Chapter 4

What Green Growth Means for Workers and Labour Market Policies: An Initial Assessment*

A successful transition towards a low-carbon and resource-efficient economy will reshape the labour market in ways that create new opportunities for workers, but also new risks. The challenge for labour market and skill policies is to maximise the benefits from this transition for workers and help assure a fair sharing of unavoidable adjustment costs, while also supporting broader green growth policies. This chapter sheds light on these policy challenges and provides guidance for how they can best be met.

* The OECD gratefully acknowledges the financial support provided by the European Commission and the governments of Austria, Canada, Denmark, Japan and Korea for undertaking the work presented in this chapter. The opinions expressed and arguments employed herein do not necessarily reflect those of the European Commission or these countries.

Key findings[1]

It is now widely recognised that it is essential to decouple economic growth from unsustainable environmental pressures, such as those leading to global climate change, and that a successful transition towards a low-carbon economy will necessarily reshape the labour market. This chapter aims to provide guidance for how labour market and skill development policies can best contribute to a fast, efficient and fair transition to a low-carbon and resource-efficient economy, particularly in developed countries. It first analyses the main impacts on the labour market of green growth policies, particularly climate-change mitigation policy. Next it turns to how labour market and education/training policies can best facilitate the transition to green growth.

The chapter finds that:

- *The transition to green growth is best conceived of as a driver of structural economic change*. New simulations using the OECD ENV-Linkages computable general equilibrium (CGE) model demonstrate how ambitious climate-change mitigation policies may affect labour market outcomes, as well as how labour market rigidities could raise the overall cost of reducing green house gas (GHG) emissions. These simulations suggest that one of the main labour market impacts would be to alter the sectoral composition of employment, with fossil-fuel industries experiencing the steepest employment declines and renewable energy industries the sharpest increases. However, such a policy-induced increase in the reallocation of employment is likely to be modest by comparison with the underlying rates of labour reallocation generally observed in OECD countries during recent decades and have little impact on the overall level of job skill demand. The functioning of the labour market will have a significant impact on aggregate outcomes of mitigation policies: while the impact of these policies on GDP growth is small when the labour market is fully flexible, it becomes larger and employment falls when the labour market is characterised by rigidities that hinder the necessary structural adjustments. In the presence of partial labour market rigidity, introducing an emissions trading scheme and recycling the carbon revenues so as to reduce the tax wedge on labour income can generate a "double-dividend" by delivering both lower GHG emissions and higher employment.
- *Labour market policy choices should also be informed by detailed case studies of the most strongly-impacted sectors, notably "green" sectors that are likely to grow rapidly and the most CO_2-intensive sectors that will need to radically change their technologies or shed jobs in the transition towards green growth*. While certain green sectors, such as renewable energy, will grow at a rapid pace, the overall labour market impact will likely be modest because these sectors account for only a small share of total employment. The most polluting industries account for 14% of employment on average in the OECD, but this share varies significantly from country to country (ranging from 11% in Denmark to 27% in Poland). Should many workers in these industries lose their jobs in the transition towards green growth, they are likely to face above-average adjustment costs since many of these

industries are characterised by relatively low educated workers with a low level of labour mobility, while several are also highly localised.

- *The shift towards greener production practices also implies some changes in skill requirements, but there appear to be few uniquely green skills.* Adding some green content to existing vocational and training programmes and offering top-up training to the existing workforce probably can meet most of the emerging skill demands. The strong trend increase in environmental patenting during the past several decades underlies the importance of preparing the workforce for a period of rapid eco-innovation, including by raising science, technology, engineering and mathematics (STEM) skills.
- *Labour market and skill policies should play an active role in helping workers and employers to make the transition to green growth.* Existing policies, such as those identified in the *OECD Reassessed Jobs Strategy*, provide the essential framework for successfully managing the structural changes required to decouple production from harmful environmental effects. In adapting these general policies for the transition towards green growth, priority should be given to:
  - ❖ Supporting a smooth reallocation of workers from declining to growing firms, while reducing the adjustment costs borne by displaced workers.
  - ❖ Supporting eco-innovation and the diffusion of green technologies by strengthening initial education and vocational training, and assuring that overly-strict employment protection and product market regulations are not blunting the incentive to innovate.
  - ❖ Reform of the tax-benefit system for workers in order to ensure that cost pressures generated by environmental policies do not become a barrier to employment.
- *Green-specific labour market and skill policies also have a role to play, especially in meeting new job skill needs.* An OECD questionnaire sent to labour and employment ministries reveals that about 60% of the responding countries have implemented at least one labour market measure targeted on green growth, with training being the most common type of measure. However, most of these measures are of small scale and were only recently introduced. The limited experience with implementing these policies suggests that they confront two particularly difficult challenges; detecting how green growth is changing labour demand and jobs skill requirements, and co-ordinating labour market and skill policies with environmental policy. This suggests that the role for green-specific measures is likely to emerge only incrementally, as the environmental policy framework needed to support green growth develops and experience with managing the labour market dimension of the transition to green growth accumulates.

Introduction

The need to decouple economic growth and social progress from unsustainable environmental pressures, such as those leading to global climate change, is now widely recognised and the OECD has proposed a broad policy strategy for achieving green growth (OECD, 2011a). A successful transition towards a low-carbon and resource-efficient economy will reshape the labour market in ways that create both new opportunities and new risks for workers. The challenge for labour market and skill policies is to maximise the benefits for workers and help assure a fair sharing of unavoidable adjustment costs, while also supporting broader green growth policies (*e.g.* by minimising skill bottlenecks). This chapter examines this policy challenge and offers guidance for best meeting it. The chapter begins with an analysis of how the transition to green growth will reshape labour markets, which helps to define the policy challenge. The latter part of the chapter then discusses the appropriate policy responses.

Analysing the employment impact of green growth policies is not an easy task and much remains to be done is this area. One complication is that a general-equilibrium approach is required to capture all of the direct and indirect channels through which green growth policies will reshape labour markets and create structural adjustment pressures. Section 1 takes this approach which is shown to offer a number of key insights into the ways that labour markets must restructure in order to decouple production and consumption from unsustainable environmental pressures. This section also illustrates the limitations of this approach and, hence, the need to supplement general-equilibrium modelling with detailed analyses of specific sectors and occupations that will be strongly affected by the transition towards low-carbon growth. Section 2 adopts this partial-equilibrium approach. After summarising key findings from the many recent studies of green jobs and skills, new empirical findings are presented for a topic that has received much less attention from researchers, namely, structural adjustment pressures in industries with a large environmental footprint.

The second part of the chapter analyses how labour market and skill policies can best contribute to an efficient and fair transition towards a low-carbon and resource-efficient economy. Section 3 discusses general employment and skill policies, arguing that the policy orientations presented in the *OECD Reassessed Jobs Strategy* (OECD, 2006a) and the *OECD Innovation Strategy* (OECD, 2010a) provide an essential framework for managing the transition towards green growth. In particular, labour market and skill policies are identified that can:

- Ensure that displaced workers receive adequate re-employment assistance and income support.
- Help to speed the development and diffusion of environmentally friendly technologies.
- Recycle revenues from environmental taxes or emissions trading schemes so as to ensure that the cost pressures generated by environmental policies do not become a barrier to employment.

Section 4 then analyses the role of green-specific employment and skill policies. Since little is known about this type of policy, this section makes use of the responses to a new OECD questionnaire that was sent to employment and labour ministries in late 2010. The information collected provides a unique overview of the extent to which OECD countries have implemented green-specific measures and which types of targeted initiatives are most widely used. To the extent possible at this early stage, the effectiveness of different types of measures is assessed as well as cross-country differences in policy priorities.

Several important limitations of the scope of this study should be noted. A first limitation is that labour market *adaptation* to environmental degradation, such as that associated with climate change, is not analysed. Instead, the focus is almost exclusively on the implications of environmental *mitigation* policies – principally, policies aimed at curbing GHG emissions – for the functioning of labour markets. A second limitation is that the analysis is largely confined to OECD member countries. Labour market issues of particular salience for managing the transition towards green growth in emerging and developing economies, such as high rates of informal employment and large-scale migration of rural workers to urban areas, are not analysed.[2]

1. The labour market implications of a transition to green growth: Insights from general-equilibrium modelling

This section first provides a brief (and highly selective) literature review of past studies that use general-equilibrium methods to study the labour market implications of climate-change mitigation policy. New simulation exercises which have been conducted with the OECD ENV-Linkages model are then presented in order to clarify further some of the general-equilibrium effects associated with the implementation of mitigation policies, such as emission trading schemes.

Structural adjustment pressures brought about by a policy-driven transition to green growth: Lessons from earlier studies adopting a general-equilibrium approach

A growing number of economic modelling teams have developed and applied computable general-equilibrium (CGE) models or hybrid models to analyse the economic impacts of climate change policies, including the impacts on labour markets. The estimated impact of mitigation policies on economic growth and employment varies somewhat across studies and countries (see Table 4.1). In considerable part, this variation reflects differences across studies with respect to the mitigation policies considered and, for a given mitigation scenario, differences across countries with respect to the initial level of GHG emissions and hence the mitigation effort required. The assumption about how the revenues from carbon taxes (or emissions permits) are distributed also affects the estimated labour market impact. For example, Boeters and van Leeuwen (2010) estimate that a 20% reduction in energy use in selected European countries would slightly increase unemployment when energy tax revenue is distributed as lump-sum transfers to households, but slightly reduce unemployment in several countries when this revenue is used to reduce labour taxes – an illustration of the "double-dividend" hypothesis that it is sometimes possible to "recycle" revenues from a newly instituted environmental tax so as to achieve both environmental gains and higher employment or output (see Bovenberg, 1999, and other studies cited in OECD, 2012a).

Despite these differences, the estimated impacts on GDP and labour market outcomes tend to be relatively small. For example, an evaluation conducted by the European Commission concludes that the pace of employment growth in Europe would slow only slightly, should participating countries meet the EU's objectives on climate change and renewable energy for 2020 (EC, 2008). Montgomery *et al.* (2009) obtain the same qualitative result for the United States, while also demonstrating that labour market imperfections would increase mitigation costs.

Modelling assumptions also influence the estimated impacts. CBO (2010) compares the estimated economic impacts produced by three leading CGE models for the United States when used to analyse a *standardised* climate-change mitigation scenario and show that the results differ significantly across the three models. Nonetheless, many of the qualitative conclusions were consistent across the models. This includes the findings that net employment effects are small whereas there is a considerable reallocation of workers between contracting and expanding sectors.[3] The CBO analysis also provides robust evidence that real wages tend to fall compared with the business-as-usual (*i.e.* no-reform) scenario, due to the impact of higher energy prices in raising the cost of living. The findings that the transition towards low-carbon growth requires both the sectoral reallocation of labour and downward wage flexibility suggest that a substantial degree of labour market flexibility is a precondition for a smooth transition to green growth. Paroussos and

Capros (2009) illustrate this point using the GEM-3 model for EU countries. Of particular interest, they analyse the same scenario for the expansion of renewable energy sectors under three alternative assumptions concerning the degree of labour market flexibility. Their results confirm that the impact on total employment and its sectoral composition is significantly affected by the degree of labour market flexibility.

Several methodological limitations of the CGE models used in these simulation studies mean that they probably are too pessimistic about the long-run impact of mitigation policies on economic growth.[4] Whereas these models capture well the short and medium-run adjustment costs associated with reducing GHG emissions, they generally miss some or all of the economic benefits due to new green technologies, whose development would be stimulated by the mitigation policy.[5] As a result, these models also shed little light on which countries are likely to become the export and technology leaders in fast-growing green sectors (*e.g.* by developing a green Silicon Valley). These models also typically omit how mitigation policy avoids environmental damage that otherwise would have occurred. This is an important omission because the potential damages from climate change can be large, including the destruction of physical capital through more intense and frequent storms, droughts and floods. For example, a rise in the sea level means that storm surges may cause extensive flooding in heavily populated coastal areas (Nicholls *et al.*, 2008; OECD, 2012c). The estimated costs of these impacts vary widely by location and region, but may be as much as the equivalent of 14.4% of per capita consumption when all market and non-market impacts are taken into account (Stern, 2006).[6]

Further insights from new simulation exercises[7]

In order to investigate further some of the implications of a transition towards low-carbon growth for labour markets, new simulation exercises have been conducted with the OECD ENV-Linkages model. This is a global CGE that has been extensively used to assess the impact of environmental policies on GHG emissions and economic growth (see Box 4.1). In the baseline version of the ENV-Linkages model, the labour market is assumed to be fully flexible, as is common in long-run growth models. This implies that the job reallocation across economic sectors, which results when GHG mitigation policies are introduced, is costless and occurs instantaneously. It also implies that aggregate employment is not affected by mitigation policy, because the labour supply is assumed to be exogenous and real wages always adjust so that the labour market clears. While the assumption of full flexibility is at odds with extensive evidence of rigidities in OECD labour markets, this baseline version of the model provides a useful indication of the magnitude of the labour market adjustment pressures generated by mitigation policies. The first simulations discussed below use the baseline model for this purpose. An augmented version of the ENV-Linkages model, which incorporates partial real wage rigidity, is then used to explore how the adjustment challenge created by mitigation policy varies in the presence of different degrees of labour market imperfection.[8]

Economic impacts of an illustrative mitigation scenario combined with different recycling options for carbon revenues

The illustrative policy scenario applied in the modelling is an emission trading scheme (ETS) which progressively reduces GHG emissions over the period 2013-50, bringing emissions for the OECD area as a whole to 50% below their 1990 level in 2050 (Figure 4.1, Panel A).[9] The target is less stringent for non-OECD countries, where emissions

Table 4.1. **Selected evaluations of the economic impact of mitigation policies**

Scenario/Country			**Estimated impact** (deviation from the business-as-usual scenario)						**Labour market modelling**
Boeters and van Leeuwen (2010) WorldScan Model	**Target:** 20% reduction in energy use. **Policy:** uniform tax on energy use. Tax rate (as an *ad valorem* tax to the energy price exclusive of other taxes): around 50%. **Implementation period:** 2001 (static model simulation).		**Unemployment** (% points)		**Participation** (%)		**Real wage** (%)		Collective wage bargaining, endogenous labour supply. Empirical weakness of the model: no scope for calibrating the wage bargaining equation to empirical estimations of wage curve elasticities, because the only remaining free parameter, the relative bargaining power of trade unions, is needed to calibrate the model so that empirical unemployment rates are met.
			Worker skill:						
			High	Low	High	Low	High	Low	
			Recycling: lump-sum transfers						
		France	0.15	0.27	–0.58	–0.81	–3.5	–3.5	
		Germany	0.10	0.22	–0.33	–0.47	–3.5	–3.7	
		United Kingdom	0.04	0.15	–0.35	–0.40	–2.7	–2.8	
		Italy	0.09	0.27	–0.54	–0.49	–3.4	–3.5	
		Spain	0.05	0.17	–0.42	–0.47	–3.4	–3.9	
			Recycling: lower labour taxes						
		France	0.00	0.13	–0.31	–0.65	–3.7	–3.7	
		Germany	–0.12	–0.05	0.03	–0.23	–3.5	–3.9	
		United Kingdom	0.00	0.07	–0.19	–0.32	–2.7	–2.8	
		Italy	–0.14	–0.16	–0.02	–0.14	–3.8	–4.0	
		Spain	–0.26	–0.23	0.11	–0.12	–3.8	–4.2	
Montgomery *et al.* (2009) MNR-NEEM and MS-MRT models	**Target:** reduction of GHG emissions by 83% below 2005 levels by 2050. **Policy:** national cap-and-trade programme plus a minimum 20% renewables share for electricity generation by 2020. Recycling: lump-sum transfers to consumers. **Implementation period:** 2010-50.	**United States**	**GDP** (%) –1.0 in 2030 –1.5 in 2050		**Employment** (thousands of jobs) –2 200 in 2030 –3 600 in 2050		**Real wage** (USD per year) –510 in 2030 –1,250 in 2050		Wages adjust by one-half the amount required for full employment
International Council for Capital Formation (2005a-d) DRI-WEFA model	**Target:** 60% below 2000 emissions by 2050. **Policy:** international carbon dioxide trading mechanism. Recycling: lump-sum transfers to consumers. **Implementation period:** 2005-25.			**GDP** (%)			**Employment** (%)		Real gross wages are sticky and adjust to expected inflation and unemployment rate. Labour supply is exogenous.
		United States		–2.0 in 2020			–0.1 in 2020		
		Italy		–1.6 in 2025			–1.25 in 2025		
		Spain		–4.1 in 2025			–2.9 in 2025		
		Germany		–1.4 in 2025			–1.6 in 2025		
		United Kingdom		–1.1 in 2025			–1.25 in 2025		
EC (2008) GEM-E3 model	**Target:** at least a 20% reduction of GHG emissions by 2020 relative to 1990 levels, and target of 20% renewable energy by 2020. **Policy:** EU trading mechanism. Recycling: lump-sum transfers. **Implementation period:** 2005-20.	**Europe**		**GDP** (%) –0.35 in 2020			**Employment** (%) –0.04 in 2020		Labour supply not fully elastic. Wage bargaining with an intermediate value for trade-union bargaining power.

Box 4.1. **Main characteristics of the OECD ENV-Linkages model**

The OECD ENV-Linkages model is a recursive dynamic neo-classical general-equilibrium model, documented in detail in Burniaux *et al.* (2010). It has been used extensively for several OECD publications, notably the *Environmental Outlook to 2030* (OECD, 2008a) and *The Economics of Climate Change Mitigation* (OECD, 2009a). The model represents the world economy in 15 countries/regions, each with 26 economic sectors, allowing structural changes across and within countries and regions to be studied in detail. The economic sectors include five electric generation sectors, five that are linked to agriculture (including fishing and forestry), five energy-intensive industries, three sectors linked to oil and gas extraction, refineries and distribution of petroleum products. The remaining sectors are transport services, other services, construction and four other manufacturing sectors. Technological progress is exogenous, but alternative existing production technologies are modelled in great detail in the energy sector and the mix of technologies used evolves in response to changes in relative prices. A labour market clearing equation equalises aggregate labour demand to an exogenous employment level, and therefore determines wages.

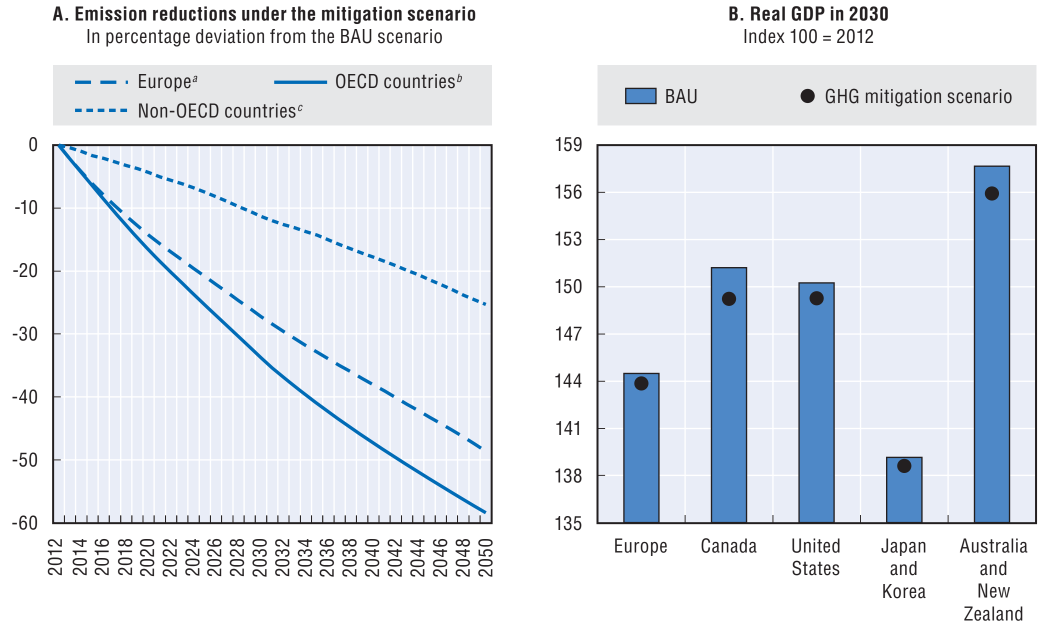
The exogenous employment levels are derived from labour force projections to 2050 and from estimates of national unemployment rates provided by the OECD Economics Department (see Duval and De la Maisonneuve, 2010). The model is built primarily on a database of national economies. The core of the static equilibrium is formed by the set of Social Account Matrices (SAMs) that describe how economic sectors are linked; these are based on the *GTAP Database*. Many key parameters are set on the basis of information drawn from various empirical studies and data sources (see Burniaux *et al.*, 2010). The "business-as-usual" (BAU) projection used as a support for economic policy scenarios is described in detail in OECD (2011b). It should be stressed that the BAU scenario is not intended to represent a prediction of how the global economy is likely to evolve, but rather to provide a baseline representing key economic developments that could be expected to occur if no further mitigation policies were introduced. It is important to emphasise that the BAU baseline does not represent a viable policy option, since such a scenario would imply a marked deterioration in global environmental conditions that would have serious consequences for living standards (OECD, 2012c).

