

MODULAR FLOATING DATA CENTRE PARK

FIELD OF THE INVENTION

This invention relates to a method and system for the establishment of a Floating Data Centre Park (FDCP). More particularly, this invention relates to a modular method and system of powering and cooling multiple Floating Data Centre Modules berthing in spatial relationship to a fixed pier and/or similar offshore structure to form the FDCP.

BACKGROUND

Singapore is the leading data centre hub of Southeast Asia. This strong base will continue to grow as people with access to high speed internet is growing steadily in developing countries. In addition, there are various other technologies that require huge amount of data such as internet of things (IOT), cloud computing, high quality media contents (4K resolution), big data, digital twins, social media, etc. Growing internet usage and new technologies that rely on internet would require massive data centres to store and access large amount of data in near future.

Besides being an island nation with small land space, Singapore also faces challenges like tropical climate and high humidity which leads to concerns on high energy footprint data centres. A 2012 site measurement study [NEA Report 2012] surveyed 23 data centres in Singapore and recorded /an average Power Usage Effectiveness (PUE) of 2.07. This indicates total power requirements (cooling and IT load) that are higher than IT load by 107%, signifying inefficiency.

According to Infocomm Media Development Authority (IMDA), the total electrical power consumed by data centres in Singapore for the year 2012 is 7.2% of Singapore's total electrical power consumption. The consumption rate will increase to 12% by 2030. With the increasing power demand comes emerging Green Data Centre technologies and solutions discovered with the aim of achieving a quantum improvement in energy efficiency.

Existing technical feasibility studies by IMDA and Keppel Data Centres, such as i) the Tropical Data Centre is to demonstrate that data centres can function optimally at temperatures of up to 38 degrees Celsius, and ambient humidity of 90 percent and higher; and ii) the High Rise Green Data Centre is to explore the possibility of saving land by building a data centre more than 20 stories high, using innovative architecture, power options and cooling technology to significantly reduce energy use and increase efficiency. Both studies work towards improved PUE rating in Singapore's challenging environment for data centre operators.

Data centres have immense footprints - sizes of 3ha or 4ha are common. They need to be scalable, which means they need land banks for future expansion. With land scarcity issue in Singapore, building data centres out in the sea could be another possibility to explore as a space solution which also opens up the possibility of tapping on the abundant seawater resource for cooling.

Thus, those skilled in the art are constantly striving to design an improved system and method of designing data centres that aims to reduce the Power Usage Effectiveness (PUE) and Water Usage Effectiveness (WUE) from the conventional land-based data centre.

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SUMMARY OF THE INVENTION

The above and other problems are solved and an advance in the state of art is made by a method and system for a modular floating data centre park in accordance with this invention. A first advantage of this method and system in accordance with this invention is that the method and system reduces the energy footprint and carbon emissions. A second advantage of this method and system in accordance with this invention is that the method and system utilizes the near-shore sea space, and thus reduces the burden for a permanent land infrastructure. A third advantage of this method and system in accordance with this invention is that the method and system reduces the Power Usage Effectiveness (PUE) and Water Usage Effectiveness (WUE) from the conventional land-based data centre. Therefore, besides being a green and sustainable solution to data centre expansion, operating expenditure of a data centre will be reduced significantly.

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A first aspect of the invention relates to a floating data centre park. The floating data centre park comprising: a modular data centre pier having a plurality of berths along two sides of the modular data centre pier; a modular power supply pier connectable with the modular data centre pier to form a modular floating data centre, the modular power supply pier having at least two berths; a plurality of floating data centre modules, each berthing at one of the plurality of berths of the modular data centre pier; and a plurality of power supply modules, each berthing at one of the at least two berths of the modular power supply pier, wherein the modular floating data centre is formed by connecting one end of the modular data centre pier to a connection point along a length of the modular power supply pier.

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In an embodiment according to the first aspect, the modular power supply pier is connectable with the modular data centre pier to form a T-shape modular floating data centre.

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In an embodiment according to the first aspect, the floating data centre park further comprises a plurality of the modular floating data centres connectable together such that the modular power supply piers are along a perimeter line of the modular floating data centre park and the modular data centre piers are within the perimeter line of the modular floating data centre park.

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In an embodiment according to the first aspect, the floating data centre park further comprises a plurality of extension piers for connecting the modular data centre piers. In an embodiment of this embodiment, one end of the extension pier is anchored to a shore.

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In an embodiment according to the first aspect, the modular floating data centre anchored to the seabed with pile support.

