ANALYSIS AND DESIGN OF DATA CENTER ENVIRONMENTAL DESIGN IN PT. XYZ USING TIA-942 STANDARD WITH PPDIOO LIFE-CYCLE APPROACH

ANALISIS DAN PERANCANGAN *ENVIRONMENTAL DESIGN DATA CENTER* DI PT. XYZ DENGAN STANDAR TIA-942 DAN METODE PPDIOO *LIFE-CYCLE APPROACH*

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Abstract

The object of this research is an energy and power supply company named PT. Medco Energi. In this company, data center plays a role to help the business in the daily operations. With the rapid increase in the capacity and size of data center, there is a continuous increase in the demand for energy consumption, and also a lot of dangerous contaminants are threatening the environment. To overcome this problem, this research focuses on analyzing the current condition of data center and designing an improvement for the data center in PT. Medco Energi in terms of environmental design so that the design of the data center meets the criteria for environmental consideration in accordance with existing international standards and increase the value of the company. The standard that is used in this research is Telecommunications Industry Association (TIA) responded with the TIA-942. This research used PPDIOO life-cycle as the methodology to prepare, plan and design the recommendation for environmental design of data center. The result of this research is a recommendation for improvement to PT. Medco Energi to help reducing energy costs and build an environmentally friendly data center design by implementing the parameters of environmental design in TIA-942 and achieving tier IV.

Keywords: Data Center, TIA-942, Environmental Design, PPDIOO Lifecycle

Abstrak

Objek penelitian ini adalah perusahaan penyedia energi dan listrik bernama PT. Medco Energi. Di perusahaan ini, pusat data berperan untuk membantu bisnis dalam operasi sehari-hari. Dengan peningkatan yang cepat dalam kapasitas dan ukuran pusat data, mangka permintaan konsumsi energi pada pusat data juga meningkat, dan juga banyaknya kontaminan berbahaya yang mengancam lingkungan. Untuk mengatasi masalah ini, penelitian ini berfokus pada menganalisis dan merancang perbaikan untuk pusat data saat ini di PT. Medco Energi dalam hal desain lingkungan sehingga desain pusat data memenuhi kriteria untuk pertimbangan lingkungan sesuai dengan standar internasional yang ada dan meningkatkan nilai perusahaan. Standar yang digunakan dalam penelitian ini adalah Telecommunications Industry Association (TIA)-942. Penelitian ini menggunakan siklus hidup PPDIOO sebagai metodologi untuk menyiapkan, merencanakan dan merancang rekomendasi untuk desain lingkungan pusat data. Hasil penelitian ini merupakan sebuah rekomendasi untuk perbaikan PT. Medco Energi untuk membantu mengurangi biaya energi dan membangun desain pusat data yang ramah lingkungan dengan menerapkan parameter desain lingkungan di TIA-942 dan mencapai tingkat IV.

Kata Kunci: Pusat Data, TIA-942, Desain Lingkungan, Siklus Hidup PPDIOO

1. Introduction

The data center is a facility used to place computer systems and other related components, such as telecommunications systems and data storage. Data center also helps business in the daily operation. Data centers can be categorized according to whether they serve the private domain or the public domain [1]. Data center provide capabilities of centralized storage, backups, management, networking and dissemination of data in which the mechanical, lighting, electrical and computing systems are designed for maximum energy efficiency and minimum environmental impact [2].

Among the crucial aspects that data center operators have to deal with is the energy consumption of both the IT infrastructure and their cooling systems. The priori knowledge of the expected consumption is very important not only in terms of cost but also in terms of operational continuity and reliability in the data center business [3]. About 45% of electrical energy is consumed by ICT equipment, which includes servers, storages, and networks. The other 55% of electrical energy is consumed by facilities, which include power distribution system, uninterruptible power supplies, chillers, computer room air conditioners, lights, and so on [4]. Not only the over consumption of power is threatening the environment, the workplace can also produce several contaminant substances that are harmful to both workers and the surrounding environment. The number of contaminants produced depends on the operational activities carried out in the workplace, as well as the physical and chemical properties of the contaminants [5].

