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Energy transition: should we fear for jobs?

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The energy transition will lead to a major structural change in production models, with macroeconomic implications that are still difficult to grasp. One particular concern relates to employment. Will the transition mean massive job losses and relocations due to higher production costs for companies and loss of competitiveness? Or, on the contrary, will it create growth and new opportunities, with the development of a large number of highly skilled, well-paid green jobs? In order to shed light on this debate, this Note presents a quantification of the employment effects of the energy transition, modelled by the introduction of a carbon tax of €100 per tonne of CO_2.

At the macroeconomic level, this tax will have a limited impact on employment in France: firstly, because companies will undoubtedly adapt their energy mix accordingly; secondly, because this carbon pricing will most likely be adopted at the European level, in parallel with a carbon adjustment mechanism at borders. The diversity of technologies and energy mixes within each sector must also be taken into account, as the considerable heterogeneity between companies implies numerous job reallocations within the same sector, which are greater than reallocations between sectors. The sum of job destruction and creation within sectors would represent 4% of total employment.

The argument of a negative impact on employment must therefore not distract us from a credible European path for increasing the carbon price, an essential instrument for decarbonisation. Our main tool in this regard, the European carbon market, should be improved to ensure its effectiveness: by targeting companies rather than plants - production shifts are easy at this scale - and by providing a stricter framework for carbon offsets. To make this transition a success, we need to support the most affected companies and regions by ensuring that difficulties in accessing credit do not prevent efficient companies with significant transformation potential from making the investments they need to move to a less carbon-intensive mode of production. However, our knowledge of energy consumption of companies is only partial. It is essential that we have the statistical resources to extend our knowledge to all sectors of the economy, not just manufacturing.

While the «job-killing» arguments are weak, the idea that the transition will create a massive number of green jobs also needs to be put into perspective. Green jobs are bound to grow, but they will represent only a modest proportion of total employment. These jobs require a wider range of skills than neutral jobs, but for the time being they do not pay more for the same work. If we are to meet our climate goals, it is therefore essential to address the potential shortfall in the attractiveness of low-carbon transition jobs.

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The global average temperature has already risen by 1.2°C compared to preindustrial levels. In France, the increase has been 1.9°C over the last decade.[1] To meet the interim targets set by the European Climate Law for 2030 (-55% net emissions), France will have to double the rate at which it is reducing its greenhouse gas emissions. Very ambitious measures are therefore needed. The structural changes required to achieve this will be a major shock, given the extent to which fossil fuels have shaped current production models. This shock is comparable in magnitude, though different in nature, to the shocks of globalisation and uneven technological progress that developed economies have experienced — and relatively poorly absorbed— in recent decades. We must therefore anticipate its consequences. It's therefore a question of anticipating its consequences.

In terms of employment, the consequences of the transition to a low-carbon economy are, at first sight, uncertain. Should we fear a «job-killing» scenario, where the transition leads to the disappearance of entire economic sectors and massive job losses? Or, on the contrary, can we see in the low-carbon transition the promise of massive green job creation? The aim of this Note is to shed light on this issue by proposing two ways of thinking about the impact of the transition. On the one hand, we examine the consequences of a transition triggered by an increase in the price of carbon, and hence the price of fossil fuels. Climate policy ultimately involves putting a price on carbon, which does not spontaneously have one. This price can be explicit, if it takes the form of a carbon tax or a market in tradable emission permits, or implicit, if the policy takes the form of regulations or bans. In fact, a ban has exactly the same effect as an infinite carbon price; regulations raise the price of carbon products or technologies, especially if they are more restrictive. Climate policy uses all these instruments at the same time, introducing different carbon prices into the economy. As it is difficult to capture this diversity in this *Note*, we illustrate the effects on output and employment of a single €100 carbon price imposed on the whole economy. We consider the reallocations that may occur between sectors, between high-emitting sectors and others, and within sectors, between the most energy-efficient firms and others. Second, we examine the nature of the changes that are likely to occur in the structure of occupations and skills.

The impact of carbon pricing

The growing ambition of European climate policy and the expected increase in the price of carbon raise the question of its macroeconomic and macro-sectoral impact. In particular, the strong heterogeneity of carbon intensity across sectors and countries implies differentiated impacts and a realignment of international value chains that will affect production and employment. In this first section, we propose a quantification of the sectoral impact of an increase in the carbon price using two methodologies: (1) a national approach, taking into account the energy mix of each sector in France, and (2) an international approach, based on the relative price of goods and trade between sectors and countries.

Impact in France, taking into account the energy mix

To simulate the impact of the introduction of a carbon tax, we use a first simulation model (ThreeMe)[2] specifically developed to analyse the medium and long-term consequences of energy and environmental policies at the national level. ThreeMe is a neo-Keynesian model and allows for the existence of sub-optimal equilibria such as involuntary unemployment. This model, used by institutions such as the French Treasury, the French Ministry for Ecological Transition, France Stratégie and Ademe, has the advantage of taking into account the energy mix of each sector, i.e. it takes into account the possibility of switching to less carbon-intensive energy sources in the event of an increase in the price of carbon-based energy. The energy sector is divided into four sectors: electricity, gas, coal and oil. In addition, this model makes it possible to examine the effects of the redistribution of income generated by the tax and to compare scenarios with and without the redistribution of tax revenues to households and businesses.[3] Finally, this model treats household energy consumption as a specific consumption good, complementary to the consumption of goods related to transport and heating.

We use this model to simulate the effect of introducing a carbon tax of €100 per tonne of CO_2 emitted by 2030. As The scope of this tax is national, the results we present below need to be compared with work that also looks at a national tax (see below). The impact of this tax varies greatly depending on whether or not its revenues are redistributed. Without redistribution, this tax reduces GDP (-0.75%), investment (-0.7%), consumption (-1.2%) and exports (-0.9%) and increases imports (+1.1%). This scenario corresponds to the allocation of the tax revenue to the reduction of public debt, which leads to a reduction in aggregate demand and therefore has a recessionary effect. If the tax revenues are redistributed, the impact on GDP is positive (+0.3%), with an increase in

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[1] Annual report of the French High Council for the Climate (2023): «Acter l'urgence, engager les moyens».

[2] Callonnec G., Landa G., Malliet P., Reynès F. et Yeddir-Tamsamani Y. (2013) : «A full description of the ThreeME model: Multi-sector Macroeconomic Model for the Evaluation of Environmental and Energy policy», Ademe-OFCE.

