Comparative Analysis of Methods of Identification of Skill Needs on the Labour Market in Transition to the Low Carbon Economy

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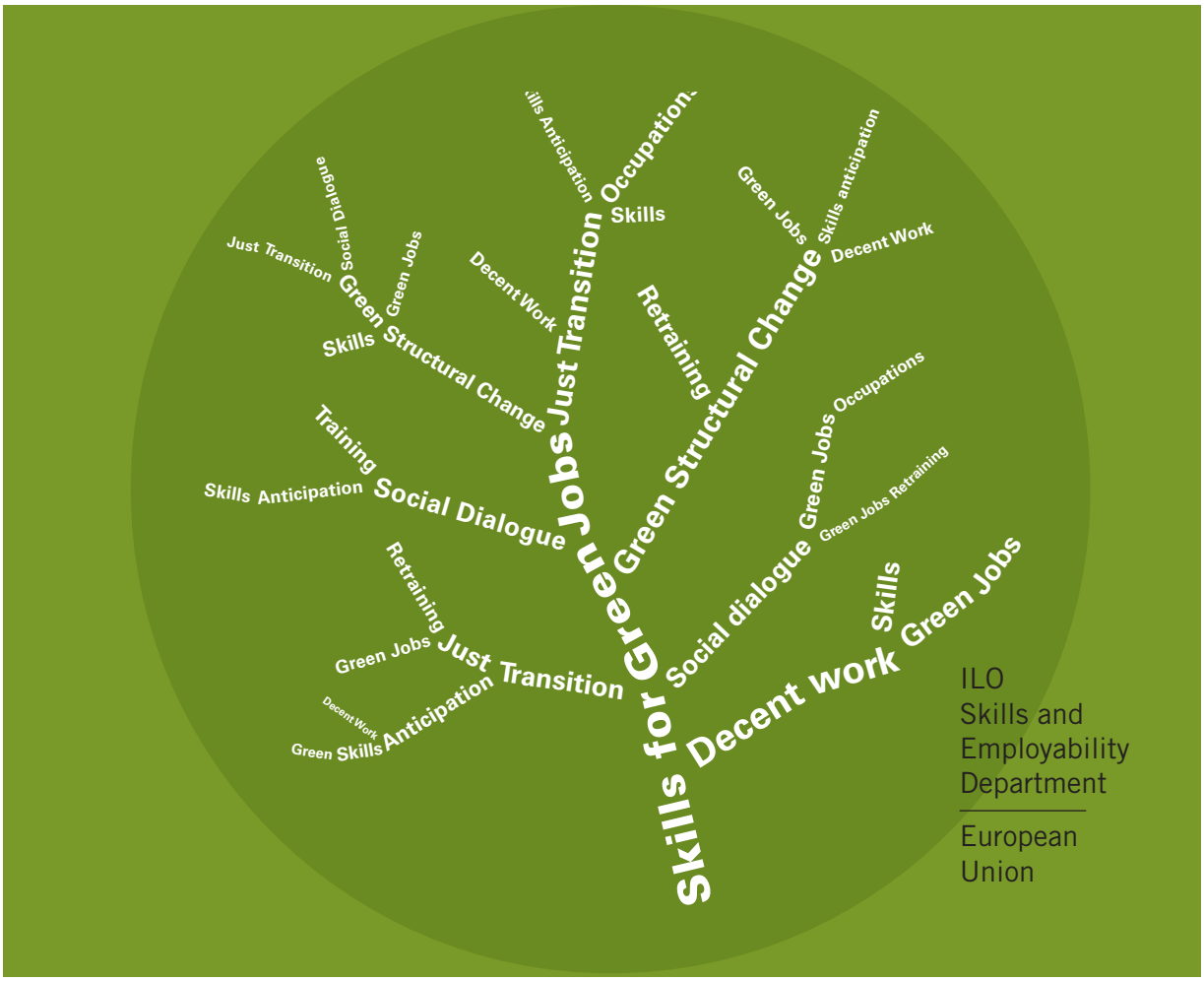

ILO Skills and Employability Department

European Union

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Foreword

Moving towards a greener economy is creating opportunities for new technologies, investment, and jobs. At the same time, environmental change and in particular climate change has detrimental effects on certain economic sectors and can cause job losses. Identifying and providing right skills for new and existing jobs can smooth transitions to greener economies and ensure that new opportunities benefit a broader share of society. The shortage of green-collar professionals with cutting-edge skills in energy efficiency, green engineering and green construction has already been identified in a number of countries as a major obstacle in implementing national strategies to cut greenhouse gas emissions or address environmental changes.

In this context, the European Commission (EC) and the International Labour Organization (ILO) concluded a joint management agreement on *Knowledge sharing in early identification of skill needs for the low-carbon economy* with the aim of enhancing cooperation and knowledge-sharing in the field of early identification of skill needs. What each organization has learned from extending state-of-the-art knowledge and analyzing good practices through this research programme will inform their own ongoing activities, not only in the EU but worldwide. This study was supported by the European Union Programme for Employment and Social Solidarity – PROGRESS (2007-2013)[1] and matched the

[1] This programme is implemented by the European Commission. It was established to financially support the implementation of the objectives of the European Union in the employment, social affairs and equal opportunities area, and thereby contribute to the achievement of the Europe 2020 Strategy goals in these fields. The seven-year Programme targets all stakeholders who can help shape the development of appropriate and effective employment and social legislation and policies, across the EU-27, EFTA-EEA and EU candidate and pre-candidate countries. For more information see: http://ec.europa.eu/progress

objectives expressed by the New Skills for New Jobs Initiative. For the ILO, the agreement supported the implementation of the Green Jobs Initiative, a partnership launched jointly with the United Nations Environment Programme (UNEP), the International Trade Union Confederation (ITUC) and the International Organization of Employers (IOE) in 2008.

Three mutually supportive global reports were produced under this joint management agreement:

- Comparative analysis of methods of identification of skill needs on the labour market in transition to the low carbon economy;
- Skills and occupational needs in green building; and
- Skills and occupational needs in renewable energy.

The studies build understanding of how to embark on a skills anticipation exercise for the low carbon economy, which is relevant for national, sectoral and enterprise level human resource strategies in mitigation and adaptation to climate change. Two sectoral analyses identified global employment and skill needs trends in renewable energy and in green building.

Anticipation of skill needs for the low carbon economy is a complex task. The exact margins of the green economic sectors and exact occupations are not universally defined; they vary by country or sector context. In addition, the pace of change makes the low carbon economy a moving target, difficult to measure and predict. Intended to assist researchers in skills anticipation, this report primarily deals with methodologies and institutional arrangements, and aims to inform decisions on the scope and level of skills anticipation research, sources of information, and available methodological approaches, both quantitative and qualitative.

Methodologies that can be employed in the task of anticipating skill needs for the low carbon economy range from quantitative modelling to various qualitative research methods. Which methodology is most suitable, or which combination of methods might be best, depends on the research objectives, country context, data availability and institutional setting. Certain research questions can be answered through purely qualitative approach. For example, finding out *what sort of skills and competencies are needed for a certain "green" occupation* requires gathering information directly from those involved in hiring, working or training in that occupation. Qualitative research objectives employ qualitative methods. At the same time, quantitative research questions, such as *how many jobs for certain skill levels or occupations will be created as a result of new "green" policy, regulation or investment,* can hardly be answered by means of purely quantitative methods.

Quantitative modelling needs data and contextual information on green activities and occupations that are not available from standard statistical sources, and thus must be obtained through additional qualitative research. Qualitative research is particularly important in developing and emerging countries where data deficiencies may preclude quantitative modelling. Regardless of development stage or availability of reliable data, institutional arrangements for skills identification and anticipation should be inclusive, drawing on the knowledge of a range of stakeholders that includes workers' and employers' organizations, industry representatives, providers of education and training, and national and local levels of government agencies.

The report *Comparative analysis of methods of identification of skill needs on the labour market in transition to the low carbon economy* was prepared by an ILO research team consisting of Con Gregg, Jon Beaulieu and Mercedes Durán, under the leadership and coordination of Olga Strietska-Ilina and Christine Hofmann, and under general supervision of the Director of the ILO Skills and Employability Department Christine Evans-Klock. Jane Auvre provided administrative support throughout the project and assisted in publishing the reports.

The report includes a substantial amount of material from a background paper prepared by James Heintz, Robert Pollin, and Jeannette Wicks-Lim of the Political Economy Research Institute (PERI), University of Massachusetts Amherst, USA. It benefited from input mainly received at an expert meeting on 25 October 2010 in Geneva, and the final technical validation workshop in Brussels on 29-30 March 2011, in particular from Rachel Beaven from Cambridge Econometrics, UK, Dietmar Edler from the German Institute for Economic Research (DWI), Antonio Ranieri from Cedefop, Adarsh Varma from AEA Technology, UK; Cristina Martinez-Fernandez and Paul Swaim from OECD; colleagues from the European Commission: Anastasios Bisopoulos, Heli Saijets, Guido Van der Seypen; and the ILO colleagues: Christoph Ernst, David Hunter, Ana Iturriza, Yasuhiko Kamakura, Larry Kohler, and Daniel Samaan.

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Abbreviations

ANZSCO	Australian and New Zealand Standard Classification of Occupations
ANZSRC	Australian and New Zealand Standard Research Classification
ANZSIC	Australian and New Zealand Standard Industrial Classification
ARRA	American Recovery and Reinvestment Act
BLS	Bureau of Labor Statistics
CGE	computable general equilibrium
CPS	Current Population Survey
DOE	Department of Energy
DySAM	dynamic social accounting matrix
EC	European Commission
EDUCATE	Environmental Design in University Curricula and Architectural Training in Europe
EGFSN	Expert Group on Future Skills Needs
EGSS	environmental goods and services sector
ESCO	European classification of Skills/Competences, qualifications and Occupations
FTEs	full-time equivalents
GW	gigawatt
ILO	International Labour Organization
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industrial Classification
ISTAS	Instituto Sindical de Trabajo Ambiente y Salud
MW	megawatt

NAICS	North American Industry Classification System
NEMS	National Energy Modelling System
NGO	Non-governmental organization
OECD	Organisation for Economic Co-operation and Development
O*NET	Occupational Information Network
PERI	Political Economy Research Institute
R&D	research and development
RES	Renewable Energy Sector
SAM	Social Accounting Matrix
UNEP	United Nations Environmental Program
VATT	Finnish Government Institute for Economic Research
VATTAGE	A dynamic, applied general equilibrium model of the Finnish economy
VET	Vocational Education and Training
WIC	Workforce Information Council

Executive Summary

Achieving a successful transition to the low carbon economy is one of the greatest policy challenges of the present day facing governments and their peoples worldwide, and is of deep concern to businesses, workers and the organizations that represent them. The quality of analysis, planning and policy formation that goes into managing the transition will have a major impact on the success of the transition itself, but will also do much to determine whether its collateral impact on people and businesses is positive or negative. This is particularly important at a time of economic stress like the present, when growth and employment conditions in many countries are weak, and when those emerging and developing countries that are doing well economically are seeking ways to curb the increased carbon emissions and other environmental stressors historically associated with growth.

Strategies to reduce carbon emissions, and indeed other environmental objectives, require people with the right skills to implement them. Shortages of skills are regularly identified as one of the major obstacles to the implementation of these strategies. Shortages of high quality skills may damage implementation, slowing it, making it less efficient, driving up costs, and reducing or eliminating the environmental benefits. Shortages of people with the right skills can bring implementation of low carbon initiatives to a halt.

The detailed design of research into skills for the transition to the low carbon economy is complex. It has to respond to differences in the availability of data and other information, differences in institutional arrangements, differences in sectors, industries and occupations, differences in education and training practices, and differences in research questions and priorities between countries and

research projects. Adding to the complexity, industries of interest in the transition to the low carbon economy mostly do not line up with standard sectoral definitions used in official statistics, and skills required often do not line up cleanly with standard occupational classifications.

Intended to help tackle these complexities, this report is primarily about methodologies. The report is for researchers in skills anticipation for the transition to the low carbon economy who need to decide on the scope of their work, identify sources of information, and choose from among the available methodological approaches, quantitative and qualitative. It is also for policymakers, policy advisors, businesses, representative organizations, NGOs and providers of education and training interested in interpreting and evaluating research carried out by others, or who may need an understanding of methodologies in order to commission research.

The report focuses on the design of research into skills for the transition to the low carbon economy. It does not seek to be a full manual. It is not possible to set out a universal methodological approach.

It is difficult to define green jobs in a way that is satisfactory for all purposes. While there are many competing definitions, most practical skills research questions are sufficiently specific so that research can proceed without any requirement for a universally agreed green jobs definition.

The report distinguishes between four main levels of skills analysis: macroeconomic; sectoral; occupations and skills; and training and education. The levels covered by a research project depend on the research questions posed. Most skills research projects concerned with the transition to the low carbon economy span more than one level, but few span the full range. Most include substantial research at sector level. Different methodologies are appropriate to different levels, and choices have to be made about alternative methodologies within each level.

The choice of methodologies available to a researcher varies between country contexts, depending on factors such as data availability. However, methodologies are available that are workable even where data availability is poor, as is often the case in developing and emerging countries.

Research questions may be quantitative, qualitative or some combination of both. Examples of quantitative questions include: *How many jobs will this initiative produce?* or *How many do we need to train in solar panel installation next year?*. Examples of qualitative questions include: *What skills are needed to be a green plumber?* or *What sort of training is needed to work as a wind turbine technician?*.

Methodologies to research skills for the transition to the low carbon economy involve quantitative modelling or qualitative research. Some questions

can be answered purely through qualitative research. However, in almost all cases research involving quantitative modelling needs data and contextual information that is not available from standard statistical sources, and so must be obtained through qualitative research. Qualitative research is even more important in developing and emerging countries than in developed countries, as deficiencies in data availability are likely to be greater.

A wide variety of approaches to quantitative modelling are adopted at sectoral level, usually starting from a qualitative analysis to identify the main factors likely to drive employment into the future. For projections that look more than a very small number of years into the future, model parameters are usually chosen to reflect scenarios rather than firm forecasts.

There is no single correct approach to macroeconomic analysis. Input-output, social accounting matrix (SAM), dynamic social accounting matrix (DySAM) and computable general equilibrium (CGE) models may all be appropriate depending on the context. Models that look forward beyond the short term should take account of time dependencies such as likely changes in labour productivity over time.

In addition to addressing methodologies, the report also addresses institutional arrangements for identification and anticipation of skills needs. In countries where existing arrangements for skills anticipation are in place, similar approaches can be used to address skills in the context of the transition to the low carbon economy, although there may be a need to put in place an initiative that crosses existing sectoral boundaries where existing systems are organized along sectoral lines. To achieve best results, institutional approaches should involve the social partners and providers of education and training. Research into skills for the transition to the low carbon economy can be used as a building block towards developing a strong system for skills identification and anticipation in countries where such systems are poorly developed.

Where governments or others propose specific initiatives to contribute to the transition to the low carbon economy they should include an analysis of the skills requirements and a plan for how these can be addressed in the proposal.

In addition to making recommendations relevant to skills identification and anticipation at national level, the report makes various recommendations specific to the EU context. These include: pointing to the need for research into skills for the transition to the low carbon economy associated with the planned system of European Sector Councils on Employment and skills to be coordinated across sectors; the positive role that the EC plays and can continue to play in facilitating sectoral interests and providers of education and training in skills relevant to the transition to identify and synthesise best practices and high

quality curricula and course content; the positive role that Sector Councils can potentially play in planning for the skills aspects of initiatives to progress the transition; and the possibility of developing and maintaining a quantitative skills CGE model to service the needs of the Skills Councils and others, capable of modelling complexities associated with the transition to the low carbon economy that are likely to also appear in other skills analysis contexts.

Section

1 Introduction

1.1 Background

There is, by now, a near universal recognition of the need for the global economy to undergo a major transition in its activities and technologies to enable it to emit steeply reduced volumes of carbon dioxide and other greenhouse gases – to undertake the transition to the low carbon economy.

The research fits into wider agendas of the EC and the ILO. It has been undertaken in the context of the EC's *New Skills for New Jobs Initiative*. The EU's Employment Council has emphasized that the need to upgrade skills can serve both as a short term strategy for economic recovery and as a means to close the skills gap over the long term.

The research also forms a part of the ILO's *Green Jobs* initiative. Earlier work on skills within this initiative includes the joint ILO-Cedefop project on *Skills for Green Jobs*.

The report is one of three main outputs from a project undertaken under a cooperation agreement between the EC and ILO entitled "Knowledge sharing in early identification of skill needs". The other two are sectoral studies looking at the Renewable Energy sector and at Green Building.

One of the major issues in the transition is ensuring that the skills required to enable it to progress are available; earlier research has identified skills shortages as an important constraint. A major challenge in this is identifying the skills required now, and anticipating what skills will be required into the future. The report is designed to address the challenges involved in skills identification and anticipation in this complex area.

1.2 Green jobs and skills for the transition to the low carbon economy

The report sometimes refers to activities and jobs as being related to the "transition to the low carbon economy", which is formally the subject of the report, and sometimes as being "green".

These are not equivalent terms. The "transition to the low carbon economy" refers to improvements in energy efficiency, substitution of renewable energy for carbon-emitting forms of energy, and more broadly to the decarbonisation of economic activity. "Green" is a broader concept, which also encompasses other sustainability issues, such as water conservation and prevention and remediation of pollution. However, both terms are used in the report, reflecting the fact that the methodologies described are equally applicable to the full breadth of green economic development and not only to the transition to the low carbon economy.

The ILO Green Jobs Report (2008) defines green jobs as:

> "... work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution." [1]

1.3 Objectives

The objective of this report is to review models and other methods and approaches in identification of occupations and skills needs on the labour market which result from the transition to the low carbon economy.

The report is to reach conclusions on quantitative modelling and softer qualitative methods in measurement of skills and occupational needs for greening the economy: at different levels – sectoral, national and European/supranational; for various needs – policy, training adjustment, guidance services etc.; and for countries at various stages of development – emerging and industrialized, with high and low informality in economy, rich and poor in statistical databases.

[1] A more detailed discussion on the definition of green jobs follows in Section 2.3.

1.4 Structure of report

This report focuses on the research methods which have been used to estimate the potential impact of these changes on employment and the skills needed to meet existing and future demand. More specifically, this report provides a comparative review of methodologies used to assess the skills and employment effects of various dimensions of the transition to clean energy and greener economies. The focus is on both quantitative and qualitative methods.

Section 2 of the report presents an overview of the territory, emphasizing that research into skills for the low carbon economy takes place across a range of levels, from macro level analysis, through sectoral level analysis, to analysis focusing on occupations and skills, and connecting findings on occupations and skills to assessments of requirements for education and training. Any individual research project may only cover a part of this range. It also reviews the main questions addressed by skills research, and discusses the definition and measurement of green jobs.

Section 3 of the report looks at issues of data sources and definitional issues for quantitative and qualitative analysis relating to the transition to the low carbon economy. It addresses the need for clarity in defining what a "job" means as a quantitative measure, and the need to take account of the differing employment dynamics associated with different types of job.

Section 4 of the report presents a comparison of quantitative methods. It focuses on:

- Quantitative approaches at macroeconomic level including input-output models, SAMs and Computable General Equilibrium (CGE) and related models;
- Quantitative approaches at sector level;
- Hybrid approaches; and
- Studies at supranational and European level.

It concludes with an integrative section that synthesises conclusions on quantitative methodologies used in skills anticipation for the transition to the low carbon economy.

Section 5 focuses on the case of the research and evaluation work undertaken by PERI in the US that provided much of the underpinning logic for the green

provisions of the US, the American Recovery and Reinvestment Act (ARRA) stimulus package.[2] This is a high profile programme of work that has spanned the full range of levels from macro level to making specific findings relevant to provision of education and training. The evaluation work is also useful in that it provides evidence that the PERI methodology, which has much in common with other methodologies reviewed, actually works at the level of modelling employment numbers.

Section 6 addresses data availability in some detail, showing that the basic data requirements for modelling are met by many countries, although the relatively high level of aggregation at which the data are available for some countries may pose challenges.

Section 7 looks at qualitative research from a number of angles. It starts with a review of research that is purely qualitative. It then looks at the role of qualitative research linked to quantitative research. It then takes a brief look at qualitative research techniques used in researching skills for green jobs.

Section 8 reviews institutional arrangements for skills identification and anticipation. It also highlights a number of examples of public-private partnerships in provision of training programmes in skills for green jobs. Finally, it reviews institutional aspects relating to migration.

Section 9 presents a synthesis of the findings on methods and institutional arrangements for skills anticipation in the transition to the low carbon economy.

Section 10 provides sets out the report's conclusions and recommendations.

[2] American Recovery and Reinvestment Act of 2009.

Section 2

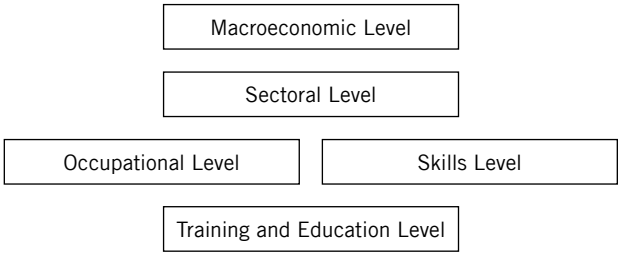
Skills for the Low Carbon Economy: Mapping the Analytic Territory

2.1 Introduction

The scope of types of analysis involved in skills research is wide, ranging in level from researching and modelling the relationship between macroeconomic developments and macro level manpower requirements to understanding the practical training implications of developments arising from organisational or technological change in a particular narrow type of business.

It is characteristic of skills research that it crosses these levels, connecting macroeconomic analysis to sectoral analysis, connecting sectoral analysis to occupational and skills analysis, and connecting occupational and skills analysis to consideration of training and education requirements and how they can be met (see figure 2.1). However, most individual skills research projects do not cover all of these levels, or at least do not do so in detail.

Figure 2.1. Levels of analysis in skills research



The policy literature on research into the skills implications of the transition to the low carbon economy spans all of these levels. The level (or levels) on which individual research projects focus varies depending on the research questions posed, and on other factors that may include data availability and the resources available to the project.

These levels are equally applicable to national, supranational and subnational or regional analysis. Each of these levels can be analysed in both macroeconomic and sectoral terms provided that suitable data are available. The macroeconomic level of analysis is less likely to be accessible or relevant to a study focused on a locality, both because official data are unlikely to be available at that level, and because the operation of local supply chains and local induced employment effects can be addressed through sectoral research if necessary.

Questions about the overall employment impact of the transition to the low carbon economy inevitably require macroeconomic analysis to explore issues such as the impact of green stimulus spending, the impact of changes in relative prices arising from taxation of carbon, or the impact of energy related subsidies or mandates.

Questions about the employment impact of specific measures, whether at sector level or across the economy, also require analysis beyond the sector level to identify wider employment effects through the supply chains of businesses in the sector (indirect employment) and through the wider effects of consumer spending by those employed in businesses in the sector and in their supply chains (induced employment).

Most questions about the transition to the low carbon economy require significant research at sector level, although the focus and scope of the research vary depending on the question. Sector level changes, such as growth in employment in renewable energy industries, the growth of industries providing services and goods for energy efficiency and loss of employment in carbon intensive activities such as coal mining and traditional coal-fired generation of electricity, are important features of the transition to the low carbon economy. Even research focused at the most macro level must model the most significant effects of these changes, and therefore must encapsulate an informed view as to what the changes will be in terms of quantitative indicators and qualitative interpretation meaningful to macroeconomic analysis.

Research on skills uses different types of indicator to describe what the skills required actually are, and this is as true for research into the transition to the low carbon economy as for other areas of focus.

- Some primarily quantitative research reports just on occupations, using standard occupational classifications, without any description of the skills associated with

each occupation. As information on actual levels of qualification in the labour force may be available from the same source (e.g. from a labour force survey), the occupational data may be supplemented with a profile on levels of qualification.

Quantitative research of this sort can be undertaken at a range of levels, varying between focusing on small numbers of highly aggregated groupings of occupations, and disaggregated levels of classification such as 3- or 4-digit International Standard Classification of Occupations (ISCO) codes.

- Some research describes key types of job in the domain of interest, focusing on occupational structures as they appear from qualitative research. While some of this research is undertaken at a relatively high level of aggregation, some is also done with a view to identifying specific occupations and describing them in detail. This work may be undertaken to develop detailed skills profiles to form the basis for designing new courses, or for redesigning existing ones. Some, also, is used to develop skills profiles that are used in other ways by human resource managers, providers of education and training and qualifications authorities.

- Some research bridges these two approaches, using standard occupational classifications where feasible, and categories based on qualitative research where the standard classifications do not fit well. The research provides specific information on the skills required in each occupational category, but may not go so far as to develop detailed skills profiles. Research of this sort plays an important role in identifying skills in occupations that are specific to the domain under investigation, and may be absent, or present in a different form, under other contexts. It can also play an important role in identifying emerging occupations that may be sufficiently significant to be included in future revisions of occupational classifications, and in identifying changes in the content of occupations that may be required to revise occupational definitions.

Where the main research question is about requirements for training and education, this usually implies substantial research into occupations and skills in the sector, whether in skills for the low carbon economy or in other domains. The research may be purely qualitative if the question is just about the skills content of the job, quantitative if the main question is about numbers needed, or combine both. A mainly quantitative focus is more feasible for researchers in contexts where the course providers that will use their results are close to industry, and have well developed course development processes to give them direct access to the qualitative information they need for course design. The institutional set-up is therefore crucial for the selection of the right methodological approach.

Emerging requirements for some low carbon economy skills are cross-sectoral, with demand for skills in energy management, for example, now becoming common across sectors. While it is possible to undertake useful qualitative research into such occupations for some purposes without detailed consideration of employment sectors, even in this area quantitative occupational research generally disaggregates numbers employed by sector, either for consistency with other research, or so as to correct for biases in survey results.

2.2 Skills questions

There is no single research approach that fits all of the major skills questions about the transition to the low carbon economy. There are a number of major types of question that arise, whether at local, regional, national or supranational level. Each of these questions may be posed at the level of the whole economy in the geography addressed, or at the level of specific sectors.
The key questions are as follows (see also figure 2.2).

- How many jobs are involved, now and into the future? This question is relevant to areas of job growth, areas of job loss, and areas where net changes in employment are likely to be minimal.
- What skills are required, now and into the future?
- What training and education is required, now and into the future?

Figure 2.2. Overview of major questions in research into skills for transition to the low carbon economy

		Whole Economy	Sector
How many jobs?	Quantitative – Direct		
	Quantitative – Indirect		
	Quantitative – Induced		
Occupations? Skills?	Quantitative		
	Qualitative		
Training and education?	Quantitative		
	Qualitative		

How many jobs are involved, now and into the future?

In general, this is posed at up to three levels – direct employment, indirect employment and induced employment. All three are relevant where the main policy interest is in measuring the overall employment impact of the transition to the low carbon economy on employment, although the complexities and greater effort involved in producing a well founded estimate of induced employment may persuade policymakers that they can settle for measures of direct and indirect employment.

What skills and occupations are required, now and into the future?

This question has both quantitative and qualitative aspects, and for most purposes relating to the transition to the low carbon economy, a good answer requires both. The right balance between the two varies, however.

- **Changing need for existing occupations:** For some areas of skill, the requirement is for people in a well defined existing occupation, often with some specialized knowledge relevant to implementing the transition. In these cases, the primary question is quantitative – how many are needed?
- **Changing occupations:** For some areas, the requirement is for people who fit quite well into one or more existing occupational classifications, but who require a skill set that differs significantly from that of people doing more traditional work in those occupations. For example, in some countries solar water heating installation is a growing area of work, which overlaps substantially with plumbing, but which differs in the specifics of its core skills requirements. In these cases, both quantitative and qualitative questions are important.
- **Newly emerging occupations:** For some area of skill, the requirement is for people with new skills in types of role that amount to new occupations, at least for purposes of the research. Examples include energy management and carbon accounting. In these cases, good qualitative research is highly important, although it is best if some effort is made to quantify the requirement too.
- **New skill needs across occupations**: In some areas of skill, the requirement is to supplement existing skills within existing occupations. Examples might include economics of sustainable transport for road engineers, carbon

management for operations managers, or balancing heating systems[3] for plumbers and heating engineers. In these cases, good qualitative research is key. If new skills requirements in the relevant area can be built into existing initial education and into existing systems of continuing education and training, there may never be a need at policy level to quantify the numbers requiring skills development.

As it is challenging for a single piece of research to simultaneously achieve the right balance for all of these, it is important that researchers and commissioners of research should explicitly consider what their priorities are at the research design stage.

The nature and scope of the research is likely to be different depending on whether the focus is at the level of a sector or the whole economy. While a large part of the research will be at sectoral level in either case, skills and activities relevant to the transition to the low carbon economy exist in so many sectors that research focused on the whole economy is unlikely to be capable of addressing each one as deeply as in a typical skills sectoral study.

In analyzing the whole economy through sectoral perspectives, there is a risk that the skills requirements of government and public administration will be missed. Qualitative research focused at the whole economy level should seek to capture this.

What training and education is required, now and into the future?

Again, this question has both quantitative and qualitative aspects, and again the right balance between the two varies. To a great extent, the right balance varies along the same lines as for identifying skills; the most important policy reason to identify skills is to trigger and inform responses through education and training.

More than for the question on skills, however, the right balance depends on the institutional arrangements within the country.

The information needed from skills research varies depending on the institutional arrangements for course design and development. Where there are well developed arrangements for ongoing development of courses in place, it may only be necessary for skills research to provide broad guidance about the changes underway, what the emerging skills requirements are and how many are likely

[3] A well balanced central heating system can be significantly more efficient than one that is poorly balanced. Balancing to a high standard requires specialist skills.

to be required. Where existing processes for course development are not as well developed as these, or where there is a desire to share courses and qualifications across a wider range of providers than in the past, there may be a need for skills research to provide very detailed guidance.

2.3 Defining and measuring "green jobs"

The ILO and the United Nations Environmental Program (UNEP) have broadly defined (a working definition) a green job as any decent job[4] that contributes to preserving or restoring the quality of the environment whether it is in agriculture, industry, services or administration (ILO/UNEP et al, 2008). This broad coverage encompasses any job that is greener, but poses a problem for measuring and monitoring. It leaves many governments with a challenge of how to define and classify sectors producing green goods and services, categorize green occupations and to identify the relevant competencies needed to perform the duties of green jobs. A statistically oriented approach is required in order to make objective and evidence based policy decisions. Forecasting labour-market skill needs is not possible without a clear definition of the economic activities and occupations which establish the boundaries of what is to be measured.

The problems faced in developing effective statistics are well captured in the efforts being undertaken in various official agencies and independent research projects to define and measure "green jobs" (Strietska-Ilina, *et al*. 2011). The serious problems one inevitably encounters in such an effort include the following:

1. *Identifying green activities vs. employment within these activities*. We could, for example, unequivocally define the manufacturing of solar panels as a "green activity." However, are all the jobs tied to that manufacturing activity "green jobs?" For example, does an accountant employed by that firm hold a green job? Would the accountant still hold a green job if she works for an independent accounting firm, and the solar manufacturing firm subcontracts out its accounting work?

2. *Divided work week*. Does a truck driver have a green job if, for example, he works 10 hours a week delivering solar panels and 30 hours a week delivering pipes for an oil refinery?

[4] Decent jobs meet requirements of decent work – adequate wages, safe conditions, workers rights, social dialogue and social protection.

3. *Indirect and induced jobs.* If an architect works on buildings that are highly energy efficient, say, 60 per cent of his/her time, we would likely consider that person as having a green job. But what about the businesses that supply the architectural firm with paper, pencils, and computers? They would not normally be considered as green jobs. On the other hand, in measuring the induced and indirect effects of green investment activities, these categories of employment would get counted as among those influenced by green investment activities.
4. *Dividing economy into green vs. non-green sectors.* Over the next generation, it is imperative that we undertake a massive transformation from fossil-fuel based to clean-energy based economies. This is a process that will engage all sectors of the economy. It is therefore more appropriate to conceptualize this transformation as engaging all sectors of the economy, at least to some degree, just as, to some degree, all sectors of the economy are presently connected to the fossil fuel economy. The divisions between green- and non-green jobs are thus not only difficult to establish within a static framework at present. It will become increasingly difficult to sustain any given definition over time, as clean energy technologies emerge and become more integrated into the overall functioning of the economy.
5. *Skill requirements for green vs. non-green employment*. Here again, conceptualizing the issue this way creates false dichotomies. In fact, for the most part, the people working on green investment projects will be engaged in activities that will very closely resemble the types of jobs they had done within the fossil fuel economy. The suggestion that a "green job" is sharply distinct from other types of employment conveys the idea that the problems of skill requirements and matching workers to new opportunities are more difficult than they are likely to be in practice. This is something we take up later in this report.

In addition, unfortunately, when attempts are made to operationalize these definitions by using them to define whether specific jobs are green, it turns out that this often leads to substantial differences in how green jobs are defined within research.

- There are substantial differences in coverage between definitions, so there is considerable scope for research based on one to be inconsistent with that based on another.
- It is frequently difficult, even with quite full information, to say with certainty whether or not a job meets some green job definitions, so different researchers using the same definition may cover significantly different populations.

- It is only partially feasible to determine reliably which jobs meet green job definitions based on the data on sectors and occupations that are commonly available from national and supranational statistical agencies. In most cases, definitions used in research that draws only on standard statistical sources will not match any of the commonly accepted definitions of green jobs closely.
- The practical meaning of many green jobs definitions depends on the country context, and varies over time. Depending on the country context, a particular type of activity may be viewed as contributing towards reducing carbon output, or may be viewed as a normal activity that does not change anything, and the way in which the activity is viewed may change over time. In some cases, researchers may decide that a particular percentage of jobs associated with an activity should be counted as green, but different researchers are likely to make different choices.
- In many cases, high quality quantitative skills research combines data from standard statistical sources with information from primary research work, or with information drawn from skills sectoral studies addressing green jobs, to bridge the gap between standard statistical definitions and green job definitions. There is considerable scope for researchers to make different choices as to which jobs to include that are fully consistent with the same definition of green jobs.
- While some countries are doing significant work on producing new statistics relevant to green jobs, much of this work is proceeding along different paths, and is not leading towards convergence in definitions.

Many countries maintain national industrial and occupational directories which refer to the International Standard Industrial Classification of Economic Activities (ISIC) and ISCO (or to national or supranational variations on these), but most do not have enough detail in either their industry or occupation classification systems to use available statistics to forecast the number of green jobs and skill requirements. Classification systems must evolve with the economic and technological progress in the world of work in order to increase precision in collecting, analyzing and reporting occupational data. Therefore, ISCO, as well as national classification systems, will need to be adjusted, at the time of periodic reviews, to reflect the greening of occupations and the structural changes foreseen with the green economy, as has already occurred to an extent with the addition of a small number of categories in ISCO-08.

Beginning in Fiscal Year 2010, the US Bureau of Labor Statistics (BLS) began developing and implementing a collection of new data on green jobs. Thus far, the BLS has released its conceptual approach to measuring green jobs in the

US economy. Actual figures based on their initiative are still forthcoming. The BLS itself describes its approach as follows:

BLS is using two approaches to measuring green jobs: (1) the output approach, which identifies establishments that produce green goods and services and counts the associated jobs, and (2) the process approach, which identifies establishments that use environmentally friendly production processes and practices and counts the associated jobs. In the output approach, BLS is concerned with jobs related to producing a specific set of goods and services, and is not concerned with the environmental impact of the production process. The output approach alone, however, would not cover some activities and associated jobs that favorably impact the environment although the product or service produced is itself not "green." The process approach is intended to address this aspect of green jobs. In the process approach, BLS is concerned with whether the business uses practices or technologies that have a favorable impact on the environment, regardless of the good or service produced. The process approach is relevant to any industry. Each approach requires different measurement strategies and will tend to count different jobs, with some overlap in industries that produce green goods and services, (see: http://www.bls.gov/green/).