As is the case for most available CGE models developed for the economic analysis of mitigation costs, the ENV-Linkages model has two limitations which tend to overstate the long-run cost of mitigation policies: *i)* technological progress is assumed to be exogenous, so that the model does not fully capture the potential effects of environmental policies in stimulating the innovation of new green technologies; and *ii)* the ENV-Linkages model does not account for the potential economic damages from climate change and, hence, omits the economic benefits from mitigation policies that operate through reduced environmental disruption. Both characteristics imply that in the long run, potential output and employment gains induced by the mitigation policy are not fully captured in the modeling framework. These limitations are, however, less important when attention is focused on the next several decades, as innovation and climate changes are slow processes. This medium-run time horizon is emphasized here because it is arguably most relevant for understanding the challenges green growth poses for labour market and skill policies.

are reduced by 25% in 2050 as compared to what would be observed in these countries in the absence of mitigation efforts, under the so-called business-as-usual (BAU) scenario. It is assumed that there is OECD-wide trading in ETS permits, but that each non-OECD country operates its separate ETS.[10]

The first set of policy simulation exercises was conducted using the baseline version of the OECD ENV-Linkages model with full flexibility in the labour market. In this set-up, the structural adjustment pressures triggered by mitigation policy can be observed through the policy impacts on real GDP, the real net wage (disposable income of working households) and a welfare measure (the so-called "equivalent variation" in real income of

Figure 4.1. **An illustrative mitigation policy scenario for GHG emissions and its impact on GDP growth in OECD countries**



Note: Simulated impacts of GHG mitigation policy are shown as deviations from a business-as-usual (BAU) baseline scenario that assumes no new mitigation policy measures are implemented and takes no account of how the resulting environmental damages would affect economic activity and well-being.

a) **European average** includes: Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Romania, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom.

b) **OECD average** includes: the European countries identified above together with Australia, Canada, Japan, Korea, New Zealand and the United States.

c) **Non-OECD** average includes: Brazil, China, India, Indonesia, and the Russian Federation.

Source: OECD ENV-Linkages model.

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all households[11]). As the harm from climate change and hence the benefits from mitigation action are *not* included in the analysis, these welfare losses represent only the cost of policy action and not the benefit.

Mitigation policy tends to slow the pace of economic growth relative to the BAU scenario, albeit not by very much. Focusing first on the standard assumption, namely, that the revenue from the ETS system is distributed to households as equal lump-sum transfers, the simulations indicate that real GDP for the OECD area in 2030 declines by less than 0.6% compared with the BAU (Table 4.2). The corresponding reduction is somewhat smaller in Europe, where a smaller reduction in GHG emissions is required. The simulated costs are small compared with the substantial GDP growth that is projected during the 2012-30 period (Figure 4.1, Panel B). Under the BAU scenario, the cumulative growth for this period ranges from 39% in Japan and Korea to 57% in Australia and New Zealand.

In fully flexible labour markets, the illustrative mitigation policy scenario would also lead to a reduction in real wages relative to the BAU scenario (Table 4.2).[12] This is because the ETS leads to an increase in the marginal costs of production and this puts a downward pressure on labour demand and thus on wages. This cost rises over time, reflecting the gradual introduction of larger emission reductions with respect to the baseline scenario. The real wage in the OECD area would decline by around 1.4% from baseline levels in 2030

Table 4.2. **Economic impact of mitigation policies for various recycling options**
Percentage deviation from the BAU scenario for an OECD-wide ETS

		Revenues from ETS[a]	Lump-sum transfers			Taxes on labour			Household income tax			Capital and labour taxes		
			Real GDP	Real net wage[b]	Welfare measure[c]	Real GDP	Real net wage[b]	Welfare measure[c]	Real GDP	Real net wage[b]	Welfare measure[c]	Real GDP	Real net wage[b]	Welfare measure[c]
Europe	2015	0.12	–0.02	–0.13	–0.02	–0.02	0.18	–0.02	–0.02	0.01	–0.02	–0.02	0.16	–0.02
	2020	0.51	–0.12	–0.59	–0.08	–0.12	0.68	–0.08	–0.12	–0.02	–0.08	–0.12	0.56	–0.08
	2030	0.92	–0.43	–1.27	–0.36	–0.43	0.74	–0.36	–0.43	–0.34	–0.36	–0.43	0.54	–0.36
OECD	2015	0.15	–0.02	–0.13	–0.02	–0.02	0.16	–0.02	–0.02	0.03	–0.02	–0.02	0.12	–0.02
	2020	0.60	–0.13	–0.61	–0.12	–0.13	0.54	–0.12	–0.13	0.02	–0.12	–0.13	0.38	–0.11
	2030	1.04	–0.55	–1.41	–0.51	–0.55	0.36	–0.51	–0.55	–0.41	–0.51	–0.55	0.11	–0.50

Note: For the country coverage of Europe and OECD, see Figure 4.1, notes *a)* and *b)*.

a) Revenues from ETS are expressed as a percentage of GDP and correspond to the policy scenario with lump-sum recycling.

b) The real net wage is defined as the net-of-taxes wage received by households divided by the consumer price index. Therefore, it is directly affected by changes in carbon prices.

c) The welfare measure is defined as the difference between the simulated level of real income when mitigation policies are introduced and the level of real income that would ensure the same utility level to consumers as would occur in the absence of such policies, *i.e.* in the baseline (or BAU) scenario. It takes no account of environmental benefits from mitigation policy.

Source: OECD ENV-Linkages model.

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and by a little less in Europe. The depressive effect of mitigation policies is always more pronounced on real net wages than it is on GDP or aggregate welfare. These policies may thus generate distributional concerns and off-setting the resulting income losses for workers could thus be one of the considerations involved in deciding how to distribute the revenues from ETS.

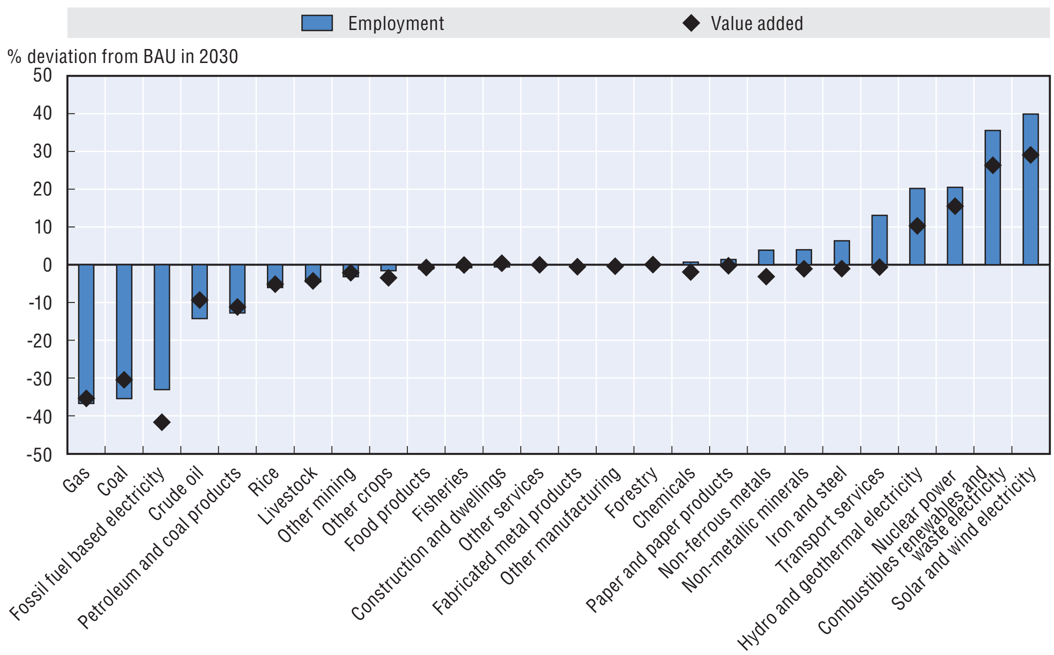
In addition to simulations where ETS revenues were redistributed to households in the form of *uniform lump-sum transfers*, Table 4.2 also shows the simulation results for three alternative recycling policies, namely, with ETS revenues being recycled so as to: *i)* lower household wage income taxation; *ii)* lower household global income taxation; and *iii)* reduce both capital and labour taxes paid by firms.[13] The results show that the mitigation policy generates net additional public revenues that are potentially large enough to offset its depressive effect on workers' disposable income. When all of the permit revenues are used to reduce taxes on wage income, real net wages increase indicating that working households could actually benefit from this mitigation policy (see the "taxes on labour" scenario). With fully flexible labour markets, this alternative recycling option has only distributional consequences, shifting part of the adjustment burden away from working households.[14] Because capital incomes are earned by households, similar redistributive patterns are found when ETS revenues are used to reduce taxes on both labour and capital incomes. However, the recycling of ETS revenues in the form of lower income taxes is much less favourable to workers, because income taxes are more equally distributed across working and non-working households than are taxes on labour and capital.

How do mitigation policies affect the sectoral mix of employment and job-skill requirements?

The transition to green growth will also require labour reallocation across sectors, which could be a source of adjustment costs and insecurity for workers. Figure 4.2 shows how employment is affected by mitigation efforts in each of the economic sectors

Figure 4.2. **Simulated changes in sectoral composition of employment, OECD**[a]

Policy-induced labour reallocation in 2030



Note: Simulated impacts of GHG mitigation policy are shown as deviations from the BAU baseline scenario that assumes no new mitigation policy measures are implemented and takes no account of how the resulting environmental damages would affect economic activity and well-being.

a) For the country coverage of OECD, see Figure 4.1, note *b*).

Source: OECD ENV-Linkages model.

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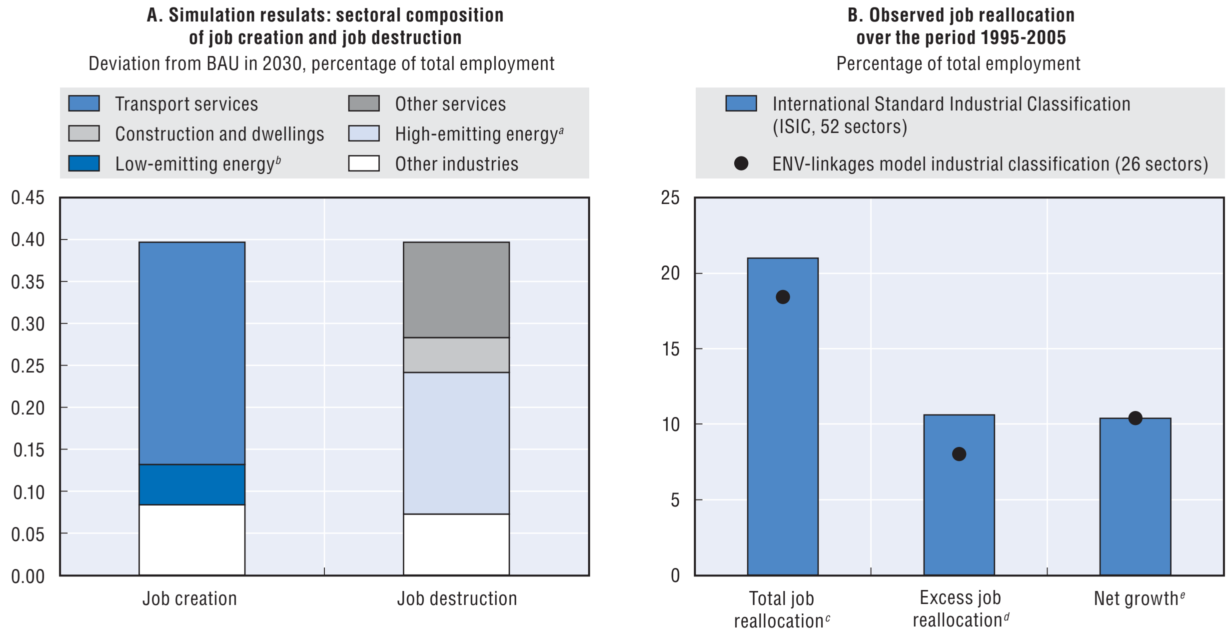
considered in the ENV-Linkages model. These results are based on the baseline mitigation scenario with ETS revenues being redistributed to households in the form of equal lump-sum transfers. The simulation indicates that by 2030 employment in the solar and wind electricity sector in the OECD area as a whole could be 40% higher than it would have been in the absence of the climate mitigation policy. By contrast, the fossil fuel and coal mining sectors could lose more than 35% of their jobs in the OECD area.

Although these expansions and contractions are very large at the individual sectoral level, they do not translate into a large *overall* reallocation of jobs, because the heavily impacted industries represent only a small share of total employment. Indeed, summing up all sectoral job creation, it appears that the new jobs created by expanding sectors represent only 0.4% of total employment in the OECD area (Figure 4.3, Panel A).[15] As labour markets are assumed to be fully flexible and total employment is not affected by the mitigation policy, the aggregate job destruction induced by mitigation policy equals total job creation. It follows that the change in the sectoral composition of employment that is induced by the mitigation policy in 2030, as measured by the sum of job creation and job destruction, would affect less than 1% of total employment in the OECD. Figure 4.3, Panel B shows that this is a small number compared with the magnitude of cross-sectoral employment shifts that has recently characterised OECD labour markets. On average in the OECD area, total job reallocation between economic sectors (*i.e.* the sum of sectoral job creation and destruction) accounted for 20% of total employment during 1995-2005.[16]

Figure 4.3. **Sectoral impact of mitigation policies on employment compared with historical benchmarks, OECD**



Note: Simulated impacts of GHG mitigation policy are shown as deviations from the BAU baseline scenario that assumes no new mitigation policy measures are implemented and takes no account of how the resulting environmental damages would affect economic activity and well-being.

a) Coal, crude oil, gas, petroleum and coal products, fossil fuel based electricity.

b) Hydro and geothermal electricity, nuclear power, solar and wind electricity, combustible renewables and waste electricity.

c) Sum of job creation and job destruction.

d) Difference between total job reallocation and absolute net growth.

e) Absolute value of net employment growth (defined as the difference between job creation and job destruction).

Source: OECD ENV-Linkages model (Panel A) and *EUKLEMS Database* (Panel B).

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This analysis suggests that GHG mitigation policy is unlikely to create structural adjustment pressures that are quantitatively large compared with historical experience, but this conclusion is subject to two caveats. First, the measurement of job reallocation between sectors is sensitive to the industry classification retained for the analysis and the use of a consolidated services sector in the classification used in the ENV-Linkages model misses employment shifts within the broad services sector. However, Figure 4.3 (Panel B) shows that the historical estimates obtained vary only slightly when the calculation is based on the industry classification in 26 economic sectors used in the ENV-Linkages model, instead of being based on the International Standard Industrial Classification in 52 sectors (three-digit level). A second caveat is that past research has shown that gross job flows *between* firms in the same sector or sub-sector are an order of magnitude larger than gross job flows *across* sectors (OECD, 2009b and 2010b). Unfortunately, the OECD ENV-Linkages model does not take account of job reallocation within sectors and how this form of labour market churn would be affected by mitigation policy.[17]

Although the magnitude of the policy-induced job reallocation between sectors is projected to be quite limited, the sectoral composition of job creation and job destruction reveals interesting patterns (Figure 4.3, Panel A). Indeed, general-equilibrium effects appear to be at least as important as the partial-equilibrium effects in that much of job reallocation is projected to take place outside the strongly impacted sectors with large percentage employment gains and losses in Figure 4.2. Two-thirds of job creation takes place in the transport services, even though this sector figures among the more polluting industries. This reflects several general-equilibrium effects. First, the demand for transport services is complementary to many other economic activities and, thus, does not fall much when transportation prices increase due to rising energy prices. Second, transport services become significantly more labour-intensive as the price of energy rises relative to wages. By comparison, job creation in the so-called "clean energy sector" represents a far smaller fraction of total job creation (12%). The high-emitting energy sector accounts for the largest proportion of sectoral job destruction (43%), but services other than transportation also contribute a significant share (29%) despite the percentage decline in this sector's employment being very small. This can be explained by the fact that the services sector is by far the largest employer, representing around two-thirds of total employment.

OECD (2012a) analyses how these mitigation policy-induced changes in the industry composition of employment would affect overall skill demand. In light of the relatively small impact of the mitigation policy on industry mix, it is not surprising that the estimated impact on economy-wide skill demand is minimal.[18]

In sum, these simulations confirm previous studies by suggesting that ambitious mitigation policies would create only relatively modest economic costs, be they measured in terms of GDP, welfare or wage loss. However, they also highlight how wage earners could bear a disproportionate share of these costs unless offsetting policies are implemented, such as recycling carbon tax revenues so as to lower the taxation of labour income. These simulations also suggest that the structural adjustment pressures in the labour market that will be created by mitigation policy will not be too difficult to manage because the estimated impacts on the industrial mix of employment and overall skill demand are small. Do these results hold up when the model is made more realistic by allowing for labour market rigidities? In order to provide a tentative answer to this question, labour market imperfections have been introduced in the ENV-Linkages model through a wage equation implying that real wages do not adjust immediately to the new economic situation when mitigation policies are implemented.

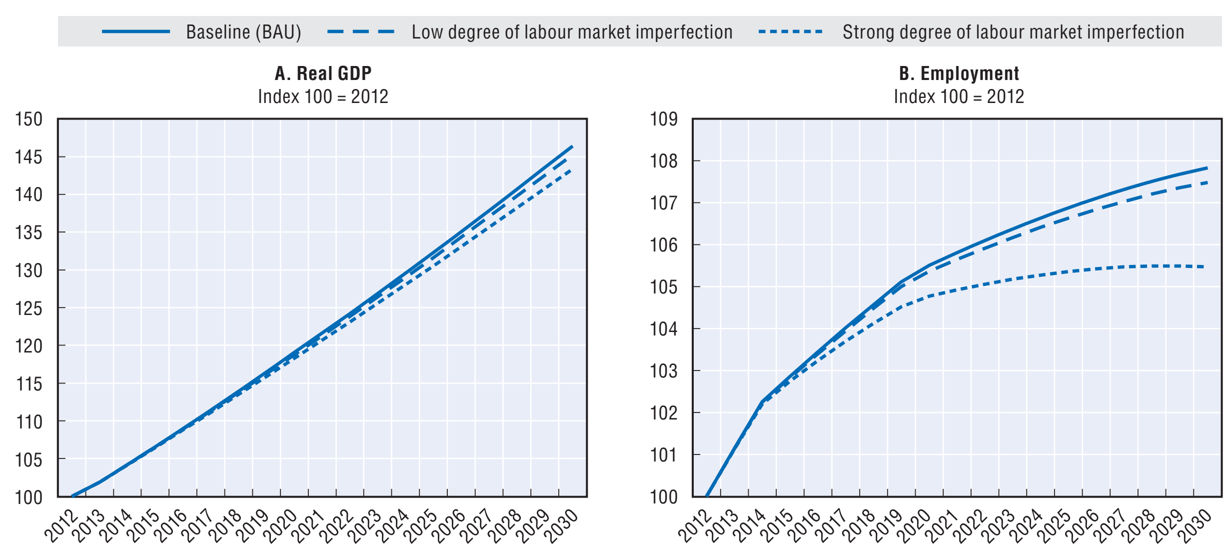
How much do labour market rigidities reshape the economic impact of mitigation policies?