[3] Revenues from the carbon tax on households are fully redistributed to them in the form of an income tax reduction. The revenues from businesses are redistributed via a reduction in social security contributions, in proportion to payroll by sector of activity.

consumption (+0.6%) and investment (+0.5%), while the external balance deteriorates less than in the absence of redistribution. In response to the changes in relative energy prices associated with the introduction of a carbon tax, firms change their energy mix by substituting the most carbon-intensive energy sources with less carbon-intensive ones. These changes in the energy mix in favour of less carbon-intensive energy make it possible to reduce the level of emissions without leading to an excessive reduction in the quantities produced.

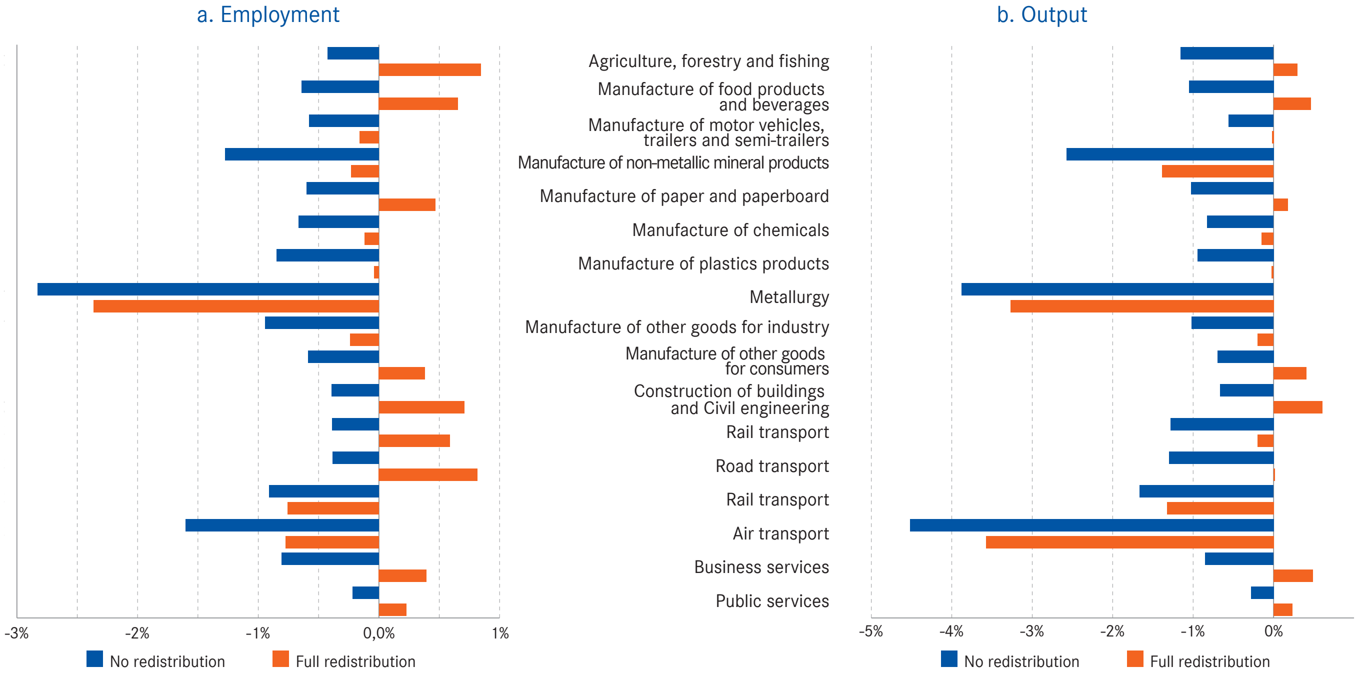
The sectoral disaggregation of the model allows us to compare the impact of the tax on different sectors, both with and without income redistribution (Figure 1). Without redistribution, output and employment fall in all sectors. The size of these reductions depends on the specific carbon intensity of each sector, ranging from -2.8% for employment in metallurgy to -0.4% in construction. The overall impact on employment is -0.6% (-167,000 jobs) by 2030. If the tax revenues are redistributed, which we consider to be the most likely scenario, the production volumes of the less carbon-intensive sectors increase, as do their employment levels.[4] The overall impact on employment is then positive: +0.3% and +92,000 jobs.

Even in the worst-case scenario, these aggregate effects on employment are smaller than the job losses caused by competition from products imported from China, estimated by Malgouyres[5] at 294,000 in the French economy as a whole (104,000 jobs destroyed in manufacturing and 190,000 indirect job losses in the rest of the economy), or the impact of robotisation, which according to Aghion et al.[6] led to the destruction of 214,000 jobs in France between 1994 and 2014.

The level of tax coverage

Using the ThreeMe model, we have simulated a domestic tax of €100 per tonne of CO_2 emitted, applied to all production sectors and to final energy consumption. However, this simulation does not allow us to explore other scenarios where the tax would be applied beyond our borders. To explore these, we have also used a multi-country, multi-sector model[7] to compare different taxation scenarios according to the geographical coverage of the tax, whether at national level in France, at European Union (EU) level or at worldwide level.[8] Extending the scope of the tax changes the impact on French

Figure 1. Impact on production and employment of a €100/tonne carbon tax



Source: ThreeME model version 3. Reynés F., Callonnec G., Saussay A., Landa G., Malliet P., Gueret A., Hu J., Hamdi-Cherif M. and Gouëdard H. (2021): «ThreeME Version 3: Multi-sector macroeconomic model for the evaluation of environmental and energy policies - A full description».

[4] It should be noted, however, that employment may increase in certain sectors that appear to be carbon-intensive. This may be explained by the effects of redistribution of tax revenues, which can stimulate economic activity in various sectors, even if they are carbon-intensive, depending on how revenues are reallocated and spent.

[5] Malgouyres C. (2017): «The impact of Chinese import competition on the local structure of employment and wages: Evidence from France», *Journal of Regional Science*, 57 (3), pp. 411-441.

[6] Aghion P., Antonin C. and Bunel S. (2019): «Artificial intelligence, growth and employment: The role of policy», *Économie et Statistique/Economics and Statistics*, no. 510-511-512, pp. 150-164.

[7] Baqaee D. and Farhi E. (2019): «Networks, barriers, and trade», no w26108, National Bureau of Economic Research.

[8] Méjean I. and Schoch M. (2023): «Carbon pricing and its implications in input-output networks: the case of France», CAE, *Focus* no. 96, June.

companies in two ways. First, to the extent that the prices of imported goods include the cost of the carbon tax, it increases the overall exposure of firms to this tax. Second, as The prices of goods produced abroad are also affected by the carbon tax, the competitiveness of French firms is enhanced. These two mechanisms interact to shape the overall impact of the tax on French firms, depending on its geographical coverage.