This project by the BLS is very useful, and will no doubt yield important new information and insights as we attempt to increasingly understand the over project of creating a green economy. At the same time, their approach is subject to the same criticisms raised above about trying to conceptualize the term "green jobs" in general. We should point out that decision-makers are aware of such concerns. It is understood from the research that the BLS is aware of criticisms such as these, and envisages refining its methodology over time.

Eurostat, the statistical office of the EC, formalized a working definition for an "environmental goods and services sector" (EGSS) in 2009, building on the prior OECD/Eurostat definition of 1999. Eurostat's EGSS definition is most similar to the BLS' "output approach" to measuring green jobs, rather than the "process approach." That is, the EGSS is defined by economic activities that produce goods and services purposefully aimed at protecting and managing damage to the environment. This approach circumvents the question of how to define specific green jobs by focusing only on green activities and the employment produced by such activities. Eurostat defines the EGSS to include produces of goods and services that:

1. Measure, control, restore, prevent, treat, minimize, research and sensitize environmental damages to air, water and soil as well as problems related to waste, noise, biodiversity and landscapes. This includes 'cleaner' technologies, goods and services that prevent or minimize pollution.

2. Measure, control, restore, prevent, minimize, research and sensitize resource depletion. This results mainly in resource-efficient technologies, goods and services that minimize the use of natural resources.

In addition, these goods and services "must satisfy the end purpose criterion, i.e. they must have an environmental protection or resource management purpose ... as their prime objective (p. 29)."

Eurostat's definition of the EGSS sector succeeds in providing a consistent and clearly defined way to measure current employment used in activities related to protecting and managing the environment. As a result, European Union member states have a framework for reporting a standardized set of measures of an environmental sector.[5] However, Eurostat's definition of the green sector is relatively broad. For example, the EGSS includes any activity that manages damage to the environment, without regard to whether the activity improves on current practices. As a result, for example, all of waste management services are included in the EGSS. Also, in contrast to this broad sectoral definition, Eurostat uses a relatively narrow definition of which jobs involved in these activities should be counted as part of the green sector. The EGSS includes only jobs in firms that have as their *primary* activity the production of environmental goods and services or intermediate goods and services *primarily used for* final environmental goods and services. As a result, it excludes, "...producers that provide components of an environmental technology or product to the main producer when these components are not to be used exclusively in environmental technologies (p. 39)."

A consequence of this way of defining the green sector is that it does not take account of how dirty an activity is, or whether it is becoming cleaner. It excludes workplaces and jobs involved in greening of production processes and improving efficiency, whether in the EGSS sector itself or across the rest of the economy.

Also in 2009, The Environment Institute of Australia and New Zealand published a government-sponsored study on this same question, *Who are the Green Collar Workers? Defining and Identifying Workers in Sustainability and the Environment*. Like the BLS project, this study produces insights useful for understanding the dynamics of building a green economy. At the same time, also like the BLS project, it faces difficult challenges in coming up with a working definition of "green collar jobs." As the authors of this study state at the outset: "there is no standard definition of the term" green collar jobs. But they then to develop

[5] However, rolling out the collection of EGSS data remains a work in progress. Eurostat currently publishes data from just eight EU countries (plus Norway), and for most of these currently publishes a single year's data. The year in question varies between countries.

one over the course of the study. Similar to the BLS, they offer a "two-part definition," that consists of the following:

1. Managers, professionals and technicians who work in green organizations or who have green skills and responsibilities within other organizations that may not be considered green.

2. Services, clerical, sales and semi-skilled workers who work in green organizations.

While the Australian and New Zealand statistical bureaus should be commended for trying to advance this project of making the green economy measurable, the proposed definition does not unambiguously solve any of the issues that we highlighted above.

Along similar lines, the US Workforce Information Council (WIC), through its Green Jobs Study Group, suggested the following definition of green jobs for inclusion in labour force and related surveys:

A green job is one in which the work is essential to products or services that improve energy efficiency, expand the use of renewable energy, or support environmental sustainability. The job involves work in any of these green economic activities:" renewable energy; alternative fuels; energy efficiency and conservation; pollution, waste and greenhouse gas management, prevention, and reduction; environmental cleanup and remediation; sustainable agriculture; natural resource conservation; education, regulation, public awareness and related services (WIC, 2009, pp. 5-6).

The WIC (2009) report considers issues relating to survey design in recommending the above definition. Specifically, the report stresses that the definition be kept as brief as possible in order to facilitate accurate responses. In addition, the report recommends that a number of illustrative examples are included in the design of the survey instruments.

The WIC study reviews pilot surveys on green jobs conducted in four US states: California, Michigan, Oregon, and Washington. In three cases (California, Michigan and Oregon), information was collected on job titles and duties, skills categories, and the skills specificity of occupations linked to green jobs. This demonstrates that such surveys can be used to gather useful information on skills, even if no precise definition of 'green jobs' is agreed.

Even if these definitional challenges can be overcome, obstacles remain in terms of designing effective surveys. Once the broad definition of 'green jobs,' 'green industries,' or 'green enterprises' has been settled, a sampling strategy must be developed to insure that the survey data is representative and based on a random sample. This creates another difficulty: is enough known about the

population of firms operating in the relevant sectors in order to develop a reasonably accurate sample? Economic censuses, registration records, and similar sources of information can be used to construct a sampling framework. However, these traditional sources of information may not always be sufficiently detailed to distinguish 'green' industries from 'non-green' industries.

With all of these difficulties involved in measuring green jobs, how important is it to be able to do so? From the attention the question receives in the policy literature, and from policymakers, it is apparent that it is of great interest to much of the policy community. Even so, there are significant policy players that take the view that the difficulties involved in establishing a definition that is useful, specific and stable over time risk distracting attention from questions that are both more relevant and easier to answer.

For example, a background paper from the EC for the Belgian Presidency Ministerial Conference on "Promoting Green Employment: a major indispensible driver behind a successful transition towards a low carbon economy"[6]

> "... suggests that less time should be spent defining what a 'green job' is. Efforts should rather focus on proposing and implementing measures to tackle what otherwise could become an enduring shortage of qualified workers for the new 'green' economy."

In expressing this view, the Commission clearly has its priorities right from a skills policy perspective. While clarity on definitions is important to all skills research, it is not possible to make progress if the research gets stuck at the point of choosing a definition. In the context of skills for the transition to a low carbon economy, it is necessary for researchers to accept that there is no single correct definition, and to make a choice that is consistent with the objectives of the research and that preferably minimizes the barriers to collecting, analyzing and interpreting data and other information.

The research on skills reviewed for this report predominantly addresses questions that are narrower and more specific in approach than addressing all green jobs. Focusing on identifying and anticipating employment and occupational and skills needs, and in some cases on the training and education measures required to meet these needs, most skills research studies on the transition to the low carbon economy focus either on:

- Needs associated with anticipated developments in specific sectors, such as renewable energy, building and/or energy intensive industries; or

[6] Brussels, 23 September 2010.

- Needs arising from specific programmes of investment or government current spending associated with the transition to the low carbon economy, such as subsidies for retrofitting homes to improve energy efficiency.

2.4 Conclusions

Skills analysis in the context of the transition to the low carbon economy takes place at four main levels:

- Macroeconomic
- Sectoral
- Occupational and skills
- Training and education

Individual research projects tend to span two or three of these levels. Relatively few span all four.

A wide range of questions are posed by different researchers, concerned both with the present and the future.

- Key types of quantitative question are about numbers of jobs in total, numbers by occupation, and numbers of people trained or educated.
- Key types of qualitative question are about changes in occupations, about specific skill requirements and about types of education and training required.

It is difficult to define green jobs in a way that is satisfactory for all purposes, and as a consequence many competing definitions have been created by different authorities and for different purposes. However, most practical skills policy questions relating to the transition to the low carbon economy are relatively specific, allowing research to be undertaken with no requirement for a single green jobs definition.

Section
3

Data Sources and Definitional Issues

3.1 Introduction

This section addresses data sources and some related definitional issues that arise in research into skills for the low carbon economy under the following headings:

- Labour force surveys
- Enterprise and employer surveys
- Need for clarity in defining and measuring a "job"
- Different employment dynamics in different types of job
- National occupational and skills databases

3.2 Labour force surveys

Labour force surveys are nationally representative household surveys which collect information on employment by industry, occupation, and skill level. Often, they are also representative at sub-national levels, such as at the region/province/state and metropolitan area levels.

Labour force surveys are a centrally important source of data for skills and labour market analysis that are undertaken regularly in most developed countries (quarterly within the European Union), and also at varying intervals in many emerging and developing economies. Despite limitations discussed below, they are a cornerstone of quantitative analysis and modelling of skills and labour markets, both in relation to the transition to the low carbon economy and more generally.

Unlike enterprise surveys (addressed later), labour force surveys collect data by focusing on the supply-side of the labour market. In many cases, labour force surveys collect information on certain aspects of enterprises, but this information will be reported based on the knowledge and perceptions of the workers in the enterprise (or of another member of their household), as opposed to enterprise owners or managers.

Labour force surveys are sample surveys by statistical agencies, used to produce estimates of actual numbers. Because they are sample surveys, the estimates are subject to sampling error, which may be of little concern where the sample size is relatively large and the group of workers of interest is broad. However, it can be a significant issue for narrow groups (such as a specific narrow occupation within a specific narrow sector), particularly where the sample is not large. Where an analysis is subject to acceptable levels of sampling error, adding another criterion, such as gender or age group, to the analysis may raise the level of sampling error on some groups of workers to an unacceptable level.

Labour force surveys can be used to ascertain the formal educational attainment of individuals working in jobs which are considered to be green. In some cases, overall experience and other measurements of skills are available. The unit of analysis is the job or the individual worker, not the enterprise. Given the design of existing labour force surveys, it is hard, if not impossible, to segregate individuals in jobs linked to green economic activities on the basis of information collected in the survey, since the standard industrial and occupational codes used in labour force surveys are often not designed to identify green jobs. Some industrial/occupational categories (e.g. recycling activities) are generally easier to identify than others (e.g. biomass, which is likely to be difficult to distinguish from other agriculture and forestry activities). In addition, as is the case with defining 'green industries,' unambiguously defining a 'green job' can prove to be problematic. For example, restaurants serving organically produced food might be considered to be green, but difficult to identify in labour force surveys.

In principle, existing labour force surveys could be modified to gather information which could be used to identify these types of jobs. Ideally, occupational or industrial codes would be extended to include specific categories of interest. However, there are several concerns that would need to be addressed. Sample sizes may, in some cases, limit the number of detailed categories that can be included in the survey and still retain statistical significance. The number of occupational codes needs to be kept at a manageable level. Moreover, changing international codes is typically a long process subject to demands from many competing objectives.

In the short-run, a labour force survey questionnaire could be extended to specifically identify green jobs. The challenge would be to design new questions

which would allow the accurate identification of green jobs – i.e. 'green jobs' may not mean the same thing to all people. One simple solution would be to define a green job as any employment in a green enterprise. However, in addition to all the challenges associated with defining 'green industries' or 'green enterprises' discussed later, labour force surveys may not always yield the best information on enterprise characteristics, since not all employees may be knowledgeable about the productive activities of the firms in which they work. In addition, most medium and large-scale enterprises have employees performing a range of jobs – some which might be considered 'greener' than others.

Finally, labour force surveys provide information on the supply of skills, particularly the supply of skills for workers currently employed in a particular job. However, by themselves, they cannot provide information on insufficient supply of skills (i.e. jobs left vacant because of a lack of qualified applicants) or anticipated future demand for certain skills. In order to get at these issues, labour force surveys need to be combined with information from enterprise surveys, from estimates generated by economic models or from other skills anticipation techniques. Likewise, labour force surveys will not directly provide information on the job creating potential of increased investment in green industries. At the same time, depending on the questions asked, they may shed light on certain labour supply constraints. For example, do skilled workers in green jobs enjoy similar remuneration to similarly skilled workers in other sectors?

3.3 Enterprise/employer surveys

One of the most direct ways of gathering information on current and future skills demand in clean energy, energy efficiency, and related activities is to ask firms currently operating in these areas to report their current employment levels, human resource requirements, and anticipated needs. Enterprise surveys directly gather information on employment and demand for skills. If the survey is specifically designed to measure skills demand in 'green' industries, the questionnaire can be tailored to collect detailed information on the current workforce and areas in which a perceived skilled shortage may exist. Identifying 'green' enterprises may be more relevant than defining 'green' industries, since some enterprises operating in a given sector may be classified as green while others would not, depending on the character of the firms.

Enterprise surveys (whole enterprise or establishment) represent a potentially important instrument for collecting relevant labour force information. But

a number of challenges also exist. The scope of the survey needs to be defined. Specifically, the population of firms under consideration must be identified. Depending on the research goals, sectoral approaches may be the best way forward. However, if the aim of the survey is to capture all firms engaged in green activities, this requires establishing criteria for identifying these enterprises. There is no single obvious approach to this task.

An alternative to developing a stand-alone survey of employment and skills in industries engaged in various green activities would be to modify existing enterprise surveys so that the appropriate firms can be identified for analysis. This may involve incorporating additional questions into the existing survey questionnaire or, in the longer term, modifying industrial and occupational codes to allow the identification of enterprises operating in the activities of interest.[7] This is the approach being pursued by the BLS. Given the expense of administering large-scale, representative surveys, this approach may be able to collect information through employer surveys at a lower cost than a dedicated survey – as long as national statistical offices are able and willing to modify their existing surveys to take these issues into account.

There are a few drawbacks with relying on direct survey data from enterprises. The information on employment and skills will refer to direct employment only – that is, the employees at a specific firm. As we have emphasized above, the full economic impact of green investments is much broader than that which can be attributed directly to the firms identified. In order to develop an assessment of the broader employment and labour market effects, the enterprise survey information would have to be combined with a more complete economic impact assessment along the lines described in the previous section on economic models.

An example of the use of a national-level targeted employer survey that follows a random sampling strategy is a report by ISTAS (Instituto Sindical de Trabajo Ambiente y Salud), *Renewable Energies and Employment Generation in Spain: Present and Future*. In this study, 1,027 companies were identified and a sample based on 422 of these companies was gathered using telephone surveys. This survey avoids the problem of defining the category of 'green jobs' by restricting its attention to the renewable energy industry in Spain. The survey results were used to estimate direct employment and to assess expectations for future employment growth. These results were linked to estimates of future energy supply and demand in order to develop various scenarios for future job creation. Training needs, as reported by employers, were also identified using the survey data.

[7] The report, Measuring Green Collar Jobs in British Columbia, discusses at some length the limitations of existing industry and occupational classifications used by Statistics Canada with regard to estimating the number of 'green jobs' (BC Stats, 2010).

Enterprise or establishment surveys are most promising compared to household surveys, for example, for the following reasons:

- Many household respondents will not be able to answer questions on the work of others in their home, or even on their own employment, in sufficient detail and with sufficient reliability.
- Changing systems of classification will take a long time, and even when it does there will be limits to how much they can be reshaped to meet data needs on the transition to the low carbon economy while still servicing important existing needs, and avoiding placing unsustainable demands on the statistical agencies responsible for implementing them.
- The scope to benefit from coding household surveys at a greater level of resolution is limited. Labour force surveys are the main type of household survey used for labour market analysis, but the fact that they are sample surveys means that there are limits to how far the results can be disaggregated meaningfully. For many countries, this means that there is little to be gained from coding at a greater level of detail.

Most countries with well established statistical systems undertake large scale surveys of business establishments, at least annually, either across all sectors, or split in some way, such as between industry and services. Many have more than one of these surveys, with a major enquiry requiring considerable detail and more frequent returns to be made on topics such as numbers employed and earnings.

In many cases, a threshold is set for the minimum size of businesses to be covered by a survey, often in terms of the number of employees.

In addition to large scale business surveys, many countries run periodic sample surveys of establishments, either independently or in coordination with other countries. Many of the surveys run on cycles of more than a year. Examples include surveys on R&D personnel and expenditure based on the OECD's Frascati manual and the EU's Continuing Vocational Training Survey and Community Innovation Survey.

In addition, it is common for one-off business establishment and enterprise surveys to be undertaken for policy purposes, sometimes by the national statistical service, but more frequently by policy and research organizations.

This suggests four feasible approaches to surveying business establishments with questions relevant to skills for green jobs.

- Permanently adding a small number of questions to a regular large scale survey. This could be as limited in extent as a question designed to identify

whether the business establishment should be counted as "green", and another question designed to categorize what sort of green organization it is.

- Adding a more extensive module to an existing large scale survey once-off, or perhaps on a cycle of once every 1, 2 or 3 years.
- Creating a new sample survey to be conducted periodically, perhaps every three years.
- Undertaking a one-off policy-focused sample survey, that can be repeated if circumstances warrant.

For most countries, the first of these would be more relevant to general green economy research than to skills research, as most large scale enterprise surveys do not include extensive questions on skills and occupations. Even so, generating accurate and fine-grained data on the green economy would make an important contribution to sectoral aspects of skills analysis.

From the perspective of a skills researcher, the second could be the most attractive, potentially generating detailed occupational and skills data linked to a fine-grained sectoral analysis. The biggest potential problem is that existing surveys generally already strike a balance between the amount of information sought and the amount of effort required on the part of respondents to provide it. Adding a module may upset that balance, leading to greater difficulty in obtaining full responses, a greater workload on businesses, and a need for greater effort from the surveying organization to obtain an acceptable level and quality of response. The greater the amount of additional information sought, the more the existing balance is likely to be upset.

The third, a new sample survey focused on green jobs, would also potentially be of great value to skills researchers. Its value could be broadened by also focusing on other aspects of the green economy, in the same way that R&D surveys following the OECD's Frascati Manual focus both on people and on business spending on R&D. While the sample nature of the survey will make the results less fine-grained than with a large scale survey, this could in principle be balanced through sample design, with high sampling rates among sectors, or segments of sectors, that are of particular policy interest.

A key issue is that a new survey such as this will require a substantial investment of resources by a statistical agency. Another consideration is that there is a question over how useful such a survey will be over time. It is possible that the survey might have to undergo significant redesign for each iteration, in order to keep up with change in what represents carbon-saving activity. It is also possible that policy interest in the area will decrease as progress towards the low carbon

economy becomes more routine, reducing the scope of current skills issues. These factors could make those responsible for prioritizing the work of statistical agencies more reluctant to build a survey such as this into their plans.

The fourth, a one-off policy-focused survey undertaken by a policy or research organization has the advantage that undertaking it is largely just a matter of designing it, and paying a research organization to do it, without any longer term implications for the country's statistical system. It may also be easier to include qualitative questions than with an official statistical enquiry. It has the disadvantages that the conduct of the work will not be as well tied into the country's statistical system, and may not be as comparable with official statistics as with a survey undertaken by the national statistical organization. Depending on how it is resourced, it may be a relatively high cost approach.

The discussion above has addressed enterprise surveys in the context of the transition to the low carbon economy in general terms. The report addresses them again later as one of the types of research methodology available to researchers considering how to tackle a specific research question.

3.4 National occupational and skills databases

In some countries, national governments maintain systems to assess the skills required to perform detailed occupations. That is, databases are maintained which provide skills and occupational profiles linked to specific activities. Such information can be combined with quantitative estimates of changes in employment in order to shed light on the skills requirements associated with a green transition. Strietska-Ilina, et al. (2011) highlight some examples in which these systems have begun to track occupations associated with green activities:

1. O*NET – a US on-line database of occupational requirements linked to specific economic activities
2. Taxonomy of occupations in Australia
3. Upgrading classifications of occupations in Poland
4. Observatory of Occupations (Spain)

Many other countries have similar activities in place, either as independent observatories for green skills or as areas of focus within the activities of bodies that have a wider skills observatory function. These could become an important source of information on occupational and skills requirements linked to the greening of economies in the future.

*O*NET in the US*

Research has been conducted on the impact of green economy activities and technologies on occupational requirements. The US Department of Labor has sponsored the report "**Greening of the World of Work: Implications for O*NET-SOC and New and Emerging Occupations**" (O*NET, 2009). Results of the research led to the identification of green economic sectors, green increased demand occupations, green enhanced skills occupations, and green new and emerging occupations. These occupations are now reflected in the O*NET-SOC system.

- **Green sectors:** Renewable energy generation; Transportation; Energy efficiency; Green construction; Energy trading; Energy and carbon capture and storage; Research, design and consulting services; Environment protection; Agriculture and forestry; Manufacturing; Recycling and waste reduction; Governmental and regulatory administration.
- **Green occupations:** The research has been conducted at the occupation level. Because green economy activities and technologies may have different effects on different occupations, O*NET believes a focus on the **"greening" of occupations** is a useful approach to studying the green economy.

Following these definitions, they developed three general occupational categories, each describing different consequences of green economy activities and technologies on occupational performance.

- **Green Increased Demand Occupations**: The impact of green economy activities and technologies is an increase in the employment demand for an existing occupation. However, this impact does not entail significant changes in the work and worker requirements of the occupation. The work context may change, but the tasks themselves do not. A total of 64 occupations were indentified in this category.
- **Green Enhanced Skills Occupations:** The impact of green economy activities and technologies results in a significant change to the work and worker requirements of an existing O*NET-SOC occupation. This impact may or may not result in an increase in employment demand for the occupation. The essential purposes of the occupation remain the same, but tasks, skills, knowledge, and external elements, such as credentials, have been altered. A total of 60 occupations were indentified in this category.
- **Green New and Emerging Occupations:** The impact of green economy activities and technologies is sufficient to create the need for unique work and

worker requirements, which results in the generation of a new occupation relative to the O*NET taxonomy. This new occupation could be entirely novel or "born" from an existing occupation. A total of 45 O*NET-SOC new and emerging occupations previously identified through research on in-demand industry clusters were found to qualify as Green new and emerging occupations, and 46 candidate new and emerging occupations in the green economy were found to qualify as Green new and emerging occupations.

Methodology – The major steps and activities of the process to determine occupations identified in the report as undergoing greening were to: locate and review existing literature; identify and compile job titles; review and sort collected job titles; cluster them; determine overlap with O*NET occupations; identify potential green economy occupations; build and consolidate evidence for final determination; and compile and report evidence.

Taxonomy of occupations in Australia

The Government of New South Wales in Australia supported research in order to commence the process in Australasia on defining green jobs and developing a way to measure them[8] (Ehmcke et al., 2009). They defined green collar workers to be:

- Managers, professionals and technicians who work in green organizations or who have green skills and responsibilities within other organizations that may not be considered green.
- Services, clerical, sales and semi-skilled workers who work in green organizations.

Based on existing national classification systems used by the Australian Bureau of Statistics and Statistics New Zealand, they believe that any green collar job can be coded in occupational (ANZSCO), industry (ANZSIC), and skill (vocational education and training (VET) Certificate I to university degree) classifications, and distinctions between the environmental and/or sustainable nature of 'green' work can be introduced.

The elements of this taxonomy are given in Figure 3.1, and could be extended to other industry and occupational classification schemes.

[8] Region covers Australia, New Zealand and some Pacific Islands.

Figure 3.1. Proposed Australian taxonomy

Environmental/Sustainable

E Mostly environmental
ES Both environmental and sustainable
S Mostly sustainable

Occupation

1 Managers
2 Professionals
3 Technicians and trades workers
4 Community and personal service workers
5 Clerical and administrative workers
6 Sales workers
7 Machinery operators and drivers
8 Labourers

Level of qualification

1 Degree
2 Diploma
3 Certificate III with experience or Certificate IV
4 Certificate II or III
5 Certificate I or Semi-skilled

Sector

A Agriculture, Forestry and Fishing
B Mining
C Manufacturing
D Electricity, Gas, Water and Waste Services
E Construction
F Wholesale Trade
G Retail Trade
H Accommodation and Food Services
I Transport, Postal and Warehousing
J Information, Media and Communications
K Financial and Insurance Services
L Rental, Hiring and Real Estate Services
M Professional, Scientific and Technical Services
N Administrative and Support Services
O Public Administration and Safety
P Education and Training
Q Health Care and Social Assistance
R Arts and Recreation Services
S Other Services

Source: Ehmcke et al. (2009).

Note: An electrical engineer with a university degree working for a power utility on green policy issues, for example, would be classified as "S31D" (predominantly sustainable = S [whereas jobs classified as predominantly environmental = E and jobs classified as both environmental and sustainable = ES], ANZSCO Occupation = 3, ANZSCO Skill Level = 1, ANZSIC Electricity Industry = D). (Rafferty, M. et al., 2010).

Upgrading classification of occupations in Poland

Poland has introduced new occupations into its occupational classification system to adapt to the greening of occupations. National authorities frequently adapt international standard occupational classification systems to meet their own specific needs. In this case, ISCO-08 was adapted for use by the Polish Public Employment Service by adding a number of occupations. The Public Employment Service uses

the occupational classification system in job matching, and in identifying skills shortages and surplus and deficit occupations. The classification system "also serves as a tool for vocational guidance and preparation of training and retraining programmes for the unemployed". Introducing new occupations and specialisations into the classification system allows more targeted actions and labour market interventions by the Public Employment Service. (Sienkiewicz, 2009). Table 3.1 provides some examples of the new occupations that were proposed as of 2009.

Table 3.1. Example of new entries of green occupations in the classification of occupations and specializations in Poland

Occupations requiring higher education	
Environmental auditor	Responsible for issuing opinions on the environmental influence of investments and proposing solutions minimising their negative consequences
Mechanical engineer – heat-mechanical equipment, installations and energy transfer grids	Engineer responsible for projects involving energy equipment within the framework of sustainable energy
Occupations requiring secondary education	
Energy technician	Existing classification, but new tasks have emerged in the classification relating to renewable energy
Ecology educator	Conducts classes on ecology
Occupations requiring basic vocational education	
Organic food producer	A newly introduced specialization for farmers
Renewable energy equipment technician	Installs, starts and services sustainable energy appliances

Source: European Employment Observatory Review: The Employment Dimension of Economy Greening in Poland (Sienkiewicz, 2009).

Experience of the Observatory of Occupations in Spain

Identification of occupations in the Green Sector of Spain's economy has been an ongoing process since 2002, when the Ministry of Labour produced an initial study to extend environmental occupations in the National Occupations Classification of the Public Employment Services. In 2006, the Ministry (MTAS, 2006) followed up with more specific research using the definition of EGSS by the OECD (OECD, 1999) as a starting point. They determined that some of the

green jobs were already part of their classification system while a few others were not. This project made recommendations to create new occupations, and divide some existing occupations into more detailed occupations.

The Observatory of Occupations under the Spanish Public Employment Services conducted further research in 2008 (National Public Employment Service Occupational Observatory, 2008). The methodology consisted of a literature review of previous studies on environmental occupations, analysis of existing data and sent questionnaires to key informants (including companies) and held in depth interviews. Their qualitative research revealed 82 occupational profiles in the environmental sector.

The outline of each occupation profile was as follows:

- Brief description of the occupation;
- Sector of activity where the occupation belong to;
- Skills relevant for the occupation;
- Educational profile with levels of qualification;
- A list of technologies, innovation and tools related to the occupation;
- Regulation framework;
- Employment perspectives; and
- Observations from experts.

Occupational observatories, sectoral skills councils and other approaches

Some other national level initiatives include:

- France: L'observatoire national des emplois et métiers de l'économie verte has been established to function as a skills observatory focused on skills for green jobs for France.
- Ireland: In Ireland, skills needs are analysed by the Expert Group on Future Skills Needs (EGFSN) across all sectors, with quantitative support from the Skills and Labour Market Research Unit of the National Training and Employment Authority. EGFSN has reported on the Future Skills Needs of Enterprise within the Green Economy in Ireland.

In addition, many countries have decentralised systems for occupational analysis, forming part of sectoral or regional skills councils, in some cases with both

present simultaneously. Examples include the UK, France and Australia. Some of these undertake activities focused on skills for green jobs. In many cases, the work is relatively low profile, forming a part of the organization's ongoing work to keep occupational profiles up to date and guide training provision.
Examples include the following:

- In the UK, the Construction Skills UK and the Construction Industry Council have updated National Occupational Standards, and have set out Recommended Qualification Structures for a range of occupations related to green building and energy efficiency at both technical and professional levels.
- In Australia, restructuring of the agrifood sector in the context of bioenergy is addressed through Agrifood Skills Australia, one of the country's 11 Industry Skills Councils. It assesses demand for and supply of skills and subsequently reviews the units of competency, the training packages required and the corresponding qualifications.

Conclusions

The four country examples reviewed provide examples of the ways in which countries have reviewed their existing statistical outputs, and have adapted (or considered adapting) them to provide more information on green jobs.

- The main innovation in the proposed Australian approach is to add an extra data field to the coding of each job. In addition to sector, occupation and level of qualification (which are, for example) recorded in most labour force surveys anyway, a green collar job can be given one of three codes. These distinguish between environmental jobs concerned with physical processes and sustainable jobs concerned with more generalised processes, policies or attitudes.

  In practice, it appears that this would mean adding a single question to an existing survey, without having to change other elements of the survey. The particular example in this approach would be most suited to a labour force survey or a census of population, but it is reasonable to think that a similar question could be asked in an enterprise survey to identify enterprises or local units that should be counted as green.

  In an existing enterprise survey that asks about the occupational profile of employees, the responding enterprise could be asked to distinguish between those with green roles and those not in green roles, although this would add significantly to the workload imposed on the enterprise.

As this is an approach that does not rely on changing existing coding systems or creating additional surveys, it is one that could be implemented with relatively little difficulty, either once-off or on an ongoing basis by any country if policymakers decided the information was sufficiently important.

It could be implemented in those developing and emerging economies that undertake labour force surveys or enterprise surveys.

It could be implemented in a coordinated way within the European Union through the labour force survey once-off using existing "special module" arrangements if it was felt to be sufficiently important to fit into the crowded schedule, or even on an ongoing basis.

- The approaches from the US, Poland and Spain all include creating new occupational classifications. This may be justifiable at the level of an individual country, but it will be difficult to implement more widely. It is likely that a list of green jobs to include as occupations that would be satisfactory for all countries would be rather long, increasing the complexity of occupational coding and substantially reshaping the existing system of classification. Moreover, ISCO, which is usually revised only once every 20 years, was last revised in 2008 and there is little scope for another revision soon. Even if a revision was underway, competing objectives would limit the extent to which the revision could respond to the current policy focus on green jobs.

- The Spanish and US approaches both involve identifying a list of green job types, and profiling these jobs. This makes an important contribution to informing policy, as indeed do other approaches to skills research. However, this specific type of skills research initiative is particularly useful as the basis for communicating information on green jobs and related skills and occupations to people making career decisions and to providers of education and training.

From the O*NET web site:

> "Welcome to your tool for career exploration and job analysis! O*NET OnLine has detailed descriptions of the world of work for use by job seekers, workforce development and HR professionals, students, researchers, and more!"

In overview, while the work on national occupational and skills databases described makes a useful contribution to understanding skills required for the transition to the low carbon economy, other countries have undertaken a considerable amount of research into skills for green jobs that addresses much the same end objectives. Two of the practices described have obvious potential to be adapted for wider use.

- Adding an extra question to identify green jobs to existing labour force and/or enterprise surveys to identify green jobs and green occupations could produce very useful statistical information without a large overhead, either once-off or on an ongoing basis. As almost all developed countries and many emerging and developing economies undertake labour force surveys with varying degrees of regularity, this could be applied widely.
- The O*NET approach usefully turns skills research on green jobs into job market information for job seekers, students, HR professionals and others. Other countries might wish to emulate the whole process, or adapt information from it and from other providers of information on green job careers (such as RES Compass on renewable energy).[9] Adapting existing information could be particularly relevant where countries cannot justify the resources required to do this work themselves.

3.5 Need for clarity in defining and measuring a "job"

From reviewing both the research and the wider policy literature on employment linked to the low carbon economy it is apparent that in many cases there is a need for greater precision and clarity about what is meant by "a job" as a unit of measurement when reporting on the results. In some cases, the need for greater precision and clarity may extend into the conduct of research too, although it is mostly not possible to be certain about this just from reviewing published findings. The need for clarity has a number of dimensions.

- The issue of whether or not a job is "green" was addressed earlier. However, because there are different definitions that make different choices as to what to include, and vary in the extent to which they are clear, precise and unambiguous, it is important that there should be clarity about which definition is being used.
- Many green job definitions do not align well with the standard sector and occupation definitions used by statistical agencies that are the source of much of the quantitative data used in skills analysis. This adds practical complexity to defining what a job means quantitatively. As many research projects must rely on sector and occupation data prepared by national statistical agencies using standard definitions, clarity about how this data is reworked to estimate

[9] RES Compass is an initiative funded by the EC Intelligent Energy Europe programme. It has a web site (http://www.rescompass.org) and book in several languages that provide guidance on jobs in renewable energy.

green job numbers is required. If difficulties with fitting official data prepared using standard classifications are addressed by undertaking original survey work based on other sector and occupation classifications, clarity about the definitions behind these classifications is necessary.

- Measures of job totals associated with the transition to the low carbon economy are generally based either on job-years or on the total numbers employed at specific times. For example, 1,000 job-years could amount to one year's work for a thousand people or ten years' work for a hundred people. Findings about the numbers employed at a specific time may be presented as a chart or table specifying employment by year.

  Some researchers construct slightly different measures based on these to help communicate their results, such as:

  - averaging job numbers over a number of specified years;
  - focusing on either peak employment, or the terminal employment at the end of the forecast period; or
  - talking about "sustained jobs", which can mean anything from a measure of the jobs that will be sustained once a project is past the start-up phase to (in at least one case) the number of job-years divided by 5.

  In addition, there are cases where researchers focus on the number of jobs created, without reference to their lifespan.

  There is a need for clarity within research, and in reporting on research, as to the definition being used.

- The most straightforward dimension to the need for clarity, because it is a standard issue in measurement of employment, is that of how to measure part time jobs. Options include counting full-time equivalents (FTEs), counting full time and part time separately or including each job in the total whether full time or part time. Related issues are how many hours a week are required for a job to be considered full time, and whether people working more than one job are counted more than once. As different approaches to modelling favour the use of different definitions (some tend to favour FTEs, and others favour using some measure of actual job numbers), it is not surprising that this divergence would exist.

- A closely related issue that arises specifically in measuring jobs associated with the low carbon economy is that some people work part of the time at work that can be considered to be associated with the low carbon economy and part of their time at work that cannot. For example, a planning consultant may spend part of their time on work associated with installing renewable energy

installations such as wind farms, and part on obtaining permission for commercial premises with no distinguishing low carbon characteristics. A driver may average two days a week delivering to businesses working on the transition to a low carbon economy, and three days to businesses that have no distinctive involvement in the transition. Much the same questions about how to count arise as with part time work.

- An area where there is a need for clarity in presenting job totals relating to the transition to the low carbon economy is whether the total refers to direct employment alone, to direct plus indirect employment, or to direct plus indirect plus induced employment. There is an interest among policymakers not just in the specific skills required for the transition to the low carbon economy, but also in the wider contribution that the transition can make to recovery in employment levels following the global crisis that started in 2007. Sectoral surveys may capture the parts of indirect employment most directly associated with green activities (e.g. planning consultants), but not indirect employment in services required by any business, such as financial auditing. Again, there is a need for clarity in these areas.
- While estimates of induced employment ideally come from macroeconomic modelling, there are cases where policy reports rely instead on a simple multiplier on direct employment. There are also cases where a total for indirect plus induced employment is calculated in this way. Where this approach is taken, there is a need for clarity about what the multiplier is, and broadly what evidence exists that it is reasonable.

The complexities in measuring job numbers in the transition to the low carbon economy:

- Present researchers with significant pitfalls;
- Make effective and accurate communication of results challenging; and
- Cause difficulties in comparing results.