The modelling of labour market imperfections in the augmented version of the ENV-Linkages model follows the approach adopted by Montgomery *et al.* (2009) for evaluating the economic and employment impact of the American Clean Energy and Security Act of 2009. Extensive empirical evidence suggests that in most OECD countries wages do not adjust immediately to economic changes, be they cyclical or structural. To reflect this, simulations were carried out where the real net wage in each period was set at an intermediate value between the real net wage that would be observed in the absence of mitigation policies (*i.e.* the wage corresponding to the BAU scenario) and the real wage that would be reached if wages adjusted instantaneously so that the employment level is not affected by mitigation policies (*i.e.* the market-clearing wage). This provides a stylised representation of an economy in which workers temporarily resist the reduction in real wages associated with mitigation policy. This partial rigidity in wage setting implies that part of the labour market adjustment to mitigation policy takes the form of temporary job losses. While this simple representation captures wage rigidities in a qualitative manner and keeps the simulation model tractable, the numerical results need to be interpreted with caution since labour market imperfections that may impede adjustment to mitigation policy are much more complex than the simple representation used in these simulation exercises.[19]

Figure 4.4 shows how the introduction of labour market imperfections into the OECD ENV-Linkages modifies the projected mitigation costs when permit revenues are redistributed in the form of uniform lump-sum transfers. As it is difficult to parameterise the model to the degree of wage rigidity in different countries, lower- and upper bound projections are provided: a low degree of labour market imperfection refers to a situation where 80% of the decline in the market-clearing wage rate is absorbed by workers immediately, while this proportion is set at only 20% when strong labour market imperfection is assumed. As would be expected, the economic cost of mitigation policy increases as the degree of wage rigidity increases. Nonetheless, economic growth slows only moderately when a strong degree of wage rigidity is assumed. Whereas real GDP for the OECD area as a whole increases by around 46% over the period 2012-30 in the BAU scenario, cumulative growth declines to 43% when mitigation actions are implemented in the context of strong rigidity (Figure 4.4, Panel A). A weaker degree of wage rigidity generates an intermediate growth path.

Introducing wage rigidity has a more pronounced effect on employment (Figure 4.4, Panel B). Whereas mitigation policy has no effect on employment when the labour market is fully flexible, the additional production costs associated with reducing GHG emissions depress employment levels when wages do not adjust fully to falling labour demand. For the OECD area as a whole, employment declines by 0.3% from baseline levels in 2030 in the scenario with a low degree of wage rigidity, and by 2.4% in the presence of strong wage rigidities. Indeed, the mitigation policy in the presence of strong rigidity substantially reduces the pace of

Figure 4.4. **GDP and employment impacts for different degrees of labour market rigidity when ETS revenues are recycled in the form of lump-sum transfers, OECD**[a]



Note: Simulated impacts of GHG mitigation policy are shown as deviations from the BAU baseline scenario that assumes no new mitigation policy measures are implemented and takes no account of how the resulting environmental damages would affect economic activity and well-being.

a) For the country converage of OECD, see Figure 4.1, note *b*).

Source: OECD ENV-Linkages model.

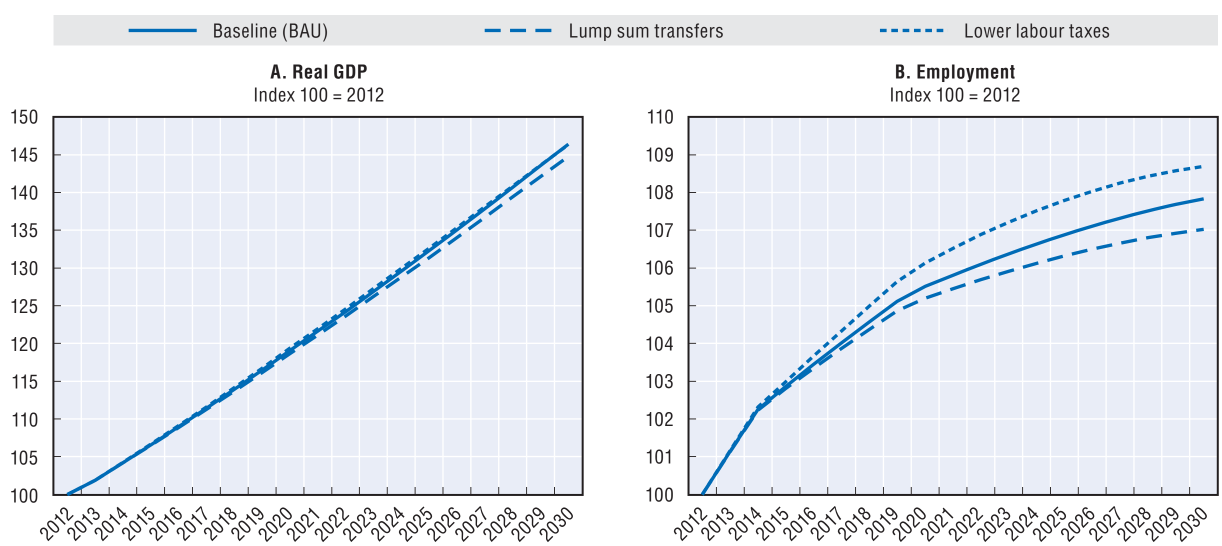
StatLink http://dx.doi.org/10.1787/888932651864

employment growth over the period 2012-30, namely, from 7.8% to 5.5%. However, this scenario is likely overly pessimistic as it assumes stronger wage rigidities than are likely to persist over an 18-year period.[20]

In the presence of labour market imperfections, the employment impact of mitigation policies depends crucially on how ETS revenues are distributed. This is illustrated in Figure 4.5, which compares two recycling options when the degree of labour market imperfection is set at an intermediate level (40% of the decline in the market-clearing wage rate is absorbed by workers immediately). As in Figure 4.4, mitigation policy depresses employment below the BAU path when revenues are distributed as lump-sum transfers to households. By contrast, recycling permit revenues so as to reduce taxation on labour income accelerates the pace of employment growth slightly relative to the BAU scenario. With this policy package in place, OECD employment increases by 8.7% over the period 2012-30, as compared with a 7.8% increase in the absence of mitigation actions. Combining mitigation policy with this recycling scheme boosts job creation more strongly in Europe, where the tax wedge on labour income is relatively high and hence acts as a larger drag on employment: European employment grows by 5.9% in the BAU scenario, but by 7.3% when the ETS is introduced and the resulting revenue is used to lower the labour tax wedge (Chateau *et al.*, 2011).

These simulation exercises illustrate the *double-dividend* principle that certain policy mixes can improve both environmental and labour market performance, while also illustrating the importance of taking account of the quality of labour market institutions when making choices about how permit revenues will be recycled. While these conclusions are in line with several earlier studies analysing the employment impact of mitigation actions within the framework of a CGE or hybrid models (see discussion of earlier studies

Figure 4.5. **GDP and employment impacts for different recycling options of ETS revenues and an intermediate degree of labour market rigidity, OECD**[a]



Note: Simulated impacts of GHG mitigation policy are shown as deviations from the BAU baseline scenario that assumes no new mitigation policy measures are implemented and takes no account of how the resulting environmental damages would affect economic activity and well-being.

a) For the country coverage of OECD, see Figure 4.1, note *b*).

Source: OECD ENV-Linkages model.

StatLink http://dx.doi.org/10.1787/888932651883

above), they are subject to several caveats. In particular, policy combinations that could not be modelled with the current version of the ENV-Linkages model might be superior to the policy scenarios simulated here. For example, mitigation policy could be combined with labour market reforms that reduce rigidities that would otherwise impede structural adjustment, freeing up the carbon permit revenues for other uses, such as reducing public deficits or subsidising eco-innovation.[21]

2. Direct impacts on employment and skill requirements in key winning and losing sectors: Lessons from partial-equilibrium analysis

The general-equilibrium approach in the previous section emphasises how the transition to green growth will be an important driver of structural changes across the labour market. It also provides a number of insights into economy-wide policy issues. However, these general-equilibrium models also have important limitations as a guide for making labour market and skill development policy choices, at least in their current form. One of their biggest limitations is that they provide little information about how the transition to low-carbon growth will affect job-skill demands, because it is difficult to incorporate much detail about job-skill requirements into these complex models and, in any case, very little is known about how the switch to greener technologies will alter job-skill requirements across the economy. These models also provide little guidance concerning how easily labour can be shifted from declining to growing sectors, even though that represents a potential "choke-point" that could slow the necessary structural change.

Partial-equilibrium analysis and case studies focussing on key sectors or workforce groups can help to overcome these limitations. They thus represent an essential complement to general-equilibrium modelling when analysing how labour market and skill development policy can best support an efficient and fair transition to green growth. This section focuses on those segments of the labour market that will be most intensely affected by a transition to green growth, including both green sectors which are likely to experience rapid growth and high-polluting sectors which are likely to shrink or profoundly re-engineer their production processes.

Green jobs: Emerging employment opportunities and emerging skills requirements

How many green jobs will be created?

Despite all of the uncertainty about the form that green growth will take, it can confidently be predicted that the transition to a low-carbon and resource-efficient economy will entail a significant expansion of employment in a number of "green" economic activities that either replace polluting activities with cleaner alternatives (*e.g.* renewable energy displacing fossil fuels) or provide environmental services (*e.g.* waste management and reforestation).

It has become common to refer to some or all of the employment in these activities as "green jobs". A number of different approaches have been proposed for defining green jobs, but no consensus has yet emerged (see Box 4.2). Indeed, the most widely cited definitions imply widely different estimates of the share of green jobs in total employment. For example, a major study for European Union countries presents three definitions which imply EU-wide green jobs shares that range from 2% to 21% (GHK Consulting *et al.*, 2007). This huge variation reflects different judgments about the appropriate criterion for

Box 4.2. **Defining and counting green jobs: A work in progress**

A number of definitions of green jobs have been proposed, but no consensus has emerged and the OECD has not endorsed a specific definition. Most statistical definitions take an *industry approach*, identifying green jobs with employment in industries that are judged to produce green goods and services. However, judgments differ concerning which industries should be classified as green, leading to disparate estimates of the number of green jobs. Two definitions have been proposed at the international level:

- Building on the 1999 OECD/Eurostat definition of eco-industries (*i.e.* industries producing environmental goods and services, such as pollution and resource management industries), Eurostat has developed a relatively narrow definition which implies that green jobs account for 2% of total employment in the EU area (EC, 2009). The US Department of Commerce (2010) has implemented a similar approach and concludes that green jobs accounted for between 1.5% and 2% of total employment in the United States in 2008.
- The United Nations Environmental Programme and the ILO developed a broader industry-based definition of green jobs (UNEP *et al.*, 2008). This definition also encompasses employment in industries that are heavily dependent on environmental resources (*e.g.* agriculture and forestry) and environmental quality (*e.g.* environment-related tourism). One drawback with this expanded definition of green sectors is that many firms in these environmentally-dependent sectors may not operate in an environmentally-friendly manner. However, the broader definition has the advantage of drawing attention to sectors that are likely to be adversely impacted by climate change or other forms of environmental degradation and thus are likely to be especially relevant for adaptation policies. When applied to the EU area, this broader definition classifies approximately one job in five as "green".

A growing number of national governments are developing their own definitions of green jobs to serve as a basis for collecting statistics and making policy choices (see OECD, 2012b, for more details). Of the 27 countries responding to an OECD questionnaire on green jobs, ten have adopted a definition of green jobs, five are in the process of developing a definition and 12 have yet to take a decision to define and count green jobs (see OECD, 2012b, for more complete information). Nine countries have produced estimates of the number of green jobs using either a recently adopted definition or an experimental definition. These national initiatives have often been guided, at least in part, by the international standards mentioned above, but have also incorporated novel aspects, as is illustrated by on-going work in the United States to develop statistics on green jobs:

- The US Bureau of Labor Statistics (BLS, 2010) is using two different approaches to measuring green jobs: *i)* an *output approach,* which identifies business establishments that produce green goods and services (GGS), estimates the GGS share of their total sales and then counts that same proportion of all jobs in these establishments as green jobs; and *ii)* a *process approach* which identifies business establishments that use environmentally friendly production process and practices, regardless of the nature of the good or service they produce, and counts the jobs associated with these processes as green jobs. The first approach is a variation on the already common approach that relies on the nature of the good or service produced and begins by identifying industries that produce GGS. Rather than treating all output and employment in these industries as green, the BLS method estimates the share of green output in each establishment and counts the same share of its employment as green. First estimates implementing this approach indicate that 2.4% of total employment was green in 2010 (BLS, 2012). The second approach is even more of a departure because it allows for the fact that some workers in firms that do not produce GGS may, nonetheless have green jobs (*e.g.* pollution control workers in a steel mill). The BLS will publish its first estimates using the process approach later in 2012.

considering a job to be green when the degree of "greenness" is difficult to assess precisely and varies more or less continuously across jobs. A related complication is that the most appropriate "green" threshold will evolve as technological progress makes it increasingly economical to reduce adverse environmental impacts. By the same logic, this threshold could also vary between more and less developed countries, if the latter lack either access to the most sophisticated green technologies or the capacity to apply them effectively.[22]

Even if convergence on a widely accepted definition of green jobs remains elusive, efforts to identify types of employment that are particularly critical to achieving green growth are valuable for guiding labour market and training policy. Demand for certain types of green workers will have to grow rapidly if the transition to green growth is to succeed and policy makers should attempt to anticipate recruitment and skill bottlenecks that would impede the transition. This pragmatic approach requires only that key types of green jobs be identified and that future hiring needs and job-skill requirements be assessed with a certain degree of accuracy. There are a growing number of successful applications of this pragmatic approach which has also proven to be useful for assessing skill development needs in the emerging green economy (see ILO, 2011a, for an excellent survey of many studies taking this approach).

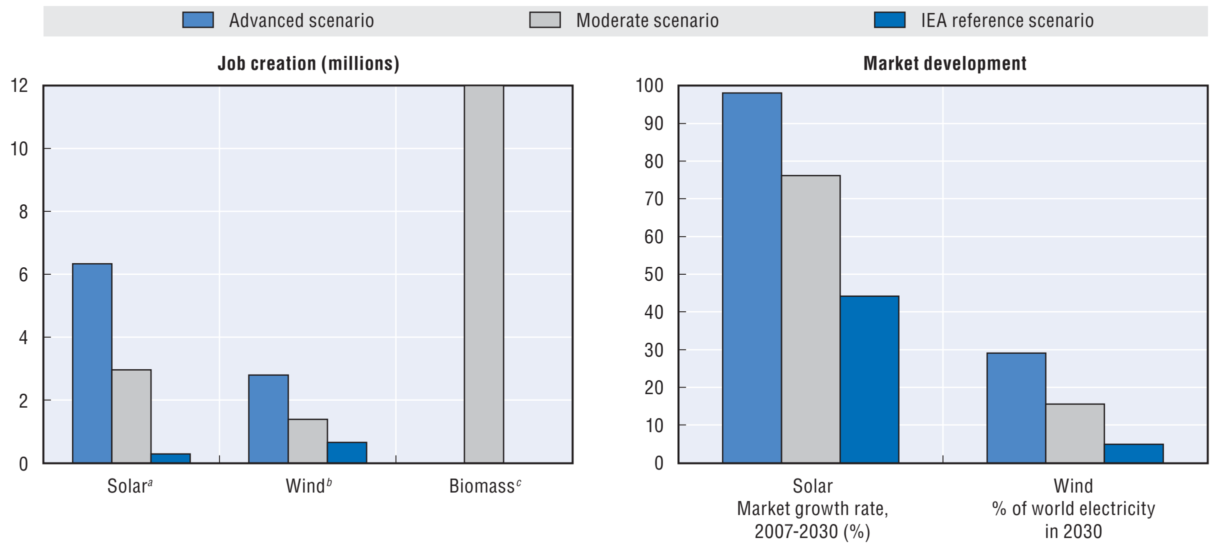
An increasing number of studies put forward the potential for job creation associated with the expansion of renewable energy generation and distribution. After an extensive review of available studies, the recent report by UNEP, ILO, IOE and ITUC estimates that in 2006, about 2.3 million people were employed worldwide in the renewable energy sector (UNEP *et al.*, 2008). While the majority of these jobs are in developed countries, the development of renewable energy and other environment-related jobs extends well beyond advanced economies. UNEP (2011b) updated its estimate of worldwide employment in durable energy to more than 3 million workers in 2009. While this number is growing rapidly, it is still a tiny share of total employment. China has the largest absolute number of workers in renewable energy (1.1 million), but that represents only about 0.1% of total employment. The employment share of renewable energy is somewhat higher in a few EU countries (*e.g.* 0.7% in Germany and 0.8% in Denmark).

Employment growth in the renewable energy sector is projected to be rapid in the coming decades. UNEP (2011b) suggests that by 2030, given the increasing interest in energy alternatives, up to 20 million jobs could be created worldwide: 2.1 million jobs in wind energy production, 6.3 million in solar photovoltaic and 12 million in biofuels-related agriculture and industry. Similarly, Fraunhofer ISI *et al.*, (2009) estimate that achieving the EU target for the share of renewables in total energy consumption to attain 20% in 2020 could create more than 2 million jobs in the European Union, while Wei *et al.* (2010) estimate that implementing a 30% renewable portfolio standard together with aggressive energy efficiency measures would expand US employment in the energy sector by 4 million jobs in 2030.

As Figure 4.6 shows, these various employment estimates are quite sensitive to the assumption made regarding the expansion of renewable energy markets.[23] They are also in constant need of updating as economic conditions and policy stances change. For example, the European Commission (EC, 2010) estimated the employment impact of implementing the "high pledge" from the climate change conference in Copenhagen in 2009 and concluded that shifting from a 20% to a 30% share for renewable energy in 2020 would create an additional 65 000 jobs in the renewable sector. All such estimates also rely on a number of modelling assumptions regarding the employment content of the whole

Figure 4.6. **Projected global employment in the renewable energy sector by 2030**

Estimates taken from the UNEP/ILO/IOE/ITUC report



a) Underlying assumptions (EPIA and Greenpeace International, 2007, p. 48): ten jobs are created per megawatt (MW) during production; about 33 jobs per MW during the process of installation; wholesaling of the systems and indirect supply (for example in the production process) each create 3-4 jobs per MW; and research adds another 1-2 jobs per MW. Over the coming decades, it can be assumed that these numbers will decrease as the use of automated machines will increase (especially for jobs involved in the production process).

b) Underlying assumptions (GWEC and Greenpeace International, 2006, p. 46): 16 jobs are created for every MW of new capacity through manufacture and component supply; a further 5 jobs by wind farm development, installation and indirect employment; and 0.33 jobs for regular operations and maintenance work at wind farms. As production processes are optimised, the number of manufacturing jobs falls to 11 jobs for every MW of cumulative capacity by 2030.

c) Estimates based on various studies, for different countries and areas.

Source: UNEP, ILO, IOE and ITUC (2008), *Green Jobs: Towards Decent Work in a Sustainable, Low-carbon World*, Geneva.

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production, transformation and commercialisation process of renewable energy sources. Most importantly, however, these estimates represent only the potential for *gross* job creation within the renewable energy sector.

A somewhat more comprehensive picture is provided by a number of detailed studies of the restructuring of the energy sector towards a cleaner energy-mix (*e.g.* Kammen *et al.*, 2004; Pearce and Stilwel, 2008; and IEA, 2009). These studies have typically concluded that *net* employment gains will result for energy-related activities, even after taking account of the jobs lost in the more polluting energy sector; because the renewable energy sector is more labour intensive and thus requires more jobs per megawatt of energy produced than the fossil fuel-based energy sector. Based on an in-depth analysis of 13 independent reports and studies on the direct economic and employment impacts of the clean energy industry in Europe and the United States, Kammen *et al.* (2004) argue that increasing the share of renewable energy in the United States to 20% of consumption levels by 2020 could create more than 200 000 jobs (against less than 90 000 jobs in a scenario without renewables). Similarly, a study supported by the European Commission concludes that net employment gains of nearly 1.4 million jobs could be generated in Europe by meeting the current policy goal of raising the renewable energy share to 20% in 2020 (MITRE, 2004). It needs to be emphasised, however, that these are still partial-equilibrium studies that do not capture the full macroeconomic impact of environmental policies on employment. While a general-equilibrium approach is required to assess the overall employment impact of green initiatives, such as shifting the energy sector towards greater reliance on renewable sources, these sectoral studies provide a much more finely grained picture of the types of new jobs being created in the sectors that will grow most rapidly and where job-skill requirements are least likely to be met by the existing vocational training system.[24]

What skills will green workers need?

