Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2021.27805

239 (2021) 181–191
November

Electric energy saving control method of water conservancy project based on cloud computing

Qiang Wang[a,b,*], Ke Yao[a], Pyeoung-Kee Kim[b]

[a]*College of Architecture and Information Engineering, Shandong Vocational College of Industry, Zibo 256414, China, email: zbwq2020@126.com (Q. Wang)*
[b]*Division of Computer Software Engineering, Silla University, Busan 612022, South Korea*

Received 17 August 2021; Accepted 23 September 2021

A B S T R A C T

With the increasing number of water conservancy and hydropower projects, in order to better meet the objective requirements of energy saving and consumption reduction, this paper puts forward the research on electrical energy-saving control methods of hydraulic engineering based on cloud computing. From the point of view of analyzing the main causes of power waste in water conservancy projects, this paper constructs a data model of electrical energy consumption of water conservancy projects based on cloud computing, completes the electrical energy-saving design of water conservancy projects through a data energy-saving algorithm classification and data energy-saving algorithm based on dynamic voltage and frequency scaling, realizes the evaluation of energy efficiency index of electrical energy consumption data, and finally designs a three-phase asynchronous motor dual CPU system based on cloud computing design. Through the experiment, it is proved that the energy-saving effect is obvious, which effectively improves the utilization rate of water conservancy and electric power energy, greatly improves the quality of people's lives, and provides a reference for improving the operation effect of water conservancy projects.

Keywords: Cloud computing; Water conservancy project; Electricity; Energy saving; Three-phase asynchronous motor

1. Introduction

With the development of the concept of a low-carbon economy, a series of clean and renewable energy such as hydropower, wind power and photovoltaic power generation has been rapidly popularized. With the continuous improvement of China's science and technology level, the innovation and creation of energy production technology have been highly concerned by the state. Therefore, China's current basic industries on energy production are highly valued by the state, and water conservancy and electric power energy are also one of the energy sources that people are exposed to in their daily life. The effective utilization of water conservancy and electric power energy can greatly improve people's quality of life and promote the development of socialization [1,2].

In ocean energy power generation, tidal power generation has broad development prospects [3]. Aiming at this, a tidal power generation experimental device was designed, and preliminary research was carried out in the laboratory, which laid the foundation for the ocean test of tidal power generation. In the tidal power generation simulator control system, the frequency conversion speed regulation of three-phase asynchronous motors is the key technology of power flow simulation. For this reason, the LabVIEW operation interface and program flow chart are designed on the host computer. The data transmission adopts VISA technology. The continuous operation of the inverter is controlled by RS485 communication. The three-phase asynchronous

* Corresponding author.

motor drives the two-way impeller pump to drive the water flow, and the simulation research of tidal power generation can be carried out. Nowadays, cloud computing has been more and more used in many scientific and manufacturing fields because of its flexibility to adapt to high-demand computing requirements. The energy factor adds another layer of complexity to task scheduling because it needs to be used to the maximum. Resource and reduce its idle state [4]. Yang et al. [5] found that in the cloud computing paradigm, due to the existence of heterogeneous applications, the energy-saving allocation of different virtualized Information and Communications Technology (ICT) resources is a complex issue, and the ICT resource capacity is controversial to allocate required workloads. The existing hardware and software technologies related to energy-saving resource allocation are summarized, and the available technologies in the literature are summarized based on the classification of energy-saving research dimensions. Vila et al. [6] found that cloud data centers consume a lot of power, which increases their operating costs. This shows the importance of investing in energy-consuming technologies. Using meta-heuristics to dynamically place virtual machines to appropriate physical nodes is one of the ways to reduce energy consumption. In meta-heuristic algorithms, there should be a balance between exploration and utilization, so that they can find a better solution in the search space. Exploration means finding solutions in a broader field, while development means generating new solutions from existing solutions. A scheduling framework is proposed: a hybrid scheduling framework based on ABC and PSO algorithms. Experimental results show that the energy consumption of the non-migration mode is reduced by 4%–8%, and the energy consumption of the migration mode is reduced by 3%–12%. In addition, in the non-migration mode, computing power consumption is reduced by 5%–14%, and in the migration mode, computing power consumption is reduced by 5%–28%. In the model without migration, the total execution time can be reduced by up to 15%, while in the mode with migration, the total execution time is reduced by approximately 27%. In the non-migration mode, up to 53% throughput can be obtained, and 67% throughput can be obtained through migration. Finally, 9%–23% of SLA violation improvements were also evaluated. Zhang et al. [7] considered the complex characteristics of urban bus line traffic flow and the nonlinear characteristics of vehicle dynamics, energy optimization management based on clustering and driving status recognition is still a challenging problem. A cloud computing-based energy optimization control framework for plug-in hybrid electric buses is proposed. The framework includes an offline part and an online part, which can realize the driving condition clustering of the offline part and the energy management of the online part. In the offline part, the operating data transmitted to the remote monitoring center by the bus is used to cluster the driving conditions using the K-means algorithm to generate a Markov probability transition matrix to predict the possible operational needs of bus drivers. Simulation and hardware-in-the-loop tests are carried out using actual urban bus lines as an example. The results show that this strategy can significantly improve vehicle fuel economy. With the increase of traffic flow data feedback, each plug-in hybrid bus's is fuel consumption on a particular bus route tends to a stable minimum. Due to the large volume, multiple types, and high speed of big power data, traditional computing is difficult to handle well [8]. On the basis of in-depth research on cloud computing technology, try to use cloud computing in the dispatch business. Introduced a scheduling cloud framework, detailed the hierarchical structure of the scheduling cloud infrastructure layer, platform layer, and service layer, clarified the five application services of the scheduling cloud and designed the topology and workflow of the scheduling cloud. Through simulation, the efficiency of cloud computing and traditional computing is compared, and the feasibility of using cloud computing to process electric power big data is verified. Finally, a cloud computing method for processing power big data in the system memory is proposed, and experiments prove that the cloud computing method can optimize the scheduling cloud.

Based on the above research, this paper puts forward the research of electrical energy-saving control methods of water conservancy projects based on cloud computing. Firstly, from the perspective of analyzing the main reasons for power waste in water conservancy projects, the electrical energy consumption data model of water conservancy projects is constructed based on cloud computing, and the electrical energy-saving design of water conservancy projects is completed by a data energy-saving algorithm classification and data energy-saving algorithm based on dynamic voltage and frequency scaling (DVFS). At present, the energy efficiency index evaluation of electrical energy consumption data, the final design based on cloud computing design of three-phase asynchronous motor dual CPU system, to achieve electrical energy-saving control of water conservancy projects, improve the rationality of electrical energy-saving design, optimize the energy-saving design management environment, and improve the design level. Through the verification, the energy-saving effect is obvious, ensuring the implementation of the electrical energy-saving design.