To overcome this problem, it is necessary for data center to be standardized especially in terms of environmental design so that the formation of data center criteria is process efficient, energy efficient and environmentally friendly. Optimizing existing data center infrastructure to make it a green data center infrastructure is a vital step that can be taken to face those challenges. This can be achieved using one of the international standards governing data centers namely TIA-942. This standard has environmental considerations include, humidity levels, temperature operations, architecture, electricity and mechanical system specifications. It specifies in reducing the environmental impact when the data center is operating. It controls the contaminants, cooling system, power supply, vibration and the use of radio sources in data center.

This research discussed the data center in an energy and power supply company named PT. XYZ which located in Energy Building Jakarta. In 2009, the company used the company's Tier II Classification as standard for its data center design. In conducting the analysis and design of data center, the author used Tier IV in TIA-942 (2012) standard and PPDIOO Network Life-Cycle Approach method in determining the main needs needed by the object of research in its implementation.

2. Literature Review

2.1. Data Center

Data centers are typically centralized facilities in the form of a set of computer servers, networks, data storage, procedures and management that occur at certain standards. Data center is strategic because it shows the existence of valuable assets, namely data and information [6]. According to Data Center Fundamentals book by Cisco Press (2003)[7], data center has facilities to support a high concentration of server resources and network infrastructure for a 24-by-7 operation. The demands posed by these resources, coupled with the business criticality of the applications, create the need to address power capacity, cooling capacity, cabling, temperature and humidity controls, fire and smoke systems, physical security, rack space and raised floors.

2.2. Environmental Design

Environmental Design or designing for environment known as a perspective in which environmental aspects of an existing or new product, process or facility, design or redesign are optimized systematically and continuously for minimal adverse impact on the environment [8]. In TIA-942 environmental design, it covers contaminants, HVAC systems, radio sources restriction, backup batteries and vibration [9].

2.3. PPDIOO Life-cycle Approach

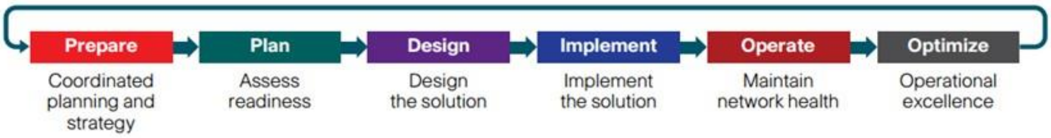

Figure 1. PPDIOO Life-cycle Approach [10]

PPDIOO is also called as Cisco Lifecycle Services. It is an analysis method to the development of computer network installations developed by Cisco on the material of Designing for Cisco Internetwork Solution (DESGN). The Cisco Lifecycle Services approach provides a coordinated sequence of activities in deploying and operating technologies and optimizing their performance helping company to prepare, plan, design, implement, operate and optimize [10].

3. Methodology

In this research, the PPDIOO method is used to support the stages during the process of this research. The final result of this research is a design recommendation for a data center environmental design in PT. XYZ. This research only implements three main stages from PPDIOO Life-cycle which are prepare, plan, and design.

