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ICT Skills and Employment

NEW COMPETENCES AND JOBS FOR A GREENER AND SMARTER ECONOMY

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COMMITTEE FOR INFORMATION, COMPUTER AND COMMUNICATIONS POLICY

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Unclassified

Working Party on the Information Economy

ICT SKILLS AND EMPLOYMENT

New competences and jobs for a greener and smarter economy

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English - Or. English

FOREWORD

This report was presented to the OECD Working Party on the Information Economy (WPIE) in June 2011, as part of its work on ICT skills and employment. It was recommended to be made public by the OECD Committee for Information, Computer and Communications Policy (ICCP) in October 2011. The report was prepared by Christian Reimsbach-Kounatze and Cristina Serra Vallejo. It is published under the responsibility of the Secretary-General of the OECD.

For more information about the OECD project on ICT Skills and Employment, please visit *www.oecd.org/sti/ICT-employment*

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SUMMARY

Information and Communication Technologies (ICT) are increasingly viewed as a vital infrastructure for all sectors of the economy. As a result, promoting ICT skills and employment is an increasingly important goal of policy makers looking to harness the economic and social potential of these technologies.

There has been significant growth in ICT employment as a result of ICT dissemination throughout the economy. This includes employment directly in the ICT sector but also indirectly in terms of ICT-specialists in non-ICT sectors (*e.g.* health) and also among ICT-intensive users in all sectors which rely on ICT skills to perform their work.

Employment in the ICT industry and employment of ICT specialist skills each accounts for up to 5% of total employment in OECD countries and ICT intensive-users account for more than 20% of all workers. The ICT labour market has been under pressure due to the recent financial crisis but recovery in ICT services employment and ICT-skilled employment has been much faster than across the economy as a whole, leading to employment gains in the last quarter of 2010.

In contrast, ICT manufacturing employment continues to follow the downward trend initiated by the 2000-2001 crisis. This confirms that OECD countries are increasingly specialising in ICT and Internet-based services while outsourcing ICT manufacturing to non-OECD economies. The net effect of these changes have largely been positive for the ICT sector as a whole in most OECD countries as increases in ICT services employment outweighed declines in ICT manufacturing employment.

One key area governments have focused attention on is the development of ICT skills and employment in the evolving "green" and "smart" economy because of the potential of eliciting a *double dividend* by "both jumpstarting job creation and accelerating the transition towards green growth" (OECD, 2011d). Indeed, as unemployment remains high in most OECD countries, the economic stimulus packages of many governments addressing the economic crisis have been explicitly aimed at boosting employment, with a significant number having a strong commitment to promote the creation of "green jobs".

These plans will further the development of ICT-related employment as many of the promoted green jobs are related, directly or indirectly, to ICTs (*e.g.* jobs in R&D, production, deployment, maintenance, and use of green technologies such as "smart" electricity grids and wind energy turbines). Thus, demand for ICT-skilled workers will continue to increase not only in the ICT sector, but more rapidly across the wider non-ICT economy, for example, to develop and deploy ICT- and Internet-based products and services such as software in non-ICT sectors (*e.g.* financial services) or data-intensive products and services such as automobile systems or the "smart grid".

As a consequence, skills for big data management and analytics (*e.g.* SQL and Apache Hadoop) and the development of Internet-based software applications (*e.g.* Ajax and PHP) are increasingly in demand. Additionally, network security skills will be in greater demand, particularly as ICTs are increasingly adopted across sectors. In many cases, these skills need to be complemented with sector-specific skills such as business and administration skills or, as in the case of green ICTs, with environmental knowledge. This means that ICT employment will require relatively high levels of experience and education and governments may need to adjust policies accordingly.

The data indicate there is growing demand for ICT skills and yet there are still parts of the population that are significantly underrepresented in ICT-related jobs. Women, in particular, still account for a low share of roughly 30% of ICT sector employment and almost 20% of ICT specialist occupations. When women do work in ICT specialist jobs they tend to concentrate in particular industries such as in:

i) education and health, *ii*) finance and insurance; and *iii*) public administration. In the United States, however, women are particularly underrepresented in *professional and business services*, which is among the highest wage industries. These industries are potential targets for governments to encourage more women to enter ICT-related occupations.

Higher- education institutions have a pivotal role to play in providing the needed skills related to ICTs, and green ICTs in particular. However, the total number of graduates in computer science has declined since 2006, increasing the risk for skill shortages in OECD countries. Universities are developing new programs related to computer and information sciences that focus on meeting the demand for green technology experts. Other universities may not focus on green ICTs but are still incorporating subjects related to the environment into their curriculum.

It is not just higher-education institutions that are refocusing. The very new and rapidly changing nature of advanced ICTs including green ICTs makes workplace training, in addition to formal education, increasingly important for augmenting and adapting workers' skills. This is especially true for older workers, for whom skills acquired through the educational system are likely to be missing or substantially depreciated in the field of green ICTs. There are significant challenges though as available data reveals that the share of firms with vocational training has decreased between 1999 and 2005.

(Offshore) outsourcing of ICT-related tasks is another way of supplying ICT skills. This is also true for green ICT-related skills, as some ICT-related green tasks can potentially be outsourced (in offshore locations), although security concerns may restrict such use cases. For example, "smart" electricity grids could be administered offshore, as this is being already done with services delivered through data centres. Some of the ICT related occupations needed for green-ICTs such as *computer software engineers* are among the occupations potentially affected by offshoring. Although the share of these occupations have remained stable over time (at 18% since 2008 in OECD Europe), some strong variation between countries exists.

Migration is another means for meeting the demand for scarce skills. Data on H-1B visa applications in the United States, which are used to temporarily employ skilled foreign workers, reveals that demand for foreign ICT specialists decreased until the first quarter of 2010. However, the decline in H-1B visa applications for ICT specialists was slower than for workers in other occupations. In the second quarter of 2010, H-1B visa applications in the United States have increased again, suggesting that demand for ICT specialists has increased and that the local market cannot meet demand.

OECD governments have a wide range of policies to support ICT-related employment and skills. As the OECD 2010 policy questionnaire reveals, only a minority of governments are explicitly promoting green ICT-related skills and jobs. In contrast, almost half of OECD governments have put an emphasis on measures for tackling the job crisis; with some of these measures being related to green ICTs. Overall, most OECD governments have established policies and programmes *i*) furthering IT education and training; *ii*) improving labour market information; and *iii*) promoting international sourcing of ICT skills.

ICT-RELATED SKILLS AND EMPLOYMENT: NEW COMPETENCES AND JOBS FOR A GREENER AND SMARTER ECONOMY

Introduction

Information and Communication Technologies (ICTs), and particularly the Internet, are driving innovation, labour productivity and growth (OECD, 2010e; 2011g; 2011h). Their applications are also key enablers for "greening" the society and all sectors of the economy (OECD, 2010d; 2011a), and thus for laying a new path for *green growth*.[1] Top areas of these *green ICT* applications include "smart" electricity grids, "smart" transport systems, and "smart" buildings, for improving resource efficiency. "Smart" grids, for example, can improve resource efficiency in the production and distribution of energy (see OECD, 2010d).

Investments in the ICT sector for broadband and green ICT, as well as investments in knowledge and data intensive products and services in non-ICT sectors (finance, automobile, energy) will continue to drive global economic growth (see OECD, 2010c; 2011a).[2] As ICTs and the Internet become more pervasive and economies greener and smarter, ICT skills become more crucial for ensuring social inclusion and for permitting and complementing the production and use of ICT- and Internet-based products and services.[3] With unemployment still remaining high in most OECD economies,[4] and with current policy attention towards promoting a transition to green growth, advancing ICT employment and skills has never been more important. This is particularly true given the crucial role ICTs and the Internet play for greening the economy.

However, the real creation of new jobs can only occur if the right mix of skills and competences are available in the labour market. Shortages of required ICT-related skills have been observed in some OECD countries, and this is particularly true for skills related to green ICTs. According to surveys, for example, most organisations still lack the knowledge and skills necessary to deploy green ICTs effectively (see OECD, 2009c). So policy action aiming in particular at the labour market as discussed later in this report may be required to prevent the slowing of ICT and green initiatives and to realise the full job creation potential of ICT-related investment as also promoted by many of the government recovery packages and green growth initiatives.

This report analyses developments in ICT-related skills and employment, focussing in particular on the potential of green ICTs for job creation in the post crisis era. It provides an outlook on ICT-related skills and competences needed in a greener and smarter economy as promoted, for example, by the OECD Green Growth Strategy (OECD, 2011c). This report is structured as follows:

1. The report first analyses the post-crisis state of ICT-related employment, including employment in the ICT sector and employment across the economy, where ICTs are used as main tools for the job (*i.e.* ICT-skilled employment).

2. The report then discusses the impact of green ICTs on employment and skills. This includes in particular the development of a working definition for "green ICT-related employment" and the

identification of emerging green ICT-related jobs in the ICT sector as well as across the economy based on use cases and examples.

3. The report then analyses the skills and competences required for the new ICT-related jobs, and to what extent existing skill sets are sufficient or need to be upgraded. This requires, as a consequence, a discussion of labour market transformation induced by the increasing deployment of ICTs and ICT-intensive technologies including green technologies. It also requires a discussion on means of acquiring needed skills; namely through education, training, (offshore) outsourcing, and migration.

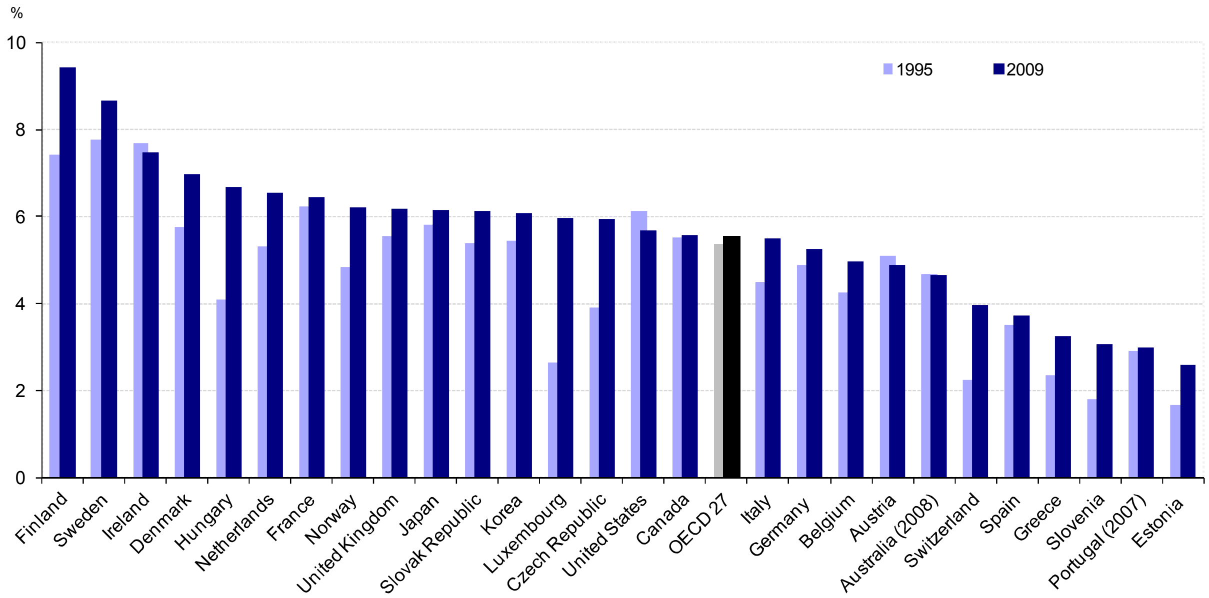
4. Finally, the report analyses OECD government policies and programmes promoting ICT-related skills and jobs, and in particular green ICT-related skills and jobs. The analysis in this section is mainly based on data provided through the OECD (2009c) report "Towards Green ICT Strategy: Assessing Policies and Programmes on ICT and the Environment" and the OECD Information Technology 2010 Policy Questionnaire.

ICT-related employment after the crisis

ICT sector employment

The ICT sector contributes to a significant share of total employment, employing almost 15 million people in OECD countries in 2009, or almost 6% of total OECD business sector employment (Figure 1). The sector's employment long-term growth (1995-2009) has been 0.8% a year, but still higher than total business employment growth. Finland and Sweden had the largest shares of ICT employment in total business employment at over 8%, and these shares have increased markedly, as they also have (in decreasing order) in Luxembourg, Hungary, the Czech Republic, Switzerland, and Norway. ICT sector employment in the United States accounted for more than 30% of total OECD ICT sector employment in 2009, by far the largest share, followed by Japan (16%) and Germany (9%).

Figure 1. Share of ICT employment in business sector employment, 1995 and 2009
Percentage

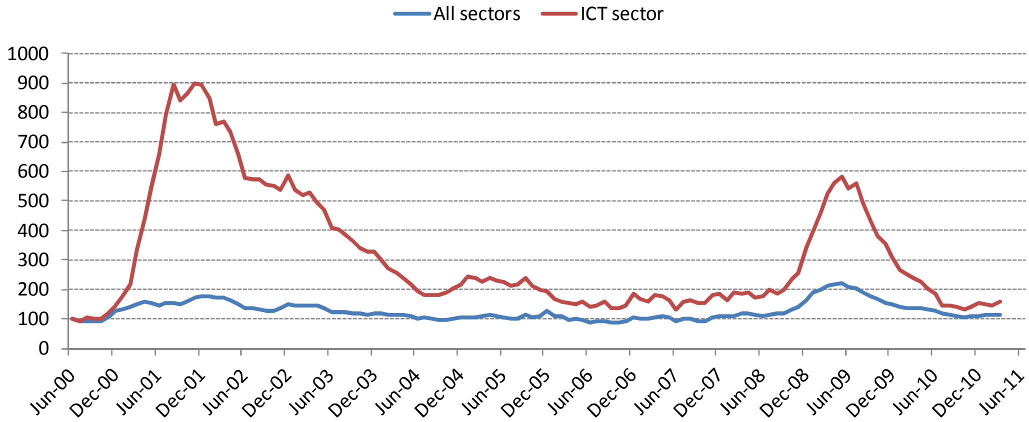


Note. 2001 for Estonia instead of 1995. Data are not available for Chile, Iceland, Israel, Mexico, New Zealand, Poland and Turkey. The ICT sector is defined according to the 2002 OECD ICT sector definition based on ISIC rev.3.1. In order to obtain ICT aggregates that are compatible with national accounts totals, data have been partly estimated based on data from other official sources. In some cases such estimates were not possible, resulting in an underestimated ICT sector. This is the case for Estonia, Slovenia and Switzerland where data on Software publishers (ISIC 72) in Estonia and on Telecommunications (ISIC 642) Slovenia and Switzerland, were not available. For industries such as Renting of office machinery and equipment (ISIC 7123) estimates were only available for seven countries.

Source: OECD estimates, based on national sources, STAN and National Accounts Databases, March 2012.

The share of employment in the ICT sector declined, for example, in the United States, Ireland and Austria, an indication of increasing manufacturing and services trade and sourcing with non-OECD economies. In the United States, for example, the number of workers affected by mass layoffs in the ICT sector increased as of the second half of 2008 (Figure 2). In the second half of 2009, the number of affected workers reached a peak, and three times more ICT employees were laid off than in June 2000. Nevertheless, employment in the ICT sector suffered less than in the dot.com bust in 2001-03, when almost seven times more people were laid off than in June 2000. As in the 2001-03 crisis, job cuts were deeper in ICT manufacturing than in ICT services in 2009.

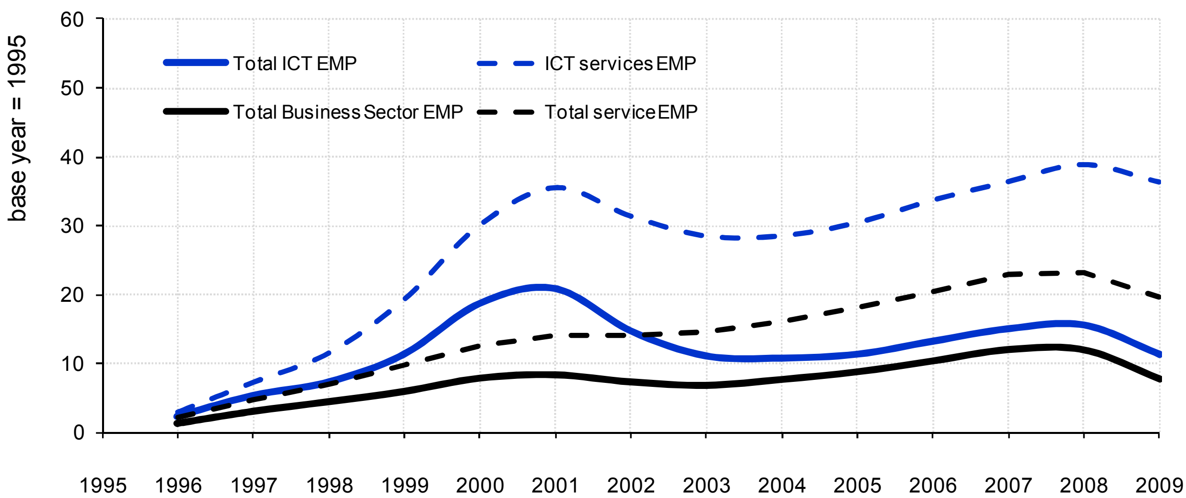
Figure 2. Workers affected by mass layoffs in the ICT sector and overall in the United States, 2000-11
100=June 2000, six-month moving average



Source: OECD calculations based on the Mass Layoff Statistics (MLS) Database of the US Bureau of Labor Statistics.

ICT services sector contributed the largest extent to ICT sector employment in OECD countries, employing more than 10 million people (4% of total business sector employment) compared to almost 4.5 million in ICT manufacturing (less than 2% of total business sector employment). From 1995 to 2009, employment in computer and related services and IT services has grown more rapidly than business services as a whole (including IT services) (more than 2% a year and 1.3% a year, respectively) (Figure 3). Over the same period, ICT manufacturing employment declined more rapidly than manufacturing employment overall (1.9% a year and 1.5% a year, respectively). In most OECD countries, increases in ICT services employment outweighed declines in ICT manufacturing employment, so that the ICT sector continued to increase its share of total business sector employment. In the United States, however, the increasing share of ICT services employment did not compensate falling ICT manufacturing employment; so that the share of ICT employment in total business sector employment slightly decreased from 6.1% in 1995 to almost 5.7% in 2009.

Figure 3. ICT sector employment in the OECD area by sector, 1995-2009
Base year= 1995



Note. OECD 27 - Data for Chile, Israel, Mexico, New Zealand, Poland, Turkey have been excluded as time series were not available at this date. The ICT sector is defined according to the 2002 OECD ICT sector definition based on ISIC rev.3.1.

Source: OECD estimates, based on national sources, STAN and National Accounts Databases, March 2012.