2. Main causes of power waste in water conservancy projects

The electrical design of water conservancy project directly affects the economic efficiency and energy-saving effect of water conservancy project operation, so we must pay attention to the relevant electrical energy-saving design, but in the actual design process, there are many problems, which make the energy-saving effect of water conservancy project is greatly affected, which leads to the phenomenon of power waste.

2.1. Lack of electrical energy-saving design system for water conservancy projects

In the process of electrical energy-saving design of water conservancy projects, there are often some documents with insufficient standardization and poor consistency, and the corresponding rules and regulations are also lack of necessary perfection. Relevant rules and regulations need to be improved. In the process of electrical energy-saving design of water conservancy projects, there are often some documents with insufficient standardization and poor uniformity, as well as some earlier specifications. In the actual implementation process of the project, many construction units only consider the needs of their own units when carrying out water conservancy construction, resulting in the project electrical quality is not unified enough.

2.2. Backward energy-saving products

The application of energy-saving products in water conservancy projects lags behind. From the current construction situation of the water conservancy project, there is a situation that the capital investment and management are not in place, resulting in the actual procurement and installation process of products reduce the standard. In the process of electrical energy-saving design of water conservancy projects, various energy-saving products are often used according to the design needs. However, at present, the design of energy-saving products in many fields in China is not perfect, and even there are no relevant energy-saving products. At present, China has begun to pay attention to the energy-saving design of related projects, so a lot of money has been invested in the energy-saving design of the project, but the achievements are not so great. This is because many managers misappropriate their own funds and use conventional products to replace energy-saving products in order to reduce engineering costs. Many managers even use some products that should be eliminated as conventional equipment, and this equipment not only does not have the corresponding energy-saving effect, but also produce large energy consumption, which leads to the electrical energy-saving design of water conservancy projects is not ideal.

2.3. Energy saving consciousness of designers is not enough

In the electrical design of the water conservancy project, the designer's understanding is not enough. With the development of water conservancy projects, there are still some designers who have not changed their thinking, only pay attention to the needs and interests of construction, ignoring energy-saving design, resulting in energy waste. Therefore, as a professional designer, it is necessary to pay attention to energy saving in design and implement energy saving. Some designers pay more attention to the overall functional design of the system, but ignore the design of energy-saving. In this way, after the design is completed, although it can provide normal functions, it cannot achieve the purpose of energy-saving. Although designers attach great importance to the relevant functional design, they only consider the design specifications and design requirements of the project and ignore the influence of the surrounding environment and use factors. As a result, although the water conservancy project also has corresponding functions after the completion of the project, due to the lack of consideration of the needs of the surrounding users in the design, there are big problems in the power supply, and the enterprises and residents in the surrounding environment need to use electricity, which brings some inconvenience, which makes the engineering design unreasonable. Relevant rules and regulations need to be improved. In the process of electrical energy-saving design of water conservancy projects, there are often documents with insufficient standardization and poor uniformity, as well as some earlier specifications. The application of energy-saving products in water conservancy projects lags behind. From the current construction situation of the water conservancy project, there is a situation that the capital investment and management are not in place, resulting in the actual procurement and installation process of products reduce the standard.

3. Building data energy consumption model based on cloud computing

Due to improper energy-saving measures of water conservancy projects, it is likely to cause large-scale and large-scale power waste. In addition, as the main national policy in the new period, energy conservation and emission reduction, green environmental protection and energy-saving projects have long been included in the 12th Five Year Plan. However, the long-term high load of water conservancy projects leads to the occurrence of high-risk accidents such as a fire caused by overload, which is threatening people's life and property safety. Based on this, using the advantages of cloud computing to build water conservancy project energy consumption model, statistics of water conservancy project electrical consumption data, for energy-saving control preparation.

3.1. Setting electrical data environment of water conservancy project based on cloud computing

The Research scenario-focused in this paper is to set the electrical data environment of water conservancy projects based on cloud computing, which refers to the scheduling and management of virtual computing resources in cloud computing data centers for energy saving. Its operation and maintenance object is the virtualized data center infrastructure running MapReduce distributed computing load, and the focus is computing resource server providing IT services, which can be expressed as DC = $\{H_1,H_2,\ldots,H_N\}$. H_N refers to the computing node, that is, the physical server that provides computing power. In the data center of distributed computing, nodes are divided into computing nodes and storage nodes. Data and files are stored on storage nodes using a network file system (NFS). The physical host HN of the computing node is isomorphic and has the same computing resource capacity (CPU, memory, disk). The physical host runs heterogeneous virtual machines on it and is provided by VMware or Xen. Although the virtual machine is heterogeneous, it is not randomly heterogeneous. There are a certain number of virtual machine types defined in advance. The virtual machines in each type are isomorphic, and the resource occupancy is R.

In order to record and describe the current state in the cluster, a matrix is used to describe the state in the virtual cluster:

$$C_k = \begin{bmatrix} (R_1,1) & (R_2,1) & (R_3,1)\cdots \\ (R_2,2) & (R_3,2) & (0,2)\cdots \\ (0,3) & (0,3) & (0,3)\cdots \end{bmatrix} \quad (1)$$

Each row of the matrix represents the current state of a physical host, and each element of the matrix represents the virtual machine running on that host. Each element of the matrix has two parameters: the resource occupancy of the virtual machine *R* and the label of the physical host where the virtual machine is located (i.e., the row mark in the matrix). The sum of resource occupancy *R* of each element in each line represents the allocated resource amount of the physical host. If it is equal to, it means that there is no virtual machine running in an idle state on the host. The third line in the above formula indicates that the host is idle.

Distributed computing job is a typical application in the cloud computing environment, which is used to process and analyze large-scale data, such as data mining applications. Because the distributed computing method requires isomorphic computing nodes, the virtual machine resources allocated to a job in this paper belong to the same virtual machine type. The type of the virtual machine computing instance can be specified by the user or assigned by the management system. The computing jobs in the private cloud are predictable, and a considerable number of the same jobs are often executed. Therefore, this paper assumes that the job execution time can be estimated based on the historical data of previous jobs. The jobs in cloud computing are isolated and do not affect and preempt each other.