The transition towards low-carbon and resource-efficient growth clearly will affect job-skill demands due to both rapid employment growth in emerging green sectors, such as renewable energy, and the diffusion of environmentally-friendly production technologies and practices more broadly across the economy. It would be difficult to predict *a priori* how skill demand will be affected. Accordingly, it is a very welcome development that detailed empirical information has recently become available about how skill demands are changing. This section briefly reviews the key lessons about emerging demands for green skills and how well they match with the vocational education and training (VET) systems in place. It relies particularly on two important sources of detailed information:

- *International studies conducted by the ILO*. Working together with the European Union and other partners, the ILO has recently completed a series of international studies of the impact of the transition to green growth on job-skill requirements (ILO, 2011a, b, c, d; and Cedefop, 2010). Twenty-one national case studies, along with detailed international case studies of the renewable energy and construction sectors, form the core of this work.
- *Labour market information systems*. Another valuable source of information about the emerging skill requirements of green jobs is provided by public labour market information (LMI) systems, which are intended to support job brokering by public employment services, guidance counselling services and labour market actors generally. For example, the US Department of Labor (DOL) is making a major investment in the collection and dissemination of better information about emerging green occupations, including projected recruitment needs, pay, working conditions, the skills required by those jobs and sources of training to acquire those skills.[25]

A first finding is that green jobs – understood to encompass new green specialties, such as energy auditors, familiar but rapidly growing green occupations, such as waste-recycling operators, and existing occupations, such as the construction trades, that have not been associated with environmental benefits in the past but which are evolving so as to become greener – are very diverse in their skill requirements. This is true in terms of the overall levels of skills required by these jobs, the specific content of the skills required and in how novel those skills are as compared to familiar occupational requirements for which training pathways are already in place.

Perhaps the most important finding from the point of view of skill policy is that there appear to be relatively few unique "green skills". Instead, most green jobs resemble familiar occupations, requiring a mix of generic skills, which are in wide demand throughout the economy (*e.g.* problem-solving, management and mathematical skills), and specific occupational skills. Furthermore, most of the specific occupational skills required by these jobs are familiar, although some are novel and directly related to the green character of the production activity (ILO, 2011b).

Since technological innovation will be essential to lower the cost of meeting environmental objectives (OECD, 2011a), it is sometime argued that green sectors will be characterised by intense innovation, implying that the generic skill requirements will tend to be higher overall than for similar occupations in other parts of the economy, where workers are less frequently called upon to develop or adapt to new technologies. It has also been argued that many of the jobs in these sectors will require at least a solid grounding in science, technology, engineering and mathematics (STEM) skills (ILO, 2011b). However, much remains to be learned about how eco-innovation will alter job-skill requirements, including how intense these pressures will be in different countries and industries (see Box 4.3).

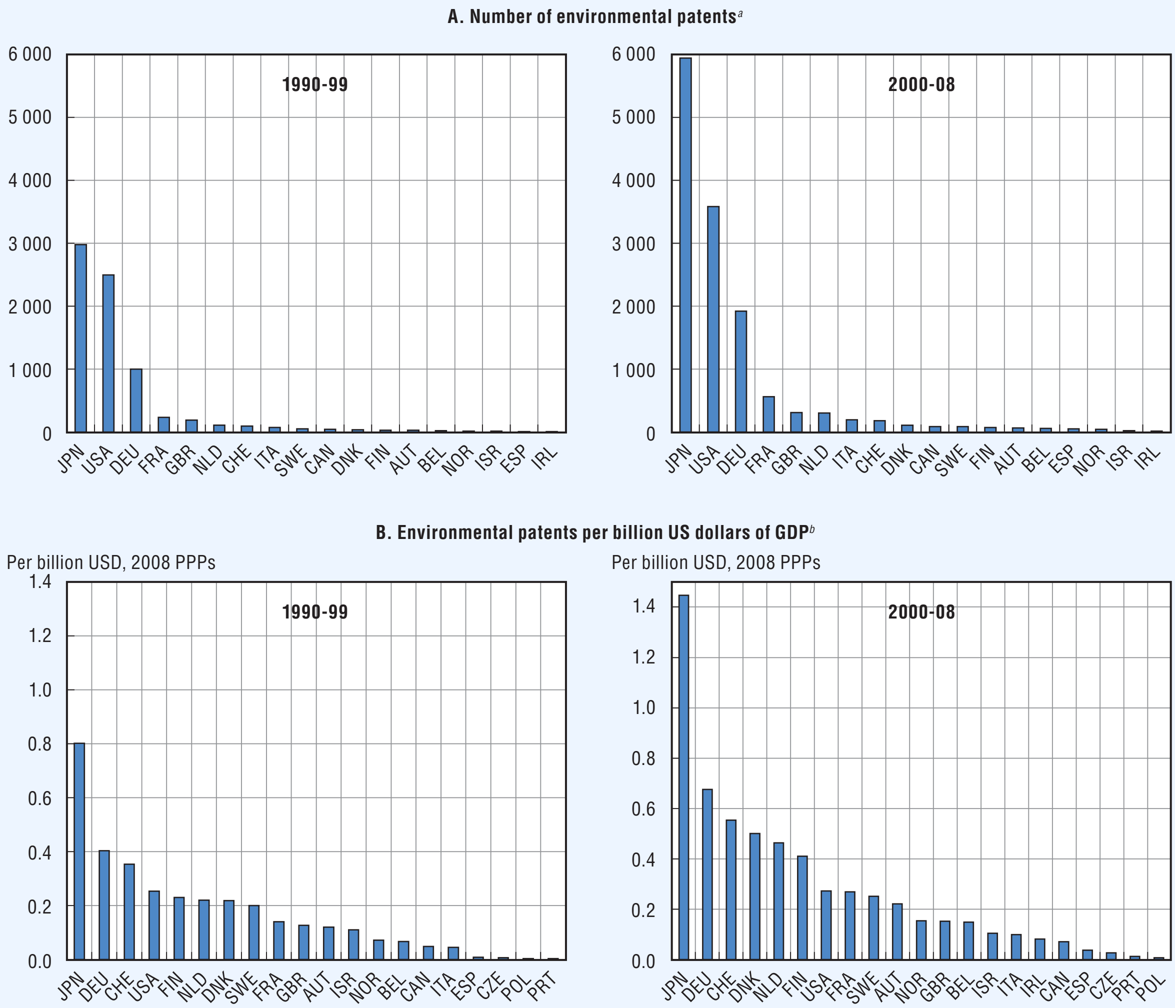
Box 4.3. **Eco-innovation: Which countries and industries are in the lead and how are new green technologies changing job-skill requirements?**

OECD (2012a) presents new evidence about how the intensity of eco-innovation varies across countries and industries, as well as some tentative evidence concerning how jobs skill requirements and other employment conditions are affected. Among the key findings:

- Environmental patenting data for 21 OECD countries show a strong upward trend between the 1990s and the 2000s, confirming that eco-innovation has intensified (see Panel A of the figure below). Three high-income countries (Japan, the United States and Germany) accounted for 84% of total patents during 2000-08, suggesting that only relatively few countries are presently well positioned to become market leaders in environmental technologies. However, several smaller European countries, such as Switzerland, Denmark and the Netherlands, have a high intensity of environmental patenting per unit of GDP (see Panel B of the figure below) and may also be able to gain technological leadership in certain green technology niches that could serve as the basis for developing new export markets.
- Relatively few industries account for a large share of environmental R&D. The two sectors accounting for the most environmental patents are non-financial business services – which includes research and development, and computer services – and the manufacture of electrical machinery and optical equipment – which includes ICT hardware. Interestingly, the industries typically singled out as green are not among the main inventors of new environmental technologies, but several of the most-polluting industries are quite active in environmental patenting, most notably the chemicals industry. The motor vehicle manufacturing sector (including automobiles) is also an important developer of new green technologies in Japan, Germany and France, but not in the United States where environmental regulation has provided less incentive to innovate in this industry in recent decades.
- The concentration of environmental patenting in a few industries suggests that relatively few workers and firms are involved in developing novel environmental technologies, even in the countries conducting most of the environmental R&D. However, new green technologies developed in one industry are often intended for use by other sectors, potentially affecting employment levels and job-skill requirements more broadly. For example, a large majority of the environmental patents registered by the electrical machinery and optical equipment industry were for the following five types of technologies: *i)* climate-change mitigation; *ii)* renewable energy; *iii)* abatement of air and water pollution, and waste; *iv)* energy efficiency; and *v)* transportation.
- Firm-level data for Germany confirms that eco-innovation – defined broadly to include the adaptation of green technologies developed by other firms – is much more widespread than green patenting. Environmental regulation is an important motivation for adopting new green technologies, as is customer demand for environmentally responsible products. Eco-innovation is associated with higher skill requirements, training and pay, as well as a stronger export orientation. However, the links between innovation and these employment conditions may be somewhat weaker for environmental than for non-environmental innovations.

Box 4.3. **Eco-innovation: Which countries and industries are in the lead and how are new green technologies changing job-skill requirements?** *(cont.)*

Intensity of environmental patenting by country, 1990-2008



a) Data not shown for countries with fewer than 100 total patents. This exclusion applied to Czech Republic, Poland and Portugal.
b) Billions of USD in purchasing power parities.

Source: OECD calculations based on OCDE PATSTAT and ORBIS databases.

StatLink http://dx.doi.org/10.1787/888932652035

Occupations requiring specifically green vocational skills also typically require many skills that overlap with those required by similar non-green occupations. This pattern suggests that the special training associated with green jobs often can take the form of "top-up" training that adapts workers, who are already qualified in an occupation, to using greener technologies or greener ways of working.[26] For example, designing and constructing energy-efficient buildings requires primarily familiar skills from the construction sector, but it also requires incremental training to understand how those skills can be applied in the construction of energy-efficient structures (ILO, 2011d).

There is also a need to update initial VET to prepare future labour market entrants to meet emerging green skill demands. In many cases, this is best done by enriching the curriculum of existing training and apprenticeship programmes to incorporate green elements, rather than by developing new green training pathways. Indeed, experience in Germany has shown that many secondary students are reluctant to take up specialised environmental apprenticeships due to the perceived risk of being trained too narrowly, which may be a disadvantage for them in the future.In response, basic knowledge in environmental protection has been incorporated into the vocational curricula across sectors in Germany (Cedefop, 2010). However, some emerging green occupations do appear to justify the creation of new educational or training pathways, especially at the highest skill levels. Since these occupations often take the form of new sub-specialties within long-standing disciplines, such as research and engineering positions in the renewable energies sector or systems analysts who develop ICT supports for "smart power grids", it may be relatively easily to add the new courses of study to existing programmes.

Even if the evolution of job-skill needs proves to be as incremental as is suggested by the evidence summarised above, it will still be a challenge to anticipate the new skill needs generated by the transition towards green growth and to adapt initial and continuing VET quickly enough to avoid significant skill mismatches from developing. Indeed, evidence from a number of countries suggests that skill shortages have already developed in certain sectors or occupations, where green growth policies have created a need for new skills or new combinations of familiar skills. Energy-efficient construction and retrofitting, renewable energy, energy and resource efficiency and environmental services appear to be among the most affected sectors. For example, a report to the French government recently identified a number of emerging occupational specialties in the construction sector (*e.g.* energy auditors and solar panel installers), which are not well served by traditional training institutions and hence face potential recruitment bottlenecks (COE, 2010; OECD 2012a). Other examples of skill shortages identified by Cedefop (2010) include difficulties reported by employers in recruiting skilled photovoltaic workers (Germany), design engineers for smart grids (the United Kingdom), installation and maintenance of solar electrical systems (Spain), and project managers with competencies in renewable energy (Denmark). Recent OECD work has shown that small and medium-sized enterprises (SMEs) face particular challenges in upgrading their workers' skills to meet new skill requirements created by the transition towards green growth (OECD, 2012e and 2012f).

While these examples of skill shortages confirm the importance of co-ordinating environmental policy initiatives with an assessment of their implications for the VET system, it is difficult to assess how general and severe green skill shortages are based on evidence from highly diverse case studies.[27] Consequently, it is unclear whether skill shortages are presently a significant brake on the transition towards green growth. At a minimum, it can be concluded that skill shortages could become more of a problem as labour markets recover from the 2008-09 recession and more ambitious green growth policies are put in place.

Brown jobs: Structural adjustment pressures in the most polluting industries

Even as a transition towards green growth stimulates job creation in environmentally beneficial activities, employment losses can be expected in other sectors, particularly those with the largest adverse environmental impacts. This pattern is illustrated by the simulations of climate-change mitigation policy in Section 1, which show that a tax on

CO_2 emissions leads to expanded employment in the renewable energy sector, but employment losses in the extraction of fossil fuels and their use in generating electricity. Potential employment losses in highly polluting industries may be reduced or even avoided, if changes in production technology can be introduced that reduce harmful environmental impacts (*e.g.* carbon capture and storage). Even in such cases, the industry's workforce would still face structural adjustment pressures, as new technologies and work practices change the composition of employment and the skills required to do the work. This section analyses potential adjustment costs in the most polluting industries, as proxied by high CO_2 emissions intensity. It identifies the most polluting industries, documents how many workers they employ and analyses how the characteristics of workers in these industries and their turnover patterns are likely to influence their ability to adapt successfully, should they lose their job or need to retrain in order to retain it.

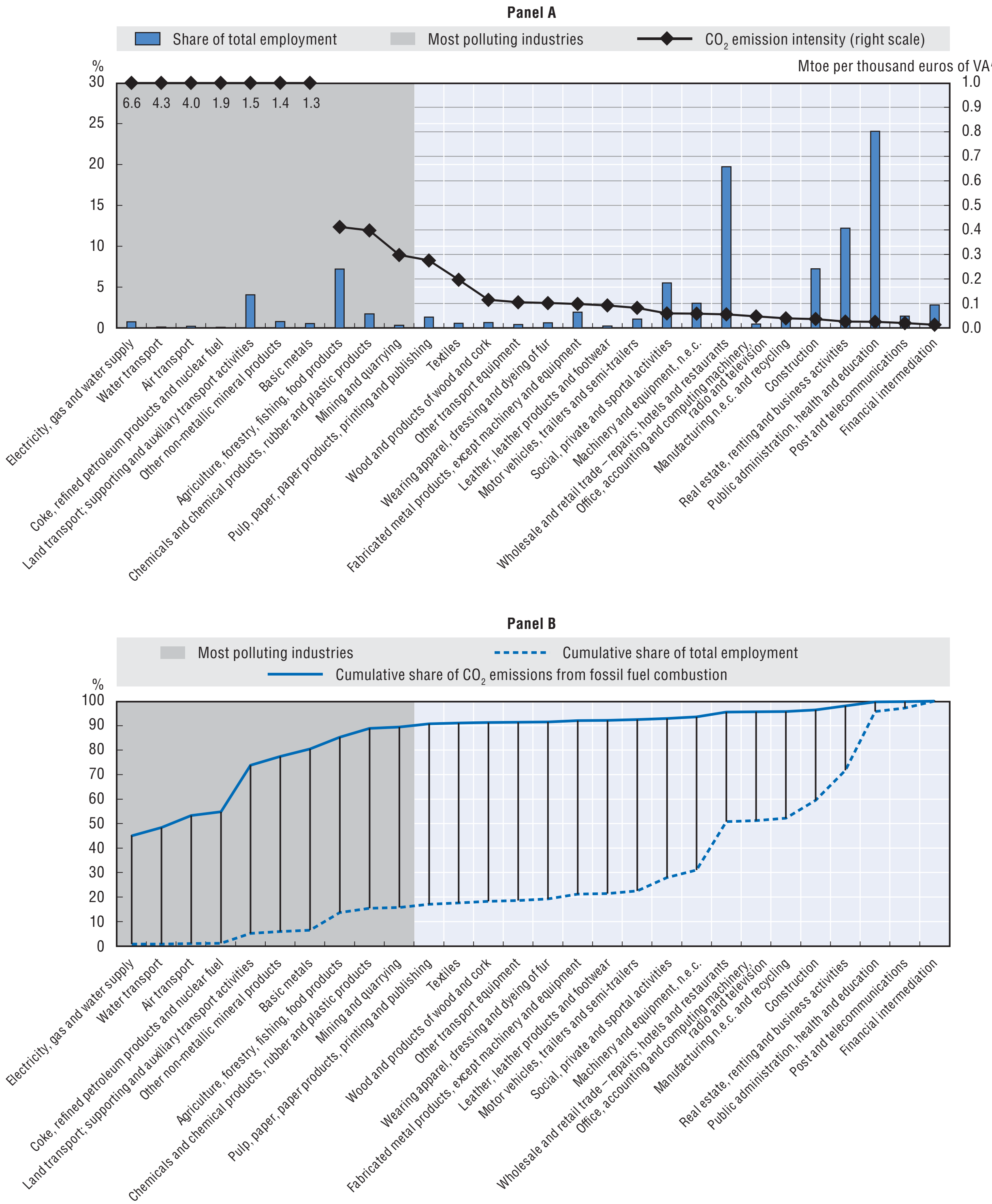
Which are the most polluting industries?

Carbon taxes and similar policies are more likely to result in job losses in industries characterised by a relatively high ratio of CO_2 emissions to value added than in industries with a relatively low intensity of CO_2 emissions, even though this measure is an imperfect proxy for structural adjustment pressures.[28] As shown in Panel A of Figure 4.7, the average CO_2 emissions intensity in 25 EU countries varies widely across industries, ranging from 6.6 Mtoe of CO_2 emissions per thousand euros of value added in the electricity sector to almost no emissions in financial intermediation services. Ten sectors can be identified as being the most polluting: two energy producing sectors (electricity and fossil/nuclear fuels), three transport sectors (including water; air; and land and supporting and auxiliary transport activities), three manufacturing sectors (basic metals; other non-metallic mineral products; and chemicals), as well as agriculture and mining.[29] It is notable that agriculture and land transportation are the only industries in this group accounting for substantial shares of total employment (a combined 11.3% of total employment in the EU25 region). By contrast, CO_2 emission intensity is low in the three biggest sectors in terms of employment – namely, public administration, health and education (24.1% of total employment), wholesale and retail trade, repairs, hotels and restaurants (19.7% of total employment), and real estate, renting and business services (12.2% of total employment) that together account for more than half of total employment.

Figure 4.7, Panel B shows that the ten most intensely-polluting sectors account for a large share of total CO_2 emissions (nearly 90%), while they account for less than 16% of total employment. This suggests that the structural adjustment pressures in the labour market that would be created by a significant increase in the price of carbon may be concentrated on a relatively small portion of the total workforce.[30] It is also notable that some of these industries (agriculture, mining, coke and basic metals) have been characterised by a secular decline in employment for some time, especially in the most advanced OECD economies. This suggests that any additional job losses in these sectors, as a result of green growth policies, are likely to generate structural adjustment pressures of a type that has already been present and may be adequately managed by existing labour market programmes.

While the most polluting industries account for only a relatively small share of total employment (14% of total workforce) in the 15 major EU countries included in Figure 4.8, there are significant cross-country variations, with the proportion ranging from a low of 11% in Denmark and Germany to a high of 27% in Poland. Among the countries with the

Figure 4.7. **CO_2-emissions and employment by industry in 25 EU countries, 2005**[a]



a) Averages for the EU25 region.

b) Mtoe: Million tonnes of oil equivalent.

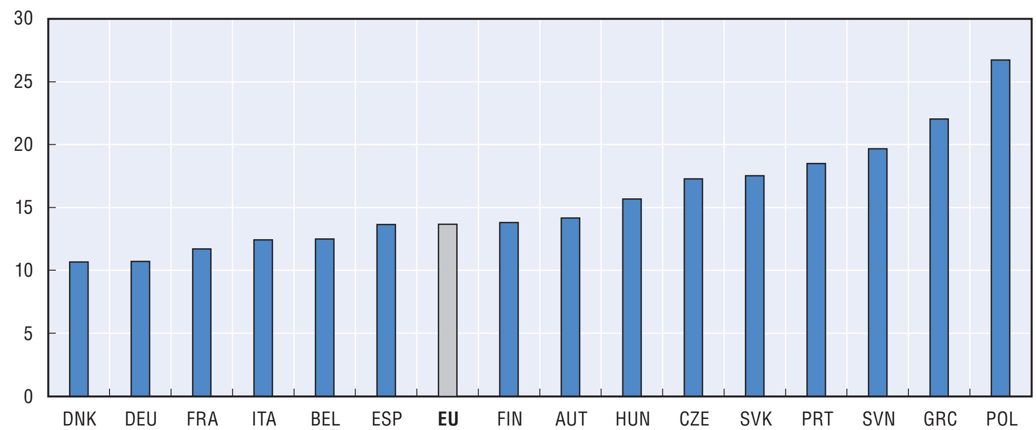
Source: Employment and value added data from EUKLEMS, CO_2 emissions data from GTAP.