In an embodiment according to the first aspect, the modular floating data centre comprises: a power line for receiving power supply from the power supply modules and supplying the received power supply to the floating data centre modules; a supply fluid line for receiving chilled fluid from the power supply modules and supplying the chilled fluid to the floating data centre modules; and a return fluid line for receiving less chilled fluid from the floating data centre modules and returning the less chilled fluid to the power supply modules.

In an embodiment according to the first aspect, each of the floating data centre modules comprises: a floating barge having a double hull structure wherein a data centre is located within the double hull structure.

In an embodiment according to the first aspect, each of the floating data centre modules is a catamaran having a platform to house the data centre.

In an embodiment according to the first aspect, each of the floating data centre modules is a semi-submersible having a platform to house the data centre.

In an embodiment according to the first aspect, each of the floating data centre modules is a jackup rig having a platform to house the data centre.

In an embodiment according to the first aspect, each of the power supply modules comprises a power plant and a sea water chiller plant.

In an embodiment according to the first aspect, the power plant is a dual-fuel engine comprising gas engine generating heat to spin a gas turbine and a steam engine generating steam to spin a steam turbine, the spinning of the steam turbine and gas turbine is translated to power supply.

In an embodiment according to the first aspect, the sea water chiller plant is a heat absorption chiller.

In an embodiment according to the first aspect, the heat absorption chiller produces a chilled water to be supplied to the data centre.

In an embodiment according to the first aspect, the heat absorption chiller utilises a hot water or steam from a steam generator of the steam engine.

In an embodiment according to the first aspect, the power line for receiving power supply comprises a first power line, a second power line and a switch between the first and second power lines. The first and second power lines are connected to the data centre in the floating data centre modules in parallel and the switch is operatively close when both gas engine and steam engine are supplying power and operatively open when either one of gas engine and steam engine is not supplying power.

In an embodiment according to the first aspect, the dual-fuel engine is configured to supply at least 2 times of the power required to operate the data centre and can be expressed in the following expression,

$$2 \times P = X + Y1 \text{ and } Z$$

where, P refers to power supply from each of the dual-fuel engine, X refers to power drawn by the data centre, $Y1$ refers to power drawn by a power and cooling unit for cooling the data centre and Z refers to remaining power that can be exported to a national grid.

In an embodiment according to the first aspect, the floating data centre park further comprises solar panel mounted on a top deck of the FDC modules, and roof of the modular data centre pier and modular power supply pier, generating additional power supply.

5 In an embodiment according to the first aspect, the floating data centre park further comprises tidal turbine installed under the modular data centre pier and modular power supply pier to capture under current, generating additional power supply.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The above and other features and advantages in accordance with this invention are described in the following detailed description and are shown in the following drawings:

Figure 1 illustrating a Floating Data Centre Park (FDCP) that is fixed to a shore in accordance with an embodiment of this disclosure;

15 Figure 2 illustrating a first configuration of the FDCP and a second configuration of the FDCP in accordance with an embodiment of this disclosure;

Figure 3 illustrating a third configuration of the FDCP and a fourth configuration of the FDCP in accordance with an embodiment of this disclosure;

20 Figure 4 illustrating a fifth configuration of the FDCP and a sixth configuration of the FDCP in accordance with an embodiment of this disclosure;

Figure 5 illustrating a seventh configuration of the FDCP in accordance with an embodiment of this disclosure;

Figure 6 illustrating an embodiment of the floating data centre module in accordance with an embodiment of this disclosure;

25 Figure 7 illustrating a cross section view of the line A-A and a cross section view of the line B-B of floating data centre module shown in figure 6;

Figure 8 illustrating a catamaran floating data centre module in accordance with an embodiment of this disclosure;

30 Figure 9 illustrating a semi-submersible floating data centre module in accordance with an embodiment of this disclosure;

Figure 10 illustrating a jackup rig floating data centre module in accordance with an embodiment of this disclosure;

Figure 11 illustrating the components in the power plant module in accordance with an embodiment of this disclosure;

35 Figure 12 illustrating flow of fluid between a steam generator of a power plant and a heat absorption chiller of a sea-water chiller plant for supplying chilled water to the data centres in accordance with an embodiment of this disclosure;

Figure 13 illustrating a schematic diagram of the electrical connection of the power plant modules, data centres and other devices when in full operation;

40 Figure 14 illustrating a schematic diagram of the electrical connection of the power plant modules, data centres and other devices when one or more power generator is faulty; and

Figure 15 illustrating a tidal turbine installed below the modular data centre pier and/or the modular power supply pier in accordance with an embodiment of this disclosure.

