The jobs potential of a shift towards a low-carbon economy

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EXECUTIVE SUMMARY

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. Labour market and skill policies can make an important contribution to a successful transition by facilitating the structural change required to put green production practices in place, for example by minimising skill bottlenecks in expanding green sectors. The "greening" of the labour market will create new opportunities for workers, but also new risks that could undermine political support for green growth policies. Accordingly, labour market and skills policy should also seek to maximise the benefits of green growth for workers while assuring that unavoidable adjustment costs are shared fairly.

2. Therefore, the aim of this report is to provide guidance for how best labour market and skill development policy can contribute to a fast, efficient and fair transition to a low carbon and resource efficient economy, particularly in developed countries. Part I of the report provides an assessment of the main impacts on labour markets of climate change mitigation and, to a lesser extent, other policy measures to promote the transition to a low-carbon and resource efficient economy. This topic has been much studied in recent years, but many questions remain unanswered. The intention here is to summarise what has already been learned while providing new insights in a number areas. Under-researched issues that are considered include how easily workers in the most polluting industries can move into jobs in growing green industries and how different forms of eco-innovation are reshaping employment patterns and job skill requirements. Cross-country differences in the intensity of green restructuring pressures and the likelihood that green growth policies could become a source of significant net job creation (*e.g.* by developing a green "Silicon Valley") are also analysed. This part of the report is intended to describe the challenge facing policy makers.

3. Part II of the report then analyses how labour market and education/training policy can best contribute to a fast, efficient and fair transition towards a low-carbon economy. Attention is devoted to the potential contributions of both general labour market and educational policies, which provide the broad framework conditions determining the structural adjustment capacity of the labour market, and measures that are specifically targeted at "greening" the labour market (*e.g.* public training programmes for green jobs). Since little is known about the latter type of policy, this section makes use of responses to a new OECD questionnaire that was sent to employment and labour ministries. The information collected provides an overview of the extent to which developed countries have implemented green-specific measures and which types of targeted initiatives are most widely used. To the limited extent possible at this early stage, the effectiveness of different types of measures is assessed as well as cross-country differences in policy priorities. However, the report emphasises that the analysis of the labour market implications of a transition to green growth and the role that labour market and skill development policies should play in facilitating that transition remains very much a work in progress.

4. Several important limitations of the scope of this study should be noted. First, the analysis is largely confined to EU and OECD member countries and, hence, to developed economies. Labour market issues of particular salience for developing economies, such as high rates of informal employment and large-scale migration of rural workers to urban areas are not analysed. A second limitation of the study is that very little attention is devoted to labour market adaptation to environmental degradation, such as that

associated with climate change. Instead, the focus is almost exclusively on the implications of environmental mitigation policies for the functioning of labour markets and the role that labour market and skill development policy can play in complementing these policies.

The labour market implications of a transition towards green growth

5. From the perspective of labour market and skill policies, this report argues that the transition to green growth is best conceived of as a driver of structural economic change. Historical analogy to the ICT revolution and the deepening of globalisation suggests that certain sectors and occupations will be most strongly and directly impacted by environmental policies intended to bring about the progressive decoupling of production from harmful environmental impacts (*e.g.* the energy sector), but that workers in all sectors and occupational groups will be affected indirectly as the relative price of energy rises and green technologies and working practices diffuse throughout the economy. General equilibrium modelling provides a powerful tool for analysing all of the direct and indirect effects of environmental policies, such as climate change mitigation policies, on employment patterns, real wages and living standards. Accordingly, a major focus of the work reported here has been the extension of the OECD ENV-Linkages simulation model to analyse how policies to reduce green house gas (GHG) emissions will affect labour markets.

6. New simulation exercises have been undertaken that provide a more detailed analysis of the labour market implications of climate change mitigation policies and the contribution that labour market and skill policies can make to the achievement of a quick, efficient and just transition to a low-carbon economy. In many respects, these findings are similar to those obtained recently by other teams of researchers using computable general equilibrium models (CGEs) to analyse the economic impact of mitigation policies, notably the research funded by the European Commission MODELS project (ICCS/NTUA, 2010). Among the key findings to emerge from the general equilibrium simulation modelling are the following:

- An aggressive mitigation policy will alter the sectoral composition of employment by comparison with how it would evolve under a "Business As Usual" (BAU) scenario, with fossil fuel industries experiencing the steepest employment declines and renewable energy industries the sharpest increases. However, the additional reallocation of employment across industries up until 2030 is likely to be modest by comparison with the rates of reallocation observed in OECD countries in recent years and have little impact on the overall level of job skill demand. The main reason for this is that much of the economic restructuring implied by an aggressive mitigation policy occurs within the energy sector and that sector employs only a small share of the total workforce.

- Even when it is assumed that the labour market adjusts with full flexibility, policies that significantly reduce GHG emissions depress real GDP, real wages and aggregate living standards (evaluated in terms of the consumption of marketed goods and services) below their growth paths under the BAU scenario. The percentage fall in wages is larger than the fall in GDP, indicating a risk that workers will bear a disproportionate share of the costs of the transition in the absence of compensating policies.

- These findings highlight two key differences between the structural change associated with green growth and that associated with the ICT revolution and the deepening of globalisation. A first difference is that the two earlier drivers of structural change expanded the size of the "economic pie", whereas green growth policies shrink the pie in the sense that they impose extra costs on producers whereas the resulting environmental benefits generally do not generate additional sales revenue. While well-designed green growth policies should result in a higher level of well being

when all costs and benefits are considered, including the future benefits due to improved environmental quality, many of these benefits do not translate into market income, especially in the short run. This raises difficult issues about how the loss in net market income should be shared. A second particularity of structural changes associated with green growth is that it is driven largely by government policies, such as the climate change mitigation policies modelled here, and these future policy choices are subject to great uncertainty.

- The additional public revenue generated by carbon taxes or an emission trading scheme can be recycled so as to prevent wage earners from bearing a disproportionate share of the cost of mitigation policies, for example when labour taxes are lowered by an equivalent amount.

- Mitigation costs increase when labour markets are imperfectly flexible and it is possible that total employment will fall significantly. Recycling carbon tax revenues so as to lower the tax wedge on labour income can reduce the risk that the structural change required by mitigation policies will lower employment rates. Indeed, a "double-dividend" can sometimes be achieved, with gains in both environmental outcomes and employment. Policies directly increasing labour market flexibility probably would also significantly reduce mitigation costs, but could not be adequately incorporated into the ENV-Linkages model. Nor does the model take account of the risk that certain types of flexibility, or flexibility enhancing structural reforms, could increase the level of insecurity for workers.

- The results of this simulation analysis need to be interpreted carefully in light of the many possible channels through which mitigation policies could influence the performance of the labour market and the overall economy which were not incorporated into the analysis. Two such omissions are particularly important and may provide an overly pessimistic picture, especially as regards longer-run implications of green growth for workers and living standards:

  - The model does not account of the possibility that mitigation policies could induce an intensification or redirection of technological progress. Endogenous technical change is difficult to predict, but it could significantly change how mitigation affects labour markets, for example by reducing or eliminating the tendency of these policies to depress real wage growth, changing how job skill requirements evolve or allowing some countries to become technology leaders and develop green export champions that become a source of net employment gains.

  - The model does not account for the deterioration of environmental conditions under the BAU scenario and the implied costs (*e.g.* poorer health and lower agricultural yields due to drought). Avoiding these costs is the rationale for the mitigation policy, but these benefits are not taken into account in assessing the economic impact of mitigation due to uncertainty about how they will evolve.

7. While instructive, the simulation analysis based on the ENV-Linkages model also illustrates that the current state of knowledge is insufficient to allow the overall transition towards a green labour market to be modelled with much precision or at a fine enough scale to inform labour market policy at a detailed level. Accordingly, the general equilibrium analysis of the labour market implications of green growth is complemented by partial equilibrium analysis focussing on specific sectors where structural adjustment pressures will be particularly strong. This part of the report considers both green sectors and occupations, which will need to grow rapidly if production is to be decoupled from harmful environmental impacts, and "brown" sectors, which have a large environmental footprint and will need to shrink or re-engineer their production process. While the partial equilibrium methodology misses many of the indirect effects of green growth policies that operate across the economy and cannot provide reliable estimates of the impact of

green growth policies on total employment or average wages, it provides very useful information for conducting labour market and skill policies. For example, it becomes possible to assess how well the workforce profile of declining industries is likely to match the recruitment needs of expanding industries and, hence, the extent to which the transition towards green growth is likely to result in increased labour market mismatch.

8. A number of recent studies have analysed emerging green jobs and their skill requirements in detail and this report summarises the key findings. New empirical analysis is also undertaken to assess how eco-innovation affects employment patterns and job skill requirements. Among the key findings:

- Employment in many strategic green sectors, such as renewable energy, represents a very small share of total employment. Even though employment is likely to grow rapidly in these sectors, their recruitment needs will be modest. However, it is critical that education and training institutions respond promptly to meet the skill requirements of these sectors. The fact that much of the most intensive restructuring will occur within the energy sector also implies that employers and trade unions within this sector will play a key role. Indeed, spotty evidence suggests that a significant share of the conversion of the electricity sector from fossil fuels to renewable sources is occurring within large electrical utilities, a number of which are actively retraining their workforces as part of their implementation of a transition to clean energy.

- The construction sector is a larger employer that is also poised to make a large contribution to decarbonising the economy, provided government policy creates a large and stable market for energy-efficient buildings. Such a reorientation will require some retraining of the incumbent workforce, but green construction would rely largely on existing workforce skills, albeit sometimes combined in novel ways. The key challenge appears to be to coordinate the promotion of a growing market for green structures with the generally incremental greening of both initial vocational training (*e.g.* apprenticeship programmes and university architectural programmes) and continuing vocational training for the incumbent workforce.

- Some degree of green top-up training is also likely to be desirable across much of the workforce, but is difficult to characterise with much specificity. In most cases, these changes in job skill requirements can probably be met via incremental changes to existing systems of vocational training.

- Green jobs are very heterogeneous in terms of job skill requirements, pay levels and working conditions. The transition towards green growth is thus unlikely to either significantly exacerbate or ameliorate concerns about job quality or inequality, which are best addressed by other policy instruments.

- Environmental patenting data reveal that relatively few industries in a few high income countries account for a very large share of environmental R&D. This suggests that relatively few workers and firms are involved in developing novel environmental technologies and only relatively few countries are presently well positioned to become market leaders in environmental technologies. While relatively few industries account for most of the new environmental patents, the new technologies developed are often intended for use by other sectors, potentially affecting employment levels and job skill requirements more broadly.

- Firm-level data on eco-innovation, defined more broadly to include the adaptation of green technologies developed by other firms, is much more widespread than green patenting. Indeed, several highly polluting industries, such as chemicals and the automobile sector, are active green innovators and environmental regulations are important drivers of this type of eco-innovation.

Novel empirical analysis suggests that eco-innovation is associated with higher skill requirements and stronger export performance, but that these links may be weaker than for non-environmental innovations.

9. The report's analysis of adjustment pressures in highly polluting industries attempts to fill a gap in past research, which has devoted relatively little attention to the segments of the labour force that are likely to bear the largest adjustment costs during the transition to green growth. IILS/ILO (2011) is a notable exception. This recent study uses a similar approach to analyse this issue and reaches similar conclusions. However, the discussion here examines the characteristics of the workers and jobs in the most-polluting industries in greater detail and it also provides a novel analysis of mobility patterns in these industries. Among the key findings:

- Around 90% of total CO2 emissions are attributable to 10 industries that account for just 16% of total employment. These ten industries are: Agriculture, hunting and forestry; Fishing; Mining and quarrying; Electricity and gas; Inland transport; Air transport; Water transport; Other supporting and auxiliary transport activities; Activities of travel agencies; Coke, refined petroleum and nuclear fuel; Chemicals and chemical products; Other non-metallic mineral; Basic metals. Most of the employment in carbon-intensive industries is found in agriculture and inland transport.

- There are important differences across EU countries in the share of employment in the most polluting industries. The overall share ranges from around 10% in Denmark up to nearly 30% in Poland. Displacement problems related to a transition towards a low-carbon economy are likely to be greater in countries with a greater concentration of employment in high-polluting industries. These tend to be EU countries with below average GDP per capita and, in some cases, greater localisation of certain highly polluting industries within their national borders.

- The workers in the most polluting sectors, who are likely to experience an elevated risk of displacement, are very heterogeneous across these sectors. Low-qualified workers are overrepresented in agriculture, mining and inland transport, while older workers are overrepresented in agriculture and water transport. Workers displaced from these sectors could face particular difficulties reintegrating into employment, because older and less educated workers tend to experience larger post-displacement difficulties. Workers in some of these sectors probably also tend to live in remote areas where there are few alternative opportunities for employment. By contrast, the workforce in the carbon-intensive electricity sectors and chemicals is quite highly skilled, underlining the diversity of the workers employed in "brown" industries and the need for labour market policies to avoid a one-size-fits-all approach.

- Another indication that green growth policies are likely to create an expanded need to support displaced workers is that workers in the most polluting industries show below-average rates of mobility between employers, both within their own industry and across industries. Agriculture is a notable exception, due to its heavy reliance on seasonal and temporary work which results in very high turnover.

10. The different strands of analysis in Part I of the report suggest that policy makers need to focus on three main policy challenges related to the greening of the labour market. A first challenge is to foster a smooth reallocation of workers from losing to winning firms in the transition towards a green economy. A second, closely related challenge is to assure that workers obtain the new mix of job skills that will be required as production patterns become progressively cleaner. To the extent that it can be predicted, it does not appear that the transition towards green growth is likely to imply rates of labour reallocation or rates of change in job skill demands that are outside of historical experience. However, that conclusion may say

more about how difficult it is to predict the labour market consequences of decoupling economic growth from harmful environmental impacts than how easily green growth driven structural change can be managed. A third challenge is to develop synergies between green growth and gains in either overall employment or the quality of employment. Although the possibility of "win-win" outcomes have been much discussed, the analysis here suggests that they are not inherent in the nature of green growth. Nonetheless, it appears that such synergies sometimes can be created through good policy design. The key to doing so is to find a policy package that simultaneously corrects a market failure leading to harmful environmental impacts and another resulting in sub-optimal labour market performance (e.g. underinvestment in continuing vocational training).

An active but largely familiar role for labour market and skill policies

11. Conceptualising green growth policies as a driver of structural labour market change helps to clarify the appropriate policy response, since managing structural change is a familiar challenge. Policy choices should also reflect the great degree of uncertainty about how labour markets will need to evolve in order to achieve green growth. These considerations suggest that one of the key policy responses should be to improve the framework conditions which enhance the general adaptive capacity of labour markets while also providing adequate social protection for workers. Three challenges merit particular attention:

- *Reducing the insecurity due to job displacement.* The transition to green growth reinforces the importance of achieving a workable model of "flexicurity" combining a high degree of labour mobility with appropriate support for job losers. This support should take the form of adequate income replacement benefits combined with effective activation of benefit recipients. Reconciling efficient flows of workers from declining to growing firms with income and employment security is a crucial precondition for achieving the necessary reallocation of labour while also defusing political opposition to green growth policies.

- *Fostering eco-innovation through education and training.* Compulsory schooling should provide all students with strong skills in core fields, including mathematics and science, while tertiary education should train quality graduates, who can contribute directly or indirectly to innovation in their workplace, while also fostering research excellence and links to industry. OECD research has shown that well-designed labour and product market regulations can also make an important contribution to a national innovation strategy.

- *Making the tax and benefit system more supportive of employment.* Putting into place a comprehensive green strategy also provides a unique opportunity to improve the effectiveness of tax and benefit systems. The general equilibrium analysis in this report demonstrates how the additional revenue from carbon pricing can be used to reduce the tax wedge on labour incomes, so as to improve employment performance. However, a careful analysis of the tax/benefit system in a given country is required to assess whether current distortions from labour taxation are severe enough that this would be the most valuable use for new tax revenues, as well as how best to target reductions in labour taxation.

12. The optimal role for green-specific labour market 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. The OECD questionnaire reveals that about 60% of the responding countries have implemented at least one labour market measure targeted on green growth, but the number of such initiatives is still limited and most are relatively new and small in scale. Training is the most common type of measure in OECD countries, but some countries have subsidised green jobs in the private sector or created public green jobs programmes. The focus on training is consistent with the report's finding that green jobs have somewhat

distinct skill requirements which may not be well met by existing sources of vocational training. It is noteworthy that some of the OECD countries that are the most advanced in terms of introducing measures to reduce carbon emissions are among the sizeable minority of countries (about 40%) reporting that they have no labour market programmes targeted on green growth (*e.g.* Denmark, Germany, the Netherlands, Norway and Sweden). This suggests that it may be of little importance whether labour market programmes specifically target green growth, provided public training and job placement services are responsive to employers' evolving needs. Indeed, responsiveness to employers' needs may be the best way to avoid instances where green training programmes get ahead of the demand for green products and services, and hence have trouble placing trainees into appropriate jobs. Another complementary approach, exemplified by the Klima:aktiv programme in Austria, is to carefully coordinate specific green labour market measures with environmental policy and green growth economic development initiatives.

13. The gradual greening of the construction sector is particularly instructive for assessing how labour market and skill development policy can contribute to green growth, since government efforts to promote more energy efficient buildings date back to the oil shocks of the 1970s. This sector illustrates how regulation and public subsidies can compensate for the market failures that result in underinvestment in energy efficiency. The construction sector also illustrates the possibility that green growth initiatives can be a significant source of job creation in the short-run, as illustrated by the rapid ramping up of employment that has been achieved by subsidies to retrofit existing buildings to make them more energy efficient, such as were contained in some of the fiscal stimulus packages enacted during the recent economic crisis. Such efforts have often encountered major problems with quality control, however, so that the environmental gains actually achieved were much smaller than anticipated. This illustrates the importance of coordinating the development of the market for green buildings with the development of qualified suppliers and workers able to provide high quality services, along with certification systems making it possible for providers to compete on the basis of high quality work and to recruit qualified workers.

14. This report attempts to characterise the challenges that green growth represents for labour markets and how best those challenges can be met in a manner that is sufficiently general to apply to all developed economies. Nonetheless, the material presented here provides some insights into cross-country differences in the intensity and nature of these challenges. In particular, the relative concentration across EU and OECD member countries of the highest polluting industries in countries with relatively low GDP per capita and eco-innovation in a few higher income countries suggests that the labour market costs and benefits associated with green growth could be distributed unevenly across countries and, potentially, in a regressive manner. Differences in national labour market institutions and systems of skill development are also likely to affect how successfully green growth driven structural labour market change can be managed. For example, countries which have better reconciled labour mobility with income security (achieving so-called "flexicurity") are likely to have an advantage managing an efficient transition, while also limiting political opposition to green growth policies grounded in concerns about the economic dislocation they could imply. Similarly, countries with education and training systems that perform particularly well in developing high-level STEM skills are likely to be better placed to become leaders in eco-innovation, while national systems of continuing vocational training that are particularly responsive to employers' evolving job skill requirements may help to foster faster and more efficient diffusion of green technologies and working practices across the economy. However, there is as yet little systematic evidence on these questions.

THE JOBS POTENTIAL OF A SHIFT TOWARDS A LOW-CARBON ECONOMY

Introduction

15. It is now widely recognised that it is essential to decouple economic growth and social progress from unsustainable environmental pressures, such as those leading to global climate change. A successful transition towards a low-carbon and resource efficient economy will profoundly reshape the labour market in ways creating both new risks and new opportunities for workers. The challenge for labour market and skills policy 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). The aim of the report is to provide guidance for how best this can be done. Part I of the report provides an assessment of the main impacts of climate change mitigation and other policy measures to promote green growth on labour markets. This topic has been much studied in recent years but many questions remain unanswered and the intention here is to summarise what has already been learned and provide new insights. Part II of the report analyses how labour market and education/training policy can best contribute to an efficient and fair transition towards a low-carbon economy. A key focus in this part of the report is how measures specifically targeted on "greening" the labour market should be integrated into both the broader framework of labour marked and skills policies, and a whole-of-government strategy for promoting green growth.

PART I: UNDERSTANDING THE LABOUR MARKET IMPLICATIONS OF GREEN GROWTH: A WORK IN PROGRESS

16. Achieving ambitious environmental goals raises important transitional issues, as OECD and emerging economies will have to adjust to new patterns of growth. In particular, the realisation of a green growth agenda may translate into deep changes in the labour market that extend far beyond the creation of what are often labelled as "green jobs". While there are a number of opportunities associated with green growth, there are also costs associated with the transition. These costs may be scattered across the economy, with a potentially heavy burden supported by "brown sectors" and local economies heavily dependent on these industries. Furthermore, reducing the environmental footprint of production will imply changes in technology, skill requirements and work organisation that occur along the whole value chain and thus affect the labour force very broadly. Both benefits and costs of a new growth model will be pervasive across the labour force.

17. Analysing and assessing the employment impact of mitigation policies is not an easy task and a lot remains to be done is this area. A general equilibrium approach is required to capture all of the direct and indirect channels through which mitigation policies can reshape labour markets and create structural adjustment pressures. Section A 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 from unsustainable

environmental pressures. This section also illustrates the current limitations of the general equilibrium approach to analysing the labour market implications of ambitious green growth policies and, hence, the need to supplement this type of modelling with detailed analysis of specific sectors and occupations which will be particularly strongly affected by the early stages of a transition towards low-carbon and resource efficient growth. Section B adopts this partial equilibrium approach. In a departure from earlier studies of the greening of the labour market, this section gives approximately as much attention to "brown" industries and jobs (*e.g.* those with a large environmental footprint and which will need to contract or re-engineer their production processes), as to green industries and jobs. Labour market and skill policies need to prioritise the management of the structural adjustment pressures that will be concentrated in both of these segments of the overall labour market.

A. The labour market implications of a transition to green growth: insights from general equilibrium modelling

18. In order to motivate the need for taking a general equilibrium approach to analysing labour market implications of green growth, this section first considers what can be learned by historical analogy to the ICT revolution and the deepening of globalisation. A brief (and highly selective) literature review of past studies using the general equilibrium methods to study the labour market implications of climate change mitigation policy is then presented. Both theoretical aspects and available empirical evidence are discussed. Finally, new simulation exercises which have been conducted with the OECD ENV-linkages model are presented in order to clarify further some of the general equilibrium effects associated with the implementation of mitigation policies, such as emission trading schemes.

1. Lessons from historical analogies: how much can we learn from the ICT revolution and deepening globalisation?

19. One of the difficulties encountered in analysing the labour market impacts of green growth is that there is so little historical experience with low-carbon and resource efficient growth from which lessons could be drawn. Similarly, economic theory does not provide much guidance in the absence of detailed knowledge about which mix of environmental policies will be implemented and which green technologies –including those not yet developed– will be of greatest importance in decoupling production and consumption from harmful environmental impacts. Even when specific policies and technologies are being studied, great uncertainty remains such as how the scaling up and diffusion of cleaner production technologies will affect the composition of labour demand, including the distribution of job skill requirements. In the context of so much uncertainty, historical analogies to other recent drivers of deep structural changes in labour markets may provide qualitative insights into the potential challenges that lie ahead.

20. The ICT revolution and the deepening international economic integration ("globalisation") were the most important drivers of structural changes in OECD economies and developing countries over recent decades. How does the emerging green revolution compare with these two more mature revolutions, and how much can we learn from this comparison? Both apparent similarities between green growth and these two previous episodes of structural change and apparent differences are suggestive of the qualitative impacts that can be expected as labour markets adjust to greener growth and the resulting challenges for employment and skill policy. However, these historical analogies must be approached with caution because there is no way to know how closely the changes associated with the forthcoming green revolution will resemble the labour market restructuring triggered by the ICT revolution and globalisation.

21. Despite this fundamental caveat, four labour market adjustment patterns associated with the ICT and/or globalization revolutions are also likely to characterize the transition to greener labour markets. First, *workers in particular sectors will be most strongly and directly affected*, both positively and

negatively, but workers across the entire economy will be affected via a number of indirect channels. Green workers are in a similar position to direct beneficiaries of the ICT revolution (*e.g.* ICT workers such as software engineers) and globalization (*e.g.* workers in successful export industries), while the workers in the most polluting industries are in a similar position to workers specialized in the use of technologies replaced by ICT (*e.g.* typists) or employed in import competing industries (*e.g.* textile workers in many OECD countries). As illustrated by both the ICT and globalization cases, the sectoral concentration of benefits and costs also tends to translate into strong spatial disparities in the economic impacts, with some regions benefiting from new development impulses and others experiencing prolonged economic decline.

22. Second, globalisation illustrates *the central role that labour reallocation is almost certain to play* in the transition to green growth, even as the impact on total employment is likely to be small. While increases in international economic integration have not had a systematic effect on total employment, changing patterns of comparative advantage have had a strong impact on the sectoral mix of employment (OECD, 2005a). Much recent analysis of international trade has emphasized that extensive labour reallocation also occurs within industries as the most efficient firms, including foreign-owned multinationals, gain market share at the expense of less efficient firms. It is less clear whether this will also tend to happen in the case of green growth, but it appears plausible that many new firms with greener technologies will displace obsolete firms. Even among existing firms, the challenge to adopt or develop green technologies is likely to give an added advantage to the best managed and most innovative firms who will thus gain market share.

23. Third, the ICT revolution illustrates *the deep and diffuse ways that green technology is likely to affect workers and jobs*. As was the case with ICT, the development and application of new green technologies will require a simultaneous development of a cadre of specialized and often highly skilled green researchers and production workers employed in firms specializing in eco-innovation and the production of advanced environmental goods and services. As has been the case with ICT, green technologies and working methods may also need to diffuse across the economy in order to realise much of the potential benefits. If so, this diffusion will affect working methods and job skill requirements across the labour force, albeit typically in an incremental rather than revolutionary manner. Just as it now makes sense to speak of most workers as being "knowledge workers," even though most are not highly skilled developers and users of ICT, it may soon make sense to speak of a general greening of jobs and the workforce. However, it is still difficult to gauge whether green technology will prove to be as general and transformative of work across the economy as ICT has been, as well as whether it will tend to systematically raise cognitive skill requirements.

24. Finally, globalisation illustrates *the important role of indirect effects operating through changes in product prices* in determining labour market impacts. For example, the Stolper-Samuelson theorem shows that relative wages will tend to rise for workers whose skills are especially suited to the industries whose relative product prices rise in the wake of trade liberalization, while changes in product prices are also a key channel explaining why the real wages of all workers tend to rise, even those working in sectors that produce non-traded goods and services. Similarly, a transition to green growth will almost inevitably imply increases in the relative price of energy and other goods and services that have large environmental footprints. These relative price changes will induce changes in the composition of final demand and hence of labour demand.

25. The labour market adjustment patterns that will characterize the transition to greener labour markets are also likely to differ from those that have been associated with the ICT and globalization revolutions in several ways. First, whereas both the ICT and globalization revolutions have generally led to raising real wages, green growth policies are initially likely to involve falling real wages, relative to what their growth path would have been, and hence a need for downward wage flexibility (at least with respect to previous expectations of wage growth). Indeed, while the adoption of green technologies has the

potential to raise productivity in sectors producing a combination of marketed goods and services and (typically) un-marketed environmental services (which will often take the form of diminished environmental damage), average labour productivity in terms of marketed output is likely to fall reducing employers' ability to pay wages and requiring wages to fall in order to maintain full employment. Achieving downward wage flexibility to minimise the disemployment effect may be quite a challenge since considerable research suggests that wages display considerable downward rigidity in many countries.

26. A second difference is that a green growth strategy also opens up the possibility of double-dividend strategies that can improve both environmental and employment outcomes, such as using revenue from a carbon tax to lower the tax wedge on labour income. By contrast, trade liberalization via reductions in tariffs typically imply lower government revenues and hence little scope for this type of policy package. Hallegatte *et al.* (2011) argue that there are quite a number of other instances in which policy initiatives to reduce environmental harm generate economic co-benefits either directly (*e.g.* through better environmental conditions improving worker health and productivity) or indirectly (*e.g.* reducing urban congestion can improve efficiency directly by reducing travel times even as it reduces pollution).

27. A final difference is that it is not yet clear whether green growth will have a systematic impact on overall skill demand, whereas the ICT and globalization revolutions appear to have generally raised job skill requirements. That ICT should generally raise cognitive skill requirements is intuitive and has been confirmed by a large body of empirical research. Although the Stolper-Samuelson theorem suggests that deepening trade integration will only raise skill demand in countries that already have the most skilled workforces, a growing body of empirical research suggests that rising skill demands is much more general, perhaps due to the role of trade and foreign direct investment in diffusing new technologies and more efficient management practices. By contrast, much less is known about whether green growth will generally raise job skill requirements. Ramping up the pace of eco-innovation will tend to raise skill demands, at least for an extended period of time, provided that the expansion in green R&D does not imply an equal reduction in R&D for less environmentally friendly technologies. While it is clear that greening the labour market will imply some changes in job skill requirements, it appears to be too early to predict any overall tendency on skill demand.

28. All in all, historical comparisons with the ICT revolution and the progressive deepening of international trade and investment illustrate how important drivers of structural change may initially affect mainly specific sectors, but come to have pervasive effects across the economy. The impact of green growth policies and eco-innovation is likely to spread well beyond the sectors directly affected *via* indirect channels and thus have rather pervasive effects across the entire labour market. This implies that the labour market and skill policy response to green growth cannot be limited to managing the impacts on the relatively small numbers of workers employed in the green and brown jobs, even if these groups of workers (and employers) require special attention.

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

29. A great degree of uncertainty still remains with regard to the impact that a policy-driven transition to green growth could have on labour market outcomes. In part, this is due the inherent unpredictability of future policy choices. Even if policy uncertainty were not present, the complexity of the general equilibrium effects that will reshape economies worldwide would still represent an important limit to how well we can predict how green growth policies, such as a carbon pricing, will reshape labour markets. These policies affect labour market outcomes through many channels, creating various structural adjustment pressures that interact with each other in complex ways. These include, by generating:

- *A new paradigm for energy production* – As carbon pricing is introduced or further developed, it will cause important changes in relative prices within the energy sector that will result in the emergence of a new and more environmentally-friendly energy-mix. This constitutes the primary purpose of mitigation policies, but as a side effect, energy prices will increase at least in the short and medium run.

- *A new paradigm for consumption* – Changes in energy prices will, in turn, affect the composition of both final and intermediate demand, as the relative price of energy intensive goods and services will increase. The extent to which this will translate into deep changes in the composition of total demand will depend on the substitution possibilities between more and less energy intensive goods and services in both intermediate and final consumption.[1] If these substitution possibilities are limited, aggregate demand could fall substantially, due to rising aggregate consumption prices.

- *A new paradigm for innovation* – These various changes in relative prices will create incentives for R&D investments in a number of economic areas, while the expected return of innovation will decrease in other economic areas. In particular, they should encourage technological innovations related to the production and use of clean energy, and boost R&D investments in energy-saving technologies. By modifying the substitution possibilities between clean and polluting energy sources and between energy and others inputs, these technological changes could attenuate the rise in energy prices and the variations in intermediate and final consumption prices.

- *New macroeconomic conditions* – Carbon pricing acts as a tax on production activities, and therefore, will tend to reduce economic efficiency and cause GDP loss at least in the short and medium run. Barriers to industrial re-structuring, such as poorly designed product market regulations or labour market institutions, would exacerbate this potential negative impact on economic growth. On the other hand, the induced technological changes will help restore economic efficiency but they will take time to materialise. However, environmental taxes raise public revenue, which can be used to reduce other taxes. Revenue-neutral mitigation policies are sometimes advocated on the basis that they can generate a "double-dividend": the first dividend in terms of more effective environmental protection and the second reflecting the efficiency gains arising from the reduction in distortive taxes, such as labour taxes (Box 1).

Box 1. **The double dividend hypothesis**

First and foremost, environmental taxes respond to the need to better internalise environmental externalities. Hence, like many other taxes not aimed at correcting economic market failure *per se*, green taxes involve potential economic costs. But these taxes also raise public revenue, which can be used to mitigate –if not to fully offset– their potential efficiency costs. In this context, the improvement of environmental quality could be achieved at relatively low costs, and may even go hand in hand with improved economic efficiency. This view corresponds to the so-called "double dividend" hypothesis:

- In its weak form, the double dividend hypothesis states that the efficiency costs of a revenue-neutral environmental tax reform are lower if the additional revenues from the environmental taxes are recycled in the form of lower distortive taxes compared to a situation where these revenues are recycled in a lump-sum fashion.

1 . Rising consumer awareness of environmental and sustainability issues is also likely to shift the composition of consumption away from goods and services with a large environmental footprint. Policy measures, such as environmental education and the provision of better information to consumers (*e.g.* eco-labelling), can be helpful in this respect, as is envisioned in the European Commission Sustainable consumption and Production and Sustainable Industrial Policy Action Plan (see EC, 2008).

- The strong form of the double dividend hypothesis asserts that an environmental tax reform enhances not only environmental quality but also non-environmental outcomes, such as employment.

The rationale behind the double dividend hypothesis relies on the likely sub-optimality of the tax system in many countries, where substantial differences in the marginal excess burden of various taxes can be observed. The weak form compares two different policy changes –that is, two different recycling options for green tax revenues– and implies that green taxes are more efficient instruments (from an economic perspective) than environmental policies that do not yield any revenues, such as regulations. The strong form of the double dividend hypothesis compares the equilibrium after a single policy change with the *status quo*, where the existence of distortive taxes –other than environmental taxes– makes room for governments to implement a revenue-neutral green tax reform that improves economic efficiency by shifting the tax burden away from production factors with high marginal excess burdens to factors with low marginal excess burdens.

Conceptually, however, a green tax reform aimed at reaping a strong double dividend can be seen as consisting of two separate policies: one policy is aimed at improving the quality of the environment; the other policy is targeted at the non-environmental objective, and aimed at reducing inefficiencies arising from the tax system. This raises the question why governments have not reformed their tax systems to address these inefficiencies. There may be a political case for linking these two issues because such a linkage increases the number of instruments that can be used to compensate losers from separate reforms. To illustrate, an efficiency-enhancing tax reform that stimulates employment may not be politically acceptable because inactive households that rely on non-labour income lose from such a reform. If these latter households attach a high value to environmental quality, however, they may favour an environmental tax reform that shifts the tax burden away from labour.

In Europe, tax reforms that would allow a reduction in labour taxes by levying taxes on polluting consumptions have long been advocated as a potential policy option for improving both environmental quality and labour market functioning, thus reflecting a widespread concern among economists that the tax burden on labour income is relatively high and distorting in many countries. Denmark, Germany, Netherlands, Norway, Sweden and United Kingdom have, for instance, implemented such green tax reforms, but *ex pos*t evaluations of these measures are scarce and do not always isolate employment effects from more general macroeconomic effects (OECD, 2007a). Yet, the likelihood of such a double dividend has given rise to a large body of theoretical literature and *ex ante* evaluations. Whether or not the strong form of the double dividend hypothesis may occur depends on two main effects: a tax-base effect and a tax-shifting effect.

- The so-called tax-base effect represents the consequences of a different tax mix for the efficiency of the tax system as an instrument to raise public revenue. In particular, an erosion of the tax base indicates that the tax system becomes a less efficient revenue-raising device, as higher marginal tax rates are required to collect the same amount of public revenue. This typically arises with environmental taxes: contrary to most taxes that are aimed at raising revenues and are all the more efficient that they do so without changing agents' behaviour very much, environmental taxes should be designed to change behaviour so as to reduce environmental externalities, that is, their tax base. In other words, improvements in environmental quality reduce the scope for enhancing the efficiency of the tax system by using revenue from environmental taxes to cut other taxes. Hence, this tax-base effect works against the strong form of the double dividend hypothesis. Its magnitude depends on two main elements: the initial pollution levies and the substitution elasticity between clean and dirty commodities. Indeed, increasing environmental taxes is less efficient as a revenue-raising device for governments when starting from a relatively high tax rate, since the higher the initial level of environmental taxes, the smaller is their initial tax base. Likewise, for a given increase in environmental taxes, a large substitution elasticity between clean and polluting goods leads to great improvements in environmental quality, but also, to a large erosion of the tax base.
- In addition to this tax-base effect, economic agents on whom a particular tax is levied are not necessarily those that, *in fine*, fully pay the tax in question since various market adjustments may result in tax shifting. For the strong form of the double dividend hypothesis to occur, consumers of polluting goods should not be able to shift the green taxes they pay onto economic agents that are already overtaxed from an efficiency point of view. In large part, this so-called tax-shifting effect –its direction and its magnitude– is shaped by the various elements that govern the functioning of product and labour markets, and in particular, the policy framework. Therefore, even in countries where non-wage costs are relatively high and may restrain firms' labour demand, a green tax reform that would allow for lower labour taxes may not necessarily result in a lower level of unemployment. The outcome of such a reform depends on the extent to which workers will succeed in shifting the tax they pay on their consumption of polluting goods onto their employers, in the form of higher wages. Hence, the employment impact of a green tax reform may differ from one country to another, depending on national labour market policies and institutions that influence the wage determination process, such as the wage bargaining system, the existence of a legal minimum wage and the unemployment benefit system.

Overall, it comes out relatively clearly from this theoretical literature that pre-existing labour market distortions must be relatively strong for green tax reforms to raise employment. To take an example, Koskela and Schöb (1999) show that a green tax reform can increase employment if unemployment benefits are neither subject to the labour income tax nor indexed to the consumer price index. In this context, labour taxation is most distortive as it does not affect worker reservation wage, therefore implying that a rise in payroll taxes will translate, to a large extent, into higher labour costs and unemployment, rather than into lower take-home pay. But this constitutes a favourable context for an employment dividend to materialise. Higher pollution taxes on consumption depress the real value of worker reservation wage as unemployment benefits are not indexed the consumer price index. Furthermore, the unemployed do not get compensated by the cut in the labour tax because they do not pay that tax. Hence, the environmental tax reform shifts the tax burden towards the unemployed and away from workers.

Another lesson from this literature is that the interplay between carbon taxes and pre-existing taxes can differ markedly across countries, influencing both the scope for achieving a double dividend and which form of recycling generates the largest efficiency gains (Babiker *et al.*, 2003). Additional examples of the sensitivity of conclusions about which form of revenue recycling is most effective are provided by Faehn *et al.* (2009) and Takeda (2007): the former the study concludes that the best option for Spain would be to cut payroll taxes for skilled workers, while the latter finds that reducing the capital tax is most effective in Japan. While researchers have most often used computable general equilibrium models to analyse the possibility of achieving double dividends, different carbon tax revenue recycling options recently were analysed using large scale econometric models that incorporate endogenous technical progress, namely, the E3ME model (Cambridge Econometrics *et al.*, 2011) and the NEMESIS model (ICCS/NTUA, 2010). Both studies concluded that the best strategy was to support green R&D. It makes sense that a policy option which raises the growth rate of productivity generates larger benefits in the long run than a policy that produces a one-time fall in the unemployment rate. However, there arguably is greater uncertainty about how fiscal incentives will affect the rate of technical progress than other economic outcomes such as the level of labour supply.

Source: Goulder (1995); Bovenberg (1999); Bovenberg and Goulder (2002); Babiker *et al.* (2003); Takeda (2007); Faehn *et al.* (2009); ICCS/NTUA (2010); Cambridge Econometrics *et al.* (2011).

30. How will these multiple adjustment pressures reshape the labour market? Both industrial re-structuring and eco-innovation will affect job skill requirements, while their net impact on total employment will depend on whether expanding production activities are more intensive in labour than contracting production activities are. But first and foremost, the net employment impact of mitigation policies will be shaped by the new macroeconomic situation brought about by carbon pricing, and therefore, cannot be assessed without adopting a general equilibrium approach.

31. 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. For the sake of simplicity, labour market imperfections are most often introduced through more or less *ad-hoc* forms of wage rigidities, as environmental CGE models are complex and not easily-tractable tools.

32. The estimated impact of mitigation policies on economic growth and employment varies somewhat across countries and studies (see Table 1). In large part, this reflects differences across studies with respect the mitigation policies considered, and for a given mitigation scenario, differences across countries with respect to the initial level of GHG emissions, which determines mitigation efforts that need to be achieved. Overall, the impacts on GDP and labour market outcomes tend to be relatively small, however. A evaluation conducted by the European Commission suggests that the pace of employment growth in Europe could slow down slightly, should participating countries meet the EU's objectives on climate change and renewable energy for 2020 (Commission of European Communities, 2008). For selected European countries, Boeters and van Leeuwen (2010) show that a 20% reduction in energy use could slightly reduce unemployment, provided that energy taxes are used to reduce labour taxes. Montgomery et al. (2009) obtain the same qualitative results for the United States, while also showing how labour market imperfections could increase mitigation costs.

Table 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 *et al*. (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	**United States** **Target**: reduction of GHG emissions by 83% below 2005 levels by 2050 **Policy**: cap-and-trade program (H.R.2454). Recycling: lump-sum transfers to consumers. **Implementation period**: 2010-2050		**GDP** (%)		**Employment** (Thousands of jobs)		**Real Wage** (USD)		Wages adjust by one-half the amount required for full employment
			-1.0 in 2030 -1.5 in 2050		-2,200 in 2030 -3,600 in 2050		-510 in 2030 -1,250 in 2050		
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**: 2005-2025.		**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				
Commission of the European Communities (2008) GEM-E3 model	**Europe** **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**: 2005-2020		**GDP** (%)		**Employment** (%)				Labour supply not fully elastic. Wage bargaining with an intermediate value for trade-union bargaining power.
			-0.35 in 2020		-0.04 in 2020				

33. At the national level, CBO (2010) compares the estimated economic impacts produced by three leading CGEs for the United States when used to analyse a *standardised* climate change mitigation

scenario: results differ sufficiently across the three models to make it clear that the precise modelling assumptions used require also careful scrutiny. 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 shift of workers away from declining sectors, such as coal mining (the biggest job loser) and other sectors that are producers or heavy users of fossil fuels, and towards industries producing clean energy and also goods and services whose products result in the least green house gas emissions when produced and consumed. The CBO analysis also provides robust evidence that real wages tend to fall due to the impact of higher energy prices in raising the cost of living. The findings that the transition towards low-carbon growth implies 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.

34. In essence, green growth policies represent a timing issue: they require costs and economic adjustments in the short run to avoid larger costs and irreversible damage later. CGE models allow evaluating the transition costs, but over a longer time horizon, certain gains in efficiency and employment (including job losses avoided) that are induced by mitigation policies typically are not captured. 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). Another important caveat is that, most CGE models (including the OECD ENV-linkages model) do 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. For example, the adverse health impacts of pollution can be quite large (de Serres *et al.*, 2011; Hanna *et al.*, 2011). The damages from climate change can also be large, including the destruction of physical capital through more intense and frequent storms, droughts and floods, for example from a rise in sea level and storm surge in heavily populated coastal areas (Nicholls *et al.*, 2008). 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). However, innovation and climate change are slow processes, as illustrated in a recent report by UNEP showing that an increase in green investments would start producing positive employment outcomes in 2050 (UNEP, 2011).

3. Further insights from new simulation exercises[2]

35. In order to clarify some of the implications of a transition toward green growth for labour markets, illustrative simulation exercises have been conducted with the OECD ENV-linkages model (see Box 2). In the core version of the ENV-linkages model, aggregate employment is treated as an exogenous variable since the primary purpose of this model is to assess the impact of environmental policies on GHGs emissions and economic growth. When economic shocks arise or new policies are introduced, labour market clears and all the adjustment occurs on wages. While aggregate employment remains unchanged, the model allows for instantaneous job reallocations across economic sectors. This strong assumption about full flexibility in the labour market is commonly used in long-run growth models, but it is at odds with extensive evidence about rigidities in OECD and non-OECD countries and frictions that affect the pace of labour reallocation, at least for some period of time. Nonetheless, this baseline version of the model provides a first indication of the magnitude of labour market adjustment pressures at

2 . See Chateau *et al*. (2011) for a more detailed presentation of this simulation analysis.

stake when mitigation policies are implemented. Moreover, an augmented version of the model has also been used, which introduces some degrees of real wage rigidity, so as to enable the potential impacts of green policies on both employment and wage levels to be analysed.[3]

Box 2. **Main characteristics of the OECD ENV-linkages model**

The OECD ENV-Linkages model is a recursive dynamic neo-classical general equilibrium model, documented in details 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* (OECD, 2009a). The model represents the world economy in 15 countries/regions, each with 26 economic sectors, allowing structural changes across countries and regions and within each of them 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 petroleum products, the remaining sectors being transport, 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 the aggregate labour demand to an exogenous employment level, and therefore determines wages.

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 described 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).

Economic impacts of various mitigation scenarios and recycling options for carbon revenues

36. Faced with the consequences and costs of inaction, governments have reached a consensus internationally that global emissions need to be cut significantly. In this respect, both the long-term target for emissions reduction and the type of international agreement reached are key determinants of the potential implications of mitigation efforts for economic growth.