StatLink http://dx.doi.org/10.1787/888932651921

greatest concentration of employment in highly polluting industries are the five central and Eastern European members, where high emissions intensity in manufacturing is, in part, a heritage of economic development policies during the period of central planning and where agriculture still accounts for a high share of total production. Most western European countries have below-average employment shares in the most polluting industries, although Greece and Portugal are exceptions. The concentration of employment in the most polluting industries in countries with relatively low GDP per capita presents a risk that the adjustment costs associated with the transition towards a low-carbon economy could be greater in countries where living standards are lower.[31]

Figure 4.8. **Employment share of the most polluting industries in selected EU countries, 2000-07**[a]

Percentage of total employment



a) Most polluting industries: agriculture, hunting and forestry; fishing, mining and quarrying; electricity and gas; air transport; water transport; land transport and other supporting and auxiliary transport activities, including activities of travel agencies; coke, refined petroleum and nuclear fuel; chemicals and chemical products; other non-metallic mineral products; basic metals.

Source: EU Labour Force Survey.

StatLink http://dx.doi.org/10.1787/888932651940

The adjustment costs associated with green structural change are also likely to be unevenly distributed across regions within countries, due to the high localisation of some of the most polluting industries. OECD (2012a) analyses which of the most polluting industries are the most geographically concentrated and hence a potential source of locally concentrated restructuring pressures. The least localised of the highly polluting sectors are electricity generation and supply, the two manufacturing sectors, land transportation, supporting and auxiliary transportation, and agriculture, forestry and fishing. By contrast, several of the most polluting industries are strongly localised in the Czech Republic, Poland and the Slovak Republic: coke and fuel production, and basic metals in the Slovak Republic; mining and water transportation in Poland; and basic metals in the Czech Republic. Air transportation services are also highly localised in these and most other European countries, a reflection of the concentration of air transport activity in major business centres.

If the job losses associated with the transition towards green growth should prove to be spatially concentrated, that would represent a difficult policy challenge. Plant closures and mass lay-offs can have large and long-lasting effects on the region where they occur, especially if the region is relatively isolated and there is a paucity of growing firms and sectors to absorb displaced workers. This suggests that regional and local government may be important actors in managing the structural adjustment costs associated with the transition towards green growth. Identifying skill needs and organising the provision of training related to green jobs is likely to be one of the necessary components of successful initiatives for regional economic rejuvenation (OECD, 2012e).

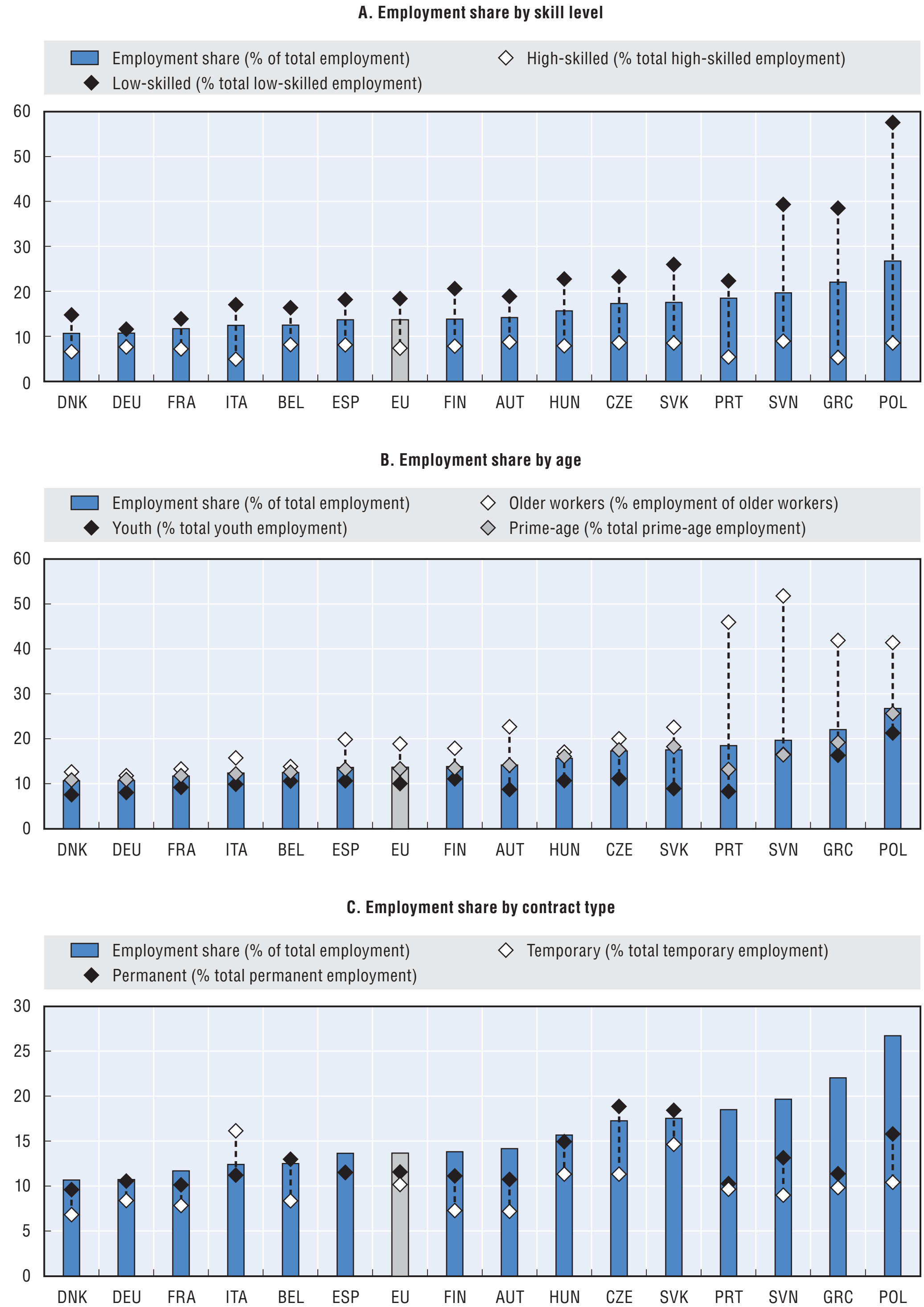
Are workers in the most polluting industries different from the rest of the workforce?

It is important to ascertain which types of workers tend to work in the most polluting industries and whether their characteristics are such as to help or hinder them should they need to move into new jobs in other sectors. An accurate profile of the workers most at risk of being displaced by green growth policies can also help to identify which re-employment and training services would minimise the resulting adjustment costs, thereby contributing to a fair and efficient transition toward green growth while reducing political resistance to the more ambitious environmental policies required to green the economy. This sub-section examines the age and skill profile of the current workforce in the most polluting industries, as well as the types of employment contracts they hold, while the next sub-section compares mobility outcomes for workers in these and other industries. This empirical analysis makes use of German CO_2 output-intensity data, because doing so allows a more disaggregated sectoral analysis (see Annex Table 4.A1.1 for a list of the sectors analysed and their numerical codes). Due to the need to obtain adequate sample sizes for a finer disaggregation of industries, the analysis focuses on the 15 larger EU countries presented in Figure 4.8.

Figure 4.9 provides a portrait of employment in the most polluting industries. The following patterns emerge:[32]

- The share of low-skilled workers employed in the most polluting industries exceeds that for high-skilled workers in all of the countries analysed. On average across the 15 EU countries, the most polluting industries accounted for 18% of low-skilled employment in 2000-07, as compared with 14% of all workers and just 7% of high-skilled workers. In other words, workers who have not finished upper secondary schooling are more than twice as likely as workers with a university-level degree to work in the most polluting industries. There is also a tendency for older workers to be over-represented in these industries (19%). The over-representation of low-skilled and older workers is particularly pronounced in the countries with the highest concentration of employment in the most polluting industries, that is in Poland, Greece, Slovenia and (as regards older workers) Portugal. By contrast, fewer than 10% of employed youth work in the most polluting industries in all of the countries considered. The low representation of youth in the workforce of the most polluting industry probably helps explain why employees in these industries are more likely to have permanent contracts than are employees in the overall economy (Italy is an exception).
- The concentration of the job-displacement risk associated with an increase in carbon taxes on low-skilled and older workers has important implications for the expected size of the adjustment costs associated with green growth, as well as for the design of labour market and training policies intended to minimise adjustment costs. A large body of empirical research has shown that low-skilled and older workers face above-average displacement costs – due to both longer durations of unemployment and greater wage losses once re-employed (see OECD, 2005a and 2005b, and the sources cited there) – and also tend to have relatively limited access to skill upgrade training (OECD, 2003).

Figure 4.9. **Employment share of the most polluting industries in selected EU countries by skill, age and contract type, 2000-07**



Note: Most polluting industries: agriculture, hunting and forestry; fishing, mining and quarrying; electricity and gas; air transport; water transport; land transport and other supporting and auxiliary transport activities; activities of travel agencies; coke, refined petroleum and nuclear fuel; chemicals and chemical products; other non-metallic mineral products; basic metals.

Source: EU Labour Force Survey.

StatLink http://dx.doi.org/10.1787/888932651959

Labour mobility differences across industries and countries

This sub-section deepens the analysis of potential barriers to achieving the labour market structural change that will be required to make the transition towards green growth, by analysing labour mobility patterns directly. Of particular concern is whether workers currently employed in the most polluting industries, or some part of this group, exhibit low levels of mobility and hence might encounter difficulties should green-driven economic restructuring require them to change employers and possibly also industry and occupation. One reason to anticipate higher adjustment costs following displacement for relative immobile workforce groups is that they tend to have accumulated greater tenure on the lost job. Research has consistently shown that higher tenure workers tend to experience greater adjustment costs following job displacement than do lower tenure workers. Cross-country comparisons also suggest an association between high adjustment costs and low mobility. Year-to-year earnings volatility for individual workers also tends to be relatively low in countries characterised by above-average worker mobility rates: workers change jobs more often in these countries, but when they do so they generally find a new job relatively quickly that offers a similar wage (OECD, 2011c).

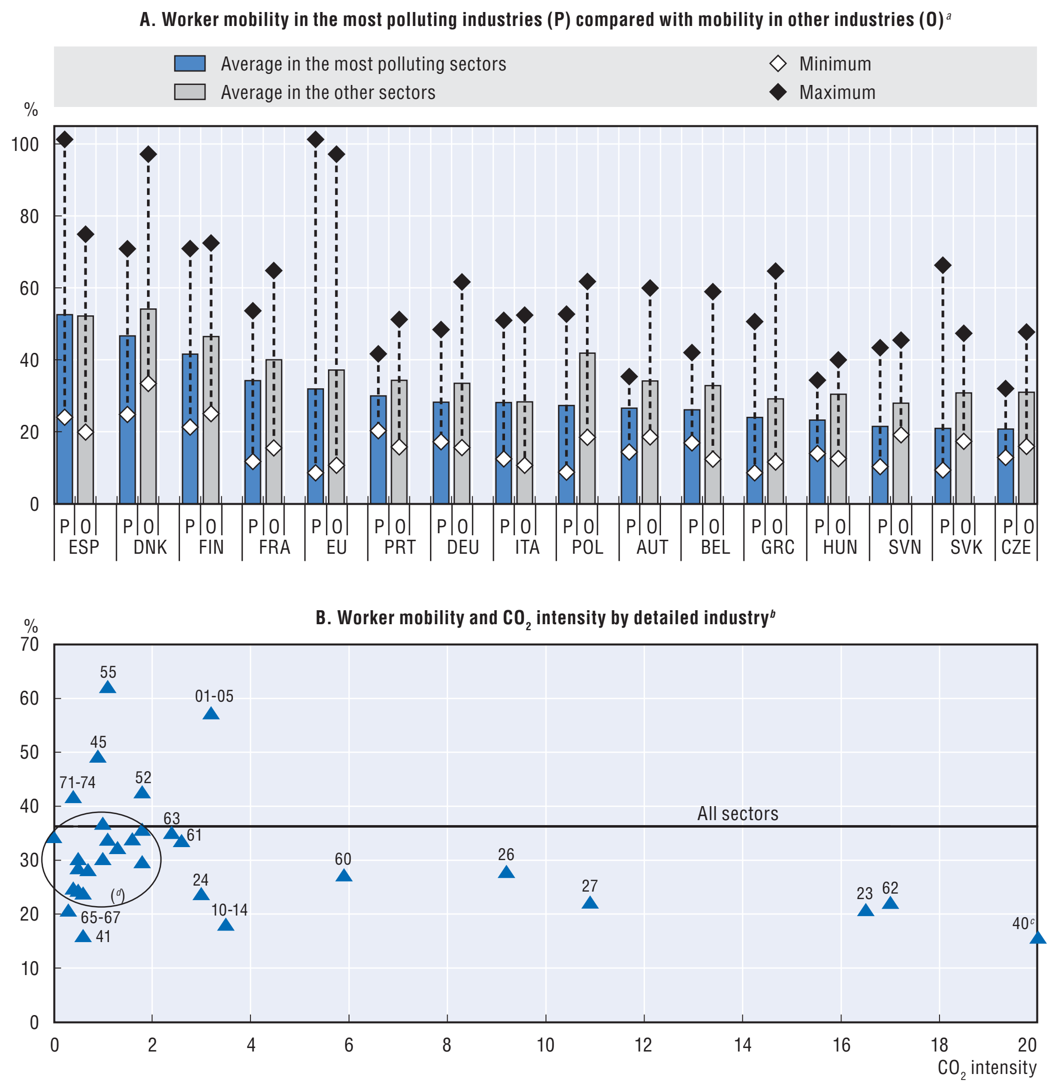
Gross worker flows data, including the total annual movements of workers into jobs (hirings) and out of jobs (separations), have been assembled at the industry level using micro-data from the EU Labour Force Survey. This was done for the same 15 large EU countries analysed in the previous section.[33] Total worker reallocation, defined as the sum of hirings and separations as a proportion of total employment, is used here to make comparisons between workers employed in the most polluting industries and those employed in cleaner sectors, as well as across EU countries.[34]

Panel A of Figure 4.10 compares worker reallocation rates in the most polluting industries and other, less polluting industries (denoted by P and O respectively) separately for 15 large EU countries. On average across these countries, annual gross worker reallocation was 32% of dependent employment in the most polluting sectors, somewhat lower than the 37% rate in less polluting sectors. The relatively low share of temporary workers in the most polluting industries (except agriculture) is probably one of the factors explaining below-average mobility rates. However, the differences in worker mobility between more and less polluting industries within countries tend to be relatively small compared with the mobility differences across countries. This pattern is consistent with an earlier OECD study finding that gross worker flows are strongly influenced by country-specific factors, such as differences in labour market regulations and the prevalence of temporary employment contracts or informal employment relationships (OECD, 2010b).[35]

Figure 4.10 also indicates that mobility rates differ dramatically across industries within both the most polluting group and the less polluting group (see minimum and maximum values in Panel A). Panel B explores this heterogeneity further by plotting mobility rates of 31 separate industries against the carbon intensity of each industry.[36] Doing so confirms that the workers employed in the majority of the most polluting industries have relatively low levels of labour mobility. The one striking exception to the association between high CO_2 emissions and low labour mobility is agriculture (01-05). This is one of industries with the highest rates of labour turnover, reflecting the seasonal nature of much of this employment and the high share of workers with temporary employment contracts. While the high rate of labour turnover in this sector is a factor likely to reduce the adjustment costs borne by agricultural workers losing jobs due to mitigation policy or

Figure 4.10. **Worker mobility and CO_2 intensity in 15 European countries**

Total worker reallocation rates, 2000-07 average values



a) See Figure 4.7 for the definitions of most polluting and other industries.

b) Mobility rates are averages for the 15 countries included in Panel A. See Annex Table 4.A1.1 for definitions of the numerical industry codes.

c) The CO_2 intensity of industry 40 (electricity and gas) is 110.8.

d) Sectors 15-16, 17-19, 20, 21-22, 25, 28, 29, 30-33, 34-35, 36-37 50, 51, 64 and 70.

Source: EU Labour Force Sruvey and IILS-ILO (2009) for the CO_2 intensity values.

StatLink http://dx.doi.org/10.1787/888932651978

environmental degradation, that advantage could be offset by the over-representation of low educated and older workers in the sector, as well as the fact that many of them live in remote rural locations with few alternative employment opportunities. By contrast, mining is among the high-polluting industries with the lowest mobility and further analysis suggests that workers displaced from mining under a green growth scenario would be likely to bear high adjustment costs: very few job separators in mining find new jobs in other sectors quickly and most of those that do are re-employed in either agriculture or high-polluting manufacturing industries (*e.g.* basic metals and other non-metallic mineral products), which are also likely to shrink.

The evidence on mobility patterns broadly concords with that on workforce composition in the most polluting industries in suggesting that significant downsizing in these industries likely would result in above-average adjustment costs. Just as older and less educated workers tend to fare worse following redundancies than their younger and more educated counterparts, redundancies in industries where labour turnover is relatively low and job tenures relatively high are also likely to result in above-average adjustment costs. The workforce in some but certainly not all of the most polluting industries combines multiple risk factors for high adjustment costs. For example, low labour mobility is combined with high localisation of employment in air transport in most countries; and this combination is also present in fuels, basic metals and mining in several countries. Similarly, low mobility rates are combined with low skill levels for land transport and other non-metallic mineral products. While these new empirical results suggest that policies to promote green growth could add to the risk of job displacement and adjustment difficulties, it is also important to put this finding in context. The numbers of workers affected is likely to be relatively small, since the most polluting industries account for only a modest share of employment in most developed economies. Furthermore, some of these industries have already been characterised by a downward trend in employment for some time and labour market actors have considerable experience managing the structural adjustment difficulties that result from job loss in these economic sectors.

3. An active role for labour market and skill policies: Establishing good general framework conditions

The evidence presented in Sections 1 and 2 highlights how a well-functioning labour market is a prerequisite for a successful transition to green growth. Since new jobs will be created even as other jobs are destroyed or transformed, a key challenge for policy makers will be to cope with the resulting job and worker flows along with the retraining needs of incumbent workers, even as they assure that labour markets support the rapid emergence of new green firms and widespread diffusion of green technologies. Sections 3 and 4 discuss how this can best be done.

Most discussions of labour market and skill policies in the growing literature on green growth have emphasised the role of green-specific measures targeted on promoting the creation of green jobs or the expansion of training for green skills (*e.g.* beginning with UNEP *et al.*, 2008; and continuing with Cedefop, 2010; and ILO, 2011b). However, it is argued here that general policies will play at least as important of a role as targeted programmes, because general policies shape the institutional framework within which labour markets adapt to structural economic change and changing job skill demands (OECD, 2005b). Drawing on the most salient elements of the comprehensive policy framework provided by the *OECD Reassessed Jobs Strategy* (OECD, 2006a), this section analyses the types of general policies required to establish good framework conditions for fostering the structural adjustment that will be required to make a transition towards green growth. This discussion is organised around three key challenges associated with the transition towards green growth: *i)* to assist workers displaced by green structural change; *ii)* to foster eco-innovation; and *iii)* to make the tax-benefit system more supportive of high employment rates. Section 4 then discusses the role of green-specific policies.

Overcoming political resistance to the greening of the economy by assisting displaced workers

Green-growth driven shifts in the composition of employment will cause some workers to lose their jobs and some of these displaced workers are likely to experience difficulties in finding a job with comparable pay and working conditions.[37] The most visible costs borne by displaced workers are the earnings losses attributable to unemployment immediately following layoffs, but total displacement costs are often much higher due to re-employment earnings that are lower than pre-displacement earnings and the typically long period then required for earnings to recover fully (OECD, 2009b and 2010b). Minimising the costs that result from the job displacement associated with the transition towards green growth is thus an important policy challenge associated with managing the transition towards green growth. In this context, it is reassuring that the evidence presented in Sections 1 and 2 suggests that the structural adjustment pressures resulting from green growth policies will be neither more intense nor qualitatively different from those experienced in the recent past. Whether or not that proves to be the case, it should be a help that one of the guiding principles of labour market reforms conducted by OECD governments over the past two decades has been to better reconcile flexibility and security by focussing on securing workers' employability and income, rather than their jobs.

