSÃO AÉREO

em cabo Greeley 500 mm² - CAL com aproximadamente 3 km de extensão da SED Papicu até a subestação do Cliente.

INSTALAÇÃO MÓDULO SAÍDA DE LINHA 72,5KV

na SED Papicu com disjunçãoi automática

Elaborado:	*Visto:*	*Aprovo:*
Anibal Queiroz Braga	B Santanelli	
ANIBAL QUEIROZ BRAGA Engenheiro	BRUNO BARBOSA SANTANELLI Engenheiro	PAULO PETRONIO G L DE F VERAS Chefe Departamento

7.2. Possible High Voltage Feeder Referral

AVT requests the construction of a high voltage circuit from the Papicu substation to the plant. Below is a picture with the possible transmission line routing from the Power Distribution Company that will supply the Plant's energy. It must be emphasized that this is only an alternative. The definitive referral will be determined by ENEL.

Picture 1 – Transmission Line Routing

8. Participating Team

8.1. By CAGECE

The table below lists the Cagece team participating in the review and complementation of this study.

CAGECE	
Electrical engineering	Amanda Rodrigues Rangel
Electrical engineering	Raul Tigre de Arruda Leitão
Overall Coordination	Silvano Porto Pereira

8.2. By the Authorized Company

The table below lists the team indicated by the Authorized Company as a participant in the execution of this study.

GS INIMA	
General Coordinator	Eduardo Berrettini
Electrical Engineering	Raul Castaño
Electrical Engineering	Carlos Carretero
Automation Engineer	Albert Vazquez
Mechanical Engineer	Francisco Díez
Economist	Fernando Schlieper
Lawyer	Rodrigo de Pinho Bertoccellli
Designer	Alberto Barceló
Designer	Manuel Rodriguez
Designer	Lola López
Responsible for the process	David Gonzales
Responsible for pre-treatment	Almudena Aparicio
Coastal and Maritime Works Manager	Alberto Casado
Responsible for Submarine Outfall	Enrique de la Plata
Responsible for SQMA	Cristina San Miguel Avedillo
Responsible for Energy Efficiency	Luis Miguel Garcia
Responsible for Marine Hydrodynamics	Mario Sanchez
Technical Operational Studies Coordinator	Adriana Lucas Alcaraz Lopez
Process Engineer	Anna Gironés
Pipe Specialist	Victor Juan
FUJITA ENGENHARIA	
Sector Coordinator	Paulo Ayrton Cavalcante Araújo
BF CAPITAL	
CFO	Renato José Silveira Lins Sucupira
CFO	Jacy do Prado Barbosa

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