

# Scrutinizing and analysis of convergence of the ICT with environment

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## ABSTRACT

Owing to the fact that ICT has got its distinctive helpful and harmful effects on the environment, this study scrutinizes and analyzes the convergence of ICT with environment with a great attention to that, and with a quantitative approach; in addition, with exploiting of Green Communication implications. In this article, following factors were taken into account as forceful elements: management and leadership, physical infrastructure resources, human resources, organizational processes and attention to beneficiaries, investment and financial benefits. Outcomes of the research verify the existence of correlations between mentioned factors and green ICT. Furthermore, organizations allocate a particular position to themselves, if they have a great consideration on environment in any aspects; moreover, they reach to the same goal with having belief on the following fact: "the way to the organizational sustainability passes from society stability and convergence with environment has to be their initial principle in order to have society sustainability."

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**KEYWORDS:** Green ICT, Environment, ICT Sustainability.

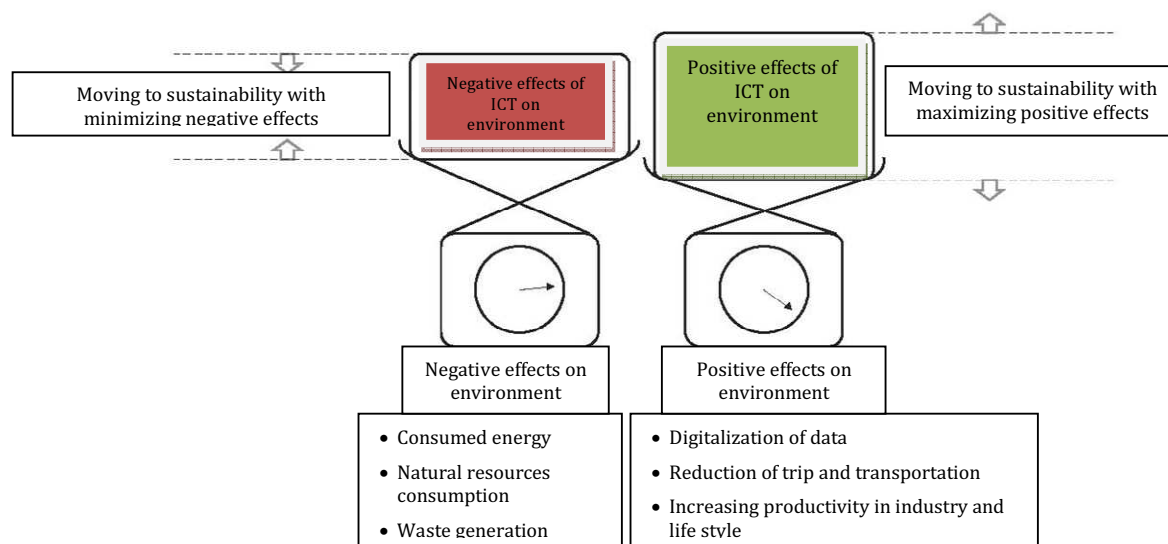
## 1. INTRODUCTION

Technology is not merely a set of technological products and it is also related to other phenomena, how people and namely engineers can make these products to be operated, how they are applied to meet their specific goals and how the world we know can be changed. Indeed, technology indicates the efforts of people, an effort to make the world we live as suitable to meet our needs and desires [1].

ICT has two usefulness and harmfulness aspects for environment [2] (Figure 1). On one aspect, we can consider the useful effects of ICT on life style and on the other aspect, negative impacts of construction and operation of data centers and consumption equipment, consumed energy and Green House Gases emission, electronic wastage and using rare materials and non- renewable sources and electromagnetic pollution [3-5].

According to religious teaching, appropriate application of sources and facilities including energy and lack of damage to environment is one of the important duties.

Based on the increasing growth of ICT and the affection of environment via technology and global community will to reduce energy consumption, the investigation of ICT is useful from this aspect and can show its negative impacts and leads to industries efficiency [6-8].



**Fig.1:**Schematic model of ICT effects on environment.

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Here, using experiences and standards and providing the models presenting the comprehensive evaluation of ICT and considering all its dimensions is a valuable goal for business managers in long-term. This study aimed to analyze convergence of ICT with environment and determining its various dimensions.

