ЕКОЛОГІЯ ПРОГРАМНОГО ЗАБЕЗПЕЧЕННЯ

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GREENING OF INFORMATION TECHNOLOGIES TECHNIC

The concept of sustainable development is the realization of the idea, which now and in the near future will play a key role in the development of global community. Practical introduction of sustainable development in human life is made by through information technology. Greening of knowledge and experience associated with the spread to the information technology the general principles and requirements of environmental applications, production and use of technical objects of sustainable development. Such information technologies are called green. The problems of Green IT is divided into three components: organization of "green enterprise", including optimization of supply, improvement of production cycle, using video-conferences and mobile devices in order to reduce the need for movement of staff; minimizing of physical pollution of environment; minimizing energy costs of data centers and personal computer systems.

It is necessary to make the procedure "greening" for the entire IT industry. The process of planting should be done by producing innovative solutions for technology. One of these solutions is a method of greening that is offered in the article. Greening of information technology consists of the following stages: monitoring – carried out the study of environment for greening, defined elements that are not green; planning - planned activities for greening. The means to eliminate defects are chosen to address issued that were identified in the previous step; implementation – performing of actions that were planned; assessment - assessing the results of greening techniques.

The following conclusions could be made. There are two type of stimulus for greening. First, greening for reputation. Reputation plays important role for them. Therefore, in such companies greenness and energy saving can be used as a means of improving the company's image. Second, the ratio of effort. It seems that electricity bills in the company are small compared with other expenses. As for other technic of greening, it is important for companies that effort and money spent on greening is justified.

Концепція сталого розвитку є реалізація ідеї, яка в даний час і в найближчому майбутньому буде відігравати ключову роль у розвитку світової спільноти. Практичне впровадження сталого розвитку в житті людини виробляється за допомогою інформаційних технологій. Озеленення знань і досвіду, пов'язаних з розповсюдженням в області інформаційних технологій загальні принципи та вимоги екологічних застосувань, виробництва і використання технічних об'єктів сталого розвитку. Такі інформаційні технології називають зеленим. Проблеми Green IT складається з трьох компонентів: організація «зеленого» підприємства, в тому числі оптимізації харчування, поліпшення виробничого циклу, використовуючи відео-конференцій та мобільні пристрої для того, щоб зменшити потребу в русі персоналу; мінімізація фізичної забруднення навколишнього середовища; мінімізація енергетичних витрат центрів обробки даних і персональних комп'ютерних систем.

Це необхідно зробити процедуру «озеленення» для всієї IT-індустрії. Процес посадки повинно бути зроблено шляхом створення інноваційних рішень для технології. Одним з таких рішень є спосіб озелененні, який пропонується в статті. Озеленення інформаційних технологій складається з чотирьох етапів: моніторинг – здійснюється вивчення навколишнього середовища для озеленення, визначається елементами, що не зелений; планування - заплановані заходи для озеленення. Засоби для усунення дефектів обрані адреси, видане які були визначені в попередньому кроці; реалізація – проведення заходів, які були заплановані; оцінка – оцінка результатів методів озеленення.

Наступні висновки можуть бути зроблені. Є два типи стимулів для озеленення. По-перше, озеленення для репутації. Репутація відіграє важливу роль для них. Тому, в таких компаніях зелені та економії енергії може бути використаний як засіб поліпшення іміджу компанії. По-друге, ставлення зусиль. Здається, що рахунки за електрику в компанії малі порівняно з іншими витратами. Що стосується інших методів озеленення, важливо для компаній, які зусилля і гроші, витрачені на озеленення є виправданим.

Концепция устойчивого развития является реализация идеи, которая в настоящее время и в ближайшем будущем будет играть ключевую роль в развитии мирового сообщества. Практическое внедрение устойчивого развития в жизни человека производится с помощью информационных технологий. Озеленение знаний и опыта, связанных с распространением в области информационных технологий общие принципы и требования экологических применений, производства и использования технических объектов устойчивого развития. Такие информационные технологии называют зеленым. Проблемы Green IT состоит из трех компонентов: организация «зеленого» предприятия, в том числе оптимизации питания, улучшения производственного цикла, используя видео – конференций и мобильные устройства для того, чтобы уменьшить потребность в движении персонала; минимизация физической загрязнения окружающей среды; минимизация энергетических затрат центров обработки данных и персональных компьютерных систем.