5 DETAILED DESCRIPTION

This invention relates to a method and system for the establishment of a Floating Data Centre Park (FDCP). More particularly, this invention relates to a modular method and system of powering and cooling multiple Floating Data Centre Modules berthing in spatial relationship to a fixed pier and/or similar offshore structure to form the FDCP.

10 Figure 1 illustrates a FDCP 100 that is fixed to a shore. The FDCP100 comprises a modular floating data centre 110, Floating Data Centre (FDC) modules 200, and power plant modules 300.

The modular floating data centre 110 comprises a modular data centre pier 120 and a modular power supply pier 130. The modular data centre pier 120 and modular
15 power supply pier 130 are concrete-based construction platform. Alternatively, the modular data centre pier 120 and modular power supply pier 130 may be a steel-based platform, mixture of concrete and steel or any other suitable metal platform. The modular data centre pier 120 and modular power supply pier 130 are supported and anchored to the seabed with pile support.

20 The modular data centre pier 120 has a number of berths along two sides for berthing the individual FDC modules 200 as shown in figure 1. The modular power supply pier 130 is connected to the modular data centre pier 120 to form the modular floating data centre 110. The modular power supply pier 130 has at least two berths for berthing the power supply modules as shown in figure 1.

25 The modular data centre pier 120 and modular power supply pier 130 are connected together to form the modular floating data centre 110. Specifically, the modular floating data centre 110 is formed by connecting one end of the modular data centre pier 120 to a connection point along the length of the modular power supply pier 130. As shown in figure 1, one end of the modular data centre pier 120 is connected to a
30 connection point along the length of the modular power supply pier 130 forming a T-shape modular floating data centre 110. One skilled in the art will recognise that beside a T-shape modular floating data centre 110, other configuration such as a Y-shape shape modular floating data centre may be provided without departing from the disclosure. More importantly, the modular power supply pier 130 is away from the shoreline so that fuel
35 supply vessels 390 can berth adjacent to the power plant modules 300 to supply the necessary fuel. This arrangement also reduces the disturbance, caused by the berthing of fuel supply vessels 390 to the power plant modules 300, to the FDC modules that are berthed to the modular data centre pier 120.

40 The modular data centre pier 120 and modular power supply pier 130 are standardized block for easy and efficient construction. Further, the modular data centre pier 120 and modular power supply pier 130 comprise standardized connectors so that the modular data centre pier 120 and modular power supply pier 130 can be connected

together easily to form the modular floating data centre 110 for FDC modules 200 and power plant modules to berth and couple to the modular floating data centre 110. With majority of the designs pre-determined, shorter lead time is required for construction and this allows demand for data centres to be fulfilled more efficiently. Specifically, the standardized blocks can be fabricated on land and transported to the designated location, from land and/or sea, before being anchored to the seabed with pile support. For FDCP 100 comprising one modular floating data centre 110, the modular floating data centre 110 is adaptably installable with one end of the modular data centre pier 120 extending from a shoreline and the modular power supply pier 130 is connectable to another end of the modular data centre pier as shown in figure 1. Alternatively, the modular floating data centre 110 may be anchored to the seabed away from the shore. Other configurations of the FDCP 100 may be provided and will be discussed below.

The modular floating data centre 110 functioned as the pathway linkage to connect the power and cooling utilities for individual FDC modules 200 in a 2N redundancy configuration, i.e. dual-power supply for redundancy. Further details on the 2N redundancy configuration will be described below.

The modular floating data centre 110 comprises a power line for receiving power supply from the power supply modules 300 and supplying the received power supply to the floating data centre modules 200. In another embodiment, the power line comprises 2 parallel power lines for receiving power supply from the power supply modules 300 and supplying the received power supply to the floating data centre modules 200 to form a 2N redundancy configuration. More details on the 2N redundancy configuration will be described below. The modular data centre pier 120 comprises network connectivity cables for connecting the data centres residing in the FDC modules 200 to external servers.

The modular floating data centre 110 also comprises a supply fluid line and a return fluid line. The supply fluid line are configured for receiving chilled fluid from the power supply modules 300 and supplying the chilled fluid to the floating data centre modules 200. The return fluid line is configured for receiving less chilled fluid from the floating data centre modules 200 and returning the less chilled fluid to the power supply modules 300.