## REVIEW OF LITERATURE

### Theoretical literature

The term sustainability is defined for various purposes, this term is derived from Latin term *Sustinere* as “keeping and maintenance”, “support” or “toleration”. Since 1980, the term sustainability is related to human and land sustainability. There are extensive definitions of sustainable development. UN Environment and sustainable development commission defines sustainable development as:” Meeting the demand without endangering the future generation abilities to meet their demands [9].

Estimates show that ICT has consumed about 9% of total produced energy in the world in 2009, and if growth continues at the current speed it will reach 20% [10]. Furthermore, it should be noted that in many countries, energy is obtained from hydrocarbon resources that are not renewable and lead to the emission of greenhouse gases (GHG). Producing electrical energy for running network infrastructures emitted 4.53 million tons of CO<sub>2</sub> in the air during 2002, and it is predicted that it will reach 350 million tons in 2020 [11]. These show that even a small reduction of power consumption in ICT infrastructures can save costs and help to decrease emission of GHG. The growth of ICT energy consumption has focused the attention of ICT researchers on studying approaches of conserving energy in computer networks [5].

From a research conducted in 2009 by the U.S. Environmental Protection Agency (EPA) emission from electricity generation accounted for the largest portion of GHG emissions (about 30%). Transportation activities accounted for the second (27%) and the emissions from industry made up the third largest portion [12].

It has been estimated that each PC in use generates a ton of carbon dioxide every year (Gartner, 2007). Therefore IT affects our environment in several different ways; moreover in each stage of its life from its production, throughout its use, to its disposal, IT is becoming a motive of major concern. Fabricating computers and their electronic and non-electronic components consumes electricity, raw materials, chemicals and water, and generates hazardous waste. All these impact the environment. Moreover, computer components contain toxic materials. Increasingly, consumers discard a large number of old computers, monitors and other electronic equipment two or three years after purchase and most of this end up in landfill, contributing to the soil and water contamination [7].

We shouldn't ignore electromagnetic pollution as the result of ICT and is not observed considerably but it has adverse effects as observed in long-term. It has been estimated that “global carbon emissions attributable to ICT have been calculated at 2% to 2.5% of world totals - about the same as the airline industry - and as high as 5-6% of developed nation totals” (Gartner, 2007). McKinsey forecasts that the ICT sector's carbon footprint will triple during the period from 2008 to 2020 [13, 14].

In more recent times (2008) San Murugesan has defined the field of Green IT as: "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems, such as monitors, printers, storage devices, and networking and communications systems, efficiently and effectively with minimal or no impact on the environment"[15].

This idea is raised that total ICT processes are occurred as friendly and consistent with environment, economy and society. Green IT is nothing more than “adopting a mindset that helps businesses in performing at least at the same level of productivity and profit margins, but in a more environment-friendly manner” (Bright Hub report, 2010). Some items are mentioned regarding the reduction of negative effects of ICT as follows [7].

1. Design for environmental sustainability
2. Power management
3. Energy efficient computing
4. Server virtualization
5. Responsible disposal and recycling
6. Regulatory compliance
7. Environmental-related risk mitigation
8. Usage of green power
9. Eco-labeling of it products
10. Data centers design, layout and location
11. Reduction of electromagnetic pollution

In a comprehensive definition, green ICT is convergence of all dimensions of management and engineering of ICT structure (technical and management) with environment. Human resources management of green ICT, leadership of green ICT, financial management of green ICT, management of commodity of green ICT, project management of green ICT, maintenance management of green ICT, et are initial layers of green ICT unit as macro approaches of ICT unit and organization are formulated. In the next layer, there are

infrastructures, materials, equipment, building etc. The organization considering environment in all dimensions and is sure that to achieve organization sustainability, society sustainability path should be passed and to achieve society sustainability, we should consider convergence with environment as the initial principles of organization.

### Empirical literature

Some evidences are performed in green ICT in various dimensions. Table 1 refers to the important models, standards and studies with the study view.

In recent years in new studies, management and technical frameworks of ICT as (ITIL, COBIT, ETOM and etc.) green communications are emerging as new approach. The effect of green communication in different in each model.