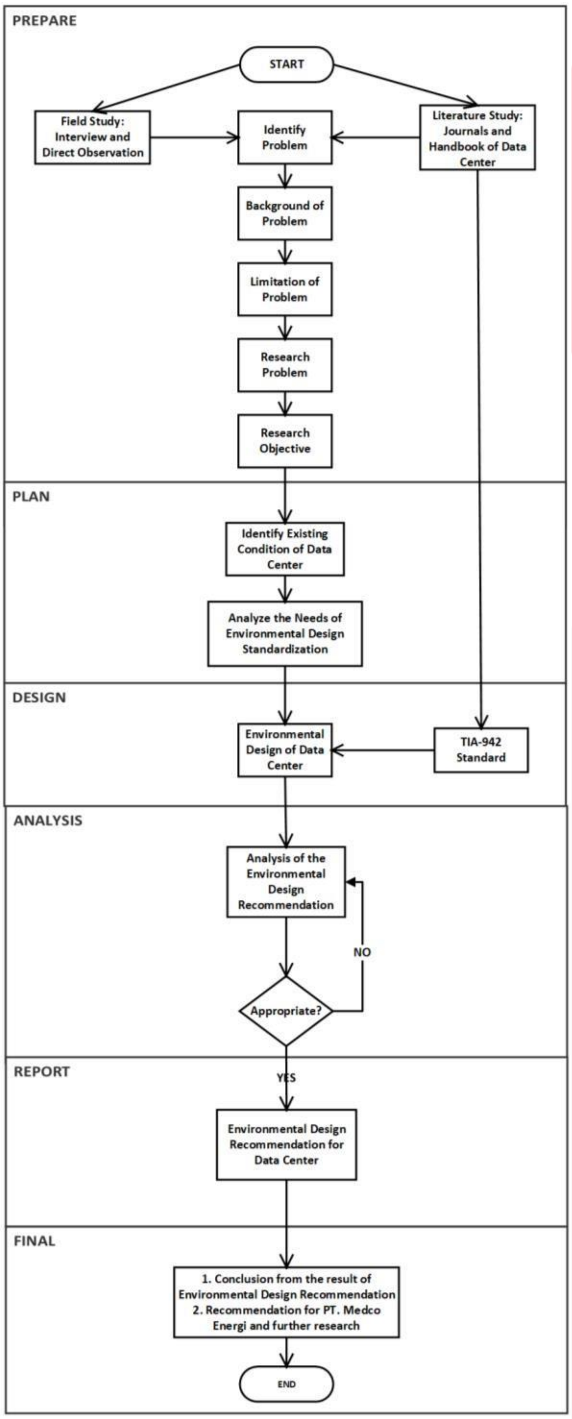

Figure 2. Systematics of Research

There are six stages that must be done, namely the prepare, the planning, the design, report, analysis and final stage. The explanation of each stage are as follows:

1. Prepare
   There are two preliminary studies conducted, namely literature studies and field studies. Literature studies are used to deepen the theory used through journals and books. Field studies are used to find the right solutions to the existing problems through interviews and direct observation with stakeholders in PT. XYZ.
2. Plan

At this stage, an analysis of the current conditions related to the environment at the data center in PT. XYZ will be adjusted to the TIA-942 standard so the results will be used to make a recommendation design for improvement of data center.

3. Design
   At this stage, a recommendation of data center environmental design will be designed. This design is based on the results of the analysis conducted in the planning stage, so it is expected to produce an environmental design that meets the requirements in TIA-942 standard.
4. Analysis
   At this stage, an analysis of the recommendation design that has been made whether it is already in accordance with the research objectives, business needs, and in accordance with the TIA-942 standard.
5. Report
   This phase consists of the proposed design recommendation for PT. XYZ.
6. Final
   This stage consists of conclusion and suggestions based on the results of research that has been done.

4. Analysis of Existing Condition

In PT. XYZ, there is an Information Services (IS) division. The division is responsible for managing information technology in the company to provide servers and infrastructure in a data center in order to provide a system for operational activities in the company. The data center was built by a vendor chosen by PT. XYZ.

PT. XYZ data center is operating for 24 hours every day with no downtime record at all since early 2008 with redundancy for multiple active power and cooling distribution path in every component. It is not vulnerable to any interferences since they already had a Disaster Recovery Center. They have installed raised floor 60x60m sized with piping installations inside. The power used comes from UPS and generator belong to the main building. A regular preventive maintenance will not disturb the availability of data center itself during the maintenance. The implementation of this data center required 6 months.