The modular floating data centres 110 are configured with sufficient width to provide office space, human walkway and equipment transportation means. Other necessary outfitting, railing, mooring and lighting and other basic facilities may be provided on the modular floating data centre 110.

All power lines, network connectivity cables, and supply and return fluid lines are concealed within the modular data centre pier 120 and modular power supply pier 130 so that platform on modular data centre pier 120 and modular power supply pier 130 allows for office space, human walkway and equipment transportation means.

Figures 2-5 illustrate various configurations of the FDCP 100.

A first configuration of the FDCP 100a as shown in figure 2 illustrates a number of modular floating data centres 110 arranged parallel to each other and in a staggered

arrangement along the shoreline. Extension piers 160 are provided to connect the modular floating data centres 110 to the shore.

A second configuration of the FDCP 100b as shown in figure 2 illustrates a number of modular floating data centres 110 that are connected to extension piers 160 where the extension piers are interconnected forming an inverted V-shape with 2 ends of the V-shape extension piers anchored to the shore.

The third configuration of the FDCP 100c as shown in figure 3 illustrates a number of modular floating data centres 110 that are connected to extension piers 160 where the extension piers are interconnected forming a cross with one end of the cross anchored to the shore.

The fourth configuration of the FDCP 100d as shown in figure 3 illustrates a number of modular floating data centres 110 that are connected to extension piers 160 where the extension piers are interconnected forming an inverted U-shape with two ends of the inverted U-shape extension piers anchored to the shore.

The fifth configuration of the FDCP 100e as shown in figure 4 illustrates a number of modular floating data centres 110 that are connected to extension piers 160 where the extension piers are interconnected forming an oval shape with a portion of the oval shape extension piers anchored to the shore.

The sixth configuration of the FDCP 100f as shown in figure 4 illustrates a number of modular floating data centres 110 that are connected to extension piers 160 where the extension piers are interconnected forming a lollipop shape with an end of the stem of the lollipop shape extension piers anchored to the shore.

In short, the third configuration of the FDCP 100c, fourth configuration of the FDCP 100d, fifth configuration of the FDCP 100e and sixth configuration of the FDCP 100f are generally in a fan shape arrangement.

The seventh configuration of the FDCP 100g as shown in figure 5 illustrates a number of modular floating data centres 110 that are connected to extension piers 160 where the extension piers are interconnected forming two bidents, one connected to the other at respective ends of the shaft to form a mirror image. The seventh configuration of the FDCP 100g is anchored to the seabed and away from the shore.

One skilled in the art will recognise that the first, second, third, fourth, fifth and sixth configuration of the FDCP 100a-100f may also be anchored to the seabed and away from the shore. This means that the FDCP 100a-100f are not anchored to the shore. Further, two or more of each of the first, second, third, fourth, fifth and sixth configuration of the FDCP 100a-100f may be connected together to form a FDCP 100. For example, two of the first configuration of the FDCPs 100a may be connected together forming a mirror image. In another example, two of the second configuration of the FDCPs 100b may be connected together respective 2 ends of the V-shape extension piers forming a quadrilateral. In yet another example, the third and sixth configuration of the FDCP 100c-100f may be connected together with one end of the cross connected to one end of the stem of the lollipop shape extension piers.

More importantly, in any arrangement of the FDCP 100, the modular floating data centres 110 are connected together such that the modular power supply piers 130 are along a perimeter line 150 of the FDCP 100 and the modular data centre piers 120 are within the perimeter line 150 of the FDCP 100 as shown in figures 2-5. This allows power supply modules 300 to berth to the modular power supply pier 130 supplying power to the FDC modules 300 from the perimeter line 150 of the FDCP 100. The FDC modules 200 are berthed at designated berth along the modular data centre piers 120 which are within the perimeter line 150 of the FDCP 100. In this arrangement, the modular power supply pier 130 along the perimeter line 150 surrounds the modular data centre piers 120, stabilising the FDC modules berthed at the modular data centre piers 120.

FDC module 200

The FDC module 200 provides the function of mobility which is an unusual approach compare to land-based real estate. The FDC module 200 is detachable from the existing deployment and make ready for re-deployment as required. Comparing to constructing a data centre on land, the FDC module 200 is more economical as lesser site works will be required to prepare for its deployment and to return to the site's original state upon its extraction.

The FDC module 200 is flexible for deployment, adopting a plug and play model, which is readily make for operation use when a power source is plugged in. The FDC module 200 can be arranged to suit the different and various shapes and sizes of the deployment location or area of operation.