Finally, the virtual machine in the virtualization platform is used to complete cloud computing and set the electrical data environment of water conservancy projects. The virtual machine provides the function of real-time migration and realizes the migration which is transparent to users and has little impact on the quality of service. In the integrated cluster, the physical servers can be turned on and off, and the energy consumption of the shutdown or dormant servers is approximately zero. The job load in a cloud environment is dynamic and continuously arriving and leaving. Virtual machine migration can make full use of virtual machine migration to achieve more efficient resource aggregation. However, virtual machine migration brings time and energy costs, so it is necessary to reduce excessive frequent migration in dynamic resource placement strategy.

3.2. Realization of electrical energy consumption management system architecture of water conservancy project

Based on the above water conservancy engineering electrical data environment, an energy-saving independent management system architecture for the cloud computing virtualization cluster is proposed. The overall framework is shown in Fig. 1. Through centralized management, real-time monitoring of cluster operation status and online energy consumption analysis, and through monitoring data analysis modeling, formulate the corresponding scheduling strategy, so as to achieve self-management.

As shown in Fig. 1, the energy consumption management architecture mainly includes real-time cluster monitor, data analysis model, central control manager and managed virtual cloud computing cluster.

3.2.1. Real-time cluster monitor

The basic stage of cluster management is to collect and monitor the status data and application execution of the infrastructure. The cluster monitor is mainly responsible for collecting the real-time status data of the physical machines in the cluster and the virtual machines running on them, including the utilization rate, memory utilization rate, disk read-write rate and other performance data of the physical host and each virtual machine, and the performance

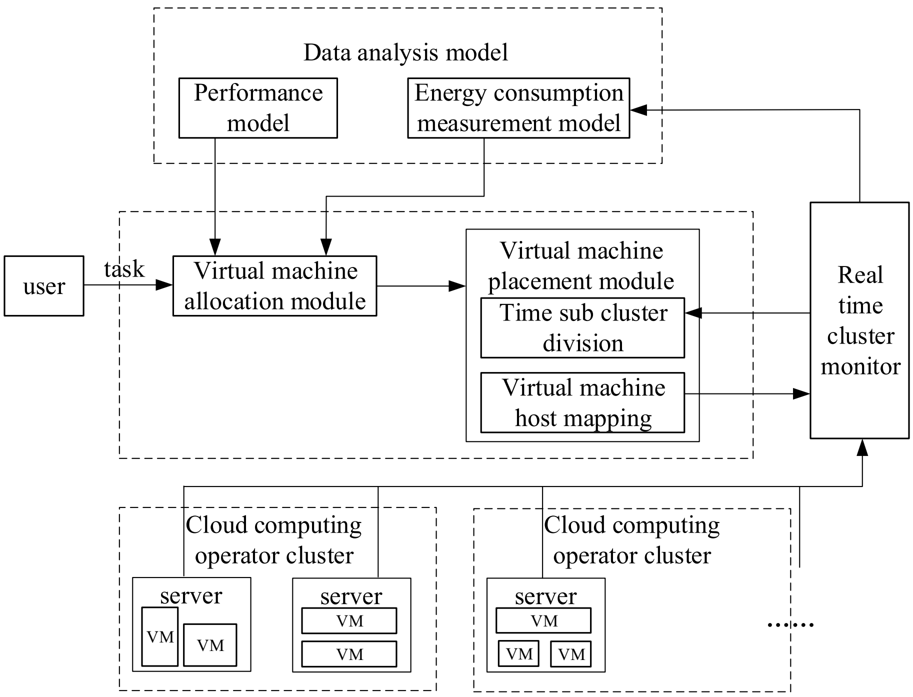

Fig. 1. Energy consumption management architecture.

data collected by the external power meter consumption of relevant data. Performance data can be collected through the tools provided by the operating system. The collected data are collated and summarized and transmitted to the data analysis model and central control manager, which is used to model the cluster state, provide effective data support for energy-saving management strategy, and evaluate the energy-saving strategy.

3.2.2. Data analysis model

The data analysis model establishes the energy consumption measurement model and performance model for the virtual cluster according to the cluster operation data collected by the cluster monitor.

Energy consumption measurement model: Because virtualization technology makes cluster management pay more attention to virtualization level, but the energy consumption value of virtual machine cannot be directly monitored by an external power meter, so the energy consumption management framework designs an energy consumption measurement model based on the performance data (CPU, memory, disk) of the virtual machine obtained by the above cluster monitor and the physical machine monitored by the power meter energy consumption value, the establishment of virtual machine energy consumption measurement model, and the use of historical data to complete the model training, is conducive to a better understanding of the energy consumption in the virtual cluster.

Performance model: When deciding to allocate resources for an application, the allocation solution should be obtained according to the trade-off between performance and energy consumption required by the application. Therefore, while building the energy consumption model, it is also necessary to analyze and model the performance of application execution. The data of performance model analysis comes from the number of allocated resources and execution time of an application recorded in the cluster monitor. In addition, different types of applications need to be modeled.

The central control manager mainly formulates an energy-saving optimization strategy, completes the virtual resource allocation strategy for tasks and deployment scheduling strategy for the cloud computing clusters. Therefore, the central control manager is mainly divided into virtual machine allocation modules and virtual machine placement modules. The virtual machine allocation module is mainly responsible for determining how much virtual resources are allocated to each job. The virtual machine placement module mainly controls the dynamic allocation of virtual machines to physical machines.

4. Energy saving algorithm classification and DVFS based energy saving algorithm for electrical energy consumption data of hydraulic engineering

4.1. Classification of energy-saving algorithms for electrical energy consumption data of water conservancy projects

Based on the energy management architecture, different classification standards often lead to different classifications for energy-saving mechanisms of cloud computing. In the power management stage, there is not only dynamic power management, but also static power management. In the stage of reducing the electrical energy consumption of water conservancy projects, combined with the closing and opening technology, pay attention to the application process of virtual machine technology [9,10]. For dynamic power management, idle energy consumption is often reduced; while for static power management, the energy consumption of task execution is often significantly reduced. Dynamic power management combines with the load status of a cloud system, pays attention to the change of time, and makes a dynamic adjustment of power state under the combination of performance requirements; while static power management mainly combines DVFS strategy to realize the energy-saving process of data in the analysis process of virtualization strategy [11].