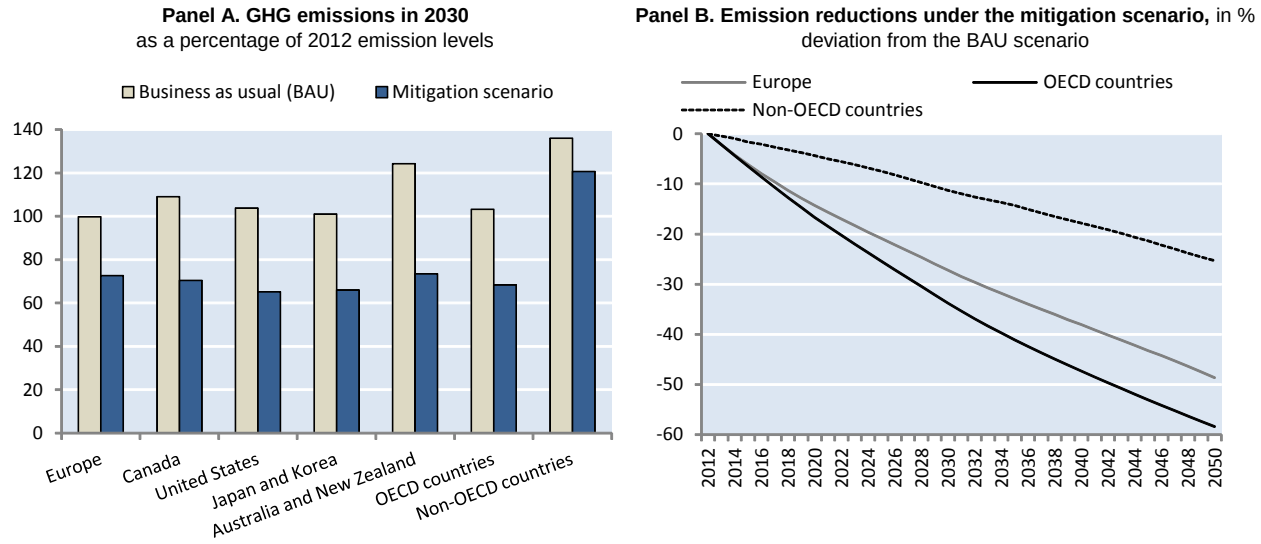
37. The illustrative policy scenario applied in the modelling is an emission trading scheme (ETS) which, over the period 2013-2050, progressively reduces greenhouse gas (GHG) emissions in the OECD area as a whole by 50% in 2050 as compared to their 1990 levels (Figure 1).[4] The target is less stringent for non-OECD countries: emissions 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. Three different kinds of international agreements have been considered in this analysis: *i)* a "Fragmented ETSs" scenario, where all countries are reducing their own emissions through emissions trading schemes without linking to others countries' action: carbon markets are fragmented; *ii)* an "OECD-wide ETS" scenario: OECD countries are allocated emission rights (permits) corresponding to the same emission reduction targets as those in the fragmented scenario, but they can trade their permits. In this OECD cap-and-trade scheme, non-OECD countries still undertake their emissions reductions alone; and *iii)* a "Worldwide ETS" scenario, whereby all countries are participating in a global and linked carbon market,

3. Because labour market policies and institutions vary widely across countries and interact in complex ways with policies in other markets, it remains quite a challenge to introduce a thorough representation of labour market functioning in general equilibrium environmental models that 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.

4. For Mexico, it is assumed that emissions are reduced by 50% in 2050 as compared to 2005 levels.

with initial emission permits still allocated according to the "Fragmented ETS" case. This allocation rule for emission rights is purely illustrative and not intended as a policy recommendation.

Figure 1. **Greenhouse gas (GHG) emissions: policy scenarios**



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 in note a together with Australia, Canada, Europe, 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.

38. Simulation exercises have been conducted using the baseline version of the OECD ENV-linkages model, with full flexibility in the labour market. Therefore, structural adjustment pressures triggered by these various mitigation policies are apprehended through their impact on GDP levels, disposable income of working households (real net wage) and a welfare measure, the so-called "equivalent variation" in real income of all households. This variable 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. Therefore, the equivalent variation in real household income can be interpreted as the variation in aggregate welfare induced by the introduction of mitigation policies. As the damages from climate change, and hence the benefits from mitigation action, are not included in the analysis, these welfare losses represent only the cost of action and not the benefits.

39. All of these mitigation policy scenarios tend to slow down the pace of economic growth. In Europe, real GDP declines by less than 0.5% from baseline levels in 2030 and by 0.1% to 1.4% from baseline levels in 2050, depending on the policy scenario (Table 2). These GDP losses are slightly more pronounced for the OECD area as a whole, but larger than those projected for non-OECD countries (in part due the less stringent mitigation target that has been retained for these countries). Although these costs are certainly not negligible, *they should be viewed in the context*: these GDP losses are very small compared to the substantial growth in GDP in the baseline (Figure 2, Panel B).

Table 2. **Impact on GDP, wages and welfare of various mitigation policy scenarios**

In % deviation from the business-as-usual scenario

		Central scenario: OECD-wide ETS			Fragmented ETSs			Worlwide ETS		
		Real GDP	Real net wage	Welfare measure	Real GDP	Real net wage	Welfare measure	Real GDP	Real net wage	Welfare measure
Europe	2015	-0.02	-0.13	-0.02	-0.01	-0.06	-0.01	0.00	-0.03	0.00
	2020	-0.12	-0.59	-0.08	-0.06	-0.38	-0.07	-0.01	-0.08	-0.02
	2030	-0.43	-1.27	-0.36	-0.36	-1.16	-0.36	-0.04	-0.30	-0.14
	2050	-1.36	-2.52	-1.38	-1.41	-2.61	-1.39	-0.14	-0.47	-0.53
OECD	2015	-0.02	-0.13	-0.02	-0.02	-0.12	-0.02	0.00	-0.03	0.00
	2020	-0.13	-0.61	-0.12	-0.13	-0.58	-0.12	-0.01	-0.09	-0.03
	2030	-0.55	-1.41	-0.51	-0.54	-1.42	-0.52	-0.09	-0.34	-0.22
	2050	-1.71	-2.56	-1.46	-1.74	-2.68	-1.49	-0.25	-0.51	-0.59
Non OECD	2015	-0.01	-0.09	-0.04	-0.01	-0.09	-0.04	-0.01	-0.16	-0.02
	2020	-0.06	-0.34	-0.25	-0.05	-0.36	-0.23	-0.07	-0.50	-0.08
	2030	-0.27	-1.13	-0.73	-0.26	-1.16	-0.71	-0.40	-1.67	-0.32
	2050	-0.65	-1.56	-1.40	-0.64	-1.60	-1.41	-1.08	-1.87	-0.87

For various definitions, see Figure 1, notes a), b) and c).

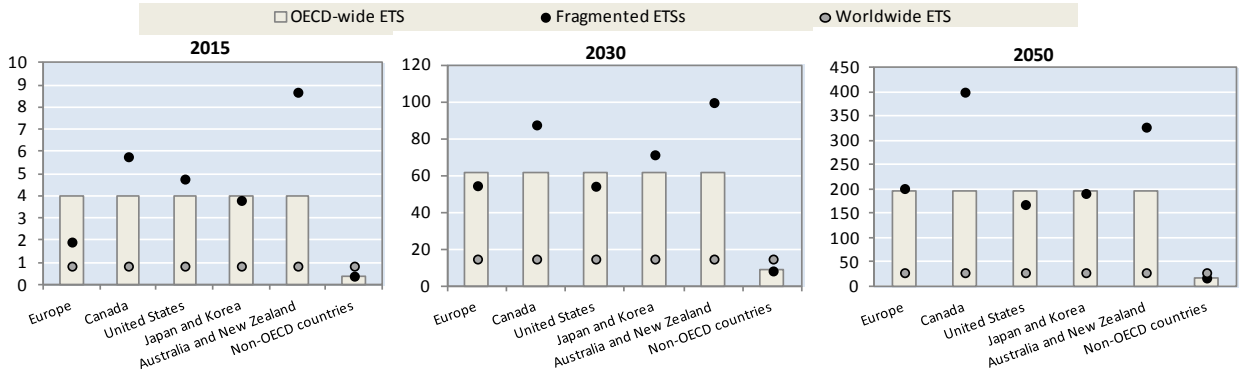
a) The welfare measure is defined as the difference between the simulated level of real income when mitigation policies are introduced and the level of real income that would ensure the same utility level to consumers as would occur in the absence of such policies, *i.e.* in the baseline (or BAU) scenario.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

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

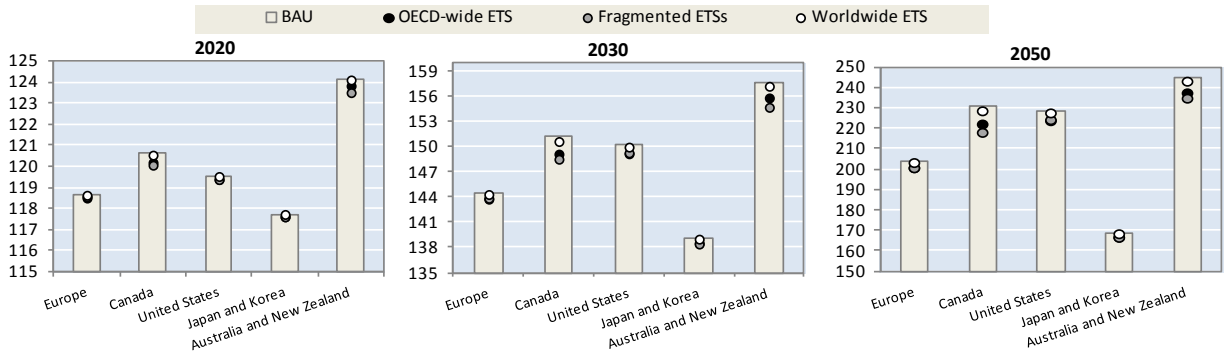
Source: OECD ENV-linkages model.

Figure 2. **Mitigation costs for various mitigation policy scenarios**

Panel A. Carbon prices, in 2007 USD per ton of CO2 equivalent



Panel B. **Real GDP (100 = 2012)**



Europe, non-OECD: see Figure 1, notes a) and c).
Source: OECD ENV-linkages model.

40. The cost of reaching a global target or a regional target could be significantly reduced by emissions trading. The trading of emission permits, among a group of participating countries, helps to equalise marginal abatement costs of GHG emission reductions across different countries and emission sources. These marginal abatement costs are reflected by carbon prices, which vary greatly between countries or regions and between the three mitigation scenarios considered for any given country or region (Figure 2, Panel A). The more the marginal mitigation costs differ among a group of countries in a unilateral action scenario ("Fragmented ETSs"), the higher the cost-efficiency benefits of linking their mitigation effort through trading permits (OECD, 2009a).

41. GDP effects in the "Fragmented ETSs" scenario vary across countries with the stringency of the target with respect to the baseline, reflecting *inter alia* the degree of carbon intensity of each economy and the different degree of flexibility of their economic structures. Compared with the Fragmented-ETS scenario, the integrated cap-and-trade scheme (OECD-wide ETS) has different implications for the cost of mitigation depending on whether countries are importers or exporters of permits. In the "OECD-wide ETS", Europe exports a growing amount of permits until 2030; then, this amount gradually declines and the European region becomes a net importer after 2040. By contrast, the United States benefits from the possibility of importing permits until 2020 and then becomes a net and growing exporter of carbon permits. Other OECD countries always benefit from the trading system as net importers. As a result, in terms of GDP, Europe starts to benefit from the OECD trading system linking after 2040 only while, for the United States, this scheme becomes costly, relative to the fragmented case, after 2020. All other OECD countries always benefit from the OECD trading system linking.

42. But GDP is not the most accurate indicator for examining the benefit of ETSs linking: potential gains are better reflected in the welfare measure of mitigation costs.[5] According to this measure, all participating countries would generally benefit from meeting their joint targets through a common ETS (Table 1). The "Worldwide ETS" scenario shows larger reduction in overall mitigation costs, in particular

5. Real exchange rates are fully flexible in the model, which explains GDP changes in the ETS linking scenario relative to the fragmented scenario. Net importers of permits face a degradation of their current account and real exchange rates fully depreciate. Therefore, the trade balance in real terms increases as well as real GDP. For permit exporters, the opposite occurs. Moreover, the value of the exported permits equals zero in real terms (as the original price of permits in the BAU equals zero) and thus does not contribute to GDP in constant 2007 USD as it is discussed here. For these and other reasons, GDP is not the most accurate indicator for examining the benefit of ETSs linking.

for OECD countries. This is because carbon price heterogeneity prior to ETSs linking is estimated to be relatively larger across all participating countries than it is within the OECD area (Figure 2, Panel A).

43. In fully flexible labour markets, all of these mitigation policy scenarios would lead to a reduction in real wages. This is because ETSs result in GDP losses through the increase in marginal costs of production that they imply. 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. In the OECD-wide ETS and Fragmented ETSs scenarios, real wage in Europe would decline by around 1.2% from baseline levels in 2030 and by around 2.5% from baseline levels in 2050 (Table 2). By contrast, wage losses are almost negligible in the Worldwide ETS scenario. Similar projections are obtained for the OECD area as a whole. Besides, the depressive effect of mitigation policies is always more pronounced on real net wages than it is on GPD or aggregate welfare, whatever the scenario retained. These policies may 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.

44. In the simulation exercises described above, ETS revenues were redistributed to all households in the form of *uniform lump-sum transfers*. For illustrative purposes, four alternative recycling policies have been simulated within the "*OECD-wide ETS*" scenario, with ETS revenues being recycled respectively to: *i)* lower household wage income taxation; *ii)* lower household global income taxation; *iii)* reduce both capital and labour taxes paid by firms; and *iv)* subsidize gross-output or production. The two latter policy options are in part sector-specific in the sense that tax relief is assumed to be proportional to initial taxation.

45. Table 3 shows that the mitigation policy generates net additional public revenues that are large enough to offset its depressive effect on workers disposable income when the total amount of permit revenues is used to reduce taxes on wage income. Working households actually benefit from this mitigation policy as real net wages increase. In fully flexible labour markets, this alternative recycling option has only distributional consequences, shifting part of the adjustment burden away from working households.[6] 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. 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 taxes on labour and capital are.

Table 3. **OECD-wide ETS: Economic impact of mitigation policies for various recycling options**

In % deviation from the business-as-usual scenario

			Taxes on labour			Household income tax			Capital and labour taxes			Production subsidies		
		Revenues from ETS	Real GDP	Real net wage	Welfare measure	Real GDP	Real net wage	Welfare measure	Real GDP	Real net wage	Welfare measure	Real GDP	Real net wage	Welfare measure
Europe	2015	0.12	-0.02	0.18	-0.02	-0.02	0.01	-0.02	-0.02	0.16	-0.02	-0.01	0.03	0.00
	2020	0.51	-0.12	0.68	-0.08	-0.12	-0.02	-0.08	-0.12	0.56	-0.08	-0.05	0.02	-0.02
	2030	0.92	-0.43	0.74	-0.36	-0.43	-0.34	-0.36	-0.43	0.54	-0.36	-0.26	-0.33	-0.25
OECD	2015	0.15	-0.02	0.16	-0.02	-0.02	0.03	-0.02	-0.02	0.12	-0.02	-0.01	0.02	-0.01
	2020	0.60	-0.13	0.54	-0.12	-0.13	0.02	-0.12	-0.13	0.38	-0.11	-0.10	-0.02	-0.09
	2030	1.04	-0.55	0.36	-0.51	-0.55	-0.41	-0.51	-0.55	0.11	-0.50	-0.48	-0.49	-0.46

OECD, Europe: see Figure 1, notes a) and b). Real net wage, welfare measure: see Table 1, note a) and b).
a) Revenues from ETS are expressed in % GDP and correspond to the policy scenario with lump-sum recycling.
Source: OECD ENV-linkages model.

6. 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.

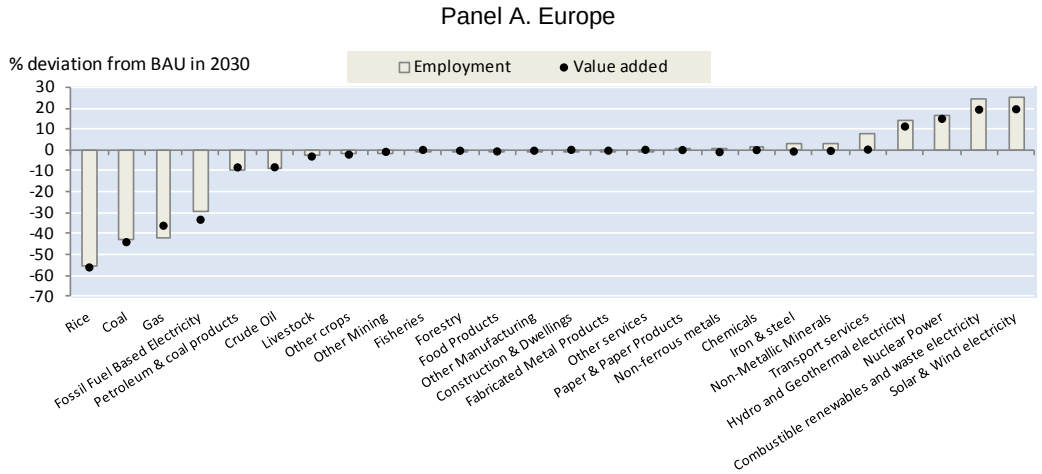
46. These three alternative recycling options do not reduce GDP losses or aggregate welfare costs compared to the lump-sum redistribution presented in Table 2, since labour supply is exogenous and savings are not affected by recycling policies. For these policies to have some implications on GDP and aggregate welfare in this framework, they need to be directed towards producers in order to influence price-setting and offset, at least partially, the rise in marginal costs of production induced by the introduction of climate mitigation policies. And indeed, when ETS revenues are redistributed in the form of production subsidies, the recycling policy has only a small indirect redistributive pattern (through relative price changes) but limits costs to all households by attenuating GDP losses induced by the mitigation efforts. Consequently, this latter recycling option still reduces significantly the magnitude of wage losses compared to the lump-sum redistribution presented in Table 2.

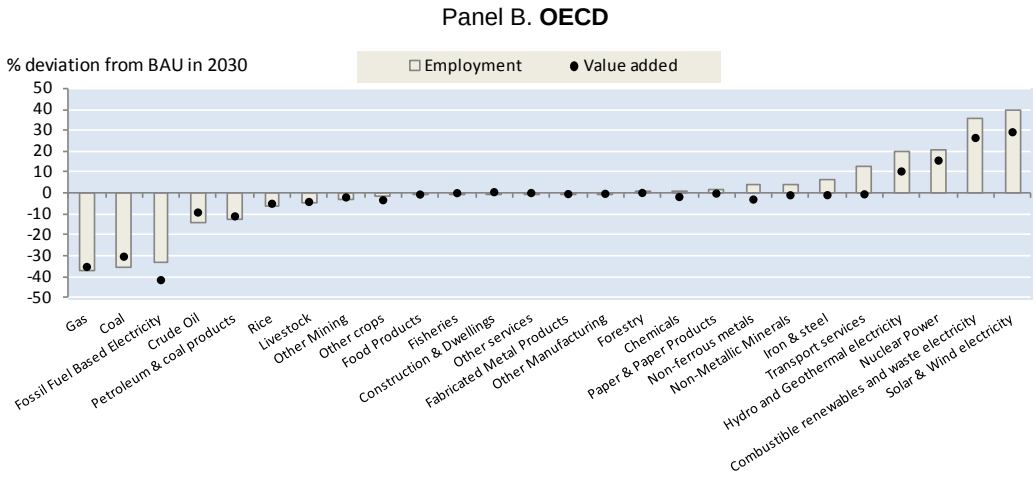
How do mitigation policies affect the sectoral mix of employment and job skill requirements?

47. The transition to green growth will also affect labour reallocation across sectors, which is another source of distributional consequences from these policies. Labour reallocation is an intrinsic feature of all market economies, with large flows of jobs and workers across sectors but especially across firms within each individual sector. These sizeable job and worker flows imply both costs and benefits for firms, individual workers and the whole society (see OECD, 2009b and 2010a). As seen before, mitigation policies are likely to affect this process since the resulting rise in energy prices will translate into changes in relative prices between and within economic sectors.

48. Figure 3 shows how sectoral employment is affected by mitigation efforts in each economic sector considered in the ENV-linkages model. These results are based on the central mitigation scenario, the "OECD-wide ETS" case, and ETS revenues are redistributed towards households, either in the form of lump-sum transfers, or in the form of tax reliefs on labour income (with fully flexible labour markets and rigid labour supply, these two recycling options lead to the same results). The simulation suggests that by 2030 employment in solar and wind electricity sector in Europe and in the OECD area as a whole could be 25% and 40% higher than it would have been in the absence of the climate mitigation policy. By contrast, the fossil fuel and coal mining sectors in Europe and in the OECD area could lose more than 30% of their jobs in Europe, and 35% in the OECD area.

Figure 3. **Change in sectoral composition of employment**





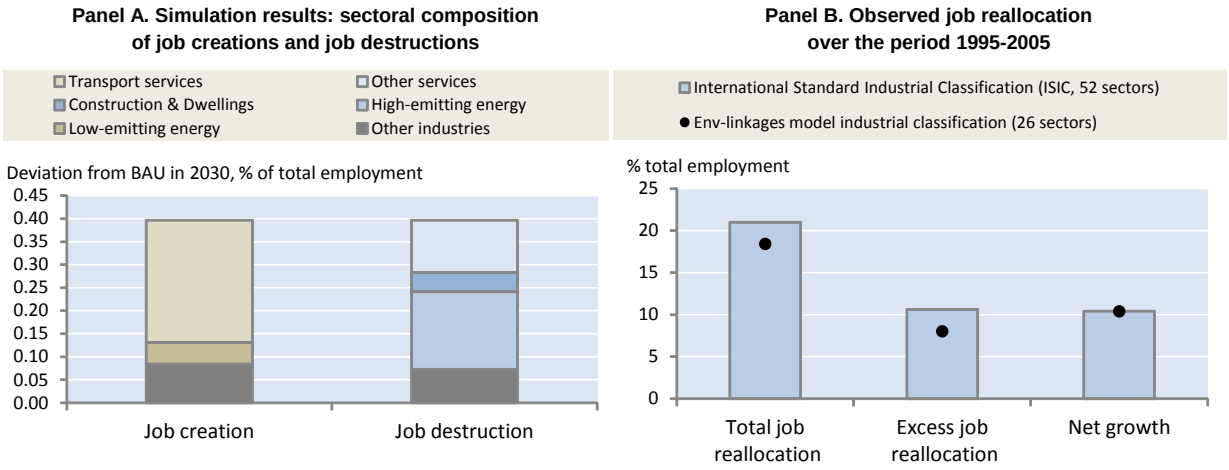
OECD, Europe: see Figure 1, notes a) and b).

Source: OECD ENV-linkages model.

49. Although these expansions and contractions are quite dramatic, they do not translate into a large overall reallocation of jobs, because the heavily impacted industries represent only a small share of total employment (Figure 4, Panel A). Indeed, summing up all sectoral job creations, it appears that jobs created by expanding sectors represent only 0.4% of total employment in the OECD area, and 0.3% in Europe. As national labour markets are assumed to be fully flexible, total employment is not affected by the mitigation policy, hence equalising job destructions and creations at the aggregate level. Therefore, by 2030, the change in the sectoral composition of employment induced by the mitigation policy would affect less than 1% of all jobs in the OECD and Europe. These are quite small numbers as compared to the magnitude of cross-sectoral employment shifts that were observed over the last decade (Figure 4, Panel B). Indeed, over the period 1995-2005, total job reallocation between economic sectors –*i.e.* the sum of sectoral job creation and destruction– accounted for 20% of total employment on average in the OECD area. Of this 20%, only 10% correspond to changes in the sectoral composition of employment for a constant level of total employment, the so-called "excess job reallocation". But even when the model projections for climate mitigation policies examined here are compared with this observed excess job reallocation, they are still small: less than a 1% change over a 18-year period as compared to a 10% change over a 10-year period.

50. Of course, the measurement of job reallocation between sectors is sensitive to the industry classification retained for the analysis. However, Figure 4 (Panel B) shows that the results 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 (3-digit level). This is because most of job creations occurred within the same broad economic sector, namely the service sector (other than transportation), while most of job destructions took place within the manufacturing sector. However, OECD evidence suggests 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, 2010a). But unfortunately, the OECD ENV-linkages model does not allow examining job reallocation within sectors, and therefore, some caveats are needed when considering the magnitude of job reallocations induced by mitigation policies presented in Figure 4.

Figure 4. **Change in sectoral composition of employment compared with historical benchmarks, OECD**



a) High-emitting energy sector: Coal, Crude oil, Gas, Petroleum and coal products, Fossil fuel based electricity.

b) Low-emitting energy sector: Hydro and geothermal electricity, Nuclear power, Solar and wind electricity, combustible renewables and waste electricity.

c) Definitions: *Total job reallocation* = sum of job creation and job destruction; *Absolute net growth* = absolute value of net employment growth (defined as the difference between job creation and job destruction); *Excess job reallocation* = difference between total job reallocation and absolute net growth.

Source: OECD ENV-linkages model (Panel A) and EU KELMS database (Panel B).

51. Although the magnitude of job reallocation between sectors is projected to be quite limited, the sectoral composition of job creation and job destruction reveals interesting patterns (Figure 4, Panel A).[7] Indeed, general equilibrium effects appear to be larger than partial equilibrium effects in that most of job reallocations are projected to take place outside the green and brown sectors. The bulk of job creations take place in the transport services, even though this sector figures among the most polluting industries. First, the demand for transport services is complementary to many other economic activities and, thus, does not fall much although transportation prices increase due to rising energy prices. Second, transport services become more labour intensive due to changes in relative. By comparison, job creations in the so-called "clean energy sector", represent a small fraction of total job creations. And although a large proportion of sectoral job destructions corresponds to the contraction of the so-called "High-emitting energy sector", services other than transportation contribute to total job destruction by a large amount. This can be explained by the fact that the services sector is by far the largest employer, representing around two thirds of total employment.

52. Table 4 provides estimates of how overall skill demand would be affected by the mitigation policy, focussing on changes in skill demand that result from the induced change in the industry composition of employment. The change in overall skill demand is calculated by combining the policy-induced changes in the sectoral composition of employment discussed above with the assumption that the skill profile of the workforce in each sector remains unchanged at the level indicated by currently available data. In light of the relatively small size of the impact of the mitigation policy on industry mix, it is not surprising that the estimated impact on economy wide skill demand is minimal. The transition towards a low carbon economy may, of course, have a significantly larger impact on job skill requirements than is

7 . 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.

suggested by this calculation, which takes no account of possible changes in job skill requirements within sectors due to the progressive adoption of greener technologies and work practices (i.e. it considers only the between industry effect and not the within industry effect).

Table 4. **Change in overall skill demand, Europe** [a]

Deviations from the BAU of three skill indicators in 2030[b]

	Share of workforce:		
	Receiving training[c]	Highly educated[d]	In a high skilled ocupation[e]
Assumption 1			
Employment (thousands)	-15.2	-54.3	-74.6
Share in employment (percentage points)	-0.01	-0.02	-0.03
Assumption 2			
Employment (thousands)	-13.5	-53.0	-74.6
Share in employment (percentage points)	-0.01	-0.02	-0.03
Assumption 3			
Employment (thousands)	n.a.	-52.4	n.a.
Share in employment (percentage points)	n.a.	-0.02	n.a.

n.a. Not applicable.

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) The change in overall skill demand due to mitigation policy is calculated by combining the policy-induced changes in the sectoral composition of employment (as shown in Figure 3, Panel A) with the assumption that the skill profile of the workforce in each sector remains unchanged at the level indicated by data from the European Union Labour Force Survey (EULFS) for 2010. Since the industry coding implemented in the EULFS (i.e. NACE, revision 2 three-digit codes) is not sufficiently detailed to estimate separate skill indicators for the five sub-sectors of the electricity sector contained in the ENV-Linkages model (i.e. fossil fuel based electricity; hydro and geothermal electricity; nuclear power; solar and wind electricity; and combustible renewables electricity), three alternative assumptions were used to estimate skill indicators for these sectors: *Assumption 1* – The EULFS estimates for the total electricity sector are assigned to all five sub-sectors; *Assumption 2* – The EULFS estimates for the total electricity sector are assigned to fossil fuel based electricity, while the four clean energy sectors are assigned the maximum skill indicator values observed for the 22 non-electricity sectors; *Assumption 3* – The EULFS estimate of the highly educated share of employment for the total electricity sector is assigned to fossil fuel based electricity, nuclear power, and combustible renewables electricity; while the share of highly educated workers in solar and wind electricity, and hydro and geothermal electricity is calculated based on data from a survey of renewable energy enterprises in Germany as reported in German Federal Ministry for the Environment, Nature conservation and Nuclear Safety (2011).

c) Workers receiving continuing vocational training during the previous year.

d) Workers who have completed a university-level tertiary degree.

e) High skilled occupations are defined as Legislators, Senior officials and managers and Professionals and technicians and associate professionals (ISCO 1 to 3)

Source: OECD calculations using data from OECD ENV-linkage model, European Labour Force Survey and Germany Federal Ministry for Environment, Nature conservation and Nuclear Safety (2011).

53. All in all, in fully flexible labour markets, mitigation policies would not involve very large changes in the industrial mix of employment or overall skill demand, and mitigation costs are projected to be relatively limited, be they measured in terms of GDP, welfare or wage loss. To what extent would the introduction of labour market rigidities affect these results? 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 immediately adjust to the new economic situation when mitigation policies are implemented.

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

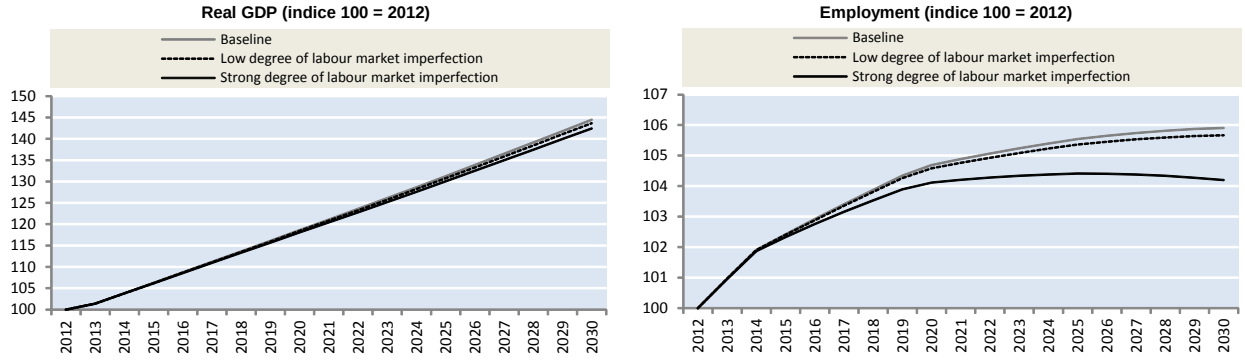
54. The modelling of labour market imperfections in the augmented version of the ENV-linkages model follows the approach adopted by Montgomery *et al.* (2009) for evaluating the economic and employment impact of the American Clean Energy and Security Act of 2009. As empirical evidence suggests that wages do not immediately adjust to economic changes, be they cyclical or structural, the real net wage is set, in each period, in-between: *i*) the real net wage that would be observed in absence of mitigation policies (*i.e.* the wage corresponding to baseline scenario), and; *ii)* the real wage that would be reached if wages fully adjust so that the employment level is not affected by mitigation policies (*i.e.* the market-clearing wage). In other words, workers in the short-run resist the reduction in real wages associated with mitigation policy and thus part of the adjustment is absorbed *via* job losses instead. In the model, temporary shocks have only a temporary effect on employment and wage levels since after the shock, the economy will return progressively to its BAU pathway. However, since the carbon permits are only gradually introduced and become increasingly more stringent over time, mitigation efforts will have a long-lasting effect on employment. While this very simple representation of the labour market functioning summarises some of the main wage rigidities in a qualitative manner while also keeping the model tractable, all numerical results need to be considered with caution since labour market imperfections that may impede adjustment to mitigation policy are much more complex than can be captured in the model.[8]

55. Figure 5 and Table 5 show 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 there is no way to know precisely the degree of wage rigidity that would be relevant for calibrating the wage equation, 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.

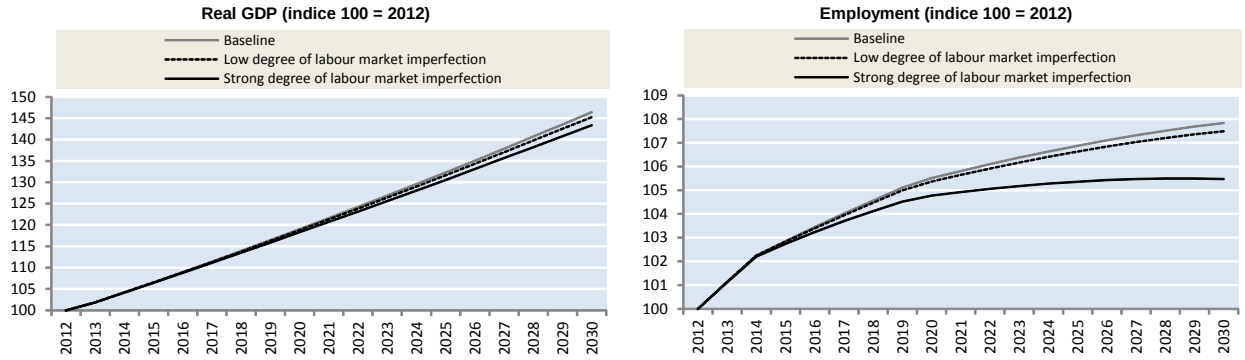
8 . Several other multi-country CGEs that recently have been extended to include labour market imperfections and how they affect the transition costs created by climate change mitigation policy include the GEM-E3 model (Capros et al., 2007 and Commission of European Communities, 2008) and the WorldScan model (Boeters et al., 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 reflects workers' bargaining power (or alternately, efficiency wage considerations or matching frictions in the case of the GEM-E3 model — results in variable amounts of unemployment and may also influence labour supply. Whereas the approach adopted in this report focussed on potential "stickiness" in the adjustment of the labour market to the structural shocks caused by mitigation policy, these earlier studies focussed on 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.

Figure 5. **GDP and employment impacts for different degrees of labour market imperfections, when ETS revenues are recycled in the form of lump-sum transfers**

Panel A. Europe



Panel B. **OECD**



OECD, Europe: see Figure 1, notes a) and b).

Source: OECD ENV-linkages model.

Table 5. **Economic impact of an OECD-wide ETS for different degrees of labour market imperfections, when ETS revenues are recycled in the form of lump-sum transfers**

In % deviation from the business-as-usual scenario

		Real GDP		Employment		Real wage		Welfare measure	
		Low rigidity	Strong rigidity	Low rigidity	Strong rigidity	Low rigidity	Strong rigidity	Low rigidity	Strong rigidity
Europe	2015	-0.03	-0.08	-0.02	-0.09	-0.10	-0.03	-0.04	-0.10
	2020	-0.18	-0.45	-0.10	-0.54	-0.52	-0.17	-0.17	-0.58
	2030	-0.57	-1.41	-0.23	-1.62	-1.17	-0.52	-0.58	-1.88
OECD	2015	-0.04	-0.10	-0.03	-0.12	-0.11	-0.03	-0.04	-0.13
	2020	-0.23	-0.62	-0.13	-0.70	-0.53	-0.18	-0.25	-0.80
	2030	-0.78	-2.09	-0.32	-2.19	-1.30	-0.56	-0.83	-2.68

OECD, Europe: see Figure 1, notes a) and b).

Source: OECD ENV-linkages model.

56. Overall, the simulations indicate that the mitigation policy has a limited impact on economic growth. Even in the worst-case scenario, under very strong labour market imperfections, economic growth is only slightly affected by the introduction of carbon permits. In the OECD area as a whole, real GDP increases by around 43% over the period 2012-2030, as compared to 46% in the absence of mitigation actions. And in Europe, the pace of economic growth is reduced by two percentage points, as compared to a GDP increase of 44% over the 2012-2030 in the baseline scenario.

57. The resulting slowdown in job creation can be much more pronounced, however. Mitigation costs increase with the degree of labour market imperfection, as structural distortions, *ceteris paribus*, reinforce the deadweight losses associated with a given carbon price. In Europe, employment declines by 0.2% from baseline levels in 2030 in the best-case scenario, and by 1.6% in presence of strong wage rigidities. Similar outcomes are projected for the OECD area as a whole. In both regions, the worst-case scenario represents a strong deficit in job creation. Indeed, the mitigation policy reduces substantially the pace of employment growth over the period 2012-2030, from 7.8% to 5.5% in the OECD, and from 5.9% to 4.2% in Europe. However, this scenario is most likely to be overly pessimistic as it assumes very strong wage rigidities than are unlikely to persist over a 18-year period.

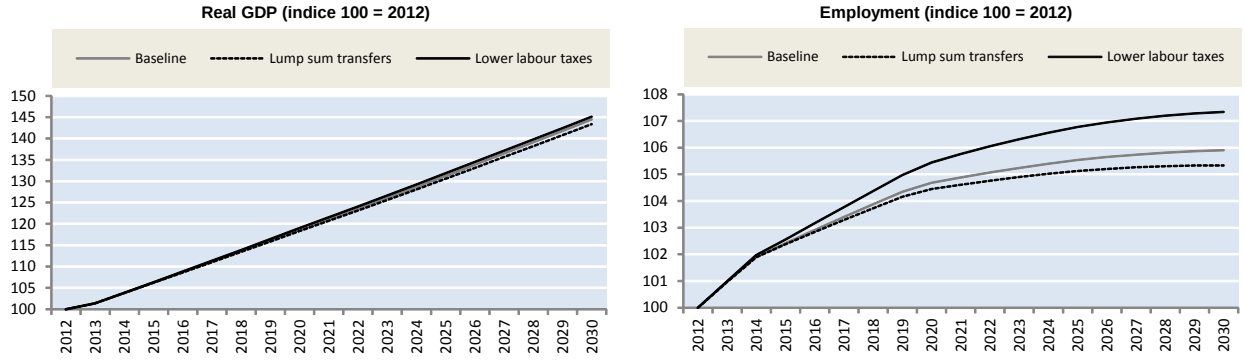
58. Moreover, as is the case for most available CGE models developed for the economic analysis of mitigation costs, the ENV-linkages model has two limitations which tend to overstate the long-run cost of mitigation policies: *i)* technological progress is assumed to be exogenous, so that the model does 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, certain employment gains (or avoided job losses) induced by the mitigation policy are not captured in the modelling framework. These characteristics are, however, less important when attention is focussed on the coming two decades, as innovation and climate changes are slow processes.

59. Last but not least, the employment impact of mitigation policies crucially depends on how ETS revenues are redistributed. This is illustrated in Figure 6 and Table 6, which compare two recycling options when the degree of labour market imperfection is set to an intermediate level (40% of the decline in the market-clearing wage rate is absorbed by workers immediately). When permit revenues are used to reduce taxation on labour, the pace of employment growth would accelerate, and this, without any loss of purchasing power for workers. OECD employment would increase by 7.3% over the period 2012-2030, against 5.9% in absence of mitigation actions. In Europe, the migration policy boost job creation even more substantially: employment increase by 7.3% over the period 2012-2030, against 5.9% in the baseline scenario. In turn, this positive impact on employment could temporarily raise GDP levels above the baseline projection.[9]

9. The positive employment impact reduces over time because the rising deadweight-loss associated to carbon pricing will offset the recycling effects on labour taxation in the long run. In the modelling scenarios examined here, mitigation efforts –and thus corresponding carbon prices– are increasing over time and they progressively impact capital accumulation. Carbon pricing raises energy prices, and hence, the user cost of machinery and other physical capital since energy and capital are complementary inputs. This, together with the reduction in real GDP, lowers investment, but capital stock takes time to adjust. As seen before, this also puts a downward pressure on labour demand through the induced increase in marginal costs of production, and in the long run, when capital stock has fully adjusted downward, through the resulting decrease in labour productivity. On the other hand, as the relative price of labour inputs decreases, firms will tend to substitute employment from other more expensive production factors, which tend to raise labour demand. This positive substitution effect can dominate in the short and medium run as the capital stock adjusts slowly over time thus leaving labour productivity almost unchanged.

Figure 6. **GDP and employment impacts for different recycling options of ETS revenues, and an intermediate degree of labour market imperfections**

Panel A. Europe



Panel B. **OECD**

OECD, Europe: see Figure 1, notes a) and b).

Source: OECD ENV-linkages model.

Table 6. **Economic impact of an OECD-wide ETS for different recycling options of ETS revenues, and an intermediate degree of labour market imperfections**

In % deviation from the business-as-usual scenario

		Real GDP		Employment		Real wage		Welfare measure	
		Lump sum transfers	Lower labour taxes	Lump sum transfers	Lower labour taxes	Lump sum transfers	Lower labour taxes	Lump sum transfers	Lower labour taxes
Europe	2015	-0.05	0.07	-0.04	0.14	-0.08	0.18	-0.06	0.15
	2020	-0.26	0.33	-0.22	0.72	-0.43	0.96	-0.28	0.73
	2030	-0.76	0.43	-0.54	1.35	-1.04	1.85	-0.87	1.09
OECD	2015	-0.06	0.06	-0.05	0.12	-0.08	0.11	-0.07	0.09
	2020	-0.34	0.26	-0.29	0.59	-0.44	0.54	-0.40	0.44
	2030	-1.08	-0.03	-0.75	0.80	-1.14	0.76	-1.26	0.24

OECD, Europe: see Figure 1, notes a) and b).

Source: OECD ENV-linkages model.

60. These simulation exercises illustrate how certain policy mixes can improve both environmental and labour market performance. They also show that both the quality of labour market institutions and the

redistribution of permit revenues need to be addressed together by policy-makers in order to reap the full potential benefit of climate change policies in terms of job creation. These conclusions are in line with many other studies analysing the employment impact of mitigation actions within the framework of a CGE or hybrid model (cf. Section 2 above). An important issue that is not explored in these simulations is whether using the permit revenues to subsidise eco-innovation (*e.g.* R&D in renewable energy) would have a larger, if more indirect, effect in raising employment and GDP than would using these revenues to lower labour taxes. Recent modelling studies that endogenise R&D activities and technological change confirm that this can be the case (Cambridge Econometrics *et al.*, 2011; ICCS/NTUA, 2010).

B. Direct impacts on employment and skill requirements in key winning and losing sectors: lessons from partial equilibrium analysis

61. The general equilibrium approach just discussed 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, such as the presumption that green growth will not lead to a significant increase in total employment unless the environmental measures in question also remedy a market failure depressing employment below its optimal level. Or, if these measures are combined with other measures that do so, such as a reduction in labour taxation. This observation also underlies the importance of how the revenues from a carbon tax are recycled for determining both the size of the GDP and employment impacts of mitigation policies and the distribution of mitigation costs. However, the general equilibrium approach also has important limitations as a guide for making labour market and skill development policy choices, at least at the current level of knowledge. One of the biggest limitations of general equilibrium models currently 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.

62. Partial equilibrium analysis that focuses on key sectors or workforce groups can help to overcome these limitations. It thus represents an essential complement to general equilibrium analysis when analysing how labour market and skill development policy can best support an efficient and fair transition to green growth. This section takes a partial equilibrium approach to analysing the labour market adjustment pressures and skill development needs, focusing first on the segments of the labour market that will be most intensely affected by a transition to green growth: green sectors which are likely to experience rapid growth (Section1) and brown sectors which are likely to shrink or profoundly re-engineer their production processes (Section 2). Sections 3 and 4 then provide a novel analysis of how eco-innovation is reshaping employment patterns in Europe, a crucial issue that has thus far received little attention from researchers. Two important issues to be addressed are which industries are most engaged in innovation activities related to environmental technologies and how eco-innovation is affecting firm-level performance indicators such as employment levels, skill demands and export orientation.

1. Green jobs: emerging employment opportunities and emerging skills requirements

How many green jobs will be created?

63. Despite all of the uncertainty, it can confidently be predicted that the transition to a low-carbon and resource efficient economy will require 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 3). Indeed, the most widely cited definitions imply widely different estimates of the share of total employment that represents green jobs. 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 et al., 2007). This variation reflects different judgments about the appropriate criterion for 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 either lack access to the most sophisticated green technologies or the capacity to apply them effectively.[10]

Box 3. **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 products 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 of green jobs account for 2% of total employment in the EU area (EC, 2009). The US Commerce Department (2010) has implemented a similar approach and concludes that green jobs account for between 1.5% and 2% of total employment in the United States.