To scale up, another FDC module 200 can be built offsite and towed to the site for deployment. A few of the FDC modules 200 can be berthed on a modular data centre pier 120 forming a FDC cluster (FDC node). This enables a scalable FDCP 100 which aids in the speed to scale (i.e. fast and scalable approach).

Compared to a land-based data centre, the FDCP 100 helps to close up the demand-supply gap for data centres as it allow data centres users are able to scale contiguously upon demand at ease. There is no need to construct new data centres in anticipation of demand and thus lesser uncertainty risk for data centre users.

The FDC module 200 is designed in a floating barge platform which is mainly used to house/store the data centre with the relevant IT loads and cooling loads. Figure 6 is an illustration of an embodiment of the FDC Module 200a. Top of figure 7 illustrates a cross section view of the line A-A in figure 6 and bottom of figure 7 illustrates a cross section view of the line B-B in figure 6. As shown in figure 7, the FDC module 200 includes a double hull structure 210. Flooding of the double hull structure 210 provides passive cooling for the DC halls 220 below the main deck 230 within double hull structure 210. In additional, the sea is a convenient heat sink. This can provide additional cooling on top of active cooling from the mechanical chillers provided by the power supply modules 300. Specifically, the FDC module 200 comes in a barge form structure with a double hull structure 210, i.e. ballast tanks acting as double layers to the platform hull structure. The work space environment in the DC halls 220 located below main deck 230

and within the double hull structure 210 is hot in nature and needs constant cooled air and ventilation to control the temperature of the DC hall at an acceptable temperature range. With the tank in double hull structure 210 filled with sea water, it could possibly transmit and/or dissipate some of the heat source away. Hence, acting as an intermediate heat sink between machinery room and sea since the sea is a convenient heat sink. This can provide additional cooling on top of active cooling from the convention Computer Room Air Handler (CRAH) which is a mechanical air-cooled handling system.

Figures 8-10 illustrate other embodiments of the FDC module 200. Top of figure 8 illustrates a front side view of the catamaran FDC module 200b and bottom of figure 8 illustrates a side view of the catamaran FDC module 200b. In this embodiment, the FDC module 200b comprises a pair of hulls 810 supporting a platform to house or store the data centre with the relevant IT loads and cooling loads. While figure 8 illustrates 2 decks of data centre, one skilled in the art will recognise that other number of decks of data centre can be loaded on the platform of the catamaran FDC module 200b without departing from the disclosure.

Top of figure 9 illustrates a front side view of the semi-submersible FDC module 200c and bottom of figure 9 illustrates a side view of the semi-submersible FDC module 200c. In this embodiment, the FDC module 200c comprises a pair of columns and pontoons arranged to support a platform to house or store the data centre with the relevant IT loads and cooling loads. While figure 9 illustrates 2 decks of data centre, one skilled in the art will recognise that other number of decks of data centre can be loaded on the platform of the semi-submersible FDC module 200c without departing from the disclosure.

Top of figure 10 illustrates a front side view of the jackup rig FDC module 200d and bottom of figure 10 illustrates a side view of the jackup rig FDC module 200d. In this embodiment, the FDC module 200d comprises four jackup legs 1010 spaced apart from each other to form a quadrilateral, each jackup leg 1010 having a spud can 1020 anchored to the seabed, and a platform supported by the jackup leg 1010 to house or store the data centre with the relevant IT loads and cooling loads. While figure 10 illustrates 2 decks of data centre, one skilled in the art will recognise that other number of decks of data centre can be loaded on the platform of the jackup rig FDC module 200d without departing from the disclosure.

The FDC module 200 comprises an inlet/outlet socket module adapted to connect to the power line for drawing power from the power supply modules 300, a fluid inlet adapted to connect to the supply fluid line for receiving chilled fluid from the power supply modules 300 and a fluid outlet adapted to connect to the return fluid line for returning the less chilled fluid to the power supply modules 300. The FDC module 200 further comprises data inlet/outlet ports adapted to connect to the network connectivity cables for connecting the data centres to external servers.

Power plant module 300

The power plant module 300 may be provided on a vessel berthed at the designated berth on the modular power supply pier 130. As shown in figure 11, the power plant module 300 comprises a power plant 310 for generating power to operate the FDCP 100. Generally, the power plant 310 is required to generate power to operate the data centres housed in the FDC module 200. The power plant module 300 also comprises a sea-water chiller plant 320 for cooling the data centres housed in the FDC module 200.