The *OECD Reassessed Jobs Strategy* provides a general policy framework to assure that the labour market is both dynamic – continuously redeploying labour from declining to growing industries and firms – and inclusive. In particular, it emphasises that the public employment service (PES) – interpreted broadly to encompass both job-placement services and the administration of unemployment benefits – should lower displacement costs by providing income support during the unemployment spell and effective re-employment services that facilitate a quick re-integration of jobseekers into employment.[38] Indeed, a growing number of evaluation studies show that an effective PES lowers structural unemployment, notably by shortening unemployment duration (OECD, 2004 and 2006b), while also reducing income volatility (OECD, 2011c). It follows that an effective PES can help reconcile efficiency and equity objectives in a way that would be particularly valuable in the context of a transition towards green growth. First, an effective PES can generate an important efficiency dividend by reducing the adjustment costs due to green growth policies, including by preventing a rise in structural unemployment. An effective PES can also reduce equity concerns about how these costs are distributed, thereby helping to reduce political resistance to environmental policies and regulations that are likely to put some jobs at risk in the most polluting industries and services.

As is emphasised in the *Reassessed Jobs Strategy*, passive and active labour market programmes need to be well co-ordinated for the PES to be effective in reducing structural unemployment. This is typically referred to as "activation". The essence of activation is the principle of "mutual obligations" where, in return for paying benefits and offering a range of re-employment services, public employment agencies monitor benefit recipients' compliance with behavioural eligibility requirements. Such requirements may relate to active job search or participation in training or employment programmes. The increased role of activation/mutual obligation strategies represents one of the main labour policy reforms in the OECD over the past decade. Evidence suggests that, if well-designed, such strategies have contributed to better labour market outcomes, by ensuring that benefit recipients have a better chance of obtaining employment and minimising the risks that high and/or long-lasting benefits reduce work incentives.

In countries where displacement costs remain high, the question arises as to whether *targeted programmes* should be implemented to provide additional support for the workers who are most adversely affected by environmental protection measures intended to promote the transition to green growth. Beyond the political economy argument already mentioned, an equity argument can also be advanced for providing this subgroup of displaced workers with additional help. The argument is that it would be unjust for the broad majority of the population to benefit from the improved environment quality resulting from these policies, while high adjustment costs are borne by a minority of workers. These types of political economy and equity arguments have motivated the implementation of special programmes targeted at assisting trade-displaced workers (*i.e.* workers who lose their jobs due to competition from imports) in a small number of OECD countries, as well as the European Globalisation Adjustment Fund operated by the European Union. Several lessons can be drawn from these experiences, which can be also relevant for the transition towards a green economy (OECD, 2005a and 2005b):

- This kind of targeted programmes may entail relatively high administration costs. Within the vigorous process of "creative destruction" that characterises OECD labour markets, it can be difficult to identify what caused a particular worker to lose his or her job (Rosen, 2002). Defining entitlement criteria according to displacement reasons may result in a cumbersome, time-consuming and costly screening process that result in low take-up rates while preventing the timely provision of adjustment services to workers who do manage to qualify.
- Equity arguments may be difficult to sustain if the adjustment assistance needs of workers displaced by environmental policies are similar to those of persons displaced for other reasons. If this should be the case, then setting up a targeted programme that favours one type of displaced worker, while excluding others facing similar labour market difficulties, could be considered unfair. It is not yet known whether the adjustment costs of workers displaced by structural changes driven by the greening of the economy will differ in a systematic way from those for other job losers. The analysis in Section 2 suggests that their adjustment costs may be somewhat higher on average, but it also highlights the great diversity of workers in the most polluting industries.
- Political economy arguments also need to be considered with caution, because a programme aimed at strengthening political support for environmental reforms could actually reinforce the association in the public's mind between environmental protection, job losses and economic hardship (LaLonde, 2007). Indeed, the linking of displacement assistance to the greening of the economy might foster the false impression that displacement largely results from the introduction of new environmental policies or regulations, whereas intense labour reallocation is a pervasive characteristic of OECD economies.

All in all, past experience with special programmes targeted at trade-displaced workers suggests that general income transfer and active labour market programmes should be relied upon as much as possible to assist workers displaced by the transition towards green growth.[39] At the same time, experience with managing trade-driven structural change suggests that targeted approaches are a valuable supplement to general programmes in some instances. OECD (2005b) identifies a number of targeted programmes that offered significant advantages over exclusive reliance upon general employment programmes because they were able to provide assistance that was better tailored to overcoming specific adjustment barriers or they provided a necessary "safety valve" for diffusing political opposition to an open trading system. These examples typically involved abrupt shifts in trading patterns that displaced large numbers of workers facing particularly great barriers to re-employment, in part because they were concentrated in one or a few localities. Similar cases are likely to arise in the transition to green growth since some activities with a large environmental footprint, such as coal mining, are characterised by a relatively strong degree of geographic concentration and displaced mining workers typically are not well prepared to compete for jobs in growing sectors of the economy. When the economic dislocations associated with green growth are spatially concentrated, a targeted programme providing intensive adjustment assistance for the affected workers may be appropriate, perhaps in combination with complementary measures to revitalise the local economy (OECD, 2012e). For example, there have been public-private initiatives to refocus certain Danish shipbuilding and related marine engineering firms, which had lost market share in their traditional markets and announced large layoffs, on developing new competitive niches in the renewable energy sector, including the construction, supply and maintenance of wind turbines and wave and tidal installations (ILO, 2011b).[40]

Fostering eco-innovation

Eco-innovation is expected to be one of the key drivers of the shift toward a low-carbon and resource-efficient growth (OECD, 2011a). The *OECD Innovation Strategy* provides comprehensive policy guidance about how national governments can foster economically valuable innovation (OECD, 2010a). In general, these policies also apply to the more specific challenge to support eco-innovation (OECD, 2011d). Innovation policies in a narrow sense need to play a leading role in supporting and fostering the creation, adoption and diffusion of new green technologies and products, but will not be analysed here. Instead, the emphasis is on the role that labour market and skill policies can play in promoting eco-innovation. Most obviously, education and training systems need to assure that the workforce has the right skills to develop and apply new green technologies. Thus, a well functioning education and training system is an essential element of a general policy framework to foster green innovation. A second need is that labour and product market regulations enable, rather than hinder, the development and diffusion of new green technologies. Since business start-ups account for many new technologies, especially those that constitute important breakthroughs, it is especially important to create a supportive environment for the creation of new firms. More generally, the regulatory environment needs to allow firms that are leaders in developing and applying new green technologies to grow and gain market share, in part by recruiting workers shed by firms using inferior technologies.

Education and training are fundamental both for the conception and the implementation of innovation

The ability to adapt to new technology begins with a well-performing compulsory school system that provides students with strong skills in core fields, including mathematics and science. Cross-country indicators of student achievement in math and science reveal that the skill levels of students in these subjects vary considerably across OECD countries. According to the latest PISA results, 15-year-olds in the Asian OECD countries attain particularly high scores in mathematical and science literacy tests, while their counterparts in southern European countries and Mexico record low scores (OECD, 2009c).

A well-performing and broadly accessible tertiary education system is also important to facilitate the adoption and widespread diffusion of innovation. The main challenges for tertiary education are: *i)* to train quality graduates who can contribute directly or indirectly to innovation in their workplace; *ii)* to foster research excellence; *iii)* to build links between tertiary institutions and other research organisations and industry; and iv) to improve the ability of tertiary education to disseminate the knowledge it creates (OECD, 2006c). In this respect, evidence suggests that countries with high-quality tertiary education tend to derive more benefits from domestic R&D and from R&D spillovers from abroad (OECD, 2008b). Tertiary attainment levels have increased considerably over the past 30 years, but cross-country differences in the share of the population with tertiary-education qualifications remain substantial, even for the young cohort that has been most strongly influenced by recent education policies.[41]

Effective vocational education and training (VET) is also a vital support for the innovation process, as it is the primary source of skills that are central to incremental innovation activities, including in the environmental area. Many firms do not develop new and radically different products and processes, but they nonetheless contribute to overall innovation by making incremental improvements to existing products or processes. This requires activities such as tooling up, design work, developing prototypes and testing, which rely heavily on skills acquired through vocational training. Studies have shown that firms in countries where a relatively large proportion of the workforce possess postsecondary VET qualifications benefit from a more rapid introduction of new products, even as they also have lower defect rates, less need for quality checkers and fewer plant breakdowns (Toner, 2009).

Based on a careful review and in-depth analysis of several national VET systems, the OECD has recently published a comprehensive report, *Learning for Jobs*, which highlights a number of policy recommendations to help countries increase the responsiveness of VET systems to labour market requirements (OECD, 2010c). One of the key challenges identified – which is particularly salient to assuring that the VET system supports innovation in newly emerging areas, such as renewable energy – is to assure that VET providers connect effectively to the world of work and are constantly updating their curricula and guiding students into the subject areas that respond to employers' changing skill needs.

Learning that takes place on the job – including continuing training for the experienced workforce – is also a crucial component of skilled workers' competences and helps shape innovation outcomes. Recent work using firm-level data found for example that firm expenditures on training were strongly associated with "process modernising" modes of innovation in a number of countries (OECD, 2007 and 2009d). The importance of work-based learning highlights the fact that skills acquisition is a lifelong process. Among the strategies for promoting continuing vocational training is the creation of qualifications systems which recognise important acquired competencies and make them visible to employers and other economic actors. Research on adult education shows the importance of improving the visibility of mid-career training rewards to learning as a way to motivate people to learn (OECD, 2005c), but it can also support green innovation. For example, one of the barriers to the expansion of the energy-efficient construction sector has been the inability of employers and customers to verify which workers (and firms) have the requisite skills (ILO, 2011d; Zabin *et al.,* 2011).

Well-designed labour and product market regulations also have a role to play

The *OECD Reassessed Jobs Strategy* highlights how overly strict or poorly designed regulation in the areas of employment protection (EP) and product market regulation (PMR) can be impediments to strong labour market performance, and provides guidelines for reforming both types of regulation (OECD, 2006a, b). These concerns are heightened in the context of the transition towards green growth, because both EP and PMR can be a barrier to the smooth reallocation of labour from more polluting firms to environmentally progressive firms.[42] A closely related concern is the possibility that overly restrictive EP and PMR will impede eco-innovation.

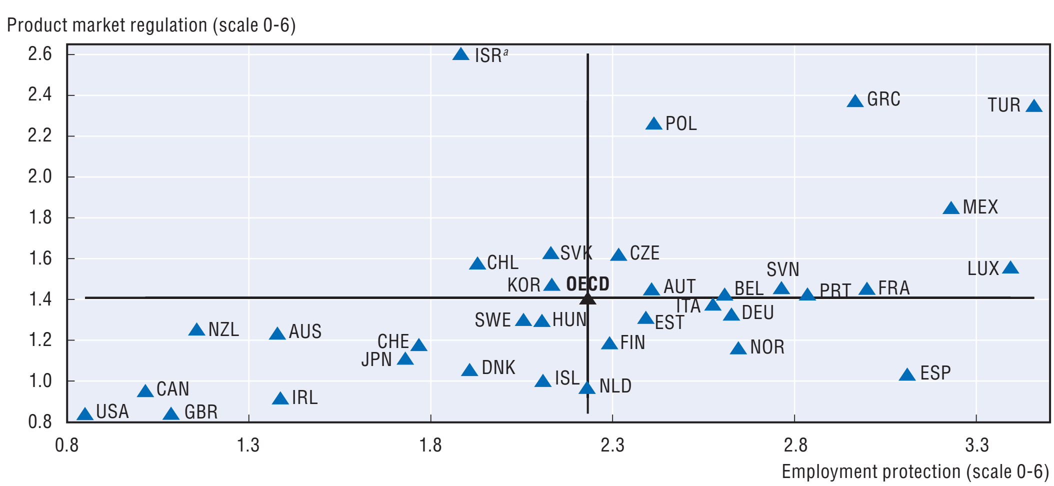
A growing body of research provides evidence that well-designed regulatory systems strengthen the incentives for innovation (de Serres *et al.*, 2010). One reason is that a large share of more radical innovations are introduced by *new* firms. The strategic role played by business start-ups underlies the importance of reducing PMR barriers to the creation of new firms. Another recurrent finding is that vigorous product market competition generally stimulates technology adoption and innovation. Several empirical studies confirm that pro-competitive regulations tend to foster innovative activity when intellectual property rights are adequately protected (*e.g.* Jaumotte and Pain, 2005; Bassanini and Ernst, 2002; Nicoletti *et al.*, 2001).

There is also growing evidence that EP regulation affects innovation patterns. Restrictive hiring and firing rules are likely to constitute an impediment to the adoption of new technologies and innovation where innovation-driven labour adjustments have to be accommodated via worker turnover (*e.g.* when greener firms expand at the expense of more polluting firms).[43] For example, Bartelsman *et al.* (2010) and Samaniego (2006) provide evidence that ICT diffusion was slower in countries with stricter EP. However, the relationship between EP strictness and innovation is complex, because greater job security and low labour turnover may encourage the accumulation of firm-specific competencies and increase worker investment in innovative activity. Consequently, the relationship between EP and innovation appears to depend on the nature of the innovations in question. For example, Bassanini and Ernst (2002) find that EP significantly deters R&D in industries where the innovation process is driven by product differentiation, since these innovations often operate through entry and exit of firms and extensive worker turnover. Strict EP also depresses R&D in industries characterised by product lines at the end of their life-cycle, where innovation often leads to downsizing. By contrast, EP does not appear to constrain R&D in high-technology industries characterised by a cumulative innovation process, because this type of innovation relies heavily upon worker skills that are highly specific to individual firms. In a similar vein, Griffith and Macartney (2009) investigate the relationship between EP and the innovation activities of multinational firms operating across 12 European countries and find that these firms do more incremental patenting in high EP countries and more radical patenting in low EP countries. In sum, EP regulation appears to have a greater effect on the focus of innovative activities than on its overall level.

It seems plausible that the findings summarised above about how EP and PMR affect innovation performance, also hold for eco-innovation. However, there does not appear to be any direct evidence about whether that is indeed the case. What is clear is that these forms of regulation are likely to have important impacts on the development and diffusion of new environmental technologies and that these regulatory policy stances differed substantially across OECD countries in 2008 (Figure 4.11).[44] Further reform efforts in one or both of these policy areas, especially relaxation of PMR barriers to firm entry where they are still high, might significantly improve the incentives for eco-innovation in some countries.

A simple juxtaposition of the 2008 EP and PMR regulatory stringency indicators reported in Figure 4.11 with the country-level measures of environmental patenting presented in Section 2 underlies the importance of assuring that these types of regulations are not impeding the transition towards green growth. When countries are ranked according to the number of environmental patents per billion USD (in purchasing power parities) of GDP (see Panel B of the figure in Box 4.3), all of the top performing countries are seen to have relatively pro-competitive PMR stance. However, top performers vary considerably in terms of the strictness of EP regulation, consistent with this type of regulation affecting the mix of innovation activity more than its overall level.[45] A potential source of concern is that EP regulation has been relatively strict in Poland, Greece, Slovenia and Portugal, the four EU countries with the highest share of employment in the most polluting industries (see Figure 4.8), although Greece and Portugal have enacted reforms in this area since 2008 (OECD, 2012g). Since strict EP is associated with low labour market mobility and long unemployment spells, policies to reduce CO_2 emissions in these countries could become an important source of structural unemployment if EP remains too strict, particularly in the first two countries which are also characterised by relatively strict PMR regulation that is likely to impede the emergence of new green firms.[46]

Figure 4.11. **Employment protection and product market regulation, 2008**



a) Information on data for Israel: *http://dx.doi.org/10.1787/888932315602*.

Note: Employment protection data refer to 2009 for France and Portugal.

Source: *OECD Employment Protection Database* and *OECD Product Market Regulation Database*.

StatLink http://dx.doi.org/10.1787/888932651997

An opportunity to improve the effectiveness of the tax and benefit system

The simulation analysis of the labour market impact of GHG mitigation policies in Section 1 illustrates how environmental policies can create cost pressures on firms that become a barrier to employment. That analysis also shows how environmental tax reform, such as shifting taxation away from labour income and towards GHG emissions, sometimes can generate a "double-dividend", achieving both environmental gains and higher employment. However, the research literature on the double-dividend hypothesis has shown that the initial labour tax distortion needs to be relatively strong for such an employment dividend to materialise (see discussion in OECD, 2012a). Recycling environmental tax revenues so as to lower labour taxation will thus be more advantageous in some countries than in others. It also cannot be assumed that reducing labour taxes is necessarily the best way to recycle carbon revenues, since they could be used instead to correct other market distortions, such as by lowering capital taxes or subsidising environmental R&D, to address distributional concerns or to reduce the public deficit. Which form of recycling is most desirable is likely to depend on national conditions in a complex way and will not be analysed here. The rest of this section addresses a narrower question, namely, in the event that carbon tax revenues are made available to lower the taxation of labour income, how should the reduction in labour taxation be structured so as to maximise the improvement in labour market performance.[47]

Since the overall tax and benefit system tends to be particularly distortive at the bottom end of the wage ladder, in large part due to the interaction of taxes and means-tested benefits, recycling carbon revenues is likely to have a larger effect in raising employment rates when targeted on low-wage earners. In a number of OECD countries, relatively high statutory minimum wages and/or high benefit replacement rates for unemployed low-wage workers translate into relatively strong downward wage rigidities (Immervoll, 2007). In such cases, tax and benefit systems could particularly discourage employment among workers with low educational attainment or limited employment experiences. Furthermore, climate-change mitigation policies are likely to amplify this distortion, as they will result in higher energy prices (at least in the short to medium run) that could require some downward real wage flexibility in order to preserve employment levels (see the simulation analysis in Section 1). This flexibility may be lacking at the bottom of the wage scale in some countries, creating the risk that unemployment will rise for more disadvantaged workers.

There may also be an equity case for targeting recycled carbon revenues to low-income working households. Since the share of energy bills in total consumption expenditure is highest for low-income households, the likely rise in the price of energy will weigh more heavily on the purchasing power of low-income households. Another possible rational for redistributing carbon revenues towards low-income households is that environmental quality is a public good which high-income households tend to value more than their lower-income counterparts. Household surveys indicate that the so-called "willingness to pay" for environmental protection tends to increase with household incomes.

OECD tax-benefit calculations show that the net returns to working tend to be low at the bottom-end of the wage ladder in many OECD countries. Workers taking up low-paid employment often see more than half of their gross earnings consumed by income taxes, employee social contributions or reduced social benefits. Financial rewards from work tend to be especially low when only one person in the household is working and this worker has a low-paid job. This is especially true when children are present, largely due to higher out-of-work benefits that are clawed back when a job is accepted, resulting in average effective tax rates of 80% or more in half of OECD countries (OECD, 2012a). This suggests that the policy priority in many countries should be to reform the benefit system rather than to reshape the tax structure for employees. In-work benefits have proved to be effective in raising the labour market participation of low-wage workers while also assuring adequate income (Immervoll and Pearson, 2009). These schemes appear particularly relevant in a context of green growth, as the likely rise in energy prices in the short and medium run raises distributional concerns that can be addressed in a more target-efficient manner using in-work benefits than using reductions in labour taxes.

4. An active role for labour market and skill policies: What role for green-specific measures?

While general policies should be relied upon to a large degree, programmes that are specifically targeted to promoting green jobs or skills will also have a role to play. A greening economy has its own specificities that policies in a wide range of economic areas, including the labour market area, will have to accommodate. One complication in implementing green-specific labour market and skill policies is that they need to be effectively co-ordinated with the key environmental and eco-innovation policies driving the transition towards green growth. Since the development of these core green growth policies is still at an early stage, it would be premature to draw strong conclusions about how employment and skill policies should be tailored to those policies and the structural adjustment pressures and opportunities they will create. The rather mixed performance of the labour market components of the green fiscal stimulus measures implemented by a number of countries in response to the 2008-09 economic crisis also suggests taking a cautious incremental approach in policy development in this area (Box 4.4). Despite these caveats, it may be possible to identify promising first steps in a pragmatic approach to developing green-specific policies. This section attempts to do so by summarising what is known about the limited experience to date with green-specific labour market and training programmes and draws some tentative conclusions concerning promising next steps.

What kinds of green-specific measures have been implemented at the national level?