In addition, complexities in measuring job numbers risk distorting perceptions as to the relative merits of different types of initiative among users of the information. For example, initiatives favouring measurement in job-years or featuring high peak employment, which can be reported as generating high job numbers, may appear preferable to initiatives generating stable employment numbers that will tend to be reported as the stable total. As an example, an initiative that generates 10,000 jobs lasting two years may be reported as generating 20,000 jobs

(based on job-years), while an initiative generating 5,000 jobs likely to last 20 years is likely to be reported as generating 5,000 jobs, without reference to the expectation that it will generate 100,000 job-years of employment. The 5,000 job initiative generates ten times as much employment over its lifetime as the 10,000 job project, but may appear from reporting to generate a quarter of the employment. To address these issues:

- It is important that researchers should offer a clear definition of the units in which their measurements of jobs are stated; and
- It is important that researchers should present their results in a way that can be compared with results from other researchers, preferably in job-years, in employment in each year over the projection period, or in an average over a stated period, and even better in some combination of these if feasible.

3.6 Different employment dynamics for different types of job

Different types of employment in the transition to the low carbon economy have different dynamics, and it is desirable for researchers to take account of this in modelling and measuring employment where these dynamics have the potential to affect employment outcomes. Their relative significance may seem different depending on the approach to measurement chosen, with measures focused on the short term yielding comparisons different to measures focused on the longer term. To illustrate this, it is useful to highlight three types of job. These types do not account for all employment linked to the low carbon economy, but each accounts for a significant share.
The three types of job are:

1. Jobs associated with operating and managing in the low carbon economy, including jobs related to operating, maintaining and managing technologies for the low carbon economy and jobs associated with production of biomass for renewable energy.
2. Jobs in manufacturing and services associated with producing and distributing technologies for the low carbon economy.
3. Jobs associated with the installation of technologies for the low carbon economy.

The quantitative analysis in most policy research reports on jobs in renewable energy classifies employment according to typologies similar to this, and

incorporates differences in the dynamics of employment between types of job in models. However, the typology also fits a wider range of sectors. Furthermore, the dynamics of many types of job from outside the typology are likely to be similar to those within it. Some are likely to grow gradually in number over time, as the low carbon economy becomes established. Some are likely to reflect international demand for technologies associated with the transition to the low carbon economy, initially growing, and behaving much as any other investment goods industry as demand matures. Some will provide strong demand for labour initially, which will fade as markets become saturated.

Jobs of the first type (operating and managing) are likely to be the most stable in number, increasing over time as more low carbon technologies requiring operation, maintenance and management are installed, and as activities including carbon accounting and carbon trading become more embedded in the economy. Productivity improvements aside, once created many jobs associated with low carbon economy infrastructure have a good chance of continuing to exist for the lifetime of the installations they support, such as wind farms and biodiesel plants, which may be designed for an operating life of 20 or 30 years.

While some investments (such as in retrofitting of residential wall insulation) are unlikely to generate continuing employment in operation and maintenance, in renewable energy the share of employment that this accounts for should rise over time as the installed base grows. For example, the US Department of Energy's (DOE) 20 per cent Wind Energy by 2030 report, which disaggregates employment between operations, construction and manufacturing, projects employment (direct plus indirect plus induced) in operations linked to wind energy exceeding 40 per cent of all employment in the sector in 2030, up from less than 10 per cent in 2008. Similar projections for Ireland (Comhar SDC, 2010) show employment in operations rising steadily, with employment in construction (associated with installation) being highly volatile, and no significant employment in manufacturing. Under the projections, significant employment in construction for wind power past 2021 depends on Ireland continuing to invest in wind power capacity after exceeding its current target of deriving 40 per cent of electricity from renewable sources.

Jobs of the second type are likely to be less stable in number. Overall, prospects for growth in employment in this area are good, with many of the industries concerned being early in their development and appearing to have good growth potential. Over the longer term, these industries are likely to have dynamics similar to those in any investment goods industry, with output and employment being more sensitive to economic conditions and technological shifts than is the case in consumption industries. The tendency towards volatility may

be accentuated by volatility in the cost of energy, as high energy prices favour low carbon technologies, and vice versa for low energy prices. The regulatory environment may add to, or reduce, volatility.

Relatively mature industries in this category, such as manufacture of wind turbines, are concentrated in particular countries and regions within countries, and are subject to substantial international and inter-regional trade. While immature industries, such as in technologies for ocean power, are much more dispersed geographically, they are likely to become more concentrated as they mature. This has two major implications for the dynamics of employment. One is that the number of jobs of this second type will vary greatly between countries, with some attracting a disproportionately large number of jobs and others possibly having very few. The other is that employment levels within a country will have some protection from purely local variations in demand that have the potential to be more extreme than overall variations in international demand.

Jobs of the third type (jobs related to installation of new technologies) have the potential to be less stable again in number at local, regional and national level.

Demand for new installations in many industries key to the transition to the low carbon economy is vulnerable to local and regional market saturation and to local policy changes, as well as to factors such as changes in energy prices that affect demand globally.

Installation of new renewable energy capacity in a region may be constrained by the availability of suitable sites for wind or ocean power, by the capacity of the region to grow biomass or by the availability of various types of waste to use as feedstock. It may also be constrained by the capacity of the electricity grid to absorb variable quantities of wind and ocean power efficiently, or be limited in pace by the rate at which the infrastructure is improved. As the constraint is approached, the market may reach saturation, resulting in much of the employment associated with new installations being lost.

Retrofitting for residential energy efficiency may slow once the homes most suitable for retrofitting have been tackled, and will eventually reach a point where little remains to be done. Again, this can be expected to impact negatively on employment.

Industries supplying the technologies and services used in installations related to the low carbon economy have some protection from local variations in demand because many of them trade internationally. Businesses in sectors involved in installation of technologies for the transition to the low carbon economy, notably construction, are more likely to trade only locally, regionally or nationally, and employment in these businesses is therefore much more vulnerable to changes in local, regional and national demand.

A more general issue, cutting across all three types of employment is that the economic underpinnings of some employment linked to the transition to the low carbon economy come from public policy measures that are subject to change. The policy imperative for the transition to the low carbon economy may drive further measures that boost employment in new or existing areas. On the other hand, green stimulus packages are vulnerable to being discontinued as countries exit from measures designed to address the economic crisis, which may impact on employment in areas ranging from home retrofitting to research. Subsidies, and favourable pricing regimes such as guaranteed feed-in tariffs for new renewable energy installations, are subject to being revised for a wide range of public policy reasons.

All of this points towards the importance of the time dimension in projecting employment, and towards differences in how numbers employed will vary over time for different types of employment. Employment arising from a stimulus package, or associated with the installation phase of a one-off investment in infrastructure, may last a small number of years. Employment in operating, maintaining and managing infrastructure may last decades, and, despite starting at a low level may grow substantially as the stock of investment accumulates. Employment in other areas may go through phases of rapid growth, and through phases of significant volatility.

While patterns of volatility may be difficult to predict with enough confidence to be useful,[10] it is reasonable that researchers should consider building other differences in how numbers employed are likely to vary over time into their models, and clarify the choices they have made. Where volatility is likely to exist, it is reasonable that they should highlight this. If the employment impact of an initiative is likely to be limited in time, or its continuation is contingent on a follow-on initiative being put in place, it is reasonable that this should be highlighted.

When presenting results, it is preferable that researchers should not just be clear as to what they mean when counting "a job", but should also describe the reasons why they have chosen this definition, and consider discussing how best readers might make comparisons with results from other researchers who use alternative definitions.

[10] The Irish example described above uses plans for future electricity grid connections that extend to 2021.

3.7 Conclusions

The main conclusions from this section of the report are as follows:

- Labour Force Surveys are centrally important sources of information on the occupational composition of sectors. This information is important in quantifying the skills and occupational profile of sectors, and in anticipating future skills requirements.
- Enterprise and employer surveys can be important sources of information for skills analysis and anticipation, particularly if they focus on current and future skills requirements, and most particularly if they focus on skills demand in green industries and on green jobs. This may be addressed either through a new survey or through adding questions to existing surveys.
- While the national occupational and skill database initiatives reviewed offer a range of examples of practices that could usefully be deployed in other countries, the most promising are:
  - Adding a question to an existing survey (such as a labour force or employer survey) to distinguish green employment; and
  - The use of skills research to generate job market information for job seekers, students, HR professionals and others.
- Researchers should offer a clear definition of the units in which their measurements of jobs are stated.
- Researchers should present their results in a way that can be compared with results from other researchers, preferably in job-years, in employment in each year over the projection period, or in an average over a stated period, and even better in some combination of these if feasible.
- Analysis and anticipation of skills requirements should take account of the fact that different types of job have different employment dynamics, with jobs in operating, maintaining and managing being stable and generally increasing, jobs in installation varying with the volume of new installation projects making them potentially volatile locally, and jobs in developing and producing technologies varying with international demand for those technologies.

Section

4 Quantitative Methods

4.1 Introduction

Research which examines the employment and skills implications of specific policies or longer term economic, environmental and energy-use scenarios most often includes a strong quantitative component – often based on a formal empirically-based economic model. In long-run analysis, the economic model may be combined with scenarios with regard to future developments in sectors that will have a significant role in the transition to the low carbon economy, such as the energy sector and sectors that a major users of energy. Often, such scenarios reflect the outcome of another modelling exercise. For example, in the case of the US, the DOE maintains a National Energy Modelling System which produces baseline scenarios of future energy demand, supply, prices, and investments (but not of employment and skills). This model and the scenarios it produces have been used as a basis for more detailed employment analysis.

A wide range of models and methods have been used to explore the impact of reductions in carbon emissions and policies to support clean energy on general economic performance quantitatively. However, as a review of these studies commissioned by the ILO found, "existing models hardly focus on employment" (Irrek, Bunse and Rudolph, 2007, p. 26).[11] Studies which incorporate a

[11] The review by Irrek, Bunse, and Rudolph (2007) mentions some additional models that have been used to analyze economic dynamics – e.g. optimal growth models and real business cycle models. These are largely theoretical models. To the extent that they are empirically grounded, they are generally confined to a consideration of very aggregated (macroeconomic) variables. Furthermore, the neoclassical assumptions underlying these models (e.g. full employment and market clearing) make it difficult to apply them to questions of employment creation and skills demand. Such models have been used to look at the impact of climate change and environmental constraints on growth (e.g. Nordhaus, 1992), but no examples of these models being applied to the research questions of concern for this report were found.

systematic treatment of skills are even rarer. Therefore, the analysis is limited to those methodologies which have examined employment outcomes, and which could be used to evaluate skills requirements.

The core economic models are used to generate estimates of employment impacts in response to policy changes or different assumptions about the future trajectory of the economy or of the transition to the low carbon economy. It is important to note that existing economic models rarely include information on skills or detailed occupational outcomes. To link the employment estimates to skills outcomes, information from labour force surveys, enterprise surveys, and case studies are often used. For example, an economic model can generate estimates of employment growth by industrial sector or occupation. These estimates are then paired with current information from other sources that describe in much greater detail the character of the jobs created. In this way, skills profiles associated with the employment outcomes in question can be generated (also, potentially, profiles of wages, benefits, and other dimensions of job quality). However, it is important to note that the sources of information on skills linked to these models may lack a high degree of specificity. The analysis of skills that accompanies them is often in terms of broad categories rather than distinct occupations, whether because of limitations of data on occupations or because the research is intentionally targeted at a high level of occupational aggregation.

4.2 Quantitative approaches at macroeconomic level

4.2.1 Introduction

Existing analysis carried out at macroeconomic level generally uses either of two broad categories of economic models to estimate employment effects:[12]

1. Input-output models and SAMs (models based on social accounting matrices) at the national or sub-national level;
2. Extensions of input-output models, such as CGE models, which incorporate additional economic relationships and constraints.

[12] Some studies perform a detailed review of existing studies (sometimes called a 'meta-analysis'), occasionally supplemented by qualitative interviews and expert assessments. An example is the report, Climate Change and Employment: Impact on Employment in the European Union-25 of Climate Change and CO_2 Emissions Reduction Measures by 2030, published by the European Trade Union Confederation, ISTAS, Social Development Agency, Syndex, and the Wuppertal Institute. We do not consider these studies in this review, since they represent a composite of methodologies contained in other research studies.

4.2.2 Input-output models and social accounting matrices

Input-output models (and models based on social accounting matrices – a closely related set of models that incorporate more comprehensive information on the economy) estimate the economy-wide and sectoral impact on output, employment, and value-added of changes in the final demand for the goods and services produced by a particular sector or combination of sectors. For example, an input-output model can estimate the increase in output and employment, sector-by-sector, caused by growing demand for construction services to modify existing houses, e.g. as would be associated with energy-efficient retrofits.

Input-output models are derived from detailed information on the supply and demand relationships between various industrial sectors and distinct categories of final demand. The data underlying input-output models show how much output is produced by each sector, the amount of the production used by each sector, and the amount of final demand for each sector's production. To give a concrete example, the input-output table will detail the production of the agricultural sector and indicate how other sectors of the economy use this output – e.g. how much is used as inputs to food processing, how much is used by the agricultural sector itself, and how much consumers purchase directly. An increase in purchases of agricultural output will cause purchases of intermediate inputs to rise; fertilizers, for example. Higher demand for fertilizers will, in turn, increase demand for the inputs used by the fertilizer industry, and so forth. The input-output model captures these relationships and uses them to track how an initial increase in demand travels throughout the productive structure of the economy.

Input-output models also disaggregate the sources of final demand in the economy. Typical final demand categories include household consumption, capital formation, government expenditures, inventories and exports. Information on imports is also included, often implicitly, in the input-output model. This allows modelling of 'leakages' – i.e. when increases in demand are met by higher imports rather than domestic production.

The level of analytical detail is determined by the construction of the input-output model itself. Some input-output models are highly disaggregated, with a large number of industrial sectors. An example of a highly disaggregated input-output model is the one used by PERI to explore employment effects of green investment in the United States (Pollin, Wicks-Lim and Garrett-Peltier, 2009). This model has over 400 industrial sectors. Most other input-output models are not this detailed, and this can impose restrictions on the type of analysis performed. For example, the research study, *Employment Impacts of a Large-Scale Deep Building Energy Retrofit Program in Hungary*, from the European Climate

Foundation, found that the Hungarian input-output model, with 57 sectors, was not detailed enough to use to model retrofitting of buildings by itself. Due to these limitations, this Hungarian study combined an input-output model with case studies to estimate employment effects.

As we continue with the comparative analysis, we will see that this is a common strategy. When one methodology runs up against a constraint, it is common to find that multiple methodologies are used to overcome these barriers.

SAMs represent extended input-output models that have additional accounts for the public sector, taxes and transfers, and household accounts. For example, a SAM may disaggregate the household sector into categories based on the household income. In this way, the model captures distributive dynamics that cannot be tracked using a basic input-output model. Similarly, a SAM can be used to look at the impact on taxes and government spending through the extended system of accounts. In operation and assumptions, a SAM is very similar to an input-output model – the primary difference is that a SAM includes types of data (much of it from National Accounts) absent from basic input-output models. Contrary to input-output tables, a SAM is a single entry system.

One challenge with using an input-output model or SAM to evaluate expenditures on clean energy and green investments is that these activities are not grouped together into distinct industrial sectors. There are no sectors for 'solar power' or 'building retrofits' in standard systems for sectoral classification including ISIC, North American Industry Classification System (NAICS) or ISIC's national and supranational derivatives. Since the input-output family of models is structured using the sector as the basic building block, this poses a significant challenge. There are two ways around this constraint: (1) use the existing sectors in the input-output model to construct a 'synthetic sector' which reflects the composition of activities associated with the activity in question or (2) conduct an enterprise survey or wider sectoral study in order to modify an existing input-output model to introduce an entirely new sector.

An example of the first approach is the study of the employment effects of green investments in the US economy (Pollin, Wicks-Lim and Garrett-Peltier, 2009). The researchers exploit the highly disaggregated nature of their input-output model to construct 'synthetic sectors' for the various activities under consideration: building retrofits, investments in renewable energy, and the creation of a 'smart grid'. The study uses industry case studies to identify which of the sectors within the input-output model are associated with the activity in question and the share of expenditures which each of the input-output sectors represents. The end result is a vector of sectors from the input-output model, each with a different weight. This information can then be used to model expenditures within a particular area.

An example of the second approach can be found in the report *Renewable Energy: Employment Effects* (Federal Ministry of the Environment, Nature Conservation, and Nuclear Safety, Germany, 2006, updated in 2007 and 2009). This study uses a variety of different methodologies, including energy supply and demand forecasting; an enterprise survey; input-output analysis; and a general equilibrium economic model. With regard to the input-output model, the researchers used information from the renewable energy industry to modify the Germany's official input-output model (which is composed of 71 sectors) to include two new activities: manufacturing of renewable energy systems and operation of renewable energy systems. These new categories were then used to model the employment effects of an expansion of renewable energy in Germany.

Another example can be found in a study entitled "Arbeitswelt in einer nachhaltigen Wirtschaft – Analyse der Wirkungen von Umweltschutzstrategien auf Wirtschaft und Arbeitsstrukturen" from the Institut für Systemtechnik und Innovationsforschung, 2001. The objective was, for five different green strategies/sectors (sustainable use and production of paper, plastic recycling, increasing product life (the example of cars), intensifying product use (the example of car sharing), and use of fuel cell cars), to estimate the employment effects, environmental effects, impact on the structure of qualifications, and impact on working conditions among others. The study develops scenarios for 2020, comparing a reference scenario with a sustainable development scenario for each strategy/sector. It creates sub-sectors in the input-output table and fills in missing information through company case studies, expert interviews etc. They call this micro-macro bridge. The input-output table is supplemented by additional data on environmental impacts (CO_2 emissions), employment (coefficients), skill structure (information comes from micro census data and consists of both tasks and qualification level) etc. The study makes quantitative projections of the impact of each scenario on qualification levels, and also comments on the impact on skill levels, and on the impact on the types of tasks involved in work (e.g. less industrial work, or more administrative work).

As noted earlier, spending on the green economy creates jobs through three channels: direct, indirect, and induced effects. Input-output models are extremely useful in documenting the indirect and induced employment which a current level of productive activity supports. These three effects in, say, investments in home retrofitting and building wind turbines can be described in this way:

- *Direct effects*. The jobs created by retrofitting homes to make them more energy efficient or building wind turbines;

- *Indirect effects*. The jobs associated with industries that supply intermediate goods for the building retrofits or wind turbines, such as lumber, steel, and transportation; and
- *Induced effects*. The expansion of employment that results when people who are paid in the construction or steel industries spend the money they have earned from producing these immediate and intermediate goods for clean energy industries on other products in the economy.

Input-output models allow researchers to identify indirect and induced job creations associated with clean energy and other green investment and activities. In the French research study, *Marchés, Emplois, et Enjeu Energétique des Activités Liées aux Energies Renouvelables et à l'Efficacité Energétique* (ADEME, 2009), direct jobs in renewable energy and energy efficiency activities are used in conjunction with the French national input-output model to estimate the number of total jobs (direct and indirect) which the current clean energy industry supports. A similar approach is used in the German report, *Renewable Energy: Employment Effects*, compiled by the Federal Ministry of the Environment, Nature Conservation, and Nuclear Safety, previously discussed.

Assessing assumptions and concerns with input-output models and SAMs

Input-output models and SAMs are empirically grounded, in that they are based on past data on the structure of the economy. At the same time, the estimates ultimately depend on the assumptions on which the model is built.

Basic input-output models implicitly include a number of simplifying assumptions. This makes the models relatively transparent and tractable, but may limit their usefulness in certain applications. For example, a basic input-output model does not consider changes in relative prices and possible substitution effects. In addition, the productive relationships in an input-output model are fixed and linear – they do not change over time and production expands along with demand. These assumptions can be altered. For example, dynamic input-output models can be developed, price effects incorporated, and supply-side constraints imposed. Similarly, DySAM models can also be used, making changes to the basic SAM model broadly similar to those involved in making an input-output model dynamic (Alarcón et al. 2011).

However, it is worth discussing the implicit assumptions and constraints of input-output and SAM models in more detail.

A basic input-output model is a linear model with no supply-side constraints imposed. Basic input-output models assume that a given amount of spending

will have a proportionate effect on employment no matter how much the level of spending changes, either up or down. For example, the impact of spending USD 1 billion on an energy efficiency project will be exactly 1,000 times greater than spending only USD 1 million on the exact same project.

The most significant consequence here is that input-output models take no account of potential supply constraints in moving from a USD 1 million project to a USD 1 billion project. Under some circumstances, this could be a serious deficiency in the model. Under the current conditions in many economies – with widespread slack arising from slow recovery from a severe recession, with elevated unemployment and with private-sector lending and investment almost flat – it is reasonable to assume that supply constraints are less binding than demand constraints. In the longer-term, these same conditions may not hold and models will need to be adjusted to reflect this reality.

Another result of the assumption of linearity, as noted above, is that a basic input-output or SAM model assumes that prices remain fixed, regardless of changes in demand. A more fully specified model would take account of such factors – for example, if the current recession leads to reduced demand for solar panels then prices of the panels will fall, perhaps mitigating the decline in demand.

Basic input-output models also assume that productive relationships remain stable over the period of analysis. But it is certainly the case that industrial structures evolve over time. This issue is especially relevant in considering employment conditions in the transition to the low carbon economy, since economies will certainly undergo significant structural changes in the course of the transformation. How does structural change affect the reliability of employment forecasts?

In fact, the use of workers in green industries and services will not change at an equivalently rapid pace over time, even though green technologies will be advancing substantially. Consider this example: a high proportion of energy-efficiency investments – such as for building retrofits, public transportation, and smart grid electrical transmission systems – will heavily rely on the construction industry. Some aspects of the work involved in retrofitting a home, for example, will change as retrofitting methods develop. But other aspects can be expected to remain stable because the technologies are relatively mature and unlikely to change quickly. Depending on the activity in question, the overall level of demand for workers to conduct retrofits may remain fairly stable, at least over the short to medium-term.

A similar situation is likely to hold with the production of renewable energy in the short run, regardless of whether the solar panels, wind turbines, or biomass fuel refining plants are more or less efficient because of technologies that convert their raw materials into useful energy. That is, the need to employ workers to manufacture, transport, and install these newly developed renewable energy

products is likely to remain fairly stable as a proportion of overall activity in the industry over a small number of years. (Over the longer term, the share of activity centred in operations and maintenance is likely to rise.) Therefore, the use of an input-output model or SAM may be appropriate for research scenarios in which technology and productive relationships can be assumed to be fairly stable.

An area of activity that is mature in developed countries will not necessarily also be mature in emerging and developing countries. Early installations of a technology may be much more labour intensive than in a developed country, with much more scope for learning to improve labour productivity.

The input-output model generates estimates as though everything is happening at one fixed point in time. A more realistic picture of the economy would of course have to recognize that the effects of public- and private-sector spending will take place in sequences over time, and that these timing effects are important. Adding a time dimension would make the model dynamic – if these considerations are of concern, a dynamic input-output model or DySAM can be used to take account of changes over time.

Input-output models and SAMs are therefore useful for estimating employment outcomes for a variety of research objectives and under a range of difference scenarios.

- To examine the impact of public policies and private expenditures in the short- to medium term, when productive relationships can be assumed to be stable.
- To estimate employment outcomes associated with green investments when supply-side constraints are relatively insignificant and there are few barriers to expanding capacity in these areas (i.e. there is growing demand for clean energy, energy efficiency, and other green activities).
- To evaluate policies when the primary effects are on the level of expenditures and the quantity of output, in contrast to modelling price effects.
- To estimate the total number of jobs which the current level of activity in energy efficiency and renewable energy supports (i.e. including direct, indirect, and induced jobs).

In comparison with general equilibrium models, which are discussed next, input-output models are relatively transparent and easy to understand. This gives them two important practical advantages.

- Often the assumptions and mechanics of more complex models make it extremely difficult to evaluate whether the use of such complex models is appropriate in a particular situation, or to validate whether their predictions are

plausible. Although input-output models and SAMs are not simplistic, their mechanics and assumptions are typically easier to grasp and check against reality.

- General equilibrium models are often so complex as to make it very difficult to explain the detail of their operation, or to explain in detail why they generate a specific conclusion, to policymakers. In contrast, it is typically feasible to explain the mechanisms and outputs of an input-output model or SAM to policymakers. This can give policymakers much greater confidence in a model's results and predications.

Input-output models and SAMs can be extended in various ways in order to incorporate concerns over price dynamics, technological progress, and structural changes. Consider the Hungarian study of retrofits discussed earlier, *Employment Impacts of a Large-Scale Deep Building Energy Retrofit Program in Hungary*, from the European Climate Foundation. This study uses case studies (which are scaled up to the national level) and the Hungarian input-output model to examine employment and skills outcomes associated with different policy scenarios with regard to retrofitting residential and public buildings. The researchers incorporated an analysis of productivity improvements over time, associated with 'learning-by-doing' and technical changes associated with the accumulation of know-how over time. These dynamics affect expenditures on retrofits over time. Different assumptions regarding learning over time were incorporated into the research, depending on the technologies involved.[13] This provides an example of how research can build on a basic input-output model to incorporate new issues or address specific concerns.

In fact, many CGE (computable general equilibrium) models are simply input-output models and/or SAMs with price dynamics, supply-side constraints, and assumptions about technological change added. We turn now to a consideration of this second class of quantitative methodologies.

4.2.3 Computable general equilibrium and related models

Like input-output models and SAMs, CGE models are empirically based models that estimate how an economy may react to specific policies, new technologies, and external shocks or changes. With regard to exploring the transition to a clean energy economy, they can be used for many of the same applications as input-output models.

[13] For some activities, the technology was assumed to be mature – i.e. there would be no gains in terms of learning-by-doing. However, for technologically more demanding retrofits (i.e. 'deep retrofits'), learning dynamics were included.

CGE models consist of a series of equations which describe economic behaviour. In most cases, the assumptions built into CGE models are neoclassical in character – i.e. households and firms respond to price signals and pursue some form of optimizing decision-making. Many CGE models assume full-employment as a labour market equilibrium condition. However, these assumptions are not essential to the model; the most recent generation of CGE models includes models that have been constructed with equilibrium unemployment, mark-up pricing, and market externalities.

CGE models typically place a much stronger emphasis than input-output and SAM models on the role that prices play in influencing behaviour and determining economic outcomes. In this respect, they are quite different from input-output models and SAMs, in which the role of price dynamics is minimal. The core of a CGE model is typically an input-output model, showing the various relationships between industrial sectors and final demand. The input-output framework is typically supplemented by a variety of elasticities, which describe how demand reacts to changes in prices. CGE models also incorporate some kind of equilibrium condition – such as market clearing (prices adjust so that supply must equal demand) or full-employment – so that a unique solution to the system of equations exists. This is in contrast to input-output models, in which supply-side constraints are absent. Market clearing does not need to characterize the equilibrium condition, although it has commonly been chosen. Macroeconomic equilibrium conditions (e.g. savings must equal investment *ex post*) are also important in CGE models. There can be important differences in estimated outcomes, depending on the assumptions used in the model (e.g. does savings adjust to match investment or does investment follow savings?)

Complex CGE models are costly to develop. Moreover, given the high fixed cost of creating the models, CGE models are often proprietary – access to the model is restricted to the organization or researchers who developed the model. This can raise concerns regarding transparency and independent verification of the accuracy of the model's assumptions.

An example of a CGE model which has been used to model the green economy at the level of the European Union (super-national) are the E3M models developed by Cambridge Econometrics (www.e3mgmodel.com). E3M can model economic activity at the national, European Union (E3ME), and global (E3MG) levels. The model is disaggregated into 42 industrial sectors, and has been specifically developed to explore energy-economy linkages and pollution dynamics. The relationships which structure the model are estimated from a variety of data sources. The model was specifically developed to examine long-run economic impacts. For example, the E3MG model consists of:

- Basic input-output tables, extended to include accounts associated with SAMs (institutional income and expenditures).
- Data on flows of emissions.
- A set of 22 equations, estimated using time series, describing product demand, factor substitution, labour force participation, and investment behaviour, among other factors.
- Exogenously determined energy supplies and population dynamics (Pollitt and Junankar, 2009).

There are several examples of research studies which model the green economy using the E3M models. One example is the report, *Links Between the Environment, Economy, and Jobs,* commissioned by the European Union. This study is an ambitious effort documenting the links between employment outcomes and a wide range of activities, including natural resource based industries (agriculture, mining, utilities), eco-tourism, and environmental conservation and management. The aim was to capture the full scope of 'eco-industries'. After having defined a template that describes the set of eco-industries analyzed, national level input-output tables were used to estimate direct and indirect effects. The basic input-output analysis was then linked to the E3ME model in order to experiment with various policy scenarios, including some which affect the underlying relationships in the input-output models. The policy scenarios explored include increasing the use of recycled inputs, switching from conventional to organic agricultural production, increased use of biofuels, and the adoption of water saving technologies. The analysis of these policies included an assessment of the net change in the number of jobs. There was no detailed analysis of the demand and supply of skills.

An example of research which does use the E3ME model to forecast skills supply is *Futures Skills Supply in Europe (forecast up to* 2020*)* (Cedefop,2010). This report focuses on skills, but does not specifically analyze the expansion of green economic activities. The forecasts in the study are generated on the basis of a variety of models and sources of information. Broad economic outcomes are modelled using the E3ME model. However, the parameters of the E3ME model are not sufficient to estimate changes in the supply of or demand for skills. Therefore, the basic CGE model had to be augmented with specific labour supply and demographic information and relationships – specifically, Eurostat labour force survey data to predict individual skill, education, and qualification attainment. Finally, information on flows of skilled workers – based on enrolment and graduation rates for educational institutions – was incorporated into the estimates. Although focused on labour supply issues, this study provides an example

of how economic models can be linked to labour force surveys in order to provide an analysis of skills.

Obviously, not all CGE analysis of the green economy uses the E3M series of models. However, most do use pre-existing CGE models which have been adapted to analyze clean energy investment and green activities.

An example from Australia is *Growing the Green Collar Economy* (Hatfield-Dodds, Turner and Schandl, 2008). This study forecasts employment outcomes associated with various 'low-carbon' scenarios for the Australian economy and discusses the possible implications for skills demand. The principal focus is an examination of the likely long-run impacts of significant reductions in greenhouse gas emissions. Two approaches to economic modelling were used: a CGE model (developed and maintained at Monash University), which includes analysis of response to changing prices; and a technology-based model which predicts future scenarios for energy efficiency and energy use in terms of the physical flows of commodities and inputs. The report acknowledged that, at the time of the study, information on skills requirements linked to green investment activities was underdeveloped. Therefore, a detailed analysis of future skill needs tied to the employment forecasts was not part of the study, although the report does discuss the types of information which, if available, would enable such estimates. This underscores an important limitation of existing CGE models. In many cases, the models, as they currently stand, do not have the ability to link employment estimates to skill needs. Additional analysis would be required to do so. There is, however, a long history of using the Monash model for labour market forecasting (Meagher et al., 2000).

Like SAMs, CGE models may have additional institutional details which allow researchers to delve deeper and look beyond macro-level or sector level outcomes. Again, a CGE model is only capable of more in-depth analysis if the model has been designed to undertake such analysis. An example of research which looks at the distributional effects of clean energy policies is the Finnish study, *Distributional Effects of Finland's Climate Policy Package* (Honkatukia, Kinnunen and Marttila, 2009) from the Government Institute for Economic Research (VATT). This study uses a new income distribution module of the VATTAGE model – a national level CGE model. Specifically, the study uses the VATTAGE model to estimate the distributional impact of Finland's climate policy package by year 2020. VATTAGE is based on the Monash CGE model (mentioned earlier in the Australian context. As with many other CGE models, it takes account of sectoral input-output relationships.

Unlike many other studies, this one specifically considers the distributive impact of the policies across eight different socioeconomic groups in

terms of income and total real consumption expenditures. The socioeconomic groups – defined by the status of the household head – include the following: (1) farmer, (2) entrepreneur, (3) upper-level employee, (4) lower-level employee, (5) manual worker, (6) student, (7) retired, and (8) unemployed and others.

This study forms a part of a wider programme of research based on the VATTAGE general equilibrium model, much of which is unpublished having been undertaken on behalf of the Finnish government. Two features of this research are very relevant to this review.

1. The model has been extended, using statistical data on occupations and qualifications, so that it can be used to project future employment by occupation and by type and level of qualification. It models approximately 70 occupational categories.

2. The research makes use of an "engineering model", developed by another organization and based on sectoral research, to model the behaviour of the energy sector within the wider model of the economy. It also makes use of information from expert sectoral panels to inform how each sector is modelled. The engineering model covers both renewable and non-renewable parts of the sector, and addresses employment and other implications of the shift from non-renewable to renewable sources.

   The approach of using bottom-up sectoral research to model the behaviour of chosen sectors (or parts of sectors) within a macro level model is similar to that adopted by other researchers modelling the whole economy employment impacts of the transition to the low carbon economy. The specific approach adopted by VATT has much in common with that behind the Australian *Growing the Green Economy* report referenced earlier, in that both are based on the Monash model, and both make use of engineering-type models of the energy sector.

   An important feature of this approach is that it does not just focus on parts of the energy sector that will grow as a consequence of the transition to the low carbon economy. By also looking at the parts of the sector where employment will decrease, it provides a much fuller picture of the labour market and skills impact of the transition to the low carbon economy.

The VATT research is one of a number of programmes of research underway in EU countries that use CGE models in the context of analysing climate change impacts. Another is the Austrian MERCI (Model for Evaluating Regional Climate Change Impacts) dynamic computed equilibrium model. This project is looking at the effects of climate change on growth, wealth, employment and

unemployment, and at the impact of energy strategies, investment in energy efficiency of buildings and investment in infrastructure and public transport. It projects employment at three skill levels.

The complex and proprietary nature of most CGE models makes it difficult to perform a careful analysis of the assumptions used in different applications and to determine if the assumptions are reasonable for answering a specific research question. This is because detailed descriptions of the models (including the equations which constitute the model) are often not publicly available. The individual assumptions are often difficult, if not impossible, to identify from the general description of such models, and the implications of specific assumptions are hard to trace. The reliability of such models therefore depends first and foremost on an assessment of the model's assumptions, and this makes it advisable to ask a number of critical questions to the developers of a CGE model before proceeding with a modelling request. That is, are the assumptions realistic? Do they help us to understand important issues about the likely growth trajectory of the green economy?

To give one important case in point, as noted earlier, a CGE model may assume the economy operates at full employment at all times. Working with this assumption, it is inevitably difficult to trace out any possible impacts of green investment as net generators of new employment opportunities.

More generally, as we have emphasized before, the specific model used depends on the objective of the research. Input-output models are commonly used to evaluate targeted economic policies and to estimate short- and medium-term employment impacts. Extensions of these models, including most CGE models, are used when the research objectives include:

- exploration of price effects;
- a detailed analysis of substitution with regard to consumption or productive inputs;
- significant changes in productive relationships over time;
- the impact of policies on *long-run* output and employment growth.

For example, in estimating the effects of a cap-and-trade policy over time, one has to incorporate changes in prices and available supplies of various energy sources in some way. This is because the whole point of a carbon cap is to raise the price and restrict the quantity of fossil fuel energy sources.

4.3 Studies at sector level

All of the approaches discussed above and all of the research studies with significant quantitative components reviewed include, at some level, one or more sector analyses. This is partly due to the nature of the research under examination in this report – the impact of green activities on employment, including the skills profile of the jobs. The 'green economy' is not captured in a single statistical category. For the purposes of analysis, the concept has to be broken up into component sectors – e.g. solar, wind, biomass, heating and cooling efficiency, fuel efficient and alternative fuel vehicles, mass transit systems, and so forth.