4.2. Data-energy saving algorithm based on DVFS

The so-called DVFS is an energy-saving process of CPU power control. In the stage of CPU utilization, the power supply voltage of the CPU is reduced directly, and the performance of the CPU is reduced by combining with clock frequency. The dynamic power consumption of cubic order of magnitude in hydraulic engineering has no direct impact on the performance in the reduction stage [12]. DVFS has a certain significance in the application of mobile terminal equipment.

DVFS can reduce energy consumption significantly. When the computer runs the task, combined with the instruction and data-driven situation, it produces the direct analysis of energy consumption in the process of computer hardware operation. In the execution phase of this task, different execution power combined with different operation stages will produce various changes. In the process of reducing CPU voltage, it also pays attention to the effective combination of CPU execution power. However, DVFS data energy-saving algorithm often reduces the CPU voltage, and the CPU performance will be in a state of continuous decline.

4.3. Virtualization energy-saving algorithm and host off and on an energy-saving algorithm

4.3.1. Energy saving algorithm of virtualization

The application process of this technology is virtualization technology. The key technology of cloud computing, namely virtualization technology, is to create multiple virtual machines on the host, which can significantly reduce the use of hardware resources and improve resource utilization. This kind of virtualization application often needs to share the same computing nodes to fully realize the performance isolation [13]. The dynamic migration technology pays attention to the effective migration between virtual machine nodes. In the real-time reallocation stage of the virtual machine, it pays attention to the basic consolidation of dynamic load, and realizes the direct conversion of energy-saving mode in the process of merging a small number of physical nodes.

As for a virtual machine in the cloud data center, it is mainly combined with the form of units to do a good job in the allocation of electrical resources of water conservancy projects, and users can implement the service execution in the process of running the virtual machine [14,15]. In the deployment and migration phase, energy optimization is carried out in combination with a virtual machine in the center of the Transportation Bureau. The migration process of the virtual machine is shown in Fig. 2.

Through the development of a hierarchical energy consumption control system, in the application process of host level and user level subsystem, combined with the user's request, do a good job in the reasonable allocation of hardware resources. In the actual energy consumption process of the virtual machine, we should pay attention to the effective allocation of resources on the virtual machine layer, and effectively control the user's task energy consumption.

In the actual allocation process of virtual resources in the cloud computing environment, combined with the construction of a path, a high-efficiency allocation strategy is proposed. Combined with the restricted elite strategy, the basic resource allocation scheme optimized by the ant colony system is introduced to reduce the number of servers and the energy consumption of the system. In the process of reducing the number of servers, the dynamic migration of virtual machines and the closing of space computing nodes are effectively combined to improve the utilization of material resources and realize the balance of water conservancy project electricity.

The deployment process of a virtual machine is regarded as a global virtual machine. Assuming that the data allocation matrix of electrical energy consumption of water conservancy project is represented by $\mathbf{R}_g$, then:

$$\mathbf{R}_g = \left[R_{1,1},\cdots,R_{i,j},\cdots,R_{m,s}\right] \tag{2}$$

where j of virtual machine represents the process of data distribution of electrical energy consumption of water conservancy projects; i represents the amount of data allocation of electrical energy consumption of water conservancy projects. For the application of actual deployment conditions, the following conditions are met:

$$\forall h \in \{1,2,\cdots,n\}\, E_{v=1}^{l} P_{h,v} \times \mathrm{CPU}(v_v) \le \mathrm{CPU}(H_h) \tag{3}$$

$$\forall h \in \{1,2,\cdots,n\}\, E_{v=1}^{l} P_{h,v} \times \mathrm{mem}(v_v) \le \mathrm{mem}(H_h) \tag{4}$$

That is, the total amount of CPU and memory allocated to each virtual machine should be within the energy range of CPU and memory provided by the physical machine. The objective function is to maximize the number of idle physical machines Nidle:

$$\begin{aligned} &\max \quad \mathrm{Nidle} = \sum_{h=1}^{n} x_h \\ &\text{s.t.} \quad x_h = \begin{cases} 1 & \text{if} \quad \sum_{v=1}^{1} P_{h,v} \\ 0 & \text{otherwise} \end{cases} \end{aligned} \tag{5}$$

Virtualization technology not only improves the utilization of electrical resources in water conservancy projects, but also significantly reduces the execution energy consumption, but also increases the complexity of system management. In the stage of virtual machine provision and deployment, the form of a virtual machine is often combined with the mode of the virtual machine to realize the effective allocation of application task resources. Virtual machine deployment is often to realize the mapping between the virtual machine and physical host and pay attention to the data center policy-driven process in resource management.

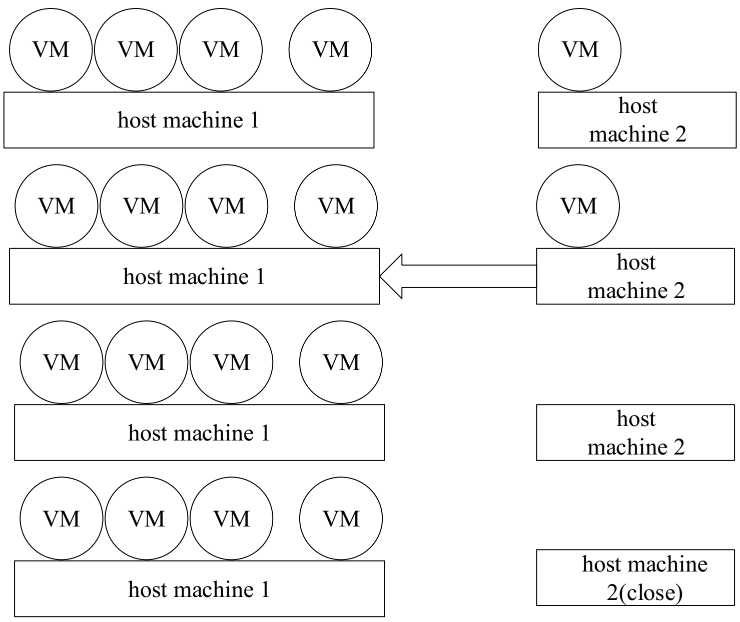

Fig. 2. An energy-saving method for virtual machine migration.

4.3.2. Energy saving algorithm of host off and on

In the process of energy saving, there are not only random strategies and timeout strategy, but also predictive strategies. In the process of server closing and opening, this random strategy combines with the basic model of stochastic optimization to control the algorithm reasonably. In the presetting stage, the overtime strategy mainly combines with the basic shutdown of the server mode to adjust the system load adaptively. A storage structure for data classification, as shown in Fig. 3.