- 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, 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 Annex 1 for more details than are provided here). Of the 25 countries whose responses to an OECD questionnaire on green jobs have been analysed, 10 have adopted a definition of green jobs, 4 are in the process of developing a definition and 11 have yet to take a decision to define and count green jobs (see Annex 1 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) has recently announced that it will use two different approaches to measuring green jobs: (i) an *output approach,* which identifies business establishments that

10 . It is sometimes argued that employment needs to exceed minimum job quality or social sustainability 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 somewhat unclear whether this is part of the 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 production activity may be low quality jobs (e.g. low-paid, insecure and dangerous work such as much disassembly of obsolete ships and ICT equipment in South Asia).

produce green goods and services and then counts all of the jobs in these establishments; and (ii) a *process approach* which identifies business establishments that use environmentally friendly production process and practices and counts only the jobs associated with these processes as being green jobs. The first approach is a variation on an already common approach that relies on the nature of the product or service produced, but differs from industry-based definitions because the share of establishments within an industry that are classified as producing green goods and services can range from 0-100%. The second approach is even more of a departure because it allows for the fact that some workers in firms that produce products that have a large environmental footprint may nonetheless have green jobs (*e.g.* pollution control workers in a steel mill). Similarly, some workers in green industries may not be classified as holding green jobs (*e.g.* clerical workers in a firm that manufactures wind turbines). The BLS will publish its first estimates of the numbers of green jobs using these definitions in 2012.

64. 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.[11] 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 and head off 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 is also shown to be useful for assessing skill development needs in the emerging green economy (see ILO 2011 for an excellent survey of many studies taking this approach).

65. An increasing number of studies put forward the large 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 of people were employed worldwide in the renewable energy sector (UNEP/ILO/IOE/ITUC, 2008).[12] 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: large developing countries have also undertaken large-scale initiatives; even though these countries still contribute heavily to worldwide CO2 emissions (see Box 4). UNEP (2011b) updates its estimate of worldwide employment in durable energy to more than 3 million workers in 2009. Nonetheless, this is still a very small share of total employment. China has the most workers in renewable energy (1.1 million), but that represents only about 0.1% of total employment, a share that is somewhat higher in a few EU countries (*e.g.* 0.7% in Germany and 0.8% in Denmark).

66. While renewable energy only accounts for a small share of total employment, this sector is growing at a rapid pace. IEA (2011) makes use of data on renewable energy output growth between 2005 and 2009 in 56 countries, including all of the OECD countries and several large emerging economies, and confirms rapid growth rates during that period despite the global economic crisis. Growth was especially fast for newer technologies, such as wind and solar photovoltaic, and the IEA predicts continued strong growth due to rapidly declining production costs for many of these technologies. However, it is still the case that hydro accounts for the largest part of renewable electricity generation (86%) and the absolute growth of hydro power during 2005-09 was approximately equal to the combined growth for the newer

11 . For policy purposes, it may not be particularly important to identify the best definition of green jobs, since expanding the number of green jobs is not, in and of itself, a reliable indicator of progress in achieving green growth. The ultimate policy goals related to green jobs are improved environmental outcomes (e.g. lower emissions and the protection of biodiversity) and improved labour market opportunities (e.g. high employment rates and wages). An increase in the number of green jobs is not a reliable indicator of progress in either area, although it often will be a useful indicator for other purposes, as is discussed in the main text.

12 . Given the gap in employment information, the report notes that this is undoubtedly a conservative figure.

technologies, largely due to a significant expansion of hydro capacity in China. Another important caveat is that most of the growth in newer forms of renewable energy has occurred in a relatively small number of countries.

Box 4. **Developing green activities and jobs: large-scale initiatives in China**

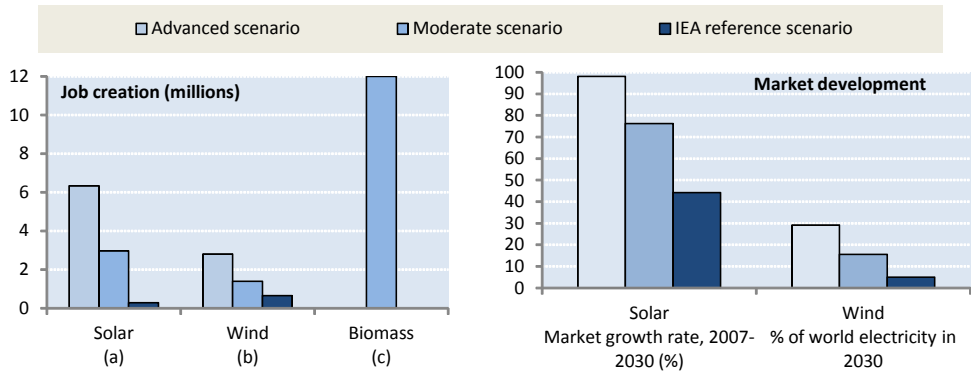
While the primary source of energy in China is coal, the development of renewable energy is a fundamental part of China's national strategy (ILO, 2011). Concerns about energy security, power capacity shortages, air pollution and climate change have all motivated a decision to place greater emphasis on raising energy efficiency while progressively switching to alternative technologies and fuels, including "clean coal" technologies, nuclear power, and renewable energy. As a result, the Chinese government took a number of policy initiatives: a renewable energy law was passed in 2005 and a plan was set in 2007, which put forward guiding principles, objectives, targets and measures for the development of renewable energy in China up to 2020. During the period 2006-2008, 12 detailed regulations for promoting renewable energy development were passed. And in 2008, total investment in renewable energy by China was ranked the highest in the world (Martinot and Junfeng, 2007). In addition, China's stimulus package included the largest green stimulus programme enacted by any country, accounting for almost 40% of the total USD 586 billion package (OECD, 2010*a*). Although there are no systematic surveys or other firm statistics indicating the number of people employed in the renewable sector, the Energy Research Institute and the Chinese Renewable Energy Industries Association have estimated that close to one million people in China are currently employed in the wind, solar PV, solar thermal, and biomass industries (UNEP/ILO/IOE/ITUC, 2008).

67. Employment growth in the renewable energy sector is projected to be impressive for the coming decades. The UNEP report 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. Likewise, Fraunhofer ISI *et al.*, (2009) estimate that EU target for the share of renewables in total energy consumption to attain 20% in 2020 could create more than 2 million jobs, while Wei et al. (2010) estimate that implementing a 30% renewable portfolio standard (RPS) together with aggressive energy efficiency measures would expand US employment in the energy sector by 4 million jobs in 2030.

68. As Figure 7 shows, these various employment estimates are quite sensitive to the assumption made regarding the expansion of renewable energy markets. They are also in constant need of updating as economic conditions and policy stances change. For example, EC (2010*b*) estimates the employment impact of implementing the "high pledge" from the climate change conference in Copenhagen in 2009 and concludes 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 production, transformation and commercialisation process of renewable energy sources. Most importantly, however, these estimates represent the potential for *gross* job creation but do not take account of the fact that renewable energies will develop, to a considerably extent, at the expense of more polluting energy sources. In other words, the transition toward green growth will produce new opportunities for workers, but also potential adjustment difficulties.

Figure 7. **Projected 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): 10 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/ITUC (2008).

69. A number of detailed studies of the restructuring of the energy sector towards a cleaner energy-mix have concluded that *net* employment gains will result for energy-related activities.[13] This is because the renewable energy sector generates more jobs per megawatt of power installed, per unit of energy produced, and per dollar of investment, 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 thousand jobs (against less than 90 thousand jobs in a scenario without renewables). Therefore, the winners would clearly outnumber the losers. In a similar vein, a study supported by the European Commission suggests that, summing up employment gains and losses in energy-related activities, nearly 1.4 million jobs could be created in Europe under the current policy –*i.e.* the 20% target for renewable energy by 2020 (MITRE, 2004).

70. Overall, the bulk of studies examining the direct employment impact of greening the economy conclude that a shift away from conventional energy sources could lead to substantial net employment gains. As both the *direct* and *induced* labour requirements for the various energy technologies are reasonably well known, these studies provide reliable estimates of the employment content of a given energy-mix across the entire supply chain of production. [14] However, these are only the "first-round" net employment impacts. In most cases, these studies do not fully account for the "second-round" effects of a change in energy-mix: for instance, they usually do not model the policy drivers of this change and

13 . Considerable work has been done on the employment impact of mitigation actions in the energy sector. See work by Kammen *et al.* (2004), Pearce and Stilwel (2008) and IEA (2009).

14. For example, the task of installing wind turbines is a direct job, whereas manufacturing the steel that is used to build the wind turbine is an induced job.

therefore, they do not fully capture the full macroeconomic impact of environmental policies, unlike the studies using a general equilibrium approach (*cf.* Section A above). The general equilibrium approach thus seems most reliable for assessing the impact on total employment of green initiatives, such as shifting the energy sector towards greater reliance on renewable sources. By contrast, sectoral analysis provides a finer grained picture for the types of new jobs being created. For example, the American Solar Energy Society argues that job growth in the renewable energy and energy efficiency industries is biased towards technical, scientific, professional, and skilled staff, and the wind energy is considered a reliable job creator for both skilled and unskilled workers by the European Wind Energy Association (Wei et al. 2010).

71. Similar, but generally less detailed analyses, have been conducted for a number of other green sectors — for example, green ICT as analysed in OECD (2010f) — or recent green policy initiatives — for example, green fiscal stimulus packages enacted in response to the 2008-2009 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). This type of information is clearly helpful for providers of career guidance counselling/job search assistance or vocational training, both public and private. However, it should be borne in mind that the number of potential placements in green jobs is only a small share of total hiring and job vacancies. Accordingly, the main barrier to being able to adequately meet the recruitment needs of growing green sectors is more likely to take the form of a mismatch between the skills of the available labour supply and the skill requirements of green jobs, rather than an overall shortfall in labour supply.[15]

What skills will green workers need?

72. Working together with the European Union and many other partners, the ILO has recently completed a major series of international studies of the skill requirements of green jobs which have provided a much needed overview that had heretofore been lacking (ILO, 2011a; along with CEDEFOP and ILO, 2010a; ILO, 2011b,c,d). Another valuable source of information about the emerging skill requirements of green jobs are from public labour market information (LMI) systems, especially those structured so as to support guidance counselling, public employment services and other labour market actors. For example, the US Department of Labor (DOL) is making a major effort to collect better information about emerging green occupations, including pay levels, working conditions and the skills required by those jobs.[16] Information about green jobs and their skill requirements, and how green technologies and production practices are changing existing occupations, is also 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.[17] The O*NET system is tracking 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). The top-down data collection being undertaken by the BLS and ETA is complemented by a more bottom-up approach undertaken by many states. About one-third of state workforce development agencies have undertaken surveys, statistical analysis and other research to obtain information on green jobs, potential growth in these jobs and their skill requirements which can be integrated into existing LMI systems (NASWA, 2011).

15 . Local shortages in labour supply could be important especially in the context of large green economy investments in remote areas. Similarly, there is likely to be considerable spatial mismatch between workers dislocated from declining brown sectors and new job vacancies in growing green sectors.

16 . For example, BLS (2010) provides a detailed assessment of the occupational profile of the wind energy sector, including job qualifications and median wages.

17 . The O*NET database include detailed information about more than 900 occupations, including the nature of the work performed, working conditions, wages and job skill requirements.

73. A first finding is that green jobs, both new green specialties such as energy auditors and existing occupations that have been modified to be greener, are very diverse in their skill requirements. This is true both in terms of the overall levels of skills required by these jobs and in how novel these skills are as compared to familiar occupational requirements for which training pathways are already established. This diversity is illustrated by the summary sketches of selected green occupations in Table 7.[18]

74. Perhaps the most important finding from the point of view of labour market 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, most of which are familiar but some of which are novel and directly related to the green character of the production activity (ILO, 2011a). Some green sectors are characterised by intense innovation, implying that the generic skill requirements are somewhat higher overall than for similar occupations in other parts of the economy where workers are less called upon to adapt to new technologies. However, this is not true for all green jobs.

75. The specific vocational skills that green jobs require typically overlap to a large extent with those used in 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 ways of working.[19] 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. However, some emerging green occupations do appear to require new educational or training pathways, although they often take the form of emerging sub-specialties within long-standing disciplines, such research and engineering positions in the renewable energies sector or systems analysts who develop ICT supports for "smart power grids."[20]

Table 7. **The skill profile of green occupations and greening occupations: Illustrative examples**

Occupations	Growth profile	Skill profile	Policy challenges and initiatives
Recycling & Waste management (continued development of long-established sector)			
Waste sorting and reception	Long-established occupation	Low qualification (minimal on-the-job training)	Low job quality and health risks are main concerns, not skill deficits
Recycling and waste technician; waste-recycling operator	Long-established subsector	Vocational qualification	In France: general certificate of vocational qualification ("Certificat de Qualification Professionnelle"); in Germany: dual apprenticeship training ("Duale Berufsausbildung") The number of take-ups falls short of satisfying demand for technicians
Hazardous waste management specialist	Growing demand expected in medium and	Medium and high level	Indentified shortage of qualified workers in Spain in the medium term

18 . The entries in this table summarise findings reported in the CEDEFOP and ILO studies already cited, along with a number of other studies.

19 . Similarly, initial occupational training is typically best provided via traditional training and apprenticeship programmes where the curriculum has been enriched to incorporate green elements. Experience in Germany has also shown that many secondary students are reluctant to take up specialised environmental apprenticeship 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 & ILO, 2010b).

20 . Even in specialized subsectors like renewable energy and energy management, CEDEFOP (2010) argues that an effective revision and upgrade of the skills of existing workers can fill most skills gaps adequately.

Occupations	Growth profile	Skill profile	Policy challenges and initiatives
	long run due to tighter regulations		
Sustainable design manager, recycling and reclamation engineer, coordinator of recycling activities, regulatory program compliance officer	Rising longer-term demand from other sectors (*e.g.* manufacturing) and tighter regulations	High-level skills to address organizational sustainability issues, to embed recycling, reuse and remanufacturing in products' design	Role for new professional development tracks in tertiary education
Transportation (increase energy efficiency and/or reduce the environmental impact of various modes of transportation)			
Specialized technicians of fuel cell batteries, automotive maintenance technicians	Introduction of renewable and cleaner fuels for transportation	Low to medium level for installation and maintenance	Uncertainty about which fuels for transportation will eventually mainstream
Railroad conductors, locomotive engineers, truck and bus drivers	Greening existing occupations	"Topping-up" existing skills	
Automotive engineers, freight forwarders, fuel cell engineers, logistics analysts, logistics engineers, logistics managers, supply chain managers, transportation engineers and transportation planners	Reorganisation and the re-engineering of the transportation systems	Medium and high level skills, combined with sector-specific, pre-existing medium and high-level competencies	Best candidates could be incumbent employees with retraining to get needed skill mix, but with a substantial retraining process for some occupations and a role for new professional development tracks in tertiary education
Vehicle manufacturing (energy-efficiency, waste and product lifecycle management, shift of business model from products to services)			
Engineering technicians, welders, transportation equipment painters, metal fabricators, computer-controlled machine operators, engine assemblers, and production helpers	Greening production techniques for vehicles components	Low to medium general skills with medium job-specific skills	Close integration of industry and education. In the UK North East's Low Carbon Economic Area (LCEA): creation of the National Training Centre for Sustainable Manufacturing
Computer software engineers, electrical engineers and operations managers	Changes in production methods and business models	Medium and high	Low Carbon Future Leaders Graduate Placement Scheme placing recent university graduates in the UK
Applied researchers, fundamental researchers	Development of future technologies	High	National Low Carbon Vehicle Research and Development Centre in the UK
Mining and extractive industry (shrinking the environmental footprint)			
Operators of heat coproduction, Geospatial Information Technologists	Upgrading core technologies	Medium	Eesti Energia developed training programmes for current and new employees
Geospatial Information Scientists and Technologists, managers for heat coproduction, energy auditing, and technology developers and managers	Supply chain re-organization, and upgrading management practices	High level for development of new technologies and production re-organization	Estonia revised and coordinated higher-education programmes in mining
ICTs (green applications of ICT)			
"Smart" grids specialists, "smart" buildings specialists, database administrators	Rapid growth projected for "smart" ICT applications to raise energy efficiency (*e.g.* "smart" grids, transport systems, buildings)	Medium and high	Cross-sectoral demand, with using sectors subcontracting to ICT service providers
Precision agriculture and biomass farming technicians	Increasing application of geographic information systems to agriculture and forestry production, and the management and construction of buildings	Medium and high, mixed with skills for gathering and interpreting physical topography data	

76. 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 and Box 5 for more detail). Other examples of skill shortages 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 in Denmark (Cedefop and ILO, 2010). However, it is difficult to assess how general and severe these green skill shortages are based on evidence from highly diverse case studies. Recent OECD work has shown that small and medium sized enterprises (SMEs) face particular challenges in upgrading or adapting their workers' skills to meet emerging job skill requirements associated with green growth (see Box 6).

Box 5. **Bottlenecks in Ecobuilding: A French case study**

France has experienced a shortage of qualified trainers in the eco-building sector since 2009, despite a number of recent national, regional and private sector initiatives to expand the supply of trained eco-building technicians. The Bourgogne region set up a vocational training programme for eco-building and eco-renovation in 2009.[1] The Champagne Ardenne region has set up a programme that introduces building entrepreneurs and professionals to the latest technologies and regulations about retrofitting and energy diagnosis over a few days. The "Provence-Alpes-Côte d'Azur" region has developed specific trainings for eco-building and renewable energy installations in buildings. Bretagne has financed a vocational training (CAP) for eco-building. It has used the joint national-regional funding contracts dedicated to employment and training actions (Groupement d'Intérêt Public Relation Emploi Formation) to specifically subsidize its network of public training centres (Groupements d'Établissements, GRETA).

But qualified trainers are scarce and hiring them has proved problematic in numerous cases. At the national level, the lack of qualified trainers was identified as a challenge as early as 2008.[2] The national initiative for training for building retrofitting EnergieBAT, set up by the "Agence de l'Environnement et de la Maîtrise de l'Energie" (ADEME, a public agency jointly supervised by the ministries for education and environment) and a public-private joint-venture "Club de l'Amélioration de l'Habitat", similarly lacked trained trainers to staff its programmes.[3] In the Rhône-Alpes region, the public funds needed to train trainers have not been provided by the local branch of national ministries for employment and for economy (DIRECCTE), but the action does not fit in the plan of budget of the regional authorities.[4] The lack of trainers was identified as a bottleneck preventing firms from meeting rising demand on the eco-building market, jointly with the lack of qualified on-the-job supervisors to oversee the implementation of eco-building techniques inside firms.[5]

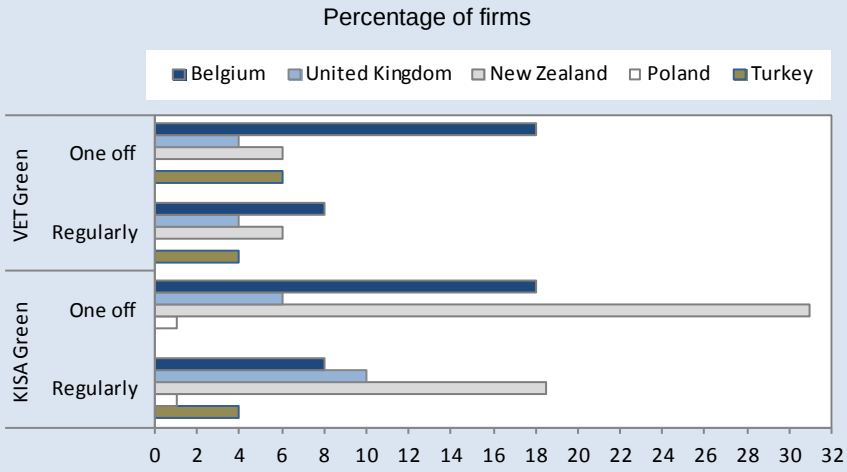
1. AFP, Visa competence (http://www.afpa.fr/fileadmin/media/Visuels_AFPA/Visa_competence/Magazine_n_9/PDF/En_direct_des_regions.pdf).
2. Assises Nationales de la Formation à l'EcoConstruction, 2008.
3. CEDEFOP & ILO, *Skills for green jobs in France*, 2010.
4. DIRECCTE Rhône-Alpes, Impact du développement durable sur l'évolution des métiers et des formations dans le BTP et les énergies renouvelables en Rhône-Alpes.
5. Maison de L'emploi, Conjoncture Septembre 2009.

Box 6. **SMEs face particular difficulties in accessing green training**

OECD research suggests that the overall labour market adjustment to green growth is taking place at a slow pace, at least until now, with few jobs already transformed or new or different staff recruited to meet green product demands or implement greener production processes (OECD, 2012b). However, greening the economy is likely to quicken and seizing opportunities along the transition will require profound transformations of occupational profiles and business operations (OECD, 2010g). Since SMEs account for approximately 99% of all enterprises and two thirds of employment across the OECD area, their adaptation to environmentally sustainable practices, in both manufacturing and services, is a key to a successful transition to green growth.[1] It is of concern that most SMEs appear to have little awareness about the future needs for new green skills and their investments in green training and knowledge-intensive activities are very limited (OECD, 2010e, 2012a)..

The OECD surveys on "Leveraging Training and Skills Development in SMEs" (OECD, 2012a) and "Climate Change, Employment and Local Development" (OECD, 2012b) find low levels of awareness of the need to up-skill employees as part of a strategy to green products and production. This is reflected in SME training activities. The figure below show that employee participation in green Vocational Education and Training (VET) programmes operated by firms and informal green knowledge intensive service activities (KISA) is quite low, with green KISA being more frequently used by firms as a way to acquire knowledge than traditional forms of VET (OECD, 2012a). The limited availability of green training services in the market and the difficulties for VET firms and trainers to design curricula that are relevant for SMEs in their adjustment process probably play a role in explaining low participation. It appears that SMEs face important obstacles to accessing training, but that informal knowledge intensive activities offer more flexible access to the knowledge required by firms to take advantage of green opportunities arising in the market.

Participation rates in green training tend to be quite low for employees in SMEs



Source: OECD (2012a).

1. The transition towards green growth is likely to be particularly demanding in manufacturing firms, including SMEs, as they account for a large part of the world's consumption of resources and generation of waste. Worldwide, the energy consumption of manufacturing industries grew by 61% from 1971 to 2004 and accounts for nearly a third of the global energy usage. Likewise, manufacturing industries are responsible for 36% of global carbon dioxide (CO_2) emissions (IEA, 2007).

77. Zabin *et al*. (2011) is a particularly valuable study because it brings together a detailed empirical analysis of emerging green skill demands with an analysis of the available skill supply, so as to identify skill gaps and strategies for closing them. This study provides an in-depth assessment of the skill demands resulting from the state of California's ambitious energy efficiency and GHG abatement goals. It is shown that meeting these goals will require a significant expansion of certain types of green employment; with the largest hiring needs being for several construction occupations that are required to build new energy efficient buildings and retrofit existing buildings for greater energy efficiency. A particularity of the

California labour market at the time that the study was conduct is that it was in a deep recession which had occasioned very large employment losses in the construction sector. Due to the high numbers of unemployed construction workers, the report concludes that almost all of the workers required to realise the energy efficiency and GHG abatement goals could be recruited from local workers who already have most of the required skills, but may need some top-up training in energy efficient construction methods. While this finding is strongly influenced by the specific conditions prevailing in the regional labour market at the time that an ambitious mitigation programme was launched, and similarly ambitious green growth initiatives elsewhere may require a larger vocational training component or efforts to recruit workers from other regions, this study does nicely illustrate that job skill issues are best analysed by considering both demand and supply.

2. Brown jobs: structural adjustment pressures in the most polluting industries

78. Even as a transition toward green growth stimulates the expansion of employment in environmentally beneficial activities, employment losses will tend to occur in the sectors with the largest adverse environmental impacts. For example, a tax on CO2 emissions will lead to expanded employment in the renewable energy sector, but also to employment losses in the extraction of fossil fuels and their use in generating electricity. These employment losses may be reduced or even avoided if major changes in production technology can be introduced that reduce harmful environmental impacts (*e.g.* carbon capture and storage), but this would still be likely to imply that the industry's workforce will face structural adjustment pressures. More generally, the most polluting industries can be affected in two ways as carbon taxes increase: *i*) carbon taxes will tend to raise the relative price of the most polluting goods and services, decreasing product demand and causing employment in the corresponding industries to contract; and *ii*) although this downward pressure on employment could be partly overcome by technological progress reducing the CO2 emissions intensity of these industries, adapting the production process to the new cleaner technologies could create significant adjustment costs for workers in the sector.

Which are the most polluting industries?

79. In many cases, the "brown" jobs put potentially at risk by green growth policies are easier to identify than the new green jobs that will be created and may, thus, carry particular weight in political decisions relating to green growth policies. Whereas green activities are still at an early stage of their development and it is difficult to predict which will be large sources of employment in the future, historical data are available on sectoral CO2 emissions and it is thus straightforward to identify the most polluting sectors and assess their importance as employers.

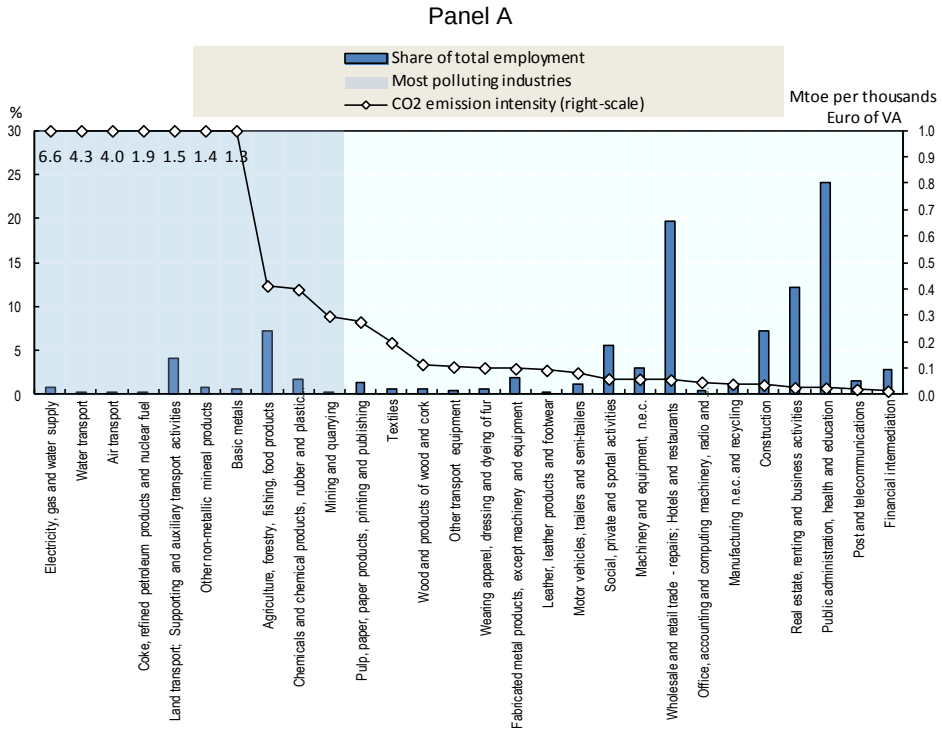
80. Industries characterised by a relatively high ratio of CO2 emissions to value added (or gross output) generally will be more subject to adverse employment effects from carbon taxes than industries with a relatively low intensity of CO2 emissions.[21] Nonetheless, there is considerable uncertainty about the quantitative and qualitative impact of policy measures to lower GHG emissions on labour demand in the most polluting industries (*e.g.* whether greener technologies that are adopted in these sectors will be more or less labour-intensive and/or skill-intensive than the technologies they replace). These impacts will also be affected by the detailed design of the carbon pricing mechanism (*e.g.* how emissions permits are allocated). Finally, the impacts on employment may be shifted from the high CO2 emitting industry to supplier firms in a different industry. For example coal mining jobs will be lost as renewable energy sources are substituted for fossil fuels in electrical generation. Despite these caveats, CO2 emissions

21 . A recent study by the Institute for International Labour Studies at the ILO adopts a similar strategy to identify labour market segments that will face particularly intense restructuring pressures and reaches similar results to those reported in this section (IILS/ILO, 2011).

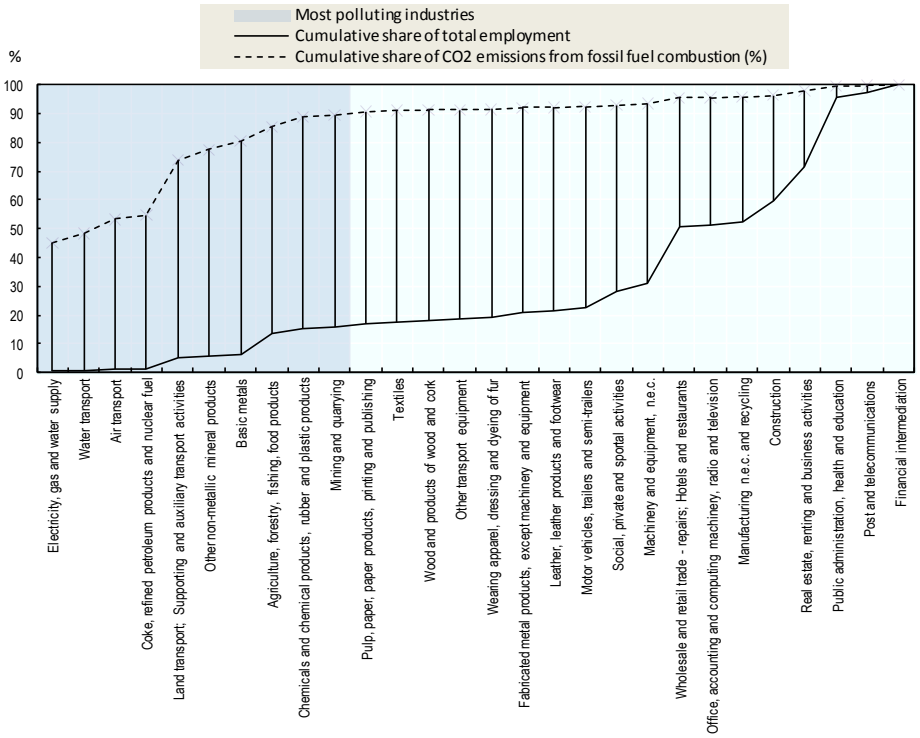
intensity helps to identify the sectors which are likely to face the strongest structural adjustment pressures in the wake of climate change mitigation policies.

81. As shown in Panel A of Figure 8, the average CO2 emission intensity in 25 EU countries varies widely across industries, with CO2 value added-intensity ranging from 6.6 Mtoe of CO2 emissions per thousand Euros of value added in the electricity sector to 0.0 in financial intermediation services. At the level of disaggregation shown in the figure we identify ten sectors as being the most polluting: two energy producing sectors, three transport sectors (including inland, water, air and supporting and auxiliary transport activities), three manufacturing sectors (basic metals, other non-metallic mineral products, and chemicals), as well as agriculture and mining. Workers in these sectors are likely to be particularly vulnerable to displacement if carbon taxes are significantly increased or other measures are taken to sharply reduce GHG emissions. However, it is notable that agriculture and inland transportation are the only industries in this group accounting for a substantial share of total employment (a combined 11.2% of total employment in the EU-25 region). By contrast, CO2 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 8. **CO2-emissions and employment in the EU-25 area in 2005**



Panel B



Notes: Averages for the EU-25 region.

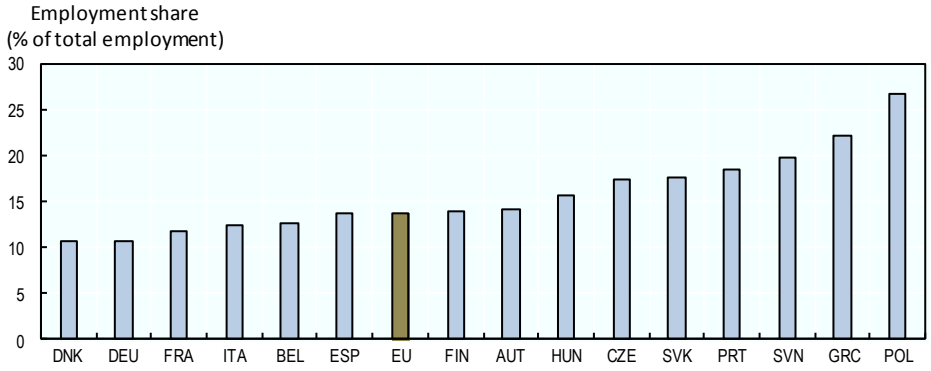
Source: Employment and value added data from EU-KLEMS, CO2 emissions data from GTAP.

82. Panel B confirms that the ten most intensely-polluting sectors account for a large share of total CO2 emissions (nearly 90%), while they account for only a small share 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 small portion of the total workforce.

83. While the most polluting industries account for only a relatively small share of total employment (13.7% of total workforce) in the 15 major EU countries included in Figure 9, there are significant cross-country variations, with the proportion ranging from a low of 10.7% in Denmark and Germany up to 26.7% in Poland (2.5 times higher). Among the countries with the greatest concentration of employment in highly polluting industries are the five Central and Eastern European EU members, where high emissions intensity in manufacturing is probably a heritage of economic development policies during the period of central planning and 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 relatively low GDP per capita countries within the EU area presents a risk that the adjustment costs associated with the transition towards a low carbon economy could be greater where living standards are below the EU average.[22]

22 . Similarly, Capros *et al.* (2011) show that the least-cost policy mix for achieving EU-wide targets of reducing greenhouse gas emissions at least 20% in 2020 compared to 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.

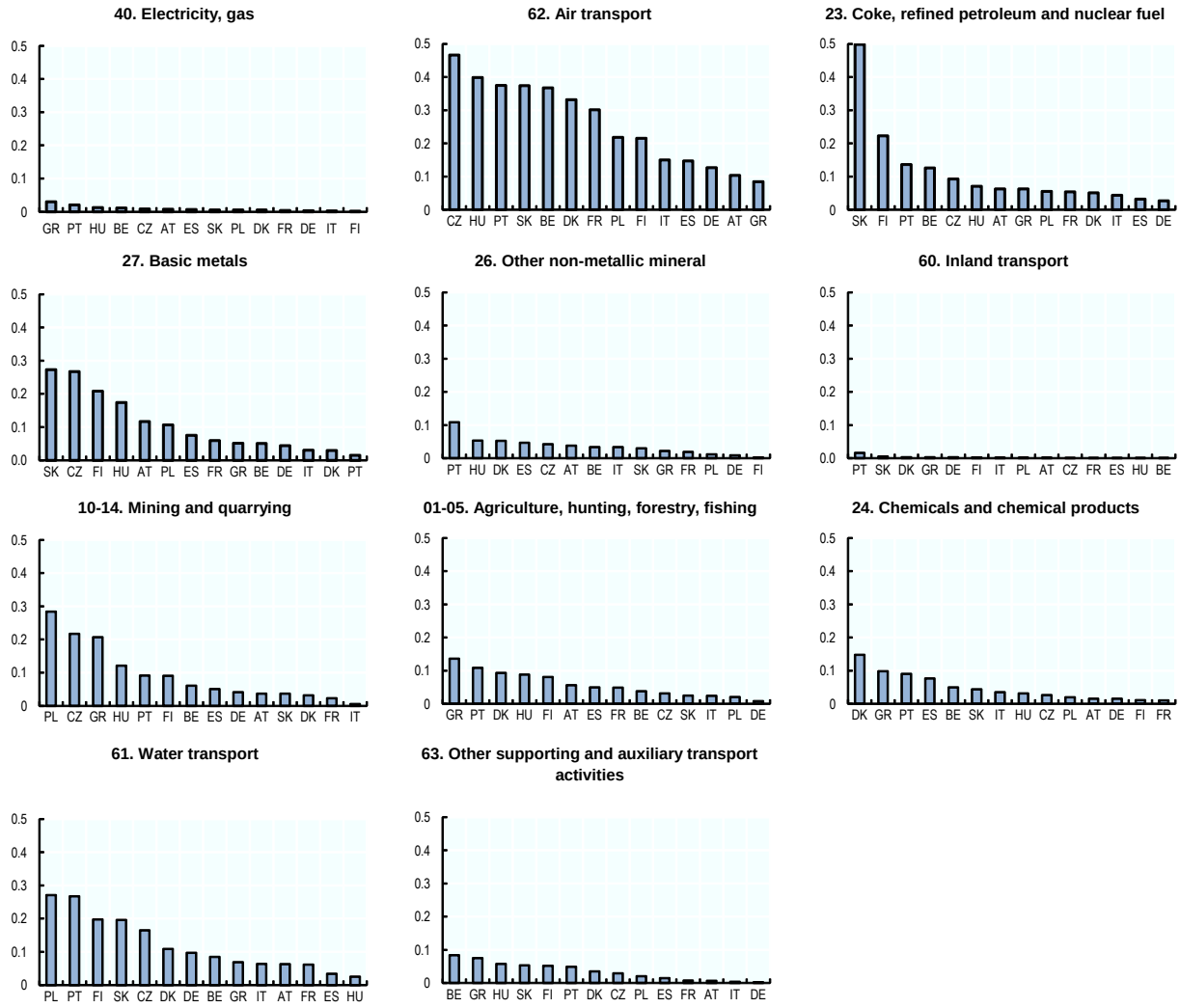
Figure 9. **Employment share of the most polluting industries in selected EU countries, 2000-07**



Notes: Most polluting industries include Agriculture, hunting and forestry; Fishing; Mining and quarrying; Electricity and gas; Inland transport; Air transport; Water transport; Other supporting and auxiliary transport activities; Activities of travel agencies; Coke, refined petroleum and nuclear fuel; Chemicals and chemical products; Other non-metallic mineral; Basic metals.

Source: EU-LFS.

Figure 10. **Geographic concentration[a] of the most polluting industries in 14 EU countries, 2000-07**



a) Ellison and Glaeser (1997) index of "raw" geographic concentration. A value of 0.25 is conventionally used as the threshold for defining highly localised industries.

Source: EU-LFS

84. Figure 10 suggests that the adjustment costs associated with green structural change will also be uneven across regions within individual countries, due to the high localisation of some of the most polluting industries. Using the index of "raw" geographic concentration of industries developed by Ellison and Glaeser (1997), we are able to identify sectors and countries which appear to be particularly susceptible to locally concentrated restructuring. Figure 10 shows that the least localised of the highly polluting sectors, across all countries in the sample, are the electricity generation and supply (40), the two manufacturing sectors (26 and 24), land transportation (60), supporting transportation (63), and agriculture, forestry and fishing (01-05). In the former socialist countries Czech Republic, Poland and Slovakia, several polluting industries seem to be strongly localised. (An index value above the threshold of 0.25 is conventionally viewed as reflecting a highly localised industry.) Coke and fuel production (23) and the manufacturing of basic metals (27) are highly localized in Slovakia, as are mining and water transportation in Poland and the Czech basis metals sector. Air transportation services (62) are also very localized in these countries, but also in Hungary, Portugal, Belgium, Denmark and France. This reflects the concentration of air transport activity in major business centres, often the capital city and its surrounding

region. However, even air transport is rather more decentralised in several countries, including Germany, Spain and Italy.

85. The likely concentration of job losses related to the transition towards green growth represents a particularly difficult challenge for employment and local economic development policy, because plant closures and mass lay-offs can have large and long-lasting effects on the regions 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 regions will be important actors in managing the structural adjustment costs associated with the transition towards green growth, ideally by effectively partnering with the private sector to shift the local economic specialisation into more sustainable activities. Identifying skill needs and in 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. This is illustrated by the French region of Aquitaine, which provided funding for employee training in an automobile engineering company in the region, after a German industrial company took over a former Ford Aquitaine site with plans to diversify its activities into wind energy (ILO, 2011a).

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

86. Policies to decarbonise the economy will place workers employed in the most polluting industries at an elevated risk of dislocation. Accordingly, it is important to ascertain which types of workers tend to work in these 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 sorts of reemployment and retraining services would to minimise the resulting adjustment costs, thereby contributing to a fair and efficient transition toward green growth while reducing political resistance to decoupling production from green house gas emissions and other harmful environmental impacts. This subsection 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 (*e.g.* permanent versus temporary employment contracts), while the next subsection compares mobility outcomes for workers in these and other industries. This empirical analysis makes use of German CO2 output-intensity data, because doing so allows a more disaggregated sectoral analysis (see Table A2.1 in Annex 2 for a list of the sectors analysed and their numerical, which are used in some of the charts in the following pages). Due to the need to obtain adequate sample sizes for a finer disaggregation of industries, the analysis focuses on the fifteen larger EU countries presented in Figure 9.

87. The following portrait of employment patterns in the most polluting industries emerges:

- Figure 11 shows that 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 European countries considered, the most polluting industries accounted for 18.4% of low-skilled employment in 2000-07, as compared to 13.7% of all workers and just 7.3% 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 (18.9%). The over-representation of low-skilled and older workers is particularly pronounced it the countries with the highest concentration of employment in high 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), suggesting that many are looking to their current jobs as a source of employment and earnings over a considerable period of time.

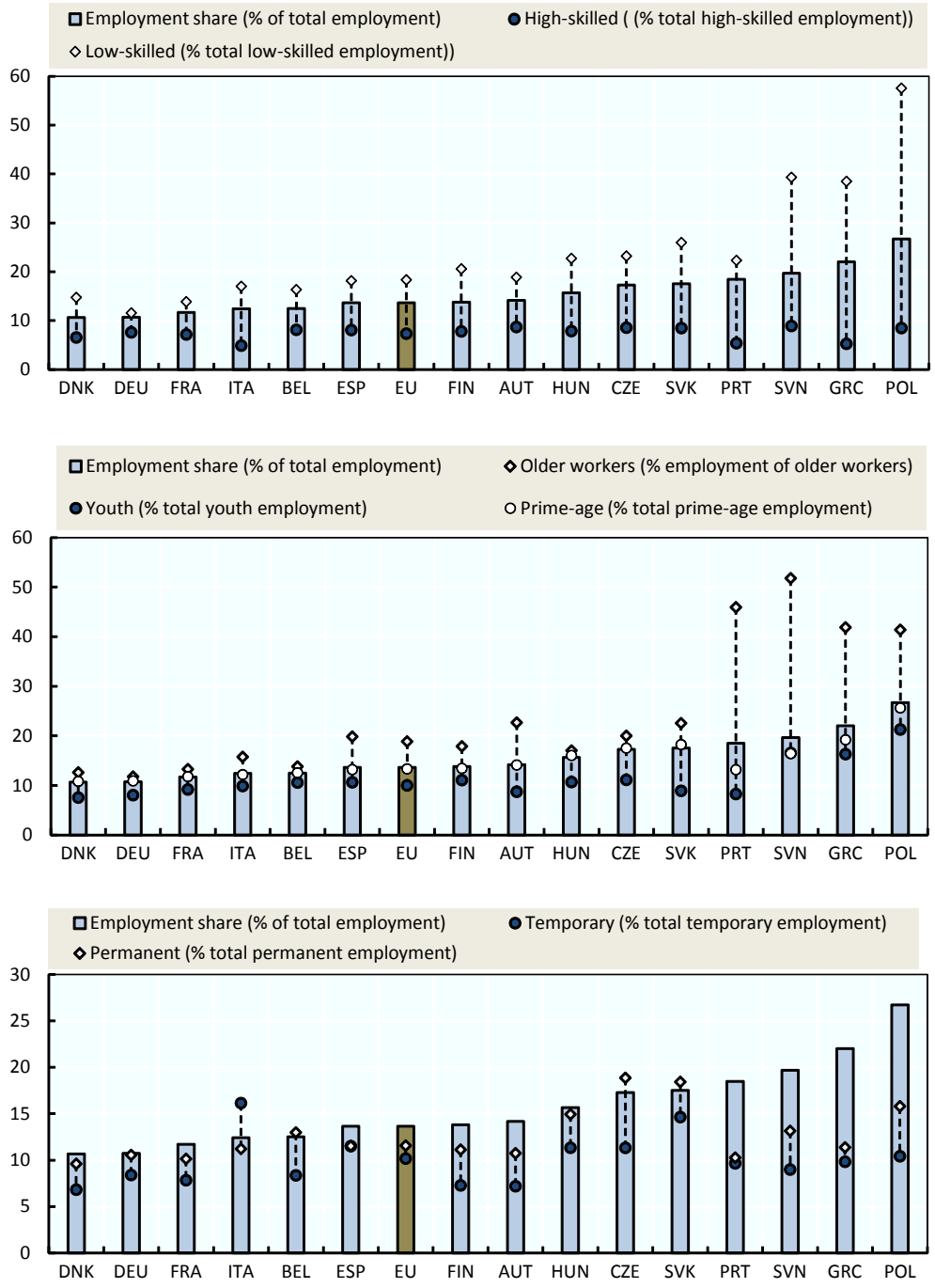
- The concentration of the job displacement risk associated with an increase in carbon taxes on low-skilled and older workers has important implications for the expected size of the adjustment costs associated with green growth as well as for the design of labour market and training policies intended 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).