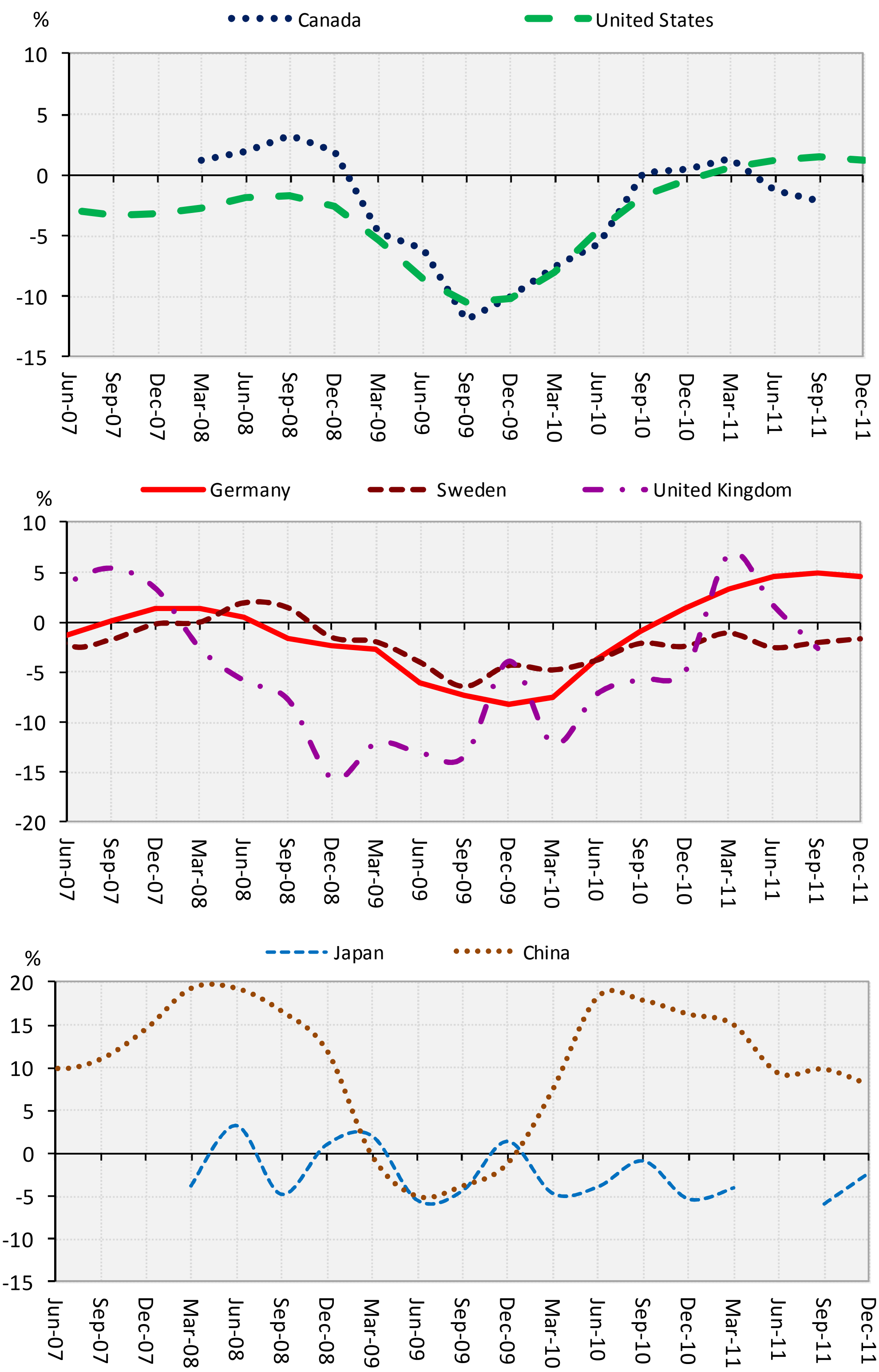
Short-term indicators of employment in ICT goods and services

In the last quarter of 2009, employment in ICT manufacturing in all reporting economies had dropped by between 5% and 15% year on year (Figure 4). Canada, United Kingdom, and the United States have fared the worst, with the downturn in ICT manufacturing employment falling by more than 10% at the end of 2009. Nevertheless, one year later in 2010, employment in ICT goods was holding up better, in particular with employment in Germany and the United States growing again. Compared to the downturn of 2002-03, ICT manufacturing employment was performing better in 2008 to 2011.

Where data are available, ICT services employment[5] during the crisis in 2008-09 has tended to remain flat in most European countries or decrease slightly (by not more than 4%) in Canada and the United States. In Germany and in most Asian countries, ICT services employment increased by between 2% and 7% during the crisis (Figure 5). In 2010 ICT services employment in most countries regained momentum, with the exception of Canada and the United States.

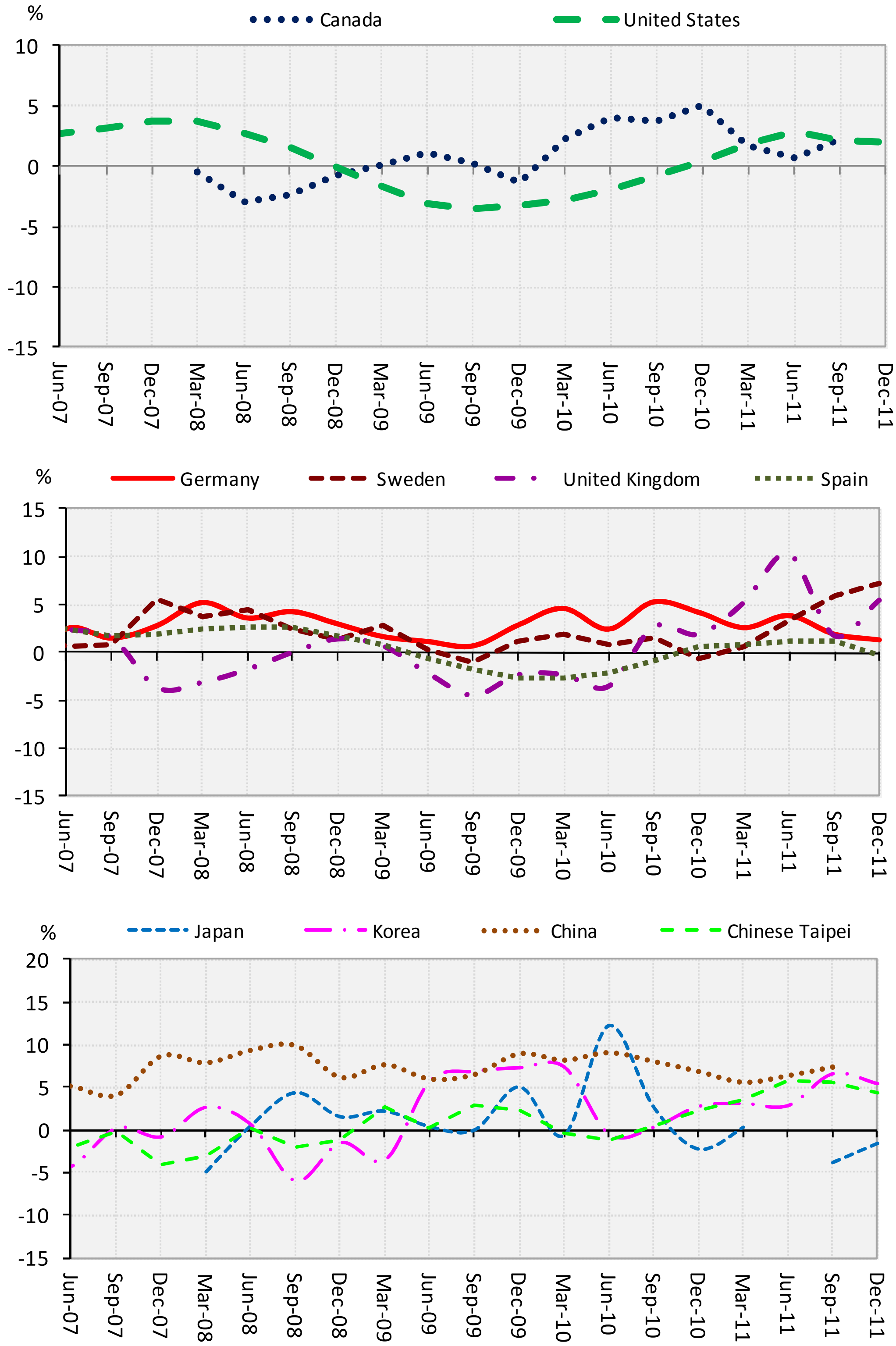
Overall, at the end of 2010, employment in ICT manufacturing in most regions fell by not more than 5%) year on year except in Germany and China, where ICT manufacturing continued to grow. ICT services employment was more stable compared to ICT manufacturing and started to grow again in most regions by around 5%. In Asia, ICT services employment recovered three to six months earlier than in Europe. In North America in contrast, ICT services employment is still declining, although at a slow pace.

Figure 4. Quarterly employment in ICT manufacturing
Year-on-year percentage change



Source: OECD, based on official data from national statistics offices, March 2012.

Figure 5. Quarterly employment in ICT services
Year-on-year percentage change



Source: OECD, based on official data from national statistics offices, March 2012.

ICT-skilled employment across the economy

ICT-skilled employment is widely spread throughout the economy. Many ICT employees carry out ICT tasks in other sectors of the economy and some employees in the ICT sector do not have ICT-related jobs. Two measures of ICT employment are used based on ICT-related occupations. One is a narrow measure that comprises ICT specialists whose jobs focus on ICTs, such as software engineers. The other is a broader measure of ICT employment and concerns employees who use ICTs regularly as part of their jobs, but whose jobs do not focus on ICTs, such as researchers or office workers (see Box 1).

Box 1. Defining ICT specialists and ICT users

Three categories of ICT competencies are distinguished:

1. *ICT specialists*, who have the ability to develop, operate and maintain ICT systems. ICTs constitute the main part of their job.

2. *Advanced users*: competent users of advanced, and often sector-specific, software tools. ICTs are not the main job but a tool.

3. *Basic users*: competent users of generic tools (*e.g.* office suites and Internet-related tools such as browser and e-mail clients) needed for the information society, e-government and working life. Here too, ICTs are not the main job but a tool.

The first category covers those who supply ICT tools (hardware and software), and the second and third categories those who use them. This section uses the first category for the narrow measure of ICT-skilled employment, and the sum of all three categories for the broad measure of ICT-skilled employment.

ICT specialists are increasingly expected to have additional skills, including “business” skills. Similarly, non-ICT related professions increasingly require at least basic ICT user skills.

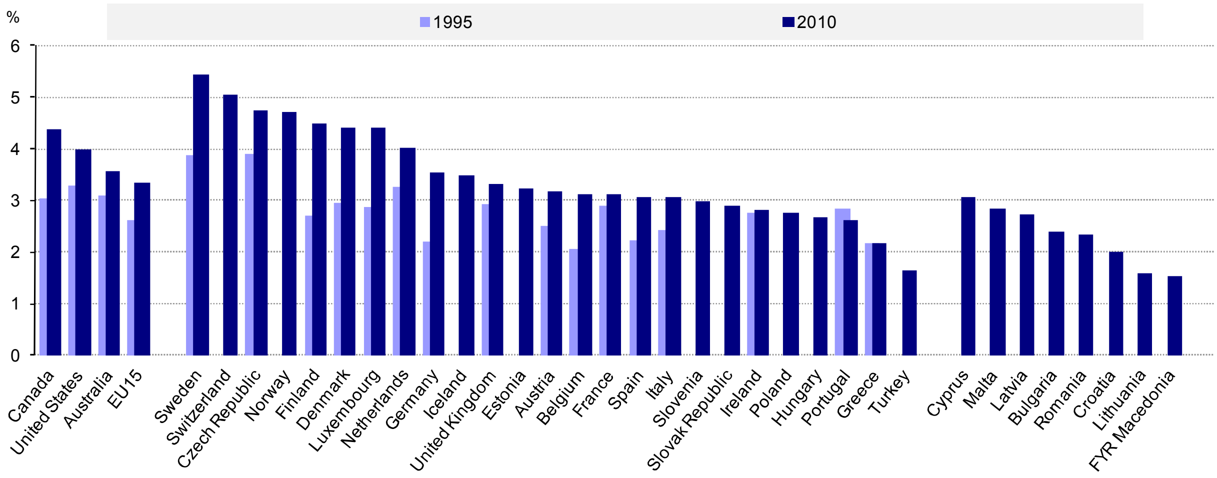
See OECD (2004).

ICT specialists

Around 3-4% of total employment in most OECD countries was accounted for by ICT specialists in 2010, although the shares are lower in Eastern Europe (Figure 6). The share has risen consistently in recent years in most countries, and somewhat faster than growth in the share of ICT sector employment in business sector employment (see preceding section). ICT specialists are needed in the ICT sector, but increasingly they are also employed across the wider non-ICT economy, for example to produce both ICT products such as software in non-ICT sectors (*e.g.* financial services) and knowledge- and data-intensive products such as automobile systems with ICTs and in particular software embedded in them (Figure 7) (see OECD, 2011e for the role of intangible assets such as software for innovation). Furthermore, among OECD ICT specialists, women still account for a relatively low share of almost 20%, with Finland, Iceland and the United States above the OECD average (see Box 2).

Figure 6. Share of ICT specialists in the total economy, specialist users, 1995[1] and 2010[2]

Percentage



Note: "Specialist users" corresponds to the narrow definition based on the methodology described in Chapter 6 of the *OECD Information Technology Outlook 2004*. Shares for non-European countries are not directly comparable with shares for European countries, as the classifications are not harmonised.

1. For Australia, Finland and Sweden, 1997 instead of 1995.

2. For Australia: 2009 instead of 2010.

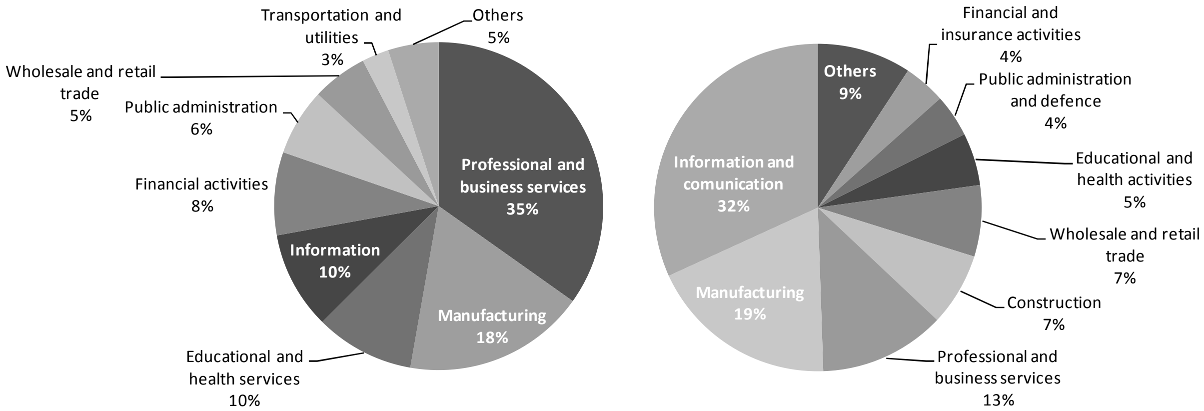
Footnote by Turkey: The information in this document with reference to « Cyprus » relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognizes the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

Footnote by all the European Union Member States of the OECD and the European Commission: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: OECD calculations based on EULFS, US Current Population Survey, Statistics Canada, Australian Bureau of Statistics, May 2011.

Figure 7. Share of ICT specialists by sector in the United States (left) and the OECD Europe (right), 2010

Percentage

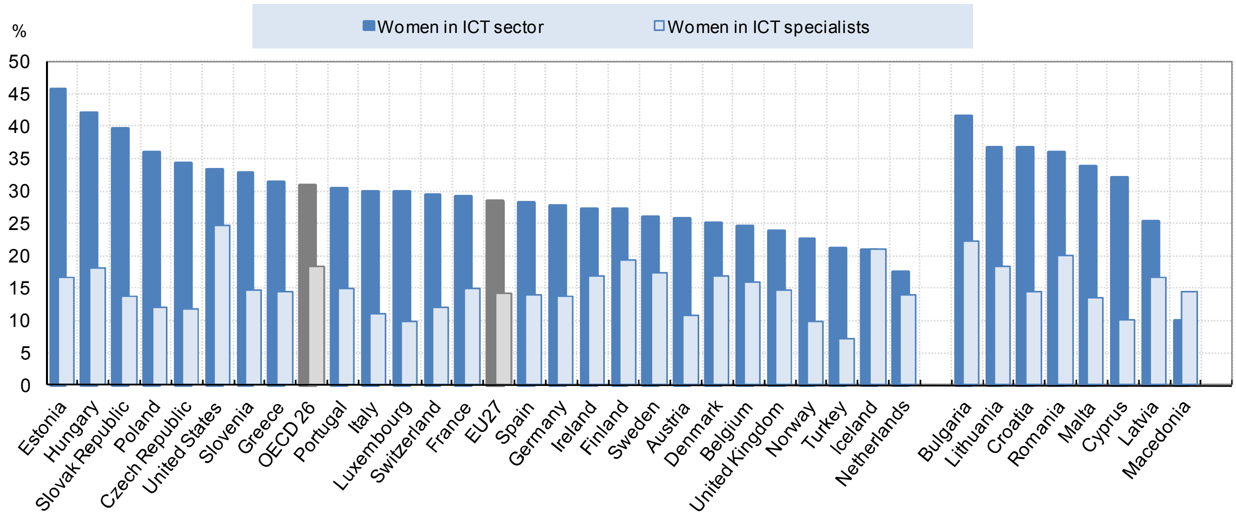


Source: OECD calculations from US Current Population Survey (CPS); Eurostat Labour Force Survey (LFS)

Box 2. ICT-related employment and gender

Women still participate significantly less in the ICT sector and ICT specialist occupations than men, but their share in employment is increasing in most countries. In 2010, the share of women employed as ICT specialists in selected countries was over 18% (Figure 8). This is almost two thirds of the share of women employed in the ICT sector (over 30%). Estonia and Hungary are clearly above the OECD average, with women accounting for over 40% of ICT sector employment. The picture is somewhat different for ICT specialist occupations; the highest shares of females working as ICT specialists are in the United States (almost 25%), followed by Iceland, Finland and Hungary (over 18%). In contrast, the share of women employed as ICT specialists in Turkey, Luxembourg, and Austria are the lowest among OECD countries.

Figure 8. Share of women in the ICT sector[1] and in ICT specialist occupations[2] in selected countries, 2010



Note. Data for the United States and Macedonia are for 2008. The aggregate OECD 26 includes European OECD countries plus the United States. Shares are not directly comparable between the United States and European countries..

1. The “ICT sector” is defined as the sum of ISIC Rev.4 sectors 26, 61, 62 and 63 for European countries.

2. “ICT specialists” are defined as the sum of the ISCO-88 codes 213, 312, 313 and 724 for European countries.