Depending on the methodology used, these activities have to be linked to the specific sectors that exist in the model or scenario used. Input-output models and SAMs are models with a sectoral structure. Their major value-added is in terms of the detailed linkages between sectors which are incorporated into the models. Many CGEs – particularly those with a core input-output model or SAM – are also explicitly built on a sectoral structure. Indeed, a sectoral structure is generally required for a CGE model to produce skills analysis results in any depth.

The challenge is that the sectors in existing input-output models, SAMs, and CGE models may not match the activities of interest in the 'green economy'. That is, a 'retrofitting sector' or a 'wind energy equipment manufacturing sector' will not exist in standard statistical sources. As noted earlier, in these circumstances researchers need to develop synthetic sectors, possibly based on case studies and qualitative assessments of the activities of interest, or develop new categories within the input-output model based on national survey data.

Sufficiently detailed national survey data on enterprises operating in specific segments of the green economy are often not readily available (Strietska-Ilina, *et al*. 2011). In such cases, such a survey would need to be undertaken in order to introduce a new sector into an input-output model, SAM, or sector-based CGE model.

Although input-output models, SAMs, CGE models, and similar approaches are often developed at the national level, these models can be used to perform sectoral analysis of employment impacts and skills. The advantage of using such models for sectoral analysis is that they embed the analysis within the large economy and are able to explore inter-sectoral linkages.

However, these models are not the only option for quantitative sectoral analysis. Instead of beginning with a model of the national economy, alternatives are to:

- pursue a 'bottom-up' approach, in which individual sectoral studies are combined to yield a composite picture (Irrek, Bunse and Rudolph, 2007); or to

- pursue a balanced approach under which sectoral studies focused on sectors particularly relevant to the transition to the low carbon economy are embedded within a well developed macro model. Research in Finland and Australia mentioned earlier has taken this approach, with substantial studies of the energy sector being married to Monash-based CGE models.

Energy sector models

One particular sector for which future employment has been modelled for many countries in order to explore the transition to the low carbon economy is the energy sector.
Modelling typically:

- focuses on one or more renewable subsectors;
- models the whole energy sector disaggregated into subsectors; or in some cases
- models the electricity sector disaggregated into subsectors.

The sectors included in these energy scenarios do not suffer from the same 'sector-mismatch' problem associated with input-output models, SAMs, and CGE models. That is, the scenarios are expressed directly in terms of the sectors of interest – be it wind, solar, or biomass.

The simplest approach to estimating employment outcomes involves expressing current employment as a ratio of current generation (e.g. jobs per megawatt (MW) in the wind energy industry). This ratio is then multiplied by the future amount of energy generated in order to estimate future levels of employment. Skills and occupational profiles can be obtained using a similar procedure.

This method has the advantage of being transparent and intuitive. It does have a number of limitations, but again, its usefulness will depend on the research objectives. The method will yield estimates of the number of direct jobs that can be expected from a given level of energy generation in any given sector. However, it will not necessarily provide estimates of indirect or induced job creation. These estimates can be derived by using an input-output model to analyze the indirect and induced job creation associated with the direct effects.

As with an input-output model, the employment effects will be linear (i.e. the ratio of jobs per MW is typically treated as constant, although in some cases researchers assume that the ratio falls over time to reflect productivity improvements). In addition, the analysis may not include economy-wide effects. Much depends on how the future energy scenarios are generated. In some cases, such

scenarios are produced using detailed energy forecasting models which include a considerable variety of economic relationships. In other cases, the scenarios may be based on general assessments of where the sector is heading, or past growth experience. The source of the energy forecasts also has implications for whether this approach could be used to model different policy scenarios. There is considerable variability in the methods by which such scenarios are constructed and it is difficult to generalize with any accuracy.
Two sets of information are needed:

1. Future energy scenarios for the various sectors in question – either qualitatively-derived scenarios (e.g. this is what a realistic clean energy economy would look like in 2030) or based on a formal energy forecasting model.

2. Information on current energy generation and employment in the sectors of interest. If the analysis is to include skills and occupations, information on the current skills profile and occupational composition of the sectors is also needed.

For example, the industry report from the European Wind Energy Association, *Wind at Work: Wind Energy and Job Creation in the EU*, develops estimates of current and future employment in the E.U.'s wind energy sector using a combination of different methodologies. Current levels of employment were estimated using an enterprise survey combined with national-level information from certain E.U. member States. Baseline growth scenarios for the wind sector were used along with current employment information to generate estimates of future employment. The report identifies the job categories associated with specific activities of the wind energy sector, including turbine manufacturing, finance and management, and wind farm construction. These job profiles were then linked to specific skills to assess potential skills shortages.

The bottom-up approach can be extended further, to individual plants operating within a particular sector. An example is a study of employment in biomass plants in the U.K., *Quantification of Employment from Biomass Power Plants* (Thornley, Rogers and Huang, 2008). This study uses quantitative case study methods to develop plant-level assessments of staffing patterns at different types of biomass plants. The staffing patterns are broken down into specific occupations and activities (e.g. maintenance, shift operators, management, etc). Operations and maintenance jobs are examined separately from the employment associated with plant construction. For each plant type, the researchers are able to develop an employment profile (including the specific occupations and activities). These employment profiles could be used to generate estimates of employment and skills outcomes, based on the expansion of specific types of the biomass plants. This is a

more detailed approach to employment estimation than basing estimates on a single ratio of the jobs per MW. However, it is also much more information intensive.

Another example of the bottom-up, sectoral approach can be found in the Irish study, *Skills and Training for a Green New Deal*, published by the Comhar Sustainable Development Council. This report considers retrofitting existing residential property as a sectoral activity, in addition to renewable energy sectors. For the retrofitting sector, the study estimates total labour costs associated with specific construction tasks and uses these as a basis for calculating the estimated number of jobs created under different scenarios. For the wind, ocean power, and biomass sectors, ratios of jobs per GW in installed capacity were determined through a review of industry sources and government reports. These were then used to estimate total employment creation associated with future energy scenarios. An allowance for indirect job creation was also incorporated into the estimates. These employment estimates were linked to information on occupational and skills requirements – again, derived from industry and government reports and sectoral case studies.

Sectoral approaches have been used to produce global employment estimates – for example, the Greenpeace report, *Energy Sector Jobs to 2030: A Global Analysis* (Rutovitz and Atherton, 2009). The study bases its employment estimates on future energy scenarios. These are combined with sectoral estimates of the number of jobs per MW for each technology (coal, gas, nuclear, biomass, hydropower, onshore wind, offshore wind, solar photovoltaic, geothermal, solar thermal, and energy efficiency). The study makes further assumptions about technological progress (expressed as productivity improvements) and regional multipliers. Employment estimates are based on future projections of installed generation capacity and the ratio of jobs per MW, adjusted for technological progress. These estimates are calculated for each sector/technology and for broad regions (North America, OECD Europe, Africa, Middle East, Eastern Europe and Central Asia, Latin America, developing Asian countries, China, and high-income Asia and Pacific countries). Clearly, to produce these estimates, significant assumptions had to be made. In addition, the analysis did not include an assessment of skills or occupations. Nevertheless, it provides an example of producing global estimates using a sectoral analysis as a starting point.

Modelling other sectors

An obvious point is that this approach is only applicable to an analysis of employment effects associated with energy generation and demand, including investments in energy efficiency.

In the case of energy efficiency, employment effects could in principle, for example, be estimated on the number of jobs per unit of energy saved, instead of jobs per MW generated. However, there are large variations in the volume of labour required per unit of energy saved depending on the technology involved, the state of the existing building stock and consumer behaviour, which would make this difficult in practice.

Alternatively, expenditures on energy efficiency investments could be quantified for a given level of conservation and these expenditures used to estimate employment effects – for example, using an input-output model or equivalent approach.

The study, *Renewable Energies and Employment Generation in Spain: Present and Future* (ISTAS, 2008), provides an illustrative example of how this method may be applied. This study provides estimates of the number of jobs engaged in the renewable energy sector as of 2007, based on survey data, and a forecast of jobs for 2010 and 2020. The authors used Spain's "Renewable Energy Plan" to anchor these employment forecast estimates – i.e. the projections are derived from a future energy scenario. The report also includes an occupational profile of the renewable energy sector using broad occupational categories based on their survey data. This occupational profile is then applied to the employment forecasts for 2010 and 2020 to show how new jobs will be distributed across these broad occupation categories within eight renewable energy subsectors. This quantitative analysis is supplemented by information from in-depth interviews with key informants in renewable energy industries and the survey data are used to identify current employers' concerns about general skill needs (e.g., English language) and specific skill needs (e.g., specialized knowledge of working with medium and low voltage). There are a number of situations in which this method may be useful:

- As a straight-forward method for analyzing employment outcomes associated with future energy scenarios, including long-run scenarios.
- Analysis of employment, skills, and occupational profiles of specific clean energy sectors (e.g. wind, solar, geothermal, biomass, etc).

Furthermore, it is important to reiterate that these methods are not 'stand-alone' approaches and can be usefully combined. Input-output models can be used along with future energy scenarios in order to deepen the analysis. Similarly, CGE models have been linked to energy forecasting models. The most informative approaches to analyzing skills and employment outcomes associated with movement towards cleaner and greener economies involve the creative use of multiple methodologies to answer specific research questions.

4.4 Hybrid approaches

The description of the types of methodology has been organized as if they were distinct, isolated approaches.

However, as can be seen from the detailed discussion of each type of methodology, multiple approaches are generally used and the methods can be usefully combined. An input-output model can be linked to an energy scenario in order to produce estimates of indirect and induced jobs. The macroeconomic constraints reflected in many CGE models can be incorporated into basic input-output approaches without necessarily making the method overly complex or opaque. Most of the studies which consider employment and skills impacts reflect an integrated approach. But, as an ILO-commissioned report by the Wuppertal Institute for Climate, Environment, and Energy makes clear, basic models, such as an input-output model, can be combined with top-down (e.g. macroeconomic) and bottom-up (e.g. sectoral information from energy scenarios) to produce a reasonably coherent methodology (Irrek, Bunse and Rudolph, 2007).

The study, which was already mentioned, *Renewable Energy: Employment Effects*, commissioned by The Federal Ministry of the Environment, Nature Conservation, and Nuclear Safety in Germany, is an excellent example of a hybrid approach being applied to the growth and development of the renewable energy sector. The report shows how multiple methodologies can be usefully combined to produce a stronger composition picture. The methodologies used included:

- energy supply and demand forecasting – which provided two future scenarios for the renewable energy sector in Germany;
- an enterprise survey – to provide additional information needed on the renewable energy sector in order to better estimate employment and to modify the national input-output model;
- input-output analysis – to account for direct, indirect, and induced job creation; and
- a more long-term economic model – to take into account technological and structural changes.

The results of all these approaches were synthesized in the report to provide a composite picture of the current situation and future employment impacts of the expansion of the renewable energy sector in Germany.

4.5 Studies at supranational and European level

Supranational estimates of job creation associated with a transition to clean energy economies are relatively uncommon. Three supranational studies were reviewed: the Greenpeace report based on global future energy scenarios (Rutovitz and Atherton, 2009); the report commissioned by the European Union, *Links Between the Environment, Economy, and Jobs*; and a study undertaken by the ILO and published in the World of Work report for 2009 (ILO/IILS, 2009), with further work reported in the report *Towards a greener economy: The social dimensions* (ILO/IILS, 2011). The first of these uses global energy forecasts and assumptions about regional employment dynamics to produce global job estimates. The second uses the E3ME CGE model for the European Union to assess the impacts of different policy scenarios. The third projects changes in the sectoral composition of the global economy assuming the introduction of a carbon tax (or similar), and draws conclusions as to the impact that this compositional shift would have on total employment. It builds on an input-output table.

A key challenge to developing supranational models and methodologies is the lack of comparable data between countries, particularly at the sectoral level. Simplifying assumptions are often made to get around this problem. Given Eurostat's efforts to harmonize data definitions and methodologies within the EU (and candidate countries), the difficulties of combining national level data to produce supranational estimates are less pronounced in the European Union relative to other broad regions (e.g. sub-Saharan Africa). It should be noted that we have not found a single example of supranational analysis which specifically considers the skills requirements associated with the transition to the low carbon at anything but the most highly aggregated level. The closest example is the report, already discussed, *Futures Skills Supply in Europe (forecast up to* 2020*)* (Cedefop, 2010), although the analysis does not specifically consider employment linked to the development of the green economy.

The quantitative measurement and analysis of data at supranational level, such as the European Union, requires the use of standardized concepts and definitions. Supranational research is facilitated in the EU due to the existence of Eurostat, and because of the compatibility of most classifications and standardized data collection through national statistical offices. The same can be said for Australia and New Zealand, which share the Australian and New Zealand Standard Research Classification (ANZSRC). This is jointly produced by the Australian Bureau of Statistics and Statistics New Zealand. For industrial and occupational classifications, they developed the ANZSIC and ANZSCO.

The 2007 GHK report (GHK, 2007) for the Directorate General of Environment in the European Union was an attempt to evaluate the economic significance of the environment in terms of European jobs, output and gross value added associated with the range of activities that make use of, or contribute to, environmental resources. It did not look at occupations and skills, but it is a supranational approach to modelling environmental impacts on aggregate employment at the sectoral level, and perhaps could be modified to consider occupational and skill demand, using a sector-occupation matrix based on labour force survey and perhaps case study data.

Since it applied the 1998 OECD/Eurostat definition eco-industries classification, which permits clear boundaries and is aligned with European standards for data in this area, it measured a wide range of economic environmental activities. Therefore, it is not comprehensive and does not include all jobs and economic activity dependent on the environment. However, the results of the study were quite robust, but the application of standard definitions and classifications in the Eurostat database was the key to such a rich study across the European Union.

They used input-output tables to estimate the economic consequences of environment related activities through a number of environmental policy scenarios by tracing impacts through supply chains and income effects. In addition, they used the E3ME economic model developed by Cambridge Econometrics, which allows the available input-output tables to be integrated with data on the national economies of the EU to allow the input-output links to be related to the size of national and the EU economy. This model also enables the manipulation of the input-output tables in order to assess the economic impact of policy scenarios. Furthermore, it has a qualitative part which identifies green sub-industries. This approach was then used in a study in Bangladesh and will be used in a number of future studies in other Asian countries. But one pitfall to the research was that it did not account for price effects which could skew results, especially when considering shocks to the economy as observed during the global economic crisis. This methodology should have the capacity to incorporate a module on occupations.

From a solely qualitative aspect, a multinational study was conducted by researchers in Austria through enterprise surveys in Germany, Netherlands, Austria, Spain and Sweden (Fritz, O. et al, 2001). The questionnaires were sent to companies that implemented integrated environmental protection measures. Although they did not consider a skills aspect, they did review job quality. A similar approach could be applied to green jobs.

4.6 Studies at subnational level

The economic models discussed can theoretically be created for sub-national regions. Again – the availability of detailed, comparable data can be a major obstacle. In practice, the information needed to build detailed sub-national models may not be available for all countries. In the US, for example, input-output models have been constructed at the state-level and at the sub-state level. This allows regional modelling of the employment and skills effects of clean energy and environmentally sustainable activities and investments.

A recent report by Economic Modelling Specialists, Inc. provides an example of how this approach can be applied to local economies.

Economic Modeling Specialist Inc. (2009) Green Pathways – A data-driven approach to defining, quantifying, and harnessing the green economy, Green Jobs, Part 3, presents a methodology for linking job creation associated with green investments with occupations at a local level – in this case, the metropolitan region of Grand Rapids, Michigan. The analysts' approach involves estimating the jobs impacts of green investments, identifying the occupations associated with those jobs, and developing strategies to transition workers into the new job opportunities. The report uses a regional input-output framework to show how occupational analysis can be applied to a specific region within the US. The main features of their approach include the following:

1. Estimates of job creation through green investments through the regional model;
2. Identifying the occupations which have experienced the greatest job loss in recent years – that is, displaced workers in need of employment – using standard labour market data; and
3. Identifying the occupations associated with the jobs that would be created through green investments.

Working with these three elements of their research, they then proceed to map a transition strategy at the local level, including identifying potential skills gaps.

As with country-based analysis, not all regional employment analyses use an input-output or other formal model. One alternative is to use regional energy scenarios in place of formal economic models. For example, in a regional breakdown of the Spanish economy, Moreno and Lopez (2008) apply regional employment ratios—i.e. the number of jobs per unit of energy – for each of eight different renewable energy sectors to estimate future employment in the renewable energy sector. The authors derive these employment ratios from a review of

information from the Regional Energy Foundation and the Spanish Renewable Development Plan 2000-2010. Different ratios are used to estimate employment in (1) construction and installation activities and (2) operation and maintenance jobs. Employment estimates are generated for three growth scenarios by 2010: (1) baseline (2) optimistic and (3) pessimistic. These scenarios vary according to whether current and future plans – as outlined by the Spanish Savings and Energy Efficiency Strategy 2004-2012 – become effective by 2010. The authors then combine these employment projections with qualitative information from past research to forecast jobs by detailed occupational categories such as "thermal solar collector installers" and "photovoltaic solar installers."

4.7 Synthesis of findings on quantitative methodologies

4.7.1 Introduction

Up to this point, this section of the report has reviewed and discussed quantitative methodologies used in analysing and anticipating employment and skills requirements in the transition to the low carbon economy. To be of most use to future researchers, the section concludes with a framework that synthesises the findings.

The synthesis also endeavours to fill in gaps in areas of quantitative skills analysis that may be important from a policy perspective, but are not well covered in the existing literature. Much of the quantitative literature relevant to skills for the transition to the low carbon economy does not go beyond addressing employment totals, and much of that which goes beyond employment totals only disaggregates these totals into occupational categories that are so broad that they can provide little guidance towards the design of skills responses.

Very little of the quantitative analysis attempts to look behind standard occupational classifications to estimate what the transition to the low carbon economy means quantitatively for the new and changed occupations that are emerging, or to link this to estimates of skills supply so as to estimate gaps in supply. The synthesis draws on lessons from skills research in other domains to suggest how researchers might approach this if it is relevant to their research question.

4.7.2 The synthesis framework

This synthesis is organized along the lines of the framework presented earlier in Figure 2.1, which distinguishes between four main levels of analysis in skills research:

- **Macroeconomic** level
- **Sectoral** level
- **Occupational** and **skills** level
- **Training and education** level

The synthesis also focuses on the linkages between these levels. Figure 4.1 presents a framework outlining how the elements fit together.

The content of any individual research project may only map to parts of the framework. If existing research is any guide it will be unusual for a project to map to all parts of it.

What parts a project uses are likely to be a function of:

- priorities arising from the research question;
- data availability;
- access to complementary qualitative information and analysis; and
- time and resources available to the project.

4.7.3 Modelling at macro and sector levels

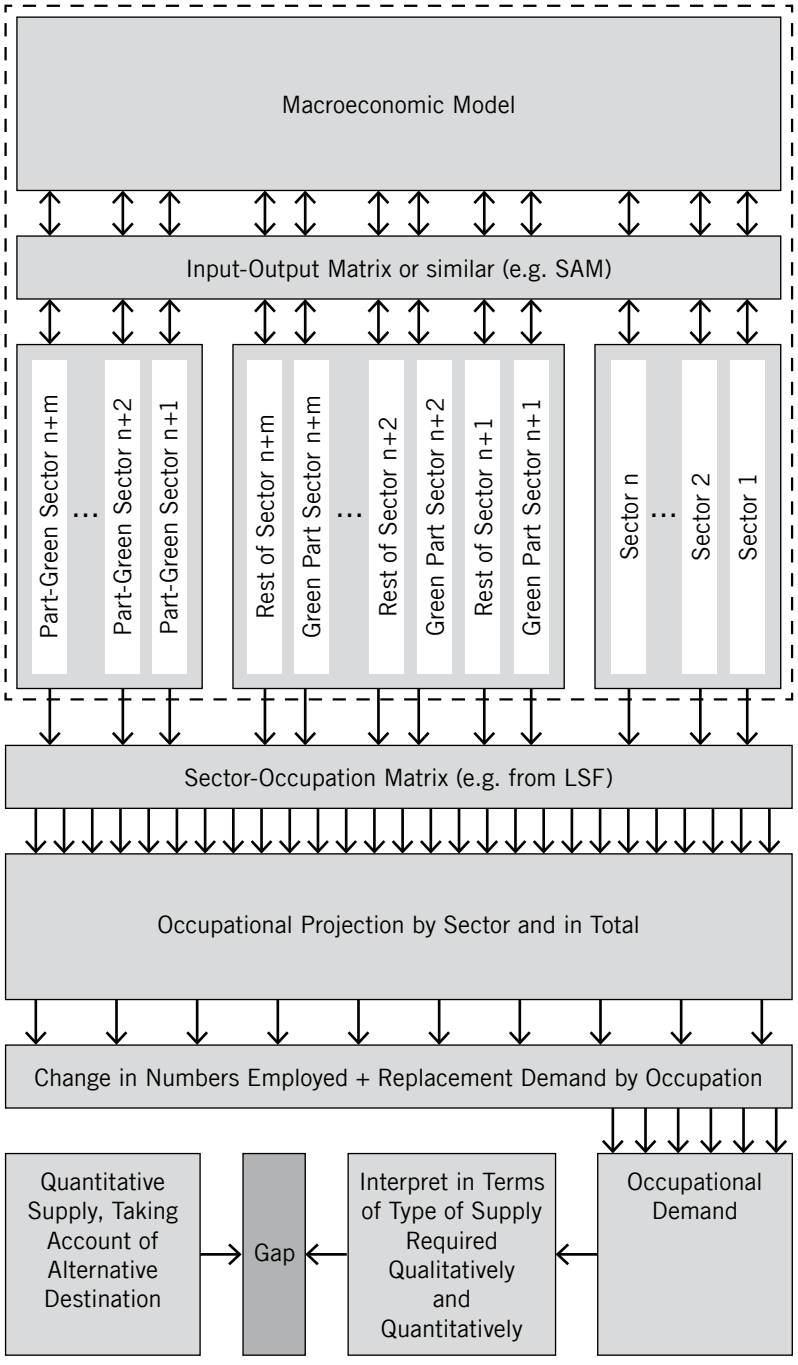
It is possible for an analysis to focus just at macro level or just at sector level.

- A research question about direct employment in a sector can be addressed just at sector level.
- Some broad questions can be addressed just at macro level, but any resulting skills analysis will be at very high level of aggregation, and will not take account of any of the fine detail of skills change. Examples include high level research into impact of higher energy prices or carbon taxation on employment.

Most of the quantitative skills research reviewed combines macro and sector level analysis in order to tackle research questions that cannot be tackled at macro or sector level alone.

- A sector level research question that is interested in indirect and induced employment has to incorporate macro level analysis.

Figure 4.1. Overview of quantitative methodologies



- A research question interested in whole economy impacts that wishes to take account of specific sectoral developments (such as in renewable energy or retrofitting) has to incorporate sectoral analysis.

4.7.4 Macroeconomic level models

The main types of macroeconomic model seen in modelling employment and skills in the transition to the low carbon economy, including hybrids with sector-based models, are:

- Input-output models
- Social Accounting Matrix (SAM) models
- Computable General Equilibrium (CGE) models (also known as Applied General Equilibrium models)
- Other models, including legacy models whose origins predate the popularity of CGE models and special purpose models.

Input-output and SAM models are relatively transparent, easy to understand and communicate to policy audiences, and require a relatively modest amount of work to establish from scratch. As SAM models encompass a more complete view of an economy, they can have advantages over input-output models depending on the research question. Input-output models are sufficient for many purposes, including where the main need is to model the indirect employment effects of sector level developments.

CGE models are complex, require much work to establish from scratch, and are difficult to validate. However, they are commonly used for policy oriented macroeconomic modelling in developed countries. They take account of prices and supply constraints. They are suited to exploring the possible impacts of a wide range of types of policy choice.

In many cases, an existing CGE model with a track record can be adapted, cutting the amount of work involved to a level that may be feasible, and reducing the validation challenges. CGE models require trust from policy audiences, as their complexity makes them difficult to explain.

Depending on context, research question and resources, either an input-output/SAM or CGE approach to modelling can be appropriate. If carried out with due attention to the limitations of each type of model, the choice of macro-economic modelling approach should have less impact on the employment findings

than the assumptions fed into it. If there is more than one good candidate, the researcher's choice of model may be less significant than subsequent choices about assumptions.

4.7.5 Time and macroeconomic level models

Basic input-output and SAM models are static – the relationships embodied in them do not change over time. However, in the real world, economic relationships do change over time. In the case of the transition to the low carbon economy there is a considerable amount of change and innovation underway. For analyses that extend beyond the short term, it is therefore important to take account of developments in labour productivity, supply constraints, price dynamics, carbon pricing mechanisms and other time-dependent variables in low carbon economy sectors, and (where relevant to the research question) the effects of these developments across the wider economy.

There are important skills anticipation research questions relevant to the transition to a low carbon economy that can be tackled well with a static model. Perhaps the research question is about skills demand arising from a stimulus package expected to last two years. Perhaps it is about anticipating skills demand far enough into the future to inform decisions about the current year's intake into technical vocational education and training courses of one or two years duration linked with the transition to the low carbon economy.

However, there are also questions that demand, or at least favour, a dynamic approach. It can be four, five, six seven or more years between the time a university student applies for admission and their graduation. Investments in infrastructure linked to the low carbon economy may have an expected operating lifetime of 20 or 30 years, and policymakers may pose research questions about the anticipation of employment and skills over that period.

CGE models are well adapted to building in assumptions about future developments. If an existing model is being adapted to tackle questions about the transition to a low carbon economy, it may already include equations that can be used to represent the main assumptions. CGE modelling software typically facilitates adding suitable equations in any case.

While basic input-output and SAM models are static, they can be adapted to incorporate dynamic assumptions. SAM models are commonly extended to tackle longer time horizons by changing their relationships dynamically over time, turning them into Dynamic SAM (DySAM) models.

4.7.6 Linking sector level modelling and macro level modelling

The purpose in establishing links between sector level and macro level modelling may be:

- Sector level analysis to inform macro level analysis;
- Macro level analysis to supplement estimates of direct employment and skills impacts in one or more specific sectors with estimates of indirect and induced employment and skills impact;[14] or
- Linking substantial macro and sector level work together to draw coherent conclusions.

Whatever the purpose in linking sector and macro level modelling together, the link is generally drawn either using an input-output matrix or something similar such as a SAM or a supply-use matrix.

Most **macro level models** used in analysing the employment and skills implications of the transition to the low carbon economy include representations of the sectors that make up the economy.
These representations are of a number of types.

- There are sectors not specifically associated with the transition to the low carbon economy, which are represented using standard data from statistical sources based on standard sector definitions. Figure 4.1 depicts these as sectors 1 to n.
- There are sectors which are specifically associated with the transition to the low carbon economy. Generally, each of these forms a part of a wider sector, and is dissimilar to the rest of the sector in significant respects, both economically and in terms of skills. For example, electricity generation includes renewable and non-renewable sectors. These sectors can be handled in either of two ways:
  - A study of the sector can be undertaken as the basis for representing both the low carbon and non-low carbon parts of the sector. Figure 4.1 depicts sectors addressed in this way as "Part-green" sectors n+1 to n+m.
  - The sector can be disaggregated into a low carbon sector and a non-low carbon sector. To do this, some research is undertaken into the low carbon

[14] In principle, macro level analysis might also be undertaken in the context of a skills sectoral study to model supply constraints, but the study has not noted cases of this being done in practice.

sector as the basis for representing it in the model. The non-low carbon sector may be given the characteristics of the wider sector (if it is dominant within the wider sector), or these characteristics may be adjusted to take account of segregation from the low carbon sector. Figure 4.1 depicts sectors addressed in this way as "Green part sector" n+1 to n+m and "Rest of sector" n+1 to n+m.

These approaches address both areas of **job growth** and of **job loss** arising from the transition to the low carbon economy. Where the sector is studied as a whole, the research covers both job growth and job loss. Where it is split between a "green part sector" and a "rest of sector", if the growth of green activity (such as renewable energy) is expected to displace demand for rest-of-sector activity (such as coal-fired generation) then this will be represented in the model by reduced demand for the outputs of rest-of-sector activity leading to reduced rest-of-sector employment.

A **study of a single sector** is represented in Figure 4.1 as either "Part-green" sector n+1 or "Green part sector" n+1. If there is no interest in indirect and induced employment effects, then in most cases there will be no need for a link to the macro level. If there is an interest in these effects, then all other sectors of the economy will be represented by sectors 1 to n. Any non-low carbon part of the sector may be represented as "Rest of sector" n+1.

4.7.7 Sector level models

Sector level models range from the very simple to the rather complex.

The principle that most follow is to project one or more measures of activity, and to derive estimates of employment from these projections.

- The link may be direct, such as an empirically established estimate of the relationship between installed wind power capacity and employment in wind operations and maintenance. In this case, it may start from a forecast or scenario on future installed wind capacity, and use the empirically established relationship to generate a projection of what this means for employment.
- It may be indirect. For example, the model may start from a forecast or scenario on the future rate of installation of new solar photovoltaic panels, and convert this to a projection of spend based on a view of future costs. It may then break this projection out between labour and non-labour cost elements, and apply an estimate of labour costs to convert this to an employment projection.

While the latter approach may appear more awkward, it is necessary to include estimates and projections of the value of activity somewhere in the model if it is to be linked to a macro level analysis through an input-output table. In some cases, the model may even start with an estimate of the value of activity, such as where the employment to be measured is driven by predictable spending under a programme of capital expenditure.

Based on past experience with skills research in sectors not specifically related to the transition to the low carbon economy, there can be cases where trends in employment in growing sectors are more stable and predictable than trends in other indicators. In these cases, projecting employment directly based on existing trends may be justifiable, subject to a careful assessment of the possibility that the trend may end or undergo some other form of discontinuity.

Employment in different parts of a sector may be driven by different types of activity. For example, a stylised view of drivers of employment in most renewable electricity sectors is that:

- The appropriate measure of activity for employment in project development, construction and installation is the new capacity[15] installed each year in the country or region being modelled;
- The appropriate measure of activity for employment in design and manufacturing is the new capacity installed each year globally (as the main producers of equipment depend heavily on export markets); and
- The appropriate measure of activity for employment in operations and maintenance is the installed capacity.

There is no single right way to choose the measure of activity or activities on which a sectoral employment model is based. It should be founded both on a strong qualitative analysis of the sector and on quantitative data from the available statistical sources. Relationships between the measure of activity, value of activity and employment should be established through empirical research where sufficient information is not already available from statistical sources or earlier research.

4.7.8 Linking sectoral employment to occupational employment

Linking sectoral employment to occupational employment is straightforward in principle. Employment totals projected for each sector are multiplied by a

[15] Electricity capacity is measured in megawatts (MW), gigawatts (GW), terawatts (TW) etc.

sector-occupation matrix describing the occupational composition of employment in the sector.

In most developed countries, up to date sector-occupation matrices are easily available, derived from labour force surveys, with population census data sometimes providing an alternative, if less frequently updated, source. Many developing countries also have labour force survey data that can be used for this purpose, although it is not always very current.

However, the occupational structure of sectors has time dependencies that should be taken into account.

- In most sectors, there are existing trends in occupational structure that will not cease because of the transition to the low carbon economy. Projections of employment by occupation should take account of these where they are significant.
- Where a sector includes a number of subsectors, some of which are growing, and some of which may possibly be shrinking, these shifts are likely to change the occupational composition of the overall sector. For example, an electricity generating sector with growing variable solar or wind capacity, shrinking baseload coal, and growing gas powered peaking capacity (to compensate for variations in solar and wind) will show significant changes in occupational composition attributable just to changes in relative sizes of the subsectors concerned.
- Sectors subject to significant innovation may display discontinuities with past occupational trends. As the sectors most directly involved in the transition to the low carbon economy are in many cases experiencing significant innovation, projections of employment by occupation should ideally endeavour to take account of these discontinuities. This will require sector level research.
- For sectors segregated from standard sectors in the analysis, including newly emerging sectors, existing data from standard statistical sources may not provide useful insights into occupational composition. In these cases, there is likely to be a need for sector level research to provide a basis for projecting employment by occupation.
- In some cases new or significantly changed occupations will become significant in particular sectors. The sector level research into occupations can address this if it is not tied rigidly to a standard system of occupational classification.

When modelling employment numbers by occupation, it is necessary to take care to ensure not just that the numbers themselves appear plausible, but that the rate

of change in the numbers is plausible too over the period covered by the projection. The rate of change in numbers is often the main component of projections of occupational labour demand (or indeed projections of job losses) derived from employment projections.

Stops and starts in projected employment growth can imply big fluctuations in labour demand. This is a useful model feature if they are likely to occur in practice, but is a problem where they are only an artefact of the model's design.

4.7.9 Linking occupational projections to projections of occupational labour demand

While a considerable amount of skills research stops at the point of projecting employment at the level of the occupation, some goes beyond this to generate projections of labour demand.

There are two main components to labour demand for an occupation in a sector:

- Growth-related demand; and
- Replacement demand.

Growth-related demand is demand that arises from growth in numbers employed in the occupation, and it can be calculated arithmetically based on the change in numbers projected to be employed from one year to the next.

Replacement demand is demand that arises from people leaving employment in that occupation in the sector, and needing to be replaced. Where people move between employers in the same sector, without changing occupation, they do not need to be replaced and so do not count towards replacement demand.

Projections of replacement demand are most often calculated as a percentage of numbers currently employed. The decision on what this percentage should be is not straightforward. Researchers frequently choose and state a number they feel is plausible, giving a mainly qualitative explanation for their choice.

However, it is possible to look to quantitative sources for some guidance.

- The US BLS, for example, includes replacement demand estimates in its Occupational Employment Projections.
- In principle, it should be possible to obtain estimates of historical replacement rates from labour force survey data where the survey is based on panel

of households that allows employment sector and occupation to be compared with that from an earlier period.[16]

- Enterprise surveys can be used to collect data that throws light on replacements, for example by asking about numbers in an occupation recruited from outside the sector over a period of a year.
- Data on labour turnover at businesses prepared by some national statistical agencies, or from enterprise surveys, can be used to place an upper bound on numbers leaving the sector.

However, the likelihood is that the replacement rate will vary significantly over time, depending on labour market conditions, and potentially on the age profile of the labour force. Under conditions of strong demand and limited alternative opportunities, replacement will be low, and vice versa. An overwhelmingly young workforce will not lose significant numbers to retirement, while a workforce with an older age profile may lose very significant numbers each year.

4.7.10 Comparing projections of occupational demand with supply

There are only limited cases where it is possible to mechanically match a projection of demand for an occupation with a projection of the supply of new people suitable for entry into the occupation. In most cases, it is necessary for a researcher to have a very good qualitative understanding of the occupation and of the available sources of supply in order to devise a way to make them comparable.

Particularly with new and changing occupations, and with occupations shared by other sectors, it is necessary to understand:

- What the existing sources of skills area, and what the alternatives are; what sources are core and what can be used if the core supply is insufficient;
- Whether the sources are flow (new graduates of initial education and training courses) or stock (people already working in the sector or in another sector, or unemployed);
- What the competing destinations are, and what share it is reasonable to expect the sector to be able to attract.

[16] For example, Eurostat's LABOUR FORCE SURVEY records include a variable for the sector of "Economic activity of local unit in which person was working one year before survey" – NACE1Y2D.

The answers to all of these questions are likely to be contingent on the sector and on the specific institutional arrangements in each country. It takes a significant effort to make an analysis such as this fit the reality seen in industry, so it is best applied to a small number of key occupations, if it is used.

Sources of data particularly useful in calibrating the match between supply and demand against current and historical reality include vacancy surveys, surveys of graduates of initial education and training courses and data on vacancies recorded by public employment services and (if treated with a degree of scepticism and regard for double counting) recruitment agencies. Graduate surveys containing data on sector and occupation of employment can be particularly useful in quantifying historical flows from initial education and training.