Это необходимо сделать процедуру «озеленение» для всей ИТ-индустрии. Процесс посадки должно быть сделано путем создания инновационных решений для технологии. Одним из таких решений является способ озеленении, который предлагается в статье. Озеленение информационных технологий состоит из четырех этапов: мониторинг – осуществляется изучение окружающей среды для озеленения, определяется элементами, которые не зеленый; планирование - запланированные мероприятия для озеленения. Средства для устранения дефектов выбраны адреса, выданное которые были определены в предыдущем шаге; реализация – проведение мероприятий, которые были запланированы; оценка - оценка результатов методов озеленения.

Следующие выводы могут быть сделаны. Есть два типа стимулов для озеленения. Во-первых, озеленение для репутации. Репутация играет важную роль для них. Поэтому, в таких компаниях зелени и экономии энергии может быть использован в качестве средства улучшения имиджа компании. Во-вторых, отношение усилий. Кажется, что счета за электричество в компании малы по сравнению с другими расходами. Что касается других методов озеленения, важно для компаний, которые усилия и деньги, потраченные на озеленение является оправданным.

Keywords: *information technologic, sustainable development, green IT, data centers.*

Introduction

The concept of sustainable development is the realization of the idea, which now and in the near future will play a key role in the development of global community. Practical introduction of sustainable development in human life is made by through information technology. Greening of knowledge and experience associated with the spread to the information technology the general principles and requirements of environmental applications, production and use of technical objects of sustainable development. Such information technologies are called green (Green IT) [1].

Statement of the problem and state of research

The problems of Green IT is divided into three components [2]:

- organization of "green enterprise", including optimization of supply, improvement of production cycle, using video-conferences and mobile devices in order to reduce the need for movement of staff;
- minimizing of physical pollution of environment;
- minimizing energy costs of data centers and personal computer systems.

Nomination of green IT industry at the forefront of management practices makes it an active player in sustainable economic development. This requires the propagation of policy of innovation, reducing of negative impact of the users and infrastructure and most software applications on the environment. By the way of experience accumulation, the usage of outsourcing software development, efficient logistics, efficient recycling of old equipment. It is necessary to make the procedure "greening" for the entire IT industry. The process of planting should be done by producing innovative solutions for technology. One of these solutions is a method of greening that is offered in the article.

Metodic of “Greening”

Information technologies have an impact on the environment at all stages of their life cycle, that is why to achieve "greenness" of information technologies it is necessary to pay attention to all stages of the life cycle.

Greening of information technology consists of four stages:

1. Monitoring – carried out the study of environment for greening, defined elements that are not green;
2. Planning - planned activities for greening. The means to eliminate defects are chosen to address issued that were identified in the previous step;
3. Implementation – performing of actions that were planned;
4. Assessment - assessing the results of greening techniques.

Implementation of green IT is made for the following sectors: offices; equipment; data centers.

Electricity is used for lighting, heating and cooling. Users uses electricity for personal computers and accessories. Servers use electricity for work and cooling. Data centers are the largest energy consumers in information technology. They use a lot of power for operation and cooling.

Quantitative technic of empirical software engineering, interviewing, data modeling, visualization, questionnaireare used in methodology [3].

Components of greening techniques

Monitoring. In the first stage "greening" information technology necessary to collect information on the current state estimate the equipment and technology used. Also, find out the commitment of the management and all its employees to "green" ideas.

Thus it is necessary to assess the following:

- The amount of equipment, identify equipment which are not necessary.
- Equipment for its energy efficiency standards compliance (Energy Star);
- The level of power consumption.

Further, it is necessary to conduct a survey for managers in order to identify the status of "green" practices. Proposed the following list of questions for the survey:

1. Is there a person engaged in energy-saving in the company?
2. Is energy-efficient office lighting used?
3. Is training on energy efficiency conducted among employees?
4. Is equipment turned off when not used?
5. Is the equipment turned off at night and on weekends?
6. Where "greenness" of equipment taken to account during purchase?

7. If old equipment is send to recycling?

8. Does the company established and announced targets for energy efficiency, energy conservation and reducing of carbon emissions?

9. Does the company have programs that encourage or require employees to adhere to the principles of energy saving (turn off equipment etc.)?