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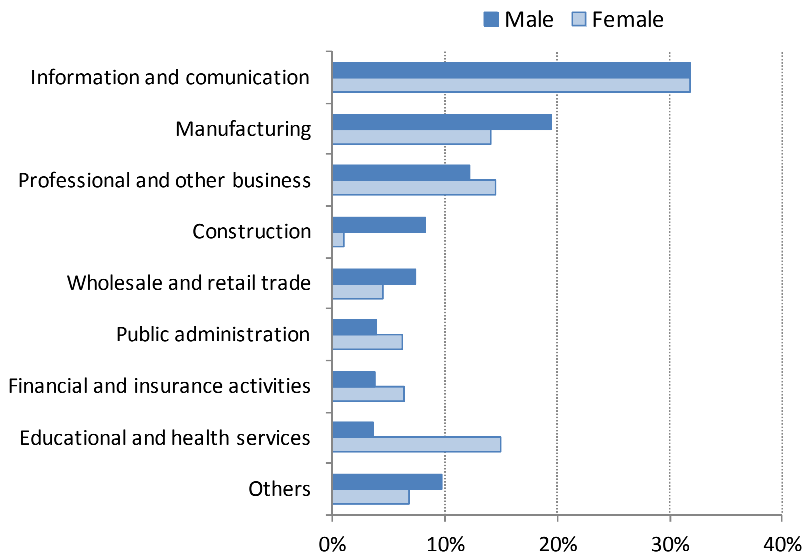
Source: OECD, based on EULFS and US Current Population Survey for United States, May 2011.

Box 2. ICT-related employment and gender (cont.)

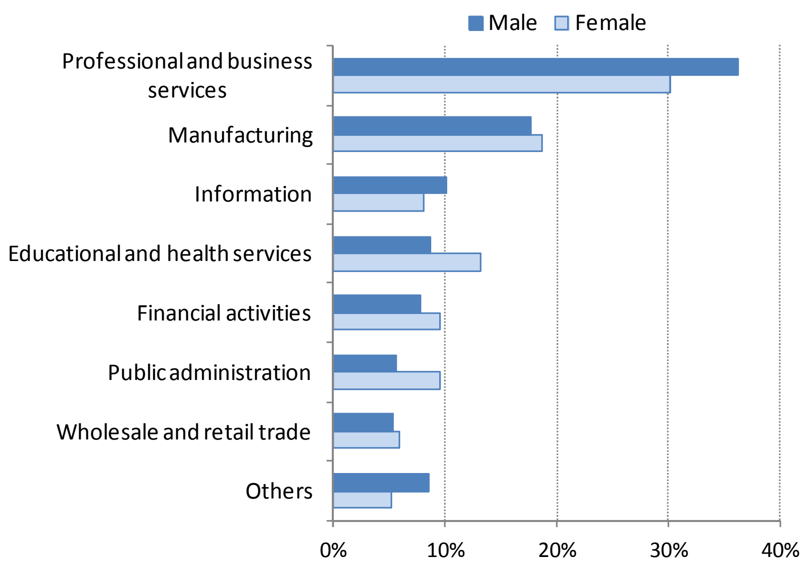
Compared to their male colleagues, women in ICT specialist occupations tend to concentrate in particular industries: (i) *educational and health activities*, (ii) *financial and insurance activities*, and in (iii) *public administration* (see Figure 9 for OECD Europe and the United States). In contrast to the United States, women in OECD countries within Europe are more likely to work in *professional and business services* occupations, which are among the high wage industries.

Figure 9. Share of ICT specialist occupations in OECD Europe and the United States by gender and industry

OECD Europe, 2010



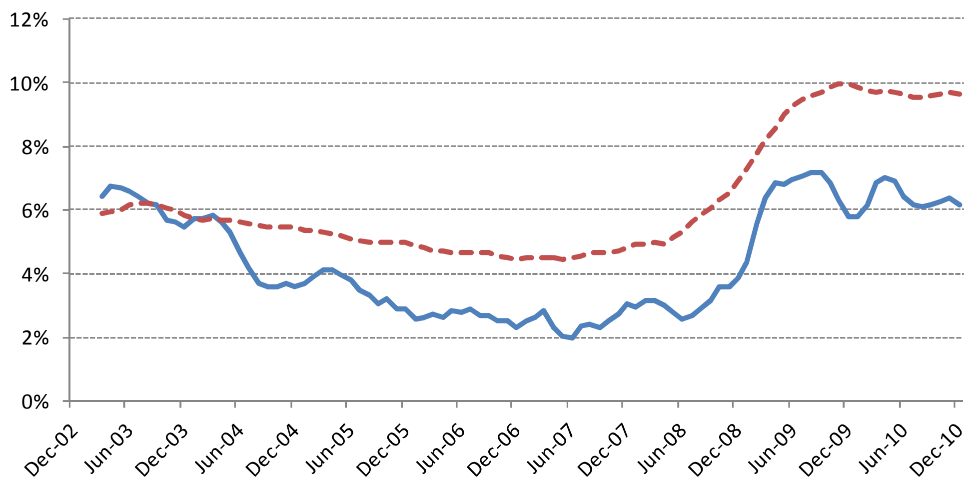
United States, 2010



Source: OECD, based on US Current Population Survey for United States and EULFS for OECD Europe.

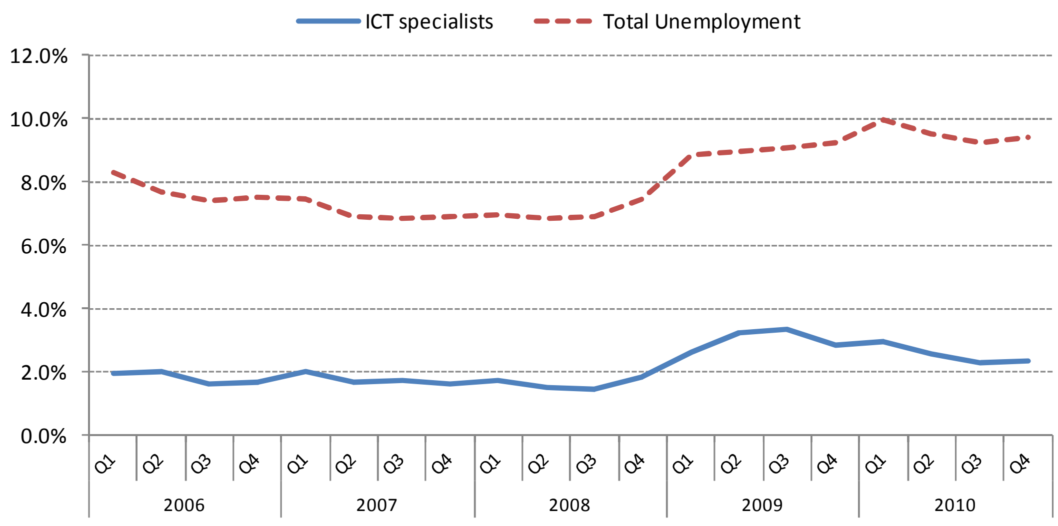
The job crisis has also affected ICT specialists. In contrast to ICT sector employment, however, employment of ICT specialists declined less than overall employment and appears to be recovering faster. The unemployment rate of ICT specialists in the United States, for example, increased from the second half of 2007, and accelerated in the second half of 2008 (Figure 10). In June 2009, the unemployment rate of ICT specialists reached a peak at 7.5%, a level previously reached in 2003.[6] At the end of 2010, however, the unemployment rate among ICT specialists dropped to 6%, whereas total unemployment stabilised at slightly below 10%. The only period in which unemployment of ICT specialists was higher than total unemployment occurred between 2001 and 2003 during the dot.com bubble. In April 2003, the unemployment rate among ICT specialists was 1.3 percentage points higher than total unemployment. A similar trend can be observed in Europe. However, unemployment rates of ICT specialists are much lower than in the United States (Figure 11).

Figure 10. Monthly unemployment rates of ICT specialists in the United States, 2003-10
Three-month moving average



Source: OECD calculations based on US Current Population Survey.

Figure 11. Quarterly unemployment rates of ICT specialists in the EU15, 2006-10

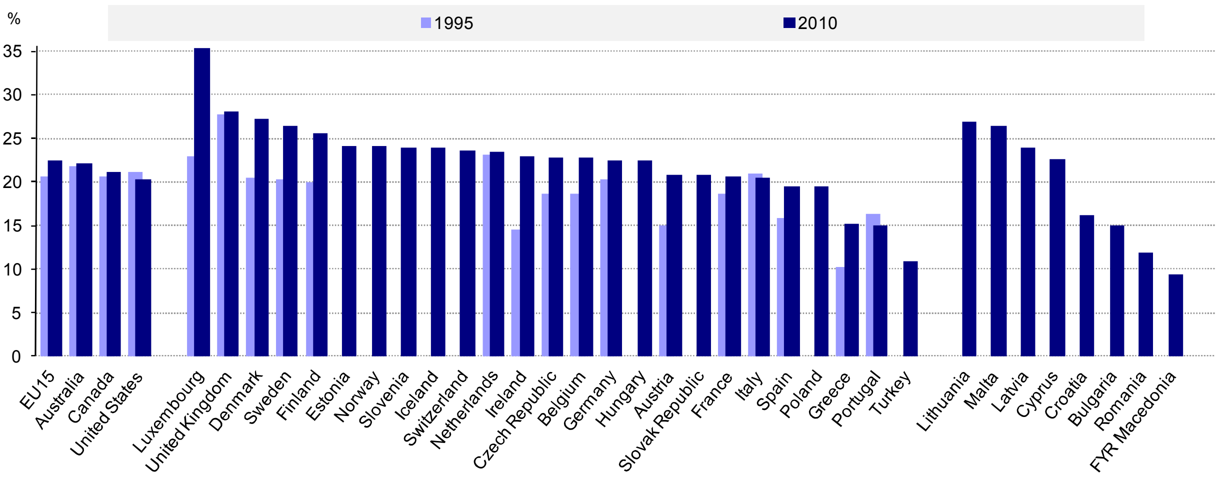


Source: OECD calculations based on the European Union Labour Force Survey (EU LFS).

ICT-using occupations

ICT-using occupations (including specialists) make up over 20% of total employment in most countries except in Eastern Europe (Figure 12). These occupations include scientists and engineers, as well as office workers who rely entirely on ICTs to perform their tasks, but exclude teachers and medical specialists, for example, as the use of ICTs has generally been assumed to be not essential for their tasks. Overall, these estimates show the importance of ICT-related occupations across the economy, the continuing growth of ICT specialists as a share of the total labour force, and a flattening of the share of ICT-intensive users.

Figure 12. Share of ICT-intensive occupations in the total economy, intensive users, 1995[1] and 2010[2]
Percentage



Note: "Intensive users" corresponds to the broad definition based on the methodology described in OECD 2004, Chapter 6. Shares for non-European countries are not directly comparable with shares for European countries, as the classifications are not harmonised.

1. For Australia, Finland and Sweden, 1997 instead of 1995.

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Source: OECD calculations based on EULFS, US Current Population Survey, Statistics Canada, Australian Bureau of Statistics, May 2011.

ICT-skills needed across the economy

Surveys that track quarterly ICT job openings are good sources for indentifying the needed ICT skills across the economy. The analysis of job openings reveals in particular that software engineers, computer programmers, systems analysts and computer support are highly in demand across the economy, and in particular in industries identified in Figure 7 (see also Knapp *et al*., 2010a, 2010b). In the United Kingdom, according to ComputerWeekly's quarterly surveys of appointment data, skills are increasingly needed for data management (*e.g.* SQL, SQL Server, Oracle) and the development of Internet-based applications (*e.g.* Ajax, PHP, Javascript, Flash) (see Table 1). This supports the observation according to which firms are increasingly investing in data-intensive and Internet-base products and services (see for example the skill implications of Big Data in Loukides (2010) and McKinsey Global Institute (2011).

Table 1. Top 25 IT skills most in demand in the second quarter of 2009 in the United Kingdom

Position Q2 2009	Skill	Change from Q2 2008 to Q2 2009	Position Q2 2009	Skill	Change from Q2 2008 to Q2 2009
1	SQL	-37%	14	PHP	17%
2	C	-37%	15	Unix	-54%
3	C#	-43%	16	XML	-46%
4	SQL Server	-39%	17	Office	-43%
5	.Net	-44%	18	Exchange	-40%
6	ASP	-37%	19	Ajax	28%
7	Java	-51%	20	CRM	-21%
8	HTML	-16%	21	J2EE	-56%
9	Javascript	0%	22	Flash	0%
10	Oracle	-58%	23	Access	-46%
11	C+	-52%	24	Focus	-32%
12	Visual Basic	-44%	25	Object oriented	-32%
13	Linux	-30%	**All IT skills**		**-54%**

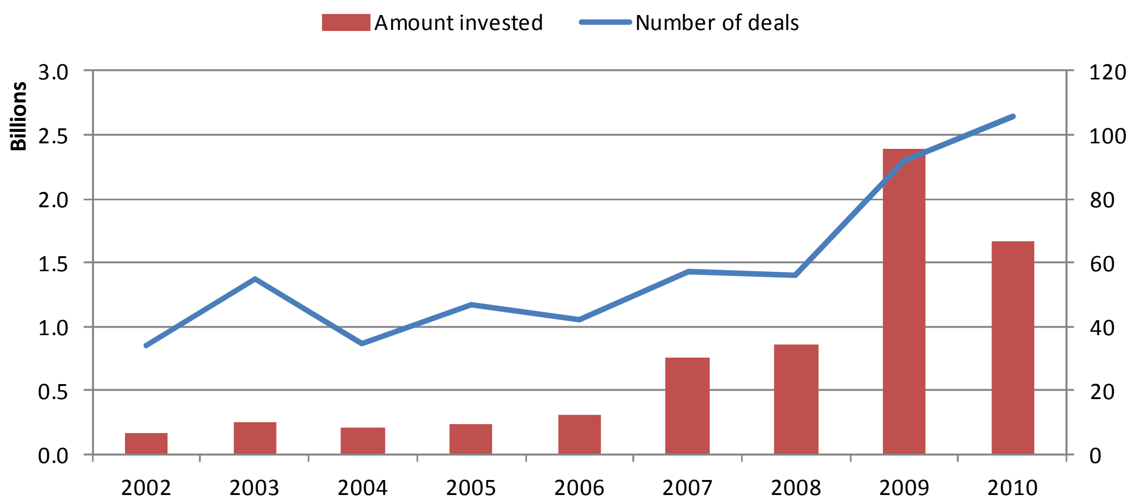
Source: Computer Weekly survey of appointments data and trends compiled by Jobadswatch for Salary Services Ltd (SSL).

Emerging green ICT-related jobs and skills

OECD governments have a wide range of initiatives dealing with the impacts of information and communication technologies (ICTs) on the environment and climate change (OECD, 2009c; 2010c; 2010d). These *green ICT* initiatives include the promotion of *i*) ICTs with reduced environmental burdens;as well as *ii*) "smart" (ICT) applications, such as "smart" grids, "smart" transport systems, and "smart" buildings, for improving environmental performance across the economy. Many OECD governments have also taken the financial and economic crisis as an opportunity to further deploy green ICTs through their economic stimulus packages, laying a new path for *green growth* (OECD, 2009a; 2009c; 2009f).[7] Furthermore, the private sector continues to invest in green ICTs (OECD, 2010c; 2010d), and venture capital is flowing strongly into ICT-intensive clean technologies (see Figure 13).[8]

Figure 13. Venture capital investments in ICT-intensive clean technologies[1], 2002-10

USD billions



Note: This includes seed, first round, follow-on, private equity, and mezzanine investments in firms focussing on the following clean technologies: *i)* electric & hybrids, *ii)* electro textiles, *iii)* electronic, *iv)* flow batteries, *v)* lithium-ion, *vi)* power monitoring & metering, *vii)* sensors, *viii)* sensors & controls, ix) smart grid, *x)* smart irrigation, *xi)* smart lighting systems, *xii)* smart metering & control, *xiii)* software, *xiv)* software systems, and *xv)* traffic monitoring software.

Source: OECD based on the Cleantech Market Insight Database

Many of these initiatives and investments on green ICTs are likely to support the creation of the new ICT-related jobs in the green and smart economy. This is the *double dividend* that is expected from green ICT investments: "both jumpstarting job creation and accelerating the transition towards green growth" (OECD, 2011d; see also OECD, 2011c). Indeed, as unemployment remains high in most OECD countries,[9] many government economic stimulus packages addressing the recession have explicitly aimed at boosting employment, with a significant number having a strong commitment to promote the creation of "green jobs".[10] These plans will further the development of ICT-related employment as many of the promoted green jobs are related, directly or indirectly, to ICTs (*e.g.* jobs in R&D, production, deployment, maintenance, and use of green technologies such as "smart" electricity grids and wind energy turbines).

After developing a working definition of green ICT-related employment, this section presents emerging green ICT-related jobs in the ICT sector but also across the economy based on case studies and examples. Employment considered in this section includes jobs related to the R&D and manufacturing of energy-efficient semiconductors as well as semiconductors for clean technologies such as photovoltaic and wind power, or in firms providing services for the reuse, refurbishment and recycling of old ICT equipment or for the analysis and deployment of green ICTs. It also includes jobs outside the ICT sector, which are related to "smart" applications for improving resource efficiency across the economy.

Defining green ICT-related skills and employment

Green ICT-related skills and employment have rarely been discussed in the current debate on "green jobs". This is partly because the full potential of ICTs for improving environmental performance across the economy has not yet been fully recognised (see OECD, 2010d). Furthermore, a clear and widely accepted definition for "green jobs" still does not exist. This section develops a working definition for "green ICT-related jobs", which includes both, "green jobs" related to ICTs (*i.e.* "ICT-related green jobs") and jobs that are related to green ICTs but are not considered "green" by most definition on green jobs (*i.e.* "other green ICT-related jobs") in this report. Developing this working definition requires the following three steps:

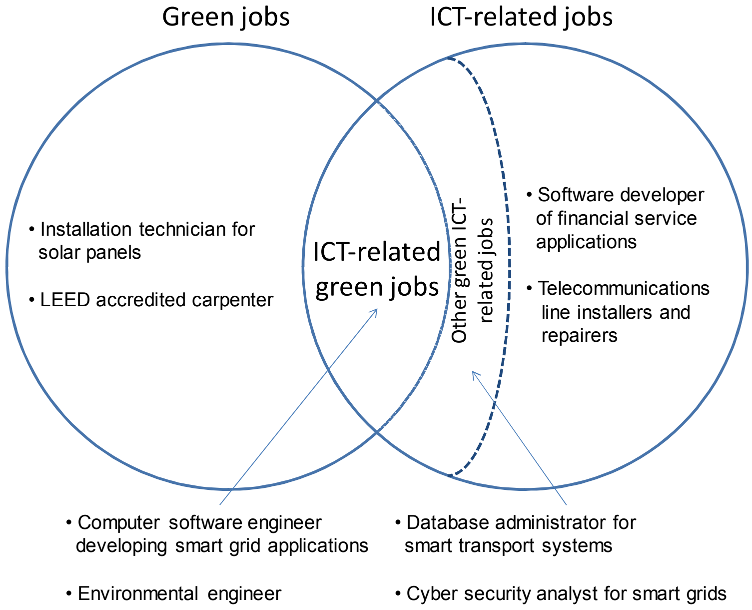
1. Reviewing existing definitions for "green jobs"

2. Identifying among these green jobs the ICT-related jobs as defined by the OECD Working Party on the Information Economy (WPIE), and

3. Identifying "other green ICT-related jobs", *i.e.* ICT-related jobs that are not considered as "green" according to most green job definitions.