4.7.11 Choice of methodologies

A key issue in choosing methodologies is the scope of the information and of existing models already available.

Developed countries with well developed statistical systems, established macroeconomic models and often an existing base of relevant sector level skills research, have more options than developing and many emerging countries.

If there is no existing, established CGE model that can be adapted, then constructing one for the purposes of research into skills for the transition to the low carbon economy is unlikely to be a serious option.

It is more likely that an existing SAM or DySAM will be available to a developing country, if only because this is part of the toolkit that the ILO often brings to assisting developing countries. If such a model is available, then adapting it is likely to be a good choice.

If the researchers (whether in developed, emerging or developing countries) do not have direct access to an established model and are interested in whole economy effects, then an input-output model may be a good choice because its relative lack of complexity will allow useful results to be produced with more limited work than would be required for a SAM or DySAM.

While information on indirect and induced employment effects is useful in obtaining a full picture of the impact of measures associated with the transition to the low carbon economy, even research that looks just at direct employment in the sector or sectors of most interest is frequently very valuable. Many skills researchers, even in developed countries, decide against looking at induced employment effects, and a significant amount of skills research focuses on specific sectors without regard for indirect employment up and down the value chain.

Researchers in a country where there are problems with data availability are more likely to choose to focus narrowly on the specific sector or sectors of greatest policy interest.

In undertaking research at the occupational and skills level, there is always a balance to be struck between focusing on hard data on occupations and the mostly more qualitative information that can be collected on skills. In countries with relatively good data availability on occupations, such as from a labour force survey that is coded to ISCO 4 digit level, it is possible to place a heavy emphasis on quantitative occupational analysis, and to emphasise mainly what is new in skills in qualitative analysis. Researchers in countries where occupational data is unavailable or available only at a highly aggregated level are more likely to decide to focus on qualitative aspects of skills to compensate for weaknesses in their data.

4.8 Conclusions

Quantitative analysis in skills research in the transition to the low carbon economy spans the four main levels highlighted in a previous chapter.

- Macroeconomic
- Sectoral
- Occupational and skills
- Training and education

Approaches to quantitative analysis within these levels vary significantly, but approaches taken to linking them are fairly standard.

- Input-output Matrices (or similar SAM and supply-use matrices) are used to link macro analysis to sector analysis.
- Sector-Occupation matrices are used to link sector analysis to occupational analysis.
- Calculations based on changes in numbers employed plus replacement demand are used to link occupations to demand; substantial qualitative analysis are required to make this comparable with data on manpower supply.

It is possible for research projects to focus just at sector level or just at macro level, but most span and link both levels.

There is no single correct approach to macroeconomic analysis. The choice is contingent on context, the research question and the resources available to the researcher.

- Input-output and SAM models are relatively transparent, easy to understand and communicate to policy audiences, and require a relatively modest amount of work to establish from scratch
- CGE models are complex, require much work to establish from scratch, difficult to validate and require trust from policy audiences because of their complexity. However, they have advantages in areas such as modelling supply constraints, and the obstacles can be reduced greatly if an existing model with a solid track record can be adapted.

Time dependencies are important in modelling quantitatively beyond the short term.

- This points towards use of DySAM or CGE models for longer term research questions, incorporating assumptions on developments in areas such as labour productivity, supply constraints, price dynamics, carbon pricing among others.
- Assumptions about developments in technology, labour productivity and industry structure should also be taken into account in sector level models.
- Occupational modelling should take account of likely future changes in occupational structure.

Section
5

Linking Employment Models to Skills: A Case Study

5.1 Introduction

The methodological review presented in the preceding section of this report focused mainly on methods for estimating employment effects of the transition to the low carbon economy. In some cases, research studies also included an analysis of skills or occupations. However, this area of analysis remains relatively underdeveloped.

Many of the models and methods described thus far can be adapted to look at skills in greater depth. This requires combining the basic features of the models with available information on occupations and skills. To illustrate how this can be done, we go through the method used to assess the skills profile of jobs that were expected to be created by the implementation of the green economy provisions of the US stimulus package – ARRA.

5.2 Green Prosperity

The main focus of this section is the report, *Green Prosperity*, a study published by PERI (Pollin, Wicks-Lim and Garrett-Peltier, 2009). In preparing the *Green Prosperity* analysis, PERI developed a methodology to bridge from the very general data from input-output tables on job creation to relatively detailed statistics available through surveys conducted by the BLS. The analysis explored the differences in employment that would arise from an investment in "clean energy" from an equal investment in fossil fuel energy.

The basic strategy to identify the types of jobs that would be added to the economy by either of the two types of invetment involved two steps.

- The first step was to calculate each industry's share of total employment created through either an investment in clean energy or fossil fuels. The percentage of new employment generated in each of the sectors in its input-output model was calculated. These industry shares took into account the direct, indirect, and induced employment effects.
- The second step was to combine this information on the industry composition of new employment created by investing in each energy sector with data on workers currently employed in the industries. PERI used the characteristics of these workers to determine the types of occupations (and the credential requirements of these occupations) that would add jobs with an investment in each energy sector. Data on current workers came from the 2008 Current Population Survey (CPS) – a national, monthly labour force survey.

PERI used the industry shares to weight the worker data in the CPS so that the industry composition of the workers in the CPS sample matched the industry composition of the new jobs that would be added by investing in the energy sector. This was accomplished by using the industry shares to adjust the CPS-provided sampling weights. These weight the survey sample so that it is nationally representative. Industry shares were used to adjust these sampling weights so that the sample of workers in the CPS was representative of the industrial mix of jobs that input-output analysis estimated would be produced by new investments in clean energy or fossil fuels.

In order to create the weights, PERI first aggregated the 440 industry shares to the 3-digit level NAICS industries (for a total of 69 industries). This allowed them to merge the industry share data to the CPS worker data using the most detailed industry variable provided in the CPS. So, for example, at the 440 sector level there are 7 construction sectors, while at the 3-digit NAICS level there is 1 construction industry.

The CPS-provided sampling weights were adjusted by multiplying each individual worker's sampling weight with the following:

$$S \times \frac{\text{Input-output model estimate of employment, industry i}}{\sum \text{CPS sampling weights, industry i}}$$

where S is a scalar equal to the number of jobs produced overall by the particular level and type of investment being considered. For example, in the analysis of the

job characteristics of the employment generated by a USD 150 billion investment in the US clean energy sector, S was set equal to 2,505,732.

These adjusted sampling weights were used to estimate the proportion of workers in each energy sector that has:

1. A high school degree, and no college experience;
2. Some college, but no 4-year university degree; and
3. A 4-year university degree or more.

It was then assumed that the same proportion of jobs in each energy sector required each level of education credentials.

As Table 5.1 shows, it was possible to provide a breakdown of the distribution of jobs created by USD 1 million in spending on both clean energy investments or within the fossil fuels sector by categories of general skill defined by

Table 5.1. Breakdown of job creation from energy sector spending in the United States. Total jobs created by formal educational credential levels per USD 1 million in spending (includes direct, indirect, and induced jobs)

	1) Green Investments in Energy	2) Fossil Fuels	3) Difference in Job Creation (= column 1 – 2)
Total job creation	16.7	5.3	11.4
College-degree jobs – BA or above – USD 24.50 average wage	3.9 (23.3% of green investment jobs)	1.5 (28.3% of fossil fuel jobs)	2.4
Some-college jobs – Some college but not BA – USD 14.60 average wage	4.8 (28.7% of green investment jobs)	1.6 (30.2% of fossil fuel jobs)	3.2
High-school or less jobs – High school degree or less – USD 12.00 average wage	8.0 (47.9% of green investment jobs	2.2 (41.5% of fossil fuel jobs)	5.8
Note: High-school or less jobs with decent earnings potential – USD 15.00 average wage	4.8 (28.7% of green investment jobs)	0.7 (13.2% of fossil fuel jobs)	4.1

Source: Pollin, R. et al. 2009. *The Economic Benefits of Investing in Clean Energy. How the economic stimulus program and new legislation can boost U.S. economic growth and employment*. PERI. Center for American progress.

Table 5.2. Occupations with large growth potential through green investments in the United States

College Degree Jobs	High-School or Less Jobs
• Operations managers	• Agricultural workers
• Human resource managers	• Janitors
• Sales managers	• Machinery assemblers
• Lawyers	• Grounds maintenance workers
• Accountants	• Material movers
• Architects	• Cashiers
• Civil engineers	• Customer service representatives
• Electrical engineers	• Retail salespersons
• Mechanical engineers	• Shipping clerks
• Computer programmers	• Stock clerks
Some College Jobs	**High-School or Less Jobs with decent earnings potential**
• Construction managers	• Carpenters
• Farmers and ranchers	• Construction labourers
• First-line supervisors of office workers	• Electricians
• First-line supervisors of production workers	• Insulation workers
• Engineering technicians	• Roofers
• Computer support specialists	• Machinists
• Accounting clerks	• Sheet metal workers
• Payroll clerks	• Bus drivers
• Secretaries	• Industrial truck drivers
• Paralegals	

Source: Pollin, R. et al. 2009. *The Economic Benefits of Investing in Clean Energy. How the economic stimulus program and new legislation can boost U.S. economic growth and employment*. PERI. Center for American progress.

educational attainment.[17] It was possible to further refine the information about the skill needs for clean energy activities by using labour force survey data to identify the most common occupations – defined in terms of current occupational categories – in the "clean energy" sector.

[17] Note that these job figures are presented as FTE figures, but do not otherwise have an explicit time dimension. They represent the total number of FTE jobs created through spending USD 1 million on the various activities incorporated in both the "green investment" and "fossil fuel" categories. For example, if USD 1 million is spent on green investments over one year, the job creation figure will represent the jobs created over that one year of spending. If the USD 1 million is spent over two years, then the job-creation figure will be that for the full two year period in which the money was fully spent down.

(Reporting of jobs supported by the stimulus programme was subsequently changed to being based on full time equivalents worked in each quarter).

Qualitative information from industry literature was also used to guide the final selection of occupations among those identified in the proxy industry definition of the green sector.

An example is provided in Table 5.2. This analysis is for a clean energy program that includes building weatherization, renewable energy, smart grid, and mass transportation elements. All direct, indirect and induced jobs generated from this increased activity were considered. The analysis could also have, however, been focused in different ways: for example, on a particular sector separately and/or on jobs generated directly.

This list of occupations approximates the types of occupations, among those currently identified through the CPS that can be expected to add the greatest number of jobs. Such a profile of occupations defined by existing job categories also provides some guidance on the amount, although not the exact content, of the training or education that newly created occupations in clean energy sectors may require.

Take for example, the occupation of wind power technician. This is a relatively new occupation and as a result, the current CPS labour force survey does not have a way to identify workers holding this specific position. However, according to a detailed case study of the wind power industry conducted by the US DOL, the duties and training requirements of this new occupation are similar to two other occupations that are currently identified in the CPS, these being industrial machinery mechanics and millwrights. Moreover, industrial machinery mechanics and millwrights are associated with existing industry categories used to proxy for the "clean energy" sector. Consequently, identifying a profile of occupations based on existing categories that include millwrights and industrial machinery mechanics instead of wind power technicians can still provide useful information about the general skills required in green industry sectors. Industrial machinery mechanics and millwrights require some level of formal training beyond their high school degree, either through an apprenticeship, courses for certification, or an associate's degree. This is the same as is the case with wind power technicians, according to the findings of the DOL's case study.

In addition, PERI sought to distinguish jobs with low qualifications requirements for which there might be greater opportunities for advancement, including through training programs. It was possible to perform this exercise by using the analysis of CPS data on occupations, combined with US Department of Labor data on the education and training requirements for each occupation provided in its Occupational Outlook Handbook. This handbook identifies the "most significant source of post-secondary education or training" for each occupation on the basis of analyses of qualitative and quantitative information. Table 5.3 provides an illustration of how this was done for a limited set of occupations.

Table 5.3. Training requirements among selected "high school or less" jobs

Occupation	Most Significant Source of Education or Training
Carpenters	Long term on-the-job training
Construction Labourers	Moderate term on-the-job training
Construction Painters	Moderate term on-the-job training
Bus Drivers	Moderate term on-the-job training
Industrial Truck Drivers	Moderate term on-the-job training

Source: PERI background report.

Categorizing potential employment this way can be used to identify potential general skills gaps. In particular, it is possible to see the general skills demands, defined by workers' educational credentials, that will arise from increased investment in green activities. If the current or projected supply of workers does not match the set of general skill needs that these activities would add, this would identify a general skills gap. It would be necessary to take account of workers not required by the fossil fuel sector, due to contraction in that sector.

What cannot be obtained from these data is information about the new specific skill demands arising from the "clean energy" sector. These new skill needs will arise among both new occupations such as wind turbine service technicians, or current occupational categories operating in a new clean energy industry. Some examples would be an electrician now responsible for installing a net meter to operate with solar panels or a carpenter who must employ green building techniques. It is necessary to get information about these specific skill needs from other data sources such as industry case studies or employer surveys.

The US DOL's report mentioned above, "Careers in Wind Energy," is illustrative here. This report describes what is currently known about the education and training of wind turbine technicians by combining information from the sources such as industry reports from the American Wind Energy Association and academic research on wind power generation. These qualitative sources of information detail the occupations in the wind power industry, as well as the education and training requirements of these positions. This excerpt illustrates:

> "Most of the occupations detailed in this section are not specific to the wind power industry. Although many of these jobs require special skills unique to wind power, in most cases, skills can be acquired in other industries. For most positions the wind companies hire people with experience in other industries and given them wind-specific training. The primary exception to this trend is the wind turbine service

> technician. Currently, a large portion of these technicians learn on the job or through apprenticeship programs. However, as more vocational training programs are developed and training is standardized, technicians will be expected to have formal training and a certificate of a degree (Hamilton and Liming, 2010, p. 8)."

Another example comes from a report by the New England Clean Energy Council, which sets out detailed information about firms that provide energy efficiency services in commercial and industrial settings. The report uses survey data collected from firms identified as "energy saving performance contractors" to produce an occupational profile of these firms, including descriptions of the duties of each occupation and the number of jobs per occupation category.

A more comprehensive picture of these new specific skill requirements can be developed as more qualitative and sector-specific studies become available. Such studies will provide better information about which current occupational categories should be replaced with new occupations, and thereby provide a more precise occupational profile of the "clean energy" sectors. They will also provide better information about the new specific skills required of current occupations operating within the new industries.

5.3 Monitoring and evaluating employment estimates

Many of the methodologies described earlier in the report base their employment estimates on modelling exercises. As discussed at some length, all of these models require making simplifying assumptions about technology, linkages between sectors, prices, constraints, and other factors. It is important to be able to check these assumptions *ex post* in order to evaluate whether the model is producing reasonable estimates – i.e. predictions which can be used as a basis for policy formulation.

We can once again use the example of the employment estimates that PERI generated to illustrate in some detail how such a monitoring and evaluation exercise could be conducted.[18] Recall that the input-output estimates focused on the employment impacts of the green economy provisions of the US stimulus package. One of the major implementing agencies for this part of the stimulus spending is the US DOE. Through a collaborative arrangement with the DOE, PERI has access to reported jobs figures in addition to having estimates generated by its

[18] The review of literature for this report found no other concrete example of monitoring and evaluation of employment estimates. The PERI study summarized here was possible due to the collaborative arrangement between PERI and the implementing agency, in this case, the US DOE.

Table 5.4. Small US Energy Department Grant Contracts from ARRA stimulus program

	Estimated jobs per project from PERI model	Reported jobs per project from Energy Dept. field reports	Difference between estimated/reported number of jobs	Percentage difference between estimated/reported figures
2009 Q2-3	3.6	3.9	0.3 jobs	– 8
2009 Q4	2.9	1.6	1.3 jobs	+ 45
2010 Q1	2.3	1.9	0.4 jobs	+ 17

Source: PERI analysis for US Dept. of Energy.

Table 5.5. Large US Energy Department Grants from ARRA stimulus program

	Estimated jobs per project from PERI model	Reported jobs per project from Energy Dept. field reports	Difference between estimated/reported number of jobs	Percentage difference between estimated/reported figures
2009 Q2-3	29.6	63.2	33.6	– 114
2009 Q4	48.6	54.3	5.7	– 12
2010 Q1	50.0	48.6	1.4	+ 2.9

Source: PERI research for US Dept. of Energy.

own input-output model. It can, therefore, compare reported jobs created with estimated jobs created, in order to see how well the model performs.

Tables 5.4 and 5.5 present figures for government grant-funded projects that compare the estimated figures for job creation versus the reported figures. They concentrate on grant-funded projects, excluding contract-funded projects as data on funding through contracts are less reliable than for grant funding. Results for small projects (those with operating budgets of USD 5 million or less) and for large projects are presented separately. All of these figures refer only to direct job creation, and do not include indirect or induced effects.

Focusing first on the most recent 2010 Q1 data with small projects, it may be seen that the difference between estimated and reported job creation is quite small, that is between the 2.3 average estimated figure and the 1.9 average reported figure. This amounts to a difference of 0.4 jobs or 17 per cent. This estimate is substantially closer than that for 2009 Q4, when the difference was about 45 per cent.

The results are at a level of accuracy approximately equal to that for 2009 Q2-3. However, in 2009 Q2-3, there were only 35 small grant projects in the total data pool, while by 2010 Q1, the full small-grant data pool had risen to 838 projects. In short, on the basis of these descriptive statistics, it is reasonable to conclude that the estimates are quite accurate in estimating job creation for small grant-based projects.

Table 5.5 reports similar figures for large grant-funded projects. Focusing on the findings for 2010 Q1, a substantial convergence between the estimated and reported figures can be seen, both relative to the previous two data sets and in absolute terms. That is, the input-output model based estimate for large grant projects was 50.0 jobs, while the reported jobs figure is 48.6 jobs, a difference of only 1.4 jobs on average between the estimated and reported figures. This is a difference of 2.8 per cent, covering a total of 260 projects. With these large grant-funded projects in particular, the difference between the input-output based estimates and the reported figures was much smaller for 2010 Q1 data than for earlier figures.

All else equal, one might expect larger variations between estimated and reported figures with the larger grant-funded projects, because the managers of these projects, with larger budgets, operate with greater latitude in their spending and hiring decisions. The very close fit with the 2010 Q1 data on large grant-funded projects therefore provides evidence that the input-output model is a robust tool for generating job estimates with regard to the relevant expenditures in the US fiscal stimulus package.

PERI also performed a series of standard regressions to analyze the statistical relationship between the DOE's jobs estimates and the reported employment creation linked to ARRA-funded projects.
The following relationship was estimated.

$$R_i = \alpha E_i + \varepsilon_i$$

R_i represents the reported number of jobs for project 'i,' E_i represents the estimated number of jobs, and ε_i is a random error term. The sample was restricted to projects for which $R_i > 0$ and $E_i > 0$.

R-squared measure describes the fraction of the total variance in reported employment explained by the estimated regression. For example, for the fourth quarter of 2009, excluding contractors, 61 per cent of the variation in the reported jobs numbers was explained by the regression model. The explained variance improved to 76 per cent in 2010-Q1, while the coefficient estimate (α) remains essentially the same.

PERI concluded that it was reasonable to conclude that the estimates that the model generates are robust predictors of the reported job figures for all grant-based DOE clean energy projects.

5.4 Conclusions

The case study presented demonstrates in a practical way how one important policy research programme tackled linking employment projections emerging from a model through to estimates of skills needs. In doing so, it demonstrates that qualitative research is important to quantitative modelling, both as a source of information for modelling and as a basis for interpreting quantitative results in terms of occupational and skills requirements.

The case study also demonstrates that it is both practical and useful to evaluate the quantitative findings of skills anticipation research in the context of the transition to the low carbon economy. In the specific case covered, it was found that actual direct employment outcomes from the stimulus programme reviewed were predicted well by the model.

Section
6

Data Availability for Quantitative Analysis

6.1 Introduction

One of the most significant information gaps that quantitative researchers encounter when estimating employment effects and skills requirements associated with green economic activities is that data for variables which would allow the exact identification of green activities often do not exist. This problem applies to enterprise surveys, labour force surveys, and economic models built on an input-output foundation. As survey instruments and available data evolve, this information gap may narrow over time. At the current time, it poses an important challenge.

To get around this constraint, research into jobs and skills in the green economy almost always has to draw on multiple sources of information in order to proceed. For example, the proxy industries constructed within some input-output models to represent green activities are created based on information available on the activity in question, such as retrofits, 'smart-grid' or renewable energy investments. Industry sources may be used to create realistic proxies. In such cases, in effect, industry case studies or surveys are performed to provide content lacking in the basic input-output model. As described earlier, when researchers deemed the level of disaggregation of the Hungarian input-output model too crude to analyze retrofit spending scenarios, they supplemented the economic model with information from case studies.

When critical data are simply missing, information available from other sources which apply to a different, but closely related, context can be used to produce a reasonable approximation of the data actually needed. For example, in a

study of clean energy and energy efficiency jobs in Ontario, Canada, occupational profiles from similar jobs in the United States were used to create estimates of what types of jobs could be expected from green investments in Ontario (Pollin and Garrett-Peltier, 2009).

In cases in which the information needed for analysis using enterprise surveys, labour force surveys, or economic models is underdeveloped, qualitative methods can be used to fill the gap. This could occur when the available data are too general to establish reliable proxies for green activities.

At the current time, no country provides a full set of tools and data for estimating employment effects and skill profiles associated with the transition to the low carbon economy. Some countries have better information than others. Moreover, as green industries grow in the future, it is to be expected that data will improve. Nevertheless, analysis of employment and skills for the green economic transformation will require using multiple methods and sources of information. The precise mix will vary from country to country, as will the relative weight of quantitative versus qualitative methods. The challenge is to develop a research approach which is reliable, relatively transparent, and reflects the context of the country in question, given the information constraints which exist. It should be noted that, in the case of most European countries, data can be obtained from Eurostat as well as from individual countries.

6.2 Data availability for selected countries

We focus on two key tools frequently used in quantitative modelling of skills requirements, to evaluate whether the more quantitative approaches discussed in this report could be applied to a range of countries.

The first tool is either a reasonably high-quality and up-to-date national input-output model, or supply-use tables on which a national input-output model can be built. The reason for focusing on the availability of the building blocks of an input-output model is that many of the models discussed in this report use an input-output model as a basis (e.g. SAMs and most CGE models that include sectoral detail).

The second tool is a labour force survey, which can provide more detailed information on occupations and skills. Input-output or supply-use tables can come either from national statistical bureaus or, in some cases from the OECD or Eurostat, while labour force and employment surveys are all from national statistical sources or from Eurostat.

Table 6.1. Availability of basic input-output data in selected countries

Country	Availability	Industries Listed	Most recent years
Americas			
US	Y	420	2008
Canada	Y		2007
Brazil	Y	50	2005
Costa Rica	Y		2002
Guatemala	Y		2001
Africa			
Botswana	Y		1996-97
Egypt	N	na	na
Ethiopia	Y		2005-06
Ghana	Y		2005
Madagascar	Y		2002
Malawi	Y		2005
Nigeria	Y		2006
Senegal	Y		1996
South Africa	Y	90	2002
Asia/Pacific			
Australia	Y	100	2005-2006
China	Y		2007
India	Y	130	2003-2004
Indonesia	Y (OECD)		2005
Japan	Y	110	2005
Korea	Y	80	2008
Philippines	Y		
Thailand	Y	180	2005
Turkey	Y		2002
Europe			
Denmark	Y	130	2006
Estonia	Y	60	2005
Finland	Y	60	2007
France	Y	115	2008
Germany	Y	70	2007
Netherlands	Y	25	2009
Spain	Y	60	2005-2006
UK	Y	120	2008

Source: Heintz, Pollin, Wicks-Lim, 2011. *Employment Opportunities and Skill Requirements for Building the Green Economy: A Survey of Research Methods*, PERI, University of Massachusetts-Amherst, Prepared for the International Labor Organization (ILO), unpublished.

Table 6.2. Availability of labour force survey and establishment survey data for selected countries

Region & Country	Establishment Survey	Labour Force Survey	Type of Data Collected Concerning Skills
Americas			
US	Y	Y	Education Attainment
Brazil	Y	Y	Education Attainment
CostaRica	?	Y	
Guatemala	?	Y	
Africa			
Botswana	?	Y	
Egypt	Y	Y	None
Ethiopia	?	Y	
Ghana	?	Y	
Madagascar	?	Y	
Malawi	?	Y	
Nigeria	?	Y	
Senegal	?	Y	
SouthAfrica	Y	Y	Education Attainment
Asia/Pacific			
Australia	?	Y	Education Attainment
China	?	Y	Education Attainment
India	?	Y	
Indonesia	?	Y	Education Attainment
Japan	Y	Y	Education Attainment
Korea	Y	Y	Education Attainment
Philippines	Y	Y	Education Attainment
Thailand	?	Y	None
Turkey		Y	
Europe			
Denmark	Y	Y	Education Attainment
Estonia	?	Y	Education Attainment
Finland	Y	Y	Education Attainment
France	Y	Y	Education Attainment
Germany	Y	Y	Educ. Attn. & Training
Netherlands	Y	Y	Education Attainment
Spain	Y	Y	Education Attainment
UK	Y	Y	Educ. Attn. & Training

Source: Heintz, Pollin, Wicks-Lim, 2011. *Employment Opportunities and Skill Requirements for Building the Green Economy: A Survey of Research Methods*, PERI, University of Massachusetts-Amherst, Prepared for the International Labor Organization (ILO), unpublished.

Table 6.1 indicates whether there are input-output or supply-use tables available for selected countries, and the level of detail in these tables. As may be seen, adequate input-output or supply-use tables are available for all developed countries reviewed, and for most developing countries, although in some cases the tables are rather dated.

Indonesia is a case where it appears that the national statistical agency has not produced an input-output or supply-use table, but that the OECD did produce one in 2005.

Table 6.2 reports on the availability of labour force and employment survey data for the same selection of countries. All of the countries reviewed have labour force surveys, and many also have establishment surveys from which to observe labour market conditions. Of course, these surveys vary in their degree of coverage and their frequency.

6.3 Conclusions

Based on the level of data availability found, it is possible to conclude that it will be feasible to conduct quantitative research on the green economy and employment along the lines described in the report in all developed countries, the major emerging countries, and many developing countries.

Section

7 Qualitative Research

7.1 Introduction

This section addresses qualitative research into skills for the transition to the low carbon economy under the following topic headings:

- Review of qualitative studies
- Linking qualitative data to quantitative models
- Qualitative research methods

7.2 Review of qualitative studies

This section analyses and compares studies on changing skill needs for the low-carbon economy that are largely based on expert opinion. The studies give a qualitative picture of changes in job content, and commonly do not refer to numbers of skilled people needed. Most studies reviewed take a sectoral perspective.

The ultimate objective of these studies is to (i) adjust the existing education and training offer – by public or private training providers, sector organizations or companies – to the new demands, and (ii) to orient students or job seekers to newly arising employment opportunities. This review does not assess if study findings actually translated into changes in skills policies and systems, it is only concerned with research methodologies.

Most study designs follow well-established empirical research methodologies. They start by reviewing available literature to understand drivers of change and the sector context, define the research question and design the research process, choose

a sample of key informants or other target groups to be addressed and a sampling strategy, choose the appropriate method to obtain information (interviews, focus group discussions, observation), collect information, analyze and validate it.

Validation is an important step in qualitative research, since research samples are usually small, and findings risk being unbalanced. In order to enhance the robustness of the findings, further expert opinion is consulted.

A good example is a study on "trend qualifications"[19] in agriculture in Germany. In order to verify if the identified trends were confirmed by the sector, researchers conducted additional expert interviews among around 100 companies, associations and training institutions in the sector to check the validity of initial findings. At the end of this process, another expert workshop validated the findings (Abicht, et al., 2006).

The following comparative analysis is organized into three major areas of interest:

- The first addresses changing skill needs in general terms: What skills will be increasingly in demand? What are the new skills needed now and in future? What combinations of skills will be most needed?
- The second relates to the occupational level: What are the key occupations for greening? Which occupations are changing? Which occupations will be most in demand? Are there newly emerging occupations?
- The third focuses on studies that build a direct link to the training offer: Are current training offers meeting the skills demand? Which existing courses need to change? Are new initial or continuing training offers needed?

Studies can be categorized broadly into these three areas of interest. It has to be noted that many studies span across all three areas, but put particular emphasis on one of the three. Several studies also address other issues such as quality of work, wages, current training provision in companies, or changes in technology, among others, that are not part of this analysis.

Identifying changing skill needs

The first category of studies is interested in fairly detailed changes in particular types of skills. The studies usually address enterprises that are the ones to define

[19] Trend qualifications are described as qualification/occupational requirements that become apparent in enterprises, and for which future demand is likely to increase.

skills demand. The people interviewed are managers, human resource officers, or employees affected by changing tasks. The information obtained is often complemented with information from key informants from business associations, professional associations, trade unions, academia and government experts.

Some studies ask open questions such as: What new skill requirements arise from new, less carbon-intensive activities? A 2005 study on the qualification requirements in the offshore wind energy covering five countries (Denmark, Germany, Belgium, the Netherlands and the UK) provides a good example. The offshore wind energy sector was divided into eight sub-sectors,[20] and key informant interviews were supplemented by interviews with managers and employees of 32 large, medium and small companies. Ten types of skills were identified as being in demand, to differing degrees depending on the sub-sector (Hammer and Rohrig, 2006). This study did not distinguish explicitly between current demand and expected future demand.

A study in the UK assembled a very detailed list of "green skills" relevant across all sectors. Researchers collected information through interviews with 'priority organizations' (many UK Sector Skills Councils, Institute of Environmental Management, Carbon Trust) and 'other organizations' (Universities and Colleges, other UK skills councils, government departments, Professional Bodies/Business Support Agencies and National Skills Academies) (ProEnviro, 2009).

Another approach to identifying changing skill needs is to provide a pre-selected list of skills and ask experts or enterprise representatives to estimate demand. A German study on continuous monitoring of skills needs aiming at early identification of change in tasks and in enterprises in the renewable energy sector (divided into six production stages from development to maintenance and disassembly) applied this method. It developed the questionnaire in an expert workshop and interviewed human resources managers in 334 companies. Experts were asked to estimate demand for 35 general and 16 specific skill needs. This study distinguished between current demand (ranked on a 0-4 scale) and expected future demand (ranked on a 1-7 scale). The information was coupled with further information obtained about framework conditions in the sector, market developments, core business activities and task clusters, innovations, R&D, role of early identification of skills in the company, and general trends in skills development. The study finally came up with general and specific hypotheses about various aspects of skills change and the driving factors behind them (Gensicke, et al., 2005). A study on the waste management sector in Scotland provided multiple

[20] Planning/ Development/ Finance/ Insurance, Foundation technology and tower construction, Mechanical engineering and plant construction, Plastics and fibre composite technology, Electrical engineering, Assembly and logistics, Service, maintenance, repairs and Maritime construction.

choice options based on pre-defined skills. Respondents in companies were asked to tick the skills they felt needed to be developed in the industry to meet future needs and improve competitiveness (Forward Scotland, 2005).

Following the identification of specific skill needs, studies may also enquire about combinations of skills. This can be done by building up randomized skill profiles for hypothetical candidates. Human resources managers are then asked to select the candidate they would prefer to hire. The German study described above took this approach (using a multivariate conjoint method) and added a second stage of interviews with 200 companies drawn from the earlier sample. Researchers selected 6 types of skills and randomized profiles for hypothetical candidates attributing high, medium or low levels of competence. The importance of the skills was ranked in the following order: client orientation, experience, cooperation, entrepreneurship, self management, internet literacy (Gensicke, et al., 2006).

In general, it is difficult for employers to identify their future skill needs comprehensively, as the challenge of anticipating consumer demand over time is difficult and they simply do not have the capacity to project for green jobs or newly arising activities, especially in a rapidly changing economic environment. Employers can define their strategies on new technologies, products and services but commonly lack the skill of translating these into demand for skills. This is why studies enquiring about future and not current skill needs, usually also involve interviews with key informants outside companies.

Linking changing skill needs to existing or newly emerging occupations

This second type of study is concerned with changes at the level of the occupation.

Identifying key occupations for environmental, low-carbon activities is one approach. Responses to this question will reveal both established occupations that play an important role in greening processes and occupations that have recently emerged. A Swiss study on clean technology knowledge identifies 69 existing occupations (of higher technical and vocational education and training) relevant for clean technology areas defined in previous studies. This part of the study only draws on literature reviews and expert knowledge of the authors (Bernhard, Zurbrügg, 2010). A study on environmental jobs in Western Australia identified key occupations through an email survey among 351 public, private and community organisations, 251 of which had already been classified as 'environmental sector organizations' , and 100 were 'general business organizations'. By asking whether

numbers in these occupations were increasing, decreasing or remaining static, researchers obtained further information about the level of demand for these occupations. Demand for 10 of the top 14 occupations in the environmental sector was perceived to be increasing (Annandale, Morrison-Saunders, 2002).

Growing demand for certain occupations can also be identified by asking companies which jobs they currently find it difficult to fill. This is an indicator for a shortage of skilled people for this occupation, although further factors need to be taken into consideration, such as business recruiting practices, attractiveness of the job, pay levels etc.

Approaches taken to identifying key occupations or occupations for which demand is increasing do not have to be linked to needs in specific skills, but they often are. Occupations can be described more in detail, which is often done by specifying tasks. These tasks then give an indication of the specific skills needed. An interesting study was conducted by Michael Page international, a large recruitment consultancy that identified the 17 occupations most in demand for green jobs in 7 green sectors[21] for which their recruitment services were requested in 2008 and 2009. For each occupation, they summarized the main tasks (Michael Page International, 2010). The above mentioned study in West Australia enquired about additional skills required for environmental occupations both currently and in future (based on a pre-defined list of skills) within the organizations surveyed. These skills needs were then disaggregated by broad ANZSCO categories such as professional, para-professional, plant and machinery operations, labourers, management and senior administrators, and clerical. Specific skill needs within occupational groups become apparent from this analysis.

If the occupation exists within a national classification of occupations, a description of tasks or skills needed for the occupation usually exists. Even so, when occupations change as sectors' activities become more sustainable, existing occupational descriptions usually do not contain specific tasks related to greening. Matching emerging skill needs with occupations is therefore relevant to updating occupational classifications.

In order to identify newly emerging occupations, studies can ask companies which vacancies they expect to open in the future. A Spanish prospective study in the renewable energy sector conducted a study among 152 companies in six renewable energy sub-sectors. It identified occupations for which companies expect to hire workers in the short and medium-term. These turned out to be both new and existing occupations. Key informant interviews from academia, social partners

[21] Renewable energy, environment, sustainable development, fair trade, living environment, waste, responsible investment funds.

and training observatories complemented the picture obtained from companies (National Public Employment Service Occupational Observatory, 2009).

A different and more elaborate way to detect emerging occupations was developed by Frequenz in Germany. Researchers aimed to identify trend qualifications/occupations in 13 sectors, some of which are relevant for the low-carbon economy.[22] After undertaking a literature review (sector scanning and scouting), researchers interviewed key informants (representatives of sector associations, research and training institutions, chambers of commerce and industry, trade unions, consulting firms etc.) and conducted expert workshops to identify sector trends and changes, and key companies that are seen as trend setters in the sector and major suppliers of new solutions/technologies. Within companies, both managers and directly concerned employees were interviewed. The research team analyzed change in societal systems, change of enterprise systems (processes and procedures), changes in work systems (including people, technology, infrastructure, work environment and materials), changes in task systems (relevant for both the work system as well as the occupation), and occupational change (including knowledge and basic skills, specialized and technical skills, attitudes and other personal traits) (Abicht, et al., 2007).

Linking changing skill needs to education and training

This third category of studies provides a clear link to education and training provision. While most studies draw conclusions and recommendations relating to skills development, not all studies are sufficiently specific to be directly useful for education and training provision. In order to provide research findings relevant for the education and training system, training pathways need to be examined.