**Table 1:** Important empirical review of literature.

Title	Provider	Dimensions of study or model
I.R.IRAN ICT National Quality Award (ICTINQA) [16].	Ministry of I.C.T., Telecommunication Infrastructure Company (TIC) since 2011.	Seven dimensions: 1- Customer Orientation and Focus on the Customer, 2- Leadership, 3- The Participation of Employees, 4- Process Approach, 5- Systematic Approach in Management, 6- Continuous Improvement, 7- Realistic (Factual) Approach in Decision Making. With the aim of qualitative and performance evaluation.
Green IT balanced scorecard [7].	G. Maccani, Faculty of engineering Milan Polytechnic, 2011.	Four dimensions: 1- Infrastructure Perspective, 2- Stakeholders and Culture Perspective, 3- Sustainability Perspective, 4- Business Value Perspective. With the aim of presenting a model to convergence with environment.
An Introduction to the Green IT Balanced Scorecard as a Strategic IT Management System [17].	Y. Wati and C. Koo in 2011 in Chosun University of south Korea.	Four dimensions: 1- Financial Perspective, 2- Stakeholder Orientation, 3- Future Orientation, 4- Process Perspective. With the aim of presenting a model for sustainability strategies.
Green Management Model of Iran (Registered in European Association for Green Management (EAGM) in Lausanne, Switzerland) [18].	Iranian Green Management Society, 2011.	8 dimensions: 1- Leadership, 2- Resources, 3- Policy and Strategy, 4- Partners, 5- Processes, 6- Social Results, 7- Environmental Results, 8- Economical Results. This model is recognized as general model of green management.
Handbook of Green Information and Communication Systems (Elsevier publications) [5].	Written by more than 60 important theorists with final edition of Mohammad S. Obaidat, Alagan Anpalagan, and Isaac Woungang, 2012.	This book in 27 chapters can deal with technical and management issues of green communication.
Telecommunication Standardization Sector of ITU, L. Series[19].	ITU-T Study Group 5, 2010.	ITU-T is developing a set of standardized methodologies to assess the environmental impacts of ICTs.
How digital information services can reduce greenhouse gas Emissions [14].	Gobinda Chowdhury, University of Technology Sydney, Sydney, Australia, 2011.	The investigation of the production of GHG and solution by green communication.
Green management and environmental Sustainability: a case of ITC Green Center [6].	Anjana Singh, Meghna Rishi and Rati Shukla, India, 2011	Technical and infrastructure investigation of green communication in data center.

### Conceptual model and study questions

Based on the review of literature, we can investigate the following questions. These questions are defined as six following hypotheses:

- 1- Does ICT convergence with environment have positive effect on total productivity and performance of ICT sector?<sup>1</sup>
- 2- Is convergence of management and leadership of IT units with environment can improve convergence of ICT with environment?<sup>2</sup>
- 3- Is convergence of infrastructural and physical sources of IT units with environment can improve convergence of ICT with environment?<sup>3</sup>
- 4- Is convergence of human resources dimension of IT units with environment can improve convergence of ICT with environment?<sup>4</sup>
- 5- Is convergence of processes and considering beneficiaries of IT units with environment can improve convergence of ICT with environment?<sup>5</sup>

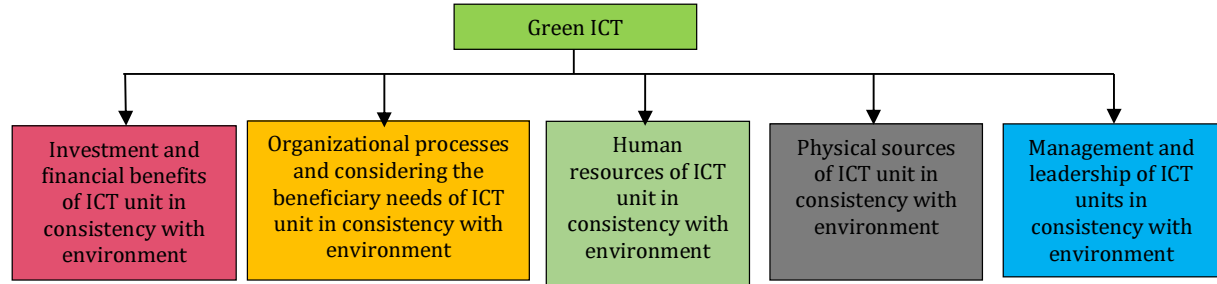
1 Shown by Green ICT

2 Shown by L

3 Shown by S R

4 Shown by H R

6- Is convergence of investment and financial benefits of IT units with environment can improve convergence of ICT with environment?<sup>6</sup>



**Fig. 2:** Conceptual model of study.

## 2. STUDY METHODOLOGY

The study is descriptive-survey design as it is based on the analysis of secondary data of review of literature, good condition based in initial data of theorists.