4.1. Data Center Floor Plan

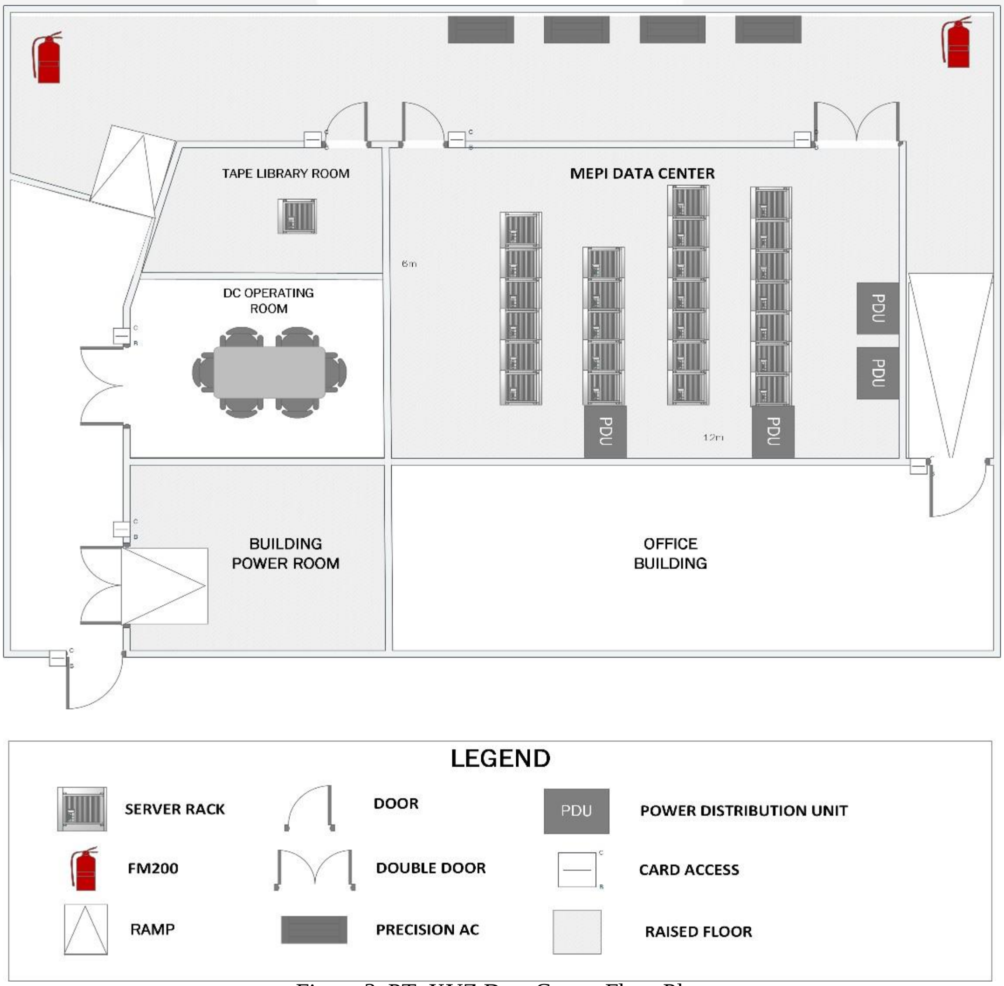

Figure 3. PT. XYZ Data Center Floor Plan

PT. XYZ data center has 3 main rooms:

1. Main data center room where all servers, storages and network equipment are placed in an area of 6x12m
2. Tape Library Room is a room for backup operator to retrieve tape library to off-site backup storage on daily basis.
3. Operating Room is a non-raised floor room for the data center operator to monitor the data center

4.2. Cooling Requirement

Based on the data center floorplan, the following Table 1 is cooling requirement in every rack using calculation of BTU. British Thermal Unit (BTU) is an energy measurement standard used to defined the amount of heat required to raise one pound of water one degree Farenheit [11]. One watt of electricity is equal to 3.41 BTU/h.

Table 1. Cooling Requirement in Computer Room

Rack	BTU/h
Rack 4-07	4603.5
Rack 4-06	11713.35
Rack 4-05	16538.5
Rack 4-04	13026.2
Rack 4-03	8286.3
Rack 4-02	12173.7
Rack 4-01	2301.75
Rack 3-07	1705
Rack 3-05	15686
Rack 3-04	22979.99
Rack 3-02	8975.12
Rack 3-01	6069.8
Rack 2-05	11559.9
Rack 2-04	1152.58
Rack 2-03	1036.64
Rack N6	9981.07
Rack N5	4023.8
Rack N4	13278.54
Rack N3	2781.88
Total (BTU/h)	**167873.62**
Total (kBTU/h)	**167.87**

The current condition of data center requires 167873.62 BTU/h for 108 devices stored in those racks running 24 hours every day inside the computer room.

4.3. Temperature and Humidity

Figure 4. PT. XYZ Precision AC Monitor

Based on the PT. XYZ Policy and Procedures regarding temperature and humidity in its data center, the temperature is set at 21 °C with a tolerance of ± 2 °C. The data center is conditioned to work at 50% humidity with a tolerance of ±5%. The infrastructure of cooling system utilization reports from the January, February and March are gathered. The utilization report from the late 3 months showed that PAC1 produced higher temperature than PAC2 and PAC2 worked more stable than PAC1. The range of temperature in main data center room from January, February and March is 19-24 °C and the range of humidity is 48-60%.