- Figures 12 and 13 disaggregate employment patterns into more detailed industries (ordered from the least polluting industry on the left to the most polluting industry on the right), revealing that employment patterns vary dramatically across industries within both the most polluting group and also within the less polluting group.[23] Youth remain consistently underrepresented in 'brown' industries, but the share of older workers lies above the mean of the whole economy only for two of the ten most polluting sectors: agriculture and water transportation. The biggest diversity across industries is to be observed in the skill structure of the workforce. The two energy sectors (40 and 23), along with air transportation (62) and chemicals (24) employ a higher share of highly skilled workers than the economy-wide average (24%). In recent years, a number of innovations in environmental technologies – renewable energy, energy efficiency, carbon storage, fuel efficiency and biotechnology, among others – have been implemented in these sectors, which helps explain their demand for well educated workers (see Sections B.2-3 below). Overall, the share of high-skilled workers appears to be highest at the extremes of the carbon intensity distribution of the economy – services like financial intermediation and IT, at the low end of the distribution, and the above mentioned 'brown' industries, at the high end. By contrast, jobs in agriculture (0105), mining (1014), inland transportation (60), and the heavy industry sectors (26 and 27) are predominantly held by low-qualified workers (i.e. with less than upper secondary education). Figure 13 shows that polluting industries are not heavy users of temporary contracts, with the notable exception of agriculture, which due to its seasonality employs a high share of temporary workers.

- Figures 11-13 show that the profile of the workforce in the same industry often varies significantly across EU countries. For example, the share of highly educated workers in the electricity and gas sector (40) averages 25.1% while varying from 10.3% to 50.1%. Clearly, 'brown' workers are a very diverse group, with much variation in their composition across the different high pollution industries and across countries within each of the industries. It follows that labour market policies must avoid one-size-fits-all approaches. Nonetheless, it is broadly the case that the transition towards a low-carbon economy is likely to place a disproportionate number of older and less educated workers at risk of losing permanent jobs in most countries and labour market authorities will need to be prepared to help these workers to reintegrate into job openings that make good use of their skills and aptitudes.

23 . See Table A2.1 in Annex 2 for definitions of the numeric industry codes used in Figures 11, 12 and 14.

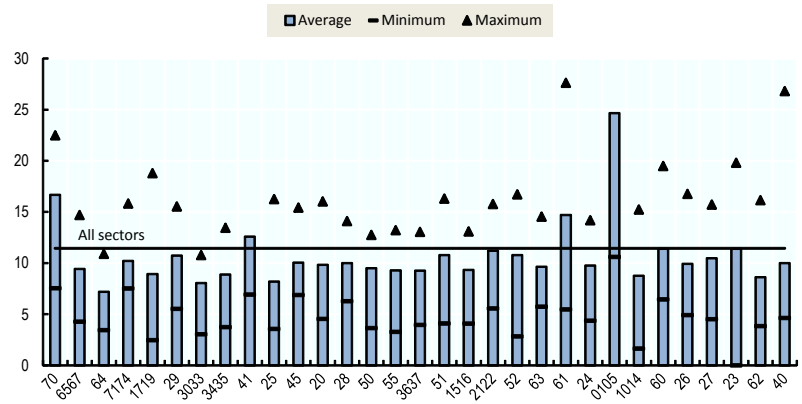
Figure 11. **Employment share of the most polluting industries in selected EU countries by skill, age and contract type, 2000-07**



Note: The most polluting industries include Agriculture, hunting and forestry; Fishing; Mining and quarrying; Electricity and gas; Inland transport; Air transport; Water transport; Other supporting and auxiliary transport activities; Activities of travel agencies; Coke, refined petroleum and nuclear fuel; Chemicals and chemical products; Other non-metallic mineral; Basic metals.
Source: EU-LFS.

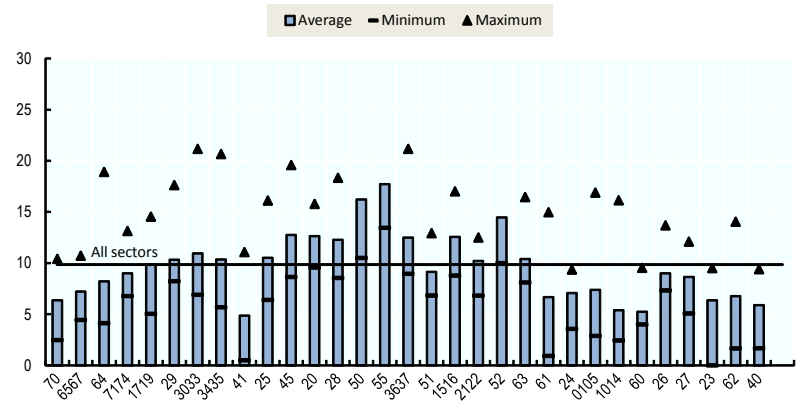
Figure 12. **The age and educational profile of workers in industries ranked by CO2 intensity[a], 2000-07**
Average, minimum and maximum values across 15 EU countries[b]

Panel A. **Share of older workers (55+) in total employment**



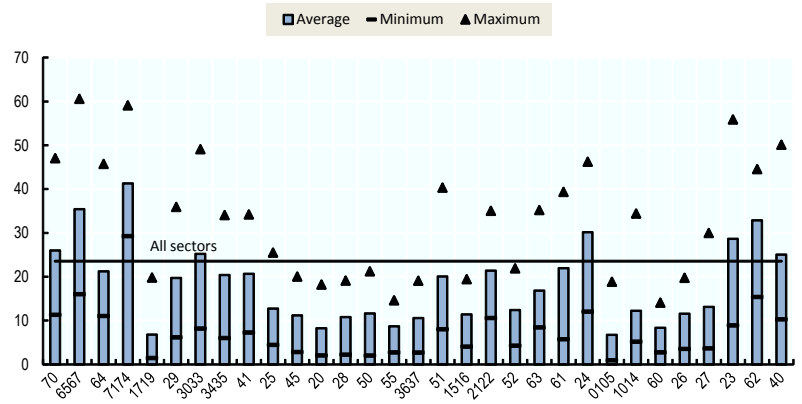
Note: maximum for 0105: 60% (PT) and for 41: 50% (DK)

Panel B. **Share of youth (15-24) in total employment**

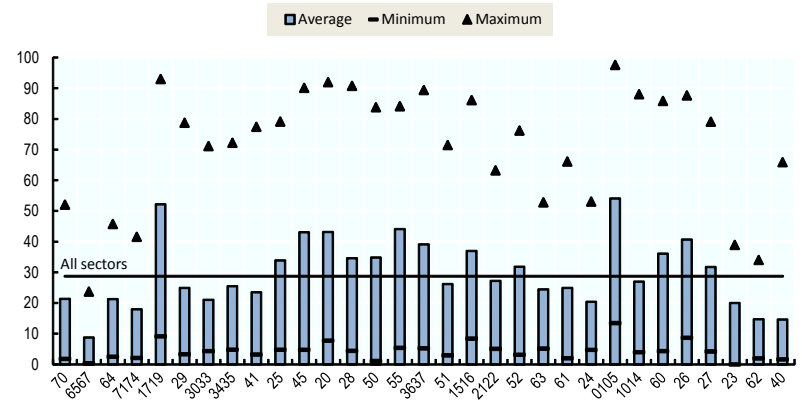


Note: maximum for 52: 42% (DK) and for 55: 44% (DK)

Panel C. **Share of highly educated in total employment**

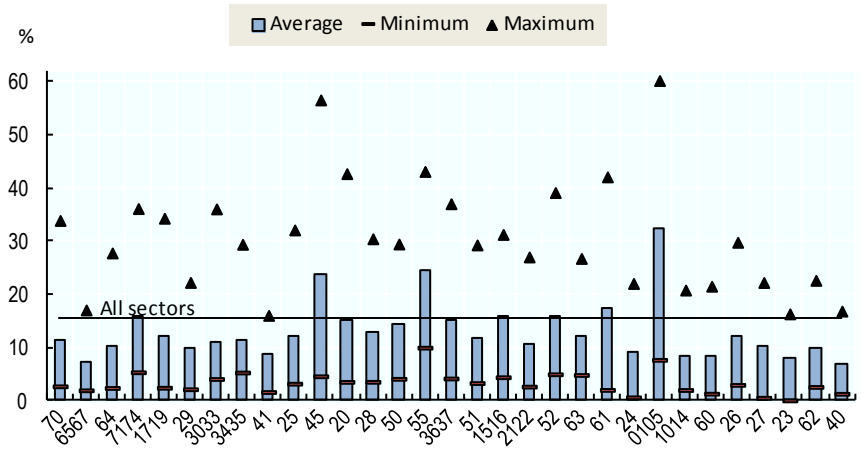


Panel D. **Share of low educated in total employment**



a) Sectors ordered from lowest to highest CO2 emissions intensity. Numerical industry codes are defined in Table A2.1 of Annex 2. Public administration, Education and health, Other community services, Private household employees and Extra-territorial organizations are not included in the anaysis.
b) The same 15 EU countries analysed in Figure 9. For reasons of data availability, the data for Poland refer to the period 2004-07.
Source: EU-LFS.

Figure 13 **Share of temporary workers in salaried employment in industries ranked by CO2 intensity[a], 2000-07**



a) Sectors ordered from lowest to highest CO2 emissions intensity. Numerical industry codes are defined in Table A2.1 of Annex 2. Public administration, Education and health, Other community services, Private household employees and Extra-territorial organizations are not included in the anaysis.
b) The same 15 EU countries analysed in Figure 9. For reasons of data availability, the data for Poland refer to the period 2004-07.
Source: EU-LFS.

Labour mobility differences across industries and countries

88. 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 have particular difficulty should green-driven economic restructuring require them to change employers and possibly also industry and occupation. One reason to anticipate a anticipate higher adjustment costs following displacement for relative immobile workforce groups is that they tend to have accumulated greater tenure of 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 associating between vulnerability and low mobility. Earnings volatility 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 paying a similar wage relatively quickly (OECD, 2011e). Nonetheless, it should be noted that lower mobility rates for a particular group in the workforce sometimes may reflect factors, such as a high level of job satisfaction and a concomitant disinclination to change jobs, which are not necessarily an indication that these workers would encounter greater than average job search difficulties should they lose their job and need to find another.

89. Gross worker flows data, such as the total annual movements of workers into new 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. 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 (2009a), these data are further harmonized on the basis of industry-level EU KLEMS employment data to ensure

comparability over time at the industry level.[24] Hirings are estimated from job tenure data (*i.e.* as the number of workers who are employed at time *t*, but were not employed at time *t-1 and hence have less than a year of job tenure)*, while separations are obtained as the difference between hirings and employment growth. Four different flow measures are used to characterize workers' mobility and to make comparisons between workers employed in the most polluting industries and those employed in cleaner sectors, as well as across EU countries: (*i*) total worker reallocation, defined as the sum of hirings and separations (i.e. all movements of workers in and out of the firm) as a proportion of total employment; (*ii*) total job-to-job separation rate, defined as the number of job separators moving quickly into another job as a proportion of total employment; (*iii*) other sector job-to-job separation rate, defined as the number of job separators moving quickly into a new job in a different industry as a proportion of total employment; and (*iv*) job losing rate, defined as the number of job separators becoming unemployed as a proportion of employment.

90. Figure 14 compares workers' flows between the most polluting industries and other, not so polluting industries (denoted by P and N respectively) separately for 15 large EU countries. On average across these countries, annual gross worker reallocation was about 32% of dependent employment in the most polluting sectors, somewhat lower than the 37% rate in less polluting sectors (Panel C). However, the differences in worker mobility between more and less polluting industries in the same country 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, 2010a). Spain and Denmark appear to be the countries in the sample with the highest worker reallocation and job-to-job separation rate, which can be explained by their relatively large shares of temporary workers. The connection between the prevalence of temporary contracts and mobility rates also suggests a possible explanation for below average mobility in the most polluting industries: this could be explained by the relatively low share of temporary workers in all of these sectors, except agriculture.

91. The three indicators showing components of total worker reallocation confirm the tendency for workers in the most polluting industries to be somewhat less mobile than workers in other industries. This is true when job separations lead to rapid reemployment, both in the same sector and in a different sector (see Panels A and B, respectively). It is also true for the job losing rate presented in Panel D, which is intended to represent a relatively long and difficult search for a new job. The fact that mobility rates for workers in highly polluting industries are about equally below those for workers in other industries for all four of the mobility indicators suggests that workers in high emission industries are less likely to leave an on-going job, but when they do separate from a job they become reemployed about as rapidly as workers separating from jobs in other industries.

92. Figure 14 also indicates that mobility rates differ dramatically across the industries within both the most polluting group and the less polluting group (see minimum and maximum values). Figure 15 explores this heterogeneity further by plotting mobility rates of 31 separate industries against the carbon intensity of each industry.[25] Doing so confirms that the workers employed in most of the most polluting industries have relatively low levels of labour market mobility according to all four indicators considered. Indeed, mobility is notably low in the six most polluting industries: electricity, gas (40), air transport (62), coke, refined petroleum and nuclear fuel (23), basic metals (27), other non-metallic mineral (26), and inland transport (60), except that the share of workers in non-metallic mineral moving rapidly to new jobs in a different sector is very close to the average value for all sectors. Mobility rates are also relatively low

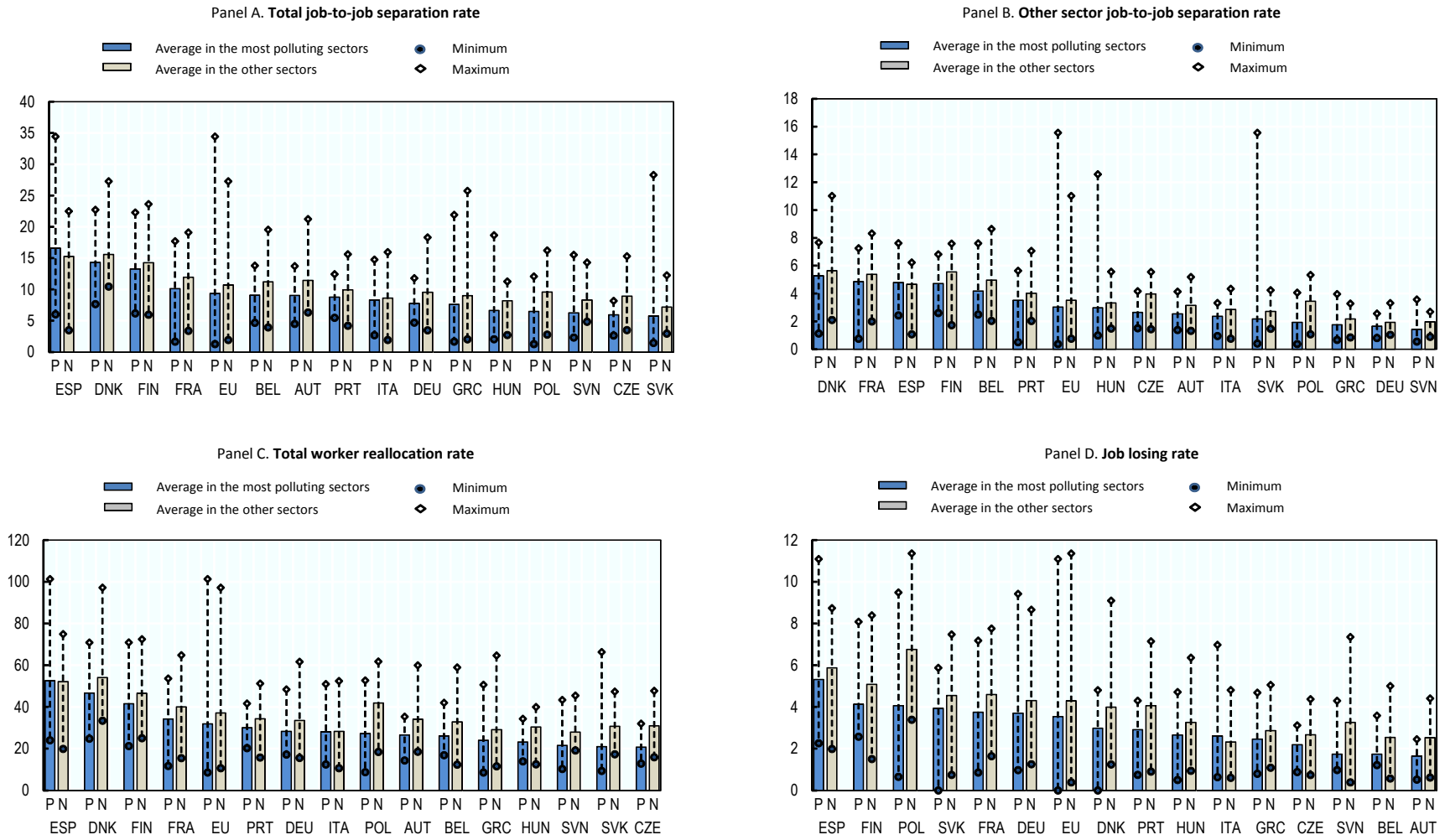
24 . Since this normalisation could not be implemented for public administration, health and education, that sector is excluded from the analysis.

25 . These mobility rates are averages across the 15 EU countries included in the analysis.

in mining and quarrying (1014) and chemical (24), which have somewhat lower CO2 emissions but are still in the highest polluter group, but are about average for water transport (61). The one striking exception to the association between high CO2 emissions and low labour mobility is agriculture, hunting, forestry, fishing (0105). This is one of industries with the highest rates of labour turnover, probably due to 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 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. These are all factors that are associated with above-average earnings losses following displacement.

93. While not definitive, this evidence suggests that significant downsizing of the workforce in many of the most polluting industries could lead to severe dislocation for many of the affected workers. While the relatively small number of workers currently separating from their jobs in these industries do not appear to have unusual difficulty finding another job, they may be a self-selected group that is not indicative of how involuntarily displaced workers would fare. The high localisation of several of these industries reinforces these concerns. As was discussed above, air transport is highly localised in most countries; whereas coke, refined petroleum and nuclear fuel; basic metals; and mining and quarrying are highly localised in several countries. An offsetting factor is that these high emissions industries with relatively immobility workforces generally do not employ above-average shares of low educated or older workers, two groups who typically have particularly high adjustment costs following displacement. Less reassuringly, the fact that a considerable number of the high polluting industries employ low shares of highly educated workers could represent a barrier to developing and implementing less polluting technologies and work practices.

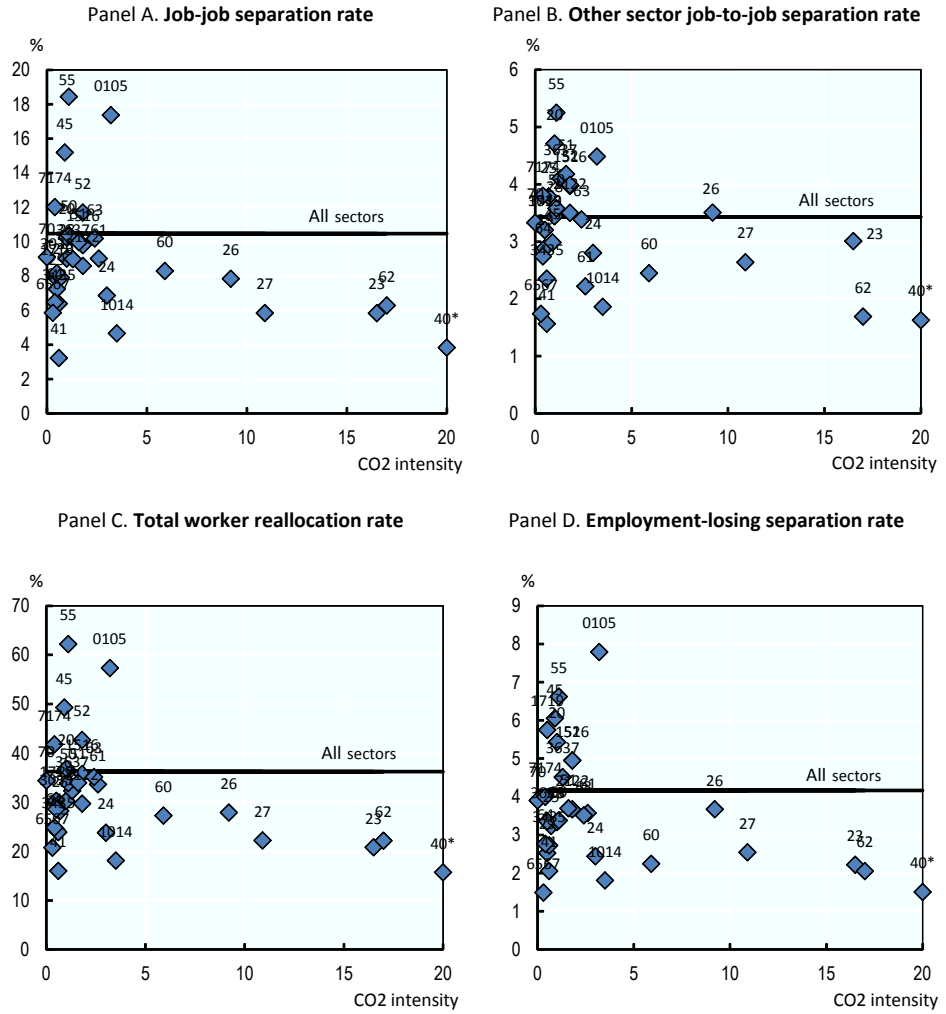
Figure 14. **How does the mobility of workers in the most polluting industries[a] compare with that of other workers? Four mobility indexes for 15 EU countries, 2000-07**



a) P denotes the most polluting industries (see Figure 8) and N denotes other industries (excluding public administration, education and health).
Source: EU-LFS.

Figure 15. **Worker mobility and CO2 emissions intensity for detailed industries, 2000-07**

Average values for 15 EU countries[a]



a) See Figure 9 for a list of the EU countries included in the analysis and Table A2.1 in Annex 2 for a definition of the numerical industry codes.
Source: EU-LFS

3. How has the intensity of innovation activity in environmental technologies evolved and which industries and countries are in the lead?

94. Technological innovation can allow environmental objectives to be realised in a less costly manner which is less costly than would otherwise be the case and potentially create opportunities to become a green exporter. However, there is considerable variation in innovative activity – both across countries and across sectors within countries (OECD, 2007c). Market and firm-level factors as well as policy factors have been identified as reasons for this variation. First, stable macroeconomic conditions are conducive to innovation, whereas low and stable interest rates are particularly important for risky investments, such as R&D. Second, firms which are exposed to international market competition are more likely to be innovative. As such more open international trade and foreign investment policies will tend to result in more innovation. Third, when a firm's products operate in markets that are less heavily regulated, innovation tends to be stronger (OECD, 2008c).

95. Besides the above mentioned general factors influencing the rate and direction of innovative activity, there are some distinct concerns which arise with respect to environmental innovation. In particular, there are two market failures involved: the positive externality associated with knowledge spillovers resulting from the innovation process and the negative externality associated with the environmental impacts (Jaffe *et al*. 2005). In general, distinct policies need to be implemented to resolve the two opposing problems. Many OECD governments have made significant efforts to co-ordinate these two sets of policies. On one hand, the innovation effects of environmental policies have become an increasingly important criterion in policy assessment for Ministries of the Environment. On the other hand, the environmental effects of innovation policies have become an important criterion for policy assessment in Ministries of Science, Technology and Industry (see OECD, 2008c). While, it is now well understood that induced technological change will play a critical role in a successful transition to a low-carbon and resource efficient economy, very little is known about how this innovation activity will affect labour markets. This section begins to address that lacuna.

96. ILO (2011a) and OECD (2011c) show that technological innovation influences demand for skills. Skill needs triggered by innovation include demand for research and development skills, entrepreneurship skills to commercialize and diffuse innovation, as well as management and operational skills to translate it into practice. However, not every innovation contributes to the greening of economies. Environmental technology should improve the resource or energy efficiency of production, reduce waste as well as air and water pollution, and increase the use of renewable resources.

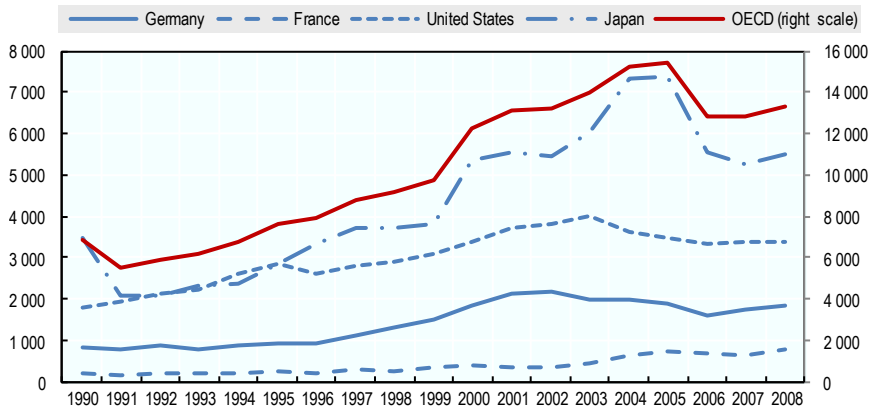
Patents as a measure of innovation

97. For this section of the report, patents are used as a measure of innovation. In order to be eligible for a patent, the innovation must be novel, involve a non-obvious inventive step, and be useful (Dernis and Guellec 2001). With the exception of the European Patent Office (EPO), patents are granted by national patent offices in individual countries. The analysis below draws upon patent applications registered with the EPO and/or the United States Patent and Trademark Office (USPTO). Patents are sorted by the priority year. Thus, if a patent is granted, protection begins from the priority date, which corresponds quite closely to the date when the inventive activity took place (OECD, 2008c). Most importantly for analysing the labour market implications of eco-innovation, the patent data (Patstat) have been linked to sectoral data from the Orbis dataset. These unprecedented matched data allow us to analyse the intensity of environmental and total innovation within each of the most polluting industries and less polluting industries defined above and, hence, to identify which parts of the total labour force are most likely to be most affected by the application of new green technologies.

98. While this combined dataset enables the sectoral disaggregation of patent statistics and a related analysis, one should be cautious in interpreting the absolute number of patents. Since the Patstat and Orbis datasets are merged using a common firm identifier, there are many applications and grants whose inventors do not pass through the relevant filters. This results into a smaller number of patent counts on the country level as compared to the rest of the literature. Nevertheless, the rate and direction of innovation is highly correlated with the most recent research studies on innovation, which allows us to draw conclusions based on a reliable qualitative analysis. For a list of all classes of environmental patents as identified by the Directorate for Science, Technology and Industry at the OECD using the International Patent Classification (IPC) consult Table A2.2 in Annex 2.

99. Figure 16 presents the aggregate number of environmental patents across twenty-one OECD countries, as well as of the major innovators in the sample, in the period 1990-2008. The trend clearly has been positive, although it has been somewhat erratic the past several years. Japan and the United States stand out as the world leaders in environmental innovation followed by the European champions, Germany and France.

Figure 16. **Number of environmental patents in the OECD[a], 1990-2008**

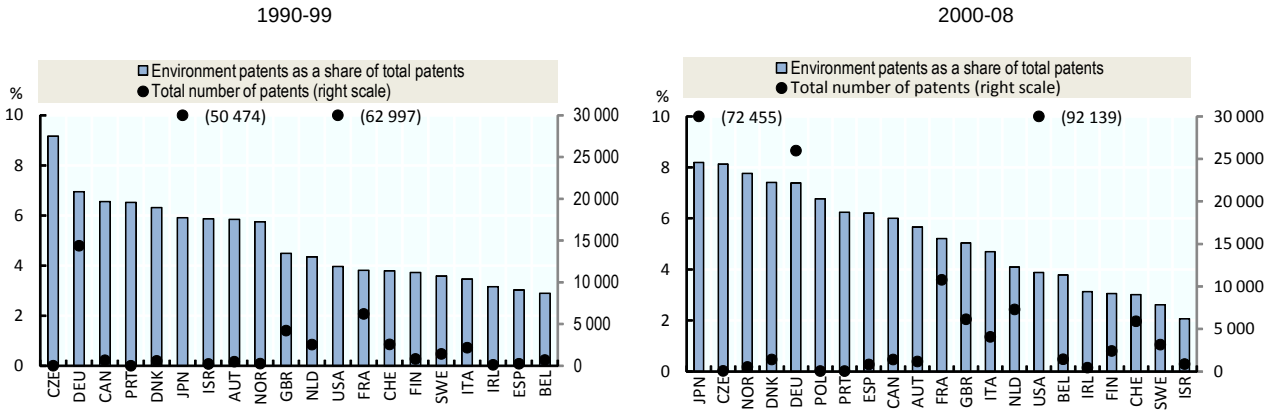


a) Tabulations based on patents applications registered with the European Patent Office (EPO) and/or the United States Patent and Trademark Office (USPTO). The OECD sample includes 21 member countries: the EU countries Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Italy, Ireland, Netherlands, Poland, Portugal, Spain, Sweden, United Kingdom, as well as Canada, Israel, Japan, Norway, Switzerland and the United States

Source: OECD calculations based on Patstat and ORBIS databases.

100. When we consider the share of environmental innovation in total innovation activity, this share turns out to have remained relatively stable in most of the countries in the sample (Figure 17). Total innovation has increased tremendously during the last two decades, thus driven partly by the increase in number of patent applications in environmental technologies. Europe has been leading in the last decade with France, Norway, Denmark, and Spain being the countries whose eco-innovation activity has accelerated most as compared to the nineties. Major fields of innovation have been transportation (France, in particular), energy efficiency and renewable energy generation (Spain's solar sector and Denmark's wind energy, just to name a few). In contrast, the relative rate of environmental innovation has declined modestly in Canada and the United States.

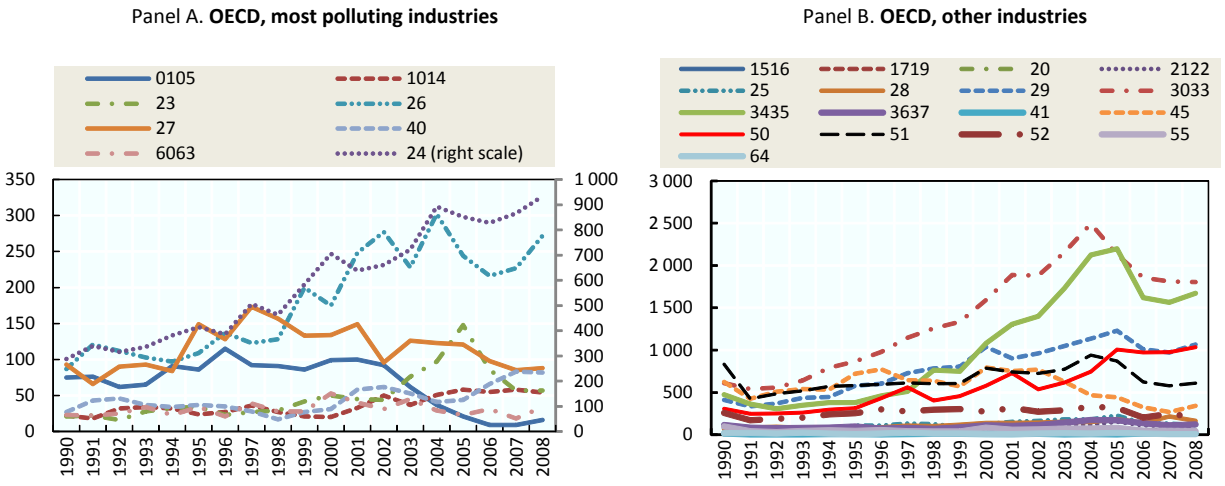
Figure 17 **Environmental patents as a share of total patents by country, 1990-2008**



Source: OECD calculations based on Patstat and ORBIS databases.

101. Figure 18 examines environmental patenting in different industries, with the most polluting industries being grouped on Panel A and less polluting industries in Panel B. Among the most polluting industries, the chemicals sector (NACE code 24) emerges as the main eco-innovator and as competitive as the major innovating sectors in environmental technologies – machinery and equipment (codes 29, 30-33) and transport equipment (codes 34-35). Although at a much lower scale, the electricity sectors (codes 23 and 40) and the manufacturing of other non-metallic mineral products industry (code 26), which are the biggest polluters in many OECD countries, have continuously increased the claims of environmental patents over the last two decades. While the agriculture, forestry and fishery sector (codes 01-05) and basic metal manufacturing (code 27) innovated actively in the nineties, their innovation rate has dropped significantly over the last decade.

Figure 18. **Number of environmental patents in the OECD by industry[a], 1990-2008**



a) See Table A2.1 in Annex 2 for definitions of the numerical industry codes.

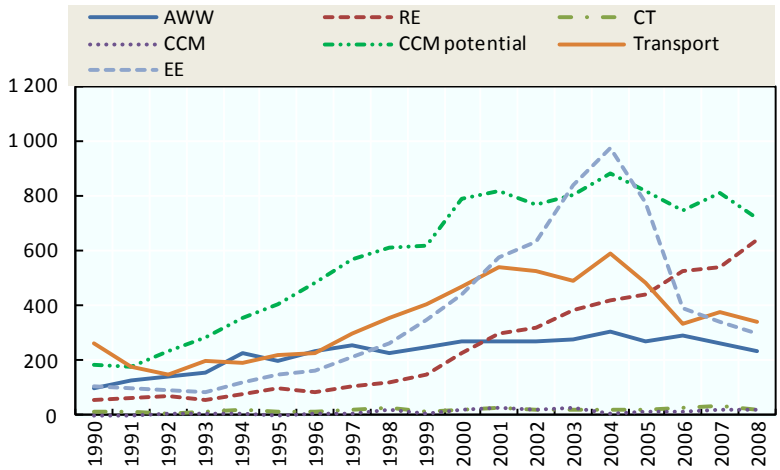
Source: OECD calculations based on Patstat and ORBIS databases.

102. The electrical machinery and optical equipment sector (codes 30-33) is a strategic part of OECD's manufacturing sector, producing a wide range of mostly high-technology products. This sector

has been at the centre of industrial development, as almost every other sector depends, at least to some degree, on the capital equipment, technology, end-products, research and innovations that are provided by the electrical machinery and optical equipment sector. It is therefore often considered to be one of the main drivers of productivity gains and central to the creation of more and better jobs. For this reason, it is important to know the rate and direction of environmental innovation in this sector, since it is so influential for the OECD economy as a whole.

103. Figure 19 presents the 1990-2008 evolution of patenting by the Electrical machinery and optical equipment sector for the OECD area, disaggregating the different classes of environmental technologies. Technologies with the potential to mitigate GHG emissions, such as energy storage, fuel cells and hydrogen technology, have accounted for the majority of patents over the last two decades. While transportation – including propulsion-specific technologies, internal combustion engines and fuel-efficiency improving technologies – was also one of the major areas of environmental technology invention in the nineties, its rate of innovation has been decreasing since 2001. Similarly, the innovation potential of energy efficiency in buildings and lighting dropped tremendously in 2004 after having experienced the sharpest increase of all environmental technologies. In contrast, the Kyoto protocol from 1997 gave a significant push to the renewable energy technologies, which has been the fastest growing area within eco-innovation over the entire period covered in Figure 19. The innovation intensity in technologies related to air and water pollution abatement as well as waste management (AWW) has remained more or less constant over the period considered here. Combustion technologies as well as climate change mitigation technologies (such as CO2 capture and storage) represent the smallest shares of all environmental patents in the OECD area.

Figure 19. **Different classes of environmental patents[a] in the Electrical Machinery and Optical Equipment Sector (NACE 30-33), 1990-2008**



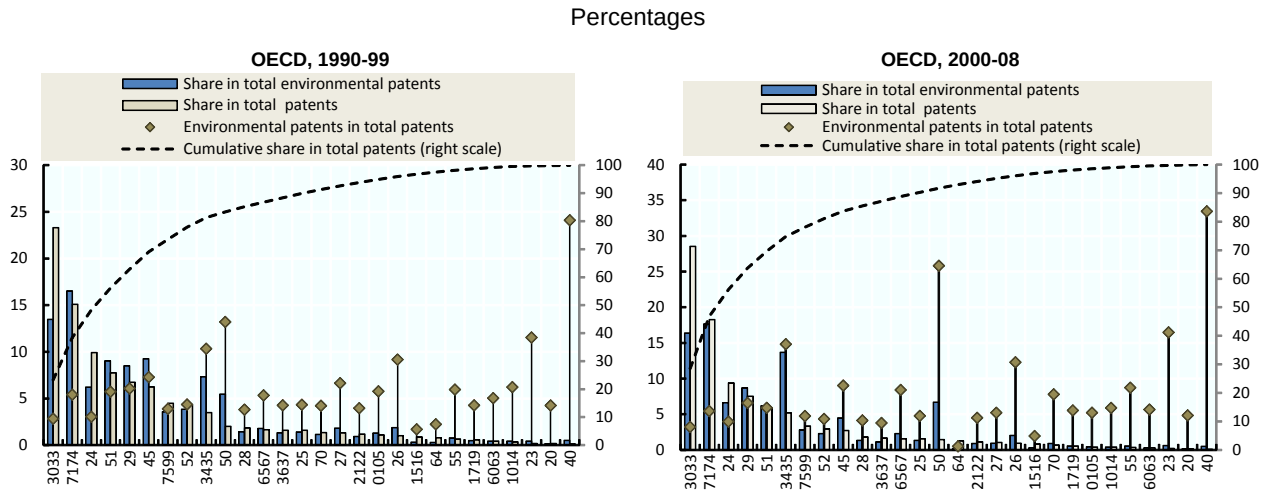
a) AWW=Air, water, waste abatement technologies, RE=Renewable energy generation, CT=Combustion technologies, CCM=Climate change mitigation technologies, CCM potential=Technologies with potential to emission mitigation, Transport=Transportation technologies, and EE=Energy efficiency in buildings and lighting.

Source: OECD calculations based on Patstat and ORBIS databases.

104. Further information about patenting intensities in different sectors and countries is presented in Figures 20 and 21. The three major innovating industries, as measured by their share in total patents, are the Electrical Machinery and Optical Equipment sector (codes 30-33), Research and Development, Computer, Renting of Machinery and Equipment and Other Business Services (codes 71-74) as well as the Chemicals sector (code 24). Among the smallest innovating industries are four heavily polluting industries,

namely, Electricity and fuel products (40 and 23), Mining (10-14) and Agriculture (01-05), as well as the Transportation sector (60-63). Focussing exclusively on innovation intensity in environmental patents, sectors 30-33, 71-74, 24, as well as the Automotive sector (34-35) have been among the major eco-innovators most recently (Figure 20). Interestingly, when we consider the share of environmental patents in total innovation in each sector, the picture looks rather different. The most polluting sector, Electricity (code 40), invents 35% of the time in environmental technologies. A similar pattern holds for sectors 23 and 26 with more than 15% of all their patents being claimed in environmental technologies.

Figure 20. **Environmental patents as a share of total patents in the OECD by industry[a], 1990-2008**



a) Industries ordered from highest to lowest share of total patents. See Table A2.1 in Annex 2 for definitions of the numerical industry codes.

Source: OECD calculations based on OECD Patstat and ORBIS databases.

105. Figure 21 presents analogous data separately for the four major innovating countries – Japan, United States, Germany, and France. The three major innovating industries in the United States are the same as for the entire OECD area, namely, (30-33, 71-74, and 24). For the three other countries, the automotive sector (34-35 and 50) plays a very significant role in environmental and total innovation as well. In France and Japan, this industry has claimed more than one third of all environmental patents in the last decade, and its share is around 25% in Germany. By contrast, the automotive sector has been playing a relatively marginal role in US environmental and total innovation activity. This striking difference is related to differences in regulation policy (see Box 7).

Box 7. **The impact of regulation on innovation activity in the automotive sector in Japan, the US and the EU**

The differences in the innovation activity of the automotive sector between the OECD countries in the sample can be explained very well by the evolution of regulations and their enforcement at the domestic level over time. The motor vehicle regulations in major OECD countries since the beginning of the seventies are summarized below:

First, for tailpipe standards on car exhausts (in particular, regulation for CO, HC, NOx and PM) the picture boils down to the following observations: US regulations were introduced rather early and restrictions imposed under the Clean Air Act became much more stringent in the 1970s for both petrol- and diesel-driven cars, but remained rather generous since this initial initiative; ii) Japan introduced regulations later than the US, but these regulations have always been particularly stringent from the very beginning; iii) The European Union was late and rather lenient for most exhaust gases from the very beginning. However, since the introduction of the Euro I standard in 1992, the standard-setting process in the EU rapidly caught up with and subsequently even appears to outrun the stringency of regulations in the US under Euro III; iv) The difference in regulation between petrol- and diesel-driven cars is substantial. Diesel cars obtained a substantial market share in the EU and CO standards became stricter for these cars compared to petrol ones since 1996. Regulation for diesel cars in the US and Japan has been more lenient which might be explained by the very small share of such cars In these two countries. For HC and NOx regulations, regulations for petrol cars in the EU and Japan have been considerably more stringent; v) Regulation of PM (particulate matter) started only in 1990 with the EU leading. Since 2000, further restrictions can be observed at the European level.

Second, fuel quality regulations are mainly related to the quality of the combustion technology, on the one hand, and emissions of CO, HCs, NOx, and PM, on the other hand: *i*) Lead standards were introduced in the US during the 1970s and 1980s, which created a gradual phase-out of leaded petrol; *ii*) Japan started its phase-out during the 1970s; by the early eighties only 1-2% of petrol contained lead and recently the production and consumption of leaded petrol has been fully eliminated; *iii*) In the EU, Germany was the first country to adopt standards to control the lead content of petrol in the seventies, which was enforced by a law in 1985. The law included the introduction of unleaded petrol, because the largest reductions of NOx and Co could be achieved by catalytic converters that were incompatible with lead. As of 1989, all EU member states had to offer unleaded petrol.

Third, fuel taxes taking the form of petrol and diesel excises have developed differently across the OECD. Due to harmonization efforts and the implementation of minimum excise rates within the EU, levels began to develop within a narrower band. The minimum rate for leaded petrol remained unchanged between 1992 and 2004. For unleaded petrol, since 1985 excise rates strongly went up, particularly, in Germany, then more or less moved in step with the US until 2000, and then again sharply increased. The pattern for the Japanese excise follows the pattern of Germany and Europe. The excise on diesel developed very similarly with the US keeping almost constant and very low levels throughout time.

Fourth, direct regulation of fuel efficiency aims to lower the amount of fuel required to move a vehicle over a certain distance. Mandatory fuel efficiency requirements are exceptional across the world. The only example is the application of the Corporate Average Fuel Economy (CAFE) standards in the US introduced in 1978. Following an initial increase in stringency, the gradual tightening was relaxed in 1984 and the standard has never changed since 1989. In contrast, voluntary schemes have been applied much more often. The CAFE standard has been typically more lenient compared to other regulators like Japan and Germany. Only recently the EU took the lead and introduced the strictest standards.

A recent empirical analysis by the OECD shows that regulatory interventions by governments are inducing serious inventions in the car industry. Regulatory pressure appears to be far more important than autonomous and contemporaneous effects from changing net of tax petrol prices. Furthermore, standards, in particular for CO and to a lesser extent NOx emissions strongly correlate with inventions in main automotive technologies. Also petrol taxes seem to have an impact, in particular, on the technologies than increase fuel efficiency, while fuel efficiency standards have rather limited effect.

Source: See Hascic (2006), de Vries (2007) and OECD (2010h) for an exhaustive analysis of government policies in the automotive sector.

106. As was true for the OECD area in Figure 20, Figure 21 shows that the most polluting industries have a very small share of total and environmental innovation in the four countries considered, with the notable exception of the chemicals sector (24). Nevertheless, the eco-innovation activity, particularly, in

the electricity sector (40), measured as a share of total patents in the sector, is particularly high in Japan (40.4%), and also quite high in the United States (26.3%) and Germany (32.7). France's electricity sector is lagging behind with only 8% of environmental patents, which can be explained to a large extent by the huge nuclear power industry in the country and scarce public incentives for innovation and investment in renewable energy. Additionally, coke, petroleum, fuel products (23), and other non-metallic mineral products (26) are active inventors of environmental technologies in Japan, US, and Germany, while the mining sector is important in France (13.3%), Germany (9.3%), and Japan (13.4%). The traditionally large agricultural industry in France has been also participating in eco-innovation (9.4% in the nineties, and 7.8% in the last decade).