The study population is 400 experts working in various organizations, The experts working in Telecommunication Infrastructure Company (TIC) of Iran, the Communications Regulatory Authority (CRA) of Iran, Department Of Environmental (DOE) of Iran, Research Institute for ICT (ITRC) of Iran, Iranian Green Management Society, green research center Iran University of Science and Technology (IUST), computer and industries schools of IUST and experts of active firms in this field, mobile communication firm, Irancell, Rightell and MobinNet company are the study population. Cochran's formula is used to determine sample size as 196, a questionnaire with five-item Likert scale is provided and distributed.

SPSS software is used to obtain reliability of questionnaire. Cronbach's alpha for the questions is 0.794 and standardized Cronbach's alpha is 0.821. These values show that the questions have reliability and show that respondents respond the questions with high precision [20].

By Pearson correlation method as a parametric method, 6 questions correlation is evaluated.

### Study findings

#### One-sample t-test

Table 2 shows the condition of study questions by One-sample t-test.

Null hypothesis (H0): Question response is negative  $3 \geq \mu$ .

H1: The question response is positive  $3 < \mu$ .

To investigate the existing condition of questions (variables) of study, one sample T-test is used based on Table 2. As the variable mean is above 3, it shows the support of variables (positive response of questions) and if it is less than 3, it shows the reject of variables. Based on the response table, the questions are in acceptable condition [21].

**Table 2:**One-sample t-student.

Study questions	T-value	Mean	SD	Significance value	Confidence interval 95%		Condition
					Lower limit	Upper limit	
LM	27.535	4.11	0.571	0.000	1.03	Acceptable	1.19
SR	20.789	4.06	0.723	0.000	0.96	Acceptable	1.16
HR	14.672	3.62	0.593	0.000	0.53	Acceptable	0.70
P	18.941	3.82	0.609	0.000	0.73	Acceptable	0.90
F	19.955	3.93	0.661	0.000	0.84	Acceptable	1.02
Green ICT	3.499	3.88	0.409	0.000	0.82	Acceptable	0.94

**Table 3:** Correlation between green ICT dimensions.

Correlations							
		LM	SR	HR	P	F	Green ICT
LM	Pearson Correlation	1	0.358**	.343**	0.302**	0.274**	0.648**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000
	N	200	200	200	200	200	200
SR	Pearson Correlation	0.358**	1	0.293**	0.459**	0.268**	0.607**

5 Shown by P

6 Shown by F

	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000
	N	200	200	200	200	200	200
HR	Pearson Correlation	0.343**	0.293**	1	0.202**	0.247**	0.673**
	Sig. (2-tailed)	0.000	0.000		0.004	0.000	0.000
	N	200	200	200	200	200	200
P	Pearson Correlation	.302**	0.459**	0.202**	1	0.468**	0.748**
	Sig. (2-tailed)	0.000	0.000	0.004		0.000	0.000
	N	200	200	200	200	200	200
F	Pearson Correlation	0.274**	0.268**	0.247**	0.468**	1	0.605**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000
	N	200	200	200	200	200	200
Green	Pearson Correlation	0.648**	0.607**	0.673**	0.748**	0.605**	1
ICT	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000
	N	200	200	200	200	200	200

\*\* . Correlation is significant at the 0.01 level (2-tailed).

### Correlation analysis among the study variables

To evaluate the relation and type of problem variables and relation of 5 dimensions with green ICT, Pearson correlation test is used. Table 3 shows the correlation of dimensions and green ICT. As shown, processes and considering organizational beneficiaries with coefficient 0.748 has the highest and investment and financial benefits with coefficient 0.605 has the lowest correlation with green ICT. The mentioned dimensions without having coefficient had acceptable internal consistency for independence to each other and determined ICT well.

### 3. Conclusion

Based on the studies, 5 mentioned factors in the study model can have good analysis of ICT with green communication approach.

By establishing the dimensions under green ICT of organization about management and leaders, by good convergence with environment, we can achieve a sustainable unit. The unit that itself and society can use its activities. Other results of choosing such approach in ICT units is reduction of GHG, reduction of consumed energy, reduction of non-renewable fuel consumption and fossils, reduction of non-renewable materials consumption and rare materials, reduction of electromagnetic pollution, reduction of occupied spaces for infrastructures of ICT, reduction of electronic wastage, reduction of environmental events and financial and life damages in society and ICT organization and etc. We can say that we can use the existing sources as no problem is created for future generations and our children and we can have the lowest effect on divine graces on land and we can have a friendly interaction with our environment.