Internationally comparative information has been lacking about specific labour market measures that countries have implemented in order to realise the full job potential of a shift towards a green economy. Accordingly, the OECD sent a questionnaire on this topic to OECD member countries in November 2010. This section summarises information from the responses received from 27 countries (more detailed information about country responses is provided in OECD, 2012b).

A gradual process, still at an early stage of implementation

Among the 27 OECD countries which responded to the questionnaire, 15 indicated that they had implemented one or more green-specific labour market measures, including at least one education and training measure (Figure 4.12). Consistent with the discussion in Section 2, these countries appear to believe that preventing skill gaps from developing, which could put a brake on the expansion of green activities is a policy priority. By contrast, job subsidies in the private sector and direct job creation in the public sector were less

Box 4.4. **Green fiscal stimulus: a mixed experience**

The potential synergies between policies to promote a transition to green growth and policies to promote employment became clear during the global financial and economic crisis that erupted in 2008. Public investments in green activities played a significant role in the stimulus packages introduced to boost demand and the economic recovery. These investments were seen to offer a potential double dividend at a time of high unemployment: both jumpstarting job creation and accelerating the transition towards green growth. Moreover, the economic return to such investments is potentially higher during a recession, when the opportunity cost of green investment is lower. Thus, de Serres *et al*. (2010) argued that the global economic slowdown provided good opportunities for investment in infrastructure that would facilitate the development of green technologies and industries by anchoring beliefs in governments' commitment to green growth. Even though the space for additional fiscal stimulus is now much diminished or totally exhausted in most countries, it is still interesting to identify the lessons learned about the use of green public spending as a spur to rapid job creation.

A number of governments projected that sizeable employment gains would result from their green stimulus measures (ILO, 2011b; OECD, 2010d). For example, the United States Council of Economic Advisers estimated that the approximately USD 90 billion of Recovery Act investments would save or create about 720 000 job-years by the end of 2012. Projects in the renewable energy generation and transmission, energy efficiency, and transit categories were projected to create the most job-years. Likewise, Korea has been implementing its "Green New Deal" policy since January 2009. The policy's aim is both to overcome the economic crisis in the short-term and to strengthen the growth potential over the long term. The KRW 50 trillion being invested were projected to create 960 000 jobs from 2009 to 2012, including jobs in an environmentally-friendly transportation network, water management and river rehabilitation, clean energy, green information technologies (IT), and waste-to-energy. France is another country that responded to the crisis by increasing its investments in the transition to a greener economy. Its stimulus package totaled USD 33.1 billion, 21% of which was designated for green measures, with an estimated net job creation of about 80 000-110 000 in the 2009-10 period.

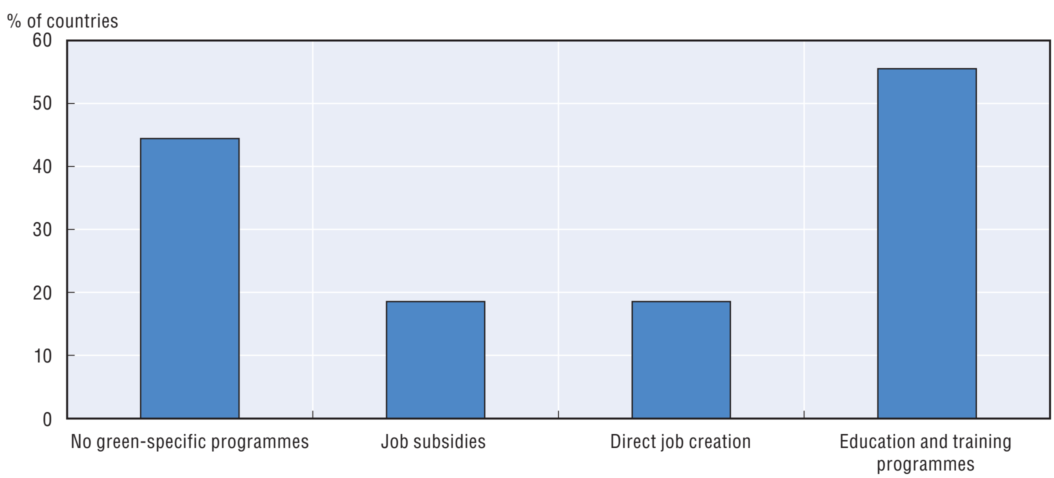
Although these green stimulus measures have not been subject to rigorous evaluation, it has become clear that they need to be carefully designed if they are to foster both macro-stabilisation in the short-run and the transition to green growth over a longer time horizon. While the potential for green stimulus measures should be exploited fully when the macroeconomic conditions justify fiscal stimulus, governments should bear in mind that there are limits to the contribution that temporary macro-stabilisation measures can make to fostering the long-run transition to green growth. A priori, some of the green fiscal measures appear well suited to play this dual role. In particular, programmes to retrofit existing public and private buildings for greater energy efficiency appeared to have a considerable potential to achieve long-run environmental gains while also satisfying the "three Ts" desirable in counter-cyclical fiscal stimulus measures, by providing a timely, temporary and targeted stimulus to labour demand by generating new jobs quickly (timely) of the kind many unemployed workers could fill directly or with limited training (targeted) and the fiscal stimulus related to these measures was designed to be phased out as the economic recovery strengthened (temporary). However, the experience with the Australian Home Insulation Program demonstrates how difficult it can be to assure the quality of the work performed when a public subsidy leads to a rapid expansion in the retrofitting

Box 4.4. **Green fiscal stimulus: a mixed experience** *(cont.)*

(see OECD, 2012a). It is also the case that many of the green policy initiatives required to bring about a transition to green growth do not satisfy the "three Ts". For example, public subsidies to stimulate eco-innovation are likely to involve a long time lag before many new jobs are created. Furthermore, few currently unemployed workers will be qualified for the R&D jobs eventually created.

More generally, the very different time horizons involved in the short-run stimulus measures and the long-run environmental policy means that it is not always possible for policies to serve both objectives well (Strand and Toman, 2010). While synergies with short-run macro-stabilisation policy are welcome when they can be achieved, it should be borne in mind that the fundamental rationale for developing green activities and jobs is to contribute to environmentally sustainable growth in the long-run. It follows that policy packages that are intended to further both environmental and employment objectives need to be considered over a longer time horizon.

Figure 4.12. **Green-specific national labour market programmes implemented by OECD countries, 2010**[a]



a) The OECD questionnaire on green jobs and policies covers 27 OECD countries. The columns sum to more than 100% because many countries operating green-specific measures reported making use of multiple types of measures.

Source: OECD questionnaire on green jobs and policies. For further detail of country responses, see Table 4.A3.1 in OECD (2012b).

StatLink http://dx.doi.org/10.1787/888932652016

widely used, being reported by only five countries each and most often these green employment programmes were temporary measures that were introduced as part of the policy responses to the global economic crisis during 2008-09. Indeed, most of the green-specific measures reported, including training programmes, were quite recently introduced and relatively small, highlighting how limited experience in this policy area remains.

More than two out of five OECD countries have not implemented any specific programmes at the national level (Figure 4.12). In some cases, this appears to reflect the fact that core green growth policies are themselves at a very early stage of implementation (*e.g.* Israel and Poland). But that is not always the case. Indeed, some OECD leaders in environmental protection and the development of the green economy, such as Germany, Denmark, the Netherlands, Norway and Sweden, are also to be found in the group of countries that have not implemented any green-specific labour market measures. A possible explanation for this apparent paradox is that these countries have long operated relatively extensive systems of general labour market and skill development programmes. It may be that these general programmes have thus far been able to meet the challenges posed by green growth-driven structural change.

In fact, the situation is even more complicated because it appears that green components have been progressively integrated into general labour market programmes in a number of the countries reporting no green-specific programmes. For example, Danish authorities report that while there may be a significant number of programmes that are already supporting green sectors in the generally understood sense, there is no official definition to classify these as being green initiatives.[48] This example suggests that the criterion for distinguishing green-specific programmes from general measures varies across countries. It follows that great caution is required when comparing green-specific initiatives in the field of labour market and skill development policies in different countries.

With these caveats in mind, it is noteworthy that several similarities emerge in the way countries are implementing green-specific measures. Along with the substantive emphasis on providing VET for growing green occupations, a second commonality is the emphasis being placed on addressing two difficulties encountered in this relatively new policy area. The first difficulty is the high degree of uncertainty about how green growth will reshape labour markets and hence also about what sort of policy measures are required. The second difficulty is the need to co-ordinate green-specific labour market and skill policies with other policies that are shaping how and how rapidly economies make the transitions towards green growth, particularly environmental policy. Among the different approaches to addressing these two difficulties are the following:[49]

- *Collection of systematic labour market data on the impact of green growth.* A number of countries are investing in the systematic collection of labour market data on the number of green jobs and their growth prospects, the skill requirements of these jobs, etc. For example, France established a National Observatory of Green Employment Occupations in 2009. Along with incorporating green occupations into national labour market information systems, efforts have also been made to make this information available to students and workers so as to provide them with guidance in developing their careers.
- *Co-ordination of employment and skill policy-making with broader green growth policy.* Many countries are making efforts to co-ordinate employment and skill policy with other policies that are also shaping green growth, especially environmental policy. In some cases, there is a formal process to integrate all relevant ministries into a national green growth policy plan, as is illustrated by the Presidential Committee on Green Growth in Korea, which is charged with co-ordinating green growth policy across the government. In other cases, the process takes the form of a cross-ministry consultative process which may also involve other stakeholders, such as lower levels of government and trade union and employer representatives (Eurofound, 2009). In other cases, an effective co-ordination system has yet to be developed.[50]

A pragmatic approach

At this early stage in setting up and operating green-specific labour market and skill policies, it is not possible to evaluate, even informally, how effective different types of measures have been, nor to judge how large the role of these targeted programmes ultimately should be. The pervasive uncertainty about what type of green-specific labour market and skill policies would be useful calls for a cautious and incremental approach to introducing new policy measures. It may also be useful to focus policy development at a sectoral level where it is typically easier to identify ways to make a targeted labour market intervention most useful, such as by avoiding or overcoming a specific skill gap. Along this line, the Belgian authorities in charge of labour market policies argue that there is no need to define what a green job is in order to design and implement effective labour market programmes in support of environmental measures. Instead, a "policy-oriented" approach has been adopted in Belgium, which consists in assessing the overall workforce and skill needs within closely targeted market segments, whether or not these jobs and skills can be classified as being green and implementing programmes when opportunities for a useful intervention are identified.

This pervasive uncertainty also suggests that green-specific labour market policies are likely to require successive fine-tunings, or even more drastic revisions, in order to correct design mistakes and remain closely aligned to continuously evolving green markets and environmental objectives. A continuous monitoring of emerging needs, a careful evaluation of new measures put into place and a progressive fine-tuning of these measure are thus likely to be critical elements in designing and implementing effective green-specific labour market programmes. While these recommendations apply to any employment and skill development programmes, they are likely to be even more important for green-specific policies. The Australian Green Skill Agreement of 2009 contains a number of provisions aimed at building a flexible and carefully-designed implementation framework, including an emphasis on monitoring and evaluation at various stages of the implementation process (COAG, 2009). The agreement calls for the development of an evaluation framework to monitor achievements against agreed goals and actions. One of the stated goals is to ensure that the actions arising from this agreement complement existing labour market, training and industry development programmes and initiatives, and other initiatives to reduce carbon pollution and promote industry and workforce adjustment to a sustainable, low-carbon economy.

The Austrian Klima:aktiv initiative, launched in 2004 as part of the National Climate Strategy, appears to be one of the best examples of a more comprehensive policy approach. Notably, it ties labour market measures to a broader "market transformation" strategy that aims to produce permanent increases in the share of energy-efficient products and services in targeted markets. This approach means that green training initiatives are closely co-ordinated with measures to develop the associated green product markets. Klima:aktiv makes use of a wide range of policy levers, including workforce training, quality standards for new products and services, information and communication campaigns, advice and support to businesses, and activating and networking partners. As regards training measures, Klima:aktiv focuses primarily on advanced vocational training, and co-ordinates training and education in the various thematic programmes (Fickl and Schmidt, 2009). Pilot training and seminars are initiated and introduced in the training market, in co-operation with universities, technical colleges, educational service of the chamber of commerce, etc. Klima:aktiv is therefore not in competition with the education market. Rather, this programme introduces new green components into the education market, in close collaboration with all relevant actors on this market.

Cross-country differences in the green jobs challenge and the relative importance of general and green-specific policy measures

This chapter has attempted to characterise the main green growth challenges confronting labour market and skill development policies and to assess how best those challenges can be met. It has done so in a manner that is intended to be sufficiently general to apply to all developed economies. Despite this generality, some of the material presented above sheds light on cross-country differences in the intensity and nature of these challenges, as well as on policy priorities in responding to these challenges. This section briefly discusses these cross-country differences.

Table 4.3 summarises key green growth challenges for labour market and skill policy (Column 1) while also highlighting factors likely to imply significant cross-country differences in the intensity of these challenges (Column 2). Columns 3 and 4 then summarise some of the types of labour market and skill development policy responses that are likely to be most important. How different countries go about implementing these responses, and how effectively they do so, will be influenced by the nature of their national systems of labour market policies and institutions, and skill development policies and institutions, as well as how well these two systems co-ordinate with each other and with environmental policy.

Table 4.3 sheds some light on the relative importance that should be placed on general and green-specific policy measures, and how the appropriate balance will vary from country to country. All of the types of policy responses that are included in Columns 3 and 4 could be implemented either as a general measure or a green growth measure. In countries where there is already a well-functioning general measure in place, there is likely little or no reason to introduce a green-specific policy measure. However, in countries where there is no such general measure or the general measure is of limited effectiveness, a specific green measure may be called for, particularly if some of the intensity factors in Column 2 suggest that there is or soon will be a strong need for such measures.

How might differences in national labour market and skill development systems affect countries' ability to successfully manage the transition towards green growth? Because our understanding of the green revolution is still so incomplete, it would be premature to draw any firm conclusions about the strengths and weaknesses characterising countries conforming more closely to one or another of the stylised models of national labour market and skill development systems that have been proposed in the research literature (*e.g.* Esping-Andersen, 1990; Ashton *et al.*, 2000; OECD, 2006a). Nonetheless, it is useful to begin reflecting upon the ways that the green growth challenge may differ across countries depending on the nature of their labour markets and national education and training systems. In that spirit, the following initial reflections are put forward:

- The two successful labour market models put forth in the *OECD Reassessed Jobs Strategy* (OECD, 2006a) appear to be well aligned overall with the requirements for managing a successful transition towards green growth.[51] In particular, both models suggest the importance of achieving an effective form of flexicurity, while illustrating that there is no

Table 4.3. **Towards a taxonomy of factors shaping cross-country differences in the green growth challenge for labour market and skill policies**

Key policy challenges	Intensity factors	Main role for labour market policy	Main role for skill development policy
1. Labour reallocation. Workers will need to shift from declining firms, particularly in sectors with a heavy environmental footprint, to growing green firms: ● One challenge is to make sure workers displaced from declining "brown" jobs can move quickly into new green jobs that make good use of their skills. ● Growing green firms will also need to be able to recruit the staff they need.	*i)* Displacement costs are likely to be higher in countries and regions where a greater share of total employment is found in high GHG-emissions industries (these shares range from 11% in Denmark to 27% in Poland). *ii)* Post-displacement adjustment costs tend to be higher where worker reallocation is lower. Also where more of the affected workers are older or low educated. (Annual reallocation rates range from 0.28 in the Czech Republic to 0.52 in Spain.) *iii)* Spatial and skill mismatches exacerbate dislocation (localisation of high emissions industries is generally greater in EU periphery countries than in the core).	An effective "flexicurity" package that reconciles high worker mobility with income security and high rates of employment: ● A balanced and not too-strict employment protection system. ● Adequate unemployment benefits. ● Effective activation of job losers via high-quality ALMPs and effective conditioning of unemployment benefit receipt on active job search or participation in measures to raise employability.	*i)* Retraining as needed as a component of the income and reemployment support offered to job losers. *ii)* When green-growth-related job displacement takes the form of mass layoffs or is associated with steep economic decline in an economically specialised locality, integrate job training services effectively into a local redevelopment strategy and/or provide outmigration assistance. *iii)* Local PES adapts its offer of training services to create pathways from declining sectors, firms and occupations to growing sectors of the economy.
2. Green-skilling the labour force. Demand for green skills will be driven by: ● Rapid employment growth is occurring for some existing green occupations (*e.g.* construction workers trained to retro-fit existing homes for energy efficiency). ● The emergence of new green occupations (mostly high skilled?). ● Incremental greening of many existing occupations necessitating top-up training.	*i)* Flexible and well-resourced system of continuing vocational training (CVT) should be an asset (average annual hours of CVT range from 3.5 in Greece to 16.2 in Luxembourg according to Sala and Silva, 2011). *ii)* Good business-tertiary education partnerships useful to develop curricula and certification for new high-skilled green occupations as they emerge (*e.g.* smart grid designer). *iii)* Strong initial vocational training combined with good basic academic skills enhances subsequent ability to profit from CVT and retraining. (mean PISA scores for mathematical and scientific literacy of 15-year-old vary from 460 in Turkey to 550 in Finland).	A high-quality labour market information system that tracks emerging skill needs and shares that information with labour market actors. Forecasting of skill needs or skill mismatches would be useful if sufficiently reliable.	*i)* Ability to expand and contract existing training and vocational education tracks as demand changes. *ii)* Ability to co-ordinate with social partners to create new tertiary-level curricula as new high-skill occupations emerge. *iii)* Employers, trade unions and vocational training providers co-ordinate to continually update workforce skills as job requirements evolve.
3. Creating synergies between environmental and employment policy. Finding ways to promote both environmental goals and employment goals at the same time by addressing multiple market failures (Hallegatte *et al.*, 2011): ● Economic co-benefits of environmental mitigation/restoration. ● Recycling carbon tax revenue to stimulate higher employment. ● Incubating green growth export champions. ● Green fiscal stimulus during an economic downturn.	*i)* High levels of localised adverse impacts from environmental degradation. *ii)* A higher labour tax wedge, especially when combined with a high minimum wage makes it more likely that using carbon tax revues to lower labour taxes would generate a double dividend (labour costs for a full-time minimum-wage worker range from 0.25 of the mean wage in Korea to 0.52 of the mean in Ireland). *iii)* An effective national innovation strategy can improve the chances of nurturing a "green Silicon Valley" (environmental patenting rates per worker are more than 30 times the OECD average in Germany and less than 1% of that average in Greece). *iv)* While labour market slack is still high in many EU and OECD countries, few have unused fiscal space for enacting more fiscal stimulus.	*i)* Structural labour market reforms can provide a substitute for using carbon tax revenues as a way to counteract a high level of equilibrium unemployment. *ii)* If synergies emerge, so that green growth becomes a significant source of net job creation, employment policy should take maximum advantage of that opportunity by taking measures to mobilise under-utilised labour supply (*e.g.* by working against excess benefit dependency or promoting family-friendly employment practices).	*i)* Strong STEM in compulsory and especially tertiary schooling provides an essential support for eco-innovation. *ii)* Strong research universities and effective university-business partnerships can play an important role in fostering a vital innovation ecosystem.

one rigid model for how to reconcile high labour mobility with security. The analysis of the green growth challenge for labour market policy in this chapter and other recent studies tends to provide further support for these broad policy orientations, while identifying some of the specific ways these normative policy frameworks should be applied to manage the transition towards a low-carbon and resource-efficient labour market.