4.4. HVAC System

In PT. XYZ data center, they have four units of precision air conditioners from Liebert DS to cool the server room. Two active air conditioners and two backup air conditioners. The type of Liebert DS they used is 28-105kW (8-30 Tons) with downflow system. The precision ACs are placed in a separate room from the server room. PT. XYZ data center chose water-cooled for its cooling system. The cold air is distributed into the server room through the installed raised floor. The computer room has two active precision air conditioners and two backup precision air conditioners with capacity of 37.1 kW and 126.7 kBTU/h per unit. From that, the total capacity that the HVAC system can fulfil is 74.2 kW and 253.4 kBTU/h if both active ACs are turned on simultaneously.

4.5. Uninterruptible Power System, Batteries

PT. XYZ data center use the building-owned UPS and generator to drain power into their data center room. The UPS are stored in a separate room, managed by the building management team. The brand of the UPS is Liebert NX. The type of UPS they used is Liebert NX 160 kVA. Liebert NX is an on-line, double conversion, three phase UPS system that delivers complete, centralized power protection for mission-critical systems [12].

The battery used for power backup is VRLA battery from Sprinter with model number S12V500. It is designed for superior, high-rate performance in uninterruptible power supply (UPS) applications [13]. S12V500 has 12 voltage with 48.1 kg weight.

4.6. Contaminants Handling

Contamination of substances that can be found usually in the data center, PT. XYZ currently does not have a specific system to monitor and handle it. The handling of contaminants that have been carried out is limited to cleaning the data center area carried out by the ISS and the data center team every day.

5. Analysis and Design Recommendation

5.1. Cooling Requirement

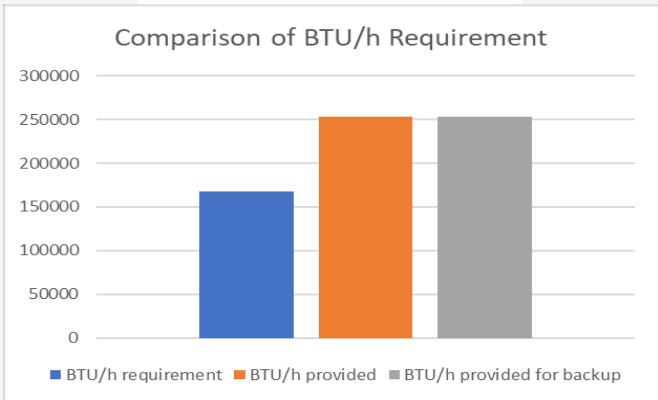

Figure 5. Comparison of Cooling Requirement in PT. XYZ

According to the result of analysis, if the ACs are turned on simultaneously, then the BTU/h requirement from the computer room has been fulfilled. Furthermore, if there is interruption with the active ACs, the two-remaining backup ACs also have fulfilled the BTU/h requirement in the computer room.

5.2. Temperature and Humidity

Table 2. Comparison of TIA-569-C Requirement with Existing Condition

ASHRAE CLASS	PARAMETER	REQUIREMENT	EXISTING
Class A1 Class A2	Temperature	18 – 27 °C	19 – 24 °C
	Maximum Relative Humidity (RH)	60%	60%
	Maximum Dew Point	15 °C	16 °C
	Minimum Dew Point	5.5 °C	7 °C
	Maximum Rate of Temperature Change	5 °C per hour	Less than 5 °C per hour

According to the Table 2, the highest dew point in the data center space reached 16 °C and the lowest at 7°C. It can be concluded that the current condition of data center space at PT. XYZ has not met ASHRAE class A1 and A2 classification standards. Therefore, PT. XYZ has to maintain the temperature range in the room no more or less than 18-27 °C, and maintain the air temperature no more or less than the range of dew point 5.5-15 °C recommended by ASHRAE [14]. If the dew point is high, the higher the humidity, the space could be uncomfortably humid and will start creating water droplets which can affect the equipment and make corrosion. Meanwhile, if the dew point is low, the lower the humidity. Lower dew point can lead to human discomfort, frost and Electro Static Discharge (ESD).