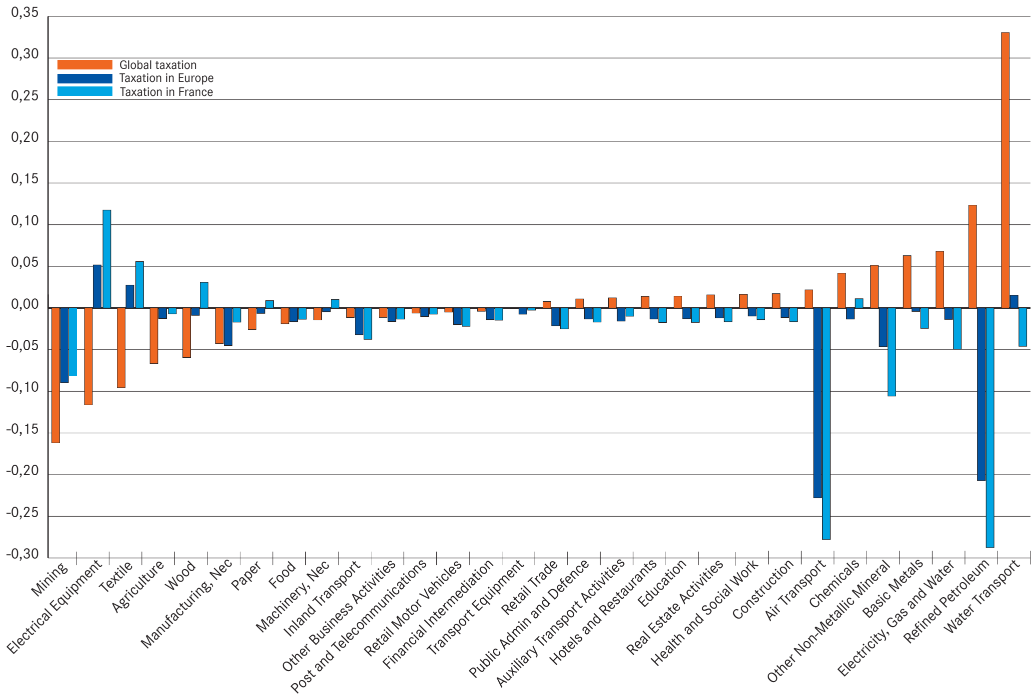
The simulation results show significant differences in the impact of the tax depending on its geographical coverage (Figure 2). For sectors with low carbon intensity, such as electrical equipment, the application of a carbon tax at national level leads to an increase in the quantities produced due to the relative reduction in labour costs and the low cost of the tax. When the tax is extended to the European or global level, French wages do not fall because the burden of the tax is shared, while the price of imported intermediate consumption increases due to the effect of the tax. As a result, the quantity produced by these sectors falls as the tax is extended.

Conversely, many carbon-intensive sectors (chemicals, metallurgy, etc.) affected by the French carbon tax would benefit from its wider application. These sectors have a high carbon intensity relative to other sectors in France, but a low carbon intensity relative to the same sectors in other countries where the energy mix is more carbon intensive. A global tax would therefore make them more competitive, as the increase in their costs resulting from the tax would be lower than that of their foreign competitors.

The prospect of a global tax is admittedly more theoretical. However, it should be remembered that the future Carbon Border Adjustment Mechanism (CBAM), which will be introduced from 2026, will play a part in this compensatory role. This new instrument, which is designed to apply a carbon price to products imported into the customs territory of the European Union, will reduce the differences between the costs incurred by producers in Europe and those incurred by producers in regions with less ambitious climate policies.[9]

While this second model makes it possible to incorporate a supranational level of taxation by considering energy as a homogeneous good, it is less suitable than the ThreeMe model, which takes into account the diversity of the energy mix in each sector. Together, these two models provide crucial information for understanding the impact of a carbon tax on different sectors of the economy at national, European and worldwide levels. The impacts estimated in the ThreeMe model or in the multi-country, multi-sector model (national or European tax scenario) should therefore be considered as an upper bound on the sectoral impacts, as they do not take

Figure 2. Impact of a carbon tax on French production by geographical coverage



Note: Impact of a carbon tax of $100/tonne of CO2 emitted on the production of sectors with three scenarios: taxation in France, in the European Union or at worldwide level.

Source: Méjean I. and Schoch M. (2023): «Carbon pricing and its implications in input-output networks: the case of France», CAE, *Focus* no. 96, June.

[9] The following sectors will be included in the CBAM from 2026: iron, steel, aluminum, cement, fertilizer, electricity and hydrogen.

[10] Fontaine F. and Marullaz C. (2023): « Choc de l'énergie, prix du carbone et emploi », CAE, *Focus* no 102, November.

[11] The EACEI covers establishments with more than 20 employees in the manufacturing sector. The sample is exhaustive for establishments with more than 250 employees, and is based on sampling for establishments with fewer than 250 employees. Approximately 8,500 establishments are surveyed each year, i.e. around 40% of the establishments concerned.

into account the introduction of the CBAM or technological developments.

Finding 1. Increasing the carbon price will not lead to massive job losses. In most scenarios there is no significant impact on employment at the aggregate level.

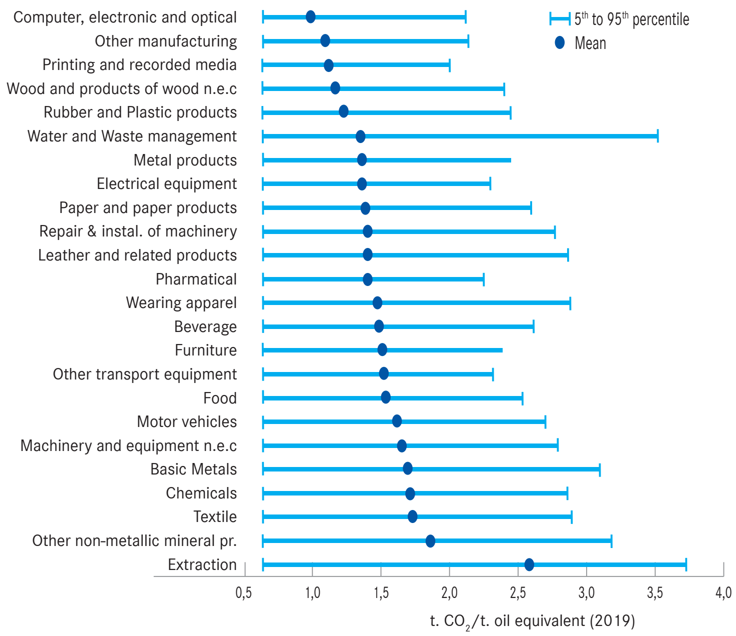
Heterogeneity within sectors

While previous analyses have shown the limited impact of a carbon price increase on employment, they overlook the extent of heterogeneity within sectors in terms of efficiency, energy mix and therefore emissions. This intra-sectoral heterogeneity will necessarily affect the employment effects of a carbon price increase, as it implies the existence of reallocation mechanisms within each sector. To investigate this issue, we use data on energy consumption in the manufacturing sector, to which we add information on company accounts and employment.[10]