By more analyses in design, construction and operation and operation culture of ICT technology, we can achieve high consistency with environment. The link and relation of active organizations in ICT and telecommunication with environment –friendly organizations and more collaboration of these two fields can be useful.

### REFERENCES

1. P. Vermaas, P. Kroes, I. van de Poel, M. Franssen, and W. Houkes, 2011. "A philosophy of technology: From technical artefacts to sociotechnical systems," *Synthesis Lectures on Engineers, Technology, and Society*, vol. 6, pp. 1-134.
2. ITU-T, L.1400, 2011/02. "Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies,".
3. M. Ma and Y. Yang, 2014. *Green Communications and Networks* vol. 54: WIT Press.
4. M. T. Riaz, J. M. Gutiérrez, and J. M. Pedersen, "Strategies for the next generation green ICT infrastructure," in *Applied Sciences in Biomedical and Communication Technologies*, 2009. ISABEL 2009. 2nd International Symposium on, 2009, pp. 1-3.
5. M. S. Obaidat, A. Anpalagan, and I. Woungang, 2012. *Handbook of Green Information and Communication Systems*: Academic Press.
6. A. Singh, M. Rishi, and R. Shukla, 2011. "Green management and environmental sustainability: a case of ITC Green Center,".
7. G. MACCANI, 2011. "Green IT balanced scorecard," Master of science, FACULTY OF ENGINEERING MILAN POLYTECHNIC, Milan.
8. Y. H. Shim, K. Y. Kim, J. Y. Cho, J. K. Park, and B. Lee, 2009. "Strategic priority of green ICT policy in Korea: Applying analytic hierarchy process," *World Academy of Science, Engineering and Technology*, vol. 58, pp. 16-20.
9. R. W. Kates, 2010. "Readings in sustainability science and technology," Centre for International Development at Harvard University.

10. P. Leisching and M. Pickavet, 2009. "Energy footprint of ICT: Forecasts and network solutions," Ofc/nfoec, vol. 9.
11. C. Group, 2008. "SMART 2020: Enabling the low carbon economy in the information age," Global e-Sustainability Initiative (GeSI).
12. EPA. (2014). Greenhouse Gas Inventory Data Explorer. Available: <http://www.epa.gov/climatechange/ghgemissions/inventoryexplorer/#allsectors/allgas/econsect/all>
13. M. Hume, P. Johnston, M. Argar, and C. Hume, 2013. "Creating the Global Greenscape: Developing a Global Market-Entry Framework for the Green and Renewable Technologies," *Advances in Sustainability and Environmental Justice*, vol. 11, pp. 151-185.
14. G. Chowdhury, 2012. "How digital information services can reduce greenhouse gas emissions," *Online Information Review*, vol. 36, pp. 489-506.
15. S. Murugesan, 2008. "Harnessing green IT: Principles and practices," *IT professional*, vol. 10, pp. 24-33.
16. ICTINQA, 2011. "National Quality Award Association". Tehran: Ministry OF I.C.T Retrieved from [http://www.tic.ir/content/media/image/2012/01/11709\\_orig.pdf](http://www.tic.ir/content/media/image/2012/01/11709_orig.pdf). (in persian)
17. Y. Wati and C. Koo, "An Introduction to the Green IT Balanced Scorecard as a Strategic IT Management System," in *System Sciences (HICSS)*, 2011 44th Hawaii International Conference on, 2011, pp. 1-10.
18. Saraidarian, M., & Emami, M. H., 2011. *Green Management Model*. Tehran: Iranian Society for Green Management. (in Persian)
19. ITU, Telecommunication Standardization Sector of ITU, 2013. *Green ICT Standards*, "A Path to environmental sustainability", pp. 24.
20. Toloei Ashlaghi, A., Safakish, S., & Poorebrahimi, A., 2011. *Multivariate Statistical Analysis (Vol. 1)*. Tehran: Islamic Azad University E-campus. (in Persian)
21. Momeni, M., Dashti, M., Bayramzadeh, S., & Soltan Mohammadi, N., 2013. *Structural Equation Modeling (Vol. 1)*. Tehran: Momeni, Mansour. (in Persian)