10. Does the company encourage its employees to show initiative on energy efficiency?

11. If company encourage employees to use teleconferencing to reduce expenses for transportation?

12. Does the company offer the possibility of virtual offices and remote work?

13. If thin clients are used and whether their usage is planned?

14. If enterprise electronic document management system is used?

15. Does the enterprise uses double sided printing?

Separately, a list of questions for IT managers:

1. If power saving modes are used for equipment?

2. If virtualization servers is used?

3. If placement optimization equipment in the data center is used?

4. If virtualization in the data center are used?

5. If the optimization of cooling systems in the data center are used?

6. If premises allocated for that data center was chosen taking into account the need for cooling it?

7. If IT professionals get information on electricity consumed?

8. If IT professionals have plan to reduce energy consumption?

9. If equipment and data center energy consumption are used?

10. Is the temperature sensors installed in the data center?

11. If were Measured and estimated power consumption of the data center?

12. Does the data center established system of automatic control of heating, ventilation and air conditioning?

13. Does the company use electricity from alternative sources?

14. Does the company use cooling system in which used external cold air.

After survey the assessment of monitoring is made.

Planning After monitoring - the results are presented to company management. The necessity and feasibility of certain practices and a plan of action that will be used in the enterprise is discussed. Discussion and planning takes place for each of the issues that were examined in the analysis of monitoring explaining their merits and prospects. For example, proposed the following list of tasks planning with relevant comments.

1. Assess equipment for its correspondence with energy saving standards (Energy Star).

Energy Star marked equipment uses 30% less energy than without it [1]. In the equipment with the marking energy consumption is reduces and implemented energy-saving which turns off the device when not in use.

2. Asses the amount of equipment, identify equipment which are not necessary.

If you find that there is a piece of equipment that is idle and not being used, or instead of several pieces of equipment can be used only one, then using it can be waived. It will immediately begin to save energy.

3. Assess the level of power consumption.

Equipment for measuring energy consumption and compared with the standard. If any equipment is not labeled Energy Star mark and consumes a lot of electricity, it is necessary to evaluate the possibility of its replacement by a new more modern. In the long run it saves money and reduces energy consumption.

1. Is there a person engaged in energy-saving in the company?

If the company have no person who is responsible for energy efficiency, it is necessary to assign it. Otherwise it will be difficult to monitor, evaluate and implement energy saving.

2. Is energy-efficient office lighting used?

Office using energy saving lamps, motion sensors on the steps that include light only when needed can store a large amount of electricity.

3. Is training on energy efficiency conducted among employees?

Often if workers even want to save electricity - they do not know how. Lectures and workshops on energy efficiency will enable workers to gain knowledge on energy saving, and gain practical experience in their application. These trainings may relate to the use of standby, sleep, off computers when not in use. Use different power saving modes, and more.

4. Is equipment turned off when not used?

Even if the equipment is not turned on, but plugged in - it uses electricity. Equipment in standby mode consumes up to 10% of all electricity. So turning it off can save up to 10% of electricity. If the equipment is on but not in use, turning it off will make even greater savings.

5. Is the equipment turned off at night and on weekends?

Most computers in offices are left on for the night. That is from six in the evening until eight in the morning when equipment consumes electricity but not used. That is about 12 hours of inactivity.

Half time just idle equipment. Turning it off can save a significant amount of electricity.

6. Where "greenness" of equipment taken to account during purchase?

Equipment has impact on the environment both during use and during its production. Therefore, the purchase of equipment necessary to pay attention to both parameters. The person responsible for purchasing of equipment must take into account the following parameters:

- Reduced or no use of toxic materials;
- The ability to recycling;
- Reduced use of materials;
- Energy efficiency;
- Extended lifetime of equipment as well as the possibility of upgrading;
- Reduced packaging;
- Packaging with recyclable material;
- The possibility of recycling at the end of the life cycle.

Taking into account these parameters equipment must be chosen so that it produces the least impact on the environment.

7. If old equipment is send to recycling?

The problems of e-waste, which includes old computers, monitors and other equipment rises more and more. The volume of waste is increasing. Therefore, to reduce its amount it is necessary to send waste equipment to disposal and recycling

8. Does the company established and announced targets for energy efficiency, energy conservation and reducing of carbon emissions?

The presence of specific goals will enable the company and its employees to keep focus on the issues of green IT. This will help to adequately implement green IT.

9. Does the company have programs that encourage or require employees to adhere to the principles of energy saving (turn off equipment etc.)?

In addition to existing of energy-saving technic, it is necessary to use them. Availability of these programs will encourage each employee responsible attitude to energy saving. Through this program developed initiatives will be implemented effectively..

10. Does the company encourage its employees to show initiative on energy efficiency?

In addition to creating top initiatives it is necessary to focus on individual initiative of employees. This will help to additionally save.