The power plant 310 is a gas power plant. Specifically, the power plant 310 is a liquid natural gas (LNG) power plant. Generally, a liquid natural gas (LNG) power plant includes a gas engine generating heat to spin a gas turbine. The heat is captured by a steam engine generating steam to spin a steam turbine. The spinning of the steam turbine and gas turbine is translated to power supply. Hence, such LNG power plant generates electricity from a dual gas and steam engines, i.e. dual-fuel engine. A dual-fuel engine gives full-flexibility as it can be suitably switched from gas mode to liquid fuel mode in the event of a lack of Liquefied Natural Gas (LNG) supply. Dual-fuel engine is environmental-friendly with its ability to produce cleaner combustion when running on LNG. The fuel supply vessel 390 such as LNG bunker or feeder vessel can easily supply LNG to the LNG power plant.

The sea-water chiller plant 320 is a heat absorption chiller. As both power plant 310 and sea-water chiller plant 320 are adjacent to each other (or housed within the power plant module 300), the hot water or steam from the steam generator of the power plant 310 can be supplied to the heat absorption chiller for generating chilled water for cooling the data centres housed in the FDC module 200.

Figure 12 illustrates the flow of the fluid between the steam generator 1210 of the power plant 310 and the heat absorption chiller 1220 of the sea-water chiller plant 320 for supplying chilled water to the data centres. First, waste heat from the gas engine is channelled to a steam generator 1210 of the steam engine to generate steam as represented by arrow 1211. The hot water or steam which is typically about 110°C is channelled to the heat absorption chiller 1220 as represented by arrow 1212. Using the hot water from the steam generator 1210 and cooling water from the sea which is about 29°C as represented by arrow 1221, the heat absorption chiller 1220 is able to produce a chilled sea water of about 7°C which is supplied to the data centres 1230 as represented by arrow. The less chilled sea water which is about 12°C is returned from the data centres 1230 as represented by arrow 1223, the less cold sea water which is about 32°C is returned to the sea as represented by arrow 1224 and the less hot water which is about 60°C is returned to the steam generator 1210 as represented by arrow 1225. The details of the dual-fuel engine power plant 310 and heat absorption chiller are omitted for brevity. More importantly, it is not necessary to equip each FDC module 200 with chiller for supplying chilled water to the data centres 1230 for cooling the data centres. In the FDCP 100, a centralised sea-water chiller plant 320 for cooling the data centres housed in the FDC module 200 is provided.

A series of power plant 310, which is made up of a floating LNG power plant having dual-fuel engine with LNG bunker or feeder vessel to supply the fuel to the power plant 310, can be deployed as a power solution to operate the FDC modules 300.

The FDC modules 300 together with the series of power plant 310 can form an all-in-one FDCP 100 near shore DC solution. This can possibly be deployed worldwide according to customer demand and need, such as private domain (enterprise data centre) or public domain (internet data centre, co-location data centre and other service provider data centre).

This self-powered all-in-one FDCP 100 is independent from the power grid. Thus, reducing the data centres reliance on national infrastructure. This reduces interference between data centres operations with national infrastructure, which translate to the following benefits:

1. Lesser burden and risk on national infrastructure given the huge power demand of data centres operations.
2. Higher data centres operations reliability as power is within the data centres operator's control.
3. Data centres users are able to scale at ease as they are not restricted by power capacity availability from the power grid.

Power supply

The number of power plant modules 200 is correlated to the number FDC modules 300. As a guide, the configuration is based on a 2N redundancy configuration for power and cooling. This allows the flexibility of deploying a cluster of FDC modules 300 independently upon 60% completion/occupancy of the previous cluster of FDC modules 300.

The schematic diagram of the electrical connection of the power plant modules 200, data centres in the FDC modules 300 and other devices is illustrated in figure 13. As shown in figure 13, the power line for receiving power supply comprises a first power line 1311, a second power line 1312 and a switch 1381 between the first and second power lines 1311 and 1312. The first and second power lines 1311 and 1312 are connected to the data centre 1320 in the floating data centre modules 200. Specifically, the first and second power lines 1311 and 1312 are connected to the data centre in parallel, and the switch 1381 is operatively close as shown in figure 13 when both gas engine and steam engine are supplying power and operatively open as shown in figure 14 when either one of gas engine and steam engine is not supplying power. This means that each of the dual-fuel engine is connected to the first and second power lines forming a 2N redundancy configuration for power and cooling.