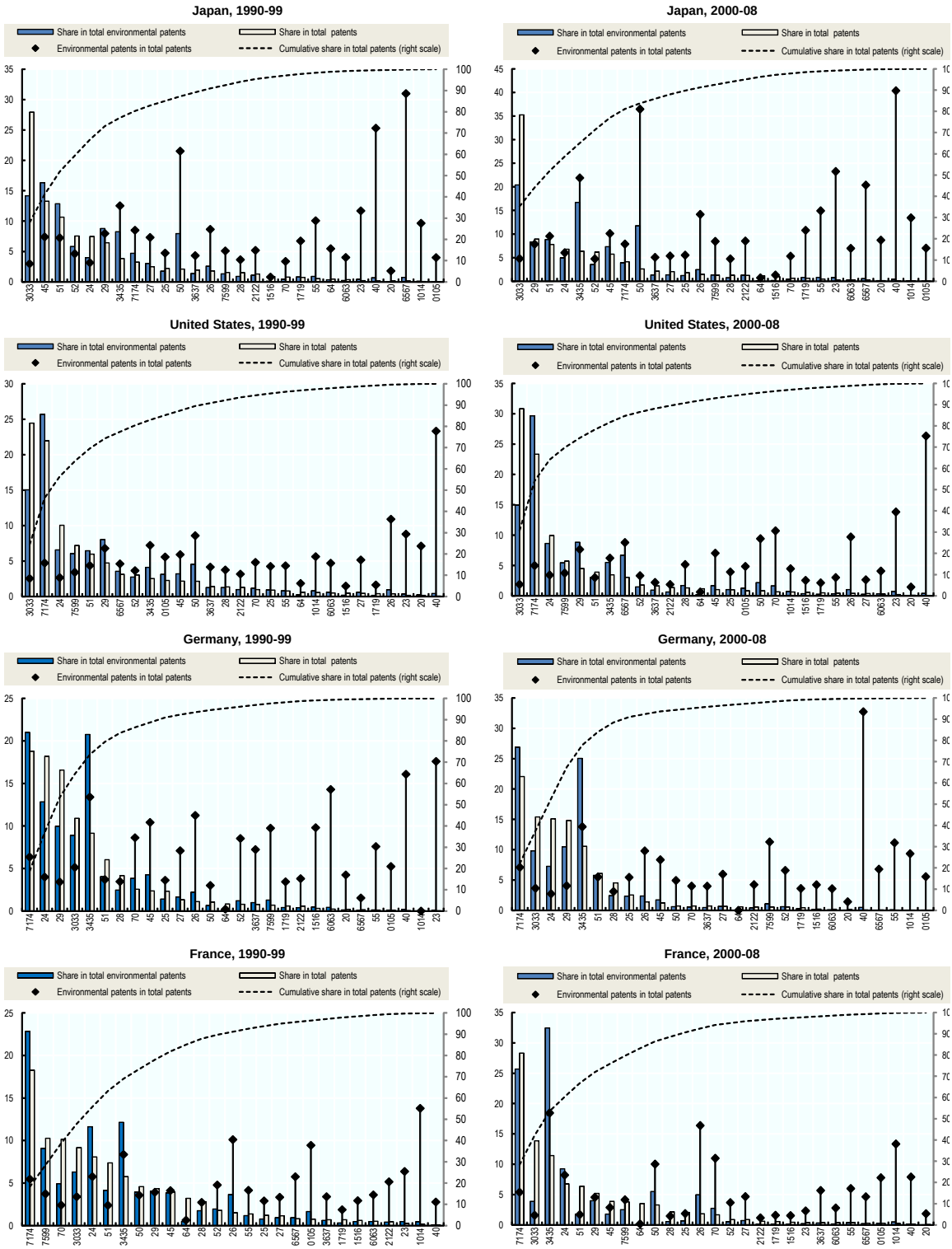
107. The analysis of the innovation activity in both the most polluting industries and other cleaner sectors allows us to complement the discussion about workforce characteristics and mobility patterns presented in section B.2 above. The workers in all of the heavily polluting industries that are also significant eco-innovators (*i.e.* 24, 23 and 40, 26 and 27) emerged as potentially at-risk of bearing high adjustment costs during the transition to a greener economy, due to their below-average total worker reallocation rate, job-to-job separation rate, and/or low probability of finding a job in another sector (Figure 15). While the workforce in sectors 23, 24 and 40 is quite highly educated, sectors 26 and 27 disproportionately employ older and less skilled workers (Figure 12), two groups tend to encounter the greatest difficulties following job displacement.

108. By contrast, the electricity sector employs an above-average share of skilled workers in many countries, although this is not the case in the former socialist countries (Czech Republic, Hungary, Poland, Slovakia), nor in Austria, Greece, Italy and Portugal. The electricity sector in Belgium, Germany, Denmark, Spain, France and Finland is relatively well educated and better positioned to participate successfully in the innovation activity required to develop and apply clean energy technologies. Workers in the chemical and the coke, petroleum and fuel products industries in these countries appear to be similarly well situated.

109. It is encouraging that some of the high polluting industries are reorienting their production models, so as to reduce their environmental footprint. In addition to the environmental benefits, this type of innovation lessens the risk of large employment losses in the sector as environmental standards rise. Furthermore, not all CO2-intensive industries need to be inventors in order to adapt successfully to the transition towards a greener economy. New technology can also be acquired and adopted, as is discussed in section B.4 below. However, the appropriate skills and competencies for the development, dissemination and adoption of technologies are crucial for the transfer of technology, either from firm to firm, industry to industry, or country to country (ILO 2011a). Often, workers already employed in a high polluting industry that shifts towards greener production patterns will be able to make the transition relatively smoothly. For example, a significant part of the conversion from fossil fuel to renewable energy sources is taking place within large firms in the energy sector (*e.g.* electricity utilities), where management often is willing to invest in retraining their workforce as required. Eco-innovation in high polluting industries will, nonetheless, subject some workers to considerable adjustment pressures. For example, the job mix and the job skill requirements may change in ways that render some current workers inapt. Job losses may also occur as market share and employment shifts towards the firms in the sector that are the most successful innovators. Since there is no guarantee that the new jobs will be in the same region as the lost jobs, nor that they will be open to workers with the same qualifications, the progressive greening of brown industries will also be a source of displacement.

Figure 21. **Environmental patents as a share of total patents by industry in Japan, the US, Germany and France, 1990-2008**

Percentages

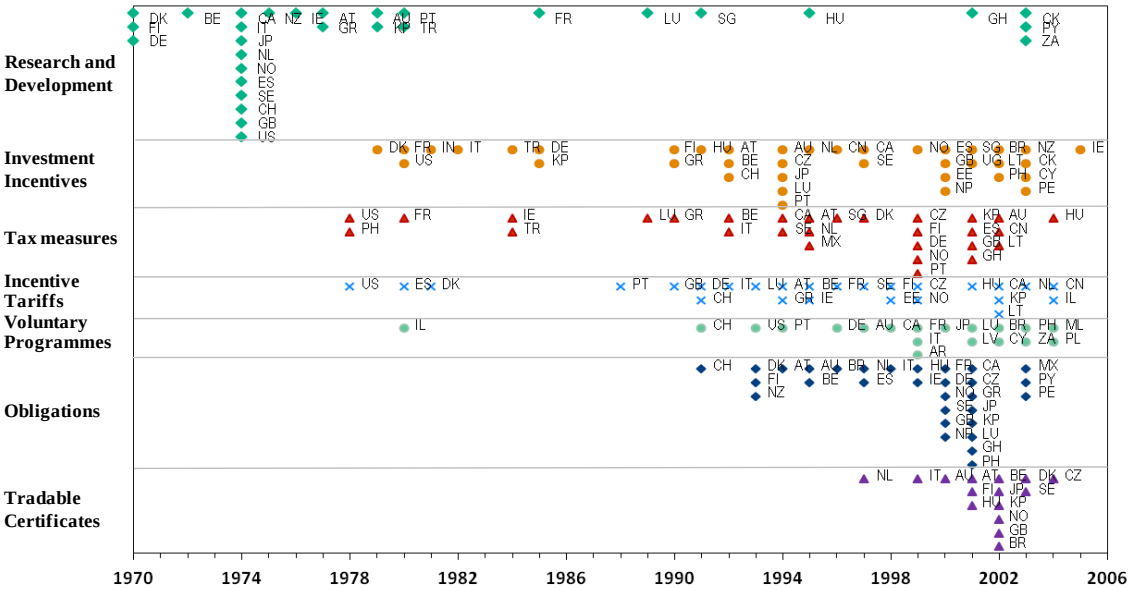


Source: OECD calculations based on OECD Patstat and ORBIS databases.

110. Renewable energy is one of the green sectors identified by various studies as having the highest potential for employment creation (EC, 2010*b*; UNEP, 2011*a*. Furthermore, investment in renewable energy sources – wind, solar, geothermal, ocean, waste-to-energy, and biomass – can contribute significantly to the realisation of environmental objectives, mainly those associated with climate change mitigation and adaptation. Innovation is critical for the expansion of renewable energy and the IEA (2006) distinguishes three generations of renewable energy technologies: *i*) first-generation technologies which have already reached maturity, such as hydropower, biomass combustion, and geothermal energy; *ii*) second-generation technologies which are undergoing rapid development such as solar energy, wind power, and modern forms of bio-energy; and *iii*) third-generation technologies which are presently in developmental stages such as concentrating solar power, ocean energy, improved geothermal and integrated bio-energy systems.

111. In recent years OECD governments have intervened in energy markets with a variety of policies intended to achieve environmental objectives, notably an increased use of renewable energy sources (IEA, 2011). Policies to promote renewable energy through support for research and development were implemented in some OECD countries in the 1970s. However, this type of measure become much more widespread in the 1980s and particularly since the Kyoto Protocol was signed in 1997. Figure 22 shows that different policy types have tended to be introduced in the OECD countries in a fairly regular order. In the 1970s, many countries introduced support for research and development (R&D), which was followed by investment incentives (capital grants, loan guarantees and low-interest rate loans), taxes (accelerated depreciation, tax credits, tax exemptions and rebates), and price-based policies (feed-in tariffs). Recently, quantity obligations, often followed by certificates in which the obligations are tradable, and net metering have been introduced in the OECD area. According to the Renewable Energy Policy Network for the 21st Century (REN21), the number of countries globally with some kind of renewable energy target and/or deployment policy related to RE almost doubled from an estimated 55 in early 2005 to more than 100 in early 2010 (REN21, 2010).

Figure 22. **Renewable energy policies by type in OECD countries in the period 1970-2006**



Source: IEA (2004), updated until 2006 by staff of the Renewable Energy Division at the IEA

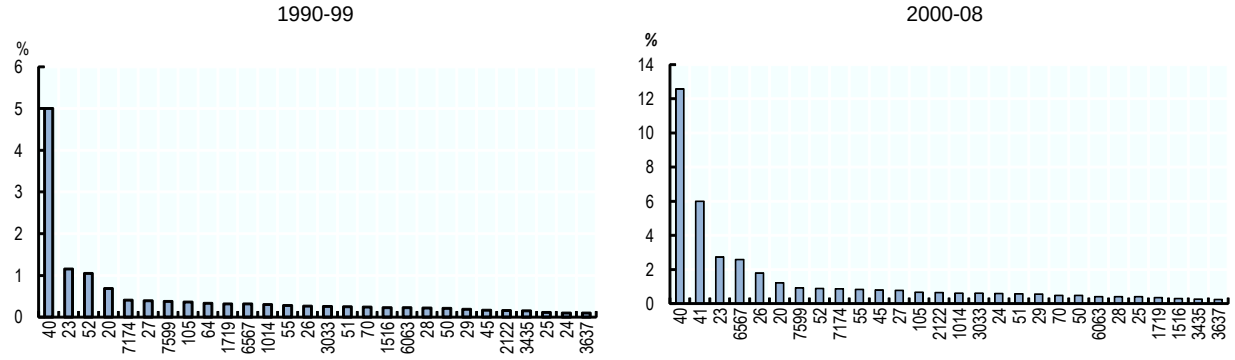
112. In many countries, governments place a strong emphasis on public policies promoting the production and use of clean energy products. However, many renewable energy products are still more expensive than traditional energy generated using fossil fuel technologies, implying that induced technological innovation will need to be the driving force behind their market penetration: as these technologies become cheaper, the markets will adopt them faster. Indeed, IEA (2011) argues that governments should support demonstration projects to enable the next generation of renewable energy technologies to reach the deployment stage. Government policies encouraging investments in expanded renewables generating capacity can also indirectly encourage private R&D. However, Johnstone *et al.* (2010) show that different policies work better for some renewable energy technologies than for others. In particular, quantity-based policy instruments, such as obligations and tradable certificates, are most effective in inducing innovations in wind power technology. Price-based instruments, such as investment incentives, tax measures and feed-in-tariffs are most effective in encouraging innovation in solar, biomass, and waste-to-energy technologies. Voluntary programmes are statistically significant policy instruments for waste-to-energy incineration.

113. Figure 23 presents data on renewable energy patenting in different industries for the period 1990-2008 (OECD averages). Patents on renewable energy represent a significant and growing share of total innovation activity in the electricity sector (code 40). While only 5% of this sector's patents focused on clean energy in the nineties, that share increased to more than 12% during the last decade. Similarly, the RE share of environmental patents nearly doubled, from 20% in 1990-1999 to 37% in the last decade.

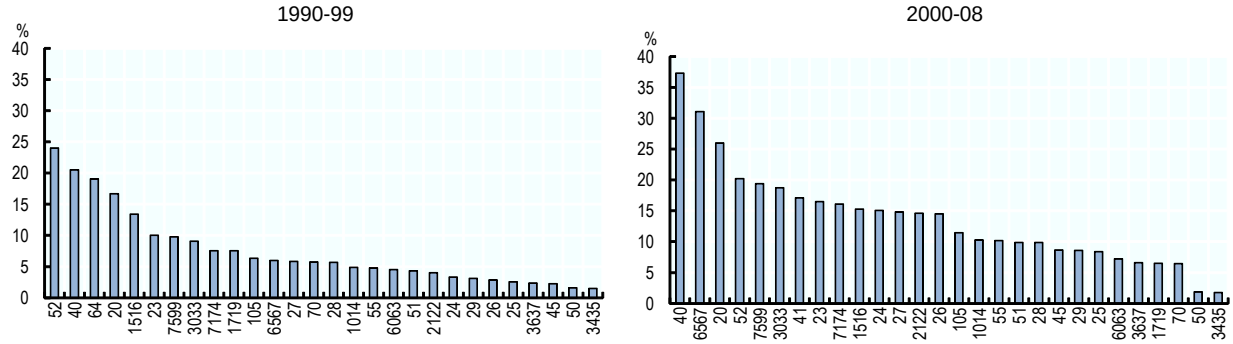
114. The same positive trend is present in four other highly CO2-intensive sectors, albeit at lower levels: fuel products (23), chemicals (24), basic metals (27), and other non-metallic mineral products (26). The share of their RE innovation activity as measured to the overall innovation in environmental technologies nearly doubled over the last two decades. Several big clean industries are also increasingly active in clean energy, represented mainly by the services and public sector (codes 52 and 65-99, excluding real estate activities, 70) as well as the electrical machinery and optical equipment industry (30-33). Innovation in renewable energy products provides an important example of how many different sectors of the economy, ranging from the most to the least polluting industries, are contributing to the improvement of strategic green technologies.

Figure 23. **OECD innovation activity in renewable energy products for the period 1990-2008**

Panel A. Patents on renewable energy (% all patents in each industry)



Panel B. **Patents on renewable energy (% all environmental patents in each industry)**



Source: OECD calculations based on OECD Patstat and ORBIS databases.

115. Demand for jobs and skills in the renewable energy sector will depend on the domestic workforce strengths, natural resources and geography, infrastructure and policy priorities, since these factors play a large role in where renewable energy industries are located (Cleary and Kopicki 2009). While it is important that new technologies be developed and high-quality equipment be installed, the best equipment may not operate satisfactorily if the installer has not been properly trained. Thus national industrial, employment and education policies should be synchronised with policies to promote the expansion of renewable energy in order to achieve smooth transition to a low-carbon economy.

116. ILO (2011a) reports that jobs created in renewable energy have the potential to absorb redundant workers from many other sectors: For instance, in the United States companies involved in wind energy generation are expected to retrain and re-employ many workers displaced from the construction sector in the wake of the housing boom. Additionally, manufacturing jobs in the wind industry require knowledge similar to that used in automobile assembly. Similarly, in Denmark shipbuilding and related marine engineering functions were refocused on offshore and on-shore renewable energy activity, including the construction, supply and maintenance of wind turbines and wave and tidal installations. One goal of labour market and skill policy in the context of green growth should be to encourage such transitions.

4. How environmental innovation is reshaping employment: New evidence from German firm-level data

117. To better examine the characteristics of the green firms and the potential of innovative green sectors to become significant sources of net job creation, this section analyses firm-level innovation data for Germany. We look at the association between environmental innovation and employment performance measures, such as workers' skills, training opportunities for employees, employee's compensation, the types of employment contracts offered and labour productivity. The export competitiveness of the company is also examined. This analysis provides an unprecedented first look at whether systematic differences exist between companies that are involved in environmental innovation (*e.g.* the production, innovation and/or adoption of environmental products and processes) and firms that are not. Any such differences could have important implications for the future level and composition of the demand for green workers, the quality of green jobs and the associated job skill requirements.

118. For the purpose of our analysis, we use data from the German part of the European Community Innovation Survey (CIS). The German contribution to CIS is the so-called Mannheim Innovation Panel (MIP). This is an annual survey based on a panel sample that is conducted by the Centre for European Economic Research located in Mannheim. In contrast to CIS in other countries, the German survey collects

information on a number of employment variables which are of central interest for this report. The target population of the survey is enterprises with five or more employees from most economic sectors, but excluding agriculture, forestry and fishing, hotels and restaurants, public administration, health and education, and personal and cultural services and construction. Our working sample consists of 6405 companies, while the empirical analysis is run on only 3235 companies due to the fact that many firms did not provide information on all model variables.

119. We use the 2009 wave of the MIP since it includes a set of questions on environmental innovations, which allows us to differentiate between 'green' innovators, other innovators and companies that do not innovate. In the survey, an environmental innovation is defined as a new or significantly improved product (good or service), process, organisational method or marketing method that creates environmental benefits compared to alternatives (CIS 2008). The environmental benefits can be the primary objective of the innovation or a co-benefit of other innovation objectives. Furthermore, the environmental benefits can occur during the production of a good or service or during its after sales use by the end-user. Thus, environmental innovations include the introduction of an abatement technology by firms, regardless whether this is a market novelty due to own research and development of the adoption of existing technology.

120. The German version of the CIS distinguishes 12 different types of environmental innovations[26]. For each type, firms were asked to rate the significance of environmental benefits of introduced innovations on a 4-point ordinal scale with the categories high, medium, low and no environmental benefits (for further details see Rexhauser and Rammer 2011). We construct a binary indicator which takes the value 1 if a firm has introduced environmental innovation of at least one of the designated types that has at least a low significance for environmental benefits. This will be our main indicator of whether or not a firm innovated for environmental purposes.

Descriptive statistics and stylised facts about innovating companies in environmental and/or non-environmental technologies

121. Table 8 provides an overview of the CIS data disaggregated across different economic sectors and innovation activity mixes. It distinguishes between three subgroups of innovators: firms that introduce only environmental technologies, firms that introduce only non-environmental technologies and firms that introduce both. The group of innovating firms is much larger than that of non-innovating firms in most sectors, but retail trade excluding motor vehicles (52) is an exception, as are two most polluting industries, water and air transportation services (61 and 62). Furthermore, the majority of innovating firms innovate in both environmental and non-environmental products and processes at the same time. Only the financial intermediation (65-67) and the renting and business activities (71-74) services sectors are mostly active in non-environmental technologies. A relatively small share of firms in each sector introduces innovations with environmental benefits only. However, the majority of innovating firms in two highly CO2-intensive sectors – electricity (40) and land transportation (60) – as well as those in water supply (41) and real estate services (70), are investing in products and processes that create only environmental benefits.

26. Out of these 12 types, nine refer to processes and three to products. The process innovations read as follows: i) Reduced material use per unit of output; ii) Reduced energy use per unit of output; iii) Reduced CO2 emissions; iv) Reduced other air emissions (e.g. SOx, NOx); v) Reduced water pollution; vi) Reduced soil pollution; vii) Reduced noise burden; viii) Replaced materials with less hazardous substitutes; and ix) Improved recycling of materials, water and waste. The three product innovations are i) Reduced energy use for the consumer; ii) Reduced air , water, soil and noise pollution; and iii) Improved recycling of product after use.

Table 8. **Number of firms by economic sector and type of innovation, 2008**

Isic	Total	Not innovator	Innovator	Innovator in environment only	Innovator not in environment	Innovator in both
10.14	98	39	59	21	7	31
15.16	308	76	232	52	45	135
17.19	195	58	137	18	44	75
20	114	34	80	17	19	44
21.22	297	66	231	49	59	123
23	15	4	11	1	2	8
24	218	28	190	8	47	135
25	203	51	152	29	25	98
26	144	36	108	16	23	69
27	102	12	90	7	14	69
28	357	92	265	44	58	163
29	444	61	383	19	122	242
30.33	610	75	535	38	166	331
34.35	193	38	155	14	33	108
36.37	137	28	109	12	31	66
40	159	69	90	33	29	28
41	79	37	42	22	7	13
50	51	20	31	13	6	12
51	233	105	128	39	46	43
52	41	26	15	5	2	8
60	197	55	142	72	17	53
61	54	31	23	9	5	9
62	10	7	3	0	1	2
63	166	50	116	40	29	47
64	60	24	36	11	11	14
65.67	219	51	168	16	91	61
70	63	30	33	16	8	9
71.74	1447	429	1018	109	547	362
80.93	191	60	131	46	15	70
Total	***6 405***	***1 692***	***4 713***	***776***	***1 509***	***2 428***

Source: German Mannheim Innovation Panel, wave 2009

122. For firms that which innovate for environmental benefits, Table 9 provides information about their motivation for introducing environmental innovation. Five different reasons are differentiated and multiple answers are allowed.[27] The innovation activity of the majority of firms across the different sectors was presented as a response to government regulations or taxes on pollution. The next most commonly identified motivations for environmental innovation were sectoral voluntary agreements for environmental good practices and consumer demand. However, differences across the industries exist.

123. Among the most polluting industries as identified in Section B.2, only land transportation identified existing government regulations and taxes as the predominant motivation for their decision to undertake environmental innovation. Electricity (40), fuel production (23), chemicals (24) and the supporting transport activities sector (63) have been driven mostly by expected environmental regulations or taxes in the future, but also by already existing regulations. The heavy manufacturing industries (26 and 27) and mining (10-14) follow, to a larger extent, voluntary codes within their sectors as well as government regulations and taxes. Government financial incentives play an important role only in the transportation services sector. In contrast, five major innovating clean industries (28, 29, 30-33, 34-35 and

27 . The survey question reads as follows: "During the period 2006-2008, did your firm introduce an environmental innovation in response to [...]", where the five possibilities are listed and multiple responses are allowed.

71-74), which constitute half of all firms introducing environmental innovations, have been influenced mostly by current or expected market demand from their customers for eco-innovations. The latter factor also plays a determining role for the chemicals and electricity sectors.

Table 9. **Reasons for introduction of environmental innovation, 2008**

	Introduction of environmental innovation in response to:				
Isic	Existing environmental regulations or taxes on pollution	Environmental regulations or taxes that you expected to be introduced in the future	Availability of government grants, subsidies or other financial incentives for env. innovation	Current or expected market demand from your customers for env. innovations	Voluntary codes/agreements for environmental good practice within your sector
10.14	13	12	4	4	13
15.16	56	48	17	27	45
17.19	16	8	8	25	21
20	18	17	6	18	16
21.22	32	34	13	42	31
23	3	4	0	2	3
24	51	52	9	44	44
25	29	34	12	38	30
26	23	23	8	14	27
27	21	20	4	18	26
28	50	49	16	50	49
29	74	72	16	98	75
30.33	121	88	21	106	77
34.35	44	47	9	51	48
36.37	17	17	2	15	14
40	24	25	10	20	24
41	8	6	5	1	8
50	9	9	2	4	11
51	25	21	4	23	19
52	2	2	1	1	2
60	56	54	42	21	38
61	6	6	2	3	5
62	1	1	0	1	1
63	30	34	24	16	29
64	4	7	4	4	10
65.67	9	7	4	10	15
70	12	12	8	8	7
71.74	99	88	49	138	141
80.93	57	49	13	19	39
Total	**910**	**846**	**313**	**821**	**868**

Source: German Mannheim Innovation Panel, wave 2009.

124. Table 10 summarises employment patterns in different industries. Four industries emerge as the biggest employers in Germany, occupying more than half of the total labour force and offering most training opportunities to their employees: Electrical machinery and optical equipment (30-33), automotive (34-35), post and telecommunications (64), and the services sector 71-74. Employment in the most polluting sectors constitutes less than 18% of the total economy. In terms of turnover, besides the above mentioned sectors, finance intermediation (65-67) and the electricity sector (40) contribute significantly to the aggregate economy's performance. Concerning exports, the two polluting manufacturing industries (24 and 27) are major players along with sectors 29-35. Skilled employment is highest in the two biggest innovating industries (30-33 and 71-74), where half of all highly educated employees work. Among the most polluting sectors 24, 27 and 40 employ 10.6% of the skilled workforce.

Table 10. **Employment, turnover and exports by sector, 2008**

Percentages

Isic	Employment	Turnover	Exports	Training costs	Skilled employment
10.14	0.8	1.1	2.3	0.9	0.6
15.16	2.2	2.4	1.5	1.1	1.0
17.19	0.9	0.6	1.1	0.4	0.7
20	0.4	0.3	0.2	0.2	0.2
21.22	1.9	1.4	1.5	1.5	2.0
23	0.2	1.3	0.7	0.3	0.2
24	3.7	5.0	12.1	4.6	5.9
25	1.6	1.1	1.8	0.9	1.0
26	1.0	0.8	1.4	1.1	0.9
27	2.8	5.0	10.7	2.1	1.9
28	2.4	1.5	2.1	1.8	2.2
29	5.4	4.9	13.2	5.0	9.6
30.33	10.2	8.2	17.8	7.1	23.8
34.35	9.4	12.0	21.2	7.6	9.6
36.37	1.0	0.7	1.0	0.7	1.1
40	1.7	10.4	5.6	4.5	2.8
41	0.2	0.2	0.0	0.2	0.4
50	0.1	0.1	0.0	0.2	0.1
51	1.3	3.9	2.9	1.5	0.8
52	0.2	0.1	0.0	0.0	0.0
60	3.8	2.4	0.2	3.2	1.2
61	0.3	1.7	1.2	0.2	1.1
62	0.0	0.0	0.1	0.0	0.0
63	2.4	2.7	0.2	2.1	1.0
64	29.9	12.0	0.2	30.0	0.8
65.67	4.3	15.3	0.0	6.8	6.9
70	0.2	0.2	0.0	0.8	0.3
71.74	11.0	4.3	0.7	14.7	23.2
80.93	0.8	0.6	0.0	0.6	0.7
Total	100	100	100	100	100

Source: German Mannheim Innovation Panel, wave 2009.

125. Table 11 presents comparative information about innovators and non-innovators as employers. We present aggregate figures as well as disaggregated information for seven groups of sectors as defined by Breinlich and Criscuolo (2011) following the NACE/ISIC industry classification. Table 10 shows that innovating firms outperform non-innovating firms, on average: they employ more people, pay higher wages, sell more on the market, have more skilled staff, export more and offer more training opportunities to their workers. However, non-innovators are characterised by higher turnover and exports, and more skilled workers than the innovators in the wholesale trade and retail sector. Interestingly, innovating firms employ better educated employees only in the technology manufacturing sectors and business services, computer and research & development.

126. Table 11 also distinguishes between three subgroups of innovators: firms that introduce only environmental technologies, firms that introduce only non-environmental technologies and firms that introduce both. The first group of firms underperforms other types of innovators, on average. Looking at economy-wide averages, firms that innovate in both areas offer lower wages, spend less on training for their employees and occupy fewer skilled people than firms which innovate only in non-environmental technologies. By contrast, firms that innovate in both areas are leaders in turnover and exports as well as employing most people. It is evident that there are many differences between the three groups if innovators within each sector. In the following regression analysis we control for this high firm and sectoral heterogeneity by including industry dummies and innovation indicators.

Table 11. **Differences between innovating and non-innovating firms in employment patterns and export orientation, 2008**

Average values across firms

	Employment						Cost per employee (thousands)					
	Total	Not innovator	Innovator	Innovator in environment only	Innovator not in environment	Innovator in both	Total	Not innovator	Innovator	Innovator in environment only	Innovator not in environment	Innovator in both
Mining	153	29	236	37	97	401	79.0	77.8	79.7	84.4	75.5	77.5
Low-medium tech manuf	140	57	167	80	120	209	66.6	60.5	68.4	62.3	63.4	72.0
High-tech manuf.	359	133	395	75	212	509	83.0	72.4	84.4	67.1	84.4	86.1
Utilities	151	90	200	149	233	239	97.1	95.1	98.6	92.1	97.5	107.9
Wholesale and retail	88	61	112	94	124	118	64.1	62.2	65.6	59.6	71.4	66.9
Other services	785	82	1 120	87	314	2 483	74.9	66.9	78.4	66.7	91.5	79.4
Business services; computer and R&D	140	103	156	84	143	195	73.3	65.7	76.6	55.2	84.6	70.9
Total	286	84	359	87	176	559	74.4	67.2	76.8	65.8	81.0	78.0
	Turnover (millions)						**Share of skilled employment (%)**					
	Total	Not innovator	Innovator	Innovator in environment only	Innovator not in environment	Innovator in both	Total	Not innovator	Innovator	Innovator in environment only	Innovator not in environment	Innovator in both
Mining	109.6	9.1	176.1	25.2	59.9	304.5	9.2	10.3	8.5	7.0	8.0	9.7
Low-medium tech manuf	77.1	22.0	94.8	27.6	55.2	129.1	9.4	7.7	10.0	8.5	10.8	10.1
High-tech manuf.	197.2	41.5	222.1	33.2	157.4	269.6	20.4	16.5	21.0	11.6	25.3	20.0
Utilities	425.5	110.9	678.2	188.0	289.3	1 677.4	16.0	16.5	15.6	13.8	15.3	18.2
Wholesale and retail	120.5	129.9	112.4	120.1	63.1	147.6	10.2	11.4	9.2	7.6	9.0	10.9
Other services	342.1	52.6	480.1	24.9	545.2	802.1	13.9	14.9	13.4	10.2	16.9	13.7
Business services; computer and R&D	29.1	16.2	34.5	5.1	37.2	39.0	41.4	34.4	44.2	23.0	49.1	42.5
Total	149.9	43.5	188.1	42.5	137.3	266.1	20.2	17.9	21.0	11.5	29.5	18.8
	Exports revenue (millions)						**Training costs per employee (thousands)**					
	Total	Not innovator	Innovator	Innovator in environment only	Innovator not in environment	Innovator in both	Total	Not innovator	Innovator	Innovator in environment only	Innovator not in environment	Innovator in both
Mining	56.6	0.9	89.6	1.7	36.7	171.0	0.4	0.2	0.5	0.3	0.5	0.5
Low-medium tech manuf	27.1	5.8	33.5	7.5	7.7	49.9	0.6	0.4	0.7	0.4	0.5	0.8
High-tech manuf.	99.5	18.2	112.4	16.4	110.4	121.4	1.0	0.5	1.0	0.5	0.9	1.1
Utilities	59.7	0.1	97.2	0.0	0.2	317.2	1.4	1.2	1.6	1.3	1.5	2.0
Wholesale and retail	22.8	30.9	16.4	2.0	3.6	41.4	0.9	0.9	0.8	1.1	0.7	0.7
Other services	5.5	3.9	6.2	0.6	4.8	12.0	1.0	0.8	1.1	0.6	1.5	1.2
Business services; computer and R&D	1.3	0.3	1.7	0.1	1.9	1.8	1.5	0.9	1.7	0.6	1.9	1.7
Total	37.8	7.5	47.9	4.4	31.5	70.8	1.0	0.7	1.1	0.6	1.3	1.1

Source: German Mannheim Innovation Panel, wave 2009.

Probing the link between environmental innovation and employment outcomes

127. In this section we apply simple regression models to the 2008 data from the Mannheim Innovation Panel to explore the impact that different types of innovating activities — but especially environmental innovation — on firm-level performance indicators that are particularly relevant for understanding how eco-innovation is likely to reshape employment patterns and job skill requirements. We analyse the differences between environmental innovators, non-environmental innovators and non-innovators using descriptive regressions that distinguish among the four groups of firms: only-environmental innovators, only-non-environmental innovators, innovators in both, and non-innovators. We regress firm characteristics on dummy variables for these categories, *ENVonly*, *nonENVonly*, *BOTH*, using non-innovators as the excluded category. The dependent variables utilised include total, skilled and part-time employment, average wage and training costs per employee, as well as labour productivity and exports. As mentioned above, industry fixed effects are included to isolate within-sector variation in the data[28]. A second version of these models is also estimated with incorporates a number of control variables in order to better isolate the impact of innovation status on employment performance.

28 We report results with industry dummies for the seven aggregated industry classes presented in Table 11. However, using 2-digit ISIC industry dummies delivers identical results.

Table 12. **Regressions of firm-level performance variables on innovation status without any control variables, 2008**

	log (Employment)	Share of skilled workers	Share of part-time workers	log (Wage)	log (Training costs per employee)	log (Turnover per employee)	log (Value of exports)	Probability of exporting	Share exports to turnover
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Innovator in environment only	0.240 ***	-2.128 *	-3.286 **	0.043	1.631 ***	-0.044	0.185	0.020	-0.007
	(0.085)	(1.142)	(1.351)	(0.036)	(0.422)	(0.056)	(0.880)	(0.089)	(0.026)
Innovator in non-environment only	0.383 ***	9.715 ***	-5.980 ***	0.229 ***	2.934 ***	0.228 ***	5.175 ***	0.534 ***	0.157 ***
	(0.078)	(1.292)	(1.156)	(0.032)	(0.357)	(0.049)	(0.706)	(0.076)	(0.022)
Innovator in both	0.860 ***	3.358 ***	-6.668 ***	0.169 ***	4.311 ***	0.186 ***	7.011 ***	0.726 ***	0.197 ***
	(0.070)	(0.989)	(1.023)	(0.028)	(0.323)	(0.044)	(0.617)	(0.067)	(0.019)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Pseudo) R-squared	0.0872	0.2585	0.0731	0.0563	0.0192	0.1635	0.0893	0.2693	0.3195
Observations	*3 235*	*3 235*	*3 235*	*3 235*	*3 235*	*3 235*	*3 235*	*3 235*	*3 235*
Uncensored observations					*528*		*1 553*		*1 553*

Notes: Columns (1)-(4) and (6) present results from ordinary least squares estimations. Columns (5), (7) and (9) report results from Tobit estimations. Column (8) reports Probit estimates. In brackets we report robust standard errors. The Tobit specification for the exports equation in Column (7) and the training costs equation in Column (5) is censored at log(0.001) which is assigned to firms reporting zero exports and zero training costs, respectively. The censoring point for the Tobit regression in Column (9) is 0 which is assigned to firms reporting zero exports. The dependent variables in columns (1) and (4)-(7) are in natural logs. All models include an intercept term (not shown). Significance levels are reported at 10% (*), 5% (**), and 1% (***).

Table 13. **Regressions of firm-level performance variables on innovation status incorporating control variables, 2008**

	log (Employment)	Share of skilled workers	Share of part-time workers	log (Wage)	log (Training costs per employee)	log (Turnover per employee)	log (Value of exports)	Probability of exporting	Share exports to turnover
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Innovator in environment only	0.062	-1.283	-2.812 **	0.011	1.296 ***	-0.069 *	0.056	0.020	-0.011
	(0.046)	(1.150)	(1.274)	(0.031)	(0.389)	(0.035)	(0.805)	(0.097)	(0.024)
Innovator in non-enviroment only	-0.048	9.297 ***	-3.590 ***	0.118 ***	2.204 ***	0.013	3.036 ***	0.352 ***	0.091 ***
	(0.040)	(1.285)	(1.120)	(0.029)	(0.336)	(0.035)	(0.657)	(0.084)	(0.021)
Innovator in both	0.087 **	3.507 ***	-2.784 ***	0.010	2.889 ***	-0.061 **	4.188 ***	0.559 ***	0.116 ***
	(0.038)	(1.017)	(1.002)	(0.026)	(0.307)	(0.029)	(0.582)	(0.076)	(0.018)
log (Turnover)	0.737 ***								
	(0.029)								
log (Employment)		-2.920 ***	-1.785 ***	0.030 ***	0.783 ***	-0.005	-0.356	-0.055	0.041 ***
		(0.325)	(0.331)	(0.009)	(0.078)	(0.010)	(0.253)	(0.034)	(0.005)
log (Capital assets)	0.069 ***						0.080	0.008	
	(0.012)						(0.137)	(0.018)	
log (Capital assets per employee)		0.512 **	-1.217 ***	0.057 ***	0.360 ***	0.093 ***			0.008
		(0.256)	(0.241)	(0.006)	(0.066)	(0.008)			(0.005)
log(Material costs)	-0.067 ***						2.031 ***	0.220 ***	
	(0.020)						(0.179)	(0.024)	
log (Material costs per employee)		1.297 ***	-2.426 ***	0.124 ***	0.192 **	0.395 ***			0.057 ***
		(0.349)	(0.335)	(0.009)	(0.079)	(0.015)			(0.006)
Share of skilled workers						0.003 ***	0.060 ***	0.007 ***	0.002 ***
						(0.001)	(0.010)	(0.001)	(0.000)
Exporter (=1)	-0.146 ***	4.777 ***	-3.043 ***	0.087 ***	-0.183	0.081 ***			
	(0.031)	(0.995)	(0.815)	(0.021)	(0.250)	(0.026)			
Corporation (=1)	0.044	4.840 ***	-1.935 ***	0.117 ***	0.512 ***	0.147 ***	0.510	0.038	0.059 ***
	(0.032)	(0.897)	(0.735)	(0.020)	(0.194)	(0.028)	(0.441)	(0.067)	(0.015)
Location (=1 if East Germany)	0.095 ***	5.386 ***	-6.659 ***	-0.221 ***	0.326	-0.244 ***	-2.342 ***	-0.274 ***	-0.094 ***
	(0.027)	(0.819)	(0.714)	(0.018)	(0.205)	(0.022)	(0.427)	(0.059)	(0.014)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Pseudo) R-squared	0.8055	0.3167	0.181	0.3237	0.0325	0.6575	0.1258	0.3439	0.4597
Observations	*3 037*	*3 037*	*3 037*	*3 037*	*3 037*	*3 037*	*3 037*	*3 037*	*3 037*
Uncensored observations					*432*		*1 431*		*1 431*

Notes: Columns (1)-(4) and (6) present results from ordinary least squares estimations. Columns (5), (7) and (9) report results from Tobit estimations. Column (8) reports Probit estimates. In brackets we report robust standard errors. The Tobit specification for the exports equation in Column (7) and the training costs equation in Column (5) is censored at log(0.001) which is assigned to firms reporting zero exports and zero training costs, respectively. The censoring point for the Tobit regression in Column (9) is 0 which is assigned to firms reporting zero exports. The dependent variables in columns (1) and (4)-(7) are in natural logs. All models include an intercept term (not shown). Significance levels are reported at 10% (*), 5% (**), and 1% (***).

Total, skilled and part-time employment

128. In Table 12 columns (1)-(3), we examine the relationship between the three different types of innovation and some basic firm characteristics related to employment. The results show that relative to firms that do not innovate, both environmental and non-environmental innovators have a larger workforce with the BOTH group employing the most people on average. Furthermore, the share of part-time employees is lower for all type of innovating firms than it is for non-innovating firms. However, the picture is more mixed for the share of skilled workers. Compared to non-innovators, firms that introduce only innovations with environmental benefits employ a lower share of highly educated workers, while firms that introduce non-environmental innovations and both environmental and non-environmental technologies employ, on average, 10 and 3 percentage points more skilled employees, respectively[29]. Identical regressions using a different specification of the control group (firms which do not belong to the EPM-only and BOTH categories) deliver the same results: firms introducing innovations with environmental benefits do not employ more highly educated workers than other innovating firms.

129. Columns (1)-(3) in Table 13 present results from more sophisticated employment equations, similar to those estimated by Becker and Shadbegian (2009), who differentiate between "green" and "brown" manufacturing firms in the US. In particular, we estimate two different equations, one for total employment and the other for the shares of skilled or part-time workers:

$$\log(Employment) = \alpha_0 + \alpha_1 EPMonly + \alpha_2 nonEPMonly + \alpha_3 BOTH + \alpha_4 \log(Turnover) + \alpha_5 \log(Capital) + \alpha_6 \log(Material) + \alpha_7 Exporter + \alpha_8 Corporation + \alpha_9 Location + \sum \alpha_{ind} CODE + e$$

$$\text{Skilled or Part} - \text{time} = \alpha_0 + \alpha_1 EPMonly + \alpha_2 nonEPMonly + \alpha_3 BOTH + \alpha_4 \log(Employment) + \alpha_5 \log(Capital\ per\ employee) + \alpha_6 \log(Material\ per\ employee) + \alpha_7 Exporter + \alpha_8 Corporation + \alpha_9 Location + \sum \alpha_{ind} CODE + e,$$

where *Employment* represents total employment in each firm and *Skilled* or *Part-time* are the shares of skilled or part-time workers as measured to total employment. *Turnover* is firm's revenue, *Capital* is the value of capital assets,[30] *Material* is measured by firm's material costs, *Exporter* is a dummy variable equal to one for exporting firms, *Corporation* is a dummy variable indicating that the firm belongs to a group of firms, *Location* is a dummy variable equal to one when the firm is located in Eastern Germany, *CODE* is a set of industry dummies and *e* is the error term.

130. The more sophisticated regressions confirm the results for the part-time workers from Table 12. In contrast, there is no longer a significant effect of the environmental innovators only on the share of skilled employment, but the positive effect on the skilled worker share and its magnitude is little changed for the other two groups of innovators. A similar picture emerges for total employment. Only the most intensive innovators, those firms that introduce both types of innovation, employ more workers (column 3). All else being equal, such firms employ 9% more workers than otherwise similar firms in the same industry group that did not introduce any innovations.

29. Here and throughout the section, the elasticity (a percentage point change) of a dummy variable when the dependent variable is *X* is its estimated coefficient, while the marginal effect (a percent change) of a dummy variable when the dependent variable is measured as *log(X)* is calculated as *exp(α) – 1*.

30. Similar to other studies using the Mannheim Innovation Panel for their analysis (e.g. Rexhauser and Rammer 2011 and Peters 2008) we use the value of tangible and intangible assets as a proxy for capital assets.

Wages and training opportunities

131. We now turn to wages and training opportunities. For the purpose we use average annual compensation as a measure of wage and training costs per employee as a proxy for training opportunities. First, we present the results from the descriptive regression reported in Table 12, columns (4) and (5). Firms that introduce only innovations with environmental benefits are not significantly different from non-innovators as regards the *wage* they pay. By contrast, the innovating groups, *nonENVonly* and *BOTH*, provide their employees 25.7% and 18.4% higher wages, respectively. In terms of training costs, all innovating firms spend more per employee than non-innovators, consistent with innovation requiring higher skilled workers.

132. Table 13 columns (4) and (5) present results from more sophisticated equations. In particular, we estimate:

$$\begin{aligned}\log(\text{Wage}) \text{ or } \log(\text{Training costs per employee}) = {} & \alpha_0 + \alpha_1 EPMonly + \alpha_2 nonEPMonly + \alpha_3 BOTH \\ & + \alpha_4 \log(Employment) + \alpha_5 \log(Capital\ per\ employee) \\ & + \alpha_6 \log(Material\ per\ employee) + \alpha_7 Exporter + \alpha_8 Corporation + \alpha_9 Location \\ & + \sum \alpha_{ind} CODE + e.\end{aligned}$$

133. The results in Table 13 tell a largely similar story to that presented by the less complex regressions. We again find that innovators provide more training opportunities for their employees than non-innovators, with the *BOTH* group leading (column 5). By contrast, only the non-environmental innovators appear to be paying higher wages (12.5% more) than the control group, once we account for capital and material intensity, and other firm characteristics.

Labour productivity

134. Next, we explore the impact of being environmental and non-environmental innovators on productivity. Following Becker and Shadbegian (2009) and Peters (2008) we use turnover per employee as a proxy for labour productivity. A simple regression in Table 12 column (6) suggests that non-environmental innovators and those firms that introduce both, environmental and non-environmental technologies, have 25.6% and 20.5% higher productivity than non-innovators, respectively. In contrast, productivity of firms involved only in environmental innovations does not differ significantly from that of non-innovators.