Some studies, often related to new green sectors such as renewable energy, merely aim to improve transparency in the training market. RES Compass, a European project bringing together partners from six countries, built up a web-based information portal for high school and university students and for professional career advisors. It provides information about renewable energy sector job profiles, a career test for students to match their skills and qualifications with job opportunities, and a training database for all 27 EU countries. Four surveys

[22] One sector was renewable energy; other sectors relevant for greening are agriculture (trend qualification (TQ): energy farmer), retail (TQ: nutrition consultant), life science/biotechnology, construction (TQ: specialist for recycling in construction, specialist for green refurbishing, specialist in mudbrick building, energy consultant), and *Biologisierung*, spanning areas such as biotechnology, bionics, environmental technology, medicine and bioinformatics (TQ: Biology technician *Biokant*, specialist in bionics, specialist in bioinformatics, specialist in green biotechnology).

provided the information base for the portal, one among career advisors, one among companies in the sector, one among students, and one among education and training providers.[23]

Other studies aim to define the content for new training programs. The Brazilian government designed a large-scale social housing program which plan to build houses with solar water heating systems. Since no training in solar water heating existed, the government commissioned a study to identify the content of a training course. Apart from interviews with key informants from government institutions, social partners, consultants and training institutions, researchers conducted a survey among 35 manufacturers (response rate 26 per cent) asking for the skills content a training course should contain (Prado, Abiko, 2009).

In New Zealand, the Agricultural Industry Training Organization prepared a strategic position paper on training for sustainable management in the pastoral sector. Consultations with key informants and a brief survey among regional councils in the country identified priority topics/skills areas for the development of programs of learning in sustainable management, and proposed stages of how to design learning packages and resources (Rush, 2008).

Studies aiming at more holistic revisions of current education and training offers take a broader perspective and often more complex approaches. A fairly straightforward approach was used in the study on clean technology knowledge in Switzerland mentioned above. It analyzed training curricula for the occupations identified as being important for clean tech sectors. This analysis revealed that several training programs lacked sufficient skills content related to clean technologies. Interviews with industry experts and training professionals led to recommendations as to how training offer and existing qualifications needed to be adapted (Bernhard, Zurbrügg, 2010).

A French approach to skills identification in the context of the implementation of the Mobilisation Plan for Green Jobs is based on broader stakeholder engagement. Eleven sectoral committees (comités de filières) were set up, representing the sectors considered most promising in terms of green economy jobs creation (such as the automobile industry, building, tourism or renewable energy sectors). Their mission is to carry out a quantitative and qualitative analysis of each sector's needs in terms of skills needs, training and employment policy. As one example, the sectoral committee in the automobile industry reviewed available statistics and literature and obtained information through interviews and focus groups discussions with experts from professional organizations, trade unions, training institutions, government and large manufacturers and suppliers.

[23] See www.rescompass.org

Its study identified newly emerging skill needs in existing occupations and for new occupations, implications for education and training, and new actors to involve in training provision (MEEDDM, 2009).

A similarly complex approach is chosen in the State of New York to improve labour market information for green jobs and update training curricula in cooperative educational services, community colleges and colleges/universities. In this case, new skills needs stem from public investment, in particular from the ARRA. The approach includes qualitative research on skill characteristics of existing and newly emerging jobs coupled with statistical information on projected demand for selected jobs and on training offer and capacity. The work is being coordinated by the Department of Labor with five research partners and seven New York State government agencies, six investor-owned utility companies, two public utilities, seven business/industry associations and three trade unions. It addresses 13 green clusters identified in New York State. The methodology includes business surveys, focus groups, one-on-one meetings with human resources managers/executives, and data mining of current talent banks, student enrolment and certificates/degrees conferred (New York State Department of Labor and Research Partners).

7.3 Linking qualitative data to quantitative models

In the earlier comparative review of quantitative methods, it was noted that qualitative methods are often used to supplement information available in input-output models, SAMs, CGE models, energy forecasts, enterprise surveys, and labour force surveys. There are several important areas in which these qualitative methods can be usefully linked to economic models and other quantitative approaches.

Defining sectors. The sectors contained in economic models (input-output, SAM and CGE) often do not correspond to the green sectors of interest. Qualitative information from case studies and expert assessments can help resolve this problem of sector 'mismatch'. Specifically, the composition of expenditures on green activities can be identified and linked to the relevant sectors of the economic model.

Occupational and skills composition. Detailed information on occupational categories and skills may not be available for standard surveys, given that there is no single definition of green jobs and standard industrial and occupation categories do not precisely correspond to clean energy and green activities. In these cases, qualitative methods – including case studies, focus groups, and Delphic methods – may provide some baseline information. When combined with the

employment estimates from quantitative approaches, the qualitative information can provide insights into skills demand and gaps.

Direct employment estimates for targeted activities. As noted already, in some countries the level of sectoral detail may be insufficient to model direct employment effects using input-output and related models. In these cases, qualitative methods may yield rough estimates of direct employment. If these estimates can be scaled up to the national level, they can be used in input-output models and SAMs to estimate indirect and induced effects.

Projecting, forecasting or constructing scenarios on what is likely to happen. In most cases, constructing plausible projections and scenarios for the future requires a good qualitative understanding of trends. This is particularly the case at sectoral level, where a good understanding of the likely dynamics of future developments in employment is necessary to developing plausible views on how employment may develop.

7.4 Qualitative research methods

7.4.1 Introduction

Qualitative research methods are discussed under the following headings:

- Secondary research
- Statistics
- Informed opinion and specialist knowledge
- Case studies
- Enterprise surveys
- Other surveys
- Scenarios
- Cost of methods

7.4.2 Secondary research

Secondary research is important in skills anticipation relating to the transition to the low carbon economy, as it is in every other area of policy research. Useful skills anticipation research in the domain builds on a large body of earlier research, policy debate and experience with formation and implementation of policy.

While many issues have a different flavour or somewhat different implications in different country contexts with their different climatic conditions, different building practices, different institutional arrangements, different sectoral structures and different arrangements for education and training, there is also a great deal in common.

The key challenge of reducing carbon emissions, and many other challenges such as conserving water, are shared globally or by many countries. The technologies and strategies used to tackle these challenges are broadly similar globally, and are often very similar in countries where conditions are similar. As a consequence, the skills required, and the training and education responses required to address those requirements, often have substantial similarities in different country contexts.

As can be seen from this report, broadly similar research methodologies are appropriate for the study of skills for the transition to the low carbon economy, whatever country or countries are involved. There is much that researchers can learn about how to tackle this sort of research, and to overcome the challenges and complexities that arise, from reviewing how others have tackled the same questions in other country contexts.

Researchers addressing skills in the transition to the low carbon economy should undertake a wide ranging review of relevant policy and other research undertaken internationally and in their own country.

7.4.3 Statistics

Statistics have an important place in qualitative research as well as in quantitative modelling. Data on employment, occupations, output, exports, the qualifications profile of the workforce, numbers engaged in education and training and the number of graduates from courses of different types are useful in setting the context and anchoring qualitative analysis, even if they are not incorporated in a quantitative model.

It is preferable if statistics used in qualitative skills research reflect sectoral and occupational definitions that are meaningful to the research.

As statistics prepared by official sources use systems of classification that often do not match the requirements of research into the transition to the low carbon economy, researchers often have to make a choice between using official statistics and using other approaches to obtaining data. Qualitative research approaches such as enterprise surveys and case studies can be used to produce data based on classifications tailored to the needs of the research.

An alternative, less rigorous, approach is to adapt the findings of other research in similar contexts, for example perhaps incorporating in the research an occupational profile for the same industry sector drawn from another country.

7.4.4 Informed opinion and specialist knowledge

Consulting with informed opinion and with sources of specialised knowledge is almost invariably an important part of the methodology for skills anticipation research. Much of the understanding and qualitative information required both for qualitative and quantitative analysis will not be found in secondary sources. It is necessary to draw on the knowledge and understanding of people who know the domain well.

We distinguish between informed opinion and people with specialized knowledge, although the dividing line between the two groups is fuzzy.

- Informed opinion is likely to come from prominent industry figures, representatives of workers' and employers' organizations, academics and consultants with a research interest in the domain, enterprise and trade development agencies, providers of education and training, qualifications agencies and relevant NGOs. The most relevant people are typically well known in the sector, making them easy to identify.
- By people with specialized knowledge, we mean people with first-hand knowledge of technical detail such as the specific skills associated with a particular type of job. More effort may be required to identify people with this level of knowledge.

In most cases, any individual consulted will only have a part of the overall picture. It is necessary for the research to develop a synthesis based on all the information collected, and to test this with people who are well informed.
The main research approaches used are:

- Interviews, whether in person or by telephone;
- Focus groups with anything from four or five participants up to perhaps 16 participants (overly large groups limit the contribution that each person can make);
- Workshops which can be similar in size to a focus group or larger, often with break-out sessions for small group discussion of key issues; and
- Qualitative questionnaire surveys.

A common approach is to use interviews and/or focus groups for the initial round of research, and to later use a small number of workshops to test and improve the initial findings.

Focus groups similarly collect detailed qualitative information from a selected group of individuals. Participants are individuals whose knowledge, perceptions, and opinions are important for the research objectives. For example, a focus group of workers in green activities across different types of activities could be formed in order to learn more about the detailed skills required for the jobs they do and how they obtained those skills. Similarly, a focus group of employers may provide perspectives on future hiring needs.

Typically, questions are posed to the whole group and participants interact with other group members. Participants are able to react to the responses of other individuals. The potential for interaction distinguishes focus groups from a series of one-to-one interviews. There are many variations on the basic focus group concept which may be adopted depending on the goals of the research (e.g. conducting two groups at once, having multiple moderators, setting up debates, etc.).

In the context of skills research, meetings of steering groups or groups drawn together to discuss or validate findings in the course of the research often function in part as if they were focus groups.

Group discussions make an important contribution to research into skills for the transition to the low carbon economy, bringing a vital breadth of perspective to bear on what are frequently complex and multifaceted issues, and bringing up to date information on developments at sectoral level to bear.

Sector focus groups can play an important role even in macroeconomic analysis of the transition to the low carbon economy, informing sector level components of the analysis, as is done in the work of the VATT research institute in Finland referenced earlier.

Qualitative questionnaire surveys are most useful in consulting informed opinion and expert knowledge where there is a need to collect structured information, such as for example information on the specific skills associated with an occupation, from a significant number of people.
They are also useful under other circumstances, including the following:

- Many research projects are interested in soliciting responses on key qualitative questions from a group or groups of people knowledgeable about the topic of the research, such as for example members of a professional organization or members of an employers' or workers' representative organization. Web-based questionnaires offer a practical way to do this.

- In some cases, people approached for an interview decline, but ask for a questionnaire instead.
- In some cases, researchers are interested in inviting submissions from a range of interested people and organizations, or even advertising for submissions. A questionnaire helps to shape responses to fit with the research agenda, and facilitate analysis.

Delphic methods offer a structured approach to consulting with informed opinion and sources of expert knowledge. Delphic methods are qualitative forecasting techniques which rely on expert assessments. Experts are identified and surveyed, and their responses to questionnaires form the basis for the analysis. Normally, the Delphi techniques are iterative – i.e. a first round of responses is summarized and reported to the full group of experts, and then the experts are able to revise their responses in light of the information gathered in the first round. The expectation is that the experts will converge to something approaching a common opinion if the process is repeated sufficiently. The motivation for surveying experts, instead of, for example, enterprises, is that experts may consider a broader range of issues relative to the issues that may be identified by a manager/owner at a particular firm. The information which can be obtained through this process is sensitive to the choice of experts and the knowledge they bring to the process.

Delphic methods have been used to gather information on expectations of future economic performance and key trends, such as stock market prices or inflation. They could be used to gather expert information on the future growth prospects of green industries, the expected employment impacts, and anticipated skill needs and shortages. However, there is not yet much evidence of formal Delphic methodologies being used in skills research relating to the transition to the low carbon economy.

7.4.5 Case studies

Case studies of employment outcomes and skills requirements are in-depth studies of particular firms, industries, or policies. Case studies typically draw on a variety of methods for compiling and analyzing information: including secondary sources (e.g. financial statements, annual reports, trade journals, or journalistic accounts), quantitative data, and qualitative methods (e.g. interviews, surveys, and focus groups). Although we include case studies under 'qualitative methods,' they often use a combination of quantitative and qualitative information. Case studies differ

from statistical approaches in that they do not try to collect samples which could constitute repeated random sampling – case studies may be restricted to smaller samples (sometimes a single case).

In research into skills for the transition to the low carbon economy, case studies often play a central role in plugging gaps in official data that arise from the lack of a close match between sectors as defined in official statistical classifications such as ISIC (and its derivatives) and sectoral definitions that are relevant to the study of the transition to the low carbon economy.

7.4.6 Enterprise surveys[24]

Enterprise surveys can often be used as a source of valuable information for skills anticipation research.

For many countries, data from past enterprise surveys is available to researchers, and this information is frequently relevant to skills anticipation research. The World Bank gathers enterprise level data from a large number of countries, both under its own Enterprise Survey programme and through the Business Environment and Enterprise Performance Survey, which is a joint initiative with the European Bank for Reconstruction and Development.

Researchers may also have access to data or results from enterprise surveys undertaken at country level, or in the case of European countries to enterprise surveys undertaken by institutions such as CEDEFOP.

In some cases, the results of specialist enterprise surveys, such as vacancies surveys, may be available.

Where other sources do not provide sufficient information, and where sufficient resources are available to the research project, skills anticipation researchers may choose to undertake an enterprise survey. This is most frequently done in sector level research.

Key choices to be made in the design of sector level enterprise surveys are about the scale of the survey and how representative it should be. At the low end, a survey of a relatively small number of enterprises may be sufficient to obtain a fairly accurate profile of the occupational composition of a synthetic sector. At the upper end, a survey covering most significant enterprises and a significant sample of small enterprises may be required to obtain an accurate employment total for a sector for which this information is not available, whether because of weaknesses

[24] This should be read in conjunction with Section 3.3 of the report on enterprise/employer surveys.

in the country's statistical systems or because its definition does not correspond with standard sectoral classifications.

Key advantages of conducting a sectoral enterprise survey include the following:

- The survey can be tailored to the sector or sectors of interest to the research. If relevant, it can cover a whole value chain that spans parts of several sectors as defined using standard sectoral definitions.
- The survey can ask any question that may be relevant to the research.
- The survey can ask a combination of quantitative and qualitative questions.

7.4.7 Other surveys

Skills research often makes good use of the existing results of other surveys.

- Labour force surveys are household surveys that are key sources of information for skills research. Sector-occupation matrices derived from these are fundamentally important both to quantitative modelling and qualitative analysis in skills anticipation.

  Labour force surveys gather a vast amount of other labour market information that can be valuable in skills anticipation research. National statistical agencies generally publish summary results. Many have arrangements to give researchers access to more detailed data, which may include restricted access to microdata under conditions designed to protect confidentiality.

  In the European context, Eurostat publishes analyses of labour force data in significant detail online, and complements this with a data extraction service to give researchers access to data at a much finer level of detail.
- Some key questions on supply and demand for skills require data on graduate numbers and the stock of students and trainees. In some cases, this is available in a suitable form from published statistics. In other cases, it is necessary to assemble the numbers from course level data, based on identifying courses whose graduates meet the specific skills needs that are the subject of the research. Depending on the country context, it may be possible to obtain course level data from surveys carried out by funding bodies, education ministries, qualifications agencies or others. In other cases, it is necessary to survey providers of education and training in order to obtain the data required.
- Many education and training institutions conduct surveys among their recent graduates to identify whether they are employed, in further education or

training, unemployed or inactive, and to identify their sector and occupation of employment if they are employed. In some country contexts, statistics covering all institutions are prepared, either by aggregating survey results from individual institutions or by surveying recent graduates separately from institutional efforts. Graduate surveys are useful in identifying what actually happens in graduate labour market, which is useful in validating and improving predictions from models.

7.4.8 Scenarios

Scenario techniques are frequently used in skills anticipation where it is necessary to look a number of years into the future. Economic forecasts this far out are usually tentative at best, and there may be changes in areas such as technology, the policy environment and industry structure that affect demand for skills both in terms of numbers needed and the specific skills they are required to have.

Where there is significant uncertainty, it is better that skills anticipation research refrains from making predictions about the future, and instead puts forward one or more scenarios for the future that are speculative but plausible.

Much of the literature on scenarios favours a very descriptive approach, and favours an imaginative exploration of contrasting but plausible futures. However, because many of the key research questions in skills anticipation are quantitative, the finished versions of most skills anticipation scenarios include a quantitative projection of employment and a description of the future that fits with the projection.

Purely qualitative scenarios of the sort favoured by the literature would be suited to qualitative skills anticipation research questions, but have not been used much for this purpose to date.

This focus on the quantitative tends to produce scenarios that are relatively narrow in focus in comparison with those favoured by the wider literature on scenarios. Frequently, two or three scenarios are prepared which are, in effect, a base case and a target case, or a high growth case, a central case and low growth case. In other cases, scenarios in skills anticipation are based on speculation about a more diverse range of futures.

Scenario descriptions in skills anticipation often focus on the quantifiable variables required for the model used to produce the employment projections. For example, almost every model will quantify trends in labour productivity, and many will make assumptions about market growth and prices. These, and other variables in the model, can be addressed in the scenario description, either

directly or through a qualitative discussion of the technological, economic and skills developments that are likely to underpin them.

Scenarios developed along these lines are commonly used in the policy literature on the transition to the low carbon economy. One example is the IEA's Blue Map scenario for renewable energy. Another is the "mean of all baseline scenarios" in the IPCC's recent renewable energy report. While these scenarios do not project employment and skills needs, it would be possible to use them as the basis for employment and skills projections. However, while these scenarios look forward as far as 2050, very long term skills projections are unlikely to be useful and would be subject to a very high level of uncertainty. Only the first few years of projections under the scenarios would be useful for quantitative skills anticipation modelling.

7.4.9 Cost of methods

Cost is an important consideration when choosing methods of qualitative research. Using existing sources of data and of past research is generally cost effective, and it is almost invariably appropriate for researchers to use what is available. The cost of primary survey work, of consulting with informed opinion and expert knowledge, and of undertaking case studies depends very much on the approach taken, on the size of the exercise and on the cost of undertaking research in a particular country context.

Large scale surveys and significant numbers of in-person interviews and site visits are relatively costly. Telephone interviews are less so, but often at the cost of offering less depth. Telephone surveys and postal surveys with telephone follow-up cost less than sending survey personnel out to enterprises or households. Web surveys are relatively inexpensive, but offer more risk of bias than most other forms of research well designed and executed.

Focus groups, workshops and similar approaches can be relatively inexpensive if they bring significant numbers of people together at their own expense in a low cost venue, but can be more substantial if this is not feasible.

While labour intensive qualitative research methods are always costly in a developed country context, whether they are in a developing country context depends on the extent to which researchers can tap into low local labour costs as opposed to being constrained to work with service providers whose price expectations are attuned to international market conditions.

In practice, research design has to take account of a range of issues, of which cost is only one, and tradeoffs may be necessary. The choice of methods has to be driven mainly by the requirements of the research.

7.5 Conclusions

Qualitative research methods form an important component of research into skills for the transition to the low carbon economy. They form a substantial part of most research projects, and are the dominant form of research in many.

Aside from addressing the many questions in the domain that are primarily qualitative in nature, they also make a crucially important contribution to quantitative analysis. They fill important gaps in available data that arise from mismatches between standard systems of sectoral and occupational classification and the sectoral groupings and occupations as they are emerging in the transition to the low carbon economy, and also providing necessary context.

Qualitative research methods are likely to be even more important in developing and emerging countries than they are in developed countries.

- There are likely to be more gaps in the data available.
- Available data are more likely to be relatively old, and in need of updating.
- Available data are more likely to be available only at relatively high levels of aggregation, requiring more supplementary research to make them useful for analysis of skills for the transition to the low carbon economy.

As a consequence, developing and emerging countries are more likely to need qualitative research to help bridge gaps in standard data. To the extent that they can dispense with quantitative analysis in research, they may be more likely to decide to do so.

The main qualitative methodological approaches used in skills anticipation research are as follows:

- Secondary research
- Statistical analysis
- Informed opinion and specialist knowledge
- Case studies
- Enterprise surveys
- Other surveys
- Scenarios

Cost is a consideration in choosing between methodological approaches, but the choice of methods has to satisfy meeting the requirements of the research.

Section

8

Institutional Arrangements for Skills Identification and Anticipation

8.1 Introduction

This section looks at institutional arrangements for skills identification and anticipation under the following headings.

- Social dialogue in institutional arrangements
- Sectoral and regional institutions
- Employment services
- Labour market information systems
- Public-private partnerships
- Migration issues

8.2 Social dialogue in institutional arrangements

In countries, where tripartite bodies at national, regional or sectoral level exist, such as sector skill councils or national training boards, they play an active role in early identification of skill needs in the context of economies undergoing major changes – such as in transitions to the low-carbon economy.

Social dialogue makes an important contribution to encouraging employers and workers to invest in the right skills through education, training and lifelong learning together. Workers and employers should be involved in initiatives to promote employment anticipation and skills anticipation, and in approaches to upgrade or adapt skills to meet demand. This can happen in several ways:

- Social dialogue and bi- or tripartite bodies can play a role in making decisions about what skill areas to research.
- Workers and employers and their organizations should be involved in designing research, in acting as sources of informed opinion and expertise, and in validating findings. This is typical of quantitative and qualitative approaches to identifying skills for green jobs reviewed. Methodologies applied to approaches vary, and are tailored to meet specific needs considering the availability of data and other information. The research indicates that sectoral and sub-sectoral approaches are common in anticipating employment demand at the occupational level, and in looking at skills requirements. Methods often include a combination of modelling with some sort of survey, focus group or interview approach with employers and workers.
- Social partners can have a role in interpreting research findings, and in helping to translate recommendations into feasible measures and changes to the education and training system.
- Social partners involved in institutions that provide skills or vocational guidance, such as employment services, can contribute to the implementation of recommendations stemming from skill identification research.

8.3 Sectoral and regional institutions

Many countries rely heavily on sectoral and regional institutions for skills anticipation. The presence of sectoral institutional frameworks has proved to be a strong mechanism for identification of skill needs and for the transfer of the findings into practice. For example, in the UK, Sector Skills Councils – 25 employer-led, government-sponsored organisations overseeing the skills landscape in their sectors – have been active in overcoming skills bottlenecks for the areas with high employment potential, including those in the low carbon activities. Some Sector Skills Councils have developed specific skills strategies for sectors and sub-sectors affected by the transition to the low carbon economy, such as LANTRA (land based and environmental industries), SEMTA (manufacturing sector), Summitskills (building services engineering sector), ConstructionSkills and Cogent (chemicals, nuclear, oil & gas, petroleum and polymers sectors).

SEMTA, the Sector Skills Council for manufacturing, is working alongside business and the National Skills Academy for Manufacturing to ensure that low

carbon skills are provided in sufficient volume to meet current and future workforce needs.

ConstructionSkills has set up a Future Skills Unit with a specific remit of collecting intelligence to undertake skills forecasting in the sector, with part of its focus being on renewables, zero carbon, low carbon, environment and technological change (Cedefop – country studies, in *Skills for Green Jobs. European Synthesis Report,* 2010b).

In the UK Gas sector, the British Gas Green Skills Training Centre in Tredegar, South Wales was opened in 2009. The Centre was developed through a partnership including the Welsh Assembly Government and the county government, employment service providers JobMatch and Jobcentre Plus, and SummitSkills, the Sector Skills Council for the building services engineering sector.

In Australia, skills development policy is driven by the work of 11 industry-led Industry Skills Councils (ISCs), which are mandated to identify and respond to the skills needs of their respective industries, and to advise Skills Australia. The ISCs are privately registered organisations whose funding is substantially provided by the Australian Government. Amongst many others, Government Skills ISC identified skill needs and developed training packages for water management, Agrifood ISC for sustainable farming, and Construction and Property Services ISC for waste management. Manufacturing Skills Australia has developed a 'Competitive Manufacturing' qualification. Collectively, the ISCs have examined the current impacts of environmental sustainability on their industry sectors (ISC, 2009) and implemented a range of initiatives to address current and emerging priorities (ILO –country studies, 2010).

A public-private partnership in Australia has recently forged a Green Skills Agreement in order to promote stronger collaboration and coordination between governments, employer and worker representatives, the VET sector, universities, schools and community organizations. The members of the implementation group include the Australian Government and state and territory governments, TAFE (technical and further education) Directors Australia, the Australian Council of Trade Unions, the Australian Industry Group, the Australian Chamber of Commerce and Industry, Adult Learning Australia, the Australian Council for Private Education and Training, and Universities Australia. The main focus is to provide nationally consistent and coordinated responses to these needs and to foster the development of skills for sustainability across the VET and higher education sectors in the country. Part of the implementation plan is to prepare a study of the impact on future skills needs of moving to a low carbon economy, but the four main objectives of the Agreement are to:

1. Develop national standards in skills for sustainability within the requirements of the National Skills Framework (the Australian Quality Training Framework, the Australian Qualifications Framework and National Training Packages);
2. Upskill VET practitioners so they can provide effective training and facilitation in skills for sustainability;
3. Review and revise Training Packages to incorporate skills for sustainability; and
4. Implement strategies to reskill vulnerable workers in the transition to a low carbon economy.

In France, where there is no equivalent of sectoral skills bodies similar to the United Kingdom or Australia, the system is characterized by the existence of a broad network of Observatories for employment and training, which bring together the various players in the labour market with the aim of reaching a common diagnosis. These research and monitoring centres work at the sectoral level (industry observatories) or regional level (regional observatories), and combine macro-economic projections and quantitative surveys with qualitative information. The mode of work is collaborative with a strong tripartite basis where the research findings are normally negotiated with social partners. Commitments are made to overcome observed skills bottlenecks, to improve the attractiveness of jobs and working conditions and so on (Guegnard, 2007). The new Plan for the Mobilization for green jobs includes the establishment of a new observatory for emerging environmental professions. This network of observatories complements national level forecasts and studies (through the General Planning Commission and Development agreement for employment and skills) (Strietska-Ilina, et al., 2011).

Another feature of the French system is the presence of the so-called Contracts of prospective studies (les Contrats d'études Prospectives) which have been implemented by the State since 1988 (Guegnard, 2007). The contracts aim to define major trends for occupations, jobs, qualifications and skill needs and their evolution in the context of economic, demographic, technological, organizational and social changes. The studies can be performed in a particular sector or region, or for a group of occupations. The activity is co-funded by the State through a contract between the State and professional bodies, and sometimes trade unions. It envisages consultations with regional and employment agencies and other relevant public bodies and social partner organizations. These contract studies are also used in sectors where it is proposed to establish a sectoral observatory. In

the green jobs context, a contract study was conducted in the recycling industry. The study proposed a vision of the industry perspective until 2020 based on three scenarios for market development, based on different assumptions about global growth. The analysis of this fast growing industry with employment growth of 36 per cent in the last decade, allowed it to produce estimates and projections for five core occupations for ferrous and non-ferrous metals, paper, glass and plastic. The study indicates that social phenomena, the Grenelle Environment Roundtable (Grenelle de l'environnement) and rising environmental concerns, as well as scarcity of natural resources and related rising prices, strongly affect recycling businesses (DGEFP, 2010).

France is, therefore, actively using the established features of its labour market information system and social dialogue mechanisms for anticipation of skill needs for green jobs. However, in the framework of preparation of the Plan for Mobilization for green jobs, France established 11 sectoral committees outside its mainstream system of anticipation of skills needs. As described earlier, the committees produced reports for the sectors.

In the Republic of Korea, Sector HRD Councils were established in 2003 to identify and monitor the skills needs in selected industries. Their number has grown over time, and in 2009, new SCHRDs were established in green industries including green finance, new renewable energy, global healthcare, ubiquitous sensors, reflecting the current priority that national policy places on the green economy (Lee et al., 2010).

8.4 Employment services

Public employment services have a major role in measuring the green jobs arena and in matching supply and demand, but this requires an updated classification with corresponding competences. Improving labour market information on what opportunities will be available and what competencies (both soft and hard skills) are required to perform those jobs helps employers, workers and training institutes better understand the labour market. Both public and private employment services are a link between supply and demand, but are not always used to full capacity by labour market stakeholders.

Public employment services methods of job matching based on competences are new for many countries, but the Netherlands and Belgium seem to have relatively well developed approaches. However, solely matching on competences is not enough; matching based on education, hard skills and years of experience along

with soft competences is also important.[25] Generic and core skills such as, literacy and numeracy, communication, leadership, entrepreneurial, information technology, and innovation skills have been identified as being critical for green jobs (Cedefop, 2010b; Strietska-Ilina, et al., 2011) and are transferable across occupations. These types of skills that are relevant for all green jobs should be identified by stakeholders and formally standardized for job matching at national and possibly even international levels. There is concern about a shortage of science, technology, engineering and mathematics skills which are important to parts of the green jobs arena (Cedefop, 2010b; Strietska-Ilina, et al., 2011).

Standardizing competences in Europe, sufficiently broadly to cover all occupations throughout the continent, would help facilitate such an approach to do matching as there is a need to identify a set of specific soft competences relevant to all green jobs. These could be shared between public employment services of sending and receiving countries in labour migration. There is also a need for more comparable data overall in order to do cross-border comparisons and for developing appropriate EU policy directives, such as migration to meet labour market demand. Employers should be engaged in this process so as to ensure employability since they need to trust the system if they are to participate. The comprehensive skills and competences validation program *Qualifation+* in Switzerland is an interesting example of engaging the private sector in the validation of qualifications for migrants and for providing supplementary training where required (EC Employment, Social Affairs and Inclusion, 2010).

8.5 Labour market information systems

A key point that the global economic crisis underscored for labour market analysts was that labour market information systems in a number of countries need to be upgraded, as it was difficult to determine the impact of the crisis on countries because of a lack of timely and up to date labour market information. Although many countries do have state of the art systems in place, capturing green economy information remains a challenge even for the best systems.

The US BLS has earmarked USD 8m (of a USD 611.4m budget for labour market statistics alone) to monitor green jobs and a number of state governments are tapping into the DOL's *State Labor Market Information Improvement Grants*

[25] From the WCC and UWV WERKbedrijf – the Dutch Public Employment Service – webinar on using competences to improve the effectiveness of job matching, November 2009. See: http://www.wcc-group.com/

with approximately USD 50 million in grant funds for Workforce Agencies "to collect, analyze, and disseminate labor market information, and to enhance the labour exchange infrastructure for careers within the energy efficiency and renewable energy industries" (US Department of Labor ETA Federal register, 2009).[26]

This entails a number of green labour market information activities, including the following:

- Green Industry Demand Survey and Report: Assessing skills gaps, market demand, supply chain, and cross industry opportunities;
- Green Occupation Projections: Developing updated, regional industry/occupational projections based on primary data collection;
- Training Provider Survey and Report: Survey to identify issues with service demand, education gaps, and best practices;
- Statewide and Regional Green Growth Reports: Regional roll-up of green industries and job opportunity trends with local insights;
- Enhanced Career Explorer Tool: Web-based job exploration system updated with dynamic interface and green tools.[27]

The outputs of skills research described throughout this report are of course also examples of labour market information, as are this report and its two companion reports on skills for green building and renewable energy.

8.6 Public-private partnerships

Once skill needs and gaps have been identified, programs can be developed to assist with transitions. Martinez-Fernandez, Hinojosa, and Miranda (2010) examine the processes through which climate change impacts labour markets and how labour markets may in turn adjust. Their report cites some specific examples of public-private partnerships to address skill shortages. Selected examples include:

- *The Professional Reference Centre for Construction*, established by public and private entities in Brussels, to provide training for construction workers. This centre identifies and develops new training fields and modules, facilitates placement between newly trained workers and employers, and coordinates

[26] It is interesting to note that they indicate their collaboration with other agencies and suggest this to applicants for the grant in order to ensure coherence.

[27] See the example of New York State DOL: http://www.labormarketinfo.edd.ca.gov/contentpub/GreenDigest/MO-Abstract.pdf

training programs. To guide these activities the center relies both on feedback from industry as well as by tracking technological developments to anticipate future needs.

- *The Green Energy Lolland-Falster—Regional Energy Plan* in Denmark that has been highly successful in developing the renewable energy industry in that region (the region is made up of two islands, Lolland and Falster). As part of this project, a holding company named LOKE – Lolland Energy Holding was created by the municipal governments of the two islands to finance future regional projects, with a preference for projects that lead to local job creation and new educational programs.
- *The Fund for Electric Energy Savings* is a joint initiative between a state owned utility (Federal Commission for Electricity) and the Mexican Electric Workers trade union, and some businesses. The FIDE supports, among other things, a national training program on energy efficiency that is delivered through local educational institutions.

Other examples include the following.

- *The Apollo Alliance* is a coalition of labour, business, environmental, and community leaders in the US, focused on catalyzing activity in clean energy revolution and generate employment in green-collar jobs. It promotes investments in energy efficiency, clean power, mass transit, next-generation vehicles, and emerging technology, as well as in education and training.
- *The Aldersgate Group* is a coalition of progressive businesses, environmental groups and individuals in the UK who believe that high environmental standards will be a major part of future economic growth and international competitiveness. The Group engages with government and other decision makers to contribute to the future development of economic, environment and sectoral policies, as well as providing a voice that advances the agendas of better regulation and sustainability.

8.7 Migration issues

The identification of skills shortages may support the rationale for meeting labour market demand through immigration and employment visa policies. A number of countries, such as Canada, France, Germany, Japan, the Netherlands, Switzerland,

the United Kingdom and the United States have immigration policies that have skills as part of their ranking criteria for visa applications. However, other countries are more specific, publishing short lists of specific occupations by giving priority to workers with recognized competences. For example, the Australian government publishes a Migration Occupations in Demand List[28] and New Zealand has an Essential Skills in Demand List[29] for both short and long term. Both identify skill shortages and prioritize visa applications for workers with these skills – among other requirements.

However, the skills shortage lists apply their classification and qualification systems. This is an example of the significance of taxonomy in the measurement of green jobs. Should a system already contain occupations such as environmental engineers or hydro geologist, as it is the case in the United Kingdom, it is fine because they can be clearly identified as green. However, given the lack of some new jobs being classified, such as Nanosystems Engineers, it would be difficult to justify the provision of a work visa by the immigration agency without appropriate skills being identified and qualified with competences to ensure that workers with the right skills are allowed to migrate.

Ireland provides another example of skills shortages being linked to immigration policy. The EGFSN is a good example of business and government working together in skills issues. The Group maintains regular monitoring of skills demand/supply and publishes regular skills bulletins, relying on a number of research materials of both qualitative (interviews, sectoral analyses) and quantitative character (labour market information, forecasts produced by Economic and Social Research Institute). The National Training and Employment Authority Skills and Labour Market Research Unit provides EGFSN with data, analysis and research and manages the National Skills Database. Forfás (national policy advisory body for enterprise and science) provides the Group with research and secretariat support. The Group's work programme is managed by the Head of Secretariat based in Forfás. The EGFSN's budget comes from the National Training Fund.

The Bulletins published by EGFSN present key labour market trends with the aim of assisting policy formulation in the areas of employment, education and training, and immigration. Ireland's migration policy is linked to the monitoring and the lists of occupations which are in short supply.[30]

[28] The process for this is being revised in 2010.

[29] See: http://www.immigration.govt.nz/migrant/stream/work/skilledmigrant/LinkAdministration/ToolboxLinks/essentialskills.htm?level=1

[30] See: http://www.skillsireland.ie/ The EGFSN advises the Irish Government on current and future skills needs of the economy and on other labour market issues that impact on Ireland's enterprise and employment growth. It has a central role in ensuring that labour market needs for skilled workers are anticipated and met.