The relationship between these three job categories (green jobs, ICT-related green jobs, and other green ICT-related jobs) together with ICT-related employment is presented in Figure 14. At this point, it should be noted that the boundaries between green jobs and non-green jobs are more blurred than clear, and so are the boundaries between ICT-related green jobs and in particular the "other green ICT-relation jobs" and non-green ICT-related jobs.

Figure 14. The relationship between green jobs, ICT-related green jobs, and ICT-related jobs with examples



Green jobs

There is no widely agreed on definition for "green jobs". Common for many existing definitions is that activities related to "green jobs" should contribute (directly) to the mitigation of environmental burdens or the adaptation of climate change. The UNEP (2008), for example, defines green jobs as "positions in agriculture, manufacturing, construction, installation, and maintenance, as well as scientific and technical, administrative, and service-related activities, that contribute substantially to preserving or restoring environmental quality". The UNEP, however, requires that green jobs "also need to be good jobs that meet longstanding demands and goals of the labour movement, *i.e.*, adequate wages, safe working conditions, and worker rights, including the right to organize labour unions". In this report, the definition provided by OECD/Martinez-Fernandez, Hinojosa and Miranda (2010) will be used. According to this definition: *Green jobs are "jobs that contribute to protecting the environment and reducing the harmful effects human activity has on it (mitigation), or helping to better cope with current climate conditions (adaptation)".*

In addition, definitions can include a set of criteria or indicators in order to further specify what kind of jobs are to be considered green. OECD/Martinez-Fernandez, Hinojosa and Miranda (2010) list nine indicators, which can be used in order to indentify green jobs (see Annex Table A1.5). It includes references to:

1. Industry (*e.g.* sector and produced goods and services)

2. Organisation (*e.g.* production method and value chain)

3. The job itself (*e.g.* occupation and required skills).

It should be noted that most of the indicators presented in Annex Table A1.1 are interdependent: For example, a green production method will usually require employees to have a certain level of green skills. Many definitions therefore refer to only two of the three criteria listed above. In the case of the first criteria (the industry of the produced goods and services), existing definitions for the green industry as provided, for example, by the OECD and Eurostat (1999) manual defining the environmental goods & services industry can be used.

For example, the definition of green jobs provided by Connection Research (CR) in conjunction with the Department of Environment, Climate Change and Water, New South Wales and the Environment Institute of Australia and New Zealand is based on both, the type of organisation and occupational profiles. According to this definition, green jobs include:

1. Managers, professionals and technicians who work in green organisations

2. Those who have green skills and responsibilities within other organisations that may not be considered as green

3. Service, clerical, sales and semi-skilled workers who work in green organisations (CR, 2009).

However, as OECD/Martinez-Fernandez, Hinojosa and Miranda (2010) have highlighted, "the question remains as to what can be considered to be a 'green organisation".

The U.S. Bureau of Labor Statistics (BLS), as another example, has developed a two-part definition including the type of produced goods and services and the applied production method. According to this definition, green jobs are:

1. Jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources".

2. Jobs in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer natural resources" (BLS, 2009; also see Annex 1 for details).

The definition will be used in the data collection in two planned surveys focussing each on the two different parts of the definition.

The first part of the definition includes jobs on "research and development, installation, and maintenance services" in industries that produce green goods and services and which fall into one or more of the following five groups:

1. Energy from renewable sources.

2. Energy efficiency.

3. Pollution reduction and removal, greenhouse gas reduction, and recycling and reuse.

4. Natural resource conservation.

5. Environmental compliance, education and training, and public awareness.

The US BLS has selected 333 green industries out of 1192 industries based on the North American Industry Classification System (NAICS) 2007 at the six-digit level. Selected industries include, for example, farming of USDA certified cotton (111920), Leadership in Energy and Environmental Design (LEED)-specific architecture services or energy efficient architecture services (541310), and manufacturing of Energy Star certified computers (334111).

The second part of the definition includes workers across all industries, who “research, develop, maintain, or use technologies and practices to lessen the environmental impact of their establishment, or train the establishment’s workers or contractors in these technologies and practices” (BLS, 2010). This includes again the following technologies and practices:

1. Energy from renewable sources
2. Energy efficiency
3. Pollution reduction and removal, greenhouse gas reduction, and recycling and reuse
4. Natural resource conservation.

Table 2 lists representative occupations where demand can be expected to increase due to the deployment of selected green technologies.

Table 2. Occupations in demand due to the deployment of selected green technologies

Green technologies	Representative occupations in demand
Energy efficient building	Electricians, heating/air conditioning installers, carpenters, construction equipment operators, roofers, insulation workers, carpenter helpers, industrial truck drivers, construction managers, building inspectors.
Smart grid	Computer software engineers, electrical engineers, electrical equipment assemblers, electrical equipment technicians, machinists, team assemblers, construction labourers, operating engineers, electrical power line installers and repairers.
Wind power	Environmental engineers, iron and steel workers, millwrights, sheet metal workers, machinists, electrical equipment assemblers, construction equipment operators, industrial truck drivers, industrial production managers, first-line production supervisors.
Solar power	Electrical engineers, electricians, industrial machinery mechanics, welders, metal fabricators, electrical equipment assemblers, construction equipment operators, installation helpers, labourers, construction managers.
Cellulosic biofuels	Chemical engineers, chemists, chemical equipment operators, chemical technicians, mixing and blending machine operators, agricultural workers, industrial truck drivers, farm product purchasers, agricultural and forestry supervisors, agricultural inspectors.

Source: Pollin and Wicks-Lim (2008)

ICT-related green jobs

A significant share of jobs identified as green according to the above definitions is related to ICTs. This includes green jobs in the ICT sector (*i.e.* ICT-sector employment) as well as ICT-skilled green jobs (*i.e.* ICT-skilled employment). Both categories of jobs are defined in the following as *ICT-related green jobs*.

Green jobs in the ICT-sector

Some ICT industries contribute directly to the production of environmental goods and services. For example, among the 47 industries included in the ICT sector definition presented in Annex 1, 17 have been identified by the US Bureau of Labor as producer of green goods and services (see Table 3). In its forthcoming data collection, the US Bureau of Labor Statistics will “estimate the number of green jobs for a NAICS industry based on the green jobs found at individual establishments classified within the industry" (BLS, 2010). Based on these data, which will be available to the public in the beginning of 2012, the contribution of the ICT sector in green job creation can be better assessed.

Table 3. ICT industries in the United States where green goods and services are classified

NAICS 2007	Title	Examples
334111	Electronic computer manufacturing	Energy Star certified computers
334113	Computer terminal manufacturing	Energy Star certified computers
334119	Other computer peripheral equipment mfg.	Energy Star certified printers
334210	Telephone apparatus manufacturing	Energy Star certified telephones
334220	Broadcast and wireless communications equip.	Energy Star certified cable boxes
334310	Audio and video equipment mfg	Energy Star certified products
334413	Semiconductors and related device mfg.	Solar cells
511210	Software publishers	Training software, software used to reduce or monitor energy usage, pollution
512110	Motion picture and video production	Environmental content, training movies or videos
512120	Motion picture and video distribution	Distribution of environmental, training content
515111	Radio networks	Environmental content for radio broadcasting
515112	Radio stations	Environmental content for radio broadcasting
515120	Television broadcasting	Environmental content for TV broadcasting
515210	Cable and other subscription programming	Environmental content for cable distribution
519130	Internet publishing and web search portals	Environmental, training, compliance websites
541511	Custom computer programming services	Programming services for computer systems to monitor or regulate emissions or energy usage
541512	Computer systems design services	Design services for computer systems to monitor or regulate emissions or energy usage

Source: OECD based on green jobs definition of the United States Bureau of Labor Statistics.

ICT-skilled green jobs

The largest share of ICT-related green jobs can, however, be expected to exist among ICT-skilled workers, partly because they are spread widely across the economy. Two measures of ICT-skilled employment have been developed in OECD work on ICT-skilled employment. One is a narrow measure, comprising ICT specialists whose job is in ICTs, *e.g.* software engineers. The other is a broader measure of ICT-skilled employment where ICTs are used regularly as part of the job, but where the job is not focused on ICTs, *e.g.* a researcher or an office worker.

As shown in Table 4, the deployment of green technologies will most likely directly increase demand for ICT-skilled workers (for ICT specialists as well as ICT advanced users). A preliminary analysis reveals that smart applications such as smart grids, smart transportation systems or smart buildings will increase demand for ICT specialist skills (such as computer software and electrical and electronic engineering skills), while the use of renewable energy sources such as wind and biomass will rather increase demand for workers such as agricultural, chemical and environmental engineers, who are considered to have advanced ICT-skills as they are using advanced hardware and software tools.

Table 4. ICT-skilled occupations is due to the deployment of selected green technologies

CODE Census 2000	DESCRIPTION	Smart grid	Solar power	Wind power	Biomass
1020	Computer software engineers	X			
1330	Agricultural engineers				X
1350	Chemical engineers				X
1410	Electrical and electronic engineers	X	X	X	
1420	Environmental engineers			X	
1720	Chemists and materials scientists				X
7410	Electrical power-line installers and repairers	X			
7720	Electrical, electronics, and electromechanical assemblers	X	X	X	

Note: ICT specialist occupations are highlighted and correspond to the narrow definition for ICT-skilled employment based on methodology described in OECD (2004, *OECD Information Technology Outlook*, Chapter 6). The others are ICT advanced user occupations, which together with the ICT specialist occupations, correspond to the broad definition.

Source: OECD based on Pollin and Wicks-Lim (2008).

Defining green ICT-related jobs

ICT-related green jobs as presented above only include jobs that contribute directly to the mitigation of environmental burdens or to climate change adaptation (see green job definition presented above). This also includes jobs which are directly related to research and development, installation, maintenance, and use of green ICTs such as energy efficient electronics or smart applications such as smart transportation systems. However, some jobs directly created due to research and development, installation, maintenance and use of green ICTs cannot be considered green according to the definition for green jobs adopted in this report, given that these jobs do not directly contribute to the mitigation of environmental burdens or the adaptation of climate change. These jobs may, however, still contribute indirectly to the positive environmental impacts of green ICTs and thus are considered in this report in order to capture the full employment impacts of green ICTs. They are highlighted as “Other green ICT-related jobs” in Figure 14.

For example, a computer software engineer developing applications for enabling smart grids occupies a green job according to definition presented above, since the job’s activities directly improve the energy efficiency of the grid. In contrast, a database administrator, who is managing the increasing amount of data arising from intelligent energy distribution networks and smart meters in particular, will not be considered as green according to the definition for green jobs adopted in this report, given that the job only contributes indirectly to energy efficiency improvement in the grid. This remains true, even though the job is a crucial enabler for further data analyses, which in turn can be used by other employees to improve the energy efficiency of the grid.

The above discussions finally lead to the following definition for green ICT-related jobs: which is proposed in this report. Green ICT-related jobs are:

1. Jobs that are related to the research and development, installation, maintenance, and use of green ICTs, i.e. ICTs with reduced environmental impacts as well as “smart” (ICT) applications for improving environmental performance across the economy and society, such as “smart” grids, “smart” transport systems, and “smart” buildings.

2. ICT-related jobs that contribute to protecting the environment and reducing the harmful effects human activity has on it (mitigation), or helping to better cope with current climate conditions (adaptation).

Green jobs in the ICT sector

The semiconductor industry

Increasing demand for green ICTs has encouraged the semiconductor industry to further increase the environmental efficiency of its products. The heat given off per semiconductor unit increases with Moore's Law and has made energy efficiency a continuing requirement for semiconductor reliability.[11] Given the increasing demand for green ICTs, semiconductor firms have increased research and development (R&D) investments to improve energy efficiency and associated employment in R&D and production is expected to increase.

For example, Intel and AMD are upgrading or building new manufacturing facilities to produce more energy-efficient CPUs. Intel has announced that it will invest USD 7 billion in upgrading production in the United States to the new 32 nanometre manufacturing technology for faster and smaller energy-efficient chips, and this "will support approximately 7 000 high-wage, high-skill jobs" (Intel, 2009). GLOBALFOUNDRIES, a joint venture between AMD and the Advanced Technology Investment Company (ATIC), will invest USD 4.2 billion to provide 32 nanometre manufacturing technology to chip makers. It is expected to create "more than 1 400 high-tech manufacturing jobs" (AMD, 2009; GLOBALFOUNDRIES, 2009).

Semiconductors for clean technologies are expected to have considerable job creation potential although job cuts in some parts of this segment have been notable, probably due to weak firm performance (Ashford, 2009a; Ashford, 2009b, OECD, 2009b). Growth areas include sensors and actuators for "smart" applications (OECD, 2009g), energy semiconductors for photovoltaic and wind power installations, and automotive semiconductors for low-consumption and low-emission (hybrid and electric) cars (Ballhaus, Pagella and Vogel, 2009).

Power semiconductors for renewable energy were expected to have a compound annual growth rate (CAGR) of 18% between 2008 and 2013 (IMS Research, 2009, cited in Ballhaus, Pagella and Vogel, 2009), followed by a CAGR of 9% for automotive semiconductors for engine regulation and hybrid cars (Strategy Analytics, 2009, cited in Ballhaus, Pagella and Vogel, 2009). For comparison, semiconductors for data processing and communications, which together account for 64% of semiconductors, were expected to have a CAGR of 9% (Ballhaus, Pagella and Vogel, 2009). Given that employment in the semiconductor industry follows annual revenues, employment in these segments can be expected to increase.

The reuse, refurbishment and recycling Industry

Electronic waste (e-waste) has increased dramatically and is expected to continue to do so (see OECD, 2010c). In the United States, for example, e-waste per capita increased by more than 7% annually between 1999 and 2007. E-waste legislation such as the EC Directive on Waste Electrical and Electronic Equipment (WEEE) has obliged companies to rethink the end-of-life management of their electrical and electronic equipment. Furthermore, the continuing depletion of rare minerals such as tantalum, which is essential for manufacturing many ICT devices (*e.g.* mobile phones), and the subsequent increase in the price of these minerals, has made reuse, refurbishment and recycling of ICTs more attractive.[12]

An increasing number of firms are providing ICT reuse, refurbishment and recycling services. The most recently founded firms have focused on mobile phones and have been able to raise significant venture capital for their businesses. Their business model usually involves collecting old mobile phones directly from consumers or the network operator's store and then sorting devices to be recycled or refurbished. Revamped phones can be sold to consumers in emerging markets and valuable materials can be re-used (Reuters, 2010). As processes such as sorting and refurbishing are labour-intensive, employment is likely to increase.[13]

The virtualisation industry

Virtualisation is one of the most promising technologies for improving the energy efficiency of data processing and data centres. It replaces physical computers with software applications that simulate computers. Because it is possible to deploy multiple virtualised computers on a single physical machine, virtualisation enables the consolidation of physical servers and helps optimise energy consumption. It can help firms reduce capital expenditures as well as energy costs. According to Gartner (2009) only 18% of server workloads have been virtualised, but the share is likely to increase very rapidly (Messmer, 2009). This should affect employment in the virtualisation industry as well as in using industries.

A number of large software firms provide virtualisation software, whether as an integrated part of their IT products (*e.g.* Microsoft, Oracle) or as single software products (*e.g.* VMware, Citrix Systems). VMware is the market leader with more than 80% of virtualised computing workloads running on its platforms; Microsoft, Citrix Systems, Oracle and others share the rest (Lohr, 2009).[14] Employment trends in VMware and Citrix Systems typify employment in the virtualisation industry. Employment in VMware grew at a CAGR of 33% between 2006 and 2009. It employed 7 100 people in 2009, 400 (6%) more than in 2008 and 2 100 (42%) more than in 2007. Employment in Citrix Systems was less dynamic with a 9% CAGR between 2006 and 2009. In 2009, the company cut jobs for the first time since 2002 (by almost 200 out of 4 800 people). However, employment in Citrix Systems has grown faster than the average top 10 software firms, but from a lower base.

Although virtualisation may favour employment in the software industry, it will also increase pressure on employment in the hardware manufacturing industry. With increasing server consolidation through virtualisation, demand for hardware can be expected to slow. However, price effects (lower average costs of computing) may also increase demand for equipment, as seen in the rapid growth in data centres. Virtualisation is also likely to have a considerable impact on ICT skills. For ICT specialists this means, for example, that traditional skills such as server and network administration will need to be complemented with virtualisation skills (Dubie, 2009). Furthermore, virtualisation increases security requirements, making security management more complex and increasing the need for security expertise (Antonopoulos, 2009).

The IT service industry

Most organisations still lack the knowledge necessary to deploy green ICTs effectively (OECD, 2009f; IDC, 2008; Wikberg, 2008). This creates an opportunity for consulting and service firms, which increasingly offer green ICT services to businesses and the public sector. These services include environmental impact assessments, development and evaluation of green ICT strategies, and optimisation of data centres.

Estimates suggest that green ICT consulting revenues could have a CAGR of 60% and reach USD 4.8 billion by 2013, with associated demand for ICT-related environmental skills (Mines, 2009).[15] This includes ICT specialists with additional knowledge and experience in server virtualisation and consolidation, cloud computing, green procurement, and carbon reporting and offsetting. Their potential employers are the top 10 IT services firms identified in OECD (2010c) (*e.g.* IBM, Accenture and

Capgemini), data centre design specialists such as Dell and Sun, and Indian IT services providers such as Infosys and Wipro which are also increasingly looking for green ICT specialists.

Estimates of growth of green ICT services usually only include green ICT in its narrow sense (*i.e.* direct effects of ICTs) but do not take "smart" infrastructures and the wider enabling environmental capabilities of ICTs into consideration. The total value of the consulting market for green ICTs is likely to be higher, if services such as engineering design and construction services for "smart" transport infrastructures or operations and facility management services for "smart" buildings are included. Consequently, green ICT-related skills will play a greater role in occupations outside of the ICT sector.