135. We next estimate a type of a traditional Cobb-Douglas production function as follows:

$$\begin{aligned}\log(\text{Turnover per employee}) = {} & \alpha_0 + \alpha_1 EPMonly + \alpha_2 nonEPMonly + \alpha_3 BOTH \\ & + \alpha_4 \log(Employment) + \alpha_5 \log(Capital\ per\ employee) \\ & + \alpha_6 \log(Material\ per\ employee) + \alpha_7 Skilled + \alpha_8 Exporter + \alpha_9 Corporation \\ & + \alpha_{10} Location + \sum \alpha_{ind} CODE + e.\end{aligned}$$

136. The results presented in column (6) of Table 13 differ significantly from the descriptive regression. Here, productivity, measured as turnover per employee, is.6% lower for firms introducing environmental innovations than for non-innovators and 5% for workers introducing both types of innovations, while the estimated difference is insignificant for the non-environmental innovators. The rest of the explanatory variables deliver reasonable results, suggesting that higher capital and materials would result in better productivity, as that exporting firms more productive than their counterparts. However, we should emphasise that revenue per employee is an extremely rough measure of labour productivity, so that

these estimation results have to be interpreted with some caution. Unfortunately, the MIP survey does not collect information on the value added of firms.

Exports

137. Last but not least, we turn to exports, which is a key point of discussion regarding the green industry (i.e. whether green export champions can be developed). We measure exports in three different ways: value of exports, the probability of exporting, and the share of exports in total turnover. In Table 12 columns (7)-(9), we model each of three measures of exports as a function of the three innovator variables – *ENVonly*, *nonENVonly*, and *BOTH*, and a set of industry dummies. The results suggest that the latter two groups outperform are significantly more export oriented than non-innovating firms. Furthermore, the firms that innovate in both, environmental and non-environmental technologies, have the highest value of exports and the highest probability of being exporters. However, the firms introducing only environmental innovations do not significantly differ from the non-innovators. Results from more complex export equations presented in Table 13 columns (7)-(9) fully verify these outcomes. They are based on the estimation of three different export equations for the value of export, probability of exporting, and the share of exports to total revenue:

$$\begin{aligned}\log(\text{Exports}) = {} & \alpha_0 + \alpha_1 EPMonly + \alpha_2 nonEPMonly + \alpha_3 BOTH + \alpha_4 \log(Employment) \\ & + \alpha_5 \log(Capital) + \alpha_6 \log(Material) + \alpha_7 Skilled + \alpha_8 Corporation + \alpha_9 Location \\ & + \sum \alpha_{ind} CODE + e\end{aligned}$$

$$\begin{aligned}\Pr(\text{Exports}) = {} & \alpha_0 + \alpha_1 EPMonly + \alpha_2 nonEPMonly + \alpha_3 BOTH + \alpha_4 \log(Employment) \\ & + \alpha_5 \log(Capital) + \alpha_6 \log(Material) + \alpha_7 Skilled + \alpha_8 Corporation + \alpha_9 Location \\ & + \sum \alpha_{ind} CODE + e\end{aligned}$$

$$\begin{aligned}\text{Share of export to turnover} = {} & \alpha_0 + \alpha_1 EPMonly + \alpha_2 nonEPMonly + \alpha_3 BOTH \\ & + \alpha_4 \log(Employment) + \alpha_5 \log(Capital\ per\ employee) \\ & + \alpha_6 \log(Material\ per\ employee) + \alpha_7 Skilled + \alpha_8 Corporation + \alpha_9 Location \\ & + \sum \alpha_{ind} CODE + e.\end{aligned}$$

138. Let us have a quick look at the other explanatory variables in the models. Trade theory predicts that firms employing more high skilled workers, as well as those that belong to a corporation, are more likely to be exporters and to export more, which is confirmed in Table 13 columns (7)-(9). Furthermore, for the specific German case, the dummy for Eastern states appears to have a negative impact on exports, which is to be expected, since the majority of German exporting industries and multinational companies are located in the West.

Main insights from the German firm-level data analysis

139. This exploratory analysis of the implications of environmental innovation for employment patterns confirms important differences between innovating and non-innovating firms as employers. Much more tentatively, it suggests that there may be differences between firms engaged solely in environmental innovation and other innovating firms, with the former being intermediate between non-innovating firms and firms in non-environmental areas (whether or not they are also environmental innovators). Among the findings that could serve as a starting point for conducting further research (hopefully also making use of data for additional countries), are the following:

- The majority of firms innovate in both environmental and non-environmental products and processes at the same time. Those that introduce innovations with environmental benefits only make up the smallest group in the sample. Firms in the most polluting sectors, as defined in section 2 (above), rarely introduce non-environmental innovations only. If they innovate, at least some of their innovation is environmental.

- Firms from the most polluting sectors introduce environmental innovations most often as a way to comply with government regulations and voluntary agreements in their industries or to reduce their environmental tax liabilities. By contrast, the biggest clean innovators are driven mainly by their customers' present or expected demand for environmental-friendly products and processes.

- The most polluting sectors employ less than 18% of the total workforce in the sample and 15% of the skilled employees. The chemicals and electricity sectors outperform the other polluting industries in terms of turnover, exports, and training opportunities for their employees.

- On average, innovating firms outperform non-innovators in terms of total employment, workers' compensation, training opportunities, turnover and exports.

- All types of innovating firms employ fewer part-time workers than non-innovators.

- Wages and training opportunities provided by innovators are superior to those provided by non-innovators. However, wages and training opportunities are lower for environmental innovators as compared to non-environmental innovators on average. This is particularly true in Other services and Business services, computer and R&D.

- Firms introducing both environmental and non-environmental innovations have, on average, more employees, higher turnover and exports than other categories of firms, including those that introduce only environmental innovations, only non-environmental innovations, as well as, non-innovators.

- Overall, it appears that the general association between innovation and superior labour market performance is somewhat weaker for firms that only engage in environmental innovation than for other innovating firms. However, it is not clear whether this reflects something specific about environmental innovation or, instead, a difference between firms innovating in multiple areas versus firms innovating in only a single area.

PART II: AN ACTIVE ROLE FOR LABOUR MARKET AND SKILL POLICIES

140. Labour market and skill policy can make an important contribution to a comprehensive strategy to achieve a transition to environmentally sustainable growth, even if it is more of a supporting role as compared to the leading roles played by environmental and innovation policy. One part of this supporting role lies in the political realm. Much of the political resistance to a transition to green growth reflects wide-spread concerns that the jobs and well-being of many workers would be at risk. These concerns could be assuaged, at least in part, if an effective package of labour market and skill development measures is in place, which can assure that workers will receive the help they require to successfully navigate in a labour market that is being reshaped by the transition to green growth.

141. Quite apart from their potential to increase the political viability of green growth, policies fostering successful labour market adjustment to the green growth are also valuable in their own right. The transition towards green growth may lead to an intensification of structural economic changes, with the development and diffusion of more eco-friendly technologies and production practices throughout the economy. Therefore, achieving ambitious environmental goals raises important transitional issues, and adequate labour market and skill policy can make the transition to green growth quicker and less costly than would otherwise be the case.

142. Due to the great uncertainty surrounding the precise impact that a transition to green growth could have on structural changes and thus on labour market outcomes, it is not possible to predict in detail the specific labour market and skill policy measures that will be required. In particular, the many environment-related components of the overall policy package that will shape this transition are still largely unknown. Environmental regulations and policies are evolving in many countries and the process will continue to gain momentum in the years to come, at both national and international levels. Moreover, technological innovation, which is expected to constitute another key driver of the transition to green growth, is inherently difficult to forecast.

143. However, OECD countries have already faced major economic transformations, which have required innovative labour market and skill policies to enhance the adaptive capability of the labour market. Accordingly, the policy discussion begins by drawing out key lessons learned from these past experiences to identity a number of broad policy areas that need to receive priority in order to ensure good general framework conditions for meeting the structural adjustment challenges posed by the transition to green growth (Section A). Programmes that are specifically targeted to promoting green jobs or skills will also have a role to play and these types of measures are analysed in Section B. What governments are doing to foster the greening of their national labour markets is first reviewed, drawing upon a new OECD questionnaire to labour ministries. Some concrete examples of good and bad experiences are then provided, drawing upon the now fairly extensive experience with policies to green the construction sector.

A. Establishing good general framework conditions

144. A prerequisite for a successful transition to green growth is a well functioning labour market, with good general framework conditions that enable workers and firms to take advantage of, and to adjust quickly to, new patterns of growth. New jobs will be created, while other jobs will be destroyed or transformed. A key challenge for policy makers is thus to cope with the resulting job and worker flows, along with the retraining needs of incumbent workers. But this does not constitute a new challenge for

labour market policies. The ITC revolution and the deepening international economic integration have considerably weaken the lifetime job paradigm, so that securing workers employability and income, rather than jobs themselves, has been one of the guiding principles of labour market reforms conducted by OECD governments over the last two decades. These various reforms, their in-depth analysis and rigorous evaluation, have improved the understanding of what works. Taking stock of the most important policy initiatives and recent research findings, the *OECD Reassessed Jobs Strategy* (RJS; OECD, 2006a) 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. Therefore, the RJS is relevant to identify the key policy areas that need to receive priority to promote a smooth and just transition towards green growth.

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

145. OECD labour markets are characterised by a continuous reallocation of labour and other productive resources across firms and workers (OECD, 2009a and 2010a). Each year, more than 20% of jobs, on average, are created and/or destroyed, and around one-third of all workers are hired and/or separate from their employer. And in countries such as the United States or the United Kingdom, annual job and worker reallocation are as large as 25% and 45%, respectively, of dependent employment. By contrast, in a number of continental European countries, less than 15% of jobs are created and/or destroyed and about 25% of all workers are hired or separate from their employer in a given year. This remains large numbers. A growing body of evidence suggests that this continuous reallocation of labour is one of the engines of economic growth and welfare enhancement. In large part, this reallocation process reflects the fact that better business opportunities are created while inefficient production activities are destroyed. And from the perspective of workers, labour reallocation is also a process through which better job opportunities are created and seized.

146. However, not all workers benefit from the dynamism of the labour market in the same way. Workers who separate from their employer against their will are likely to experience difficulties in finding a job with comparable pay and working conditions. While comparative data on dismissals are scarce, OECD (2009a) 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. For these workers, displacement costs may go well beyond the earnings losses attributable to the unemployment immediately following layoffs (OECD, 2009a and 2010a). In particular, re-employment earnings can be considerably lower than pre-displacement earnings and it can take a long time for earnings to recover fully. Several US studies argue that displaced workers are more likely to end up in precarious jobs and, in general, tend to have much smaller earnings, once re-employed. Post-displacement wage and consumption losses are also observed for many European countries and Canada. The negative impact of job loss appears to be particularly large if it leads to protracted unemployment spells.

147. One of the key functions of public employment services (PES) is to 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, therefore reducing the potential "scaring" effects of unemployment. Indeed, a growing number of evaluation studies show that an effective PES contributes to lower structural unemployment, notably by shortening unemployment duration (OECD, 2004 and 2006b). To some extent, an effective PES can help reconcile efficiency with equity objectives: it reduces structural unemployment by redistributing resources – through spending on both active and passive labour market programmes – towards those workers negatively affected by the intensive labour reallocation process conductive of productivity gains and economic growth. In that sense, an effective PES can help reduce the political resistance to those environmental policies and regulations that are likely to put at risk many jobs in polluting industries and services. Such political economy arguments have already been highlighted in the context of the trade liberalisation (OECD, 2005a). For example, 60 years of public

opinion survey evidence for the United States indicates that fears of job loss account for the low level of public support for further trade liberalisation, but that support is significantly increased if trade liberalisation is combined with increased adjustment assistance for trade-displaced workers (Scheve and Slaughter, 2001).

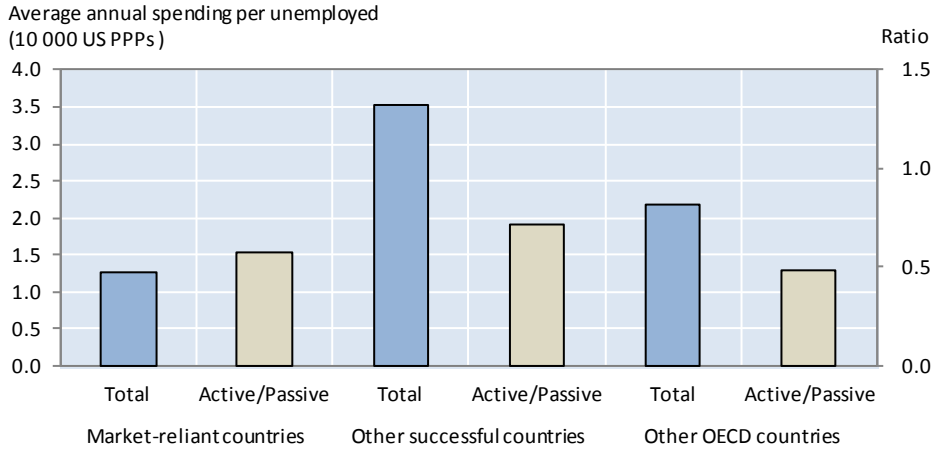
148. Figure 24 illustrates how cross-country differences in the resources devoted to labour market programmes reflect variation in both national preferences concerning the overall level of resources devoted to these types of measures (*e.g.* countries with above-average passive spending also tend to have above-average active spending) and national differences in the relative emphasis placed on active versus passive measures. Making use of three broad country groupings, which were identified based on a principal-components analysis grouping countries according to similarities in aggregate employment outcome and labour market policies at the beginning of the 2000s (OECD, 2006b), the following patterns emerge:

- "Market-reliant countries" and "other successful countries" differ dramatically in the level of spending on labour market programmes while achieving similarly strong aggregate employment performance. Prior to the recent economic crisis, total spending was nearly four times higher in the second group than in the first, while the two groups of countries placed a similar emphasis on active measures, relative to passive measures. However, unemployment rose more sharply during 2007-09 in the market-reliant countries than in the other successful countries (2.9 versus 1.4 percentage points), leading to a relatively sharp increase in spending on income support for the unemployed in the first group of countries (OECD, 2011e). As a result, total spending in market-reliant countries rose to be nearly one-third of that in other successful countries in 2009, while its ratio of active to passive spending fell to become somewhat lower.

- Spending is at an intermediate level, but more concentrated on passive benefits, in the third group of countries, which had much weaker aggregate employment performance in the early 2000s than the two above-mentioned groups of countries.[31]

31 . The 2009 data shown in Figure 24 reflect, in part, the uneven impact of the recent crisis across these three groups of countries, with unemployment and hence UI/UB spending rising more sharply in the market-reliant countries than in the other two groups of countries. Prior to the crisis, the more active mix of labour market spending in market-reliant countries as compared with the mix in the third group of countries was considerably more pronounced. Since 2009, the unemployment impact of the crisis has evened out across the three groups. Once 2010 data for labour market spending become available, differences in spending patterns across these groups are likely to more closely resemble the pre-crisis pattern.

Figure 24. **Expenditure on active and passive labour market programmes, 2009**



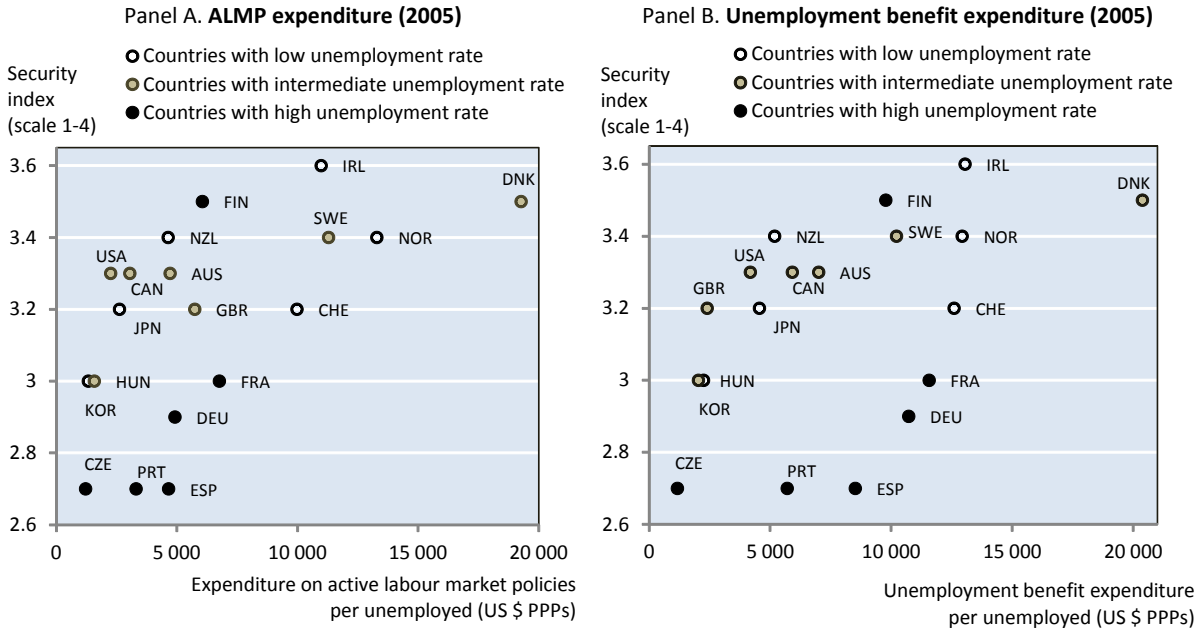
Market-reliant countries: Australia, Canada, Japan, Korea, New Zealand, Switzerland, United Kingdom, United States.
Other successful countries: Austria, Denmark, Ireland, Netherlands, Norway, Sweden.
Other OECD countries: Belgium, Czech Republic, Estonia, Finland, France, Germany, Hungary, Italy, Luxembourg, Portugal, Slovak Republic, Slovenia, Spain.

Source: OECD database on Labour Market Programmes.

149. This illustrates one of the key results of the RJS: passive and active measures should be closely aligned and well coordinated 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. Previous OECD reports have described the components of an effective activation scheme in detail (OECD, 2005a, 2006 and 2007; Carcillo and Grubb, 2006). 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.

150. While "market-reliant countries" and "other successful countries" achieve similarly strong aggregate employment performance, the political support for environmental reforms is likely to be higher in the second group of countries, which are characterised by a strong social protection system that should further reduce fears of job loss for workers employed in polluting industries and services. In this respect, Figure 25 suggests that workers tend to feel more secure about their labour market situation in countries that spend more on active labour market policies and offer stronger income supports to job-seekers, although the impact of such measures is difficult to disentangle from that of national labour market performances. More sophisticated analysis, controlling for regional unemployment rates (at a sub-national level), as well as, for observed and unobserved individual heterogeneity, still suggest that both active and passive labour market programmes contribute to strengthen workers' feeling of employment security (Postel-Vinay and Saint-Martin, 2005; Clark and Postel-Vinay, 2009). In a similar vein, OECD (2010a) finds that generous unemployment benefits appear to foster labour mobility among relatively young workers, in part by lowering the potential cost of taking a new job in risky industries.

Figure 25. **Workers' perceptions of employment security**



a) For each country, the security index corresponds to the average answer to the following question (from ISSP): "Do you worry about the possibilities of losing your job?". Scale 1 (I worry a great deal) to 4 (I don't worry at all).

b) Unemployment rates refer to 2005; Security Index refers to 2003.

Source: ISSP (2003); OECD LMP Database; OECD MEI Database.

151. In countries where displacement costs remain high, the question arises as to whether targeted programmes should be implemented so as to provide additional supports to those workers most adversely affected by environmental protection measures. Beyond political economy considerations, equity arguments can be advanced: environment is a public good and it may be judged unjust for the broad majority of the population to benefit from improved environment quality while high adjustment costs are borne by a minority of workers.

152. These political economy and equity arguments have resulted in the implementation special programmes targeted at trade-displaced workers in a small number of OECD countries (see Box 8). Several lessons can be drawn from these experiences, which can be also relevant for the transition towards a green economy:

- 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). Therefore, defining entitlement criteria according to displacement reasons may result in a cumbersome and costly screening process. Besides, overly complex entitlement criteria and procedures may result in low take-up rates, therefore preventing the programme from fulfilling its objectives.

- Equity arguments may be difficult to sustain if the targeted population does not constitute a distinct group whose members' adjustment assistance needs differ in some respects from those of persons displaced for other reasons, be they structural or cyclical. Setting up targeted programmes that favour one type of displaced worker while excluding others facing similar

labour market difficulties may give an arbitrary advantage to workers displaced by structural changes driven by the greening of the economy.

- Political economy arguments should be considered with caution. If not carefully designed and implemented, a programme aimed at strengthening the political support for environmental reforms may have the opposite effect of cementing the connection in popular debates between environmental protection and economic hardship (LaLonde, 2007). Indeed, the linking of displacement assistance to the greening of the economy may foster the false impression that displacement largely results from the introduction of new environmental policies or regulations, whereas intense labour reallocation is a general pattern of OECD economies.

153. 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 because specific programmes tend to increase administrative complexity and may lead to inequities (OECD, 2005a and 2005b). A careful assessment of the size, nature, and distribution of the adjustment costs associated with trade-related displacement was essential to implement successful targeted programmes, which should have remained limited to cases where they offered a clear advantage over reliance upon general employment programmes or provided a necessary "safety valve" for diffusing political opposition to an open trading system. This appears most likely to apply when shifting trade patterns displaced a large number of workers facing particularly great barriers to re-employment in one or a few localities.

154. The same appears be true for meeting the structural adjustment challenge posed by the transition to green growth. In particular, some polluting activities, such as the coal mining industry, are characterised by a relatively strong degree of geographic concentration. This implies that a small number of regional economies within a country may face particularly high adjustment costs, and consequently, may require specific supports from national government.

Box 8. **Special programmes targeted at trade-displaced workers: mixed results**

Targeted programmes have taken two distinct forms. First, the United States has maintained a general programme aimed at all trade-displaced workers, which provides more extensive adjustment assistance than is available to other displaced workers. Second, a number of OECD countries have operated special programmes for more or less narrowly-defined groups of trade-displaced workers, typically focussing on a particular industry or locality.

The United States is unique within the OECD for having operated a targeted programme for trade-displaced workers, the Trade Adjustment Assistance programme (TAA), for over 40 years. This programme is national is scope and, in principal, is available to all workers losing their jobs due to imports. TAA offers a more generous set of unemployment benefits and ALMPs to workers certified as trade-displaced than are available to other displaced workers. However, the mix of services offered by TAA – especially, the relative emphasis placed on supplementary unemployment benefits versus training – has fluctuated quite markedly since the programme was enacted. This programme operates in a national context where general programmes for displaced workers are modest as compared to most other OECD countries. The TAA has been subject to considerable evaluation, although the constant evolution of the programme means that many past evaluation results are now of questionable relevance (Baicker and Rehavi, 2004; Decker and Corson, 1995; GAO, 2001; OTA, 1987). Some of the services it has provided have been innovative and shown high returns (Jacobson *et al*., 2005), but others have not. However, 40 years of experience with the TAA has not revealed any clear economic efficiency rationale for having a targeted programme for all trade-displaced workers. In particular, TAA has not made use of unique types of adjustment assistance that are especially tailored to meet the distinct needs of trade-displaced workers. Rather, it has offered a shifting mix of the same types of job-search assistance, retraining and relocation services routinely offered to participants in ALMPs. Furthermore, the cumbersome procedure involved in certifying job losers for TAA has resulted in low take-up rates and often long delays in the receipt of adjustment assistance (GAO, 2004; Kletzer and Rosen, 2005).

Rather than using targeted policies that are intended to aid all trade-displaced workers, some OECD countries have chosen to target adjustment assistance measures to sub-groups of trade-displaced workers for limited periods of time. Using such targeted initiatives may help smooth labour reallocation because the impact of trade liberalisation tends to be localised, hitting particular sectors and/or regions hard. For example, targeted programmes are sometimes adopted in order to deal with trade shocks that produce localised layoffs on a scale that threatens to overwhelm the existing labour market policy infrastructure. Another potential advantage of such programmes is that their reduced size and one-off character makes it easier to tailor them to meeting the specific needs of the workers affected. Finally, targeted measures can sometimes be put in place in advance of layoffs actually occurring, thereby easing adjustment. In almost all of the eight sectors examined in the OECD horizontal study of trade and structural adjustment there are examples of sector-specific measures being used, sometimes successfully, to help the adjustment process, whether to help textiles and clothing producers in Australia to be competitive in a low-tariff environment or to cope with mass layoffs in Sweden's Östergötland county (OECD, 2005b). Often, these programmes combine adjustment assistance for trade-displaced workers with measures to revitalise the local economy and/or to improve the competitiveness of the affected industry. Nonetheless, it is difficult to generalise concerning these types of measures, since no clear criteria have emerged for determining when they are appropriate and they have been quite varied in their design and effectiveness.

2. Fostering eco-innovation

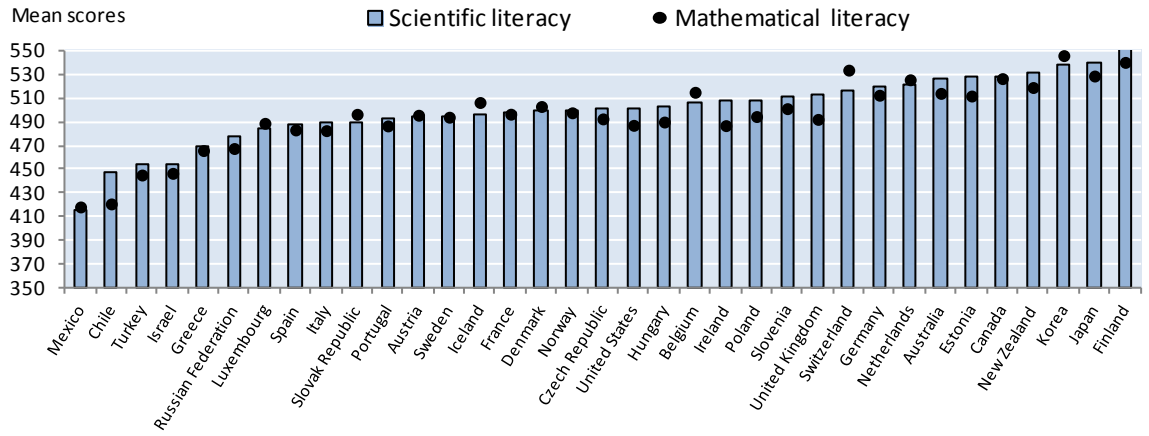
155. By targeting the prices of environmentally harmful consumption, green policies create incentives for R&D investments in green industries and services, and in fact, eco-innovation is expected to constitute one of the key drivers of the shift toward a low-carbon and resource efficient growth. The *OECD Innovation Strategy* provides analysis and policy guidance on a broad range of issues from education and training policies, to policies that provide a conducive business environment for innovation, to policies that foster the creation and diffusion of knowledge (OECD, 2010b). True, specific innovation policies will play a leading role in supporting and fostering the creation, adoption and diffusion of new green technologies and products. But ensuring good general framework conditions is also critical for innovation enhancing measures to be fully effective. The availability of a skilled workforce is a prerequisite for reaping the full benefits of new green competitive niches, and a well functioning education and training system is an

essential element of a general policy framework for innovation. And in facilitating the entry of innovative firms, well-designed labour and product market regulations will also have an important role to play.

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

156. The ability to adapt to new technology begins with a well-performing compulsory school system, namely one that provides students with strong skills in core fields, including mathematics and science. Some information about the performance in these fields of study at the compulsory school level is provided by cross-country indicators on mathematical and scientific literacy rates. They suggest that OECD countries provide young people with uneven average skill levels in these subjects. According to the latest results, the Asian OECD countries attain particularly high scores in mathematical and science literacy tests, while southern European countries and Mexico record low scores (Figure 26).

Figure 26. **Mathematical and scientific literacy of 15-year-olds: mean scores, 2009**



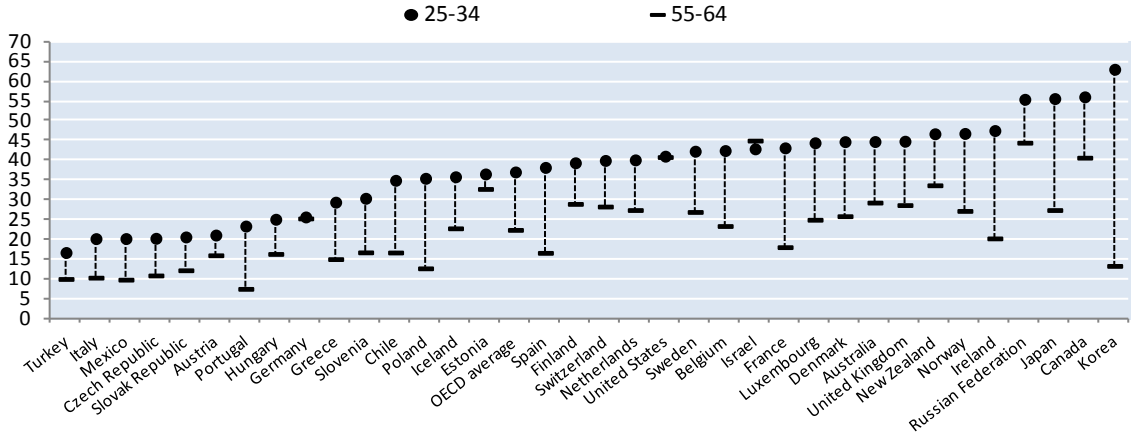
Source: OECD (2009d)

157. A well-performing and broadly accessible education system at the tertiary level is also important to facilitate the adoption and widespread diffusion of innovation. The main challenges for tertiary education are to train quality graduates who can contribute directly or indirectly to innovation in their workplace, to foster research excellence, to build links between tertiary institutions and other research organisations and industry, and to improve the ability of tertiary education to disseminate the knowledge it creates(OCED, 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, 2008).

158. Tertiary attainment levels have increased considerably over the past 30 years. In almost all countries, 25-34 year-olds have higher tertiary attainment levels than the generation about to leave the labour market (Figure 27). On average across OECD countries, 37% of the younger cohort has completed tertiary education, compared with 22% of the oldest cohort. The expansion of the tertiary sector has put Japan and Korea in the top group together with Canada and the partner country the Russian Federation, with over 50% of the younger cohort with tertiary education. However, 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. This suggests that tertiary education systems could be strengthen in a number of countries. These include, *inter alia*, providing better information to students about scientific careers, revising curricula at the tertiary level to make them more responsive to student and industry needs, increasing funding for graduate and post-doctorate training and introducing programmes to facilitate domestic access to high-skilled foreign workers (OECD, 2010d).

Figure 27. **Tertiary education attainment, 2009**

Percentage of population aged 25-34 and 45-54



Source: OECD (2011f)

159. In addition to the tertiary education system, vocational education and training (VET) is also vital for the innovation process, as the skills it provides are central to incremental innovation activities. Many firms do not develop new-to-the-world, radical products and processes. Rather, they reproduce products already on the market, using off-the-shelf technology or make incremental improvements to existing products or processes to better meet the needs of users. This requires activities such as tooling up, design work, developing prototypes and testing, which are key aspects of vocational training. Studies have also shown that firms in countries with a relatively large proportion of their production workforce with postsecondary VET qualifications have lower defect rates, less need for quality checkers, fewer plant breakdowns, and more rapid introduction of new products (Toner, 2009). With respect to innovation, a key challenge for VET is to connect effectively to the world of work to ensure that employers can find the skills they need to advance their innovation activities.

160. Based on a careful review and in-depth analysis of several national VET systems, the OECD ha 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). Since student preferences, on their own, do not always adequately reflect labour market needs, VET programmes should include an element of workplace training, as the willingness of employers to provide such training indicates labour market demand. Employers and unions need to be involved in curriculum development, and programmes should provide both generic transferable skills and occupation-specific skills that provide graduates with a basis for lifelong learning, mobility and changes in their working careers. Encouraging exchange between VET institutions and industry, so that VET teachers and trainers spend time in industry to update their knowledge and trainers in firms spend time in institutions to update their pedagogical skills, improves the quality of training and helps further strengthen bridges between education and the world of work. Other policies to be considered include sharing the costs of VET among government, employers and students, in line with their respective benefits, adopting national assessment to ensure quality and consistency, and strengthening the knowledge base on VET education to allow for continuous improvement in the sector.

161. Learning that takes place on the job 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, 2007b, OECD, 2009b). The importance of work-based learning highlights the fact that skills acquisition is a lifelong process. Learning a set of skills at school, technical college or university or through on-the-job training may no longer enough to carry people throughout their working life. Moreover, there are limits to the ever-lengthening duration of initial education (OECD, 2009c). Several tools can encourage ongoing skills acquisition. To form a base for lifelong learning, schools need to motivate individuals to continue to learn and to adopt practices that increase students' capacity for independent learning. Last but not least, all forms of learning need to be recognised and made visible on the basis of their content, quality and outcomes. Qualifications systems need to promote and be responsive to lifelong education and training systems. With the number of stakeholders involved in lifelong learning extending beyond those covered by education authorities, co-ordination in policy development and implementation will be essential. Work on adult education shows the importance of improving the visibility of rewards to learning as a way to motivate people to learn (OECD, 2005c).

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

162. In addition to implementing effective VET systems and activation strategies, the *OECD Reassessed Jobs Strategy* (RJS; OECD, 2006a) highlights that a proportionate and well designed employment protection (EP) plays a key role in promoting a well- functioning, more dynamic and more inclusive labour market. As part of the policies to achieve better labour market performance, the RJS also recommends the removal of regulations that impede the entry and expansion of new firms, and that constrain product market competition in general (OECD, 2006a). While product market regulation (PMR) has become less constraining for competition over the past two decades in most OECD countries, few governments have implemented comprehensive EP reforms. Instead, many countries have eased the use of temporary forms of employment while leaving existing, relatively strict, regulations on permanent contracts virtually intact, especially in Europe. In a number of cases, these partial reforms have resulted in a more segmented labour market by accentuating the gap between workers hired on permanent contracts ("insiders") and youth and other workers at the margin of the labour market ("outsiders"), be they unemployed or on precarious temporary jobs that offer limited opportunities to upgrade their human capital and acquire a career (EC, 2010*a*).[32]

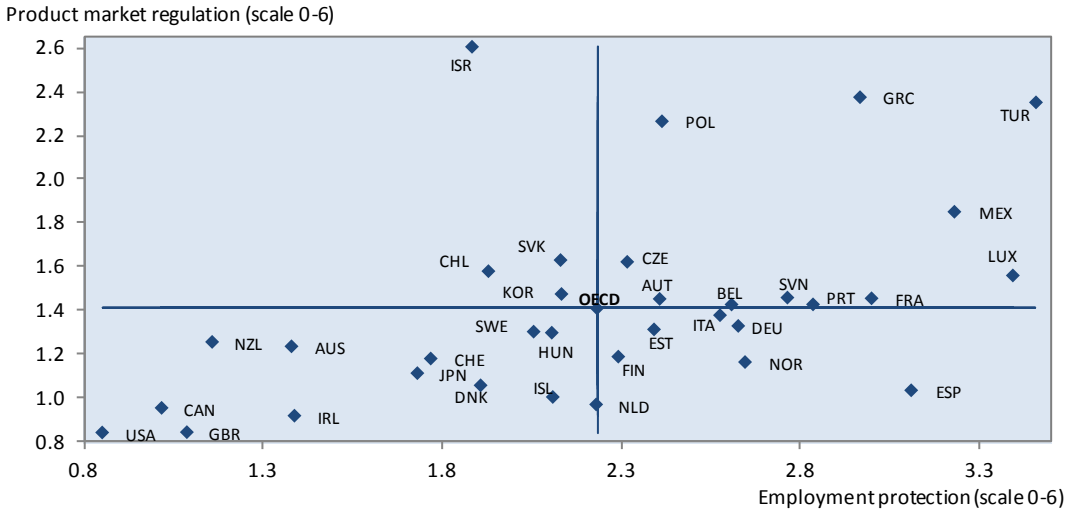
163. Notwithstanding these various reforms, the stringency of product and labour market regulations in the OECD area is still characterised by significant differences across countries (Figure 28). Further reform efforts in one or even both of these key policy areas would improve labour market performance in a number of countries. Environmental policies and eco-innovation create new green competitive niches, and in this context, moderate employment protection and strong product market competition are important supports for vigorous job creation. More importantly, by constituting an impediment to eco-innovation, poorly designed PMR and/or EP could lengthen the transition towards a green economy, as the development and diffusion of new green technologies are crucial to reduce both GHG emissions and the economic costs of carbon pricing policies.

164. A business-friendly institutional environment is necessary to provide sufficient incentives to innovate (de Serres, Murtin and Nicoletti, 2010). First, there is growing evidence that a large share of more radical innovations in an economy come from new firms, in particular those that challenge the business models of incumbents, hence the importance of reducing barriers to entry. Second, competitive pressures stimulate technology adoption and innovation. As a result, regulations that promote competition in network industries are likely to be associated with stronger capital formation, technology adoption and productivity

32 . The pattern of job loss during the 2008-09 crisis exacerbated this labour market segmentation, when job losses were especially high for youth, workers on temporary contracts. Large declines in employment in construction and manufacturing also heightened wage polarisation (EC, 2011). It is not yet clear whether these recent developments will reverse as labour markets recover.

growth. On the other hand, a degree a market power may stimulate innovation activity by facilitating the recovery of related expenses. Therefore, the right policy environment for innovative activity is one that gives adequate rewards to innovation while ensuring competitive pressures that encourage firms to create, implement, and diffuse 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).

Figure 28. **Employment protection and product market regulation, 2008**



Data refer to 2009 for France and Portugal.

Source: OECD Employment protection database; OECD Product market regulation database.

165. Facilitating the re-deployment of labour to expanding industries and new firms is also crucial to the development and the diffusion of green technologies. In this respect, the fact that strict EP reduces job and worker flows is well documented (OECD, 2010a), and there is growing evidence that EP affect innovation patterns. Restrictive hiring and firing rules may constitute an impediment to the adoption of new technologies and innovation where innovation-driven labour adjustments have to be accommodated via worker turnover.[33] One the other hand, greater job security and long-term employee-employer contracts may encourage the accumulation of firm-specific competencies and increase worker investment in innovative activity. Consequently, the relationship between EP and innovation is not univocal: it depends on the nature and size of innovation, reflecting the degree to which innovation-driven workforce adjustments are accommodated through worker turnover.

166. For instance, Bassanini and Ernst (2002) find that in OECD countries, EP can significantly deter R&D in industries where the innovation process is driven by product differentiation, with technologies often being renewed through entry and exit of firms, and extensive worker turnover. A depressing effect of employment protection on R&D is also found in industries characterised by product lines at the end of their life-cycles, where innovation often leads to downsizing. Conversely, EP appears to play no constraining role on R&D in high-technology industries characterised by a cumulative innovation process, supported by worker skills that are highly specific to individual firms. In these industries, the best worker competencies to complement innovations are often found within the firm, and upgrading skills of existing employees is

33 . 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.

likely to be less costly than training new workers. 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 activity in high EP countries, and more radical patenting activity in low EP countries. Radical innovation is potentially more profitable than incremental innovation, but requires a large and drastic employment adjustment, because workers with new skills are needed to implement the innovation. Incremental innovation increases productivity, but to a lesser extent than radical innovation, hence the possibility of retraining and up-skilling existing production workers. Likewise, Bartelsman, Gautier and de Wind (2010) suggest that differences in EP stringency can explain why the United States was better able to explore the benefits of the new information technology starting in the mid 1990s.[34]

167. This past research suggests that the return to R&D investments in green industries or services will differ depending on the national EP and PMR in force. If it is confirmed that these patterns also hold for eco-innovation, that would have important implications for green-related innovation policies. In countries with relatively lax firing and hiring rules, public investment in green-specific R&D would be most effective when targeted at new product innovation as these countries tend to have a comparative advantage in radical innovation. By contrast, in countries with stringent EP, public support to green-specific R&D could be more effective when targeted at more mature product innovation that requires incremental product development and for which demand is more certain.

168. There do not appear to have been any studies yet analysing whether the general findings about how EP and PMR regulation affect innovation and the reallocation of labour from declining to growing sectors, as summarised above, applies to the restructuring process associated with a transition towards green growth. A simple juxtaposition of the regulatory stringency indicators reported in Figure 28 with different country-level measures of green growth performance makes it clear that there is no simple link between these types of regulation and progress towards achieving environmentally sustainable growth. This is to be expected since many other factors will also influence environmental performance. Nonetheless, some suggestive patterns emerge confirming that this issue represents an important topic for future research:

- When countries are ranked according to the number of environmental patents per trillion US dollars (in purchasing power parities) of GDP, all of the top performing countries have relatively pro-competitive PM regulation. However, top performers vary considerably in terms of the strictness of EP regulation. 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.

- One potential source of concern is that EP regulation is relatively strict in Poland, Greece, Slovenia and Portugal, the four EU countries with the highest share of employment in the most polluting industries (*cf.* Figure 9). Since strict EP is associated with low labour market mobility and long unemployment spells, policies to reduce CO2 emissions in these countries could become an important source of structural unemployment if reforms are not enacted, 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.

- There does not appear to be any clear bivariate association between national regulatory stances and GHG emissions per unit of output (as reported in OECD, 2012*c*), presumably because non-policy factors (*e.g.* fossil fuel resource endowments) play such an important role. OECD countries with the highest GHG emissions intensity include Australia, New Zealand and Canada,

34 . Samaniego (2006) also provides evidence that EP is negatively correlated with ICT diffusion.

where EP and PMR regulation is relatively light, but also Poland which has a relatively strict regulatory stance.

- A recent international study of the deployment of renewable energy (IEA, 2011) shows that there is a strong relationship between government policies encouraging investment in renewable capacity (*e.g.* feed-in tariffs) and deployment rates. However, the leaders in terms of onshore wind and solar PV capacity do not show any clear pattern in terms of EP and PMR regulatory stances.

3. A unique opportunity to improve the effectiveness of the tax and benefit system

169. The literature on the so-called "double dividend hypothesis" suggests that carbon pricing policies can increase employment when carbon revenues are used to reduce taxes on labour income. However, initial labour tax distortions should be relatively strong for such an employment dividend to materialise. Consequently, such a recycling option for carbon revenues may be more effective when targeted on low-wage earners, as labour taxes, and more generally, the overall tax and benefit system, tend to be particularly distortive at the bottom end of the wage ladder. In a number of OECD countries, relatively high statutory minimum wages and/or replacement revenues for low-wage workers translate into relatively strong downward wage rigidities. Therefore, tax and benefit systems could be particularly damaging to employment prospects of disadvantaged workers with low educational attainment or limited employment experiences.

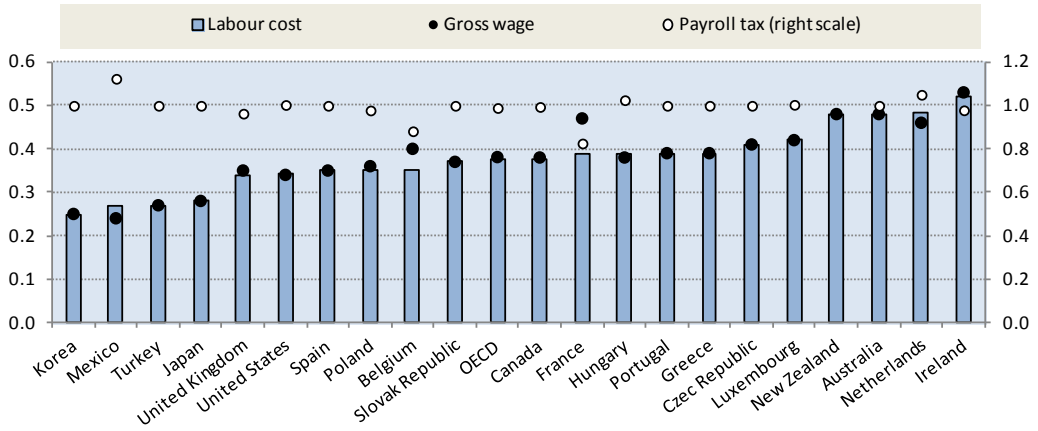
170. Climate change policies are likely to amplify this pattern, as they will result in higher energy prices (at least in the short/medium run) that could require some downward real wage flexibility in order to preserve employment levels. Another rational for redistributing carbon revenues towards low-income households lays in the fact that environmental quality is a public good which high-income households tend to value more than their lower-income counterparts. Indeed, household surveys indicate that the so-called "willingness to pay" for environmental protection tends to increase with household incomes. And as the share of energy bills in total consumption expenditure decreases with household income, the likely rise in energy price will affect more strongly the purchasing power of low-income household –even in presence of relatively stronger real wage rigidities at the bottom end of the wage ladder. Most disadvantaged households may need to receive additional income transfers; otherwise they may suffer from severe economic hardships. Therefore, there are both efficiency and equity reasons for the recycling of carbon revenues to be targeted at low-income working households.