11. If company encourage employees to use teleconferencing to reduce expenses for transportation?

Information technology consumes 2% of the energy in the world [2]. However, they save energy in other areas. For example, transport - by information technology accessible things such as newsgroups, e-mail, electronic documents. Encouraging employees to use teleconferencing will save transportation budget and therefore fuel use and emissions of gases into the atmosphere.

12. Does the company offer the possibility of virtual offices and remote work?

This question concerns the same topics as the previous one. Often, transportation to work and back takes a lot of time and fuel. Standing in traffic jams takes time and money. Combusted fuel contaminates atmosphere. With the power of remote and virtual offices can avoid it, and keep place in the office.

13. If thin clients are used and whether their usage is planned?

Using thin clients saves resources and money. And they should be used where possible and appropriate [3].

14. If enterprise electronic document management system is used?

For the production of paper needed wood. 90% of the paper, is energy that has been spent on its production and transportation. The transition to electronic document is a vivid example when information technology will not only reduce the impact on nature, but also completely avoid it. An example implementation of electronic documents in the faculty of Computer Science of the National Aviation University which was introduced several innovations that allow maximum renounce the use of paper:

Microsoft Share Point which provides the ability to exchange of documents.

Individual laptops of each student, allows to pass laboratory works, to show results of programs and reports directly with notebook displays.

According to rough estimates 500 people prints every day in the reports for 10 pages, 20 days per month and 8 months of study. 500h10h20h8 5000h160 = 800 = 000 pages or 1,600 reams of paper annually. (16000h30 = UAH 48000 USD). The introduction of electronic workflow saves significant costs and considerable resources.

15. Does the enterprise uses double sided printing?

If it is impossible to totally exclude printing – double side printing could be used. It saves half of the paper.

Discussion and planning for IT managers carried out the following questions

1. If power saving modes are used for equipment?

Using energy saving regulates energy consumption of computers, depending on their level of load, and equipment that switched into different power saving modes when not using - save electricity. To assess the potential savings it is necessary to compare energy consumption of

computer using power saving modes, and without it.

2. If virtualization servers is used?

Server virtualization would reduce the number of necessary equipment and reduce the need to buy new equipment in the event of enlargement.

3. If placement optimization equipment in the data center is used

Placement of equipment in the data center can influence the effectiveness of cooling. If the optimization of placement were not considered - they need to be considered.

4. If virtualization in the data center are used?

Also, virtualization can take placed in the data center. In addition to these things for servers - for data center also very important the conservation of area. When to free additional space. And also due to fewer equipment it will lower costs for cooling.

5. If the optimization of cooling systems in the data center are used?

Half of the electricity that is used in a data center goes to cooling them. Therefore, it is necessary to optimize cooling. One example of optimization - a temperature control. In the presence of temperature sensors can be adjusted. In addition, modern equipment can operate at higher temperatures than the old. So you can support slightly higher temperature in the data center, which will save on cooling.

6. If premises allocated for that data center was chosen taking into account the need for cooling it?

There are rooms in which is always cool, and which is hotter. If the data center will be located on the upper floors, or sunny side in the summer it will have to spend more energy on cooling. Therefore, if there is a choice location for data center it is necessary to take into account factors of cooling.

7. If IT professionals get information on electricity consumed?

You must provide information on energy saving to IT professionals. This will allow them to evaluate their performance, and manage energy conservation.

8. If IT professionals have plan to reduce energy consumption?

Just as at the enterprise level, at the level of heads of IT should be developed plans for energy savings.

9. If equipment and data center energy consumption are used?

Measuring energy equipment and data center professionals will have more objective information and therefore make more objective decisions on energy saving.

10. Is the temperature sensors installed in the data center?

Temperature sensors ensure the optimization of data center cooling.

11. If were Measured and estimated power consumption of the data center?

Data centers are characterized by performance and power consumption. There are the following parameters, the ratio between electricity consumption and performance, power and volume of data that uses electricity the data center and the power used by the IT equipment directly. Also, there is assessment tools developed energy business combination The Green Grid. These estimates provide detection current energy efficiency and possible improvements..

12. Does the data center established system of automatic control of heating, ventilation and air conditioning?

Automatic control maintains optimal parameters of temperature and power consumption.

13. Does the company use electricity from alternative sources?

Using electricity from alternative sources leads to reduction of harmful emissions from power plants and encourages the development of alternative energy.