- Green and Green (2011) put forth a descriptive taxonomy of four types of national skill development systems that are suggestive of some distinctive strengths and weaknesses in managing green growth:
  - *The market-oriented skills formation system* (often associated with the United States, the United Kingdom and other English-speaking countries) is characterised by institutional diversity and a market-led approach to the co-ordination of skills supply and demand. One weakness of this system is that low levels of achievement are common among less academically-inclined youth who can later find themselves at a disadvantage in the labour market. If green structural change should turn out to require large parts of the adult workforce to receive significant green training during the course of their working lives, less skilled workers in these counties could struggle to access and profit from this training. On the plus side, these systems offer ample "second-chance" education possibilities for adults and tend to excel at creating research universities that collaborate effectively with the business sector and are likely to be a big asset in promoting eco-innovation.
  - *The social partner co-ordinated skills formation system* (often associated with German-speaking countries) is characterised by the active role that the social partners play in managing skills supply and demand, and the prominent role of the dual system of combining upper secondary schooling with apprenticeships. While these apprenticeships are quite specialised, the students are required to continue their more academic courses as well. This system has done well at developing skilled manual and technical workers, a workforce that should cope well with the incremental greening of jobs. The system can, however, show less flexibility than the market-oriented system which might be a disadvantage for managing more discontinuous changes in labour demand, should green growth evolve in unexpected directions.
  - *The state-led social partnership skills formation system* (often associated with Nordic countries) is also characterised by the active role that the social partners play in co-ordinating skills supply and demand. However, the state plays a greater role in adult education than in the social partner co-ordinated system and the school system differs in important respects. In particular, pre-school is universally provided at a subsidised price and compulsory schooling follows a non-selective, mixed-ability, comprehensive school model that delays subject specialisation as long as possible. Adult education and ALMPs are extensive. Along with its egalitarian orientation, the breadth of initial education and training is intended to maximise the acquisition of transferable skills and to support high labour market mobility. The high mobility of the workforce should be an asset in managing incremental green structural change.
  - *The developmental skills formation system* (often associated with Japan and the former Asian Tigers) is characterised by more interventionist forms of state-led economic and social development. These systems have achieved spectacular increases in educational attainment and also very high levels of student achievement. In countries

like Japan and Korea, adult education has largely been left to be organised by large employers. The governments in these countries have often sought to actively shape future employer skill demand through industrial and trade policy. Korea is now applying that model to green growth, but it remains to be seen whether it can function as effectively at the global technological frontier, as it did when the focus was on catching-up with the most advanced countries.

Conclusions

The evidence presented in this chapter confirms that labour market and skill policies have an important supporting role to play in a comprehensive green growth strategy, as was argued in the *OECD Green Growth Strategy* (OECD, 2011a). These results also suggest that green growth represents a manageable policy challenge that primarily calls for familiar types of policy measures. However, the chapter also highlights the limits of our present understanding of how the transition towards green growth will reshape labour markets and hence of the required policy response. This is true despite the large volume of recent research on this topic and an increasing number of policy initiatives to encourage the creation of green jobs or skills. The limited understanding to date reflects the complexity of decoupling economic growth from harmful environmental impacts. Furthermore, the transition to green growth is still at an early stage and the form it will take will be shaped by future policy choices and technological developments that are inherently difficult to predict.

This chapter argues that the transition towards green growth is best understood as an important driver of structural labour market change. General-equilibrium modelling provides important insights about green restructuring. It suggests for example that there is no automatic link between greening of the labour market and changes in the overall level of employment and that the structural adjustment pressures that will result from the transition towards green growth probably will not exceed those managed in the recent past, in large part because the industries that are most affected only account for a modest share of total employment. However, general-equilibrium models are not yet able to predict how the overall labour market will be reshaped with sufficient precision to provide detailed guidance for labour market and skill policies. Partial-equilibrium analysis is filling some of these knowledge gaps. In particular, considerable progress has been made in assessing future changes in labour demand and job-skill requirements in several economic sectors that are of strategic importance for climate-change mitigation, notably the energy and construction sectors, and these findings provide useful guidance for policy makers.

Policy cannot wait for researchers to resolve all of these uncertainties. Indeed, a growing number of green-specific policy measures recently have been put into place that are intended to assure that growing green firms are able to meet their recruitment needs and retrain their incumbent workforces. Many of these measures appear promising, even if their implementation is relatively recent and they tend to be small in scale. However, there is very little experience in operating this type of policy and it will be important to carefully evaluate how well these measures work. Doing so should also gradually clarify the optimal balance between green-specific policy measures and more general labour market and skill policies. Whatever the optimal balance turns out to be, green growth almost certainly reinforces the importance of assuring that well-recognised policies to promote better labour market outcomes (*e.g.* as described in the *OECD Reassessed Jobs Strategy*) are in place and functioning well, since these policies provide the necessary framework for reconciling a high degree of labour market flexibility with economic security for workers and their families. Similarly, green growth almost certainly reinforces the returns to raising the STEM skills of the workforce and the importance of assuring that employment protection and product market regulations are not impeding eco-innovation.

Notes

1. This chapter presents material drawn from the longer OECD report, "The Jobs Potential of a Shift towards a Low-carbon Economy" which was produced for the European Commission, DG Employment (OECD, 2012a). Additional information about country responses to the OECD questionnaire on green jobs is provided in OECD (2012b).
2. World Bank (2012) and UNEP (2011a) provide detailed analyses of green growth policies in developing economies.
3. Among the declining sectors are producers or heavy users of fossil fuels, with coal mining being the biggest job loser. Labour flows into industries producing clean energy and also goods and services whose products result in the least GHG emissions when produced and consumed.
4. These limitations also apply to the new OECD simulations reported below.
5. Despite innovation being intrinsically difficult to predict, the potential effects of environmental policies in stimulating the innovation of new green technologies has been incorporated into several CGE models in the form of endogenous R&D sectors (ICCS/NTUA, 2010), as well as into an econometric model (Cambridge Econometrics *et al.*, 2011).
6. Several recent empirical studies show that the adverse health impacts of pollution can be quite large (de Serres and Murtin, 2011; Hanna and Olivia, 2011).
7. See Chateau *et al.* (2011) for a more detailed presentation of this simulation analysis.
8. Because labour market policies and institutions vary widely across countries and interact in complex ways with policies in other markets, it remains a huge challenge to introduce a realistic representation of labour market functioning in general-equilibrium environmental models which are already complex and not easily-tractable tools. Nonetheless, these simulations exercises shed light on the magnitude of labour market adjustment pressures at stake when mitigation policies are implemented, as well as the qualitative impact of labour market rigidities in amplifying adjustment costs.
9. For Mexico, it is assumed that emissions are reduced by 50% in 2050 as compared with the 2005 level, rather than the 1990 level. Reaching these policy targets generally requires less sharp emissions reductions in Europe than in non-European OECD countries, since post-1990 emissions growth has been stronger outside of Europe.
10. Chateau *et al.* (2011) consider two alternative policy scenarios: one where each OECD country operates its separate national ETS and a second where there is a globally integrated ETS. While the overall cost of mitigation is higher the more fragmented the ETS system, all of the qualitative patterns discussed here hold also for the alternative assumptions about how widely ETS permits can be traded.
11. The equivalent variation is defined as the difference between the simulated level of real income when mitigation policies are in operation and the level of real income that would be required to provide consumers with the utility level they would have experienced in the absence of these policies (*i.e.* in the BAU scenario). This variable can be interpreted as representing the variation in aggregate welfare caused by the introduction of mitigation policies.
12. The negative impacts of mitigation policy on GDP and real wage growth contrasts with the positive impacts generally associated with the ICT revolution and globalisation, two prominent recent drivers of structural change in OECD labour markets. OECD (2012a) identifies a number of similarities and differences between these two historic drivers of structural change and green growth policies as regards their impacts in reshaping labour markets.
13. The last of these policy options is partly sector-specific in the sense that tax relief is assumed to be proportional to initial taxation.
14. The model assumes that household savings are not influenced by the rate of return on savings, and therefore, capital accumulation depends upon aggregate income only.

15. Using a different methodology, Cambridge Econometrics *et al.* (2011) also conclude that the additional labour market "churn" caused by an ambitious climate-change mitigation policy is small.

16. Only 10% of this 20% corresponded to changes in the sectoral composition of employment for a constant level of total employment, the so-called "excess job reallocation". Comparing this estimate of the historical rate of excess job reallocation with that estimated to be induced by an ambitious mitigation policy, confirms that the latter affect is small: less than a 1% change over an 18-year period as compared with a 10% change over a 10-year period.

17. Research on displaced workers has shown that the adjustment costs associated with moving between employers in the same sector are generally lower than those associated with changing sectors, suggesting that the ENV-Linkages simulations capture the aspect of job reallocation that is most likely to be disruptive.

18. This calculation is likely to underestimate the total impact of green growth policies on job-skill requirements, since it takes no account of how the adoption of new green technologies and working practices will change skill demands *within* industries.

19. Several other multi-country CGEs recently have been extended to include labour market imperfections so as to study how they affect the transition costs created by climate-change mitigation policy, including the GEM-E3 model (Capros and Parousos, 2007; and EC, 2008) and the WorldScan model (Boeters and van Leeuwen, 2010). While the detailed implementation differs, both of these models incorporate labour market rigidities in the form of a variable wage mark-up above the market-clearing wage. This mark-up – which is intended to capture the effect of workers' bargaining power, efficiency wage considerations or matching frictions – results in variable amounts of unemployment and may also influence labour supply. Whereas the approach adopted in this chapter focuses on potential "stickiness" in the adjustment of the labour market to the structural shocks caused by mitigation policy, these studies analyse how the equilibrium level of unemployment and participation can be affected. In practice, both types of imperfection are probably present, but they are difficult to differentiate within these very complicated CGE models.

20. The full adjustment of wages to the cost pressures created by placing a particular limit on GHG emissions is only temporary, so that the reduction in employment would be reversed relatively rapidly. However, the policy scenario analysed here envisions a progressive tightening of the allowable emissions level during the period until 2050, effectively generating a new policy shock every year.

21. Recent modelling studies that endogenise R&D activities and technological change suggest that using the permit revenues to subsidise eco-innovation (*e.g.* R&D in renewable energy) could have a larger, if more indirect, effect in raising GDP and employment in the long-run than would using these revenues to lower labour taxes (Cambridge Econometrics *et al.*, 2011; ICCS/NTUA, 2010).

22. It is sometimes argued that employment needs to exceed minimum job-quality thresholds in order to be classified as representing green jobs. For example, UNEP *et al.* (2008) argues that *green* jobs should be *decent* jobs, but it is unclear whether this is part of their preferred definition or a policy goal. Incorporating minimal job quality into the definition is consistent with definitions of sustainable development which encompass social sustainability, along with economic and environmental sustainability. This approach does not appear to have been used to estimate the number of green jobs and it is clear that green jobs defined only in terms of the environmental impact of the associated production activity may be low-quality jobs by conventional standards (*e.g.* low-paid, insecure and dangerous work such as much disassembly of obsolete ships and ICT equipment in South Asia).

23. These estimates are largely based on engineering estimates of the amount of labour input required to produce exogenously specified targets for domestic production of renewable energy and they abstract from many of the factors likely to influence the growth of employment in this sector in any specific country.

24. Similar, but generally less detailed analyses, have been conducted for a number of other green sectors – for example, green ICT as analysed in OECD (2012d) – or recent green policy initiatives – for example, green fiscal stimulus packages enacted in response to the 2008-09 recession (*e.g.* Pollin *et al.*, 2009 for the United States) or longer-run green jobs initiatives such as the "Grenelle de l'Environment" goals in France (BCG, 2009).

25. Information about green jobs and their skill requirements, and how green technologies and production practices are changing existing occupations, is being incorporated into the Occupational Information Network (O*NET) sponsored by the DOL and web-based career exploration tools that make these data available to students, workers and occupational guidance

counsellors. The O*NET system currently tracks 215 detailed occupations in 12 sectors that have been identified as either new green occupations or existing occupations that have become significantly greener or were already green and are rapidly increasing in size (Dierdorff *et al.,* 2009).

26. Cedefop (2010) argues that an effective revision and upgrade of the skills of existing workers can fill most skills gaps, even in specialised subsectors like renewable energy and energy management.

27. For example, Zabin *et al.* (2011) provide a detailed analysis of the skill demands resulting from the state of California's ambitious energy efficiency and GHG abatement policy goals and conclude that almost all of the workers required could be recruited from local workers who already have most of the required skills, but may need modest top-up training. While this study's findings reflect in part the currently depressed state of the labour market in California, it also suggests caution about concluding that ambitious environmental policies generally will imply serious skill shortages in the absence of a major investment in new forms of VET.

28. Indeed, the general-equilibrium analysis in Section 1 emphasised how *indirect effects*, such as changes in labour demand due to rising energy prices, could potentially affect labour demand in all industries. Nonetheless, the CGE modelling of mitigation policy suggests that these effects will be relatively small during the next several decades, with sharp job losses being confined to a small number of high-emitting industries.

29. Inevitably, it is somewhat arbitrary where to set the threshold for inclusion in the high-polluting group. However, the qualitative conclusions from this analysis are robust to modest variations in the threshold. IILS-ILO (2011) also reached qualitatively similar conclusions using somewhat different thresholds, data sources and country coverage.

30. Indeed, the discussion of general-equilibrium analysis in Section 1 suggests that the most intensive restructuring will occur within the two energy sectors included in the industry taxonomy used in Figure 4.7.

31. Similarly, Capros *et al.* (2011) show that the least-cost policy mix for achieving EU-wide targets of reducing greenhouse gas emissions by at least 20% in 2020 compared with 1990 and supplying 20% of energy needs from renewable energy imply higher compliance costs, as a percentage of GDP, in EU countries with below-average GDP per capita.

32. See OECD (2012a) for a more detailed analysis.

33. In order to achieve more precise estimates and abstract from business-cycle effects, the flow estimates analysed here are averages over the period 2000-07. Following the methodology in OECD (2009b), these data are further harmonised on the basis of industry-level EUKLEMS employment data to ensure comparability over time at the industry level. (Since this normalisation could not be implemented for public administration, health and education, that sector is excluded from the analysis of worker mobility in this section.) Hirings are proxied by the number of currently employed workers with less than a year of job tenure, while separations are calculated as the difference between hirings and employment growth.

34. OECD (2012a) analyses three additional measures of labour turnover, but they show very similar patterns to those analysed here.

35. Among the countries analysed, Spain and Denmark have the highest worker reallocation rates, albeit for rather different reasons. High turnover in Spain reflects the large share of temporary workers, who frequently change jobs, whereas high turnover in Denmark reflects relatively high job changing rates for regular workers.

36. These mobility rates are averages across the 15 EU countries shown in Panel A of Figure 4.10. See Annex Table 4.A1.1 for definitions of the numeric industry codes used in Panel B.

37. While comparative data on involuntary dismissals are scarce, OECD (2009b) suggests that, on average, about 5% of dependent workers are dismissed each year in high-reallocation countries and about 3% in middle-to-low reallocation countries.

38. In a growing number of OECD countries, some of these re-employment services are provided by private firms and non-profits working as sub-contractors for the PES.

39. OECD (2012a) provides a more detailed discussion of the experience with targeted programmes for trade-displaced workers.

40. As is discussed below, the distinction between general and targeted measures can be rather artificial in some instances. A general characteristic of an effective PES system it that it constantly adjusts the reemployment and training services it provides to shifts in the labour market needs of both employers and workers. For example, the PES in some OECD countries sometimes reacts to

mass layoffs, particularly those having a major impact of the local labour market, by setting up temporary rapid response task forces to delivery adjustment assistance tailored to the local circumstances (OECD, 2005a). As green-growth-driven structural change becomes more prevalent, these types of general programmes will introduce green content into labour market programmes automatically.

41. More than 50% of 25-34 year-olds in Canada, Japan and Korea have completed tertiary education (OECD, 2011e). At the other extreme, only 16% of this age group have a tertiary degree in Turkey and this share is about 1:5 for another five OECD countries.

42. The fact that strict EP reduces job and worker flows is well documented (OECD, 2010b) whereas the link for PMR is less well established, although it stands to reason that barriers to new business formation would impede the reallocation of labour and other productive inputs. The strong potential link between PMR and the labour reallocation required to achieve green growth is the reason it is discussed here, even though it is not strictly a labour market policy.

43. Moreover, greater worker mobility in itself may foster the diffusion of technology among firms, between industry sectors, and between universities (or government laboratories) and industry.

44. These differences persist despite a broad trend during the past two decades to reform PMR, so as to reinforce competition. There have also been many reforms intended to relax EP, but comprehensive EP reforms have been rare. EP reform in a number of countries, especially in Europe, typically has taken the form of easing the use of temporary forms of employment while leaving relatively strict regulations on permanent contracts virtually intact.

45. Considering the three countries with the highest intensity of environmental patenting, the strictness of EP regulation is well below the OECD average in Japan and Switzerland, but it is above average in Germany.

46. Poland introduced reforms in 2009 and 2011 to reduce barriers to business start-ups (OECD, 2012g).

47. General tax revenues could also be used to reduce the labour market distortions discussed in this section. However, tax revenues for this purpose are typically difficult to find and it is worthwhile considering how increased revenue from greater environmental taxation might best be used to lower barriers to employment.

48. The Danish Ministry of Employment is in the process of developing a definition of green jobs and assessing whether to introduce green-specific measures into their extensive system of active labour market programmes.

49. OECD (2012b) provides a fuller discussion and more country examples.

50. The Slovak labour market authorities reported that they lacked an effective means to co-ordinate their programmes with environmental policy which falls under the competencies of several ministries.

51. OECD (2006a and 2006b) highlighted a taxonomy of labour market types which includes two different and equivalently successful implementations of much of the good practice guidelines put forth in the *Reassessed Jobs Strategy*, a more market-oriented implementation and a more Nordic implementation. There are no evident grounds to conclude that one or the other of these two models is better suited to manage the transition towards green growth.

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ANNEX 4.A1

List of Industries Used in the Analysis of Worker Mobility in Section 2

Table 4.A1.1. **List of industries and industry codes used in Section 2**[a]

ISIC	Description	CO_2 intensity[b]
01-05	Agriculture, hunting, forestry, fishing (Agriculture)	3.2
10-14	Mining and quarrying (Mining)	3.5
15-16	Food, beverage and tobacco (Food)	1.8
17-19	Textiles, wearing apparel, dressing and dying of fur, leather, leather and footwear (Textiles)	0.5
20	Wood and of wood and cork (Wood)	1
21-22	Pulp, paper and paper products; Printing, publishing and reproduction (Paper)	1.8
23	Coke, refined petroleum and nuclear fuel (Fuels)	16.5
24	Chemicals and chemical products (Chemicals)	3
25	Rubber and plastics products (Rubber)	0.7
26	Other non-metallic mineral products	9.2
27	Basic metals	10.9
28	Fabricated metal	1
29	Machinery, nec	0.5
30-33	Office, accounting and computing machinery; Electrical machinery and apparatus, nec; Radio, television and communication equipment; Medical, precision and optical instruments (ICT equipment)	0.5
34-35	Motor vehicles, trailers and semi-trailers; Other transport equipment (Transport equipment)	0.6
36-37	Manufacturing nec; Recycling	1.3
40	Electricity, gas (Electricity)	110.8
41	Water supply (Water)	0.6
45	Construction	0.9
50	Sale, maintenance and repair of motor vehicles and motorcycles; Retail sale of fuel (Vehicles sales/repair)	1.1
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles (Wholesale)	1.6
52	Retail trade, except of motor vehicles and motorcycles; Repair of household goods (Retail)	1.8
55	Hotels and restaurants	1.1
60	Land transport	5.9
61	Water transport	2.6
62	Air transport	17
63	Other Supporting and auxiliary transport activities; Activities of travel agencies (Other transport)	2.4
64	Post and telecommunications	0.4
65-67	Financial intermediation, except insurance and pension funding; Insurance and pension funding, except compulsory social security; Activities related to financial intermediation (Finance)	0.3
70	Real estate activities (Real estate)	0
71-74	Renting of machinery and equipment; Computer and related activities; Research and development ; Other business activities (Non-financial business services)	0.4

a) These numerical codes are based on two-digit codes from the International Standard Industrial Classification (ISIC), Revision 3.1. The main text sometimes refers to these industries using the short industry titles given in parenthesis following the official (and more complete) titles.

b) CO_2 intensities are ratios of the industry CO_2 emissions intensity to the median intensity and were calculated by the International Institute for Labour Studies of the ILO, using input-output tables for Germany.

Source: IILS-ILO (2009) for the CO_2 intensity data.

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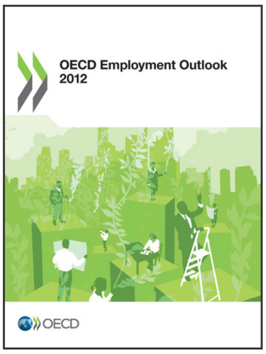

From:

OECD Employment Outlook 2012

Access the complete publication at:

https://doi.org/10.1787/empl_outlook-2012-en

Please cite this chapter as:

OECD (2012), “What Green Growth Means for Workers and Labour Market Policies: An Initial Assessment”, in *OECD Employment Outlook 2012*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/empl_outlook-2012-5-en