At all time, the power plant module 200 having a dual-fuel engine is able to each inject 11kV of power supply via the first and second power lines 1311 and 1312. The amount of power supply exported to the Data Centres 1320, power and cooling unit 1350 of the Data Centres, and national grid 1360 can be expressed in the following expression,

$$2 \times P = X + Y1 \text{ and } Z$$

where, P refers to power supply from each of the dual-fuel engine, X refers to power drawn by the Data Centres 1320, $Y1$ refers to power drawn by the power and cooling unit 1350 of the Data Centres 1320 and Z refers to the remaining power that can be exported to the national grid.

Figure 13 also illustrates the typical loss by the components. For example, there should be an expected loss of 1% passing through the step down transformer 1331 and 1332, and a further 2.8% loss passing through the Uninterrupted Power Supplied (UPS) 1341 and 1342 when power is drawn by the power and cooling unit 1350 of the Data Centres 1320. Further, it is expected that a loss of 1% passing through the step up transformer 1361 for exporting excess power to the national grid.

As shown in figure 13, under normal operation, a dual-fuel engine power plant module 200 is more than sufficient to power the data centre since only 50% of the power injected to the power line is required. This is further illustrated in figure 14 in the event that one of the dual-fuel engine power plant module 200 is down. In this circumstance, the switch 1381, 1382 and 1383 will be opened so that all power is drawn by the data centre 1320 and power and cooling unit 1350 only.

Figures 13 and 14 also illustrate adding of renewables 1370 for supplying power to the data centre 1320 and power and cooling unit 1350. The renewables 1370 may include solar photovoltaic (PV) and tidal turbine. The solar PV may be installed on the roof of the FDC modules 300 or on the surface of the sea while the tidal turbines may be installed under the modular data centre pier 120 and modular power supply pier 130 to capture under current as shown in figure 15. Top of figure 15 illustrates a front side view of the modular data centre pier 120 and/or modular power supply pier 130 with a tidal turbine and bottom of figure 15 illustrates a side view of the modular data centre pier 120 and/or modular power supply pier 130 with a tidal turbine. As shown in figure 15, the tidal turbine 1510 is installed below the modular data centre pier 120 and/or modular power supply pier 130. The tidal turbine 1510 connected to a power house 1520 to translate the kinetic energy collected from the tidal turbine 1510 into electrical energy. The power supply generated by the solar PV and tidal turbines are injected directly to the data centre 1320 and power and cooling unit 1350 and/or respective power storage. In the event that solar PV and/or tidal turbines are faulty, the switches 1384 and 1385 are opened and power can be supplied to the data centre 1320 and power and cooling unit 1350 via the power storage.

Other systems to compliment the FDCP

Solar photovoltaic (PV) systems directly convert solar energy into electricity. The FDCP 100 is designed to equip with photovoltaic solar panels mounted on the top deck of FDC modules 200 and roof of the modular data centre pier 120 and modular power supply pier 130. PV is a very modular technology and it will scale according the deployment of FDCP 100. Solar energy will be harnessed to create electricity to power the auxiliary utilities for perimeter lightings, office, security systems, etc.

Lighting system usually contributes to the small percentage of power usage in data centre. In this disclosure, the lighting power usage can be supplied through using combination of renewables such as solar energy to powered lighting and natural day light from window enclosure in the data centre corridor. Smart lighting which is powered by solar panel comes with smart sensor, with tracking function of the presence natural daylight quality and upon detection of human presence, automatic adjust and/or dim the corridor light.

In this disclosure, a computational fluid dynamic digital twin may be provided to reflect the real time heat profile of the data centre hall. Artificial intelligence will then be deployed to learn the features of this heat profile from this digital twin through deep learning methodologies. This artificial intelligence will also dynamically predict the upcoming heat profile (which is also known as the heat demand) of the data centre hall and communicate with the cooling infrastructures to supply the necessary cooling that matches the heat demand. This allows optimal cooling to be delivered to the servers without wastage, improving the cooling efficiency of the data centre.

In this disclosure, artificial intelligence can be deployed to analyse the entire system on 3 levels:

1. Equipment – where each equipment will be analysed individually and independently
2. Intra-chain – where equipment within the same sub-system will be analysed concurrently
3. Inter-chain – where equipment across the sub-systems will be analysed inter-dependently

Through this real time analysis, the artificial intelligence algorithm will be able to detect potential malfunctioning and provide early warning for early intervention. This artificial intelligence algorithm will also automatically isolate the affected equipment to ensure no effect on operations.