The basic application of policy mode goal is to reduce idle energy consumption, but once the computer has a long start-up time, it also reduces the performance of the computer. In the process of the energy-saving algorithm, the computer system has the characteristics of self-similarity in the actual business request stage. This kind of energy-saving application is often combined with the virtual machine migration method, which can effectively eliminate a kind of idle energy consumption of space hosts in the prediction stage of load information.

5. Energy efficiency evaluation index of electrical energy-saving data center of water conservancy project

5.1. Energy efficiency evaluation based on the power utilization rate

Based on the above virtual machine algorithm, PUE (power usage effectiveness) is used as the standard to measure the energy efficiency level of water conservancy project data centers. PUE refers to the ratio of the comprehensive power consumption of the data center to the power consumption of IT equipment to reflect the proportion of computing resource energy consumption. Therefore, the smaller the PUE statistical value, the better. When the minimum value of PUE approaches 1, it indicates that the energy consumption of the data center is basically no waste.

The calculation formula of PUE is:

$$\text{PUE} = \frac{E^{\text{total}}}{E^{\text{IT}}} = \frac{E^{\text{IT}} + E^{\text{AC}} + E^{\text{UPS}} + E^{\text{other}}}{E^{\text{IT}}} \tag{6}$$

where E^{total} represents the total energy consumption of the electrical data center of water conservancy engineering; E^{IT} refers to the power consumption of IT equipment such as server, including server, storage equipment, network equipment, and auxiliary equipment, such as KVM, display, workstation used to monitor or control data center; E^{AC} refers to energy consumption generated by the refrigeration system, such as chiller, air conditioner in machine room, water pump and cooling tower E^{UPS} refers to the power consumption of power supply and distribution equipment, such as UPS, switchgear, generator, PDU, battery, etc.; E^{other} refers to the energy consumed by the lighting system, security system, elevator and other equipment.

When the energy consumption of IT equipment is further refined and divided into the effective energy consumption of IT equipment and ineffective energy consumption of IT equipment, data center energy productivity DCPE (Data Center Performance Efficiency) can be used for energy efficiency evaluation, because it is difficult in practical applications Separate the functional consumption and non-functional consumption of IT equipment, so DCPE is generally not used to evaluate the energy efficiency of data centers. The use of different energy-saving transformers selected can effectively reduce the energy consumption of the system and can also reduce the emission of pollution. Therefore, the appropriate energy-saving transformer must be selected in the process of electrical energy-saving design of water conservancy projects. When using electric energy utilization rate as an energy efficiency evaluation index, according to the comparison of no-load loss and load loss between the new energy-saving transformer and the ordinary transformer, the parameters of various types of transformers are shown in Table 1.

Combined with the data in Table 1, the energy-saving device is designed, and IGBT AC voltage regulation is adopted. In order to realize the real-time control of the system, 80C196KB single-chip microcomputer Dual CPU system is used. The dual CPU system consists of the following modules: two 80C196KB chips, memory and data buffer composed of EPROM, SRAM and dual-port RAM, decoding circuit, a/D conversion circuit, D/a conversion circuit, analog input circuit, output amplifier circuit, phase-locked loop circuit, key disk and display circuit. The structure of the dual CPU system is shown in Fig. 4.

5.2. Power switch design

In the electrical energy-saving design of the water conservancy project, it is very important to do a good job in the energy-saving design of the power switch for the whole water conservancy project. The power switch directly affects the energy supply of the whole system. The traditional power switch not only produces large noise, but also produces certain switching loss, which leads to the increasing frequency of the switch. In the process of power switch design, we should focus on soft switching technology, transfer the design center from hard switch design to soft switch design, and make full use of soft switching technology to reduce power switch energy consumption.

5.3. Energy saving design of electric lighting in water conservancy project

In the process of energy-saving design of electrical lighting in water conservancy projects, in addition to the visual

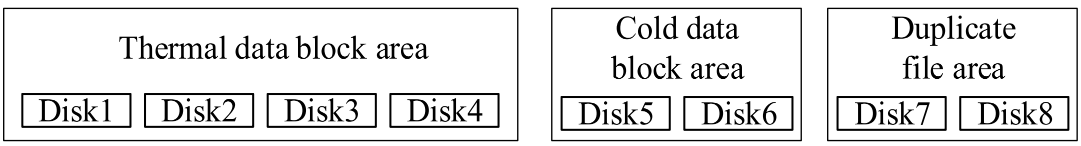

Fig. 3. A storage structure of data classification.

Table 1
Comparison of loss data between energy saving transformer and traditional transformer

Capacity	Common transformer		S9 energy saving transformer		S11 energy saving transformer	
	No load loss	Load loss	No load loss	Load loss	No load loss	Load loss
50	190	1,150	170	870	130	870
100	320	2,000	290	1,500	200	1,500
160	460	2,850	400	2,200	280	2,200
200	540	3,400	480	2,600	340	2,600
315	760	4,800	670	3,650	480	3,650
500	1,100	6,690	960	5,150	680	5,150
630	1,320	8,060	1,200	6,200	810	6,200

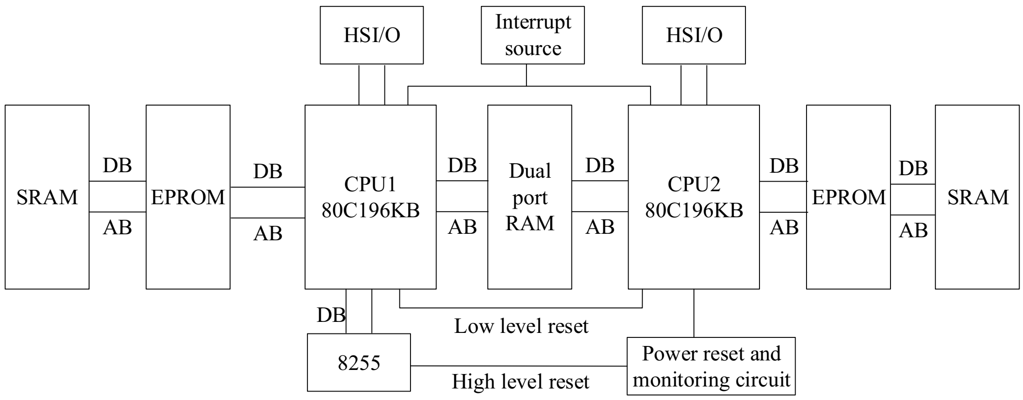

Fig. 4. Structure diagram of dual CPU system.

effect of lighting, the energy-saving effect of lighting must be considered. The lighting scheme should be designed reasonably according to relevant specifications and site work requirements. The main points of electrical lighting design are as follows:

5.3.1. Rational use of natural light

At present, there are still a lot of energy resources in nature, which are not fully used. Natural light belongs to one of them. Therefore, in the water conservancy project electrical lighting energy-saving design, should cooperate with the structural design, make full and reasonable use of natural light, reduce the layout and use time of artificial lighting, and effectively save the electric energy of artificial lighting.