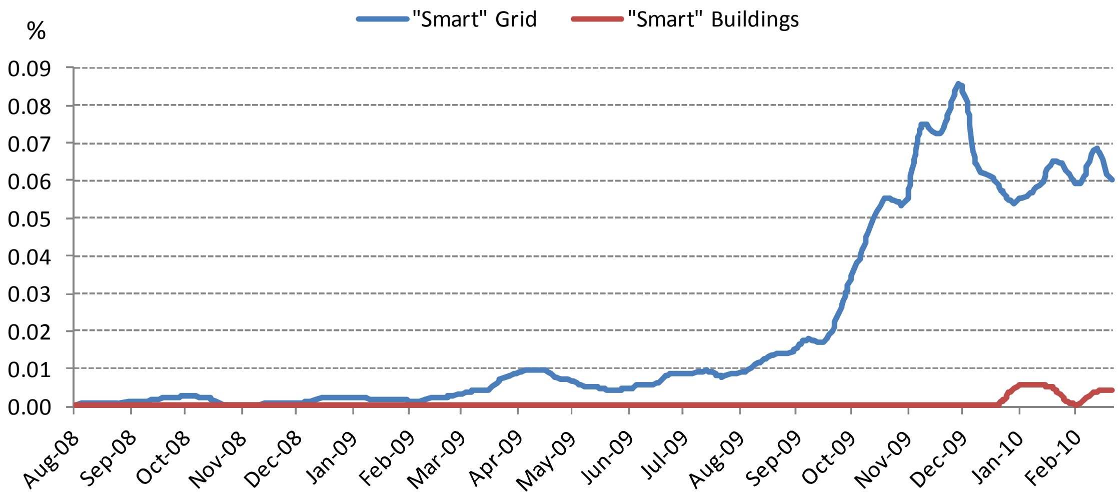
ICT-skilled green jobs

"Smart" applications such as "smart" grids, "smart" buildings, and "smart" transport, are a major part of green ICT strategies and economic stimulus packages for green growth (OECD, 2009d, 2009f). These also target the protection of existing jobs and the creation of new jobs. ICT-related employment may benefit in the short and medium term, given that "smart" applications rely directly on ICTs, and ICT skills are crucial for achieving the aims of many of these policies.

The deployment of "smart" applications such as "smart" grids is expected not only to generate substantial energy-efficiency gains, but also to create new jobs for ICT specialists across the economy and in the ICT sector. Estimates have suggested that deployment of "smart" grids could create approximately 280 000 new jobs by 2012 in the United States (KEMA, 2009). This includes job creation by "smart" application providers and by contractors and suppliers of the underlying technologies and services. However, measuring jobs created by "smart" applications is a challenge, given that national statistics do not distinguish between jobs in "smart" applications and other ICT-related jobs.

Nevertheless, private-sector demand for "smart" applications specialists in "smart" electricity grids has started to increase, although from a very low level. In February 2010 in the United States, for example, less than 0.1% of all vacancies indexed at SimplyHired.com were related to "smart" jobs, and the majority by far were for "smart" grid specialists (almost 2 000 vacancies, 0.06% in February 2010) (see Figure 15). However, there was a significant increase in vacancies starting in February 2009 and accelerating considerably from September 2009. Initial uptake in February 2009 is most likely related to the *U.S. American Recovery and Reinvestment Act of 2009*, which was enacted in that month and which provides USD 11 billion for deploying a national "smart" grid.

Figure 15. Share of "smart" job vacancies in total vacancies in the United States, August 2008-February 2010
Percentage



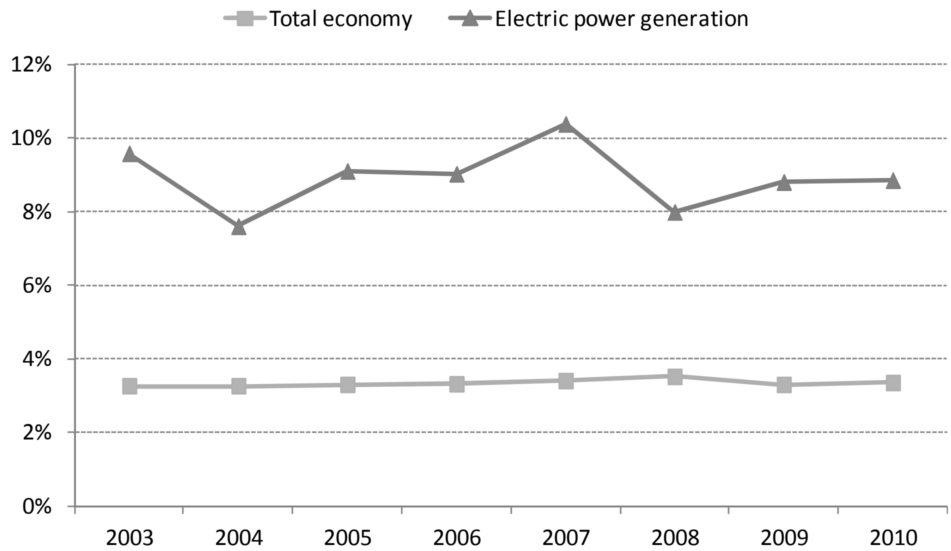
Source: *SimplyHired.com.*

Other green ICT-related jobs

The deployment of green ICTs will most likely also increase demand for ICT-skilled jobs, which are not directly related to the mitigation of environmental burdens or the adaptation of climate change, and thus are not considered as green jobs according to the definition used in this report. These "other green ICT-related jobs" need, however, to be considered in order to capture the full job creation potential of green ICTs. This is particularly true since there are indicators suggesting that these jobs may outnumber ICT-related green jobs. The following sections highlight developments in the share of ICT specialists in electric power generation, transmission and distribution in the United States in order to estimate the impact of smart grids on ICT-related green jobs and other green ICT-related jobs in the utility sector.

The share of ICT specialists employed in electric power generation has varied over time. Between 2004 and 2007, the share has increased from below 8% to more than 10% (Figure 16). In 2008, however, the share dropped significantly to the 2004 level. This was primarily due to a large increase in non-ICT occupations with the number of ICT specialists remaining stable. However, there has been a shift within ICT specialists in the sector. The share of electrical and electronic engineers among all ICT specialists fell from 50% in 2005 to 38% in 2009. In contrast, database administrators increased from 7% to 18% in 2009, and they are now the second biggest group of ICT specialists. In 2010, the share of ICT specialists employed in this industry then increased reaching again almost 10%. This indicates that the sector is becoming more knowledge and data-intensive and that data management is a more important part of the electricity sector's functions. This may be related to the uptake of "smart" applications such as "smart" grids and metres as promoted in the United States, but could as well be the result of changes in billing and customer relations.

Figure 16. Share of ICT specialists in total employment in the electric power generation in the United States, 2003-10



Source: OECD calculations *from US Current Population Survey.*

Skills in demand for green ICT related workers

Reducing the environmental impact of ICTs and through ICT applications, makes considerable demands on skills, as environmental skills are needed in addition to ICT-related skills as well as sector specific skills *e.g.* on electricity, transport and building management (including field-specific knowledge of legal frameworks). Furthermore, using ICT applications also necessitates awareness about the environmental implications of consumer behaviour. Therefore the provision of the right skills and education is of high importance to unleash the full potential of green technologies. The question, however, remains to what degree existing ICT skills may be enough, or need to be complemented with additional "green skills".

Here again, the analysis of vacancy data seems to be very promising for determining the future skill needs as well as the potential employers in demand of these skills and competences. For example, vacancy data in the United States suggest that most "smart" jobs come from ICT firms; in particular, IT services firms as well as electronic and electrical firms. In February 2010, for example, 62% of all vacancies for "smart" grid specialists in the United States indexed at SimplyHired.com were placed by IBM, followed by General Electric (7%), and Accenture (5%). Other firms with vacancies on "smart" grid jobs include consulting companies such as ICF International and Booz Allen Hamilton.

The required education level for "smart" application specialists is relatively high. Among all vacancies on "smart" grids, for example, 98% were requiring higher education (76% with bachelor's degree, 16% with master's degree, and 6% with doctorate). The years of experience required were between 7 and 10 years in 24% of all vacancies, followed by 10-15 years, and 2-5 years (in 20% each of all vacancies). Only 7% of all vacancies on "smart" grids indexed at SimplyHired.com required less than two years of working experience. For comparison, more than 22% of all IT-related vacancies required less than two years of working experience. This suggests that fresh graduates may encounter difficulties in getting "smart" grid-related jobs due to a lack of working experience, and therefore may find these jobs less attractive.

Satisfying ICT skill needs for the smart and green economy

There is a high threshold of skills in green ICTs necessary in relation to research and development, deployment, maintenance. In most cases, pure ICT skills are not enough anymore, but must be complemented with sector- or domain- specific skills such as business and administration skills or environmental skills. Furthermore, generic and soft-skills such as communication skills are becoming increasingly important, sometimes surpassing even the need for pure technical skills (see Czarnecki, 2011a and 2011b; Williams, 2011).

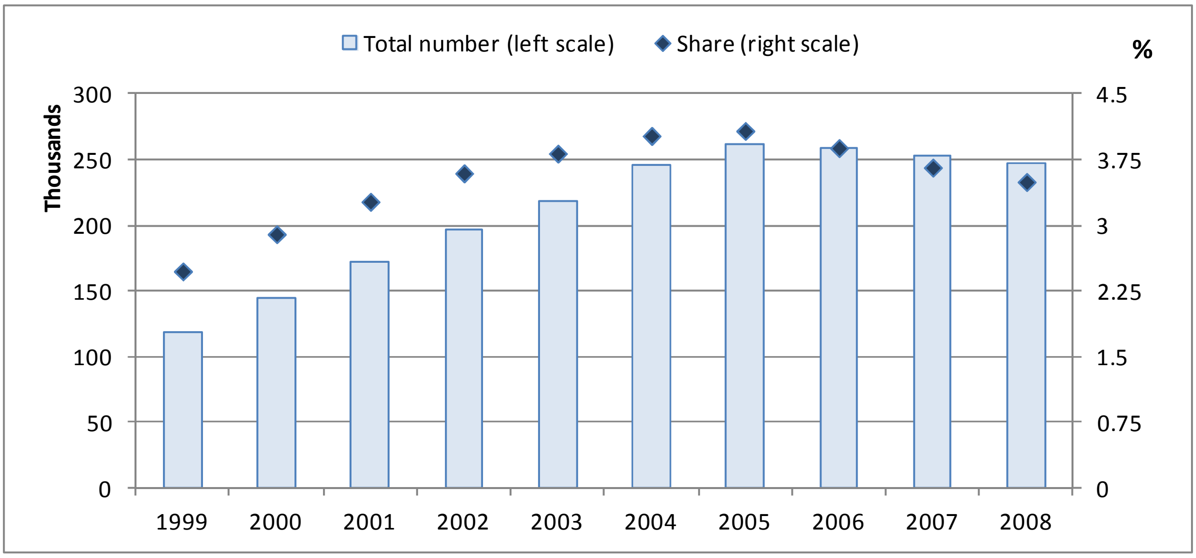
This section analyses the skills and competences required for the ICT-related jobs in the smart and green economy based on available vacancy data, and to what extent existing skills may be sufficient or need to be upgraded or even substituted with newer skills. It will, as a consequence, also discuss the labour market transformation effects induced by the increasing deployment of ICTs with a focus on green ICT. This section will also analyse whether OECD and major non-OECD countries may be facing ICT skills shortages, which in turn could prevent the uptake of new advanced ICTs, and in particular, ICT-intensive green technologies.[16] This section will end with a discussion on the implications for education, (vocational) training, outsourcing, and migration as means of meeting national ICT skills requirements.

The role of research and education institutions

Higher-education institutions have a pivotal role to play in providing the needed skills related to ICTs, and green ICTs in particular. In order to meet increasing demand they have increased their offers in masters-level programmes related to ICTs. Over a period of nine years (from 1999 to 2008), the number of graduates in computer science in the OECD doubled (Figure 17). However, the number of graduates each year began to decline in 2006, after reaching a peak in 2005. This highlights the risk of a skill shortage in OECD countries if nothing is done to reverse the trend.

New academic programmes in computer and information sciences are being developed by universities to meet demand for green technology experts. These programmes focus on smart computer systems, communications systems, systems and services engineering, intelligent systems, electronic engineering and computer networking. There are also a range of new academic programmes within the field of communications systems that offer courses with a focus on advanced applications linked to smart sensors, energy management, automotive control systems, aero-space control systems, precision machining, mobile robotics, and industrial networks. There are also a number of other programmes that do not focus explicitly on green ICTs but that incorporate subjects related to the environment.

Figure 17. Graduates in computer science related fields in OECD countries, 1999-2008



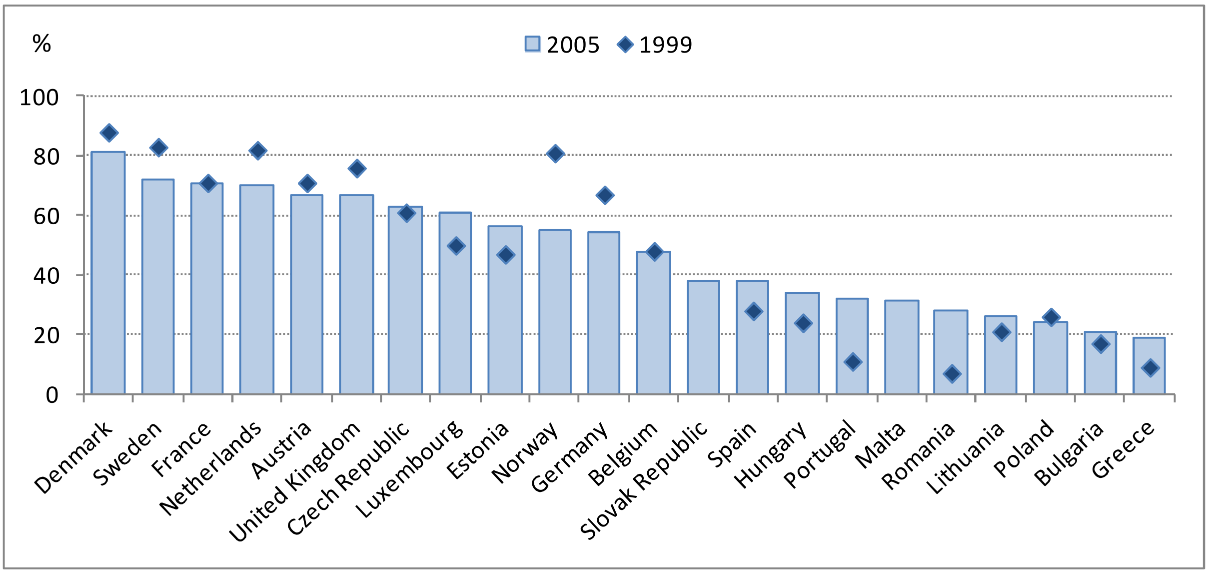
1.) Data do not include Japan. Data on Greece is only included for 2004-09, Luxembourg only for 2009. Data for Belgium in 1999 estimated using 2000 data.

Source: UNESCO-OECD-Eurostat (UOE) data collection on education statistics, compiled on the basis of national administrative sources, reported by Ministries of Education or National Statistical Offices, May 2011.

The contribution of vocational and on-the-job training

The very new and rapidly changing nature of advanced ICTs including green ICTs makes workplace training, in addition to formal education, increasingly important for augmenting and adapting workers' skills. This is especially true for older workers, for whom skills acquired through the educational system are likely to be missing or substantially depreciated in the field of green ICTs. Of concern to policy makers, however, is that available data reveal that the share of firms with vocational training decreased between 1999 and 2005 (see Figure 18), but the use of e-learning applications remains stable (Box 3).

Figure 18. Share of firms with vocational training as share of total number of firms in Europe, 2005 and 1999

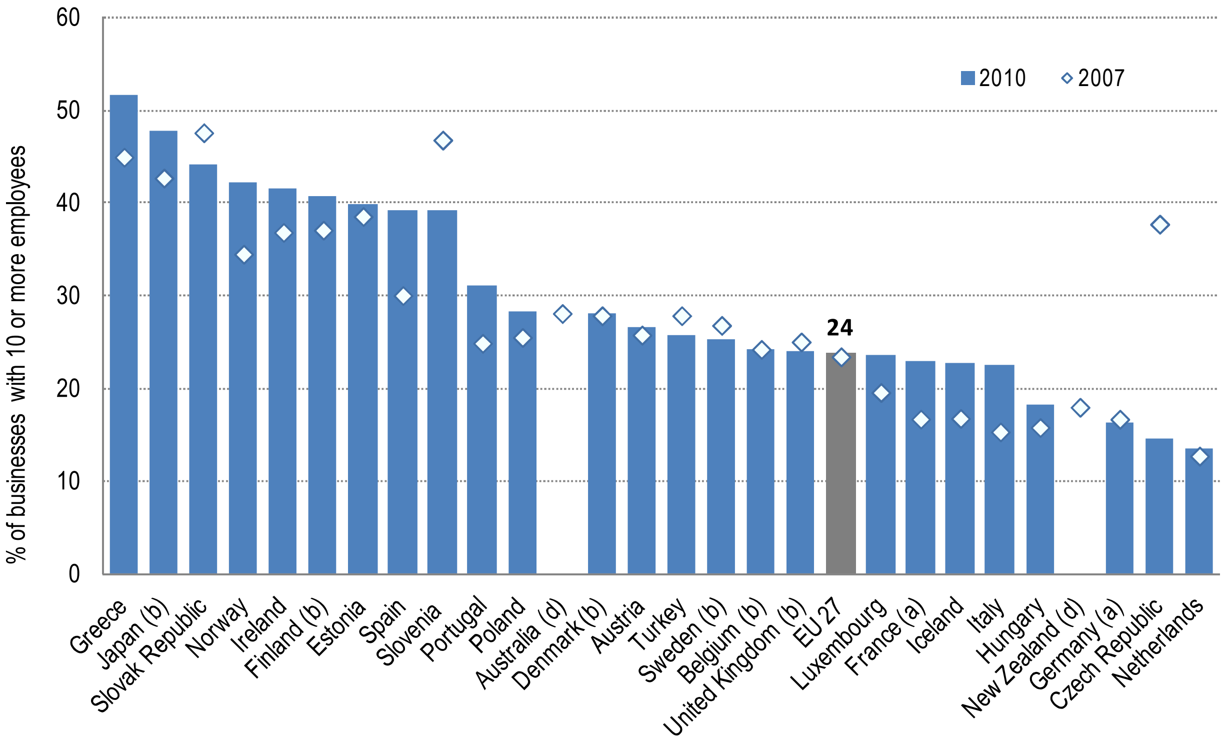


Source: OECD based on Behringer, Moraal, Schönfeld (2008)

Box 3. Businesses using e-learning applications for training and education of employees

In most OECD countries, almost 25% of the enterprises with ten or more employees, use e-learning for training and educating their employees.