5.3. HVAC System

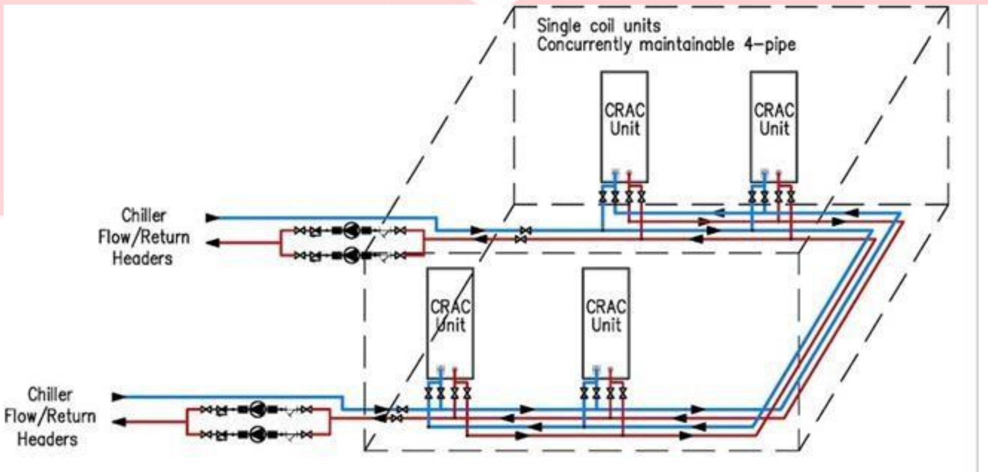

Figure 6. Illustration of Dual-Path Piping System [15]

According to the environmental design at TIA for tier IV, mechanical equipment such as air conditioning units, coolers, pumps, cooling towers and condensers must have dual path piping system for condenser water. Dual path piping system means that the system split the mixed supply air into two streams. Also, the extended loss of electrical power shall not cause loss of cooling outside operational range of critical equipment. Thus, the solution to avoid loss of cooling outside operational range of critical equipment when an extended loss of electrical power occurs is to apply the concept of Two Active Distribution Paths illustrated by Figure 9.

In Figure 9, consider there are four units of AC which are supplied through a four pipes chilled water system that is always active and ready to serve the critical condition. In each AC unit there are automatic isolation valves and dual distribution paths to standby when there is a failure on the unit or on the distribution path, the system can close the path or isolate the unit automatically and run the backup units [15].

HVAC system must also have automatic dampers. Automatic damper is one of components in HVAC that is used for controlling the air flow through a HVAC system and controlled by a thermostat or building automation system. Automatic damper can also be referred to as motorized damper because they can be controlled by solenoid. By using automatic damper, the conditioned air may be delivered to only those zones that are calling for conditioned air and automatically regulated [16].