171. Still, several options need to be considered, as carbon revenues can be used to lower taxes paid by employers or by employees, or to raise (or introduce) in-work benefits that top up wage income of most disadvantaged working households. In countries with relatively high labour costs at the minimum wage level, reducing employer social contributions could be the most appropriate option. Instead, lowering taxes paid by employees or increasing in-work benefits would constitute a better option in countries where taking up a low-paid job does not bring much additional disposable income. More generally, carbon revenues can be used to correct other market distortions, such as by lowering capital taxes or subsidising R&D. Which form of recycling is most desirable depends in a complex way on many national specificities. The rest of this section focuses on factor affecting the potential gains from reducing labour taxation.

172. Labour costs for minimum-wage workers vary substantially across countries, even when accounting for differences in average wage levels. This is shown by Figure 29, which compares the cost of employing minimum-wage workers with the cost of average-wage workers. Minimum wage costs range from less than 30% of the cost of an average worker in Japan, Korea, Mexico and Turkey to almost 50% in Australia, Ireland, the Netherlands and New Zealand. However, these differences are explained primarily by the international variation of gross minimum wages (relative to gross average earnings). By contrast,

payroll taxes play almost no role. Therefore, even in countries where minimum-wage costs tend to be very high, the policy priory may consist in compensating low-income households for the rise in energy prices by additional transfers in order to better resist to potential political pressures to further increase the statutory minimum wage level, rather than cutting employer social contributions at the bottom-end of the wage ladder.

Figure 29. **Labour costs for full-time minimum-wage workers**



Source: Immervoll (2007).

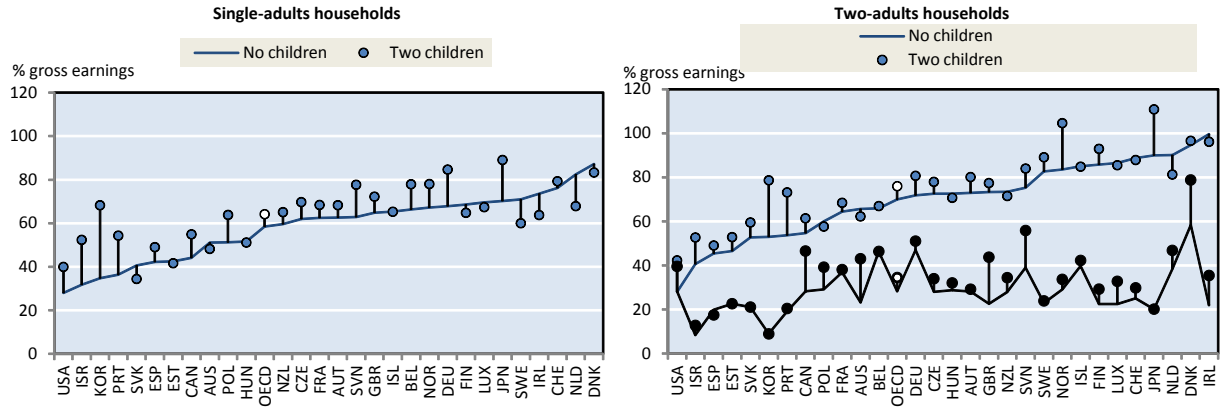
173. Moreover, deadweight losses associated with these broadly targeted tax cuts tend to be substantial,[35] and cannot be justified on equity grounds, as the overlap between low-paid employment and in-work poverty is rather low. For instance, OECD (2009a) shows that on average in Europe, only slightly more than half of the working poor live in households where there is at least one person employed in a low-paid job. In addition, a large majority of the beneficiaries of such broadly targeted fiscal measures are not poor: on average in Europe, less than one in ten low-wage workers lives in a working-poor household. Therefore, payroll tax cuts targeted on lower-wage earners pose a major funding issue, as these measures are rather costly in terms of lost tax revenue while the revenues from carbon pricing policies can be used only once: either to reduce employer wage costs or to increase net social transfers to disadvantaged workers.

174. In this respect, OECD tax-benefit calculations show that it does not pay much to work at the bottom-end of the wage ladder in many OECD countries. Those 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. This is illustrated in Figure 30 for a job with below-average earnings (two thirds of the average wage). Taking a low-paid job adds something to net income in all countries, but the size of the gain varies considerably across countries and household types. In many cases however, less than 40% of such earnings add to available net income (the so-called "average effective tax rate" is 60% or higher).

35 . Such broadly targeted tax cuts benefit also to those existing low-paid jobs that are not at risk, and to new low-paid jobs that would have been created even in the absence of the tax reduction. Thus, although this kind of measures has proved to be effective in raising low-skilled employment in countries such as Belgium and France, they are associated with high deadweight losses (OECD, 2007a).

Figure 30. **Average effective tax rates, 2009**

Reduction of net social transfers when moving from social assistance to employment at 67% of the AW



Source: OECD tax-benefit models.

175. When only one person in the household has a low-paid job, financial rewards from work tend to be very low. This is especially the case for families with children: the proportion of gross earnings offset by reduced social benefits, social contributions or income taxes reaches 80% or more in half of OECD countries. This means that less than 20% of those modest earnings add to available net income. For these households, benefits withdrawal is the key component of these high effective tax rates (see Annex 3 Figure A3.1). For two-earner households, about 35% of additional earnings are on average taxed away when the spouse takes up a low-paid job. Second earners thus face much lower effective tax rates, and for them, the tax burden on labour incomes plays a more important role than benefits withdrawal.

176. In many countries, the policy priority is not reshaping the tax structure on the employee side, but rather, the benefit system. If well-designed, employment-conditional benefits have proved to be effective in improving the labour market situation of the most vulnerable groups (Immervoll and Pearson, 2009). And in countries with binding minimum wages, employment-conditional benefits could be more appropriate than broad employer tax cuts, as such measures could help reduce the minimum wage level relative to the average wage while providing adequate income support to working household with low income. These schemes appear particularly relevant in a context of green growth, as the likely rise in energy prices in the short and medium run will pose distributional issues that need to be addressed carefully. Compared to a reduction in labour taxes, in-work benefits can be targeted more effectively at the most disadvantage working households.

B. What role for green-specific measures?

177. 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 green economy has its own specificities that policies in a wide range of economic areas, including the labour market area, will have to accommodate. Yet, the implementation of such specific programmes depends upon policy actions that are undertaken at both the national and international levels to protect and improve the environmental quality. As building a strong environmental policy framework is still an unfinished task, providing precise policy orientations on how employment and skill policies should be tailored to address the transition to green growth would be premature. The somewhat mixed experience with the labour market components of the green fiscal stimulus measures taken by a number of countries in response to the recent economic crisis also suggests taking an incremental approach in this area (Box 9). Instead, this section provides an overview of the experience to date with labour market and training programmes which are intended to foster greening of the labour market, and sheds some light on what can be done to prepare workers to a green economy.

Box 9. **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 in a recession, as one likely effect of the crisis was to lower the (short-run) opportunity cost of green investment. 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 much diminished or totally exhausted in many countries, it is interesting to assess whether green stimulus could play a positive role in future recessions, as well as what this experience has taught us 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 (OECD, 2010*a*). 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. Approximately two-thirds of the job-years represent work on clean-energy projects, either by workers employed directly on the projects or by workers in the supply chain. Likewise, Korea has been implementing its "Green New Deal" policy since January 2009. The policy's aim was both to overcome the economic crisis in the short-term as to strengthen the growth potential over the long term. The 50 trillion KRW 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 2009-2010 period.

Although these green stimulus measures have not been subject to rigorous evaluation, it has become clear that this type of measure needs 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. Macro-stabilisation requires that stimulus packages be timely, targeted and temporary (the so-called "three Ts"). 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 macro-stabilisation measures can make to fostering greener growth. A priori, some of the green fiscal measures appear to score well on the three criteria. For example, programmes to retrofit existing public and private buildings for greater energy efficiency appear to have a considerable potential to generate new jobs quickly (timely) of the kind many currently unemployed workers can fill directly or with limited training (targeted) and the fiscal stimulus related to these measures can be phased out as the economic recovery strengthens (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 (see Annex 4). 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. 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.

In sum, green stimulus during recessions is unlikely to make a major contribution to a long-term transition towards a low carbon economy. There also appears to be an important risk in trying to use green public spending to achieve employment policy goals, unless these are carefully embedded in a comprehensive green growth strategy. 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.

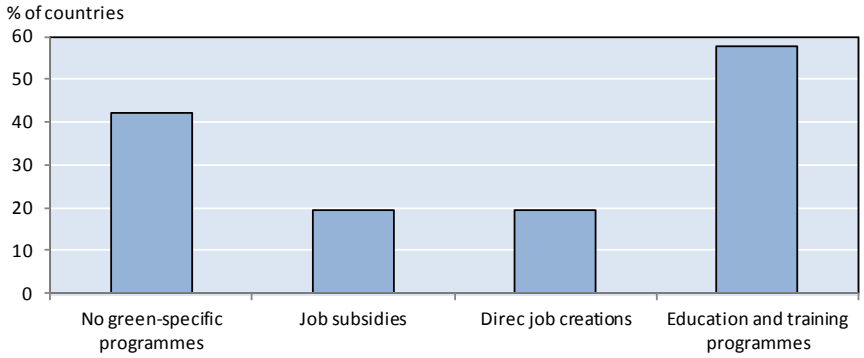
1. What kinds of green-specific measures have OECD countries implemented at the national level?

178. Since little internationally comparative information is available concerning specific labour market measures that countries have implemented in order to realise the full job potential of a shift towards a green economy, a questionnaire as been sent to OECD member countries (detailed country responses are provided in the Annex 5 of this report).

A gradual process, still at an early stage of implementation

179. Drawing on country responses to the questionnaire, training and education programmes appear to constitute a top priority (Figure 31). Most countries regard a well functioning VET system as an essential element for green growth, and consequently, green-specific skill development measures have been integrated into comprehensive national green strategies. By contrast, job subsidies in the private sector or direct job creation in the public sector are only rarely used as green employment programmes and have often been introduced as part of the policy responses to the global economic crisis, on a temporary basis.

Figure 31. **Green-specific national labour market programmes implemented by OECD countries, 2010**



The OECD questionnaire on green jobs and policies covers 26 OECD countries.

Source: Annex Table A5.1.

180. Overall, green-specific employment and skill policies still appear to be at an early stage of implementation. Two out of five OECD countries have not yet implemented specific programmes at the national level (Figure 31). In part, this may reflect the fact that labour market and training policies in support to green growth are implemented at the local level, which goes beyond the scope of this report. But this may also reflect the fact that core policies to impulse the greening of the economy are themselves at an early stage of implementation in a number of countries (*e.g.* Israel, Poland).

181. However, it is striking that a number of countries which have long been engaged in environmental protection, such as Germany, Denmark, the Netherlands, Sweden or Norway, have not yet implemented green-specific measures. In these countries, a comprehensive package of general labour market programmes and skill development measures is in place, which is seen adequate for meeting the challenges posed by different forms of structural changes, including those driven by the transition to green growth. Green components may have been progressively integrated into this general policy framework, but they are not identified as green-specific programmes *per se*. In Denmark, for instance, the authorities point out that while there may be a significant number of programmes which are already related to the green sector, there is no definition ready to classify them as green initiatives. The Danish Ministry of Employment is currently working on a definition of green jobs and investigating the potential for green initiatives in active labour market policies. More generally, the criterion for distinguishing green-specific

programmes from general measures may vary widely across countries, in the same way as different judgments exist about the appropriate criterion for considering a job to be green. Therefore, some caution is required when assessing and comparing national green-specific initiatives in the field of labour market and skill development policies.

182. With these caveats in mind, it is noteworthy that a number of similarities emerge in the way countries have implemented or are implementing green-specific measures. Reflecting the great degree of uncertainty about how labour markets will need to evolve in line with the greening of the economy, a number of countries have put in place tools for designing and implementing effective green-specific employment and training programmes. Environmental policies and regulations are the true drivers of the greening of the economy, whereas green-specific employment and skill policies are flanking measures aimed at facilitating this transition: this poses both *timing and coordination issues* that need to be addressed carefully. For example, there is no point in training workers for green occupations if environmental policies have not created a market for the goods and services these workers are being trained to produce. On the other hand, the availability of adequate skills is a prerequisite for measures aimed at supporting the development new green markets to be successful, which may require skill development policies to be somewhat proactive.

183. Building an effective coordination framework may be essential for implementing successful green-specific employment and skill development measures. Indeed, these measures need to be designed and implemented in close consultation with a range of various stakeholders. In a number of countries, authorities in charge of Environment, Agriculture, Employment, Education, Economy and Finance, as well as trade-union and industry representatives, were involved in the consultation process at both national and local levels. An explicit and effective coordination framework may be required for these consultations to be fruitful. In this respect, the Slovak Republic constitutes a striking example of a country where the absence of such a framework was a strong impediment to the implementation of green-specific labour market measures. In this country, environmental protection falls under the competency of several ministries, which tend to respond to their own mandate in a more or less independent way. But employment and skill development remain cross-cutting issues. Therefore, as rightly pointed out by the Slovak labour market authorities, implementing effective green-specific labour market programmes would require explicit inter-ministerial competencies, in order to identify and provide adequate responses to meet both the common and specific needs that may arise from the different environmental protection areas.

184. A number of OECD countries have taken specific coordination initiatives so as to enable the implementation of their national green growth strategy in a coherent and efficient way. To this end, the Korean government has recently enacted the Framework Act on Low Carbon, Green Growth, which establishes the Presidential Committee on Green Growth with the task of coordinating green policy initiatives that are partially implemented by various ministries and offices pursuant to respective Acts and subordinate statutes. This Committee comprises members from various Ministries and civil society, and is co-chaired by the Prime Minister. It deliberates on major policies and plans related to low carbon, green growth and matters concerning the performance of such policies and plans. In other countries, pre-existing institutional bodies were given the responsibility for supervising and/or coordinating policy initiatives to foster green growth. In Australia, for instance, the Green Skills Agreement was endorsed in 2009 by the Council of Australian Government (COAG), the peak intergovernmental forum in Australia. COAG comprises the Prime Minister, State Premiers, Territory Chief Ministers and the President of the Australian Local Government Association. The role of COAG is to initiate, develop and monitor the implementation of policy reforms that are of national significance and which require cooperative action by state, territory and local governments. Greening the economy poses various challenges that differ between regions within the same country, and the existence of a solid coordination framework could play an important role in reconciling national and local perspectives with respect to the implementation of a comprehensive green strategy. In particular, a number of national environmental policies may have adverse economic

consequences at some local levels, and a number of regions may oppose strong resistance to the introduction of such measures unless adequate compensation measures are implemented and strong policy initiatives are taken to sustain the local economy.

185. Identifying and continuously monitoring emerging new pockets of employment and new skill needs should constitute an integral part of any labour market policies aimed at supporting the transition to green growth. As most of the green activities that will enable the shift towards a green economy have not yet reached their mature stage of development, specific needs are not yet identified clearly and they are likely to evolve over time. In France, one of the most immediate outcome of the of the National Plan for Green Employment and Occupations, enacted in 2009, was the establishment of the National Observatory for Green Employment Occupations, with the task of providing quantitative and qualitative measurement of activities and occupations affected by the greening of the economy and, if possible, to measure the overall impact via a macro-economic analysis (Commissariat général au développement durable, 2011). To achieve this, the Observatory brings together national and regional organisations with the relevant technical skills to obtain a cross-cutting view of the issues raised by employment and to develop reference methods and figures, especially based on existing available statistical resources. Likewise, as part of the implementation framework of the Employment-Environment Plan for Sustainable Construction, recently launched in Belgium for a five-year period (in Wallonia and the Brussels region), a multipartite committee is in charge of identifying skill needs and ensuring that workers are provided with adequate skill development measures.

186. In addition to identifying new skill needs, some countries are developing tools for enhancing public awareness on new employment opportunities associated with the greening of the economy. In particular, providing PES staffs with a solid knowledge of green activities and related skill needs is essential for the PES to deliver good-quality job matching services in this area. But this may be a difficult task as dealing with green jobs and green workers still represents a very small fraction of the PES staff workload. In the United Kingdom, a recent report commissioned by the Department for Work and Pensions to evaluate sustainable development initiatives and the promotion of green jobs within the European Social Fund, points out that better outcomes could be reached if programme providers were given more and clearer guidance (Dickinson and Lloyd, 2011). This ranges from a working definition of what constitutes green skills and jobs, labour market information about which green jobs and sectors are expanding, through to good practice examples from other providers developing green projects in order to illustrate potential activities and what can be achieved for participants.

187. To address these issues, a grant programme was launched in the United States, with the aim of supporting the collection and dissemination of labour market information, and enhancing the labour exchange infrastructure to provide career opportunities within energy efficiency and renewable energy industries (USDOL, 2011). Nearly USD 48.8 million was allocated to the so-called State Labor Market Information Improvement Grants, under the American Recovery and Reinvestment Act of 2009. These investments are designed to achieve the following outcomes: *i)* the development of effective methods for estimating the impact on industry and occupational employment resulting from implementation of green technologies; *ii)* the dissemination of data through outreach strategies that inform job seekers, the public workforce system, education and training providers, and other organisations of the occupational skills and growing needs of the energy efficiency and renewable energy industries; *iii)* the development of information that provides insight into the State regulatory environment, an understanding of current programs of study and related credentials, and an identification of capital investments in green industries; *iv)* the posting of job openings to online job banks that will be highlighted for easy recognition as green jobs by job seekers, as well as the highlighting or development of other online tools and approaches that will encourage local residents to prepare for and apply for jobs being created in their local area. Thirty awards ranging from about USD 763,000 to USD 4 million were made to state workforce agencies to utilise data for workforce development strategies. Multiple state workforce agencies partnering as a

consortium will use this program to gather information that is likely to have a regional, multi-state or national impact.

A pragmatic approach

188. A lot remains to be done in understanding the employment and skill implications of a potentially large range of different green policy initiatives, which are implemented in various environmental protection areas and whose consequences can vary across countries and across regions within the same country. But this should not constitute an impediment to further policy actions to protect and improve environmental quality: while a general and comprehensive assessment of policy needs and outcomes in the labour market field remains quite a challenge, the task becomes much more tractable at a sectoral level. This calls for a pragmatic policy approach that proceeds incrementally while monitoring the different policy initiatives that have been undertaken and assessing what is working well and what is not. And in fact, national green growth strategies typically consist of a comprehensive package of measures that respectively target relatively small market segments. Such policy approaches help reconcile the great degree of uncertainty surrounding the overall economic implication of greening the economy, with the implementation of effective green measures. Along this line, the Belgian authorities in charge labour market policies underline that in practice, there is no need for defining 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 retained in Belgium, which consists in assessing the overall workforce and skill needs within closely targeted market segments, whatever these jobs and skills can be classified as being green or not.

189. The Austrian Klima:aktiv initiative, launched in 2004 as part of the National Climate Strategy, is one of the best examples of a comprehensive and pragmatic policy approach, which combines various market-constituent measures and effectuates target-oriented implementation. It follows the idea of market transformation with the aim of achieving a lasting and significant share of energy efficient products and services in targeted markets (see Box 10). This approach's main characteristic is an active and comprehensive inclusion of all relevant market players and stakeholders. A profound knowledge of the market, a strong commitment of stakeholders, the integration of different measures into a coherent program, and well managed process with good timing, are key success factors for market transformation.

190. Consisting of more than 20 sub-programmes, Klima:aktiv targets a number of barriers hampering the implementation of energy efficient technologies, standards and behaviour patterns (see Raimund *et al.*, 2005). It aims at supporting "conventional" green measures, like regulations or subsidies, through information, communication and advice. It introduces target-group oriented programmes in four areas: building, energy efficiency, mobility, and renewable energy. Its core levers are: 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 coordinates 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 cooperation 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 merely introduces new green components into the education market, in close collaboration with all relevant actors on this market.

Box 10. **Market transformation: a framework for implementing green measures**

Market transformation can be defined as a strategic intervention to achieve a lasting, significant share of energy-efficient products and services in targeted markets. By definition, market transformation efforts need to be focused on a specific market made up of definable actors and decision makers on both the supply and demand side. Market transformation activities should be designed with an end result of market changes that are sustained by the natural market dynamics, even after the policy intervention is completed. Market transformation implies identifying and addressing market barriers or opportunities, so that the market should be permanently altered if these barriers or opportunities have been correctly identified and successfully addressed. In the end, all of the market interventions are about changing the behaviour of both supply-side and demand-side market actors. This process consists of several distinct phases that are repeated as needed as the market moves upward towards achieving full potential. These phases include:

- *Identification of barriers and opportunities*: The first phase is to identify specific market barriers to adoption of all cost-effective energy efficiency available. It should also include an assessment of specific market opportunities that may be unrelated to the energy efficiency aspects of the market but that may represent significant points of leverage with which to overcome some of the market barriers.
- *Strategy development*: The next phase in the process is to develop a comprehensive strategic plan to address the identified market barriers and exploit opportunities in order to achieve the full market potential for efficiency. This step of the process also involves developing key goals, objectives, and metrics with which to measure market progress. It also involves developing an implementation plan that identifies specific market interventions and appropriate market actors to implement these activities.
- *Implementation and measurement*: The process then moves to implementation of the strategic plan along with measurement of key progress indicators and adaptive management in response to response or failure of these strategies as well as to changing market conditions.
- *Assessment, evaluation and revision*: As the implementation process moves forward, the components of the project and overall strategy need to be assessed and evaluated and adjusted or revised as indicated by the market data. Because markets are dynamic, it is critical to approach the process of Market Transformation with tools that allow for adaptive management of the implementation process.

Labour market and skill development measures can be seen as one of the components required to achieve market transformation. Within such an integrated and progressive approach, the assessment of workforce and skill needs, and the corresponding policy responses, can be closely aligned with the change in market conditions and size, therefore minimising the risk of skill bottleneck, and more generally, the risk of skill mismatch.

Source: NEEA's Definition of Market Transformation, Northwest Energy Efficiency Alliance.
Available from: http://neea.org/participate/docs/NEEAMTDefinition2008.pdf

191. Flexible implementation frameworks are needed for achieving successful green-specific labour market policies that are most likely to require successive fine-tunings, or even more drastic revisions, in order to remain closely aligned to continuously evolving green markets. A continuous monitoring of emerging needs, a careful evaluation of new measures put into place, and a progressive fine-tuning of these measure, are critical elements to design and implement effective green-specific labour market programmes. While these recommendations apply to any employment and skill development programmes, they are even more important in the particular context of green growth, as policy makers have to deal with a great uncertainty about what is needed and how these needs will evolve over time.

192. The Australian Green Skill Agreement of 2009 contains a number of provisions aimed at building such a flexible and carefully-designed implementation framework (COAG, 2009). In particular, the Agreement puts emphasis on monitoring and evaluation at various stages of the implementation process. First, research and modelling of skills needs, deficits and gaps for trades and professions to meet emission reduction targets will be supported through the Agreement. Second, an evaluation framework will be developed in order to monitor achievements against agreed actions. One of the stated goal is to ensure that

the actions arising from this Agreement complement and are integrated with existing labour market, training and industry development programs and initiatives, and also, with existing and developing initiatives to promote carbon pollution reduction and industry and workforce adjustment to a sustainable, low-carbon economy.

193. On a practical level, a so-called "Implementation Group" was established, with the task of developing successive Implementation Plans over the life of the Agreement. This committee comprises representatives from federal, state and territory governments, VET sector and universities, industries and trade-unions. Plans will be developed each year and the Implementation Group will report annually on progress to the Ministerial Council for Tertiary Education and Employment, which is responsible for VET, tertiary education, and the Australian Qualifications Framework –the national policy for regulated qualifications in Australian education and training.

194. The first tasks of the Implementation Group included the identification of green skills gaps in Training Packages – sets of nationally endorsed standards and qualifications for recognising and assessing workers skills –, which were subsequently revised after numerous industry consultation and validation processes. Industry was given the role of identifying skill needs, and Training Packages were reviewed by the Australia's 11 Industry Skills Councils. One of this Council, the Innovation and Business Skills Australia, developed a training unit to assist the VET sector deliver and assess green training. In addition, professional development programs available for VET practitioners in relation to the provision of green skills training commenced were evaluated.

195. To sum up, the way countries are preparing their labour market to transit towards a low carbon and resource efficient economy reflects some specific aspects of this economic transformation. Major structural changes in the past were primarily driven by market forces. In particular, the ICT revolution and globalisation gained momentum as private actors recognised the potential economic gains to be realised, and the main scope for policy intervention was to ensure that good framework conditions were in place and to redistribute net benefits between the winners and losers from these structural changes. In the context of green growth, policy makers are facing a greater challenge. In addition to establishing a regulatory framework for environmental protection, governments need to strengthen economic incentives for the market introduction and diffusion of green products and services, while at the same time implementing flanking measures that enable this market transformation. This requires integrating green components into existing labour market programmes and skill development measures, but does not necessarily require deep labour market policy interventions that would be specific to the transition to green work. However, a *carefully designed implementation framework* is required to address the coordination and timing issues for policy interventions in relation to the transition to green growth.

Policy lessons from the gradual greening of the construction sector

196. To the extent that green-specific measures have a role to play, it seems likely that they typically should focus on catalysing the greening of key economic sectors. It is important that any such initiatives be targeted on a sector where there is a potential to generate large environmental benefits by shifting the sector onto a greener development path that can become economically sustainable from a business perspective. The gradual greening of the building sector provides a valuable case study of long-standing, if somewhat intermittent, public interventions of this nature.

197. In a number of OECD countries, the first significant policy and economic impulse to develop energy efficient technologies in the construction sector and encourage their diffusion goes back to the late 1970s, after the two consecutive oil shocks caused a steep increase of home energy bills, raising concerns about dependency on energy imports and the economic hardship experienced by some low-income households when energy prices rose sharply. Since then, regulations on the energy performance of

buildings have been gradually introduced in many countries.[36] A number of lessons can be drawn from these past green initiatives in the building industry. And although not all of these evidence-based lessons will be relevant for other economic sectors, at least some of them can serve as a starting point for policy makers considering taking measures to foster the development of green activities in less advanced sectors.

198. Importantly, the potential for achieving significant environmental gains on attractive economic terms has been well documented for the case of energy efficient construction. The starting point for effective public interventions has been the accurate diagnosis of the market failures that preclude many investments in energy efficiency investments that would be economically viable on a life-cycle cost basis (see ILO, 2011d for a summary of these market failures). Equity concerns related to "fuel poverty" for governments to intervene to target energy efficiency measures on low-income families have also provided a motivation for public intervention in this market. During the recent recession, increased government subsidies to retrofit buildings for greater energy efficiency was also widely viewed as an effective way to generate a lot of socially productive jobs quickly.

199. While the case for policy interventions to foster the rapid development of green construction is quite strong, the performance of these measures has been quite mixed. For example, attempts to rapidly ramp up employment in home energy retrofits, as an anti-recessionary measure, ran into serious quality control problems in some countries, as in the well documented case of the Home Insulation Program in Australia (see Annex 4). More successful approaches have taken a longer-run and more comprehensive approach to simultaneously addressing a number of barriers to creating a well-functioning market in energy-efficient buildings. Of particular relevance for labour market and skill policies, worker training and certification has proven to be an important component of more comprehensive strategies to assure high-quality work and materials (Zabin *et al.*, 2011).

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

200. This report 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.

201. Table 14 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 nature of 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.

36. For instance, the European Commission adopted the Energy Performance of Buildings Directive (EPBD) in January 2003, which set minimum efficiency standards for both residential and commercial buildings, and was to be adopted in national legislations by January 2006. It followed on from the 1993 SAVE directive limiting CO2 emissions by improving energy efficiency, which required member states to develop programmes in the building sector but did not include concrete measures.

202. Table 14 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 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 then 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, then 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.

203. How might differences in national labour market and skill development systems affect countries' ability to successfully manage the transition towards green growth? Along the lines of Esping-Andersen's influential taxonomy describing three models of welfare capitalism (Esping-Andersen, 1990), a number of researchers have proposed taxonomies of national systems of labour market policies (*e.g.* OECD, 2006a,b) and national skill development systems (*e.g.* Ashton *et al.*, 2000). However, there is no consensus on taxonomy. For that reason, but also 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 these stylised models of national labour market and skill development systems. Nonetheless, it is useful to begin reflecting about how the green growth challenge differs across countries depending on the nature of the labour markets and national education and training systems. In that spirit, we hazard several very tentative conjectures:

- The normative labour market models put forth in the *OECD Reassessed Jobs Strategy* (RJS; OECD, 2006a) and the European Union Lisbon Strategy appear to be well aligned overall with the requirements for managing a successful transition towards green growth. In particular, both models suggest the important of achieving an effective form of flexicurity, while acknowledging that there is no 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 report 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.[37]

- Green *et al.* (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 US, the UK and other English speaking countries) is characterised by institutional diversity and a market-led approach to the coordination 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 of 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 lots of "second chance" education possibilities for adults and tend to excel at creating research universities

37. OECD (2006a,b) also puts forth a positive taxonomy of labour market types which includes two different and equivalently successful implementations of much of the good practice guidelines put forth in the RJS, 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.

that collaborate effectively with the business sector and are likely to be a big asset in promoting eco-innovation.

- The social partner-coordinated 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 the study of core academic studies as well. This system has done well at developing skilled manual and technical workers, a workforce that should cope well the incremental greening of jobs. The system can, however, show less flexibility that 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 coordinating skills supply and demand. However, the state plays a greater in adult education than in the social partner-coordinated 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 are intended 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.

Table 14. **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 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 (10.7% in Denmark versus 26.7% in Poland) (ii) Post-displacement adjustment costs tend to be higher where worker reallocation is lower (0.52 in Spain versus 0.28 in CZE). Also where more of the affected workers are older or low educated. (iii) Spatial and skill mismatches exacerbate dislocation (localization of high emissions industries is generally greater in EU periphery countries than in the core).	(i) 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.	(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 offering 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?)	(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 *et al.*, 2011). (ii) Good business-tertiary education partnerships likely 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 (PISA scores for mathematical and scientific literacy of 15-year-olds vary from 460 for Turkey to 550 in Finland).	(i) 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 it can be made to be sufficiently reliable.	(i) Ability to expand and contract existing training and vocational education tracks as demand changes; (ii) Ability to coordinate with social partners to create new tertiary level curricula as new high-skill occupations emerge; (iii) Employers, trade unions and vocational training providers coordinate to continually update workforce skills as job requirements evolve.

• Incremental greening of many existing occupations necessitating top-up training			
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: • 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 localized 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.

Conclusions

204. 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 by helping to assure a quick, efficient and fair transition towards environmentally sustainable growth (OECD, 2011a). However, it also highlights the limits of our present understanding of how the transition towards green growth will reshape labour markets, 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 achieved to date reflects the fact that the process of decoupling economic growth from harmful environmental impacts is complex and still at a very early stage. Furthermore, the form that the transition to green growth will take will be shaped by policy choices and technological developments that are inherently difficult to predict.

205. There appears to be an emerging consensus that the transition towards green growth is best understood as being an important driver of structural labour market change and that approach is adopted here. General equilibrium modelling is providing important insights about green restructuring, but it is not yet possible to predict how the overall labour market will be reshaped with sufficient precision to provide detailed guidance for labour market and skill policies. In particular, it remains unclear whether there will be a large role for green-specific policy approaches. It is clear, however, that green growth reinforces the importance of assuring that familiar types of labour market policies (*e.g.* as described in the *OECD Reassessed Jobs Strategy*) are in place and functioning well, since they provide the necessary framework for reconciling labour market flexibility with economic security for workers and their families.

206. Researchers have highlighted several economic sectors that are of strategic importance for climate change mitigation, notably the energy and construction sectors, and made sufficient progress in analysing near to medium-term changes in labour demand and job skill requirements in these sectors to provide useful guidance for policy makers. Indeed, a growing number of targeted policy measures recently have been taken that are intended to assure that growing green firms in these sectors are able to meet their recruitment needs and retrain their incumbent workforces. These measures appear promising, but there is very little experience in operating them and it will be important to carefully evaluate how well they work, discontinuing those that prove to be ineffective while continuously improving those that show promise. Beyond these strategic sectors, which account for only a modest share of total employment, it is unclear whether the transition towards green growth will create pressures for structural change in labour markets that are either more intense or qualitatively different from the process of creative destruction that has always characterised industrial market economies. Despite that uncertainty, it probably can be concluded that green growth reinforces the case for raising the general cognitive and STEM skills of the workforce, as well as for undertaking reforms to enhance the structural adjustment capacity of labour markets.

207. Future research will shed additional light on the labour market implications of a transition towards green growth and how best policy makers can foster this restructuring, while minimising the associated social costs and assuring that unavoidable adjustment costs are shared fairly. Since this transition is will be driven in large part by environmental policy writ large, both labour market researchers and labour market actors will need to become more aware of how environmental policy is reshaping the economic environment. It is also possible that choices about environmental policy should take greater account of the implications of these policies for labour markets and the distribution of income. At the governmental level, the development of comprehensive green growth strategies is a possible vehicle for breaking down the "policy silos" that often isolate environmental and labour ministries. It is also important to assure that employers and workers and their representative organisations are consulted in the development of green growth strategies and have as clear an idea as possible about how these policies will evolve, so that they can take these developments into account in their long-run planning and when making their investment decisions.

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ANNEX 1. NATIONAL DEFINITIONS OF GREEN JOBS AND INITIATIVES TO QUANTIFY GREEN EMPLOYMENT

208. The following two tables provide information about national definitions of green jobs (Table A1.1) and past or planned initiatives to estimate green employment (Table A1.2). This information is based on responses to an OECD questionnaire which was sent to labour and employment ministries.

Table A1.1 **National definitions of green jobs**

	Allow statistical analysis	Broad description
Australia	Work in progress	While the Australian Government currently does not produce statistical estimates on the number of green jobs, the Australian Bureau of Statistics (ABS) is investigating options to develop an environmental goods and services sector account as part of its commitment to the UN's System of Environmental and Economic Accounts (SEEA) standard. A report proposing a taxonomy of green jobs for Australia, partly funded by the New South Wales Department of Environment and Climate Change, was released in 2009. The report, *Who are the Green Collar Workers – Defining and identifying workers in sustainability and the environment*, proposes a Green Collar Worker Coding System based on the Australia New Zealand Standard Codes for Occupations (ANZSCO) and Australia New Zealand Standard Industry Codes (ANZSIC).
Austria	Yes	The Definition is based on the handbook on the Environmental Goods and Service Sector (EGSS) from EUROSTAT (2009). The EGSS in Austria was first published in 2009, reporting year 2008. This nomenclature differs from the standard classification of economic activities and Statistic Austria uses two different data sources for defining and counting green jobs in the frame of the EGSS: the Labour Force Survey and the "Konjunkturstatistik" 2009. The classifying schemes used in 2008 are being revised, and at the end of January 2011 Statistic Austria will publish a new 2009 edition of EGSS in Austria.
Belgium	No	There is no national definition of green jobs in Belgium. Rather, a policy oriented approach is followed. However, some studies conducted for the different governments in Belgium have included definitions (*e.g.* High Employment Council, IDEA/Ecorys for the Flemish Government, IDEA for the federal government).
Canada	Work in progress	While the Government of Canada does not currently have a formal definition of green jobs, work is underway within the Department of Human Resources and Skills Development Canada (HRSDC). The green jobs taxonomy combines both specific and standard nomenclatures in order to categorise industrial sectors and occupations that contribute to green economic activities. The two standard nomenclatures are the North American Industry Classification System (NAICS) and the Canadian National Occupational Classification (NOC). The green jobs taxonomy is organized into five broad green domains: Environmental Protection, Green Energy, Energy Efficient Construction, Green Manufacturing and Transportation, and Green Services. Each domain aggregates several green industry sectors. These industry sectors are based on a specific nomenclature that is then mapped to a standard industry nomenclature based on NAICS industry groupings. For each NAICS industry grouping, a selection of green occupations was identified and subsequently mapped to a standard occupational nomenclature, the Canadian NOC occupational groupings. Progress thus far on a green jobs taxonomy is based on research conducted by organizations including: Occupational Information Network (O*NET), the Bureau of Labor Statistics (BLS), the California Centre for Excellence, the United Nations Environmental Program, the Globe Foundation, the International Labour Organization, HRSDC Service Canada LMI Regional Network, Statistics Canada and ECO Canada.
Chile	No	
Czech Republic	Work in progress	At the government level there is no formal definition of green jobs, but Czech Statistical Office is working on a project (in cooperation with EUROSTAT) to identify environmental goods and services sectors in the Czech Republic, and estimate the number of green jobs in these sectors (NACE classified).

	Allow statistical analysis	Broad description
Denmark	Work in progress	The ministry of employment is currently initiating work on a definition of green jobs (early stage of the process).
Finland	Yes	A definition of green activities, entirely derived from the standard classification of economic activity, has been adopted by Statistics Finland in 2009. Green employment refers to the number of workers employed by firms having mainly green activities (NACE 3700, 3811, 3812, 3831, 3832, 3900 plus 35111). In other words, firms having some green activities, but mainly other than green activities, are not included (on the other hand, not all employees in firms providing environmental goods and services could be classified as "green jobs").
France	Yes	No official definition, but statistical work is conducted by the ministry of Ecology and Sustainable Development so as to estimate the number of green jobs. This work is based on the OECD/Eurostat classification of environmental goods and services. It draws on the French classification of products by activity and uses several available statistical sources, such as employer surveys, trade-union registers, etc.
Germany	Yes	Definition first adopted in 1996 when the Federal Environment Agency (UBA) commissioned a study on the estimation of environment-related employment in 1994. Since then, the definition was refined several times. Green jobs refer to employees who: *i)* produce environmental goods and services (pollution management; cleaner production and technologies; resource management – cf. Eurostat/OECD definition, 1999); *ii)* are involved in environment related activities (*e.g.* environment consultants, planning and administration, nature and landscape conservation). Since these two categories of green jobs are overlapping, estimates have to be adjusted in order to eliminate double counting. A dual approach is followed. First, demand-oriented evaluations use data on domestic demand (*e.g.* expenditures for environmental protection) to calculate the number of jobs involved in the production of environmental goods and services, as a basis for an input-output analysis. As a result direct and indirect employment effects can be derived. Second, supply-oriented analyses estimate the number of green jobs directly. Different information sources are taken into account, including company surveys, panel surveys or association statistics. When "green activities" cover only a fraction of the total workload, the number of green jobs refers to the corresponding share of the total workforce.
Greece	No	The Employment Observatory Research-Informatics SA (EORI) conducts Business surveys so as to collect information on the occupational, educational and geographical structure of employment in private businesses of all types and sizes at the local level and to identify of skill needs. These surveys are financed by the Ministry of Employment (under the European Social Fund). The first survey was conducted in 2003, the second in 2005 and there is a plan to continue in the future at regular intervals, but decisions are pending. Provided that the project receives an approval, EORI could include special data collection in order to count the number of green jobs.
Hungary	Yes	No official definition adopted by the government and designed to allow statistical analysis of green employment. However, the Hungarian Central Statistical Office (KSH) collects data that allow monitoring economic activities related to environmental protection. KSH makes a distinction between environmental expenditures (investments) and environmental sectors. Statistics based on environmental expenditures provide the total amount of environment-related investments and an estimate of the corresponding number of employees. Statistics on environmental sectors measure the production of environmental goods and services, and the corresponding employment level.
Israel	No	
Japan	Yes	Green jobs are defined as jobs involved in the production of environmental goods and services. This definition is based on the OECD/Eurostat classification and was adopted in 2000. The number of green jobs is derived from the estimated market size of green activities, with these estimated market size being derived from a specific industry survey conducted by the Ministry of environment.
Korea	Yes	Green jobs definition which refers to the jobs involved in the production of goods and services that contribute substantially to 'low carbon growth' by achieving higher energy efficiency across the board and by improving the environment was adopted in 2009. The definition is based on the existing Korea Standard Industrial Classification (KSIC) as well as the Korean Employment Classification of Occupation (KECO). In practice, Korean government has classified 64 green industries out of total 169 categories under the KECO and 101 green occupations among total 429 headings in the KECO. However, the definition is not based on a separate set of classification criteria for the sole purpose of identifying green jobs, and thereby some overlapping intersections between green industries and green occupations exist, while the green jobs calculation might include jobs that are not involved in green tasks.
Mexico	No	
Netherlands	No	

	Allow statistical analysis	Broad description
Norway	No	
Poland	No	
Portugal	Yes	The Portuguese Government has no definition of green jobs. However, since 2008, Statistics Portugal (INE) publishes annually environmental statistics that cover nine environmental areas, which are based on OECD/Eurostat (1999) and CEPA 2000 (Classification of environmental protection activities and expenditure). A specific survey is conducted, where (private and public) employers are asked to report the amount of human resources (by gender and by professional group) that work "majority of time" or "occasionally" in the nine environmental areas mentioned above.
Slovak Republic	No	
Slovenia	No	
Spain	Yes	Qualitative definition adopted in the 1990s by the Ministry of Environment. However, this definition serves as a basis for various studies (conducted, for example, by the Ministry of Labour and the Ministry of Environment) quantifying the number of green jobs in the Spanish economy. The approach consists in identifying green sectors, as defined by international organisations, such as the ILO, OECD or UNEP, within the national industry classification and the occupation classification. A specific employer survey has also been developed.
Sweden	No	
Turkey	No	
United States	Yes	Definition adopted in 2010 by the US Bureau of Labor Statistics (BLS). Green jobs are either: *i)* jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources; *ii)* jobs in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer natural resources. Part i) of the definition is based on standard nomenclature, specifically the North American Industry Classification System (NAICS), to identify industries where green goods and services are classified and therefore in which establishments producing these goods and services are classified. These establishments constitute the universe for an establishment survey to measure the employment related to production of green goods and services. A separate survey is being developed to measure green jobs defined in Part ii) of the definition. This survey will include all industries in NAICS except private households.

Notes:

Australia: The Australian Government considers a central challenge in the move to a greener economy is to make *all* jobs greener. Moving to a low-pollution, resource efficient economy will change the way workers do things in traditional occupations and industries while simultaneously driving the creation of new jobs in existing and emerging green sectors. Workers in any and all industries will be required to learn and apply new green skills and knowledge if the economy as a whole is to use resources more efficiently and generate less pollution and waste. The Australian Government has not adopted a national definition of green jobs. Instead, the government has focused on the concept of green skills, or skills for sustainability. Australia's definition of skills for sustainability was negotiated with the states and territories as part of the national *Green Skills Agreement*, which was endorsed by the Council of Australian Governments in December 2009. The Australian Government uses the term 'skills for sustainability' to describe the technical skills, knowledge, values and attitudes needed in the workforce to develop and support sustainable social, economic and environmental outcomes in business, industry and the community.

Germany: For further details, see "Beschäftigungswirkungen des Umweltschutzes in Deutschland" – UBA-Text 26/09 – http://www.umweltdaten.de/publikationen/fpdf-l/3846.pdf.