Data from the Annual Industrial Energy Consumption Survey (Enquête sur les consommations d'énergie dans l'industrie / EACEI)[11] are used to monitor energy consumption (in volume and value) and employment in the manufacturing sector. These data provide information on how a firm uses the different energy sources (electricity, gas, non-fuel oil products, etc.)[12]. These can be reduced to a common equivalent (tonne oil equivalent or kWh), which is used to calculate a unit price for energy and a level of emissions per unit of energy: companies emit more or less greenhouse gases depending on their energy mix.

This shows that emissions per unit of energy vary considerably both between and within sectors (Figure 3). Surprisingly, the differences between establishments in the same sector are larger than those between sectors. This is a fundamental fact in the debates on future decarbonisation efforts: it is true that sectors are unequal in terms of the task at hand, but the establishments within them up are just as unequal, if not more so.

Figure 3. Heterogeneity of emissions (manufacturing sector)



Note: The dark blue point shows the average emissions per unit of energy in each sector, while the blue line shows the dispersion between the 5th and 95th percentiles.

Sources: Fare, DADS Postes and EACEI data (2008-2020); Authors' calculations.

Finding 2. There is considerable within-sector heterogeneity in emissions per unit of energy, which needs to be taken into account when assessing the impact of the transition.

The same data can also be used to observe how a company's energy mix, i.e. The share of each energy source in its total consumption, changes in line with price trends. Over our observation period, from 2007 to 2019, average prices have fluctuated considerably, and these fluctuations have

[12] The following energies are referenced in the EACEI data: electricity, steam, natural gas, butane and propane, other network gases, coal, lignite-lean coal, coal coke, petroleum coke, heavy fuel oil and heating oil.

[13] For full results tables and further details on the methodology, see Fontaine F. and Marullaz C. (2023).

[14] These estimates include fixed effects for industry, size, employment zone, VA per worker and energy intensity (categories defined prior to the estimation period).

[15] Marin G. and Vona F. (2021), Bretschger and Jo (2023), Fontagné L. et al. (2023) find, on the same data (with slightly different periods), declines in employment of between 0.1% and 0.15%, or even statistically insignificant effects. These orders of magnitude correspond to what we can find for transitory shocks (-0.1% and weakly significant). Marin G. and Vona F. (2021): «The impact of energy prices on socioeconomic and environmental performance: Evidence from French manufacturing establishments, 1997-2015», *European Economic Review*, vol. 135 (C); Bretschger L. and Jo A. (2021), «Complementarity between Labor and Energy: A Firm-Level Analysis», *Economics Working Paper Series* 21/364, ETH Zurich; Fontagné L., Martin P. and Orefice G. (2023): «The Many Channels of Firm's Adjustment to Energy Shocks: Evidence from France», *CESifo Working Paper* n° 0548.

[16] Following an energy price shock, we can estimate how the share of each socio-professional category in plant employment evolves: the share of employees and unskilled workers increases (1.9% and 5%), while that of skilled workers and management decreases (-0.6% and -0.9%). Similarly, it is not the most unskilled-labour-intensive establishments that are most affected.

[17] Emissions from production processes are not taken into account in our calculations, as company-specific data are not available.

[18] *Focus* no. 102 (Fontaine F. and Marullaz C. 2023) also presents the effects of a variation in the absolute level of energy prices.

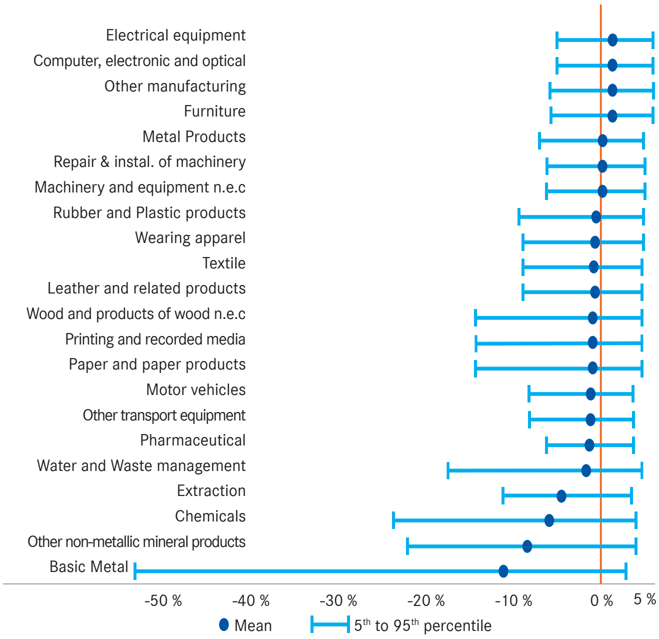
constituted shocks to which firms have had to react. We examine their response by distinguishing between temporary shocks, whose effects gradually fade, and permanent shocks. The latter are of particular interest to us because carbon energy prices are likely to rise permanently during the low-carbon transition. Our results show that when energy prices rise permanently by 1%, firms reduce their energy consumption by 1.2%.[13] Their emissions then fall by 2.2%, indicating a switch to less carbon-intensive energy sources. Turnover and value added are also revised downwards (-0.5% and -0.8% respectively). In terms of employment, a permanent 1% increase in unit energy prices leads to a fall in employment of around 0.3%, while wages absorb part of the shock and fall by 0.8%.[14] These results are consistent with existing work, although our elasticities are higher because we distinguish between transitory and permanent shocks.[15] It should also be noted that there is no evidence that the employment of the least skilled is more affected.[16]

Using the estimated effects of a permanent energy price shock, it is possible to simulate the impact on employment of a 100 €/tonne increase in the carbon price. To do this, we calculate the emissions of each company on the basis of its energy mix in 2019 in order to deduce how this tax changes the unit price of energy.[17] The calculated increase will be all the greater if the establishment is a high emitter and its energy price is low. In line with our empirical strategy, we then calculate the relative variation in the price of energy for each establishment compared to the average increase for the sector.[18] It is this variation in the relative cost of energy that corresponds to the effect on employment shown in Figure 4.