5.4. Uninterruptible Power System, Batteries and Generator

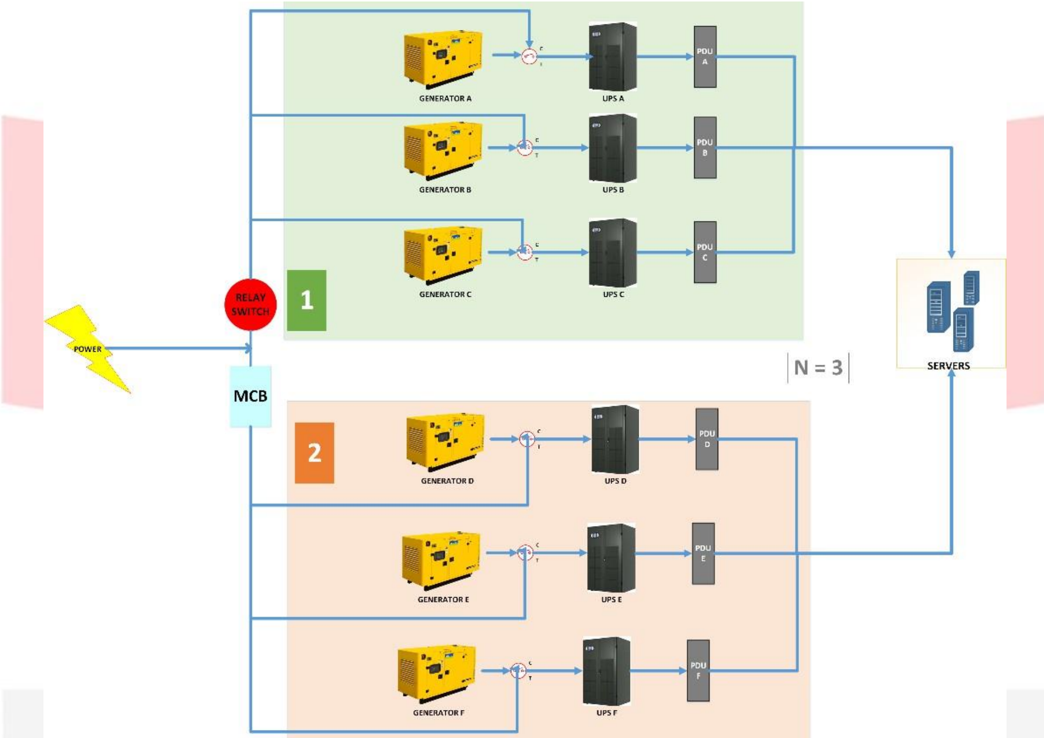

Figure 7. Illustration of 2N Power Redundancy

The UPS and generator shall have 2N distributed redundancy which means no single points of power path failure. This will not require shutdown if any failures occur and need to be repaired or replaced. If one of the generators or PDUs loss of power, the redundant units will still supply power to the rooms and avoid the possibility of being down.

Furthermore, according to TIA-942 standard, the batteries that are used for backup are valve regulated lead acid or flooded type which last for 20 years and must have a dedicated string for each module. VRLA batteries have been utilized for approximately 20 years. This technology offers a higher power density and lower capital costs than traditional vented cell solutions. VRLA batteries are typically deployed within power systems rated below 500 kVA [17].

Moreover, the battery room shall meet the requirements in OSHA CFR 1926.441. The floors should be of acid resistant construction unless protected from acid accumulations. The room shall be provided with spill containment. Face shields, aprons, and rubber gloves should be provided for workers handling acids or batteries. When workers are required to wear Personal Protective Equipment (PPE), there is the possibility of contamination with toxic materials. When this is the case, there must be a change room with storage for street clothes, so the contaminated PPE can be removed or disposed. Also, facilities must be provided for the quick drenching of eyes and the body and be within 25 feet (7.62 m) of battery-handling areas. Facilities must be provided for flushing and neutralizing spilled electrolyte and for fire protection. Designated areas need to be provided for the purpose of battery charging installations and they must be located in areas designated for that purpose. When batteries are being charged, the vent caps must be kept in place to avoid electrolyte spray. Vent caps are to be maintained in functioning condition [18].

The larger data center, the larger amount of batteries that are need to be managed. Therefore, a centralized automated system is needed to monitor each cell of batteries. A centralized automated battery monitoring system is a system that simplified the monitoring and controlling process of batteries from installation places by gathering all the performance data and integrates them all into a single central system. Later on, the system will need to measure each cell voltage, and impedance or resistance.

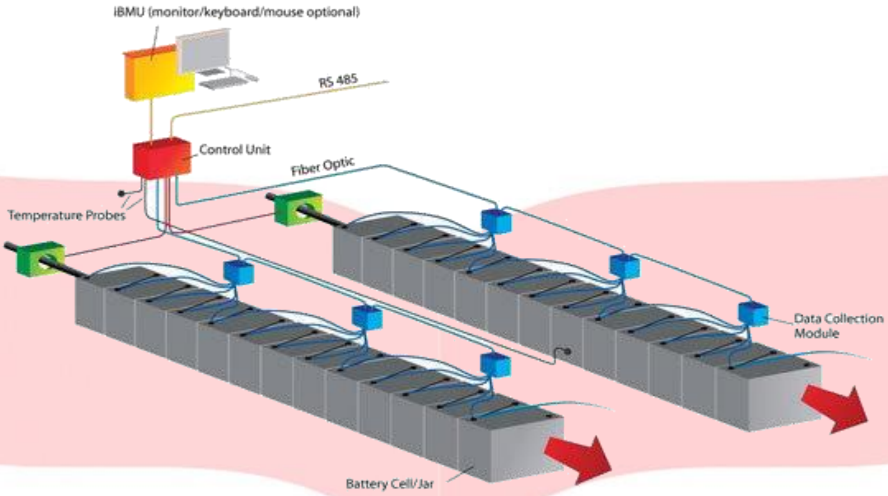

Figure 8. Illustration of Centralized Automated Battery Monitoring System

5.5. Contaminants Handling

According to TIA-942, The operating computer room environment shall conform to a C1 environmental conditions as defined in ANSI/TIA-568-C.0. Common methods for achieving C1 classification include vapor barriers, positive room pressure, or absolute filtration [19].