Figure 19. Businesses using e-learning applications for training and education of employees, 2007-10



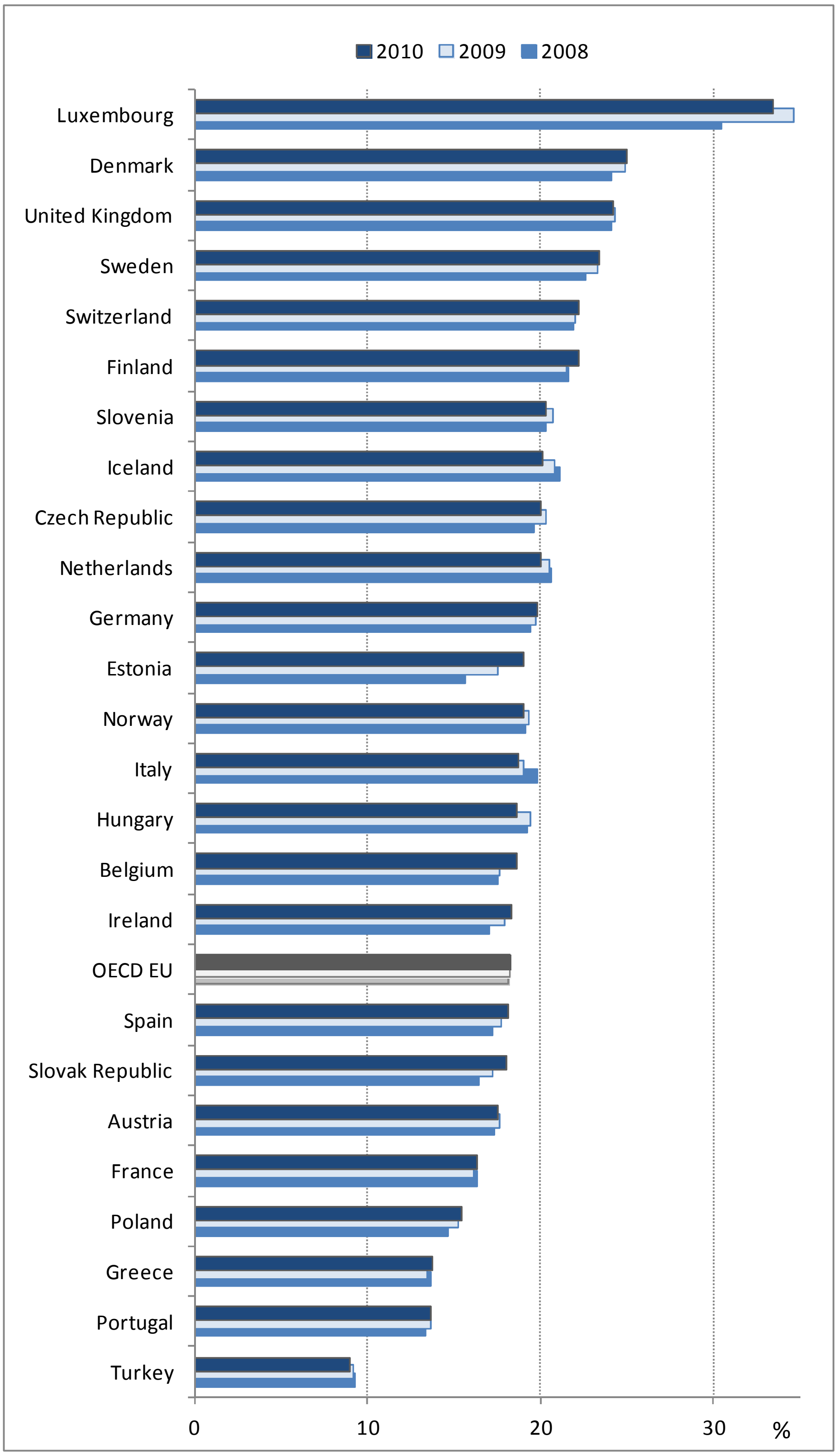
Source: OECD, ICT database and Eurostat, Community survey on ICT usage and e-Commerce in enterprises, March 2011.

The impact of outsourcing

Another way to supply ICTs skills in markets is by using offshore outsourcing. There is also a potential for green ICT-related skills, as some ICT-related green tasks can potentially be outsourced (in offshore locations). For example, "smart" electricity grids could be administrated offshore, as this is being done already with servers in data centres.

Some of the green-ICT related occupations such as *computer software engineers* (see Table 2 and Table 4) are also among the occupations potentially affected by offshoring as indentified in the Annex. Although the share of these occupations have remained stable (at 18% since 2008 in OECD Europe area), some strong variation between countries exists (see Figure 20). In Luxembourg, in particular, almost 35% of the workers are employed in occupations potentially affected by offshoring. This is more than 15 percentage points higher than the average in OECD Europe.

Figure 20. Employment potentially affected by offshoring as share of total employment in OECD Europe, 2008-10

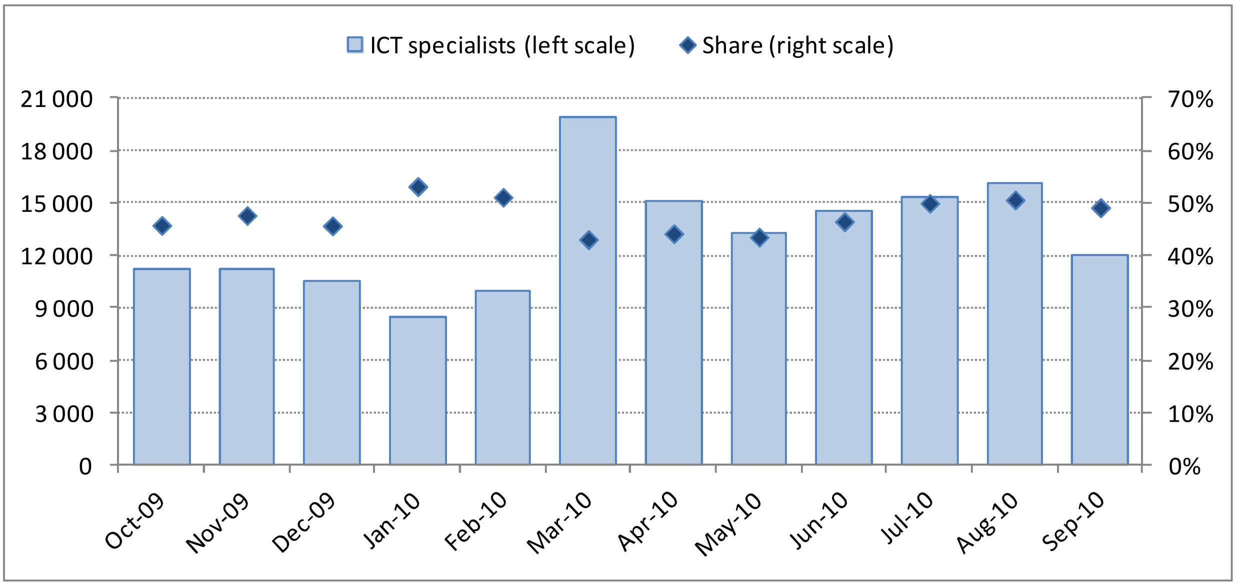


Source. OECD calculations based on EULFS

Meeting demand for scarce skills through migration

Migration is another means for meeting the demand for scarce skills. Data on H-1B visa applications in the United States, which are used to temporarily employ skilled foreign workers, reveals that demand for foreign ICT specialists decreased in the last quarter of 2009 and the first quarter of 2010 (see Figure 20). At the same period, however, the share of H-1B visa applications for ICT specialists has remained stable or has even increased, indicating that H-1B visa applications across all occupations have declined much more rapidly than applications for ICT specialists. This confirms that ICT specialist employment was not hit as hard as employment in other occupations. Furthermore, since the second quarter of 2010, H-1B visa applications in the United States have increased again, suggesting on one hand, that demand for ICT specialists has increased again, but on the other hand that local market cannot meet demand.

Figure 20. H-1B visa applications for ICT specialists in the United States, October 09-September 2010



Source. OECD calculations *from US Foreign Labor Certification Data Center Online Wage Library.*

Policies and programmes promoting ICT-related skills and employment

ICTs, and in particular the Internet, continue to have a profound impact on employment and skills across all sectors, and labour market and skill policies can play a key role in facilitating the structural changes that these technologies continue to drive. ICT employment and skills should remain a key focus given that unemployment still is remaining high in most OECD economies, and with current policy attention towards promoting a transition to green growth, advancing. This is particularly true given the crucial role ICTs play for greening the economy. It is therefore no surprise that, of 24 countries indicating an increase in the priority of at least one ICT policy area in view of facilitating economic recovery in the *OECD Information Technology Outlook Policy Questionnaire 2010* (*2010 Policy Questionnaire* in the following), the majority (15 countries) have made ICT skills and employment a priority in their policy agenda, together with policies furthering broadband diffusion but followed by policies enabling environmental impacts of ICTs (11 countries). Furthermore, ICT skills and employment continue to be among the top ten long-term policy priorities (OECD, 2010c).

This section presents OECD government policies and programmes promoting ICT-related employment and skills, highlighting, in particular, those targeting green ICT-related jobs. As the 2010 Policy Questionnaire however reveals, only a minority of governments are explicitly promoting green ICT-related skills and jobs. In contrast, almost half of OECD governments have put an emphasis on measures for tackling the job crisis; with some of these measures being related to green ICTs (see Box 4). Overall, most OECD governments have established policies and programmes *i*) furthering IT education and training, *ii*) improving labour market information, and *iii*) promoting international sourcing of ICT skills. These measures are presented below in more detail.

Box 4. Policies on ICT-related jobs in response to the crisis

Almost half of OECD countries have established policies for tackling the job crisis. The promotion of IT education and on-the-job training thereby rank high among the priorities of OECD governments. In most cases governments are upgrading already existing education programmes in order to promote (IT) education to more people, with a particular focus on the unemployed. The Dutch *Digital Skills and Digital Awareness Programmes*, for example, provide IT education for people with low levels of ICT skills. Due to the economic crisis, more activities aim at the unemployed. In Sweden, as another example, existing education and on-the-job training programmes have been scaled up in order to offer education (including IT education) to more people.

Most of the economic stimulus packages in OECD countries having an important component which relies, directly or indirectly, on ICTs (*e.g.* “smart” applications such as “smart” grids) so ICT-related jobs (including green ICT-related jobs) could benefit. This is, however, only true if the right kinds of ICT skills are available. A significant number of government programmes are therefore promoting skills needed for those ICT-based applications promoted through stimulus packages. The 2009 *American Recovery and Reinvestment Act* (ARRA) of the United States, for example, allocates USD 750 million for disbursement by the Department of Labor under the Competitive Grants for Worker Training program, the majority of which is targeted for promoting skills needed for “green” jobs (including green ICT-related jobs). In Switzerland, the third economic recovery package promotes the usage of the *Swiss Unified Company Identifier* in order to boost e-government applications, which is expected to further the demand for ICT skills. The European Cars Initiatives by the EC, as another example, provides EUR 5 billion to the automotive industry to promote the deployment of green cars. This is expected to support green ICT-related jobs in sectors such *as* the automotive semiconductor industry.

Source: OECD, 2010c

Furthering IT education and training

As ICTs and the Internet become ever more pervasive and OECD economies "smarter", IT-skills become crucial for ensuring social inclusion and for permitting and complementing the production and use of Internet-based products and services (see OECD, 2011e). Therefore, the promotion of IT education remains essential to achieving the long-term objectives of information societies. Among all respondents of the 2010 Policy Questionnaire, more than 70% pointed to policy programmes to promote *IT education*. In most cases, this includes the promotion of ICT skills in *higher education*, followed by *vocational and on-the-job training*. In contrast, *primary and secondary education* has attracted less attention. Independent of the level of education targeted, the *promotion of ICT skills for specific user groups* in particular women, youth, and the elderly ranks high on governments' agenda (see Box 5).

Box 5. Promoting ICT skills for women, young talents, and the elderly: a German example

Besides the unemployed, governments are promoting e-inclusion and encouraging specific groups in their societies to improve their ICT skills. This includes: *i*) increasing the participation of women in ICT specialist occupations; *ii*) promoting young talent in the field of ICTs, and *iii*) enhancing and upgrading ICT skills of older workers.

In Germany, for example, ICT skills for women, the young, and the elderly are being promoted through different initiatives: Women are targeted through the "National pact for women in 'MINT' occupations", which aim at bundling existing projects to encourage more female pupils and students to pursue MINT (mathematics, informatics, natural sciences and technology) careers and conducting new activities and campaigns. In addition, the youth in Germany are beneficiaries of the "IT-Hochburg Deutschland" ("Germany: IT Powerhouse") initiative, while older workers benefit from the Federal Government initiative "IT 50 plus", which is being conducted in collaboration with the ICT business association BITKOM and the IG Metall metalworkers' union.

Primary and secondary education

Some governments have started to promote ICT skills in primary and secondary education. Where they have done so, they mainly have promoted ICTs in the classroom, most frequently through broadband access. However, in many cases the deployment of ICTs and broadband is not limited to primary and secondary education institutions, but also includes higher and vocational education institutions (see next sections). Examples include:

- The i-Japan Strategy 2015 was developed by the Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society (IT Strategic Headquarters)[17] and will further the deployment of ICTs, digital content and broadband across all educational levels (see Box 6).

- Italy's *e-gov 2012 Strategy*, which will invest EUR 241 million between 2009-12 to increase digital innovation in schools, including: *i*) the widespread of Internet connection for all schools, *ii*) digital boards for didactic purposes; and *iii*) digital services for interaction with parents.

- Spain's Internet in the Classroom programme disbursed over EUR 450 million between 2006 and 2009 to equip schools with broadband connections and IT equipment for educational purposes; the programme is entering its second phase under the title School 2.0. Spain has also developed AGREGA, a national repository with downloadable educational content for teachers (see also OECD, 2010f).

- The German Federal Ministry of Education and Research (initially together with Deutsche Telekom) is promoting Internet access and use in schools but in kindergartens and vocational education institutions through the association "Schulen ans Netz e.V.".

- Portugal's *Education Technological Plan* is promoting ICT and its educational use in schools through a series of projects. For example, through the project "Internet de alta velocidade" all lower and upper secondary schools have been equipped with broadband access with at least 48Mbps since January 2006. The project "e.escola, e.professor, e.oportunidades", as another example, aims to broaden the use of computers and the Internet, among teachers, students and their families. So far more than one million computers have been delivered. Other projects include school portals with educational content for collaborative work and ICT internships in industry for technology track students.[18]

Box 6. *The i-Japan Strategy 2015*: Developing ICT-skills in kindergartens to universities

The *i-Japan Strategy 2015* is a follow-up strategy programme of Japan's Priority Policy Programme 2008. They were both developed by the *Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society* (IT Strategic Headquarters) within the Cabinet of the Prime Minister of Japan and involve the Ministry of Internal Affairs and Communications (MIC) and the Ministry of Economy, Trade and Industry (METI). The strategy envisions the ubiquitous availability and usage of ICTs and aims to "create a condition of digital inclusion throughout the economy and society". The strategy also recognizes that information and ICTs can lead to "digital innovation" generated by individuals and society as a whole.

The *i-Japan Strategy 2015* emphasises four perspectives for achieving its vision:

1. Easy to use digital technologies;
2. Breaking down the barriers that hinder the use of digital technologies;
3. Ensuring security when using digital technologies;
4. Creating a new Japan by diffusing digital technologies and information throughout the economy and society.

Besides e-government and e-health, the *i-Japan Strategy 2015* therefore promotes ICT-related education and skills as one of its major fields. All educational levels are targeted: from kindergartens and nurseries to elementary, junior high and high schools, and then to universities and further education institutions. The goal of the strategy is to:

1. Enhance the desire and ability of children to learn using methods whose effects are objectively measured;
2. Enhance the ability of children to use information;
3. Establish educational sites at universities and other educational institutions to prevent the occurrence of mismatches with respect to ICT-related skills; and
4. Expand and improve information education, digital infrastructure and remote education at universities and other educational institutions.

In order to achieve these goals, the *i-Japan Strategy 2015* stipulates the following main measures:

1. Encourage the use of digital technologies in classrooms, for example: *i)* by raising the teaching abilities of teachers using digital technologies, *ii)* by establishing supportive structures for teachers such as ICT skilled support personnel, *iii)* by establishing easy-to-understand classes that use digital equipment such as electronic blackboards; and *iv)* by increasing the computerisation level in school administration.
2. Develop highly-skilled digital human resources, for example: *i)* by broadly establishing and improving practical educational bases in collaboration with universities and cutting-edge businesses, *ii)* by improving and expanding national educational centres in collaboration between industry, academia, and government, and *iii)* by supporting the development of attractive employment and career paths on both the supply and user sides of ICT systems and services.

Source: IT Strategic Headquarters, 2009

Higher education

Governments are most frequently promoting ICT skills in higher education. In some cases, the higher education institutions are encouraged and may be obliged to take into consideration the needs of the industry when developing and offering programmes. The Norwegian government, for instance, promotes ICT education among other technology-related education programmes as part of its national *Strategy for a Joint Promotion of Mathematics, Science and Technology* (MST). Through this programme, higher education institutions have the opportunity to apply for public funding for measures increasing recruitment to MST-related programmes (see also Box 7 for an example from Korea). A similar effort is being done in Portugal through the MIT-Portugal Programme, an innovative research, innovation and advanced education initiative aiming to address key technology, economy and society issues through high quality advanced education and research in emerging green technologies. This includes in particular sustainable energy and transport systems as key areas for improving economic and social development. Last but not least, governments have also promoted ICT skills by upgrading ICT infrastructure in higher education institutions (along with other education institutions), and by increasing the deployment of e-learning applications. The Australian Government's *Education Investment Fund*, for example, will invest AUD 4 billion over 2008–13 for strategic capital infrastructure investments to improve education and research capacity in education institutions.

Box 7. Green ICT-related skills in higher education and research institutions in Korea

Higher education and research institutions play a crucial role for innovation on green ICTs and their applications. Given that they provide the place where highly-skilled workers can generate additional theoretical and applied knowledge on cutting-edge green ICTs, higher education and research institutions are important allies in promoting green-ICT related skills and competences.

In Korea, innovation in higher education and research institutions regarding ICTs (including green ICTs) has been promoted while at the same time supporting ICT skills development. Korea's Ministry of Knowledge Economy (MKE), for example, is supporting the innovation of university education programmes through co-operation and information exchange between universities and companies. Its *Nurturing Excellent Engineers in Information Technology (NEXT)* programme allows universities to quickly adapt to the IT firms' skills demands. In particular, the green technology sector has been included in its "IT Research Center Fostering and Supporting Program", where talented master and doctoral students are involved in R&D activities.

Vocational and on-the-job training

Vocational and on-the-job training rank high among government policies promoting IT education. In many cases, these initiatives focus on specific target groups such as ICT specialists, employees with no or basic ICT skills, or the unemployed. Some examples include:

- In Switzerland, the *I-CH project* is promoting vocational training for ICT professionals. It is a modular system currently offering over 100 modules for basic and advanced training.
- Hungary is promoting e-business and basic ICT skills through its five-year *Training Framework Programme for Increased Adaptability in the Information Society* (TITAN).
- In Belgium, the government is focussing on the unemployed through the Flemish institute for employment (VDAB).

- In Austria, the "Arbeitsmarktservice Österreich" (Austrian Labour Market Service) finances IT training measures, including for the unemployed. It is co-organised by different education and training institutions.

- Korea is promoting talented interns who are promising to develop outstanding ICT skills through its New-IT Internship Programme.

- In Mexico, the Ministry of the Economy launched the MEXICO FIRST (*Mexico Federal Institute for Remote Services and Technology*) initiative, which seeks to develop sufficient human capital for the IT and Business Process (BP) outsourcing industry. The initiative will invest over USD 100 million in the next five years, aiming to certify over 12 000 students per year.

- The Slovak Republic has initiatives focussing on IT-related training in civil services. For example its "Education of Employees in the Public Administration" project provides ICT training for civil servants and the opportunity to obtain the European Computer Driving Licence (ECDL).

- In the United States vocational and on-the-job training has been used to further green ICT-related skills and competences (see Box 8).