By construction, the average effect on changes (in %) in employment at establishment level is zero.[19] The overall effect on employment will therefore depend on the relative size of the establishments negatively and positively affected by the tax. In this respect, it should be noted that the most negatively affected establishments are also the largest ones. This results in an overall negative effect on employment of about -1.5%. This effect is quite small, especially considering that our estimates cannot take into account any technological breakthroughs that may occur. In this sense, these effects are medium-term.

While some sectors are more affected than others, in particular metallurgy, non-metallic mineral processing (such as glass), chemicals and mining, others are experiencing growth in employment, albeit modest. It is important to note that in all sectors, some companies with lower emissions will benefit from the reallocation of jobs as a result of the higher cost of carbon and will therefore grow. Calculating the size of the induced reallocation as the sum of job creation and job destruction as a proportion of total employment gives a figure of 4.1% of total employment: ignoring intra-sectoral heterogeneity would therefore lead to an underestimation of reallocations, which would be halved (2%) if calculated on the basis of average effects per sector of activity. However, this figure remains reasonable in view of the annual rate of job reallocation in France, which is in the order of 20%.[20]

Figure 4. Employment impact of a 100 €/tonne increase in the carbon price



Note: Simulated effects of the relative tax (tax - average tax) for an energy price elasticity of employment of -0.3 and taking into account differences in emissions between plants. We present the effect on employment in each sector and the effect on establishments (average establishment, 5th and 95th percentiles).

Sources: Fare, DADS Postes and EACEI (2008-2020); Authors' calculations.

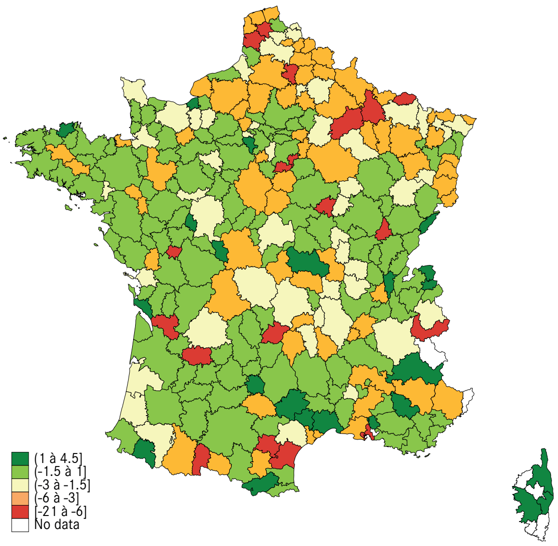
The results can also be presented by employment area (Figure 5). There are large disparities, particularly between areas in the north-east and the rest of France. However, there are only about fifteen areas where industrial employment has fallen by more than 6% (shown in red on the map). Sectoral differences between employment zones explain only a third of these disparities, which are essentially due to the concentration of companies with an unfavourable energy mix in certain zones, regardless of the sector to which they belong. This is an important dimension for targeting public policies (see below). These geographical disparities deserve a great deal of attention, especially as we know that people's territorial mobility faces many obstacles, some of which are difficult to overcome. The European Union's €17.5 billion Just Transition Fund (JTF) allocates aid by giving priority to the areas most affected by the low-carbon transition: France has been allocated €937 million for the period 2021-2027. The eligible areas are located in six metropolitan regions, with the largest beneficiaries being the

[19] We analyze a price variation specific to each establishment as a deviation from the average variation of the other establishments. The average price variation is therefore zero.

[20] Bock S., Elewa A. and Guillou S. (2023): «Comprendre le tissu productif marchand en France: une analyse de la décennie passée», *OFCE Policy brief* 119, September.

departments of Nord and Pas-de-Calais, Bouches-du-Rhône, Grand Est and Normandy. It should be noted that the results of this simulation do not include the impact of projects supported by the France 2030 programme, such as the three gigafactories for the production of batteries for electric vehicles in the Hauts-de-France region by 2026.

Figure 5. Impact of a carbon tax on employment by employment area



Note: Simulated impact of the relative tax (tax - average tax) for an energy price elasticity of employment of -0.3 and taking into account differences in emissions between plants. The map shows the average effect, weighted by employment, for each area.

Sources: Fare, DADS Postes and EACEI (2008-2020) and calculations by the authors.

What public policies?

Setting a dynamic carbon floor price

Overall, the impact of the carbon tax on employment is limited. The argument of massive job losses, which has been disproved here, should therefore not distract from an ambitious CO_2 reduction path, which requires carbon pricing and the introduction of regulations and standards to support the transition.

> **Recommendation 1.** Introduce a dynamic floor price for carbon that reflects its social cost, at least 150 euros/tCO_2 today and around 250 euros/tCO_2 in 2030.

Although there is still some uncertainty about the social cost of carbon in 2030, the estimation of a shadow price for carbon (or climate action value)[21] gives an order of magnitude: the work of the Quinet Commission suggests a value of around 250 euros/tonne in 2030.[22]

Designing our main instrument: the EU ETS market

Previous assessments have focused on increasing a carbon tax that would affect all regulated entities equally. In practice, however, there are two approaches to carbon pricing. One is a carbon tax, which puts a cost on carbon emissions and rises progressively to encourage reductions in CO_2 emissions. The other is a carbon market, where companies are allocated or can buy emission permits, which represent a quota of emissions that cannot be exceeded. If a company emits less carbon than its quota allows, it can sell the surplus on the market to a company that exceeds its quota. In this system, as the number of permits issued falls over time, the price of permits rises and emissions fall. This is the type of market that has been set up in the European Union. Known as the European Union Emission Trading Scheme (EU ETS), it is our main instrument for putting a price on carbon.

The introduction of the European carbon market has led to numerous exemptions or differentiated measures, and important compensatory measures have been implemented at European and national level, notably through the free allocation of CO_2 emission quotas and support for investment in less polluting technologies. For example, the texts establishing the ETS provide for Member States to compensate for the absence of the ETS for certain installations by equivalent national schemes. In order to avoid regulatory distortions, it is therefore necessary to ensure that national policies (carbon taxes) develop at a pace comparable to that of the European market, but also to ensure that state-subsidised investments are not entirely taken up by companies covered by the ETS. In addition, while industrial sectors receive allowances largely free of charge, this is not the case for the electricity sector, which can pass on the cost of carbon in its prices (also known as indirect carbon costs) without fear of companies relocating to countries with less restrictive legislation. The proceeds from the auctioning of allowances[23] are then used to subsidise investments aimed at reducing the consumption of fossil fuels by certain industrial installations and to finance aid to sectors exposed to a significant risk of carbon leakage due to the indirect costs of the ETS. Some of these aids and compensation measures are therefore targeted at industries with high emissions and appear to undermine the original objective of reducing CO_2 emissions. Unfortunately, it is not currently possible to measure these effects accurately due to a lack of available data.