5.3.2. High efficient light source should be selected in lighting design

The energy-saving effect of the light source depends on the luminous efficiency of the light source. In the lighting design, high-efficiency energy-saving light sources should be selected according to the place of use. For example, LED light source with an obvious energy-saving effect at this stage has gradually become the mainstream because of its high luminous efficiency, good color rendering and convenient start-up.

5.3.3. Adopt high efficiency and energy-saving lighting

Lighting lamps with energy-saving effects shall be selected. Scientific and reasonable lamps can effectively realize the reasonable distribution of light sources and maintain high luminous flux. High-quality and efficient lighting can achieve a better energy-saving effect.

6. Discussion

6.1. Optimization strategy of energy-saving design for water conservancy and electrical engineering

6.1.1. Comprehensively check, strengthen quality control and improve the comprehensive quality of personnel

In the electrical optimization design of water conservancy projects, the first thing to do is to do the relevant design scheme, and excellent scheme design cannot do without experienced designers, the smooth implementation of the scheme cannot do without the staff with solid basic skills and knowledge. Therefore, in the related water conservancy project electrical optimization design, the first thing to grasp is the personal quality of the staff. In the process of electrical optimization design of water conservancy project, experienced designers are selected to carry out relevant scheme design. After the design is completed, the feasibility analysis of the relevant scheme is done. After the scheme is confirmed to be feasible, the design of the installation scheme is carried out for construction. The construction personnel should have corresponding construction experience and cannot find ordinary workers casually, and should ensure that the construction personnel has the corresponding qualification certificate. In addition to having enough management experience, the relevant managers should also have good personal quality and moral quality, be able to adhere to their own principles in front of money and take engineering quality as the ultimate pursuit.

6.1.2. Do a good job in data collection and management

Before proceeding with the electrical optimization design of a water conservancy project, the first thing to do is to collect the data of the project. Before proceeding with the design, you must first understand the specific conditions of the design area, the specific scale and accurate parameters of the project. Only in this way can you ensure that the relevant design has rationality, not just talking about it. Only the design of basic realistic parameters has certain feasibility. In this regard, the specific parameters and data of the project should be collected before the design, and specific investigation and analysis of the climate, hydrology, geology and other environmental data of the project area should be carried out to ensure accurate data. Relevant energy-saving requirements and seismic index for engineering requirements are reflected in the plan through relevant calculations and designs, so as to achieve the relevant design requirements to the greatest extent and make the design plan more accurate and reliable.

6.1.3. Implement effective bidding management for survey and design

In order to improve the design level, we should actively implement the bidding management of survey and design, and implement the bidding management system by optimizing design institutions. The goal is to effectively prevent professional monopoly through the competition management system and to select the most qualified and reputable construction party to implement engineering design with the help of bidding management, so as to prevent the problem of design agency being dominant. Moreover, it can make the designer form a sense of crisis, and encourage the staff to have initiative and enthusiasm, so as to do a good job in the optimization design of the scheme. Once the design scheme is completed, it should be evaluated and reviewed by experts. For the design scheme that does not meet the requirements and the design quality is not high, we should propose a new proposal to improve the comprehensive benefits of quality control.

6.2. Other energy-saving algorithms

The cooling system accounts for about 40% of the total energy consumption of the cloud data center. The high-speed operation of computing resources leads to the rise of equipment temperature. The too high temperature will not only reduce the reliability of the data system, but also reduce the life cycle of the equipment. Therefore, it is necessary to cool the cooling equipment of the cloud data center and effectively reduce the cooling energy, which is of great significance to the stable operation and power saving of the cloud data center.

Prasetya et al. [16] propose to take into account the data center cooling system, install variable speed fans and temperature sensors in the server, and adjust the fan speed according to the temperature of the server, which not only ensures safety but also saves power.

Zhu et al. [17] propose that the instruction data flow of the data center includes temperature sensor data, server instructions, and air conditioning unit data in the data center space. This paper analyzes these data flows and proposes a simple and flexible model, according to given load distribution and the cooling system configuration can predict the heat distribution of the data center, and then statically or manually configure the heat load management system.

Cohen [18] proposed a data center-level power and hotspot management solution. The PTM (power and thermal management) engine determines the location of the number of active servers while adjusting the cooling temperature provided to improve the energy efficiency of the data center.

Chu et al. [19] propose a fine way to control the fan in the data center. The fan on each rack adjusts the fan according to its own thermal system, hardware usage rate and other information.

Hsu and Hefeeda [20] comprehensively considers factors such as space size, rack and fan placement, and airflow direction, and proposes a multi-level data center cooling equipment design idea, and models and simulates airflow and heat exchange. Provide theoretical support for data center layout.

In addition, after the completion of the data center, dynamic cooling strategies can be used to reduce energy consumption. For example, for servers that are sleeping, some refrigeration facilities can be appropriately shut down or the direction of air-conditioning can be changed to save costs [21]. In reference to the problem of unbalanced heat distribution in cloud data centers, Zinner et al. [22] proposed for the first time to use wireless multimedia sensor networks (WMSNs) to monitor local hot spots in real-time, and use methods such as task migration to reduce the heat load in the hot spots. "Positioning-feature extraction-hot spot elimination" is the mainline to achieve the purpose of balancing heat distribution and improving cooling efficiency [23–28].

In addition, dynamic component deactivation (DCD) is also an important energy-saving method used on hardware.

The disadvantage of Deformable Parts Model (DPM) is that if the load is always in the peak state, the power consumption cannot be reduced.

The comparison of energy-saving algorithms in the cloud data center is shown in Table 2.

7. Energy saving effect of double CPU system for three-phase asynchronous motor

In order to verify the energy-saving effect of a double CPU system of a three-phase asynchronous motor designed based on cloud computing, the method of combining computer numerical calculation and motor experiment is adopted. Table 3 shows the results of computer calculation [29].