Table 3. ANSI/TIA-568-C.0 C1 Environmental Condition

Climatic and Chemical	**C_1**
Ambient temperature	-10 °C to +60 °C
Rate of change of temperature	0.1 °C per minute
Humidity	5 % to 85 % (non-condensing)
Solar radiation	700 Wm-2
Liquid pollution (see c)) Contaminants	Concentration x 10^{-6}
Sodium chloride (salt/sea water)	0
Oil (dry-air concentration) (for oil types see b)	0
Sodium stearate (soap)	None
Detergent	None
Conductive materials	None
Gaseous pollution contaminants	Mean/Peak (Concentration x 10^{-6})
Hydrogen sulphide	<0.003/<0,01
Sulphur dioxide	<0.01/<0.03
Sulphur trioxide (ffs)	<0.01/<0.03
Chlorine wet (>50 % humidity)	<0.000 5/<0.001
Chlorine dry (<50 % humidity)	<0.002/<0.01
Hydrogen chloride	-/<0.06
Hydrogen fluoride	<0.001/<0.005
Ammonia	<1/<5
Oxides of Nitrogen	<0.05/<0.1
Ozone	<0.002/<0.005

Among all the requirements, PT. XYZ data center has only fulfilled the climatic parameters. Thus, the chemical parameters are needed to be anticipate, recognize, evaluate, and control by implementing two monitoring tools. The first tool is for detecting, measuring and monitoring the chemical hazards, the other else is for detecting the solar radiation. Those tools are necessary considering the indoor air quality needs to be assured.

5.6. Computer Room

The condition of computer room is also arranged in this standard. It is stated that the room shall be provided with floor drains and positively pressurized to reduce air infiltration from the surrounding areas [9]. Floor drains provides an opening in a floor that drains water into a plumbing system. At least one drain or other means for evacuating water for each 100 m2 area should be provided.

Meanwhile, in a positive-pressure room, the air flow is controlled so that it flows from the uncontaminated area to the surrounding environment by adjusting the pressure difference between the supply and exhaust air. Indoor air pressure under positive pressure is higher than outside, so the contaminants remain outside. Positive-pressure room is important in the microelectronics industry where the number of particulates in the environment must be very low to maintain the integrity of circuit boards produced [20].

5.7. Radio Sources

Since there is no policy which control the use of radio sources in IT policy of PT. XYZ data center work regulations, this matter is needed to be added. Regarding the environmental design requirements of TIA-942 [9], the computer room should be located away from sources of EMI (Electromagnetic Interference) and RFI (Radio Frequency Interference). Electromagnetic interference within the frequency band for radio transmission may interfere with proper operation of the information technology and telecommunications equipment in the data center.

The internal equipment of data center such as UPS, transformer, etc. are the most likely possible sources of EMI. Thus, if the data center is located near to the telecommunication tower or airport, the network equipment such as servers could be easily damaged. Also, there has to be a guidance regarding the use of wireless and radio systems and also radiated electromagnetic energy (e.g., wireless LAN antennas, cellular telephones, handheld radios, etc.) that are traveling through free space to transport information. Special attention also shall be given to electrical power supply transformers, motors and generators, x-ray equipment, radio or radar transmitters, and induction sealing devices [9].

6. Conclusion

The data center in PT. XYZ has not fully met the requirement of Tier IV for environmental design in TIA-942. In order to achieve that, PT. XYZ has to implement dual-path piping and installing automatic damper in the HVAC system. The UPS and generator shall have 2N distributed redundancy and no single points of power path failure. Data center should have a centralized battery monitoring system with 20 years VRLA batteries. The battery room shall be provided with facilities such as spill containment, quick drenching, flushing and neutralizing spilled electrolyte, fire protection and Personal Protective Equipment (PPE) for workers. PT. XYZ have to apply monitoring tools for detecting, measuring and monitoring the chemical hazards and also for detecting the solar radiation. The computer room shall have positive air pressure, provided with floor drains and located away from radiated electromagnetic energy.

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