The above is a description of exemplary embodiments of a floating data centre park in accordance with this invention. It is foreseeable that those skilled in the art can and will design alternative systems and methods based on this disclosure that infringe upon this invention as set forth in the following claims.

CLAIMS

1. A floating data centre park comprising:

a modular data centre pier having a plurality of berths along two sides of the modular data centre pier;

a modular power supply pier connectable with the modular data centre pier to form a modular floating data centre, the modular power supply pier having at least two berths;

a plurality of floating data centre modules, each berthing at one of the plurality of berths of the modular data centre pier; and

a plurality of power supply modules, each berthing at one of the at least two berths of the modular power supply pier, wherein the modular floating data centre is formed by connecting one end of the modular data centre pier to a connection point along a length of the modular power supply pier.

2. The floating data centre park according to claim 1 wherein the modular power supply pier is connectable with the modular data centre pier to form a T-shape modular floating data centre.

3. The floating data centre park according to claim 1 or 2 further comprising:

a plurality of the modular floating data centres connectable together such that the modular power supply piers are along a perimeter line of the modular floating data centre park and the modular data centre piers are within the perimeter line of the modular floating data centre park.

4. The floating data centre park according to claim 3 further comprising a plurality of extension piers for connecting the modular data centre piers.

5. The floating data centre park according to claim 4 wherein one end of the extension piers is anchored to a shore.

6. The floating data centre park according to any one of claims 1-5 wherein the modular floating data centre is anchored to the seabed with pile support.

7. The floating data centre park according to any one of claims 1-6 wherein the modular floating data centre comprises:

a power line for receiving power supply from the power supply modules and supplying the received power supply to the floating data centre modules;

a supply fluid line for receiving chilled fluid from the power supply modules and supplying the chilled fluid to the floating data centre modules; and

a return fluid line for receiving less chilled fluid from the floating data centre modules and returning the less chilled fluid to the power supply modules.

8. The floating data centre park according to any one of claims 1-7 wherein each of the floating data centre modules comprises:

a floating barge having a double hull structure wherein a data centre is located within the double hull structure.

9. The floating data centre park according to any one of claims 1-7 wherein each of the floating data centre modules is a catamaran having a platform to house the data centre.

10. The floating data centre park according to any one of claims 1-7 wherein each of the floating data centre modules is a semi-submersible having a platform to house the data centre.

11. The floating data centre park according to any one of claims 1-7 wherein each of the floating data centre modules is a jackup rig having a platform to house the data centre.

12. The floating data centre park according to claim 7 wherein each of the power supply modules comprises:

a power plant; and
a sea water chiller plant.

13. The floating data centre park according claim 12 wherein the power plant is a dual-fuel engine comprising gas engine generating heat to spin a gas turbine and a steam engine generating steam to spin a steam turbine, the spinning of the steam turbine and gas turbine is translated to power supply.

14. The floating data centre park according claim 13 wherein the sea water chiller plant is a heat absorption chiller.

15. The floating data centre park according claim 14 wherein the heat absorption chiller produces a chilled water to be supplied to the data centre.

16. The floating data centre park according claim 15 wherein the heat absorption chiller utilises a hot water or steam from a steam generator of the steam engine.

17. The floating data centre park according to any one of claims 13-16 wherein the power line for receiving power supply comprises a first power line, a second power line and a switch between the first and second power lines, the first and second power lines are connected to the data centre in the floating data centre modules in parallel, and the switch is operatively close when both gas engine and steam engine are supplying power

and operatively open when either one of gas engine and steam engine is not supplying power.

18. The floating data centre park according to claim 17 wherein the dual-fuel engine is configured to supply at least 2 times of the power required to operate the data centre and can be expressed in the following expression,

$$2 \times P = X + Y1 \text{ and } Z$$

where, P refers to power supply from each of the dual-fuel engine, X refers to power drawn by the data centre, $Y1$ refers to power drawn by a power and cooling unit for cooling the data centre and Z refers to remaining power that can be exported to a national grid.

19. The floating data centre park according to any one of claims 1-18 further comprising solar panel mounted on a top deck of the FDC modules, and roof of the modular data centre pier and modular power supply pier, generating additional power supply.

20. The floating data centre park according to any one of claims 1-19 further comprising tidal turbine installed under the modular data centre pier and modular power supply pier to capture under current, generating additional power supply.