South African Employers, through the National Skills Levy, finance the National Qualifications Framework which oversees skills identification and design of response programmes. Sectoral Educational and Training Authorities prepare annual training reports which identify scarce skills[31] and critical skills[32] shortages in a sector. These scarce lists are then combined into a National Scarce Skills List. To date several Sectoral Education and Training Authorities, most notably the Agricultural Sectoral Education and Training Authority, have included aspects of green skills to unit standards (components of qualifications) but the extent to which these have accredited training providers to disseminate learning is limited (Strietska-Ilina, et al., 2011).The scarce list does not currently link to immigration policy, but the National Human Resources policy has indicated that it should.

8.8 Conclusions

This section has described institutional arrangements for skills identification and anticipation in relation to the transition to the low carbon economies across many countries. The key point that emerges throughout is that it is important that arrangements should be inclusive, drawing on the knowledge of a range of stakeholders that may include workers' organizations, employers and providers of education and training among others.

More extensive conclusions on institutional arrangements are drawn in the synthesis section that follows.

[31] Scarce Skills: refers to those occupations characterised by a scarcity of qualified and experienced people (current and anticipated) – in other words, occupations in which numerical imbalances exist in employment because of a difference between the demand for and the supply of skills.

[32] Critical Skills: refers to particular skills within an occupation, or the qualitative deficiencies that may exist or develop in the skills apparatus of the existing workforce.

Section

9

Synthesis on Methods and Institutional Approaches for Skills Anticipation

9.1 Introduction

The report has reviewed the quantitative and qualitative methodologies available for research into skills for the transition to the low carbon economy, but without presenting an overview of where quantitative approaches are most appropriate, where qualitative approaches are appropriate, where a combination of quantitative and qualitative approaches may be preferable, and where there may be scope to choose between quantitative and qualitative methods. This section synthesises this overview, recapitulating some elements of the analysis presented earlier so as to present a coherent storyline.

The section also presents an overview of institutional approaches for skills anticipation for the transition to the low carbon economy, highlighting similarities with skills anticipation in other contexts, and highlighting what is distinctive about the low carbon economy context.

In the context of this report, "quantitative methods" refers to methods that involve quantitative modelling. "Qualitative methods" refers to methods such as interviews, case studies and surveys that may provide both qualitative and quantitative information.

What methods are appropriate depends on the questions asked. It also depends on data issues, including the availability of data and the goodness of the fit between the available data and the specific questions posed. As seen earlier, even where very good statistical systems are in place, standard sector and occupational classifications often have a poor fit with questions about skills for the transition to the low carbon economy.

Table 9.1. Skills research questions and appropriate types of methodology

Level of Question	Type of Question	Some Key Headline Questions	Type of Methodology	
			Whole Economy	Sector
Jobs	Quantitative	How many direct jobs now and in the future?	Quantitative, Qualitative	Quantitative, Qualitative
	Quantitative	How many indirect jobs now and in the future?	Quantitative, Qualitative	Quantitative, Qualitative
	Quantitative	How many induced jobs now and in the future?	Quantitative, Qualitative	Quantitative, Qualitative
Occupations/ Skills	Qualitative	What occupations? How they should be defined? Where are the boundaries between occupations?	Qualitative	Qualitative
	Quantitative	How many people in each occupation? What is the resulting demand for skills?	Quantitative, Qualitative	Quantitative, Qualitative
	Qualitative	What skills and competencies? How do these relate to occupations?	Qualitative	Qualitative
Training and Education	Qualitative	What sources of skills are available? What types of training and education are needed? How can they be provided?	Qualitative	Qualitative
	Quantitative	What is the existing stock of people with the right skills and training available to be recruited? What is the current flow of newly trained people available to be recruited? What flow will be needed in future?	Qualitative, Quantitative	Qualitative, Quantitative

Source: Authors.

Where qualitative methods are appropriate, in most cases it is preferable to use a combination of complementary methods, rather than just one. For example, a research project might use secondary research, a review of statistics, case studies with a number of businesses and consultations with informed opinion and experts through interviews and a focus group to tackle qualitative aspects of a research question.

Table 9.1 builds on the skills questions framework presented in Figure 2.2 to summarise the types of methodology required to answer each type of question. For each type of question, it sets out key headline questions that appear in skills research. The list of questions is not exhaustive. For each type of question, it summarises what types of methodology are ideally required, classified between quantitative and qualitative methodologies. It distinguishes between types of methodology required when researching the whole economy and those required when undertaking research at sectoral level.
Two important points emerge from the Table.

- Under the ideal conditions assumed, both whole economy and sectoral research require broadly the same mix of quantitative and qualitative analysis (although the specific methodologies for each within these categories will be different).
- While some important questions about skills for the transition to the low carbon economy can be addressed solely through qualitative research, every question of importance requires qualitative research, even if in the case of indirect and induced jobs the methodology is typically mainly quantitative.

9.2 Answering quantitative questions about jobs

9.2.1 Direct jobs

Answering questions about the number of direct jobs now and into the future generally requires a combination of quantitative and qualitative approaches.

When approached at sector level, it is generally necessary to estimate current employment in the sector of interest. In countries with strong statistical systems, this is usually best approached in the first instance through using standard statistical sources such as labour force surveys and enterprise surveys.

It is necessary to use qualitative methods to assess how well sector definitions accessible in standard sources match the needs of the research. When researching the transition to the low carbon economy, it is frequently desirable to segregate sectors defined through standard classifications into a synthetic green part and a part that is not specifically green. Developing a reasonable estimate of the share of employment that can be attributed to the synthetic green part requires the use of qualitative methods that may include the use of surveys, secondary sources (such as existing sectoral studies) or informed opinion, among others.

The extent to which it is necessary to rely on qualitative methods will vary between countries. For countries with well developed statistical systems that provide up to date data on employment at a fine level of sector detail, and which supplement this with enterprise surveys focused on environmental industries or green jobs, it may be possible to rely mostly on standard statistical sources. For countries with less well developed statistical systems, particularly developing and emerging countries, it is necessary to rely more on the sort of qualitative methods mentioned above. However, even many developed countries only code data at a fairly high level of sectoral aggregation, and may not have good statistics on environmental industries or green jobs, making it necessary to rely heavily on qualitative methods.

Even in the complete absence of standard statistical data from official sources, a sectoral enterprise survey can provide the basic information required.

Projecting direct employment into the future at sector level requires a heavy reliance on qualitative methods in almost all cases. Depending on the approach taken, quantitative modelling methods may also have a significant role. Future employment in green sectors cannot be modelled well beyond a small number of years based just on continuing historical trends and relationships into the future. It is necessary to form a view on the future in terms of issues such as future demand, labour productivity, technological developments, effects of international competition, regulatory developments, labour costs, and cost of energy and carbon, amongst others. Scenario methods have an important role to play in this where projections look beyond a small number of years into the future.

For most green sectors, the future is too uncertain beyond a small number of years to be the subject of a firm forecast. Scenario methods are generally more appropriate. In some cases a single central scenario may be described; in others, a baseline scenario and a scenario based on meeting decarbonisation objectives may be described; in other cases, several scenarios may be described based on different perspectives on the future. Elements of the scenarios should be quantified where possible; for example, a scenario on employment in renewable energy should generally include projections on energy demand, on the composition of supply disaggregated between major energy technologies and between the different stages of each technology's value chain, on the volume of labour required per unit of supply for each major technology, and on trends in labour productivity, based on a combination of quantitative analysis and expert opinion, and should combine these in a relatively simple quantitative model to produce projections of employment under the scenario.

In countries where dynamic macroeconomic models (such as DySAMs and CGE models) exist and are accessible to researchers, there is scope to model

demand dynamically, taking account of prices and other interactions with other sectors of the economy. This is desirable where the objective is to take a whole economy view; however, if the research question is just about the specific sector being modelled, researchers may reasonably decide that the benefits to doing this are outweighed by the disbenefits of much greater model complexity. Suitable macroeconomic models exist for most developed countries, but will not always be accessible to researchers. They also exist for some developing countries; for example, the ILO commonly develops country DySAM models as part of the assistance that it provides to developing countries.

In most cases, one of the main purposes in taking a whole economy view in skills research is to look beyond direct jobs to also take account of indirect and sometimes induced jobs. However, if the research question is limited to direct jobs, and the jobs are limited to specific sectors, and in addition it is feasible to research all the sectors individually, then it may be possible to conduct an analysis as if the economy was just the sum of these sectors, thereby producing a "whole economy" analysis without using macroeconomic tools. This could be sufficient for a research question about the direct demand for skills associated with a green government initiative that crosses a number of sectors, but most research questions are broader than this, and (as seen in the discussions about indirect and induced employment that follows) require some form of quantitative macroeconomic modelling.

While interesting research on the impact of the greening on the skills profiles of economies can be conducted using macroeconomic methods without detailed sector level analysis for countries with well developed statistical systems, the results it provides are not sufficiently specific to provide useful guidance about skills demand by sector or about what skills supply interventions might be useful.

9.2.2 Indirect jobs

Most practical research questions on skills for the transition to the low carbon economy concern not just direct employment in the core sector or sectors under consideration, but also in sectors that sell to them, or in some cases buy from them. The standard approach to estimating a sector's impact on employment other sectors is to use a model incorporating an input-output table for the economy, such as an input-output model, a SAM model or a CGE model. At its simplest, this is a purely quantitative approach which models the impact that increased activity in the sector of interest will have on other sectors based on the existing relationships between activity in different sectors encapsulated in an input-output

table for the economy. Projections of future output in a sector studied in detail can be used to generate projections of related output in other sectors, which can be converted to projections of indirect employment.

In practice, however, qualitative analysis is required to inform the quantitative input-output analysis in most cases in the context of the transition to the low carbon economy. As noted earlier, sectoral definitions of green sectors often do not match standard sector definitions; it is necessary to use information from qualitative methods such as surveys, case studies or informed opinion to assess whether they can be treated as if their impact was the same as that of the broader sector of which they form a part, and if not what changes should be made if the analysis is to be plausible. Similar issues arise where input-output tables are out of date, where the relationships encapsulated in input-output tables are changing in a way that may be predictable, or where input-output tables are only available at a high level of sectoral aggregation. Similar qualitative methods are required to address these issues. As the issues are more common in developing economies than in developed economies, qualitative methods should often have a more prominent role in developing countries.

Input-output tables are published for all developed countries, and exist at some level of detail for most developing economies. However, as with direct jobs, even in the complete absence of standard statistical data from official sources, sectoral enterprise surveys can be used in place of standard statistical sources, making it possible for even developing countries with weak statistical systems to quantify employment in green sectors.

Enterprise surveys can actually have advantages in analysing indirect employment associated with a sector. They can be designed to obtain information on businesses throughout a sector's value chain, rather than focusing separately on the slices of the value chain that exist within sectors defined by standard classifications, and analysing their interaction through input-output modelling.[33] This will not catch all indirect employment (for example, it might miss suppliers of stationary, transport or auditing services for which the green sector is only one of many sectors served), but if designed well it is capable of capturing all of the activities where skills specific to the green activity are required. The major disadvantage of this approach (aside from survey costs) is that, because it is not rooted in statistics from standard sources, it can be more difficult to compare and inte-

[33] For example, a wind energy sector survey could span businesses involved in production and distribution of wind turbines, businesses involved in project development (including wind power businesses, providers of professional and other services and providers of finance), construction and professional services businesses involved in construction and installation of wind turbines, and businesses involved in operation and maintenance of wind turbines.

grate with other research based on these sources. This is an important issue for developed countries, but will not be as significant an issue for those developing countries where the existing statistical infrastructure is weak.

9.2.3 Induced jobs

Estimating induced employment is seldom directly useful in anticipation of skills for the transition to the low carbon economy. While some skill researchers do estimate induced employment, it occurs in such a diverse range of sectors and occupations that it is difficult to identify specific skills implications that could form the basis for a policy response.

The main reason for estimating induced employment is instead that it is useful in assessing impact. Researchers interested in estimating the impact of an initiative or a change in the economy only get a full picture of the employment impact if they take account of direct, indirect and induced employment.

Calculating induced employment is primarily a quantitative modelling exercise, although it has to be informed by a qualitative assessment of labour market conditions.

- In cases where labour market conditions are loose enough so that the supply of labour does not place a constraint on employment growth, and where the marginal increase in labour costs arising from creating new jobs is close to zero, then straightforward input-output modelling methods can be used to estimate induced employment.
- In cases where an economy is at full employment, and there is little scope to increase the size of the labour force through increased labour market participation or inward migration, then induced employment will be close to zero – more consumer spending will drive up prices rather than driving up employment.
- In intermediate cases, both employment and the price of labour will rise, but the extent of the increase in employment will be constrained by the higher price of labour. Analysing this requires an approach that models supply constraints and the impact of price on demand, such as with a CGE model. A straightforward input-output or SAM model is not appropriate.
- In some cases, policy research quotes estimates of induced employment calculated by applying a multiplier to direct and indirect employment. Unless the multiplier has been calculated using the approaches described above, based on current conditions in the economy, this is not a reliable method.

9.3 Answering questions about occupations and skills

9.3.1 Qualitative questions about occupations

Qualitative questions about occupations form an important part of much skills research relating to the transition to the low carbon economy. Questions about new occupations that are emerging, new specialisations in existing occupations, and new skills and knowledge requirements emerging becoming core to existing occupations are the focus of significant research. Much of this is about how occupations should be defined, and where boundaries should be drawn.

Research methods used to answer these questions are almost entirely qualitative. These broadly fall into three groups:

- Methods such as interviews, focus groups, workshops and potentially Delphic methods designed to tap informed opinion and expert knowledge about occupations;
- Enterprise focused survey and case study methods designed to capture information about occupations and their skills content systematically; and
- Content analysis of job advertisements or of responses to surveys that ask for textual descriptions of jobs (although issues of confidentiality may limit access to the latter in the case of official surveys).

Many education and training systems have well established processes in place to enable them to be responsive to new and changing skills needs. Skills researchers mostly need to get involved in research at this level where there is a concern that providers may not be sufficiently responsive, may not be equipped to look sufficiently far ahead, or may need external direction or additional resources to respond.

9.3.2 Quantitative questions about occupations

In principle, quantitative questions about occupations can be addressed using purely quantitative modelling approaches, and some researchers do this. Current employment by occupation is typically available from a recent labour force survey in developed countries, and may also be available in a developing country. Future employment by occupation can be estimated by applying the current occupational composition of the sector to future employment. It is possible to improve upon this by identifying stable trends in occupational composition from past labour force survey data, and using these to project future occupational composition.

Given projections of future employment by occupation, it is possible to project demand for additional people based on the projected change in numbers employed, and on a reasonable estimate of the number who will need to be replaced each year.

In practice, however, it is usually better to complement quantitative methods with qualitative methods.

- Methods such as case studies and enterprise surveys are required to identify the occupational composition of synthetic sectors that do not fit standard sector classifications, particularly where there is reason to think that the occupational profile of a green synthetic sector is different to that of the wider sector of which it forms a part.
- Qualitative methods such as case studies and consulting with informed opinion have an important function in interpreting occupational projections. Some types of job important to the transition to the low carbon economy are capable of being filled by people from more than one occupational background (for example, different types of technician and/or skilled manual occupation), and a good presentation of results from modelling should reflect this as well as the raw numbers. In some cases, it may be desirable to model new occupations or specialised sub-occupations, which requires investigation using qualitative methods.
- In some countries, particularly developing countries, data on occupational structure of sectors will not be available, will only be available at a high level of aggregation, or will be out of date. In these cases, methods such as case studies or enterprise surveys can be used to bridge the gap.
- Quantitative analysis and modelling of trends in the occupational composition of sectors benefits from a qualitative understanding of the changes and what drives them, which may give advance warning of changes in the trends. Methods including case studies and consulting expert opinion can be used.

9.3.3 Qualitative questions about skills and competencies

Most questions about skills and competencies are qualitative in nature, and have little or no connection with quantitative modelling.
Appropriate methodologies depend on the depth of information required.

- A description of the competencies required for a type of job that is sufficiently detailed to guide the design of a course generally requires a systematic process

of consulting people with specialist knowledge, in some cases supplemented by a detailed survey designed to gather detailed information about current competencies and competency gaps. The process may be recursive, with a number of rounds of comments from experts, leading to improvements.

- A description of skills, competencies and gaps sufficient to give an overview of important skills, of trends in competency requirements, and of major deficiencies can be addressed through consulting expert opinion in a less rigorous way, whether through interviews, focus groups, workshops or other techniques, or through a combination of approaches.

9.4 Answering questions about training and education

9.4.1 Qualitative questions about training and education

Qualitative questions about education and training require mostly qualitative research methods. These questions are varied, and require different research approaches depending on the question and on the country context.

Where there is a simple one-to-one relationship between a particular type of course and a particular type of job, this simplifies the investigation. However, in many cases, businesses recruiting for a particular type of job will accept people with different qualifications and from a range of backgrounds, and graduates from a particular education or training course will go to a range of different types of job in a variety of sectors.

The extent to which this happens varies between countries and between types of job. Also, employers for a new type of job frequently start by recruiting people from a range of backgrounds, but may later recruit mainly from specialist courses if they are established. As many types of job relevant to the transition to the low carbon economy are new in some respects, and may be changing quickly, the extent to which jobs and courses are tightly matched may be weaker than for longer established areas of activity.

Understanding these issues is an important starting point for research into qualitative and quantitative questions about training and education, because it makes it possible to identify what types of existing course are most relevant to supplying the skills needs of the sector being researched. Key research approaches include consulting with informed opinion (employers, workers' representatives and providers of education and training), and where possible cross checking what they have to say against surveys of graduates (first destination and longitudinal)

and against survey evidence on the qualifications held by those employed in relevant occupations (which is typically available from labour force surveys). Questions that throw light on these issues are sometimes included in wider enterprise surveys, asking respondents to identify areas of skills gaps and to provide a view on the quality and relevance of training provision in these areas.

Other important types of qualitative question include the following (among others):

- From what population will students be drawn? Is the main need to give school leavers comprehensive education and training, or to supplement the existing skills of people already in the labour force or re-entering the labour force?
- What are the constraints on the availability of people suitable for training and education?
- What is the most suitable format for education and training? Taught at a college? Apprenticeship? Online or blended? Short course? Taught in the workplace? ...
- What types of education and training are ideally needed, and how do they differ from existing provision?
- What specific content should courses have to meet competency needs? How can courses best balance the need of businesses for specific technical competencies with the need for core and generic skills, and with the need to prepare students for a lifetime of learning?
- What are the resource requirements? Do they pose a constraint? If so, how can this be overcome, or is there another satisfactory option that avoids the constraint?

Tackling these questions requires researchers to consult with informed opinion – employers, workers' representatives, providers of education and training, qualifications authorities and policymakers, as well as drawing on statistics such as vacancy surveys and on other secondary research.

9.4.2 Quantitative questions about education and training

Data on education and training may be obtained from a range of types of source.

- Some data are compiled by international organizations such as OECD and UNESCO, typically using the ISCED coding system. Eurostat prepares

education statistics for the European Union also based on ISCED. International organizations also compile data on continuing education and training and lifelong learning that may be relevant.

- Depending on the country, national education and training systems, national statistical offices, qualifications bodies and/or education and training observatories prepare national or institution level statistics on provision of education and training. In some cases, they follow ISCED coding systems. In many cases, however, they also prepare statistics using coding systems better adapted to the specific design of their own education and training systems, which may provide a more informative statistical description of provision at the cost of less comparability with other countries.

  There is frequently a database of course level statistics behind the national statistics, which may be accessible to researchers. This can be an invaluable resource, allowing researchers to compile statistics on the specific courses most relevant to the skills requirement they are researching. The detailed information on specific courses required to do this is either available online, or, failing that, through contacting providers directly. The ability to do this is important to detailed research into skills for the transition to the low carbon economy, as most standard coding systems do not go into enough detail to allow specific types of green job to be matched with specific courses.

- Even where no suitable statistics are compiled nationally, researchers are likely to be able to compile statistics by making enquiries to individual providers of education and training, or in some cases to groupings of providers. As these enquiries are most likely to be successful if well targeted, preliminary research with employers, workers' representatives and others familiar with relevant provision is generally required.

Future graduate numbers can be modelled for a period into the future by taking account of the current student and trainee population, and discounting for likely rates of non-completion. This can be an entirely quantitative exercise, based on historical non-completion rates, or can also take account of qualitative information on factors that may change non-completion outcomes such as retention initiatives, changes in labour market conditions or changes in staff-student ratios. Longer term projections should take account of factors such as planned changes in the number of students admitted, expectations regarding the likely relative popularity of courses among potential applicants, any likely changes in funding arrangements and predictable changes in the size of the cohort of potential students available.

Most skills researchers do not go beyond stating past, current and future numbers of graduates from relevant education and training courses when modelling supply. It is possible in principle, however, to make deductions to take account of graduates going to other destinations, and to also take account of complementary sources of skills that may have been researched in less detail, when estimating the supply of suitable graduates.

9.5 Overview of quantitative and qualitative methods in skills anticipation for the transition to the low carbon economy

Table 9.2 provides an overview of the types of methodology suitable for use in skills anticipation for the transition to the low carbon economy described above. Not all of these approaches have to be used in every research project addressing a type of question; some are alternatives to others, or are most useful under specific conditions (such as, for example, where statistical systems are weak and it is necessary to obtain data from alternative sources). Most research projects use a combination of different qualitative methods.

The main methodological approaches used to consult informed opinion and expert knowledge are interviews, focus groups, workshops, (potentially) Delphic methods and qualitative questionnaire surveys.

In most cases where both quantitative and qualitative methodologies are mentioned, this is because qualitative research is ideally required to support quantitative modelling.

For many types of research question, there are significant issues about statistical sources and the definitions on which they are based, which are relevant both to quantitative and qualitative research. These are flagged in a separate column in the Table.

Most research projects on skills anticipation for the transition to the low carbon economy are interested in more than one type of research question. In most cases, where a type of methodology is listed under more than one question, more than one of these questions can be addressed by the same research activity. For example, there is no need for more than one DySAM to address the "how many jobs" questions. In many cases, on the qualitative side, the same sources of informed opinion can be consulted for information and views on a range of types of research question.

Table 9.2. Skills research questions and appropriate types of methodology

Level of Question	Type of Question	Main Types of Methodology Appropriate		Statistical Sources (S)/ Definitions (D)
		Quantitative Modelling	Qualitative	
Jobs	Quantitative – How many direct jobs?	Models tailored to sector, Scenarios DySAMs, CGE Models Synthetic Sectors	Scenarios, Enterprise Surveys, Informed Opinion, Case Studies, existing Sectoral Studies, Secondary Research	S,D
	Quantitative – How many indirect jobs?	Input-Output Methods, Input-Output Models, SAM/DySAM Models, CGE Models Synthetic Sectors	Enterprise Surveys, Case Studies, Informed Opinion, Secondary Research	S,D
	Quantitative – How many induced jobs?	Input-Output Methods, Input-Output Models, SAM/DySAM Models, CGE Models	Data and Informed Opinion on Labour Market Conditions	S
Occupations / Skills	Qualitative – Occupation Questions		Informed opinion, Consulting Specialist Knowledge, Enterprise Surveys, Case Studies, Content Analysis of Job Ads and of Survey Occupational Descriptions, Secondary Research	D
	Quantitative – Occupation Questions	Sector-Occupation Matrices, Trends	Case Studies, Enterprise Surveys, Informed Opinion	S,D
	Qualitative – Skills Questions		Consulting Specialist Knowledge, Surveys on Competencies, Informed Opinion, Secondary Research	
Training and Education	Qualitative – Training and Education Questions		Informed Opinion, Consulting Specialist Knowledge	
	Quantitative – Training and Education Questions	Modelling Future Graduate Numbers from Education and Training	Collecting or Surveying for Data on Students/ Trainees and Graduates, Graduate Destinations, Informed Opinion	S,D

Source: Authors

9.6 Institutional approaches to skills anticipation

In reviewing work on skills anticipation relating to the transition to the low carbon economy, the research has noted a number of significant patterns.

1. Most of the key policy work on skills anticipation for the low carbon economy undertaken at country level takes place under institutional arrangements that follow institutional practices for skills anticipation that are well established in that country. Countries that use sectoral skills councils (many of them Anglophone) still use sectoral skills councils. Countries that use thematic observatories (particularly Francophone countries and Spain) still use observatories. Countries with decentralised arrangements supplemented with research commissioned by ministries (such as Germany) still use mainly similar arrangements. In the US, the key policy work undertaken for skills anticipation purposes relating to the transition to the low carbon economy fits into broader work by the BLS and O*Net. In Ireland, where skills anticipation research is undertaken by a group established to advise the government, key research has been undertaken by that group.

   Social dialogue is a key feature of established skills anticipation arrangements in many countries. Governments, employers, workers' representatives and providers of education and training all have capabilities and knowledge that are useful in skills anticipation. Bringing them together is positive both for the quality of analysis and for effective implementation of skills policies and actions proposed based on the research.

2. What is distinctive about skills anticipation for the transition to the low carbon economy is that the issues, and often the skills requirements associated with specific developments, cut across established sectoral boundaries.

   - In countries where skills anticipation is usually conducted at sectoral level based on well established sectoral definitions, there is evidence of cross-cutting arrangements being put in place (for example in the UK and Australia) to ensure that low carbon economy skills issues are addressed in a coordinated way.

   - In countries where sectoral definitions in skills anticipation are more flexible, this is reflected in anticipation arrangements that do not match traditional sectoral boundaries, as with the Korea's sectoral skills councils in green finance, and in new renewable energy, and as with France's L'observatoire national des emplois et métiers de l'économie verte.

3. A considerable share of the adjustment in education and training provision to skills requirements associated with the transition to the low carbon economy is occurring through the normal operation of mechanisms to update education and training, and to fill skills needs identified through consultation between education and training providers, employers and workers' representatives. Organizations such as qualifications bodies and professional bodies are contributing to this process as they usually do. In some cases, there is a degree of international coordination, through international groupings of professional organizations or of providers of technical and professional education and training[34].

4. There has been a substantial amount of research work with a skills flavour undertaken independently of established skills anticipation arrangements by employer organizations, labour organizations, regional governments and civil society organizations, and also by ministries and public agencies with enterprise development or low carbon transition responsibilities. While this has made an important contribution to broader policy on the transition to a low carbon economy, the contribution to skills anticipation has been more limited. Key contributions relevant to skills anticipation have been as follows.
    - Some research has looked at the expected employment impact of specific policy proposals, or of scenarios for the future based on attaining specific policy objectives. This sort of analysis does much to clarify the feasibility of the proposal, and helps with planning for implementation, particularly in cases where the analysis goes beyond looking at employment impacts to also look at specific skills requirements. As skills availability is a key enabler (and potentially a key barrier) to implementation, this sort of analysis forms a very useful part of the planning process.
    - Some research has looked at the likely impact of the transition to the low carbon economy on employment quality, and at areas of employment loss and gain. These issues are relevant to skills anticipation.

[34] In the case of architecture, for example, the EC has contributed to this under the EDUCATE (Environmental Design in University Curricula and Architectural Training in Europe) action under Intelligent Energy Europe. EDUCATE supported a study on the state of the art and developing a framework for curriculum development in environmental sustainability in architecture courses.

9.7 Skills anticipation in transition to the low carbon economy at supranational level

9.7.1 Quantitative modelling at supranational level

Quantitative modelling requires a dataset made up of comparable data compiled, coded and analysed on a consistent basis. Quantitative modelling at supranational level is most practicable where these conditions are satisfied across the supranational entity or area, whether the modelling is macroeconomic, sectoral or a combination of both.

The European Union is the main supranational entity that satisfies this condition. North America and Australia/New Zealand are other areas that have statistical systems that are coherent across countries.

In principle, any set of countries with statistical systems based on the same versions of ISIC (industry classification) and SOC (occupational classification), and with regular statistical surveys, should be able to satisfy the condition. In practice, different survey practices, differences in the level of detail at which statistics are prepared, irregular surveys and other factors may make it difficult to compile statistics that are sufficiently detailed and comparable to form the basis for such work.

Shortcomings in available datasets at the level of an individual country can be overcome through an enterprise survey, although this is typically more feasible for sector level research than for research that models the whole economy. In principle, the same approach could be adopted for a supranational study, although there would be some challenges in maintaining consistency across country contexts. Depending on how it was organized, the costs involved might be out of proportion to the utility of the research if substantial numbers of enterprises were surveyed across a significant number of countries. However, in principle, a globally representative industry organization or a private research business with global penetration could potentially undertake quantitative research of this nature with global coverage at sector level.

As seen earlier, every important type of quantitative question on skills for the transition to the low carbon economy requires qualitative research as well as quantitative modelling. For studies at supranational level, this ideally requires significant country level research in each country within the supranational entity.

- Research undertaken for this project shows wide divergence in qualitative findings between different countries within, for example, the European Union, with some countries being strong in producing technologies relevant to the transition to the low carbon economy and others with little activity,

with radical divergence in past and planned future deployment of renewable energy technologies, and with major differences in construction practices, climate, regulations and public policies that are shaping the deployment of green building technologies in different ways.

- Major differences in education and training systems, and significant differences in the allocation of work between different occupations, mean that the optimal way to supply any particular skills requirement can vary significantly between countries.

9.7.2 Qualitative questions at supranational level

Research into qualitative questions about skills for the transition to the low carbon economy at supranational level is more straightforward than research based on quantitative modelling in that there is less need for data completeness. In quantitative modelling, every piece of data contributes measurably to the research output, and any missing data has to be estimated explicitly.

Research addressing qualitative questions is mostly more tolerant of missing information.

- There is much that is similar across countries, that does not have to be relearned separately for every country. Most technologies relevant to the transition to the low carbon economy are available globally, and even if the mix of technologies deployed varies between countries this means that many of the technological skills requirements are shared. The objectives of promoting energy efficiency and reducing carbon emissions are shared, with implications for skills requirements in business management and operations, as well as in government, that are often similar across countries. Many governments and interested organizations model their low carbon economy interventions on initiatives seen to be successful elsewhere.

- The issues involved in qualitative research into the transition to the low carbon economy are complex, and manifest themselves differently in different countries, depending on issues such as institutional arrangements, policy priorities, climate and the composition of low carbon economy activity. Fully comprehensive information on each country will generally be impractical to collect, so, even if exactly the same questions are posed for each country, researchers and sources of information and expert opinion will rightly focus on the information likely to be most useful to synthesising research findings, which will have a somewhat different focus for different countries.

- Research into a sample of countries that represent a good cross-section of all countries of interest is a reasonable approach to identifying patterns likely to be more generally true. Informed opinion can be used to test the validity of the findings across a broader range of countries.
- In most cases, only a small part of the detail gathered in qualitative research will be reported directly in the report, as opposed to contributing to the synthesis of findings.

Therefore:

- While full country coverage in supranational research is desirable, research that focuses on a well chosen subset of countries is viable; and
- Qualitative country level research can usefully be undertaken at a range of levels of detail, from very detailed enterprise surveys to consulting with informed opinion among governments and their agencies , employers and their representative organizations, workers' organizations, providers of education and training, academic and research institute experts and relevant civil society organizations.

9.7.3 Institutional issues in skills anticipation at supranational level

Four main types of entity are potentially interested in undertaking skills anticipation research at supranational level in the context of the transition to the low carbon economy.

- A supranational grouping of countries
- An international organization or group of international organizations[35]
- An international representative organization representative of employers[36] or workers[37]

[35] A number of international organizations, including the ILO and other organizations such as the United Nations Environment Programme and the International Energy Agency have an active interest in the jobs and skills implications of the transition to the low carbon economy.

[36] For example, REN Alliance, a grouping of the main global sectoral organizations of the renewable energy sector, undertook a mainly qualitative global survey of affiliates as a part of the renewable energy skills research that formed a part of this Joint Management collaboration between the EC and the ILO, complementary to this methodological study.

[37] International trade union organizations, including ITUC and the European Trade Union Institute, take an active interest in the labour market implications of the transition to the low carbon economy, with issues closely related to skills anticipation for the transition, including Just Transition, being significant priorities.

- An international NGO or grouping of international NGOs[38]

There are five main reasons why they may wish to undertake skills anticipation research at supranational level.

- To facilitate sharing of research undertaken at national level among participating countries.
- To substitute for skills anticipation research at national level. Alternatively, it may provide skills anticipation researchers with analysis that they can apply at national level, reducing the effort required, improving the quality of research outcomes, or making research outputs more comparable with those from other national level researchers.
- To plan a cross-country initiative to contribute to the transition to the low carbon economy, and include an analysis of the skills implications and a plan to address those implications.
- To undertake skills anticipation research to underpin the development or updating of competency profiles, course structures and course content to be used internationally. In some green sectors, notably in relatively mature areas of renewable energy, technologies and technical skills requirements are similar globally. In these cases, providers of education and training can respond to new demand for skills much more quickly if they can adopt existing course designs and content. Where this is done, employers and workers can benefit from international recognition of qualifications following these standards.
- To investigate an issue such as the employment, skills and quality of work impact of a specific aspect of the transition to the low carbon economy through a cross-country research project.

[38] A number of major environmental NGOs take an active interest in the jobs implications of the transition to the low carbon economy. For example, WWF quotes estimates of employment impact in reports such as its 2011 Energy Report.

Section
10
Conclusions and Recommendations

10.1 Introduction

The success of initiatives to improve sustainability depends to a significant extent on having the right skills available. Skills deficiencies can be a major barrier to implementing any initiative, and can raise the costs involved by damaging productivity and creating a need for skilled foreign labour. That can be a much bigger issue in developing countries than in developed countries because the skills base is typically weaker. The following section summarises the conclusions and produces recommendations of the report which will help governments, social partners, researchers and others involved in the identification of skill needs for the low carbon economy to employ adequate tools and approaches in carrying out research and analysis.

10.2 Mapping the analytic territory

Conclusions

Skills analysis in the context of the transition to the low carbon economy takes place at four main levels:

- Macroeconomic
- Sectoral
- Occupational and skills
- Training and education

Individual research projects tend to span two or three of these levels. Relatively few span all four. However, most research projects include a strong sectoral focus due to the fact that practical occupational and skills questions relate to specific sectors. Even macroeconomic analysis on the transition to the low carbon economy usually includes analysis of specific sectors, such as renewable energy.

A wide range of questions are posed by different researchers, concerned both with the present and the future.

- Key types of quantitative question are about numbers of jobs in total, numbers by occupation, and numbers of people trained or educated.
- Key types of qualitative question are about changes in occupations, about specific skill requirements and about types of education and training required.

Recommendations

When designing and deciding to commission research into skills for the transition to the low carbon economy, researchers and commissioning organizations should recognise the large number of types of question that appear in the domain. With many options to choose from, they should take a systematic approach to choosing which questions are most relevant to their wider objectives.

Skills researchers and commissioning organizations should recognise that most research questions even at macroeconomic level require significant sector level research, and should plan for this when defining research questions.

Researchers should take into account that the boundaries of sectors defined in terms that are relevant to the transition to the low carbon economy mostly do not match standard sectoral definitions, and are therefore a special construct. As the construct is not aligned with standard sectoral definitions, there is a particular need for clarity as to how it is defined and where its boundaries lie.

10.3 Definitional issues and data sources

Conclusions

It is difficult to define green jobs in a way that is satisfactory for all purposes, and as a consequence many competing definitions have been created by different authorities and for different purposes. However, most practical skills policy

questions relating to the transition to the low carbon economy are relatively specific, allowing research to be undertaken with no requirement for a single universal green jobs definition.

Other practical definitional issues are important in studying skills for the transition to the low carbon economy. Sectors of interest mostly do not have a clean fit with standard sectoral definitions on which national statistical agencies base their work. In most cases, only part of a sector is of interest. In some cases, sectors of interest intersect with several sectors as they are defined in standard sector classification systems. Similar issues arise with standard occupational classifications that do not capture new occupations or substantially changed or specialised occupations associated with the transition to the low carbon economy.