Box 8. Furthering green ICT-related skills and jobs through vocational training: Examples from the United States

The lack of green skills and expertise is a major obstacle companies are facing during their path to green growth. This is also true in the case of green ICTs. However, only a minority of governments are providing green ICT related training for managers and their employees. In a survey based on 50 government policies and programmes on green ICTs (across 22 OECD countries plus the European Union) in 2008, only four initiatives focused on vocational training support (see OECD, 2009c). The survey also highlighted the main policy areas of government initiatives on green ICTs and the relatively low share of initiatives on energy management skills and expertise.

In the United States, the *Save Energy Now initiative* of the Department of Energy provides training to enhance energy management skills. The training is accompanied by regular publications about best practices and improvements in energy efficiency technologies including green ICTs. Another example is the *Collaborative Labelling and Appliance Standards Program* (CLASP), launched by the United States Agency for International Development (USAID) as a partnership between governmental institutions world-wide. CLASP is aiming at technical assistance for the national implementation of standards and labels to over 50 countries. This includes building the necessary skills and institutional capacity in those countries. Last but not least, the *2009 American Recovery and Reinvestment Act* (ARRA) allocates USD 750 million for disbursement by the Department of Labor under the *Competitive Grants for Worker Training* program, the majority of which is targeted for promoting skills for "green" jobs (including ICT-related green jobs).

Overall, most initiatives focus on promoting advanced ICT skills rather than basic ICT skills. The majority were also mainly targeting young rather than older workers. IT-related training in the civil service has attracted less attention. In most cases, on-the-job and industry-based training programmes came along with IT certification programmes.

Consumer and user education

Raising environmental awareness can be expected to positively contribute to skills development on green ICTs. This is particularly true when young people are the main target group of initiatives raising environmental awareness. Consumer and user education is thus an important complementary element to policies and programmes promoting green ICT-related skills. In a survey based on 50 government policies and programmes on green ICTs in 2008, eight government policies target consumer and user education.

Denmark's *Action Plan for Green IT*, for instance, highlights that children and young people are the largest group of private ICT consumers. It envisions increasing their environmental awareness by using their favoured communication platforms such as online computer games or social networking sites. Additionally, Denmark's Ministry of Science, Technology and Innovation will inform its employees about their everyday electricity consumption. Japan's *Green IT initiative* aims at increasing society's environmental awareness through measurement and visualisation of the net impact of ICTs on the environment. Korea's Ministry of Public Administration and Security (MOPAS) has developed and conducted a green IT education program for the public and civil servants, which include a wide variety of content related to green ICT, including an introduction to the green ICT concept, policies and technology trends.[19] MOPAS has drawn up and provided guidelines for green IT in daily life on the purchase, use, and disposal of ICT products so that people can realise the benefits of green ICTs. Other examples include Hungary's promotion of "environmental information technologies" in order to monitor and publish environmental data of public interest.

Improving labour market information

Given the rising unemployment of ICT workers, the provision of labour market information has become more important in order to better match the demand for and supply of ICT workers. Many governments are therefore improving the availability of labour market information, in most cases by providing Internet based portals for job ads and searches. In a few cases, governments are also providing lists of occupations and skills, where shortages have been observed or are most likely to occur in the near future. These lists are often linked with migration policies (see below).[20]

The EURES portal of the European Commission, for example, provides information, advice and job-matching services for workers and employers. The portal supports searches by occupation, by country, or years of experience (see Box 9 for some statistics related to ICT-skilled employment). The Korean government has established the *HANIUM program* that can be used by university students for recruitment as well as for IT mentoring, IT internship, and cyber lectures. In Canada, the Labour Market Information (LMI) portal provides "detailed labour market information at the local or community level". This includes job and skill requirements, wages and salaries, as well as employment prospects by occupations and locations, allowing workers to better plan their career path and employers their recruitment.

Foreign workers and international sourcing

In times of rising unemployment, policies to attract foreign workers and to promote international sourcing of ICT skills become less attractive. This explains why few governments have established specific programmes in this policy field in 2010. In most cases the inflow of foreign workers is linked to conditions such as the worker's education level and her or his ability to fill existing positions where a significant skill and labour shortage prevail. In some cases, governments have established policies for the recognition of foreign qualifications. Rarely do these initiatives focus on ICT workers only.

In Denmark, for instance, a number of schemes have been designed in order make it easier for highly qualified professionals including ICT specialists to get a residence and work permit if they meet the conditions specified in these schemes: For instance, if the foreign worker's profession is listed in the "Positive List", which includes occupations where a shortage of qualified professionals has been observed in Denmark. In Canada, qualified foreign workers are also admitted to work for jobs that cannot be filled by Canadians and only when reasonable efforts have been made by employers to hire or train Canadian or permanent residents. Labour Market Information is being used to determine whether the supply of labour is sufficient.

Box 9. ICT-specialist vacancies in the EURES portal of the European Commission

The EURES Portal or European Job Mobility Portal provides information on jobs free of charge throughout Europe. It includes job vacancies for job seekers and CVs for employers as well as information on learning opportunities. All information is indexed by country, level of education, occupation, and years of experience. As the (relative) number of vacancies shows in Table 5, the adoption of the EURES portal by employers varies considerably across countries, and this is particularly true for ICT-related vacancies.

Table 5. Number of vacancies on the EURES portal, May 2011

Country	All occupations	ICT-related occupations	Share of ICT-related occupations
Austria	35,013	3,062	8.7%
Belgium	101,274	6,745	6.7%
Bulgaria	29	17	58.6%
Czech Republic	14,781	2,199	14.9%
Denmark	3,647	222	6.1%
Estonia	10	5	50.0%
Finland	15,818	1,104	7.0%
France	46,680	3,945	8.5%
Germany	373,155	42,497	11.4%
Greece	693	19	2.7%
Hungary	11	2	18.2%
Iceland	157	10	6.4%
Ireland	2,619	219	8.4%
Italy	1,304	146	11.2%
Luxembourg	395	60	15.2%
Netherlands	38,579	6,301	16.3%
Norway	9,142	826	9.0%
Poland	11,784	7	0.1%
Portugal	2,002	156	7.8%
Slovakia	2,280	180	7.9%
Slovenia	1,541	107	6.9%
Spain	317	60	18.9%
Sweden	25,643	3,879	15.1%
Switzerland	2,339	239	10.2%
United Kingdom	361,370	12,315	3.4%

Source: OECD based on EURES search results for *i)* all occupations, *ii)* Computing, engineering and science professionals, and iii) Computing, engineering and science associate professionals. Extracted on 10 May 2011.

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ANNEX 1

The ICT-related employment

This report builds on the OECD definition of ICT-related employment presented in OECD (2004). It distinguishes between:

i. ICT sector employment, defined as "employment in industries traditionally identified as belonging to the ICT sector (all occupations, even those with no use of ICTs)", and

ii. ICT skilled employment, defined as "employment in occupations that use ICTs to various degrees across all industries".

ICT sector employment

To the extent possible, data on ICT sector employment are collected according to the 2002 OECD ICT sector definition (based on ISIC Rev. 3.1) and extracted from the OECD Structural Analysis Database (STAN). In some cases the value of ICT sector employment is underestimated. This is the case for Switzerland for which data on Telecommunications (ISIC 642) were not available. For industries such as Renting of office machinery and equipment (ISIC 7123), estimates were only available for Canada, Italy, Japan, Korea and the United States.

Short-term indicators

For the analysis of short-term cyclical trends in ICT sector employment, official national data, mainly based on labour force surveys collected on a monthly or quarterly basis, have been used. Note that definitions of ICT manufacturing and ICT services groupings vary across countries depending on the industry classification and the available level of detail.

The following NAICS (North American Industry Classification System) industry groups are included in the ICT sector definition used in this report regarding the United States data:

- *ICT manufacturing*
    - *Communications equipment manufacturing*: 33421: Telephone apparatus manufacturing; 33422: Radio and television broadcasting and wireless communications equipment manufacturing; 33429: Other communications equipment manufacturing; 33431: Audio and video equipment manufacturing.
    - *Computer and office equipment manufacturing:* 33411: Computer and peripheral equipment manufacturing.
    - *Electronics equipment manufacturing:* 33441: Semiconductor and other electronic component manufacturing; 33451: Navigational, measuring, electro-medical, and control

instruments manufacturing; 33461: Manufacturing and reproducing magnetic and optical media.

- *IT services.* 51121: Software publishers; 54151: Computer systems design and related services.
- *IT wholesale.* 42342: Office equipment merchant wholesalers; 42343: Computer and computer peripheral equipment and software merchant wholesalers; 42362: Electrical and electronic appliance, television, and radio set merchant wholesalers; 42369: Other electronic parts and equipment merchant wholesalers.
- *Media and content.* 51211: Motion picture and video production; 51212: motion picture and video distribution; 51213: Motion picture and video exhibition; 51219: Postproduction services and other motion picture and video industries; 51221: Record production; 51222: Integrated record production/distribution; 51223: Music publishers; 51224: Sound recording studios; 51229: Other sound recording industries; 51511: Radio broadcasting; 51512: Television broadcasting; 51521: Cable and other subscription programming; 51611: Internet publishing and broadcasting.
- *Communication services.* 51711: Wired telecommunications carriers; 51721: Wireless telecommunications carriers (except satellite); 51731: Telecommunications resellers; 51741: Satellite telecommunications; 51751: Cable and other program distribution; 51791: Other telecommunications; 51811: Internet service providers and web search portals; 51821: Data processing, hosting, and related services.

ICT skilled employment

In this section the definition used distinguishes further between:

i. *ICT specialists*, who "have the ability to develop, operate and maintain ICT systems and for which ICTs constitute the main part of their job",

ii. *ICT* a*dvanced users*, who "are competent users of advanced, and often sector-specific, software tools. ICTs are not the main job but a tool", and

iii. *ICT basic users*, who "are competent users of generic tools (*e.g.* Word, Excel, Outlook, PowerPoint) needed for the information society, e-government and working life".

The first category (ICT specialists) is used as a narrow measure of ICT-skilled employment, and the sum of all three categories for the broad measure of ICT skilled employment.

The following tables present the occupations included in the narrow and broad measures of ICT-skilled employment:

Europe: *Based on ISCO 88 (3 digits)*

ISCO 88 CODE	Occupation description
121	Directors and chief executives
122	Production and operations managers
123	Other specialist managers
211	Physicists, chemists, and related professionals
212	Mathematicians, statisticians and related professionals
213	Computing professionals
214	Architects, engineers, and related professionals
241	Business professionals
242	Legal professionals
243	Archivists, librarians, and related information professionals
312	Computer associate professionals
313	Optical and electronic equipment operators
341	Finance and sales associate professionals
342	Business services agents and trade brokers
343	Administrative associate professionals
411	Secretaries and keyboard-operating clerks
412	Numerical clerks
724	Electrical and electronic equipment mechanics and fitters

Note: All occupations listed are in the broad definition, only occupations shaded in grey are in the narrow measure.

United States: *Based on 2002 CENSUS (4 digits)*

2002 CENSUS CODE	Occupation description	2002 CENSUS CODE	Occupation description
40	Advertising and promotions managers	1450	Materials engineers
50	Marketing and sales managers	1460	Mechanical engineers
60	Public relations managers	1500	Mining and geological engineers, including mining safety engineers
110	Computer and information systems managers	1510	Nuclear engineers
120	Financial managers	1520	Petroleum engineers
130	Human resources managers	1530	Engineers, all other
150	Purchasing managers	1600	Agricultural and food scientists
520	Wholesale and retail buyers, except farm products	1610	Biological scientists
710	Management analysts	1640	Conservation scientists and foresters
800	Accountants and auditors	1650	Medical scientists
820	Budget analysts	1700	Astronomers and physicists
830	Credit analysts	1710	Atmospheric and space scientists
840	Financial analysts	1720	Chemists and materials scientists
850	Personal financial advisors	1740	Environmental scientists and geoscientists
860	Insurance underwriters	1760	Physical scientists, all other
900	Financial examiners	1800	Economists
910	Loan counselors and officers	1810	Market and survey researchers
950	Financial specialists, all other	1840	Urban and regional planners
1000	Computer scientists and systems analysts	2100	Lawyers, Judges, magistrates, and other judicial workers
1010	Computer programmers	2400	Archivists, curators, and museum technicians
1020	Computer software engineers	2430	Librarians
1040	Computer support specialists	4700	First-line supervisors/managers of retail sales workers
1060	Database administrators	4710	First-line supervisors/managers of non-retail sales workers
1100	Network and computer systems administrators	4810	Insurance sales agents
1110	Network systems and data communications analysts	4820	Securities, commodities, and financial services sales agents
1200	Actuaries	4940	Telemarketers
1210	Mathematicians	5160	Tellers
1220	Operations research analysts	5200	Brokerage clerks
1230	Statisticians	5700	Secretaries and administrative assistants
1240	Miscellaneous mathematical science occupations	5800	Computer operators
1300	Architects, except naval	5810	Data entry keyers
1310	Surveyors, cartographers, and photogrammetrists	5820	Word processors and typists
1320	Aerospace engineers	5830	Desktop publishers
1330	Agricultural engineers	5840	Insurance claims and policy processing clerks
1340	Biomedical engineers	7010	Computer, automated teller, and office machine repairers
1350	Chemical engineers	7020	Radio and telecommunications equipment installers and repairers
1360	Civil engineers	7100	Electrical and electronics repairers, industrial and utility
1400	Computer hardware engineers	7410	Electrical power-line installers and repairers
1410	Electrical and electronic engineers	7420	Telecommunications line installers and repairers
1420	Environmental engineers	7720	Electrical, electronics, and electromechanical assemblers
1430	Industrial engineers, including health and safety	7900	Computer control programmers and operators
1440	Marine engineers and naval architects		

Note: All occupations listed are in the broad definition, only occupations shaded in grey are in the narrow measure.

***Canada**: Occupations included in the narrow and broad measures of ICT-skilled employment*

Based on NOCS 2006 (3 digits)

NOCS2006	Occupation description	NOCS2006	Occupation description
A013	Senior managers - finan,commu & oth bus serv	C014	Meteorologists
A015	Senior managers - trade,broadcast & oth serv	C015	Other professional occup in physical science
A016	Senior managers - good prod,util,tran & const	C021	Biologists & related scientists
A111	Financial managers	C031	Civil engineers
A112	Human resources managers	C032	Mechanical engineers
A113	Purchasing managers	C033	Electrical & electronics engineers
A121	Engineering, science & architecture managers	C034	Chemical engineers
A122	Information systems & data processing	C041	Industrial & manufacturing engineers
A123	Architecture and science managers	C042	Metallurgical & materials engineers
A131	Sales, marketing & advertising managers	C043	Mining engineers
A141	Facility operation & maintenance managers	C044	Geological engineers
A301	Insurance, real estate & financial brokerage	C045	Petroleum engineers
A302	Banking, credit & other investment managers	C046	Aerospace engineers
A303	Other business services managers	C047	Computer engineers
A311	Telecommunication carriers managers	C048	Other professional engineers, n.e.c.
A312	Postal & courier service	C051	Architects
A391	Manufacturing managers	C052	Landscape architects
A392	Utilities managers	C053	Urban & land use planners
B011	Financial auditors & accountants	C054	Land surveyors
B012	Financial & investment analysts	C061	Mathematicians, statisticians & actuaries
B013	Securities agents, investment dealers & trader	C071	Information systems analysts & consultants
B014	Other financial officers	C072	Database analysts and data administration
B022	Prof occup in business services to management	C073	Software engineers
B111	Bookkeepers	C074	Computer programmers and developers
B112	Loan officers	C075	Web designers and developers
B114	Insurance underwriters	C141	Electrical & electronic engineering technolog
B211	Secretaries (except legal & medical)	C142	Electronic serv technician (hhld & bus equip)
B212	Legal secretaries	C181	Computer and network operators
B213	Medical secretaries	C182	User support technicians
B214	Court recorders & medical transcriptionists	C183	Systems testing technicians
B311	Administrative officers	E011	Judges
B312	Executive assistants	E012	Lawyers & quebec notaries
B412	Supervisors, finance & insurance clerks	E031	Natural & applied scien policy resear, consul
B513	Records & file clerks	E032	Economist & economic policy research & analys
B522	Data entry clerks	E033	Econ devel officer & marketing resear, consul
B523	Typesetters & related occupations	F011	Librarians
B531	Accounting & related clerks	F013	Archivists
B532	Payroll clerks	G131	Insurance agents & brokers
B533	Tellers, financial services	G132	Real estate agents & salespersons
B534	Banking, insurance & other financial clerks	H214	Electrical power line & cable workers
B554	Survey interviewers & statistical clerks	H215	Telecommunications line & cable workers
C011	Physicists & astronomers	H216	Telecommunications installation & repair work
C012	Chemists	H217	Cable tv service & maintenance technicians
C013	Geologists, geochemists & geophysicists		

Note: All occupations listed are in the broad definition, only occupations shaded in grey are in the narrow measure.

Canada is currently in the process of major structural changes for its 2011 National Occupational Classification system (NOC) in particular in regards to the evolving ICT sector and ICT-related jobs. This will lead to a revision of this table.

***Australia**: Occupations included in the narrow and broad measures of ICT-skilled employment*

BASED on ANZSCO 2006 (4 digits)

ANZSCO 06	Occupation description	ANZSCO 06	Occupation description
1111	Chief Executives and Managing Directors	2346	Medical Laboratory Scientists
1112	General Managers	2349	Other Natural and Physical Science Professionals
1311	Advertising and Sales Managers	2512	Medical Imaging Professionals
1320	Business Administration Managers nfd	2600	ICT Professionals nfd
1322	Finance Managers	2610	Business and Systems Analysts, and Programmers nfd
1323	Human Resource Managers	2611	ICT Business and Systems Analysts
1324	Policy and Planning Managers	2612	Multimedia Specialists and Web Developers
1332	Engineering Managers	2613	Software and Applications Programmers
1335	Production Managers	2621	Database and Systems Administrators, and ICT Security Specialists
1336	Supply and Distribution Managers	2630	ICT Network and Support Professionals nfd
1351	ICT Managers	2631	Computer Network Professionals
1419	Other Accommodation and Hospitality Managers	2632	ICT Support and Test Engineers
1494	Transport Services Managers	2633	Telecommunications Engineering Professionals
2210	Accountants, Auditors and Company Secretaries nfd	2710	Legal Professionals nfd
2211	Accountants	2711	Barristers
2212	Auditors, Company Secretaries and Corporate Treasurers	2712	Judicial and Other Legal Professionals
2220	Financial Brokers and Dealers, and Investment Advisers nfd	2713	Solicitors
2221	Financial Brokers	3100	Engineering, ICT and Science Technicians nfd
2222	Financial Dealers	3123	Electrical Engineering Draftspersons and Technicians
2223	Financial Investment Advisers and Managers	3124	Electronic Engineering Draftspersons and Technicians
2232	ICT Trainers	3130	ICT and Telecommunications Technicians nfd
2241	Actuaries, Mathematicians and Statisticians	3131	ICT Support Technicians
2242	Archivists, Curators and Records Managers	3132	Telecommunications Technical Specialists
2243	Economists	3400	Electrotechnology and Telecommunications Trades Workers nfd
2244	Intelligence and Policy Analysts	3420	Electronics and Telecommunications Trades Workers nfd
2246	Librarians	3423	Electronics Trades Workers
2247	Management and Organisation Analysts	5100	Office Managers and Program Administrators nfd
2249	Other Information and Organisation Professionals	5121	Office Managers
2251	Advertising and Marketing Professionals	5122	Practice Managers
2252	ICT Sales Professionals	5211	Personal Assistants
2320	Architects, Designers, Planners and Surveyors nfd	5212	Secretaries
2321	Architects and Landscape Architects	5321	Keyboard Operators
2322	Cartographers and Surveyors	5510	Accounting Clerks and Bookkeepers nfd
2326	Urban and Regional Planners	5511	Accounting Clerks
2331	Chemical and Materials Engineers	5512	Bookkeepers
2332	Civil Engineering Professionals	5513	Payroll Clerks
2333	Electrical Engineers	5521	Bank Workers
2334	Electronics Engineers	5522	Credit and Loans Officers
2335	Industrial, Mechanical and Production Engineers	5523	Insurance, Money Market and Statistical Clerks
2336	Mining Engineers	6111	Auctioneers, and Stock and Station Agents
2341	Agricultural and Forestry Scientists	6112	Insurance Agents
2342	Chemists, and Food and Wine Scientists	6212	ICT Sales Assistants
2343	Environmental Scientists	6399	Other Sales Support Workers
2344	Geologists and Geophysicists	7123	Engineering Production Systems Workers
2345	Life Scientists		

Note: All occupations listed are in the broad definition, only occupations shaded in grey are in the narrow measure.