[21] This notion of the value of climate action is a tool for evaluating investments and public policies, and does not in itself prejudge the right combination of measures to be put in place. We use this notion here to estimate an upper range for the price of carbon.

[22] France stratégie (2019): «La valeur de l'action pour le climat», Rapport de la commission présidée par Alain Quinet.

[23] Revenues are redistributed to member states, which must devote at least 50% to environmental actions.

The European Emissions Trading Scheme (ETS)

Carbon markets, also known as emissions trading schemes or the EU ETS, are regulatory instruments designed to achieve greenhouse gas emission reduction targets. In 2005, The European Union set up a carbon market to measure, control and reduce emissions from its industry and electricity producers.

The EU ETS currently covers almost 45% of EU emissions, including 1,264 emitting installations in France. In order to prevent regulated companies from losing competitiveness to their foreign competitors, the carbon market has been developed in several phases, allocating free allowances in almost all industrial sectors. In Phase I, from 2005 to 2007, companies received free allowances corresponding to their past emissions and could sell them on the market (if their abatement costs were lower than the allowance price) or buy them. The impossibility of saving these allowances between Phase I and II caused their price to fall to zero in 2007. In subsequent phases (Phase II from 2008 to 2012 and Phase III from 2013 to 2021), the cap on allowances was gradually reduced and the rules for allocating free allowances were harmonised across Member States (based on the emission intensity of the top 10% of installations per sector). To address price volatility, the Market Stability Reserve (MSR) mechanism, introduced in 2019, now allows allowances to be automatically withdrawn in the event of a surplus, within a pre-defined range, and reissued in the event of a shortage. In phase IV (2021-2030), the number of allowances is further reduced with the introduction of the linear reduction factor, which reduces the number of allowances allocated to companies each year (-4.3% for the period 2024-2027 and -4.4% from 2028).

In 2023, Member States and the European Parliament agreed to accelerate the EU's energy transition by setting a series of targets: to reduce final energy consumption by at least 12% by 2030, to reduce greenhouse gas emissions by 55% by 2030 compared to 1990 (Fit for 55) and to achieve carbon neutrality by 2050. These measures include a reform of the European carbon market: the system will now also apply to housing and (gradually) to intra-Community sea and air transport. In addition, a second carbon market, known as ETS2, will be dedicated to road fuels and building heating, and a Social Climate Fund will be set up from 2026 to help vulnerable households and micro-businesses with their energy transition.

The EU's Carbon Border Adjustment Mechanism (CBAM) will apply to imports that contribute most to global warming (steel, aluminium, cement, electricity), while free emission allowances allocated to industrial companies operating in the EU will be phased out by 2034. Member States' revenues from emissions trading will be used to support climate and energy projects, as well as social support for the energy transition.

In addition, regulated companies have the opportunity to implement strategies aimed at reducing the cost of environmental policy, as highlighted in a Focus accompanying this Note:[24] regulated companies have shifted some of their emissions from plants directly subject to the ETS to those that are not, thereby circumventing the constraint.

Since its introduction in 2005, the ETS has been heavily criticised for its excessively high emission caps and numerous sectoral exemptions, which have led to very low prices for emission allowances (e.g. below €10 per tonne of CO_2 from 2012 to 2017) and, following the uncovering of VAT fraud, to a tax loss of around €1.6 billion for the state budget.[25] In Phases III (2013-2020) and IV (2021-2030), the Market Stability Reserve Mechanism (MSM) and the Linear Reduction Factor (LRF) have been used to address certain imperfections, allowing the supply of allowances to be further reduced. The price of allowances has recently risen, exceeding €40 for the first time in 2021 and currently ranging between €80 and €100. In addition, a major reform of the carbon market has been adopted for 2023, which should make the system more efficient by expanding it and gradually reducing the number of free allowances (see box). These changes are a step in the right direction, but there is still a need to be vigilant about the risk of allowance price volatility that these various reforms could create.

Recommendation 2. Set stricter limits on offsets in relation to CO_2 reduction targets and make all the establishmentsof each company subject to the European carbon market.

Supporting the transition

The differential impact of a carbon tax on employment across sectors and regions suggests that we should favour public policies that target more than just a few companies in a limited number of sectors. The companies we want to reach need to be efficient in terms of value added and able to change their production methods to less carbon-intensive ones. Their failure to invest in the energy transition must be explained by market imperfections, and in this respect three frictions seem to us to be particularly important.

The first is an information problem, especially for small and medium-sized enterprises. It can be difficult for their

[24] Barrows G., Calel R., Jégard M. and Ollivier H. (2023): «Estimation de l'effet du marché du carbone européen sur l'industrie manufacturière européenne», *Focus* no. 101, November.

[25] Cour de comptes (2012): «La fraude à la TVA sur les quotas de carbone», Rapport public annuel, pp. 147-196.

managers to identify the measures that will effectively decarbonise their activities. Given the diversity of energy mixes and the specific characteristics of each company, a personalised technical diagnosis is needed (carbon assessment, decarbonisation plan, energy audits of buildings, optimisation plan for water, energy and waste flows, etc.). To support them, a local network of experts and consultants will be set up to publicise the support schemes and then carry out the diagnoses. This is one of the objectives of the actions undertaken by Bpifrance as part of its Climate Plan, which will be significantly strengthened by 2028.

The second shortcoming stems from the lack of visibility regarding climate policy and the evolution of the carbon price in the coming years, which leads to uncertainty regarding the profitability of investments. Hence the first recommendation of this Note, to maintain an ambitious and predictable carbon price trajectory in the context of a European carbon market.

Finally, some companies may face credit constraints that limit their ability to invest in green or less carbon-intensive technologies. Public authorities have therefore set up systems of bank loans and guarantees, which, compared to subsidies, limit deadweight loss and moral hazard when the guarantee is only partial, and focus on companies for which the investment makes economic sense. They can also be accompanied by a policy of preferential interest rates when companies underestimate the social value of their investment. For example, Bpifrance's green loans will amount to €1 billion in 2022, distributed to 900 companies, compared with 140,000 French companies (excluding micro-enterprises), the vast majority of which are SMEs, including 25,000 in industry. While employment is highly concentrated in large and medium-sized companies, SMEs account for a third of employment and must not be neglected. All businesses need to have access to loan and guarantee schemes, which in turn requires them to have a clear understanding of the expected benefits and therefore the path of the carbon price.