From the calculation results, it can be seen that for the same kind of motor, the lower the load rate is, the more obvious the no-load is, the lower the optimal voltage

Table 2
Comparison results of energy saving algorithms in cloud data center

Literature/strategy	Virtualization	Target system	System resource	Optimization objectives	Energy saving strategy
Lowest-DVFS	√	Real-time system	CPU	Execution energy consumption	DVFS, DPM
δ-advanced-DVFS	√	Real-time system	CPU	Execution energy consumption	DVFS, DPM
Adaptive-DVFS	√	Real-time system	CPU	Execution energy consumption	DVFS, DPM
Literature [16]	×	Cluster system	CPU	Idle energy consumption	Off/On, DPM
Literature [17]	√	Server system	CPU	Idle energy consumption	Off/On, DPM
Literature [18–22]	–	–	Equipment	Equipment energy consumption	Statistical Parametric Mapping

Table 3
Computer calculation results of optimum voltage regulation coefficient

Electric machinery	Load + rate (m)	Voltage regulation coefficient (Ku)	Energy saving rate (Y)	sinφ1	cosφ1	sinφ	cosφ
2.2 kW	0.10	0.60155	0.54876	0.96297	0.26962	0.78943	0.61384
$K_m = 2.2$	0.13	0.70859	0.41218	0.94964	0.31336	0.80857	0.58840
$K_0 = 0.33$	0.15	0.77382	0.32306	0.93493	0.35482	0.82435	0.56608
$r_1 = 3.62$	0.17	0.83457	0.23711	0.91916	0.39389	0.83738	0.54662
$r_2 = 0.6$	0.19	0.89120	0.15556	0.90259	0.43051	0.84817	0.52972
11 kW	0.10	0.46049	0.48630	0.96903	0.24695	0.60505	0.79619
$K_m = 2.2$	0.13	0.54040	0.37715	0.94964	0.31336	0.63169	0.77523
$K_0 = 0.33$	0.15	0.59085	0.31321	0.93494	0.35482	0.64868	0.76106
$r_1 = 0.29$	0.17	0.63908	0.25766	0.91916	0.39389	0.66460	0.74721
$r_2 = 0.011$	0.19	0.68514	0.20887	0.90259	0.43051	0.67925	0.73391
22 kW	0.10	0.39246	0.33797	0.96903	0.24695	0.52188	0.85302
$K_m = 2.2$	0.13	0.45761	0.21030	0.94964	0.31336	0.53807	0.84290
$K_0 = 0.33$	0.15	0.49918	0.14447	0.93493	0.35482	0.54954	0.83547
$r_1 = 0.201$	0.17	0.53941	0.09174	0.91916	0.39389	0.56114	0.82772
$r_2 = 0.065$	0.19	0.57829	0.05015	0.90259	0.43051	0.57260	0.81983

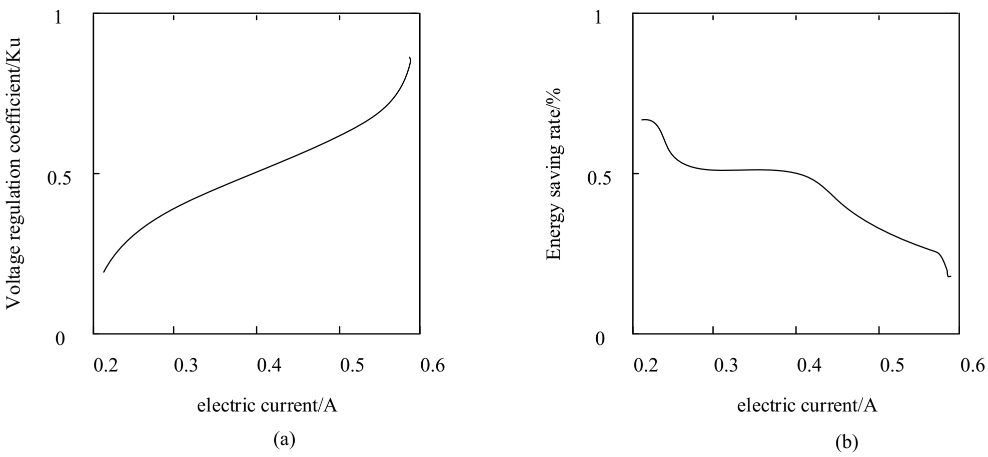

Fig. 5. Energy-saving effect of double CPU system of the three-phase asynchronous motor (a) Three-phase stator current voltage regulation results and (b) energy saving effect of three-phase stator current.

regulation coefficient is, and the better the energy-saving effect is; And compared with the high-power motor, the lower the power, the better the no-load voltage regulation effect of the motor with lower power. At the same time, the energy-saving device has been tested on a three-phase asynchronous motor. The three-phase stator current is collected by a microcomputer and the experimental results are shown in Fig. 5 [30].

It can be clearly seen from the experiment that the voltage regulation effect of the double CPU system of a three-phase asynchronous motor is gradually rising, and the energy-saving effect is obvious [31].

8. Conclusions

This paper studies the electrical energy-saving control method of water conservancy projects based on cloud computing analyzes the necessity of electrical energy-saving design in water conservancy projects and proposes to optimize the energy-saving design of water conservancy projects from the aspects of designers and equipment. Finally, the design of a dual CPU system of the three-phase asynchronous motor based on Cloud Computing is completed. In order to verify the energy-saving effect, the design experiment proves that the energy-saving effect is obtained. The results are obvious, which can provide a reference for improving the operation effect of water conservancy projects. But because this paper focuses on the analysis of other water conservancy engineering electrical energy-saving control methods, in order to carry out an in-depth exploration of the design system in this paper, such as the stability of operation, is the future research direction.

Acknowledgment

The research is supported by: Key R&D plan of Zibo City: Intelligent Water IoT cloud service platform of "Zishui Online" (NO. 2019ZBXC246).