Table A1.2. **Quantifying green employment**

	Number of green jobs: observed and projected
Australia	**Employment projection**. The 2008 *Growing the Green Collar Economy* report by the Australian Government's Commonwealth Scientific and Industrial Research Organisation (CSIRO) finds that policy action to support the transition to an environmentally sustainable society could increase employment in sectors with high potential environmental impacts by 230,000 – 340,000 new jobs over the next 10 years. Similarly, the joint Australian Council of Trade Unions and Australian Conservation Foundation report *Creating Jobs – Cutting Pollution* finds that Australia could create more than 770,000 extra jobs and stronger economic performance by 2030 through strong investment in clean energy, public transport and sustainable land management policies.
Austria	**Number of green jobs**. 162 986 in 2008. **Employment projection.** Research project by the Institute of Advanced Studies (HIS): "More and better Green Jobs for Austria - Green Jobs for a sustainable, low carbon Austrian Economy" (2010)
Belgium	**Employment projection** (Federal Planning Bureau). Scenario: 20 reduction of GHG emissions by 2020 relative to 1990 levels and 20% renewable energy in the overall energy consumption by 2020. General equilibrium effects: small slowdown of economic growth with respect to the business-as-usual scenario; small employment effects that can be positive when revenues from this mitigation policy are used to reduce employer social security contributions.
Canada	**Number of green jobs**. Using the green jobs taxonomy and 2006 Census data, the Government of Canada has conducted preliminary research internally to estimate the possible size of Canada's green workforce. Based on this research, approximately 4% (640,000 jobs) of Canada's total labour force in 2006 may be employed in a green occupation with more than half working in the domain of environmental protection. Other green employment domains being researched include, green services, energy efficient construction, green manufacturing and transportation, and green energy. This estimate (4%) is consistent with the findings of a recent study conducted by the ECO Canada Sector Council, obtained through a separate methodology.
Chile	None.
Czech Republic	**Employment projection.** *Ex ant*e estimates of the gross employment effect of the "Green Light for Savings" measure (a specific subsidy programme) were provided in 2009 by the Ministry of Environment. An *ex-post* evaluation will be conducted in 2011.
Denmark	None.
Finland	**Number of green jobs**. Statistics Finland estimates that, in 2009, 5 888 workers were employed by firms having mainly green activities. **Employment projection**. Evaluation of the economic impact of the *Renewable energy package*, an energy programme passed in 2010. Total costs over the period 2010-20 are estimated to amount to EUR 700 million (feed tariffs for wind energy, subsidies for wood energy and other bio-energy). Private investments are estimated to reach EUR 3.5 billion for wind plants and EUR 1 billion for bio-energy. However, the estimates of investments cannot be counted as budget costs; these estimates were used as assumptions in model simulations. As compared to BAU (business as usual) scenario, the package leads to slightly negative net employment effects (4000 jobs less than BAU). Direct employment effects are positive in forestry, in construction sector and in the energy sector. Indirect positive employment effects are positive in private and public services. Direct and indirect employment effects in industry, and in sectors closely related to industry, are negative.
France	**Number of green jobs**. The Ministry of Ecology and Sustainable Development estimates that green jobs accounted for 1.6% of total employment in 2010. **Employment projection.** In 2009, a study by the Boston Consulting Group, commissioned by the Ministry of Ecology and Sustainable Development, estimates that the French Environmental Strategy ("Grenelle Environnement") could result in 600 000 gross job creations by 2020. A report published in 2008 by the National Environmental Agency (ADEME) suggested that this policy package could create about 200 000 jobs in the renewable energy, building and transport sectors over the period 2007-2012.
Germany	**Number of green jobs**. The estimation of environment-related employment has a long tradition, with first estimates produced in 1994. Since then, the method has been refined and revised several times and according to recent estimates, green employment accounted for 4.5% of total employment in 2006. These results can be found in the "Report of the Environmental Economy 2009", published by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Environmental Agency. In large part, green jobs are found in renewable energy sectors and environmental related services. (See http://www.bmu.de/english/economy_innovation/downloads/doc/45261.php, Chapter 2, and for employment in renewable energy sectors, http://www.erneuerbare-energien.de/inhalt/43766/42454/)
Greece	**Employment projection**. According to the Ministry of Environment, Energy and Climate Change, the broad Greek *Strategic Action Plan* for green growth is expected to result in the (gross direct) creation of more than 210,000 jobs (including job retention in sectors such as construction), of which 29,000 will be permanent.

	Number of green jobs: observed and projected
Hungary	**Employment projection**. As part of the New Széchenyi Plan, policy measures to develop green economy are expected to create 200 000 jobs by 2020 (budget: HUF 130 billion).
Israel	None.
Japan	Information not available.
Korea	**Number of green jobs**. Using the Korea Standard Industrial Classification (KSIC) as well as the Korean Employment Classification of Occupation (KECO), the Korean government has estimated that there were 604 400 green jobs (approximately 2.6% of Korea's total employment) in 2008. **Employment projection**. Under the so-called umbrella "Green New Deal", the government expects to create 960 000 jobs, including 100 000 core green talents over the 2009-2012 fiscal years.
Mexico	None.
Netherlands	None.
Norway	**Employment projection**. A report, commissioned by the Ministry of the Environment and published in 2010, provides a general assessment of the consequences for the Norwegian economy of alternative future policy packages that may be implemented in order to reach the Norwegian Climate Targets by 2020. This report has been written by an expert group –Climate Cure 2020 – consisting of the Norwegian Water Resources and Energy Directorate, the Norwegian Petroleum Directorate, the Norwegian Public Roads Administration, Statistics Norway and the Climate and Pollution Agency, which has led the work. Climate Cure 2020 has carried out a sector by sector analysis of possible measures and instruments for reducing emissions and made a macroeconomic assessment of the total costs to society of achieving the target. The strength of the sector by sector analysis of measures and instruments is that this approach provides a high level of detail. The weakness is that the analysis is partial, that is to say it does not take into account the macroeconomic knock on effects of measures and instruments. Therefore, using the MSG TECH macro model, macroeconomic analyses have also been carried out. According to the report, mitigation actions that reduce national CO2 emissions by 20% over the period 2008-2020 could result, by 2020, in net employment gains of 0.5-1.5% –depending on the policy package considered– when revenues from carbon pricing are used to reduce social contributions.
Poland	None.
Portugal	**Number of green jobs**. Statistics Portugal estimates that green jobs accounted for 0,4% of total employment in 2008. **Employment projection**. The National Energy Strategy is expected to result in more than 120.000 gross job creations, with the majority of them arising from the development of renewable energy sectors.
Slovak Republic	None.
Slovenia	None.
Spain	**Number of green jobs**. A study supported by the Ministry of Environment estimates green jobs accounted for 2.6% of total employment in 2009 (531,000 jobs). **Employment projection**. According to the 2009 Economic Report of the President of the Government, one million of green jobs could be created by 2020, a majority of them in sustainable transport and building sectors (gross job creation).
Sweden	None.
Turkey	None.
United States	**Number of green jobs**. The BLS is currently working towards conducting such a study. **Employment projection**. The US Department of Labor (USDOL) has launched an evaluation of the State Labor Market Information Improvement Grants that will review how individual states are collecting and analyzing green jobs data. USDOL is also conducting an implementation study to develop an in-depth understanding of program design, goals, and program implementation of the following of its Green Jobs grantees: Energy Training Partnerships, the Pathways Out of Poverty, the State Energy Sector Partnership and Training, and the Health Care Sector and Other High Growth and Emerging Industries. Further studies are being discussed.

Notes:

Belgium: See http://www.plan.be/press/press_det.php?lang=fr&TM=30&IS=67&KeyPub=764.

United States: For further details on the BLS study of green jobs, see http://www.bls.gov/green/.

ANNEX 2. LIST OF INDUSTRIES AND ENVIRONMENTAL PATENT CLASSES USED IN THE ANALYSIS REPORTED IN PART I. SECTION B OF THE REPORT

Table A2.1. **List of industries and industry codes used in Part I, Section B**

Isic code	Description	CO^2 intensity
0105	**Agriculture, hunting, forestry, fishing**	**3.2**
1014	**Mining and quarrying**	**3.5**
1516	Food, beverage and tobacco	1.8
1719	Textiles, Wearing Apparel, Dressing And Dying Of Fur, Leather, leather and footwear	0.5
20	Wood and of wood and cork	1
2122	Pulp, paper and paper; Printing, publishing and reproduction	1.8
23	**Coke, refined petroleum and nuclear fuel**	**16.5**
24	**Chemicals and chemical products**	**3**
25	Rubber and plastics	0.7
26	**Other non-metallic mineral**	**9.2**
27	**Basic metals**	**10.9**
28	Fabricated metal	1
29	Machinery, nec	0.5
3033	Office, accounting and computing machinery; Electrical machinery and apparatus, nec; Radio, television and communication equipment; Medical, precision and optical instruments	0.5
3435	Motor vehicles, trailers and semi-trailers; Other transport equipment	0.6
3637	Manufacturing nec; Recycling	1.3
40	**Electricity, gas**	**110.8**
41	Water supply	0.6
45	Construction	0.9
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	1.1
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	1.6
52	Retail trade, except of motor vehicles and motorcycles; repair of household goods	1.8
55	Hotels and restaurants	1.1
60	**Inland transport**	**5.9**
61	**Water transport**	**2.6**
62	**Air transport**	**17**
63	**Other Supporting and auxiliary transport activities; activities of travel agencies**	**2.4**
64	Post and telecommunications	0.4
6567	Financial intermediation, except insurance and pension funding; Insurance and pension funding, except compulsory social security; Activities related to financial intermediation	0.3
70	Real estate activities	0
7174	Renting of machinery and equipment; Computer and related activities; Research and development ; Other business activities	0.4

Table A2.2 **List of environmental patent classes used in Part I, Section B.3**

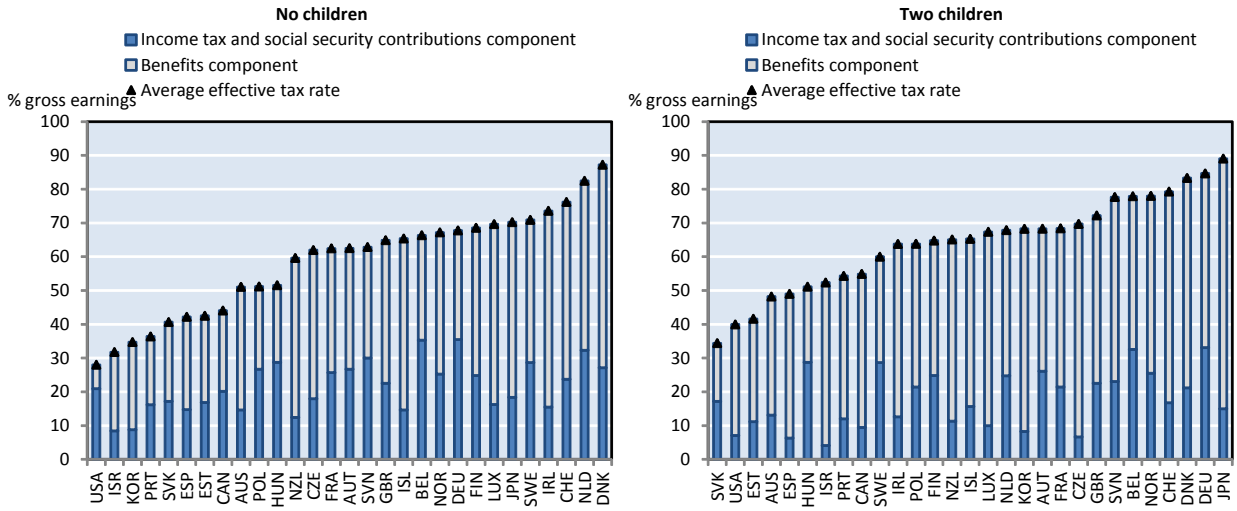
Air pollution abatement
Water pollution abatement
Waste management: Solid waste collection
Waste management: Fertilizers from waste
Waste management: Incineration and energy recovery
Waste management: Material recovery, recylcling and re-use
Waste management: Not elsewhere classified
Soil remediation
Environmental monitoring
CCM technologies: CO2 capture or storage
CCM technologies: Capture or disposal od GHG gases other than CO2
Combustion technologies: Technologies for improved input efficiency
Combustion technologies: Technologies for improved outout efficiency; Combined cycles
Combustion technologies: Technologies for improved outout efficiency; Heat utilization in combustion or incineration of waste
Combustion technologies: Technologies for improved outout efficiency; Combined heat and power
Energy efficiency in buildings and lighting: Heating
Energy efficiency in buildings and lighting: Insulation
Energy efficiency in buildings and lighting: Lighting
Energy generation: Energy generation from fuels; Biofules
Energy generation: Energy generation from fuels; Fuel from waste
Energy generation: Renewable energy generation; Geothermal energy
Energy generation: Renewable energy generation; Hydro energy - conventional
Energy generation: Renewable energy generation; Hydro energy - tidal, stream or damless
Energy generation: Renewable energy generation; Solar photovoltaic energy
Energy generation: Renewable energy generation; Solar thermal energy
Energy generation: Renewable energy generation; Solar thermal-PV hybrids
Energy generation: Renewable energy generation; Wind energy
Technologies with potential to emissions mitigation: Energy storage
Technologies with potential to emissions mitigation: Fuel cells
Technologies with potential to emissions mitigation: Hydrogen technology
Transportation: Technologies specific to propulsion using electric motor
Transportation: Technologies specific to hybrid propulsion
Transportation: Internal combustion engine; Integrated emissions control
Transportation: Internal combustion engine; Post-combustion emissions control
Transportation: Fuel-efficiency-improving vehicle design

ANNEX 3. ADDITION INFORMATION ON LABOUR TAXATION IN OECD COUNTRIES

Figure A3.1. **Average effective tax rates, 2009**

Reduction of net social transfers when moving from social assistance to employment at 67% of the AW

A. Single-adult households



B. Two-adult households, one earner

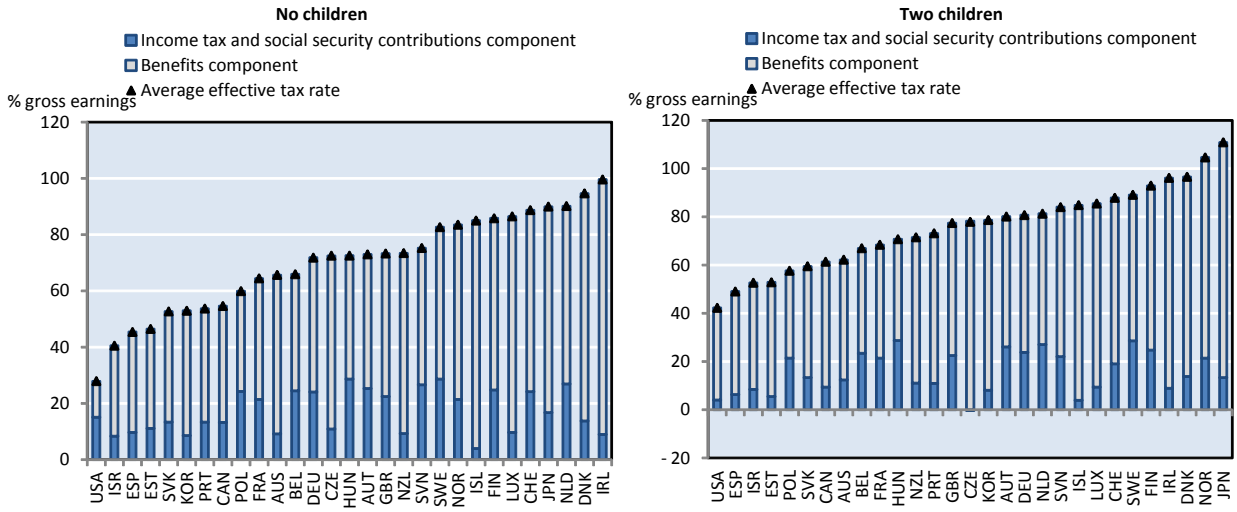
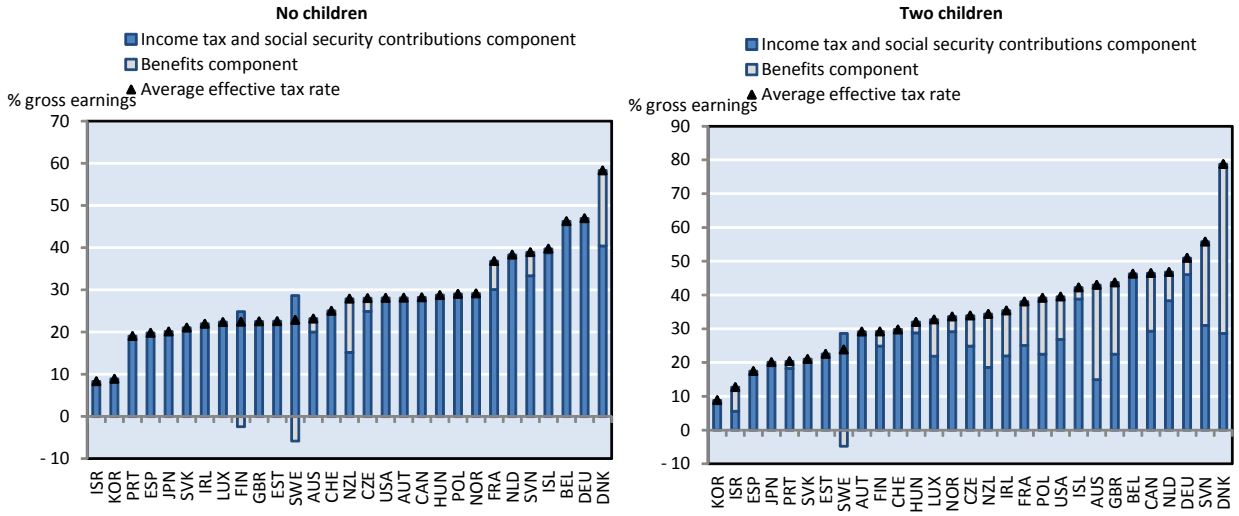


Figure A3.1. **Average effective tax rates, 2009** (*cont.*)

Reduction of net social transfers when moving from social assistance to employment at 67% of the AW

C. Two-adult households, two earners (first earnings 67% AW)



Source: OECD tax-benefit models.

ANNEX 4. THE AUSTRALIAN HOME INSULATION PROGRAM (HIP)

The Australian Home Insulation Program (HIP)

The Home Insulation Program (HIP) was announced as part of the $42 billion Nation Building and Jobs Plan in February 2009, which was launched in direct response to the global financial crisis. This Plan was designed to generate economic stimulus and support lower skilled jobs in the housing and construction industry, which was expected to be adversely affected by the economic downturn flowing from the global financial crisis. A secondary but important objective was to improve residential energy efficiency and reduce greenhouse gas emissions. As only 60% of Australian homes were estimated to be insulated, installing insulation in existing homes was regarded as one of the most cost-effective opportunities to improve residential energy efficiency. $2.7 billion was initially allocated to the HIP, providing subsidies of up to $1600 for installing ceiling insulation into 2.2 million Australian homes. The program was to run until December 2011, or until funds ran out.

Prior to the HIP, there were different regulatory arrangements in place across state and territory jurisdictions for the insulation industry. There was no existing requirement for insulation installers to be licensed or formally trained.[1] And there were no nationally accredited training programs for installing ceiling insulation. However, in order to generate economic stimulus and support jobs, the HIP roll-out proceeded rapidly after announcement. The programme was intended to be implemented in two phases, under the responsibility of the Department of the Environment, Water, Heritage and the Arts (DEWHA): an early installation phase from February to June 2009; followed by the full roll-out of the programme from July 2009. During the first phase, DEWHA consulted with a wide range of stakeholders on the design of the main programme, including industry representatives, State and Territory agencies, training organisations and non-government organisations. Following these consultations, installers were asked to register on the Installer Provider Register, which introduced a set of accreditation requirements for installers to participate in the main programme. In addition, a new (nationally accredited) training package for insulation installers was developed. From the commencement of the program until October 2009, over 3700 installers completed the insulation specific training, suggesting that the program was successful in encouraging unskilled workers to improve their skills through training. This training package was formally endorsed by the National Quality Council in February 2010 as the first national skills competency for installing ceiling insulation.

The Early Installation Guidelines required that homeowners arrange a minimum of two quotes and pay their installer upfront, but they were dispensed with at the full programme launch in July 2009. Although these requirements were intended to generate householder ownership over installer selection and potentially to drive competitive pricing, they were thought to slow the programme and were inconsistent with the stimulus imperative and the intent to provide the widest possible access to the programme, including to low-income households. As a result:

- *Take up was extraordinary and unexpected*. Early assumptions were that there would be around 90,000 installations per month. By November 2009, the number of claims had peaked at nearly 180,000 per month. Around 1.2 million homes had been insulated under the HIP at a cost of approximately $1.7 billion and many low income households participated, with the prospect of significant savings on energy bills in years to come.
- *The number of jobs estimated to have been created through the HIP was significant*. The insulation industry expanded from around 200 firms to some 10,834 registered firms throughout the program. Some 12,000 workers were estimated by DEWHA to be in the industry by the end of 2009 with an estimated 6,000 to 10,000 new jobs being created by the programme.
- *Energy efficiency gains and GHG emission reductions were also achieved.* Recently released emissions projections from the Department estimate the cumulative carbon abatement under the HIP from 2009-2020 will be 14.9 million tonnes of carbon dioxide equivalent avoided, 20,000 gigawatt hours of electricity and 25 petajoules of natural gas.

The Australian Home Insulation Program (HIP) *(cont.)*

However, as the number of claims and registered installers rose to unanticipated levels, safety and quality concerns mounted. And although a number of changes were introduced over time in response to these concerns, the HIP was terminated prematurely in February 2010.[2] As at March 2010, around 29% of the 13,808 roof inspections conducted had identified installations with some level of deficiency, ranging from minor quality issues to serious safety concerns. These problems with installation quality, the removal of insulation where safety risks were a problem, and potentially fraudulently claimed installations, have probably lowered the energy efficiency benefits that could have been achieved. But more importantly, due to the early closure of the programme, the many jobs created at the peak of the HIP were short-lived. Further, the closure of the programme has resulted in significant volumes of surplus insulation products and caused financial difficulties for many Australian manufacturers and installers, as well as reputational damage to the insulation industry. Overall HIP has been a costly programme for the outcomes achieved, including substantial remediation costs.

The deficiencies in the delivery of the HIP have meant that the Government decided to implement further measures to check and rectify the standard of installations:

- The Foil Insulation Safety Program (FISP) to offer all households with foil insulation installed under the HIP (about 58,000 homes) a safety inspection plus the option of having the foil removed or, on the advice of a licensed electrician, safety switches installed. This measure is estimated to cost $85 million.

- The Home Insulation Safety Program (HISP) to inspect a minimum of 150,000 households with non-foil insulation installed under the HIP. In addition to government-initiated safety inspections, any household with insulation installed under the HIP can request a safety inspection. The HISP is estimated to cost $340 million and aims to involve industry, including reputable installers and manufacturers, in the inspection and rectification program to ease concerns about the sustainability of the industry.

- The Insulation Industry Assistance Package to support reputable home ceiling insulation businesses with the costs of holding insulation stock. The Government has received 941 applications for support and has approved 653 applications worth $23 million. In addition, the $41 million Insulation Workers Adjustment Package provided support for the retraining and retention of insulation workers.

For the first time there was a national focus on safety standards in the industry and quality standards for materials and their installation. Several reviews of the programme have been commissioned and reported, which have highlighted a number of implementation issues and considerable gaps in the regulatory framework, and in particular:

- *There were minimal registration requirements for installers at the commencement of the HIP*. This approach reflected the high priority being given to creating jobs for lower skilled workers from the housing and construction industry and the tight timeframe in which to implement the programme. In order to register with the HIP, installation businesses needed to make an online declaration that all contractors had completed Occupational Health and Safety construction industry induction training –a mandatory requirement under State/Territory legislation for all people carrying out construction work– and the registrant satisfied at least one of the following three minimum competency criteria: at least two years prior industry experience; or qualification in an approved trade; or completion of insulation specific training. Therefore, individuals new to the industry could participate in the programme without any experience, qualifications or insulation specific training. Further, self declarations were accepted prima facie and were subject to subsequent compliance processes managed through DEWHA: registration would only be invalidated if evidence emerged later that requirements had not been met. Installers were required to provide evidence of qualifications and/or competencies at the time of registration as from September 2009, after more than 70% of installers had been registered. Consequently, the installer registration process failed to provide a satisfactory level of assurance as to the competence of installers or to the quality and safety of installations undertaken.

The Australian Home Insulation Program (HIP) *(cont.)*

- *Although training was specifically targeted at new entrants to the industry, insulation specific training could be completed in one day* (as indicated by the results of a survey undertaken by DEWHA in October 2009). This was unlikely to be a sufficient length of time to ensure that all training material was adequately covered, especially in the case of new entrants to the industry with no prior insulation or construction experience. This insulation specific training programme was developed by CPSISC (and nationally accredited) and must be undertaken through a Registered Training Organisation or a State/Territory regulatory body. While it provided the skills necessary to install various types of insulation materials in accordance with relevant safety standards and building requirements, the time taken to complete a unit of competency was entirely dependent on the ability of the individual installer to demonstrate their competency and installers were permitted to choose between two product specific units of competency. As a result, some installers may not have been alert to the specific hazards and installation methods for the type of insulation they were installing. Moreover, the Minimum Competency Requirements allowed installers who had completed the insulation specific training to work unsupervised and to supervise other inexperienced and unqualified installers without any requirement to gain a level of practical experience first. These requirements did not become mandatory for all installers until February 2010, immediately prior to program closure. Although learning on the job and allowing qualified and experienced individuals to supervise the work of inexperienced trainees is an acceptable practice within the general construction industry, installing insulation, which requires working in a roof space (particularly near electrical wiring), is hazardous and presented a high level of risk for inexperienced and untrained workers. If more stringent registration and training requirements had been in place from the start of the program, for example, mandatory training for all installers, many of the subsequent problems that arose concerning the safety and quality of the installations may also have been averted.

- *Manufacturing capacity constraints resulted in the importation of insulation material to meet HIP demand which in part led to concerns that poor quality materials may have been installed in some ceilings*. Prior to commencement of the HIP, there were between 50,000 and 75,000 retrofit insulation installations per year, and these figures were expected to increase to 1.275 million per year in the two years of the programme. Industry advised that while it would increase its production of insulation material, it was unlikely to be able to meet all of the increased demand through locally manufactured products. Industry representatives also pointed out that there was little likelihood of investments in new plants as it would take approximately 18 months to two years to have a new factory up and running. To mitigate concerns that industry would be unable to deliver sufficient quality materials within the timeframes, the program allowed for imported products which met the relevant Australian Standard. However, DEWHA did not publish an Approved Products List – identifying all products certified or tested successfully against the Australian Standard– until December 2009. Moreover, concerns have been raised by industry that the testing regimes still allow substandard products to enter the market because of inconsistent sampling and certification techniques and ineffectual compliance mechanisms.

1. Only South Australia maintained a licensing regime for installation businesses.
2. These included changes to installer competencies and training requirements, a reduction in the maximum rebate amount from $1600 to $1200, the reintroduction of the requirement that householders gain two quotes prior to installation, and the implementation of a compliance and audit framework.
3. As at 10 April 2011, 44,201 homes with foil insulation installed under HIP have been attended for inspection: the foil insulation has been removed in 32% of cases, safety switches have been installed in another 32% of inspected homes, while 14% of households were found to have non-HIP related safety issues.

Sources: Hawke (2010), ANAO (2010), and Booz & Co (2011).

ANNEX 5. NATIONAL GREEN-SPECIFIC EMPLOYMENT AND SKILL DEVELOPMENT PROGRAMMES

209. Tables A5.1 and A5.2 provide an overview of national green-specific employment and skill development programmes as of 2010. This information is based on responses to an OECD questionnaire that was sent to employment and labour ministries.

Table A5.1 **Specific green-related programmes implemented by national OECD governments, 2010**

Summary table

	Job subsidies	Direct job creations	Education and training programmes		Job subsidies	Direct job creations	Education and training programmes
Australia	X		X	Japan			
Austria			X	Korea		X	X
Belgium	X	X	X	Mexico			
Canada			X	Netherlands			
Chile				Norway			
Czech Republic	X		X	Poland			
Denmark				Portugal			
Finland			X	Slovak Republic			
France			X	Slovenia			X
Germany				Spain		X	X
Greece	X		X	Sweden			
Hungary	X	X	X	Turkey			X
Israel				United States		X	X

Source: OECD questionnaire on green jobs and policies.

Table A5.2. **National green-specific employment and skill development programmes, 2010**

Description of measures

	Broad description
Australia	The Australian Government has primarily focused policy on skills development, rather than green job creation. Australia's *Green Skills Agreement*, a partnership between the Federal Government, states and territories, aims to build the capacity and capability of the national Vocational Education and Training (VET) sector to provide skills for sustainability training to the workforce. Endorsed by the Council of Australian Governments (COAG) in December 2009, the *Green Skills Agreement* has four key objectives: *i)* develop national standards in skills for sustainability within the requirements of the national regulatory framework; *ii)* up-skill VET practitioners so they can provide effective training and facilitation in skills for sustainability; *iii)* review and revise Training Packages to incorporate skills for sustainability; and iv) implement strategies to reskill vulnerable workers in the transition to a low carbon economy. Under the *Green Skills Agreement*, all new trade apprentices who commence training after 1 January 2010 will graduate with a core set of green skills, while 30,000 apprentices in carbon exposed industries who graduate by late 2011 will have qualifications that include clean and green skills. Total public spending on this measure amounts to $5.3 million over four years from 2010/11. In addition, a job subsidy programme has been launched in 2010 on a temporary basis, the National Green Jobs Corp (January 2010 - December 2011). Job subsidies are provided for 26 weeks to employers in environment rehabilitation and protection activities, emerging green and climate change industries, hiring unemployed people aged 17-24. With 10,000 beneficiaries, public spending on this programme amount to AUD$79.6 million over two years. These two measures are part of a broader green growth programme, the Clean Sustainable Skills Package. Moreover, Australia's National Energy Efficiency Skills Initiative (NEESI) is currently under development as part of the National Strategy on Energy Efficiency, endorsed by COAG in mid-2009.
Austria	*Klima:aktiv* is the Austrian climate protection initiative launched by the Federal Ministry of Agriculture, Forestry, Environment and Water Management, embedded in the Austrian federal climate strategy. The primary objective of *Klima:aktiv* is to introduce and promote climate friendly technologies and services. The Austrian federal climate strategy consists in a bundle of measures of regulation, taxes, and subsidies. *Klima:aktiv* has gathered all voluntary and supportive measures under one umbrella. In the four thematic clusters –Building, Energy Efficiency, Mobility, and Renewable Energy–, specific programmes are carried out by different institutions. These programmes follow a comprehensive and systematic approach in supporting the market introduction of climate-friendly technologies, services and activities. *Klima:aktiv* follows a so-called "market transformation approach", which consists in a targeted effort to change the market through an active and comprehensive inclusion of all relevant market players and stakeholders. The main advantages of such an approach are comparably low costs and high sustainable effects. In this case, market transformation aims to raise the share of energy efficient products and services. The advantage of combining all these various strands under one umbrella brand mainly results from the fact that the instruments used (training, consulting, quality management, networking and awareness campaigns) might differ in content and importance in different market segments but not so much in form. Thus, the individual thematic programmes profit from each other: not only can they learn from their own mistakes but also from others, and vice-versa, success stories will quickly work a circuit and all other programmes can profit. *Klima:aktiv* 's core levers are: *i)* Training of professionals: *Klima:aktiv* provides the qualifications needed in the thematic programmes and coordinates training and education in the various fields. *ii)* Setting standards and safeguarding quality. Since young and booming markets often cannot provide for quality, *Klima:aktiv* focuses on safeguarding quality by introducing quality standards for products and services and by establishing quality management systems, *e.g.* for biomass district heating systems or for buildings. *iii)* Providing information and raising awareness: *Klima:aktiv* provides online and print information to empower consumers, companies and professionals. *Klima:aktiv* also participates at a lot of events every year. *iv)* Providing advice and support: *Klima:aktiv* mainly focuses on offering consulting to companies interested in making their production processes energy efficient, or renovating their facilities, or introducing mobility management, or changing over to energy efficient appliances and IT systems. *Klima:aktiv* provides for the empowerment of the existing consultants by equipping them with new tools, by benchmarking energy efficiency and by offering further training on specific issues to consultants. *v)* Activating and networking partners: Successful climate protection depends on the commitment of existing initiatives and networks as well as on that of the business and the public sector. *Klima:aktiv* aims at bringing these players together and at creating a powerful network for climate protection. In addition, the "Master plan of Green Jobs" was launched by the Federal Ministry of Agriculture, Forestry, Environment and Water Management (Lebensministerium) and results out of this initiative were published in 2010. Several Ministries, organisations, etc. were invited to discus where and how green jobs could be generated. The main sector identified, where most green jobs will be created, is thermal renovation. Finally, few local branches of the Pubic Employment Service offer training measures in the field of green jobs, but not all over the country.

	Broad description
Belgium	The *Plan Marshall 2.vert,* a broad environmentally-friendly measure, was launched in December 2009 in Wallonia. Several successive programmes, the so-called "Alliances emploi-environnement", will be implemented to support skill and employment development in targeted environmentally-friendly activities. The first "Alliance" programme was launched in 2010 for a 5-year period and focuses on occupations in energy-efficient construction and retrofitting. Apprenticeship, vocational training and life-long learning constitute the core elements of this measure (although some job subsidies in the private and public sectors are also available). These specific education and training programmes are implemented within the pre-existing framework for education and training. A multipartite committee is in charge of identifying skill needs and ensuring that adequate formation and training are supplied within this "general" policy framework. Precise numerical targets in terms of number of trainees and hours of formation have been set: depending on the programme, between 15% and 30% of dedicated resources should be targeted at green occupations. Moreover, 25% of the regular screenings of skills and competencies operated by the PES for various occupations will be dedicated to green occupations. Budget: EUR 56 million over 5 years dedicated to education and training in the context of the first "Alliance" programme (and a total of EUR133 million for employment, education and training).
Canada	No specific employment programmes (except the green stimulus package: public investment in green sectors). However, through the Sector Council Program launched in 1993, the Government of Canada is working with the private sector, including Canada's environmental industry, to enhance adult workers' skills through activities such as increasing employer investments training. The Environmental Careers Organization (ECO) Canada is a not-for-profit Sector Council organization that was first established in 1992. ECO Canada is focused on supporting Canada's environment industry by communicating with industry stakeholders, conducting research and creating the necessary resources required to address human resource needs in order to ensure the success of this dynamic sector. In order to define this dynamic sector, ECO Canada has identified three core areas of specialization including: environmental protection, conservation and preservation of natural resources, and environmental sustainability.
Chile	No specific employment programmes. However, in the context of urban improvement programmes, each municipality autonomously can direct its programs towards initiatives that have a positive impact in the environment. In fact, the guidelines of these programmes include the development of green areas and recycling, among other initiatives. There are about 10 municipalities with environmental certification which generate green jobs. Additionally, there are isolated initiatives in a number of public institutions, such as the impulse of sustainable tourism and the use and development of renewable energies, among others. In addition, the government, through Chilecompras (National Public Procurement System), has impulse the certification for products that promote the use of natural resources and a lower environmental impact.
Czech Republic	No specific employment programmes. However, the government has been closely involved in the formulation of a policy strategy to green the growth within the EU context, and further measures and programmes will be applied on the grounds of EU strategies. In this respect, the Ministry of Education, Youth and Sports currently anticipates the outcome of government discussion upon the "Action Plan for 2011 – 2012: Strategy for sustainable development education in the Czech Republic (2008 – 2015)". The Plan identifies objectives and resources for the Strategy and sets key topic areas for education and training, in accordance with the Strategy. Part of these topic areas are related to environmental issues. Moreover, as part of the government response to the economic crisis, a specific subsidy programme, "Green Light for Saving", has been launched in 2009 for a 3-year period. The programme is focused on green investments in households sector (building insulation, building in low-energy standard, installation of renewable energy sources for heating), and its potential effects on jobs were one of considered benefits of the programme.
Denmark	No specific employment programmes, but the potential for green initiatives in the active labour market policies is investigated. The ministry of employment is working on a definition and a follow up project analysing the potential for a green jobs strategy. Thus, while there may be a significant number of measures which are already related to the green sector (*e.g.* job training could take place in a wind mill factory) there is no definition ready to define it as a green initiative.
Finland	In 2010, education and training in energy efficiency renovation has been identified as a national priority for vocational training. Regional and local PES authorities have the responsibility for the allocation of labour market training according to regional and local needs, including skills related to low carbon economy. The National Climate and Energy Strategy and the National Forest Programme 2015 provide a general framework for the allocation of labour market training resources on green skills. The main focus rests on energy efficiency and renewable energy. Further skills development efforts related to the National Climate and Energy Strategy are under discussion.

	Broad description
France	Within the broad context of the "Grenelle Environnement", the French Environment Strategy, a national plan for green occupations and jobs has been set in 2009. The plan involves three main actors: the government, targeted industrial branches, and regions. It deserves three main purposes: i) identifying and monitoring green-related occupations; ii) integrating green-related skills into the initial and vocational education systems, through the adaptation of existing curricula, the creation of specific formations and the related modification of diploma systems and certificate (*e.g.* accreditation of work experience) systems; and iii) integrated green occupations into ALMPs, such as apprenticeship contracts or subsidised jobs for disadvantaged workers. As a result, the National Observatory of green occupations and jobs has been created in 2010, with the first task of identifying green occupations and associated skill requirements, as well as estimating the number of green jobs and the potential employment impact of various environmental measures. The Observatory is composed of members from several public bodies: ministry of ecology, ministry of labour, ministry of economy and finance, regional authorities, national institute of statistics and economic studies and other national agencies for environment, employment and education and training.
Germany	No specific employment programmes.
Greece	Several job subsidy measures, targeted towards disadvantaged groups, have been implemented in 2010. While all private employers (or individual entrepreneurs) can access to these measures, the priority is given to small businesses which promote green economy. Likewise, green-related fields have been introduced into apprenticeship or vocational training programmes. Moreover, new specialised programmes of continuing vocational training and skill-upgrading in the fields of energy performance of buildings will be implemented for unemployed and under-employed workers in the construction sector (and related occupations). These programmes have been designed while taking account of programmes, projects and aims pursued by the Ministry of Environment, Energy and Climate Change.
Hungary	Green economy development and climate policies fall under the responsibility of the Ministry for National Development. In cooperation with the Ministry for Rural Development and local municipalities, complex rural programmes will be launched to create green jobs in rural areas. The Ministry for National Development and the Ministry for National Economy (responsible for employment and training policies) also cooperate in order to support the creation of green jobs by improving workers employability and providing them with the necessary green skills. In early 2011, the Hungarian government launched the New Széchenyi Plan aimed at boosting economic growth and creating new jobs in the private sector, in particular through supporting SMEs. The objective is the creation of one million jobs over a 10-year period. Developing green economy figures among the seven priority areas of this Plan, which sets the following objectives: increasing the utilisation of alternative and renewable energy source; developing energy efficient technologies; and creating 200 thousand new jobs in these areas by 2020. As part of this Plan, a job subsidy programme has been launched recently and the government is considering the possibility of introducing measures aimed at creating jobs in the public sector as well as green-related training programmes (details of these are currently under elaboration).
Israel	No specific employment programmes. The greening of the economy is still at an early stage and the Government has not yet institutionalised the process in terms of definition, specific programmes or global strategy.
Japan	No specific employment programmes.
Korea	Korea has been implementing its "Action Plans for Job-conducive Green New Deal" scheme since January 2009 as part of their economic recovery package. The policy's aim is to overcome the economic crisis in the short-term as well as to strengthen the growth potential over the longer-term. A sum of KRW 50 trillion being invested is expected to create 960.000 jobs that are environmentally-friendly from 2009 to 2012. In addition, the Korean government in November 2009 made public its longer-term "Green Jobs Plan", which was produced through the collaborative efforts of 10 ministries, including the Ministry of Employment and Labour (MOEL) and the Ministry of Strategy and Finance. The plan is designed to support government's agenda to combine vigorous economic growth with environmental progress as well as to create green jobs and to nurture talented green workforce. In 2011, total 14 programmes among 5 ministries are implementing to create jobs in the public sector, while 34 programmes among 10 ministries are activating to foster green education and training. For example, the MOEL in 2010 has developed "Green SMEs Training Consortium Programme" to raise green workforces in SMEs to effectively address skill problems in shifting to a greener economy. The designated model centre (Korea University of Technology and Education) that gives training in nine core areas including photovoltaic, bio- and other renewable energy sources, eco-transport system is receiving temporary supports such as facilities and equipments expenses until 2016. In 2010 alone, KRW 21.7 billion was budgeted to this program, and the government expects that this would function as a bridge to channelling green technical skills in large companies such as Samsung Electronics to SMEs.
Mexico	No specific employment programmes.

	Broad description
Netherlands	No specific employment programmes. The Dutch policy relies on a general approach, considering that: *i)* labour market will adjust automatically when the production gets greener; and *ii)* for many green jobs the same skills are needed as for normal jobs, so that special employment programmes are not necessary. A well functioning education system, where employees learn to adjust to labour market changes, is seen as being most important.
Norway	No specific employment programmes. Instead, a general ALMP-approach has been adopted, as the Norwegian authorities consider that the labour market policies needed to meet "green change" are –to a large extent– the same as those needed to meet other forms of shifts and changes in the economy. But the government is continuously following the development and considering this general approach.
Poland	No specific employment programmes. Green jobs represent a new issue that the government is starting to investigate. Whether such programmes will be developed in near future is difficult to know, as presently, the greening of the economy is treated mostly from the perspective of economic growth or industries rather than from a labour market perspective.
Portugal	No specific employment programmes. However, an inter-ministerial working group has been created recently with representatives from the Ministry of Labour and Social Solidarity, the Ministry of Environment and Spatial Planning, and the Ministry of Economy, Innovation and Development. This working group was assigned the tasks of: i) collecting information regarding national policies related to environment, in particular those connected to climate change and renewable energy; ii) identifying the outcomes of these policies on employment and skills; and iii) replying to data requests from international and national organisations. In addition, a National Energy Strategy has been launched in 2010, with the aim of promoting sustainable growth. In particular, this Strategy seeks to promote job creation in economic areas connected with renewable energy sources and energy efficiency issues.
Slovak Republic	No specific employment programmes. The greening of the economy falls under the competency of several ministries. Each ministry deals with its own substantive area more or less individually, which prevents positive synergies as there is no institutionalised framework for assigning such cross-competency type of programmes.
Slovenia	The Government Office of Climate Change has been establishing in 2009, with the tasks of providing guidance and coordinating government policies and measures related to climate change. The Office is currently working on implementing a *Climate Change Act* and a long-term strategy to determine the national policy of climate change mitigation and adaptation till 2050. A number of policy options/projects and their economic feasibility are being discussed. No specific employment programmes have been implemented yet, but two pilot projects related to green vocational training were launched in 2009 by the Government Office of Climate Change in the areas of efficient energy use and renewable sources of energy, and eco-agriculture.
Spain	General policy framework: Spanish Strategy for Sustainable Development, which covers three areas: environmental sustainability, social sustainability, and macroeconomic sustainability. No specific labour market programmes *per se*, but significant public investments have been made in green activities as part of the Spanish Economy and Employment Stimulation Plan – Plan E – that has been implemented in response to the economic crisis. In 2009, EUR 1.12 billion have been allocated to environmental projects as part of the Fund for Local Entities (which represents 15% of the total amount), and one third of the Special Fund for Employment and Economic Reactivation, budgeted at EUR 3 billion, has been earmarked for environmental projects. These measures are expected to result in *direct job creations*.
Sweden	While there is no specific employment programmes designed to adapt the labour market to green growth, the Government is monitoring the available and ongoing research in this area as well as the international initiatives, and aims to undertake national measures at the appropriate stage.
Turkey	No specific employment programmes. However, in the context of EU assistance to countries engaged in the accession process, the Ministry of Energy and Natural Resources, in collaboration with the Ministry of Labour and Social Security, will implement vocational training and internship programmes to increase the employability of young worker in the electricity generation sector. EU 7 billion is allocated to this measure, including almost EUR 6 billion from EU under the "Instrument for Pre-accession" funds (within the broader context of supporting the development of the energy sector in Turkey). The measure will be launched in 2012 for a 23-mounth period. 1,000 young workers with relevant educational backgrounds will be provided with at least 45 days of vocational training, or at least 15 days of apprenticeship. Moreover, trainees will attend to workshops on green jobs, environment protection, energy efficiency, etc.

	Broad description
United States	The American Recovery and Reinvestment Act of 2009 (Recovery Act) made available $750 million in competitive grants for worker training and placement in high-growth and emerging industry sectors. Of this amount, $500 million have been awarded to green jobs programmes by the USDOL Employment and Training Administration. These funds must be used for research, labour exchange, and job training for careers in energy efficiency and renewable energy industries, as described in the Green Jobs Act of 2007 (Title X of the 2007 Energy Independence and Security Act). The US Department of Labor (USDOL) completed five Green Jobs grant competitions from late 2009 through early 2010 to award funds made available through the Recovery Act. With the exception of the State Labor Market information improvement grants, intended to support innovative approaches for identifying and obtaining information on green jobs at the state level, the Recovery Act-funded programmes provide training and placement services for disadvantaged workers that prepare them to enter the energy efficiency and renewable energy industries, as well as green occupations within other industries, with a reinforced assistance to the most disadvantaged groups living in high-poverty areas. The duration of these grant-funded programmes varies in length, with the period of grant performance ranging from a maximum of 12 to max 36 months. However, the funding for green jobs continues through the USDOL Green Jobs Innovation Fund ($40 million in FY2010), which is designed to complement and extend the competitive grant awards made through the Recovery Act of 2009. In addition, a green dimension is being integrated into pre-existing measures. For instance, Job Corps, an intensive education and training programme for at-risk youth, and the YouthBuild program, created to help at-risk youth gain education and occupational credentials while building or rehabilitating affordable housing, are implementing green curricula and many Job Corps facilities employ green technology. Finally, USDOL is represented on United States Government interagency working groups related to clean energy and has negotiated an agreement with the Departments of Education and Energy and an agreement with Department of Housing and Urban Development in order to collaborate closely on linking the U.S. workforce to jobs, training and educational opportunities.

Source: OECD questionnaire on green jobs and policies (2010)