Recommendation 3. Encourage all companies? to become more energy efficient by making even greater use of the support and funding schemes offered by the various players. Particular attention should be paid to areas identified as most vulnerable.

Furthermore, as we have seen, the heterogeneity of emissions per unit of energy between companies is an important factor in this transition period. However, our knowledge in this area is limited. The only annual energy consumption database currently available is very incomplete: it covers only 40% of manufacturing enterprises and not the other sectors of the economy. Comprehensive and accurate data are essential to measure the impact of public policies related to energy transition and to identify companies and regions that need priority support. This would also pave the way for 'carbon accounting', allowing carbon to be tracked throughout the value chain of any good.

Recommendation 4. Establish a database of all companies and sectors reporting on their energy consumption and expenditure, fed by systematic feedback from energy suppliers.

Green jobs

The arguments of massive job destruction often used by opponents of climate policy seem very fragile, as our macro- and micro-economic assessments have shown.[26] But can we really expect investment plans for the low-carbon transition to create large numbers of highly skilled and well-paid «green jobs»?

How to define green jobs?

The US Bureau of Labor Statistics[27] suggests a particularly useful distinction for refining the scope of green jobs. From an output-based perspective, a job can be described as 'green' if it is associated with a low-carbon activity. This approach, which makes it possible to distinguish between the sectors most advanced in decarbonisation and those requiring the greatest investment, has a major limitation: the least carbon-intensive activities are largely concentrated in the service sector. By their very nature, they are less directly affected by the low-carbon transition. For example, a lawyer or a financial manager may work in a low-carbon sector but not necessarily be directly involved in the decarbonisation of the economy.

The first estimates by national statistical institutes (BLS, 2013 and Eurostat, 2016)[28] focused on this sectoral approach, which consists of measuring the 'green' character of an economic sector as a whole. This approach has the advantage of being based on data that are available in most countries in a standardised and easily comparable way. However, it masks the very significant heterogeneity within most sectors of activity — only a few sectors, such as renewable energy, can be considered 'green' as a whole.

[26] The Pisani-Ferry/Mahfouz mission's thematic report on the labor market also makes this point.

[27] Bureau of Labor Statistics (2013): «BLS green jobs overview», *Monthly Lab. Rev*., 136, 3.

[28] Eurostat (2016) : *Production, value added and employment by industry groups in the environmental goods and services sector*.

A second perspective, known as 'process-based', focuses not on the carbon intensity of an activity but on its active role in decarbonising the economy. The emphasis here is on jobs that, by their very nature, help to reduce greenhouse gas emissions. It is these activities that are likely to grow with the low-carbon transition. However, it remains to be seen which occupations within the economy will make the greatest contribution to decarbonisation. In The remainder of this Note, we focus on this process-based definition of green jobs.

More recent work[29] has developed this occupational approach. These contributions are mainly based on the American O*NET classification, which systematically lists the specific tasks required to perform one of the more than 900 occupations that make up its taxonomy. This classification is particularly well suited to the study of green jobs since the introduction of a new list of 1,369 specifically green tasks, thanks to O*NET's Green Economy research programme. It is then possible to assign a score to each occupation measuring the degree of 'greenness' by estimating the proportion of specific tasks identified as green.[30]

Green jobs in France

Using this occupational measure, the Observatoire national des emplois et métiers de l'économie verte en France (Onemev) proposes a taxonomy of two types of jobs associated with the greening of the economy: green and greening. Green occupations are those with a direct environmental purpose (foresters, workers in the production and distribution of renewable energy, etc.). Greening occupations, on the other hand, do not have a direct environmental objective but may involve environmental issues (architect, building insulation installer, construction manager, etc.). Onemev estimates that green jobs account for around 0.5% of employment in France and that jobs in the process of being greened account for around 14%.[31] The first figure - based on a list of 10 green occupations - underestimates the real share of green jobs because it does not take into account certain jobs related to decarbonisation that are not only identified as having a direct environmental purpose (for example, plumbers are not considered «green», although we would like to count plumbers who install heat pumps as «green» jobs). Conversely, the figure of 14% of green jobs — based on a list of 52 occupations mainly found in the construction, manufacturing and transport sectors — greatly overestimates the real share of transition-related employment if, for example, all plumbers, all bricklayers or all taxi drivers are included in this category.[32]

The occupational approach is more precise than previous sectoral approaches, but it has significant limitations and does not allow the existence of specifically green skill profiles to be accurately identified. In addition, occupational taxonomies generally do not go into sufficient detail within occupational groups. An example is that of chemical engineers, who may find themselves at the two extremes of the low-carbon transition, depending on whether they work in petrochemicals or in the development of new insulation materials.

To overcome these difficulties, it is necessary to consider the heterogeneity within each occupation that makes up the labour market. The recent availability of large databases of job vacancies, combined with new natural language processing technologies, means that jobs related to the low-carbon transition can be identified in much greater detail. Recent studies have applied these methods to Anglo-Saxon data,[33] analysing several hundred million online job advertisements. They estimate the share of green jobs in the US and UK at around 1%, compared to 0.5% in France as calculated by Onemev.

Finding 3. Green jobs currently represent between 0.5% and 1% of total employment. They will grow, but will remain a modest share of total employment.

General characteristics of green jobs

The work on job vacancies also helps to better characterise green jobs. The common nature of the main findings on both sides of the Atlantic suggests that these are stylised facts that apply irrespective of specific national contexts - at least as far as developed countries are concerned.

Skills profiles

Job advertisements related to the low-carbon transition tend to require a wider range of key skills than 'neutral' jobs. This suggests that decarbonisation jobs are systematically more demanding in terms of skills. These observations hold for

[29] Vona F., Marin G., Consoli D. and Popp D. (2018): «Environmental regulation and green skills: an empirical exploration», *Journal of the Association of Environmental an Resource Economists*, 5 (4), pp. 713-753; Marin G. and Vona F. (2021): «The impact of energy prices on socioeconomic and environmental performance: Evidence from French manufacturing establishments, 1997–2015», *European Economic Review*, 135, 103739; Elliott R. J., Kuai W., Maddison D. and Ozgen C. (2021) : *Eco-Innovation and Employment: A Task-Based Analysis*.