There are also important definitional difficulties around questions as simple as what is meant statistically by "a job" that different researchers tackle in significantly different ways.

The diversity of definitional approaches means that clarity about definitions is particularly important in this domain.

Key sources of statistical information that bring predetermined sectoral and occupational definitions into skills research for the low carbon economy include the following.

- Labour force surveys are centrally important sources of information on the occupational composition of sectors. This information is important in quantifying the skills and occupational profile of sectors, and in anticipating future skills requirements.
- Enterprise and employer surveys can be important sources of information for skills analysis and anticipation, particularly if they focus on current and future skills requirements, and especially if they focus on skills demand in green industries and on green jobs. This may be addressed either through using information from existing surveys, through adding questions to existing surveys, or through conducting a new survey (if there are substantial gaps in the information available from existing resources).
- There are substantial initiatives underway at national and supranational level researching new developments in occupations, some focusing specifically on skills for the transition to the low carbon economy and some more broadly on new developments in occupations economy-wide. Key examples are the work of the O*NET in the US (which is a broadly focused initiative that includes a green economy focus) and the new work of DG Employment and DG Culture to develop a European classification of Skills/Competences, qualifications and Occupations (ESCO), which does not specifically target green economy

occupations. ESCO will link detailed ISCO occupational categories to a large number of job titles, and link these to qualifications and to lists of skills and competences. The project aims to develop a standard terminology – a common language – for occupations, skills and competencies, with a view to contributing to the pursuit of a variety of skills and labour market policy objectives. A variety of practical applications are envisaged. Similarly to O*NET, occupational skills research under ESCO's preparation has a good potential to provide an insight into green jobs and skills and related definitions.

Recommendations

Researchers should offer a clear definition of the units in which their measurements of jobs are stated, and of the sectoral and occupational definitions they use.

Researchers should present their results in a way that can be compared with results from other researchers, preferably in job-years, in employment in each year over the projection period, or in an average over a stated period, and even better in some combination of these if feasible. They should be explicit about how they cope with mismatches between definitions of sectors and occupations that are suited to their research, and the sectoral and occupational classifications used in standard statistical sources.

While major revisions to ISCO usually take place on a 20 year cycle, and the most recent revision was in 2008, initiatives including O*NET, and in future ESCO, are producing new information on changing and emerging occupations. The bodies developing these and other initiatives of a similar character should seek to collaborate with each other. This includes Eurostat as the main statistical agency of the EU and the ILO which is in charge of ISCO's maintenance, updates and revisions.[39]

While ESCO does not focus specifically on skills for the transition to the low carbon economy, it could make a very useful contribution to skills anticipation in this area within the EU and beyond by capturing and communicating information about new occupations, new specialisms in existing occupations, and the changing skills and competency content of existing occupations that are emerging from the transition. The process of developing ESCO should focus in part on achieving this objective in skills identification and anticipation for the transition to the low carbon economy.

[39] Decisions on ISCO are adopted by the International Conference of Labour Statisticians and endorsed by the Governing body of the ILO.

10.4 Methods

Conclusions

Qualitative research methods

Qualitative research methods form an important component of research into skills for the transition to the low carbon economy. They form a substantial part of most research projects, and are the principal or sole form of research in many.

Aside from addressing the many questions in the domain that are primarily qualitative in nature, they also make a crucially important contribution to quantitative analysis. They fill important gaps in available data that arise from mismatches between standard systems of sectoral and occupational classification and the sectoral groupings and occupations as they are emerging in the transition to the low carbon economy, and also provide necessary context. For example, they can be used to quantify output, employment, productivity and occupational composition in low carbon economy sectors that do not match standard sectors.

Qualitative research methods are even more important in developing and emerging countries than they are in developed countries, as gaps in data availability may be greater, as existing data may be relatively old, and as the level of aggregation at which data is available may be too high. As a consequence, researchers investigating skills for the transition to the low carbon economy in developing and emerging countries are more likely to need qualitative research to help bridge gaps in standard data.

The main qualitative methodological approaches used in skills anticipation research, in general and in the context of the transition to the low carbon economy, are as follows.

- Secondary research
- Statistical analysis
- Informed opinion and specialist knowledge
- Case studies
- Enterprise surveys
- Other surveys
- Scenarios

While qualitative questions about skills for the transition to the low carbon economy can be addressed solely through qualitative research, every quantitative question of importance requires a contribution from qualitative research.

Quantitative modelling

Quantitative analysis in skills research in the transition to the low carbon economy spans the four main levels highlighted earlier.

- Macroeconomic
- Sectoral
- Occupational and skills
- Training and education

Approaches to quantitative analysis within these levels vary significantly. There is no single approach that is best under most circumstances. The best choice is contingent on factors including the research question, the sector or sectors of particular interest, data availability and the resources available for research. However, approaches taken to linking the four levels are fairly standard.

- Input-output Matrices (or similar SAM and supply-use matrices) are used to link macro analysis to sector analysis.
- Sector-Occupation matrices are used to link sector analysis to occupational analysis.
- Calculations based on changes in numbers employed plus replacement demand are used to link occupations to demand; substantial qualitative analysis are required to make this comparable with data on manpower supply.

It is possible for quantitative research projects to focus just at sector level or just at macro level, but most span and link both levels.

A wide variety of modelling approaches are used at sectoral level. The choice of approach usually starts from a qualitative analysis of the sector that identifies the main factors likely to drive employment into the future. This forms the basis for a quantitative model that takes account of the factors identified. For projections that look more than a very small number of years into the future, model parameters are typically chosen to reflect scenarios for the future, rather than firm forecasts.

Some sectoral models are designed to be used stand-alone. Others are designed to be integrated with some form of macroeconomic model, either to incorporate features such as estimates of indirect employment or supply constraints and prices into the sector level analysis, or to provide a more comprehensive macro level analysis.

There is no single correct approach to macroeconomic analysis. The choice is contingent on context, the research question and the resources available to the researcher.

- Input-output and SAM models are relatively transparent, easy to understand and communicate to policy audiences, and require a relatively modest amount of work to establish from scratch

- CGE models are complex, require much work to establish from scratch, difficult to validate and require trust from policy audiences because of their complexity. However, they have advantages in areas such as modelling supply constraints, and the obstacles can be reduced greatly if an existing model with a solid track record can be adapted.

Time dependencies are important in modelling quantitatively beyond the short term.

- This points towards use of DySAM or CGE models for longer term research questions, incorporating assumptions on developments in areas such as labour productivity, supply constraints, price dynamics, carbon pricing among others.
- Assumptions about developments in technology, labour productivity and industry structure should also be taken into account in sector level models.
- Occupational modelling should take account of likely future changes in occupational structure.

Modelling of numbers employed by occupation is based on applying estimates of the occupational composition of each sector to projections of employment. At simplest, the estimates are based on occupational data from a labour force survey, from enterprise case studies or even from an enterprise survey. More sophisticated approaches change the projected occupational composition over time based on evidence from the research.

Most quantitative research in this area stops short of turning projections of employment by occupation in a sector into projections of demand for labour by occupation.

Assessing the supply of people with the skills required relative to estimated demand is a complex matter that requires substantial qualitative analysis. It is only under a minority of circumstances that there is a clear one-to-one relationship between the number of graduates from specific types of technical vocational education and training or higher education course and a specific requirement for skills.

Table 10.1 (which reprises Table 9.2) provides an overview of the types of methodology suitable for use in skills anticipation for the transition to the low carbon economy. Not all of these approaches have to be used in every research project addressing a type of question; some are alternatives to others, or are most useful under specific conditions (such as, for example, where statistical systems are weak and it is necessary to obtain data from alternative sources). Most research projects use a combination of different qualitative methods.

Table 10.1. Skills research questions and appropriate types of methodology

Level of Question	Type of Question	Main Types of Methodology Appropriate		Statistical Sources (S)/ Definitions (D)*
		Quantitative Modelling	Qualitative	
Jobs	Quantitative – How many direct jobs?	Models tailored to sector, Scenarios DySAMs, CGE Models Synthetic Sectors	Scenarios, Enterprise Surveys, Informed Opinion, Case Studies, existing Sectoral Studies, Secondary Research	S,D
	Quantitative – How many indirect jobs?	Input-Output Methods, Input-Output Models, SAM/DySAM Models, CGE Models Synthetic Sectors	Enterprise Surveys, Case Studies, Informed Opinion, Secondary Research	S,D
	Quantitative – How many induced jobs?	Input-Output Methods, Input-Output Models, SAM/DySAM Models, CGE Models	Data and Informed Opinion on Labour Market Conditions	S
Occupations / Skills	Qualitative – Occupation Questions		Informed opinion, Consulting Specialist Knowledge, Enterprise Surveys, Case Studies, Content Analysis of Job Ads and of Survey Occupational Descriptions, Secondary Research	D
	Quantitative – Occupation Questions	Sector-Occupation Matrices, Trends	Case Studies, Enterprise Surveys, Informed Opinion	S,D
	Qualitative – Skills Questions		Consulting Specialist Knowledge, Surveys on Competencies, Informed Opinion, Secondary Research	

Recommendations

Researchers and commissioners of research into skills for the transition to the low carbon economy must ensure that significant resources are devoted to qualitative research, even if the primary methodological focus of a research project is on quantitative modelling.

Level of Question	Type of Question	Main Types of Methodology Appropriate		Statistical Sources (S)/ Definitions (D)*
		Quantitative Modelling	Qualitative	
Training and Education	Qualitative – Training and Education Questions		Informed Opinion, Consulting Specialist Knowledge	
	Quantitative – Training and Education Questions	Modelling Future Graduate Numbers from Education and Training	Collecting or Surveying for Data on Students/Trainees and Graduates, Graduate Destinations, Informed Opinion	S,D

The main methodological approaches used to consult informed opinion and expert knowledge are interviews, focus groups, workshops, (potentially) Delphic methods and qualitative questionnaire surveys.

* This column flags where consideration of statistical sources and/or the definitions they use is usually an important consideration in both quantitative modelling and qualitative research.

Researchers should recognise the breadth of methodological options available, and should choose from among them on a systematic basis. Selection of the methodology should depend on factors that include, among others, the main research question, data availability and the institutional setting.

Aside from one case noted in the text of the report, no evidence was found of research into skills for the transition to the low carbon economy being evaluated ex-post. Research that underpins significant investment in skills for the low carbon economy should be subject to evaluation ex-post, in terms of the accuracy of any forecasts, the usefulness of scenario projections, and the practical value of the investment.

10.5 Institutional arrangements for skills identification and anticipation

Conclusions

Skills anticipation for the transition to the low carbon economy does not require new institutional approaches at country level, but it does require initiatives to bridge between sectors where anticipation is undertaken at sector level.

Social dialogue is important to the success of systems of early identification of skill needs, including those that analyse skills needs associated with the transition to the low carbon economy. Existing institutional mechanisms such as sectoral skills councils, observatories and skills advisory groups typically provide a forum for social dialogue that involves all relevant partners. They also provide a forum for decision making on the research undertaking.

Governments, employers and workers' organizations all have important and complementary contributions to make in terms of expertise, resources and capability to act. Social dialogue contributes to effective identification of the right issues to study, to high quality analysis, and to effective implementation of skills policies and actions proposed on the basis of the research. The need to involve a broad population of stakeholders, including governments, and representatives of workers and employers, in skills anticipation for the transition to the low carbon economy is as compelling at supranational level as it is at national level.

Institutional arrangements often shape the research approach. Strong sectoral institutions tend to produce sectorally focused research that follows traditional sectoral boundaries. Regional institutions produce regionally focused research.

In many developing countries, systems for skills anticipation are much less developed than is usual in developed countries. In their attempt to satisfy the information thirst on skills for the low carbon transition, these countries tend to create a parallel system of analysis or to conduct one-off, non-sustainable, surveys. Neither of these approaches contributes well to developing capabilities in skills anticipation at country level.

At supranational level, the European Union's Sector Councils on Employment and Skills are still in development and their mandate, scope of work and functions in addressing skills anticipation for the transition to the low carbon economy are still to be defined.

Recommendations

Institutional arrangements for skills identification and anticipation in relation to the transition to the low carbon economy should be inclusive, drawing on the knowledge of a range of stakeholders that include workers' organizations, employers and providers of education and training among others.

Where governments or others propose specific initiatives to contribute to the transition to the low carbon economy they should include an analysis of the skills requirements and a plan for how these requirements can be met in the proposal.

In countries with weaker statistical and skills anticipation systems, work on skills anticipation for the transition to a low carbon economy should be designed as a building block towards a future national system for skills anticipation rather than a one-off initiative. It represents an opportunity to put in place the beginnings of structures such as a national human resource development council involving government, employers, workers and providers of training and education (to facilitate exchange of information) and to establish industry groupings whose role could later be formalised as sectoral skills councils.

Internationally focused research addressing the skills needs of developing countries in the transition to the low carbon economy has an important role to play in laying the groundwork for research, analysis, policy formation and action in developing countries that lack the accumulated expertise that most developed countries have in skills policy. More international research of this sort would be valuable.

Initiatives to progress the transition to the low carbon economy in developing countries should ideally include a skills anticipation and skills response component. Organizations involved in promoting such initiatives should consider making this a standard part of their approach.

Experience at national level shows that where institutions for skills anticipation are organized along sectoral lines cross-cutting initiatives are required to link and coordinate skills anticipation work focused on the transition to the low carbon economy across sectoral boundaries. This experience is applicable to the system of European Sector Councils on Employment and Skills planned by the EU. Planning documents for the system envisage that a Transversal Council would be established to take a lead on issues relevant to multiple sectoral councils. If, or when, it is established, the Transversal Council should consider establishing a coordinating group to address cross-sectoral issues relating to skills for green jobs. Alternatively, a European Sector Council on skills for green and greener jobs, whose establishment is suggested in a recent document on a Resource Efficient Europe (EC, 2011), could perform a coordinating function across other Sector Councils on issues related to skills for green jobs. No matter whether a working group under a Transversal Council or whether a new specifically designated council, the arrangement should allow to benefit from expertise of the representation of green businesses and workers.

The EC should continue to play a role in facilitating sectoral interests and providers of education and training across the member States in identifying and synthesising best practices and high quality curricula and course content for occupations that are important to the transition to the low carbon economy. Various initiatives supported by Intelligent Energy Europe, including the initiative on

education in architecture (EDUCATE – Environmental Design in University Curricula and Architectural Training in Europe) illustrate well what can be achieved in this area.

International and supranational bodies (including the EC) play leading roles in developing policies and setting targets to progress the transition to the low carbon economy. Specific plans for change should in future include an analysis of the skills implications and a plan to address those implications. In the case of the EC, the analysis and planning process should be integrated with the work of the European Sector Councils on Employment and Skills, which could issue guidelines to participating member States and monitor implementation. This is a practical way to achieve policy coherence that respects the application of the open method of coordination to skills policy.

In developed countries, CGE modelling based on comprehensive sectoral disaggregation of the economy is becoming well established as the standard for macroeconomic modelling at national and supranational levels. Because of the large effort required to develop, mature and validate such models, most skills anticipation research projects that use CGE models have to rely on access to an existing model developed for wider policy purposes, and on being able to adapt the model in ways discussed earlier in this report. In the case of the EU, it seems likely that European Sector Councils on Employment and Skills will have a recurring need for modelling of this sort, both for research into the transition to the low carbon economy and for wider skills research purposes. The Skills Council system may consider developing and maintaining a European Skills CGE model, or alternatively developing and maintaining a skills adaptation of an existing EC CGE macroeconomic model. The model would be of recurring value to Sector Councils, both for one-off research and for periodic reporting on the skills outlook. It might also be of value at national level, potentially giving national skills anticipation researchers and policy makers access to a high quality capability in macroeconomic modelling that might otherwise be beyond their reach, and improving coherence in skills anticipation across participating countries. The model's design should take account of the challenges in macroeconomic modelling for skills anticipation for the transition to the low carbon economy identified in this research. The transition is a particularly challenging domain to model well, that brings to the fore issues likely to appear in a wide range of other skills anticipation domains. A model that successfully encapsulates solutions to the challenges of skills anticipation in the transition to the low carbon economy is likely to be relatively easily adapted to a wide range of other skills policy domains.

Bibliography

Abicht, L. et al. 2006. Innovativer methodischer Ansatz zur Früherkennung von Qualifikationsanforderungen am Beispiel landwirtschaftsnaher Trendqualifikationen Forschungsbericht zum Projekt, *Trendqualifikationen als Basis zur Früherkennung von Qualifikationserfordernissen,* Studie des isw Institut gGmbH, Gefördert vom Bundesministerium für Bildung und Forschung (ISW, Halle).

—. 2007. *Ermittlung von Trendqualifikationen als Basis zur Früherkennung von Qualifikationserfordernissen Schlussbericht zum Projekt,* (ISW, Halle), funded by the German Ministry for Education and Research (BMBF).

ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie). 2009. *Marchés, Emplois, et Enjeu Energétique des Activités Liées aux Energies Renouvelables et à l'Efficacité Energétique*.

Ahokas, J., J. Honkatukia, and K. Marttila. 2009. *Forecasting Demand for Labour and Skills with an AGE-model in Finland*. Government Institute for Economic Research.

Alarcón, J., C. Ernst, B. Khondker, PD Sharma. 2011. *Dynamic Social Accounting Matrix (DySAM): Concept, Methdology and Simulation Outcomes. The case of Indonesia and Mozambique*, Employment Sector Working Paper No. 88 (ILO, Geneva)

Annandale, David, Angus Morrisson-Saunders, and Louise Duxbury. 2004. *Regional Sustainability Initiatives: the Growth of Green Jobs in Australia. Local Environment* 9(1):81-87. February.

Annandale, David, Angus Morrisson-Saunders. 2002. *Environmental Jobs in Western Australia.* The results of a 2002 employer survey, Green Skills Inc, School of Environmental Science, Murdoch University Perth, Western Australia, produced for the Western Australian Department of Education and Training.

BC Stats. 2010. *Measuring green collar jobs in British Columbia*. Environmental Statistics Release January 2010, Vancouver.

Bernhard, U.; S. Zurbrügg. 2010. *Cleantechwissen. Cleantech und höhere Berufsbildung*, Bundesamt für Umwelt BAFU (greenjobs, Bern).

Boettcher, Markus; Niels Peder Nielsen, and Kim Petrick. 2008. *A closer look at the development of wind, wave, and tidal energy in the UK: Employment opportunities and challenges in the context of rapid industry growth.* London: Bain and Company.

Breisinger, Clemens and James Thurlow. 2007. "A 2005 Social Accounting Matrix (SAM) for Ghana". Accra: Ghana Statistical Service (GSS) and International Food Policy Research Institute (IFPRI).

Briggs, Chris, Mark Cole, Justine Evesson, Kate Gleeson, John Buchanan, Grahame Larcombe, Hugh Saddler. 2007. *Going with the Grain? Skills and Sustainable Business Development*. Dusseldorp Skills Forum.

CEDEFOP (Centre Européen pour le Développement de la Formation Professionnelle). 2010. *Future Skills Supply in Europe: Medium Term Forecast Up To 2020*. Luxembourg: Office for Official Publications of the European Communities.

—. 2010b. *Skills for Green Jobs. European Synthesis Report.*

—. 2008. Systems *for the Anticipation of Skill Needs in the EU Member States*. Working Paper No. 1. Thessaloniki.

Comhar SDC. 2010. *Skills and Training for a Green New Deal*. September 2010, Dublin.

Délégation générale à l'emploi et à la formation professionnelle (DGEFP). 2010. *Les entreprises du recyclage. Synthèse prospective Emploi-Compétences.*

DIW. 2009. Beschäftigungswirkungen des Umweltschutzes in Deutschland: Methodische Grundlagen und Schätzung für das Jahr 2006.

Dusseldorp Skills Forum (Australia). 2008. *Gen Green Survey*. www.dsf.org.au/resources-and-research/213-gen-green-survey.

Economic Modeling Specialist Inc. (EMSI). 2009. *Green Pathways – A data-driven approach to defining, quantifying, and harnessing the green economy*. Green Jobs. Part 3.

Ehmcke, W.; G. Philipson; C. Kold-Christensen. 2009. *Who are the Green Collar Workers? Defining and Identifying workers in sustainability and the environment* (St. Leonards , Connection Research).

El-Gabaly, Moustafa and Mehdi Majidi. 2003. *ICT Penetration and Skills Gap Analysis*. Partners for a Competitive Egypt.

Employment Committee (EMCO). 2009. *The Employment Dimension of tackling Climate Change Overview of the state-of-play in Member States*, p 8.

EMSI (Economic Modelling Systems, Inc.) 2009. *Green Pathways: A Data-driven Approach to Defining, Quantifying, and Harnessing the Green Economy*. (Green Jobs, Part 3). Moscow, ID: EMSI.

Environment Institute of Australia and New Zealand. 2007. *Who are the Green Collar Workers? Defining and Identifying Workers in Sustainability and the Environment*.

Environmental Careers Organization of Canada (ECO). 2007. *Profile of Canadian Environmental Employment, Environmental Labour Market (ELM)* (Calgary).

European Trade Union Confederation. 2007. *Climate Change and Employment: Impact on Employment in the European Union-25 of Climate Change and CO_2 Emissions Reduction Measures by 2030*, Report prepared by the European Trade Union Confederation, Instituto Sindical de Trabajo, Ambiente y Salud (ISTAS), Social Development Agency, Syndex, and the Wuppertal Institute.

European Climate Foundation. 2010. *Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Hungary*. The Hague: European Climate Foundation.

European Commission (EC). 2011. *Roadmap to a Resource Efficient Europe*. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Brussels.

European Commission (EC). Employment, Social Affairs and Equal opportunities. 2010. *New skills for new jobs*. Available at: http://ec.europa.eu/social/main.jsp?catId=568&langId=en [22 July 2010].

European Commission (EC). DG Environment. 2008. *Environment and labour force skills. Overview of the links between the skills profile of the labour force and environmental factors* (Rotterdam, ECORYS research and consulting).

European Employment Observatory (EEO). 2009. *The employment dimension of economic greening*. European Commission.

Eurostat. 2009. The Environmental Goods and Services Sector: A Data Collection Handbook. (Luxembourg: Office for Official Publication of the European Communities).

EWEA (European Wind Energy Association). 2009. *Wind at Work: Wind Energy and Job Creation in the EU*. Brussels: European Wind Energy Association.

Expert Group on Future Skills Needs (Ireland). 2010. *Future Skills Needs of Enterprise within the Green Economy in Ireland*.

Federal Ministry of the Environment, Nature Conservation, and Nuclear Safety (Germany). n.d. *Renewable Energy Employment Effects: Impact of the Expansion of Renewable Energy on the German Labour Market (Summary)*. Berlin. (Update done in 2007 available at: http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/employment_effects_061211.pdf).

—. 2010. *Renewably employed! Short and long-term impacts of the expansions of RE on the German labour market*. Berlin.

Forward Scotland. 2005. *Skills for the Waste Management Sector in Scotland*.

Fritz, O., M. Getzner, H. Mahringer, and T. Ritt. 2001. *Umwelt und Beschäftigung: Strategien für eine nachhaltige Entwicklung und deren Auswirkungen auf die Beschäftigung, Informationen zur Umweltpolitik 144, Bundeskammer für Arbeiter und Angestellte*, Wien.

Gensicke, et al. 2005. Qualifikationsentwicklung im Bereich Erneuerbare Energien, Endbericht zur quantitativen Betriebsbefragung im Projekt Arbeitsnahe Dauerbeobachtung der Qualifikationsentwicklung mit dem Ziel der Früherkennung von Veränderungen in der Arbeit und in den Betrieben (ADeBar) im Bereich Erneuerbare Energien, (tns infratest, München,), available at: http://www.frequenz.net/uploads/tx_freqprojerg/EB_ErneuerbareEnergien_30-30194.pdf

—. 2006. Qualifikationsprofile im Bereich „Erneuerbare Energien" Ergebnisse der CONJOINT-STUDIE im Rahmen der ADeBar-Studie 2. Erhebungswelle bei Betrieben im Bereich "Erneuerbare Energien", Eine Untersuchung im Auftrag des Fraunhofer-Instituts IAO und des Bundesministeriums für Bildung und Forschung (bmbf) (tns infratest, München).

GHK Consulting. 2007. *Links Between the Economy, the Environment, and Jobs*. Report prepared in association with Cambridge Econometrics and Institute of European Environmental Policy. London.

Guegnard, C. Skills identification in French regions: dream or reality? In Strietska-Ilina O., M. Tessaring. 2007. 'Systems, institutional frameworks and processes for early identification of skill needs. Cedefop, pp. 170-181.

Hammer, G.; R. Rohrig. 2006. *Qualification requirement analysis offshore wind energy industry*, Bremerhaven/Bremen, "POWER" project, IAW, Universität Bremen, EQUIB, available at: http://www.offshore-power.net/Files/Dok/final_report_qrs.pdf.

Hamilton, James and Drew Liming. 2010. "Careers in Wind Energy," *U.S. Bureau of Labor Statistics, Department of Labor*. Accessed: November 3, 2010. http://data.bls.gov/cgi-bin/print.pl/green/wind_energy/home.htm.

Hatfield-Dodds, Steve, Graham Turner, and Heinz Schandl. 2008. *Growing the Green Collar Economy: Skills and labour challenges in reducing our greenhouse emissions and national environmental footprint*. Canberra: CSIRO Sustainable Ecosystems.

Heintz, J.; R. Pollin; J. Wicks-Lim. 2011. *Employment Opportunities and Skill Requirements for Building the Green Economy: A Survey of Research Methods, Political Economy Research Institute* (PERI), University of Massachusetts-Amherst, Prepared for the International Labor Organization (ILO), unpublished.

Honkatukia, Juha, Jouko Kinnunen, and Kimmo Marttila. 2009. "Distributional effects of Finland's climate policy package – Calculations with the new income distribution module of the VATTAGE model," *Working Papers 11,* October. Helsinki, Finland: Government.

HRSD Canada. 2008. Looking-Ahead: A 10-Year Outlook for the Canadian Labour Market (2008–2017). Policy Research Directorate.

Industry Skills Councils (ISC). 2009. *Environmental Sustainability: An Industry Response*.

International Labour Organization (ILO). 2010. *Skills for Green Jobs – 21 Background Country Studies*. Geneva. Available at http://www.ilo.org/skills/what/inst/lang--en/WCMS_144268/index.htm.

—. 2009. *World of Work Report 2009: The Global Jobs Crisis and Beyond*. ILO, Geneva.

ILO/IILS. 2011. *Towards a greener economy: The social dimensions* (ILO/IILS, Geneva).

—. 2009. *World of Work Report 2009. The Global Jobs Crisis and Beyond* (ILO/IILS, Geneva).

ILO/UNEP. 2008. *Green Jobs: Towards decent work in a sustainable low-carbon world*.

Irrek, Wolfgang, Maike Bunse, and Frederic Rudolph. 2007. *Methodologies for assessing the impacts of climate change on employment and incomes*. Report commissioned by the International Labour Office, Geneva.

ISTAS (Instituto Sindical de Trabajo Ambiente y Salud). 2008. *Renewable Energies and Employment Generation in Spain: Present and Future*. Madrid.

Kratzat, Marlene and Ulrike Lehr. 2007. *International Workshop: 'Renewable Energy: Employment Effects' Models, Discussions and Results*. Berlin: Federal Ministry of the Environment, Nature Conservation, and Nuclear Safety.

Lee, S. Y., C. Song, M. Jin. 2010. *Skills for greens jobs in the Republic of Korea*. Republic of Korea Institute for Vocational Education and Training (ILO, Geneva).

Martinez-Fernandez, Christina; Carlos Hinojosa, and Gabriela Miranda. 2010. *Greening Jobs and Skills: The Local Labor Market Implications of Addressing Climate Change*. Working paper prepared as part of the Climate Change, Employment, and Local Development project of the OECD LEED Directing Committee, OECD Green Growth Strategy. Paris: Centre for Entrepreneurship, SMEs and Local Development, OECD.

Meagher, G.A.; P.D.Adams, and J.M. Horridge. 2000. Applied General Equilibrium Modelling and Labour Market Forecasting. Monash University.

MEEDDM. 2009. *Plan de mobilisation nationale sur les métiers liés à la croissance verte*. Comité de filière automobile.

Michael Page International. 2010. *Etude de fonctions et rémunérations. Emplois verts.*

Ministerio de Trabajo y Asuntos Sociales (MTAS). 2006. *Estudio Marco sobre sectores y ocupaciones medioambientales.* Spain.

Moreno, Blanca and Ana Jesus Lopez. 2008. "The effect of renewable energy on employment. The case of Asturias (Spain)," *Renewable and Sustainable Energy Reviews*, 12, p. 732-751.

National Public Employment Service Occupational Observatory. 2009. *A prospective study of renewable energies.* Spain.

—. 2008. *Perfiles de las ocupaciones medioambientales y su impacto sobre el empleo*. Spain

Nordhaus, William. 1992. Lethal Model II: the limits to growth revisited. *Brookings Papers on Economic Activity*, 2: 1-43.

New York State Department of Labor and Research Partners. Project Title: *State LMI Improvement Grant* – SGA DFA PY 08-17.Available at: http://www.labormarketinfo.edd.ca.gov/contentpub/GreenDigest/NY-Abstract.pdf [22 July 2010].

Observatorio de la sostenibilidad and Fundación biodiversidad. 2010. *Informe empleo verde en una economía sostenible.* Spain.

Occupational Information Network (O*NET). 2009. *Greening of the World of Work: Implications for O*NET-SOC and New and Emerging Occupations.* For further information see: www.onetcenter.org.

Organisation for economic co-operation and development (OECD). Eurostat. 1999. *The environmental good and services industry. Manual for data collection and analysis* (Paris).

Pearce, Alicia and Frank Stilwell. 2008. Green-Collar Jobs: Employment Impacts of Climate Change Policies. *Journal of Australian Political Economy*. Vol 62.

Pollin, Robert and Heidi Garrett-Peltier. 2009. *Building the Green Economy: Employment Effects of Green Energy Investments in Ontario,* Political Economy Research Institute, Amherst, MA.

Pollin, Robert, Jeannette Wicks-Lim, Heidi Garrett-Peltier. 2009. *How Clean Energy Policies can Fight Poverty and Raise Living Standards in the United States*. Political Economy Research Institute, Amherst, MA.

—. 2009. *The Economic Benefits of Investing in Clean Energy. How the economic stimulus program and new legislation can boost U.S. economic growth and employment*. Political Economy Research Institute, Amherst, MA.

Pollitt, Hector and Sudhir Junankar. 2009. *The Impact of Oil Prices on the Global Economic Recovery: Final Report*. Research report compiled for the Foreign and Commonwealth Office, UK. Cambridge Econometrics, Cambridge, UK.

Prado, R. ; A. Abiko. 2009. *Demanda de Capacitação Profissional de Instaladores de Sistemas Solares de Aquecimento de Água em Habitações de Interesse Social* (ILO, Abrava, Brasilia).

ProEnviro. 2009. *Skills for a low carbon and resource efficient economy. A review of evidence, (LCREE).*

Rafferty, M.; S. Yu. 2010. *Skills for Green Jobs in Australia*. Background country study for the forthcoming ILO-CEDEFOP Skills for Green Jobs: A global view report (Workplace Research Centre, School of Economics and Business University of Sydney).

RES Compass, different reports available on www.rescompass.org website, supported by the European Commission.

Rush, M. 2008. *A Strategic position paper to support the Agriculture ITO's approach to sustainable management learning and education needs in the pastoral sector*, New Zealand (AgrITO, Wellington, unpublished).

Rutovitz, Jay and Alison Atherton. 2009. *Energy sector jobs to 2030: a global analysis*. Prepared for Greenpeace International by the Institute for Sustainable Futures, University of Technology, Sydney.

Sienkiewicz, L. 2009. *The Employment Dimension of Economy Greening in Poland, European Employment Observatory Review* (Warsaw, Warsaw School of Economics).

South Africa Department of Labour, 2008. *Projected Skill Demand and Supply for the Electrical Energy Sector.* Pretoria.

SQW Energy. 2008. *Today's Investment – Tomorrow's Asset: Skills and Employment in the Wind, Wave, and Tidal Sectors*. Report to the British Wind Energy Association. October 2008.

Strietska-Ilina, Olga, Christine Hoffmann, Mercedes Duran Haro, and Shinyoung Jeon. 2011. *Skills for Green Jobs: A Global View*. Draft Synthesis Report Based on 21 Country Studies. ILO, Geneva.

Sustainlabour/ ILO. 2010. The impact of climate change on employment: management of transitions through social dialogue, available at: http://www.sustainlabour.org/dmdocuments/en337_2010.pdf

Thornkey, Patricia, John Rogers, and Ye Huang. 2008. Quantification of employment from biomass power plants. *Renewable Energy* (on-line journal: doi:10.1016/j. renene. 2007.11.011).

UNEP. (2010). *Overview of the Republic of Korea's National Strategy for Green Growth*. United Nations Environmental Program, Nairobi.

United States Department of Labor. 2010. *Occupational Handbook*, 2010-2011 Edition. Washington, DC: Dept of Labor, Labor Statistics Bureau. Accessed November 3, 2010. http://www.bls.gov/oco/.

United States Department of Labor. Employment and Training Administration (US Department of Labor ETA) American Recovery and Reinvestment Act. 2009. "Notice of Availability of Funds and Solicitation for Grant Applications for State Labor Market Information Improvement Grants" in *Federal Register/Vol. 74, No. 120/Wednesday, June 24, 2009/Notices.* Available at: http://www.doleta.gov/grants/pdf/SGA-DFA-PY-08-17.pdf [22 July 2010].

Walz, R.; C. Dreher; F. Marscheider-Weidemann; C. Nathani; E. Schirrmeister; J. Schleich; R. Schneider; M. Schön. 2001. Arbeitswelt in einer nachhaltigen Wirtschaft – Analyse der Wirkungen von Umweltschutzstrategien auf Wirtschaft und Arbeitsstrukturen. Institut für Systemtechnik und Innovationsforschung (ISI), Texte des Umweltbundesamtes 44/01; available at: http://www.umweltdaten.de/publikationen/fpdf-l/2012.pdf

Weisman, Steve. 2009. *Workforce Impact of Expanded Utility Commercial and Industrial Energy Efficiency Funds in Massachusetts: 2009.* Boston, MA: New England Clean Energy Council.

Workforce Information Council (WIC). 2009. *Measurement and analysis of employment in the green economy*. Report of the Green Jobs Study Group.

Comparative Analysis of Methods of Identification of Skill Needs on the Labour Market in Transition to the Low Carbon Economy

Anticipating skill needs for the low carbon economy is a complex task. The exact margins of the green economic sectors and occupations are not yet fully defined. What these margins are and how they vary across countries and sectors remains to be seen. In addition, the pace of change makes the low carbon economy a moving target, difficult to measure and predict. Intended to assist researchers in anticipating skills, the report *Comparative Analysis of Methods of Identification of Skill Needs on the Labour Market in Transition to the Low Carbon Economy* builds understanding of how to embark on a skills anticipation exercise, which is relevant for national, sectoral and enterprise level human resource development strategies related to climate change mitigation and adaptation. It primarily deals with methodologies and institutional arrangements, and aims to inform decisions on the scope and level of skills anticipation research, sources of information, and available methodological approaches, both quantitative and qualitative. Research objectives, country context, data availability and institutional settings will determine which combination of methods to apply.

The report arises from a joint management agreement between the European Commission and the ILO on *Knowledge sharing in early identification of skill needs*. Two sectoral reports also resulted from this cooperation: *Skills and Occupational Needs in Green Building* and *Skills and Occupational Needs in Renewable Energy.*

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