References

[1] X. Zhu, Research on electrical energy saving design of water conservancy project, Sci. Technol. Vision, (2019) 10 181–182.
[2] H. Lou, Massive ship fault data retrieval algorithm supporting complex query in cloud computing, J. Coastal Res., 93 (2019) 1013–1018.
[3] H. Bai, H. Shi, Q. Zhang, L. Bai, Research on control method of tidal power generation simulator based on LabVIEW, Electric. Eng., 19 (2018) 5–9.
[4] J. Meshkati, F. Safi-Esfahani, Energy-aware resource utilization based on particle swarm optimization and artificial bee colony algorithms in cloud computing, J. Supercomputing, 75 (2019) 2455–2496.
[5] C. Yang, L. Li, S.X. You, B.J. Yan, X. Du, Cloud computing-based energy optimization control framework for plug-in hybrid electric bus, Energy, 125 (2017) 11–24.
[6] S. Vila, F. Guirado, J.L. Lerida, F. Cores, Energy-saving scheduling on IaaS HPC cloud environments based on a multi-objective genetic algorithm, J. Supercomputing, 75 (2018) 1–13.
[7] M. Zhang, W. Wang, J. Shi, D. Zhao, Optimization of dispatching cloud based on power big data, Comput. Simul., 31 (2014) 123–126+137.
[8] A. Hameed, A. Khoshkbarforoushha, R. Ranjan, P. Prakash Jayaraman, J. Kolodziej, P. Balaji, S. Zeadally, Q.M. Malluhi, N. Tziritas, A. Vishnu, S.U. Khan, A. Zomaya, A survey and taxonomy on energy efficient resource allocation techniques for cloud computing systems, Computing, 98 (2016) 751–774.
[9] T. Yang, M. Wang, Y. Zhang, Y. Zhao, H. Pen, HDFS differential storage energy-saving optimal algorithm in cloud data center, Chin. J. Comput., 42 (2019) 721–735.
[10] Z.H. Lv, W.Q. Xiu, Interaction of edge-cloud computing based on SDN and NFV for next generation IOT, IEEE Internet Things J., 7 (2020) 5706–5712.
[11] Z. Zhou, Z. Hu, Virtual machine deployment algorithm for reducing energy consumption in cloud computing, J. South China Univ. Technol. (Natural Science Edition), 42 (2014) 109–114.
[12] J. Jiang, Y. Liu, L. Wang, J. Chen, N. Huang, X. Wei, VM selection energy-efficiency algorithm based on heuristic backward artificial bee colony method in data clouds, J. Jilin Univ. (Science Edition), 52 (2014) 1239–1248.
[13] X. Zhang, Z. He, C. Li, H. Zhang, Q. Qian, Research on energy saving algorithm of datacenter in cloud computing system, Appl. Res. Comput., 30 (2013) 961–964+970.
[14] B. Ni, Energy efficient data placement algorithm and node scheduling strategy of cloud computing system, Mod. Electron. Tech., 38 (2015) 80–82.
[15] E.E. Okon, J.O. Ikeh, C.J. Offodile, Near - surface characterization of sediments of the Sokoto group exposed around Wamakko Area, Northwestern Nigeria: an integrated approach, Geol. Ecol. Landscapes, 5 (2021) 81–93.
[16] J.D. Prasetya, D.H. Santoso, E. Muryani, T. Ramadhamayanti, B.A.S. Yudha, Carrying capacity of mercury pollution to rivers in the gold mining area of Pancurendang Village, Banyumas, J. Clean WAS, 5 (2021) 1–4.
[17] D.L. Zhu, B. Wang, H.R. Ma, H.X. Wang, Evaluating the vulnerability of integrated electricity-heat-gas systems based on the high-dimensional random matrix theory, CSEE J. Power Energy Syst., 6 (2020) 878–889.
[18] Z. Zhao, J. Gao, Robustness of water hammer protection of different formulas of frictional head loss, Desal. Water Treat., 187 (2020) 172–177.
[19] Y.-H. Chu, J. Chuang, H. Zhang, A Case for Taxation in Peer-to-Peer Streaming Broadcast, Proc of ACM SIGCOMM Workshop Practice Theory Incentives Networked Systems, ACM Press, New York, 2004, pp. 205–212.
[20] C.H. Hsu, M. Hefeeda, Achieving Viewing Time Scalability in Mobile Video Streaming Using Scalable Video Coding, Proc. of the 1st Annual ACM Conference on Multimedia System, ACM Press, New York, 2010, pp. 111–122.
[21] N. Cranley, P. Perry, L. Murphy, User perception of adapting video quality, Int. J. Hum. Comput. Stud., 64 (2006) 637–647.
[22] T. Zinner, O. Hohlfeld, O. Abboud, T. Hossfeld, Impact of Frame Rate and Resolution on Objective QoE Metrics, Proc. of the 2010 Second International Workshop on Quality of Multimedia Experience (QoMEX), IEEE, Trondheim, Norway, 2010, pp. 29–34.
[23] J.M. Monteiro, M.S. Nunes, A Subjective Quality Estimation Tool for the Evaluation of Video Communication Systems, Proc. of the 12th IEEE Symposium on Computers and Communications, July 1–4, Aveiro, Portugal, 2007, pp. 75–80.
[24] K.D. Singh, A. Ksentini, B. Marienval, Quality of Experience Measurement Tool for SVC Video Coding, Proc. of 2011 IEEE International Conference on Communications (ICC), IEEE, Kyoto, Japan, 2011, pp. 1–5.
[25] N. Gao, Y.Y. Zhang, A low frequency underwater metastructure composed by helix metal and viscoelastic damping rubber, J. Vibr. Control, 25 (2019) 538–548.
[26] H.N. Yu, S.H. Shen, G.P. Qian, X.B. Gong, Packing theory and volumetrics-based aggregate gradation design method, J. Mater. Civ. Eng., 32 (2020), doi: 10.1061/(ASCE)MT.1943-5533.0003192.
[27] J.K. Liu, Y.Q. Yi, X.T. Wang, Exploring factors influencing construction waste reduction: a structural equation modeling approach, J. Cleaner Prod., 276 (2020) 123185, doi: 10.1016/j.jclepro.2020.123185.
[28] X.Q. Han, D. Zhang, J.J. Yan, S.R. Zhao, J.P. Liu, Process development of flue gas desulphurization wastewater treatment in coal-fired power plants towards zero liquid discharge: energetic, economic and environmental analyses, J. Cleaner Prod., 261 (2020) 121144, doi: 10.1016/j.jclepro.2020.121144.
[29] X.F. Hu, P.H. Ma, B.B. Gao, M. Zhang, An integrated step-up inverter without transformer and leakage current for grid-connected photovoltaic system, IEEE Trans. Power Electron., 34 (2019) 9814–9827.
[30] X.F. Hu, P.H. Ma, J.Z. Wang, G.D. Tan, A hybrid cascaded DC–DC boost converter with ripple reduction and large conversion ratio, IEEE J. Emerging Sel. Top. Power Electron., 8 (2019) 761–770.
[31] S. Liu, F.T.S. Chan, W.X. Ran, Decision making for the selection of cloud vendor: an improved approach under group decision-making with integrated weights and objective/subjective attributes, Expert Syst. Appl., 55 (2016) 37–47.