Occupations affected by offshoring

Table A1.1. Europe: Occupations potentially affected by offshoring

3 Digit ISCO-88
123: Other specialist managers
211: Physicists, chemists, and related professionals
212: Mathematicians, statisticians and related professionals
213: Computing professionals
214: Architects, engineers, and related professionals
241: Business professionals
242: Legal professionals
243: Archivists, librarians, and related information professionals
312: Computer associate professionals
341: Finance and sales associate professionals
342: Business services agents and trade brokers
343: Administrative associate professionals
411: Secretaries and keyboard-operating clerks
412: Numerical clerks
422: Client information clerks

Note: Occupations in shading have been classified as clerical.

Source: OECD (2005), based on EULFS (2004).

Table A1.2. United States: Occupations potentially affected by offshoring

CPS categories			
accountants and auditors	23	Archivists and curators	165
underwriters	24	Economists	166
other financial officers	25	Urban planners	173
management analysts	26	Authors	183
architects	43	Technical writers	184
aerospace engineer	44	Editors and reporters	195
metallurgical and materials engineers	45	Air traffic controllers	227
mining engineers	46	Computer programmers	229
petroleum engineers	47	Tool programmers, numerical control	233
chemical engineers	48	Supervisors and Proprietors, Sales Occupations	243
nuclear engineers	49	Insurance sales occupations	253
civil engineers	53	Real estate sales occupations	254
agricultural engineers	54	Securities and financial services sales occupations	255
Engineers, electrical and electronic	55	Sales occupations, other business services	257
Engineers, industrial	56	Supervisors, computer equipment operators	304
Engineers, mechanical	57	Supervisors, financial records processing	305
marine and naval architects	58	Chief communications operators	306
engineers, n.e.c.	59	Computer operators	308
surveyors and mapping scientists	63	Peripheral equipment operators	309
computer systems analysts and scientists	64	Secretaries	313
operations and systems researchers and analysts	65	Typists	315
Actuaries	66	Transportation ticket and reservation agents	318
Statisticians	67	File clerks	335
Mathematical scientists, n.e.c.	68	Records clerks	336
Physicists and astronomers	69	Bookkeepers, accounting, and auditing clerks	337
Chemists, except biochemists	73	Payroll and timekeeping clerks	338
Atmospheric and space scientists	74	Billing clerks	339
Geologists and geodesists	75	Cost and rate clerks	343
Physical scientists, n.e.c.	76	Billing, posting, and calculating machine operators	344
Agricultural and food scientists	77	Telephone operators	348
Biological and life scientists	78	Bank tellers	383
Forestry and conservation scientists	79	Data-entry keyers	385
Medical scientists	83	Statistical clerks	386
Librarians	164		

Note: Occupations in shading have been classified as clerical.

Source: OECD (2005), based on US Current Population Survey.

Table A1.3. Canada: Occupations potentially affected by offshoring

SOC91 Canada			
A121	Engineering, Science and Architecture Managers	C012	Chemists
A122	Information Systems and Data Processing Managers	C013	Geologists, Geochemists and Geophysicists
A131	Sales, Marketing and Advertising Managers	C014	Meteorologists
A301	Insurance, Real Estate and Financial Brokerage Managers	C015	Other Professional Occupations in Physical Sciences
A302	Banking, Credit and Other Investment Managers	C021	Biologists and Related Scientists
A303	Other Business Services Managers	C031	Civil Engineers
A311	Telecommunication Carriers Managers	C032	Mechanical Engineers
A312	Postal and Courier Services Managers	C033	Electrical and Electronics Engineers
A392	Utilities Managers	C034	Chemical Engineers
B011	Financial Auditors and Accountants	C041	Industrial and Manufacturing Engineers
B012	Financial and Investment Analysts	C042	Metallurgical and Materials Engineers
B013	Securities Agents, Investment Dealers and Traders	C043	Mining Engineers
B014	Other Financial Officers	C044	Geological Engineers
B022	Professional Occupations in Business Services to Management	C045	Petroleum Engineers
B111	Bookkeepers	C046	Aerospace Engineers
B112	Loan Officers	C047	Computer Engineers
B114	Insurance Underwriters	C048	Other Professional Engineers, n.e.c.
B211	Secretaries (except Legal and Medical)	C051	Architects
B212	Legal Secretaries	C052	Landscape Architects
B213	Medical Secretaries	C053	Urban and Land Use Planners
B214	Court Recorders and Medical Transcriptionists	C054	Land Surveyors
B311	Administrative Officers	C061	Mathematicians, Statisticians and Actuaries
B312	Executive Assistants	C062	Computer Systems Analysts
B412	Supervisors, Finance and Insurance Clerks	C063	Computer Programmers
B512	Typists and Word Processing Operators	C152	Industrial Designers
B513	Records and File Clerks	C172	Air Traffic Control Occupations
B514	Receptionists and Switchboard Operators	E012	Lawyers and Quebec Notaries
B521	Computer Operators	E031	Natural and Applied Science Policy Researchers, Consultants and Program Officers
B522	Data Entry Clerks	E032	Economists and Economic Policy Researchers and Analysts
B523	Typesetters and Related Occupations	E033	Economic Development Officers and Marketing Researchers and Consultants
B524	Telephone Operators	F011	Librarians
B531	Accounting and Related Clerks	F013	Archivists
B532	Payroll Clerks	F021	Writers
B533	Tellers, Financial Services	F022	Editors
B534	Banking, Insurance and Other Financial Clerks	F023	Journalists
B553	Customer Service, Information and Related Clerks	F025	Translators, Terminologists and Interpreters
B554	Survey Interviewers and Statistical Clerks	G131	Insurance Agents and Brokers
C011	Physicists and Astronomers		

Note: Occupations in shading have been classified as clerical.

Source: OECD (2005), based on Statistics Canada.

Table A1.4. Australia: Occupations potentially affected by offshoring

ASCO 4-digit	
1221 Engineering Managers	2521 Legal Professionals
1224 Information Technology Managers	2522 Economists
1231 Sales and Marketing Managers	2523 Urban and Regional Planners
1291 Policy and Planning Managers	2534 Journalists and Related Professionals
2111 Chemists	2535 Authors and Related Professionals
2112 Geologists and Geophysicists	3211 Branch Accountants and Managers (Financial Institution)
2113 Life Scientists	3212 Financial Dealers and Brokers
2114 Environmental and Agricultural Science Professionals	3213 Financial Investment Advisers
2115 Medical Scientists	3294 Computing Support Technicians
2119 Other Natural and Physical Science Professionals	3392 Customer Service Managers
2121 Architects and Landscape Architects	3399 Other Managing Supervisors (Sales and Service)
2122 Quantity Surveyors	5111 Secretaries and Personal Assistants
2123 Cartographers and Surveyors	5911 Bookkeepers
2124 Civil Engineers	5912 Credit and Loans Officers
2125 Electrical and Electronics Engineers	5991 Advanced Legal and Related Clerks
2126 Mechanical, Production and Plant Engineers	5993 Insurance Agents
2127 Mining and Materials Engineers	5995 Desktop Publishing Operators
2211 Accountants	6121 Keyboard Operators
2212 Auditors	6141 Accounting Clerks
2221 Marketing and Advertising Professionals	6142 Payroll Clerks
2231 Computing Professionals	6143 Bank Workers
2292 Librarians	6144 Insurance Clerks
2293 Mathematicians, Statisticians and Actuaries	6145 Money Market and Statistical Clerks
2294 Business and Organisation Analysts	8113 Switchboard Operators
2299 Other Business and Information Professionals	8294 Telemarketers
2391 Medical Imaging Professionals	

Note: Occupations in shading have been classified as clerical.

Source: OECD (2005), based on Australian Bureau of Statistics.

The BLS green jobs definition

The US Bureau of Labor Statistics (BLS) defines green jobs as: *i)* "jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources;" and *ii)* "jobs in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer natural resources".

The first part of the definition includes "research and development, installation, and maintenance services" in industries that produce green goods and services and which fall into one or more of the following five groups:

1. Energy from renewable sources such as wind, biomass, geothermal, solar, ocean, hydropower, landfill gas, and municipal solid waste.

2. Energy efficiency including energy-efficient equipment, appliances, buildings, and vehicles, as well as products and services that improve the energy efficiency of buildings and the efficiency of energy storage and distribution, such as Smart Grid technologies.

3. Pollution reduction and removal, greenhouse gas reduction, and recycling and reuse, including products and services that *i)* reduce or eliminate the creation or release of pollutants or toxic compounds, or remove pollutants or hazardous waste from the environment, *ii)* reduce greenhouse gas emissions through methods other than renewable energy generation and energy efficiency, such as electricity generated from nuclear sources, and *iii)* reduce or eliminate the creation of waste materials; collect, reuse, remanufacture, recycle, or compost waste materials or wastewater.

4. Natural resources conservation including products and services related to organic agriculture and sustainable forestry; land management; soil, water, or wildlife conservation; and stormwater management.

5. Environmental compliance, education and training, and public awareness, including products and services that: *i)* enforce environmental regulations, *ii)* provide education and training related to green technologies and practices, and *iii)* increase public awareness of environmental issues.

The second part of the definition includes "workers, who research, develop, maintain, or use technologies and practices to lessen the environmental impact of their establishment, or train the establishment's workers or contractors in these technologies and practices. This definition will be used in the BLS survey of establishments across all industries to identify jobs related to green technologies and practices used within the establishment. These technologies and practices fall into one or more of four groups":

1. Generating electricity, heat, or fuel from renewable sources primarily for use within the establishment. These energy sources include wind, biomass, geothermal, solar, ocean, hydropower, landfill gas, and municipal solid waste.

2. Using technologies and practices to improve energy efficiency within the establishment. Included in this group is cogeneration (combined heat and power).

3. Pollution reduction and removal, greenhouse gas reduction, and recycling and reuse. Using technologies and practices within the establishment to: *i)* reduce or eliminate the creation or release of pollutants or toxic compounds, or remove pollutants or hazardous waste from the environment, *ii)* reduce greenhouse gas emissions through methods other than renewable energy

generation and energy efficiency, and *iii)* reduce or eliminate the creation of waste materials; collect, reuse, remanufacture, recycle, or compost waste materials or wastewater.

4. Natural resources conservation. Using technologies and practices within the establishment to conserve natural resources. Included in this group are technologies and practices related to organic agriculture and sustainable forestry; land management; soil, water, or wildlife conservation; and stormwater management.

Table A1.5. Green job indicators

Industry	**Sector**: The sector or industry refers to the fields of economic activity firms can be categorised into. The sectors most often referred to as "green sectors" or the EGS sector include renewable energy, building, transportation, recycling, food and agriculture, forestry and tourism. These sectors are usually the focal points of studies on green jobs not only because of the nature of the goods and services they are producing, but also because they tend to be labour intensive. **Product/service**: This refers to the specific output of the businesses in the different industries or sectors. There are specific products and services that can be considered "green" due to the eco-innovative processes involved in their production. For instance, products/services aimed at reducing or limiting the negative impact of human activity on the environment (*e.g*. energy-efficient home appliances) or at improving the environment directly (*e.g*. waste recycling services). These might capture changes in human consumption habits as awareness for green products and services increase.
Organisation	**Production method:** The production method refers to the environmental quality standards used by firms in their production process (*e.g*. ISO norms). Firms can set in place measures to reduce energy consumption and waste production and build environmentally friendly infrastructure for their production processes. This criterion allows for the classification of jobs in a firm that does not belong to a green sector but uses energy efficient techniques considered to be green. **Green awareness**: Organisations have different levels of commitment to green and environmental issues (Connection Research, 2009, p. 17). In some cases, the heads of firms are individuals who are deeply committed to the environmental cause and engage in associations, partnerships or community movements to protect the environment. Green awareness is also often reflected in the levels of corporate social responsibility of the organisation. This is often dependant on the history and structure of the organisation (Potts, 2009). **Position in the value chain**: The implication of a job in the green economy might vary along the value chain of the good or service being produced. A job in a company producing energy efficient automobiles might be considered to be green, but what about a job in the company producing the steering wheel for that specific car?
Job	**Occupational profile**: This refers to the nature or purpose of the job, irrespective of the sector it is performed in. Almost any occupation can be considered green as long as it contributes to reducing harmful impacts of human activity on the environment, either directly or indirectly. As a result, occupations ranging from managers, to sales workers to labourers can all at some point be considered as being green. **Required skills and abilities:** Certain jobs require workers to possess certain specialised green skills and abilities. Determining whether a job can be considered as being green can in some cases be done based on the necessary skills and competences required to perform it. **Job decency**: The UNEP and the ILO have both stressed the fact that "green jobs" need to be decent jobs, *i.e.* good jobs which offer adequate wages, safe working conditions, job security, reasonable career prospects, and worker rights" (UNEP, ILO, ITUC, IOE, 2008a, p. 4). The Apollo Alliance has also taken up this dimension in its definition of green jobs stating that "if a job improves the environment; but doesn't provide a family-supporting wage or a career ladder to move low-income workers into higher-skilled occupations, it is not a green-collar job". Job decency is thus a key dimension of green jobs. **Green workload**: Some workers may do some of their work in green areas and some of their work in traditional areas (Connection Research, 2009, p. 17). In this case, it is important to adequately measure the part of the workload that is officially dedicated to green tasks in order to determine if the job can be considered as green.

Source: OECD/Martinez-Fernandez, Hinojosa and Miranda, 2010

NOTES

1 The OECD *Declaration on Green Growth* specifically mentions the role of ICTs in meeting environmental challenges: "In order for countries to advance the move towards sustainable low-carbon economies, international co-operation will be crucial in areas such as … *application of green ICT* for raising energy efficiency (paragraph 2); and "We recognise that special efforts need to be made at the international level for co-operation on developing clean technology, including by *reinforcing green ICT activities* …" (paragraph 8) (see OECD, 2009d).

2 See also the OECD horizontal project on "New Sources of Growth" exploring and analysing the role of *intangible assets* such as R&D, computerised information (software and databases) and skills (OECD, 2011e).

3 In OECD countries, for example, more than 70% of household and 95% of businesses (with 10 or more employees) are connected to the Internet and in some non-OECD economies like Brazil, Hong Kong (China) and Morocco the share of businesses exceeds 80% (OECD, 2011f).

4 Unemployment rates in OECD countries are estimated to have fallen from 8.3% in 2010 to 7.9% in 2011 (OECD, 2011i).

5 This also includes telecommunication services employment.

6 This is most likely not as high as in 2001-02. The number of people affected by mass layoffs in the US ICT sector suggests that the last job crisis in the ICT sector had its full impact in 2001-02.

7 The OECD *Declaration on Green Growth* specifically mentions the role of ICTs in meeting environmental challenges: "In order for countries to advance the move towards sustainable low-carbon economies, international co-operation will be crucial in areas such as … *application of green ICT* for raising energy efficiency (paragraph 2); and "We recognise that special efforts need to be made at the international level for co-operation on developing clean technology, including by *reinforcing green ICT activities* …" (paragraph 8) (see OECD, 2009d).

8 See also OECD 2011a and 2011b.

9 The unemployment rate for the OECD area was expected to peak in 2010 at 8.3%; a rise of 0.4 percentage point compared with 2009 (OECD, 2010b). It is projected to fall to 8.1% by 2011 and 7.5% by 2012.

10 See section below for a discussion on the definition of "green jobs".

11 Moore's law describes the doubling in computing power every 18 to 24 months, and energy use potentially increases at the same rate unless steps are taken to reduce it. According to Anthes (2005), the failure rate of a computer processing unit (CPU) "doubles with every increase in temperature of 10 degrees Celsius".

12 Resource depletion has also become a security issue in some countries. According to the United Nations Environment Programme (UNEP), "forty percent of all intrastate conflicts are related to natural resources" (UNEP, 2009). For example, minerals such as tin, tungsten, tantalum and lithium, essential for the manufacturing of many ICT devices, originate from conflict regions such as the eastern Democratic Republic of Congo (Global Witness, 2009; Prendergast, 2009).

13 However, the toxicity of some ICT materials is one of the biggest challenges in this industry. This is particularly true in countries in which appropriate regulations on hazardous substances do not exist or are not effectively enforced, and where workers are exposed to hazardous substances without the necessary

protection (UNEP, 2010; Greenpeace, 2009). Reducing toxic and hazardous substances is a major aim in the design of new products for many firms, in order to enable easier and safer recycling.

14 See also *The North American Development Survey 2008*, according to which 56% of developers involved in virtualisation projects used VMware products, compared to 37% using Microsoft virtualisation solutions (HostReview, 2008).

15 In their 2008 survey of 130 companies, only 5% used a green IT service provider, 11% were planning to do so, and 18% were considering it for the future (Kanellos, 2008).

16 There are signs that a shortage of ICT skills could occur in the longer term in particular as an effect of the financial and economic crisis. The following facts support this hypothesis: *i)* Rising unemployment of ICT professionals may have led to a pool of ICT workers with outdated skills; *ii)* Some firms have reduced training for their employees during the crisis; and *iii)* Tertiary education may be too slow in providing the necessary new skills needed in particular for new advanced ICTs such as, for instance, green ICTs.

17 The *IT Strategic Headquarters* was established within the Cabinet of the Prime Minister of Japan in 2000 and involve the Ministry of Internal Affairs and Communications (MIC) and the Ministry of Economy, Trade and Industry (METI).

18 For more information see *www.pte.gov.pt*

19 The green IT education programme can also be accessed online.

20 None of the policy programmes on labour market information surveyed in 2010 focuses on ICT workers only.