[30] Vona F., Marin G., Consoli D. and Popp D. (2018) : *id*.

[31] The proportion of green jobs is estimated at 20% in the manufacturing and transport sectors, 10% in research and development and 6% in agriculture. Source: IMF (2022): *Country Report*, n° 22/19 [France], January.

[32] Valero A., Li J., Muller S., Riom C., Nguyen-Tien V. and Draca M. (2021): «Are 'green' jobs good jobs? How lessons from the experience to-date can inform labour market transitions of the future», *LSE Policy publication*, October.

[33] Saussay A., Sato M., Vona F. and O'Kane L. (2022): «Who's fit for the low-carbon transition? Emerging skills and wage gaps in job ad data», *Working paper*; Sato M., Cass L., Saussay A., Vona F., Mercer L. and O'Kane L. (2023): «Skills and wage gaps in the low-carbon transition: comparing job vacancy data from the US and UK», report; Curtis E. M. and Marinescu I. (2023): «Green Energy Jobs in the United States: What Are They, and Where Are They?», *Environmental and Energy Policy and the Economy*, 4 (1), pp. 202-237.

both US and UK data and appear to reveal an intrinsic characteristic of 'green' skill profiles.

Specifically, low-carbon jobs require more technical, managerial and social skills than other jobs. In addition, there is an increased demand for high-level IT and cognitive skills, in line with the ongoing digital transformation. It therefore appears that the skills gap caused by the transition to a low-carbon economy is wider and more diversified than suggested by occupational analyses.[34]

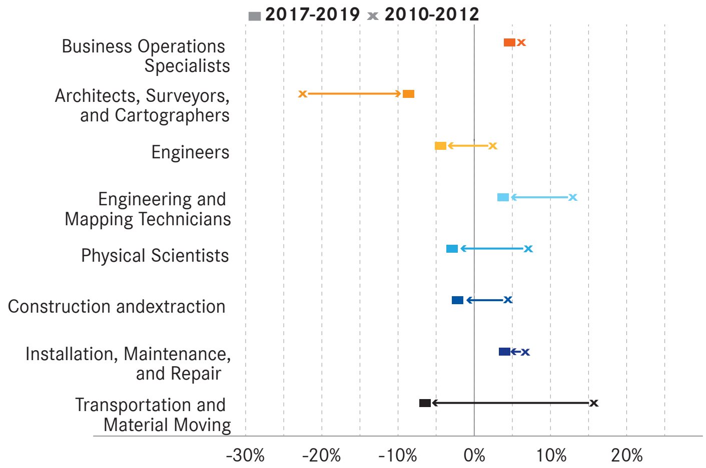
Finally, it should be noted that there are significant differences between occupational groups in terms of skills gaps and retraining needs. For example, for some occupations, such as engineers, the transition to low-carbon activities implies a deepening of existing skills - and therefore increased specialisation. Conversely, other professions, such as business managers, will need to diversify their skills - technical skills related to decarbonisation technologies are not necessarily part of their traditional skill set. Retraining solutions will therefore need to be tailored to the specific needs of each of the professions affected by decarbonisation.

These stylised facts are confirmed by Onemev in France. French employers are mainly targeting specialised workers to fill green jobs, focusing on occupations that are generally low-skilled. Only 54% of green jobs require a bachelor's degree or higher, compared to 62% for all occupations. Furthermore, a higher proportion of green job vacancies in 2019 are for skilled and specialised workers. This could be due to the high concentration of vacancies in construction (46%) and transport (23%). «Skilled» here refers to the mastery of specialised tasks and not necessarily a high level of education.

Is there a green wage premium?

The analysis of skill profiles shows that the green variant of an occupation requires specific skills, which could lead to higher wages. Job vacancy databases can be used to estimate whether or not this 'green premium' exists within a given occupation. While it was very visible in the early 2010s, it has recently fallen sharply in both the US and the UK, irrespective of skill level, to the point where it is no longer detectable in most of the occupations where green jobs are concentrated (Figure 6).

Figure 6. Green wage premium in the main occupational groups where green jobs are concentrated (United States, 2010-2019)



Source: Saussay et al. (2023)

Reading: Between 2010 and 2012, the average premium in the transportation sector was around 15% of salary.

Finding 4. Green jobs are concentrated in occupations that are not highly skilled but require specific skills. However, these specific skills are poorly or not at all valued. This inconsistency leads to a lack of attractiveness that needs to be overcome if we are to meet our climate goals.

In the early 2010s, jobs with a low carbon footprint offered a wage premium of up to 15% in most sectors, but this is no longer the case. To illustrate this, let's take the green finance sector: jobs in this sector are still better paid than the average for high-skilled jobs, but they are still less well paid than the average for the financial sector as a whole.

The wage premium observed in the initial period could reflect a shortage of «green» skills and therefore the difficulty for employers to recruit suitable profiles. Conversely, the virtual disappearance of this premium could be due to the fact that there are too few potential recruiters of green jobs, which means that they do not have to pay for specific green skills.

Whatever the cause, there is a direct contradiction between the need for specific green skills and the lack of a higher wage to reward them, which may lead to a lack of attractiveness. This observation is all the more important given that the majority of green jobs are concentrated in occupations that are not highly skilled and are already experiencing recruitment difficulties. If confirmed, this lack of attractiveness could pose a major challenge to accelerating the pace of emissions reductions over the next decade.

[34] Vona F., Marin G. and Consoli D. (2019): «Measures, drivers and effects of green employment: evidence from US local labor markets, 2006–2014», *Journal of Economic Geography*, 19(5), pp. 1021-1048..

We are already seeing the consequences in France: the demand for green jobs has increased over time, but the supply of labour has not kept pace. Companies are reporting difficulties in filling green jobs: in 2019, they said that 60% of recruitment projects related to the green economy were difficult, compared with an average of 50% for the labour market as a whole.

At this stage, the market does not seem to be sending the right wage signals to address the lack of attractiveness of green jobs in low-skilled occupations. Public authorities could play a role in filling this gap. Targeted subsidies could be used to raise wages in occupations that are essential for the low-carbon transition but face recruitment problems. However, it is important to stress the limitations of this approach. To be effective, these subsidies would need to be targeted only at jobs that are in short supply for decarbonisation. As described above, these jobs are often difficult to distinguish from their 'neutral' counterparts. Moreover, if the low green premium observed is indeed due to the monopsony power of employers in the sector, there would be a risk of capture of public subsidies for green jobs. Nevertheless, it will be necessary to address the challenge of their attractiveness if we are to meet our climate change targets.

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