14. Does the company use cooling system in which used external cold air.

As noted above, much of the electricity is going to cool the data center. For example, Google built a data center in Finland, which is used to cool the cold sea water. The company Facebook plans to build a data center in Lapland [4]. On the territory of Ukraine from October to April - cold season. You can use cold outside air for cooling.

At the final stage of planning selected list of actions to be taken, based on what the company has done, and on what should be done. It consists plan to list these actions, consistent with guidance. Then there is a transition to the next stage.

Implementation. At this stage, the activity takes place together with the employees. Introduced all the items that were listed in the plan. In case of new actions are discussed and can be added to the list of required actions..

Estimation results of implementation. The final stage is held after the implementation of the proposed action. Compared to "greenness" of the enterprise before and after implementation. Estimated level of electricity consumption and cash equivalent savings.

Methodic implementation

On the example of a particular company Ukraine was held application technic (Table 1)

Table 1
Common questions and answers

№	Questions	Answers
1.	Is there a person engaged in energy-saving in the company?	There is no such person.
2.	Is energy-efficient office lighting used?	Used fluorescent lamps. They are more economical than incandescent bulbs. But they work while the window blinds closed, because the light from the windows shine individual workers sitting directly next to windows to displays.
3.	Is training on energy efficiency conducted among employees?	There were not trainings.
4.	Is equipment turned off when not used?	It is hard to say.
5.	Is the equipment turned off at night and on weekends?	When possible the light is off, air conditioning system is off. Laptops of workers usually remain switched on all the time. Sometimes, to be able to remotely access, sometimes just remain turned on.
6.	Where "greenness" of equipment taken to account during purchase?	Hard to say. But judging by the equipment available, it is no different from the average.
7.	If old equipment is send to recycling?	No
8.	Does the company established and announced targets for energy efficiency, energy conservation and reducing of carbon emissions?	No
9.	Does the company have programs that encourage or require employees to adhere to the principles of energy saving (turn off equipment etc.)?	No
10.	Does the company encourage its employees to show initiative on energy efficiency?	No
11.	If company encourage employees to use teleconferencing to reduce expenses for transportation?	Teleconference used. But mainly not for saving, but as absence of alternatives.
12.	Does the company offer the possibility of virtual offices and remote work?	Yes, occasionally there is the opportunity to work remotely.
13.	If thin clients are used and whether their usage is planned?	No
14.	If enterprise electronic document management system is used?	Yes, it is used. Primarily for easy collaboration on documents.
15.	Does the enterprise uses double sided printing?	No

A list of questions for IT managers: (table 2):

Table 2
Questions for survey

№	Questions	Answers
1	If power saving modes are used for equipment?	Operating systems as default set for energy saving. As well as hardware of monitors and laptops that goes into reduced energy when idle.
2	If virtualization servers is used?	Ye
3	If placement optimization equipment in the data center is used?	No
4	If virtualization in the data center are used?	No

Continue of Table 2

№	Questions	Answers
5	If the optimization of cooling systems in the data center are used?	No
6	If premises allocated for that data center was chosen taking into account the need for cooling it?	No
7	If IT professionals get information on electricity consumed?	
8	If IT professionals have plan to reduce energy consumption?	
9	If equipment and data center energy consumption are used?	Yes
10	Is the temperature sensors installed in the data center?	Yes
11	If were Measured and estimated power consumption of the data center?	Yes
12	Does the data center established system of automatic control of heating, ventilation and air conditioning?	Yes
13	Does the company use electricity from alternative sources?	No
14	Does the company use cooling system in which used external cold air.	No

Conclusions

The following conclusions could be made. There are two type of stimulus for greening.

First, greening for reputation. There are public companies, activities and success of which are directly related to meeting needs of end users (B2C https://ru.wikipedia.org/wiki/B2C). Reputation plays important role for them. Therefore, in such companies greenness and energy saving can be used as a means of improving the company's image. There are companies that do not work directly with end users (B2B, https://ru.wikipedia.org/wiki/B2B) Greening does not give advantages for them.

Second, the ratio of effort. It seems that electricity bills in the company are small compared with other expenses. Electricity prices in other countries are much higher than in Ukraine and this is a factor that reduces the importance of energy efficiency in Ukraine. As for other technic of greening, it is important for companies that effort and money spent on greening is justified. Conduct trainings, distract employees from their core activities, replace equipment - in order to save several thousand hryvnias a month from the budget – seems doubtful.

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