UNDERSTANDING THE DISTRIBUTIONAL AND HOUSEHOLD EFFECTS OF THE LOW-CARBON TRANSITION IN G20 COUNTRIES

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Genevieve McInnes

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EXECUTIVE SUMMARY

Objectives

1. Action for climate and growth needs to be inclusive. The success of the transition towards a low-carbon future depends on the costs and benefits being distributed across society in a fair and transparent manner, particularly in a context of rising inequality in a majority of G20 countries (OECD, 2015a). The public acceptability of low-carbon policy instruments partially depends on how distributional effects are addressed. Understanding the distributional effects of the low-carbon transition is therefore important for a better informed public debate and for the design of effective policies to counter negative distributional impacts.

2. This report provides an overview of research into the distributional and household effects of this transition and draws lessons from experience across the G20 addressing and limiting these effects. There is much to learn from bringing together what is already known about household energy and transport affordability, the distributional effects of energy and transport policies, and tools used to mitigate these effects. From this knowledge base as well as the growing experience of G20 countries with carbon-related policies, it is possible to anticipate impacts on lower income households and identify good practice in preventing or managing distributional issues as the transition to a low-carbon economy progresses.

Analytical framework

3. Affordability is a key concept in understanding how household energy and transport costs translate into social and economic reality and how they affect development and welfare. It measures a household's ability to pay for necessary levels of transport and energy use within normal spending patterns. Low energy affordability refers to two situations, commonly described as energy poverty and fuel poverty. Energy poverty occurs when households lack or have limited access to modern energy services, constraining essential access to clean water, sanitation and healthcare, as well as efficient lightning, cooking, heating, transport and telecommunications. Fuel poverty relates to households which have access to modern services but cannot afford to make full use of them to the point where it affects their welfare, notably their health, and employment and educational opportunities.

4. Energy affordability and transport affordability are determined not only by income levels but also by the broader socio-economic context. In the case of energy poverty, energy use remains flat for lowest income groups until the household is well clear of the poverty line, which means that even though a household may be earning more, it will not spend the additional income on energy at first: there are therefore many more households in energy poverty than there are households below the poverty line. In the case of fuel poverty, findings show a clear link not only with low disposable income, but also poor housing conditions that lead to low energy efficiency, which means that fuel poverty in some countries concerns a much larger group than those on very low incomes.

5. Much work has been put into designing indicators to measuring energy affordability and assessing how households may be affected by policy changes. Widely used indicators measure energy poverty as outputs (e.g. access to electricity) rather than outcomes (e.g. electricity consumption and associated welfare gains) which are more difficult to estimate: for instance even where electrification rates are high, connected households may not be able to use electrical appliances due to voltage fluctuations. Many countries consider that the use of solid fuels for cooking is a marker of energy poverty because of the associated health risks. Concerning fuel poverty, indicators measure energy expenditure relative to income (with fuel poverty defined as household energy expenditure over of 10% of disposable income, or over twice the median household expenditure as a percentage of income), or whether disposable income after energy expenditure is below the poverty line.

6. These indicators are used for policymaking in many G20 countries, and policymakers are generally aware that though they are useful tools, the choice of indicator can significantly modify estimates of energy and fuel poverty. Nevertheless, whatever the indicator used, the review of relevant

studies carried out for this report points to large numbers of households affected. For G20 countries, energy poverty is largely a rural problem in emerging economies, notably in India where 44% of households lack access to electricity (IEA, 2016a). The use of traditional fuels is widespread in Indonesia (72% of the population) and Brazil (13%), and just under half of Chinese households use solid fuels for cooking (and often for heating as well) (Tang and Liao, 2014). Fuel poverty is high in both rural and urban areas, including in advanced economies where it affects 10% to 20% of the population, with spikes during cold weather and periods of high energy prices (Bouzarovski, 2013).

7. Transport affordability is central to the lives of low-income households. Travel needs are highly individualised and context-specific, complicating the identification of households actually spending disproportionate amounts on transport and therefore likely to be under-spending in other essential areas. Findings from a range of studies point to certain types of households (notably the working poor) and certain areas (peri-urban and rural) being most affected. It is likely that the full scale of transport poverty is underestimated. It concerns households with limited access to public transport (and devoting as much as half their revenue to running a car), zero-car households struggling with the cost of public transport, as well as those walking long distances because they cannot afford other transport options (Mattioli, 2016).

8. Some climate change policy instruments are meant to re-direct energy use and choices. They therefore have the potential to affect household spending and impact the affordability of energy and transport services, particularly for low-income households. Pricing and taxation are central to the low-carbon transition. With a few exceptions, taxes on energy use do not fully reflect its negative environmental side-effects and a significant amount of support is provided through tax reductions in or exemptions from energy taxes. By the end of 2016, about 100 countries (accounting for 58 percent of global GHG emissions) were considering carbon taxation, though a much smaller number had introduced carbon taxation or emission trading schemes (Institute of Climate Economics, 2016, and World Bank, 2016). Subsidy reform is closely linked to the taxation changes that will be necessary to support the transition towards a low-carbon economy. Other policies that can directly or indirectly affect household energy use patterns include financial support for renewable energy and energy efficiency, and prescriptive energy efficiency standards and labelling (EESL) programmes.

Distributional effects

9. The work defining and measuring energy affordability has been applied in a broad range of modelling and empirical studies of the distributional effects of energy policy measures across G20 countries. A recent review of work addressing the social implications of green growth found over 120 studies worldwide, including many empirical studies that considered the distributional effects of existing low-carbon policy measures (Heindl and Löschel, 2014). Most modelling studies rely on economic micro-simulation which produces a higher degree of detail than computable general equilibrium or input-output models. Many concentrate on the impact of a single measure (usually a price or tax change) on expenditure and income.

10. Empirical evidence regarding the distributional effects of environmental taxation is often based on static analysis, which does not take into account behavioural change: when the price of a commodity is increased by a tax, consumers normally reduce their consumption of the commodity, with behavioural changes reflected in both short and long term price elasticities. To maximise emission reduction potential, carbon taxes would need to target the most elastic energy uses, whereas revenue-raising would prioritise energy uses that are most inelastic. The extensive literature on energy price elasticities suggests that demand falls as prices rise in the long run, although not always enough to keep household expenditure constant, while adjustment costs can be large, notably for low-income households. How these households respond to price increases depends on how they trade expenditure across a range of goods and services.

11. There is widespread concern that energy taxes, and therefore carbon taxes, are generally regressive. Much of this concern stems from country-specific studies, notably early efforts indicating gasoline taxes were regressive in the United States. More recent research covering a broader range of

G20 countries suggests that this concern is not generally justified. Taking low-carbon policy measures as a whole, findings on distributional effects can be summarised as follows:

- taxes on heating fuels are generally mildly regressive and those on electricity are clearly regressive; taxes on kerosene are progressive when it is used for lighting, but regressive when used for cooking, because end-use is more important than the fuel type;
- tax increases have a different effect in urban and rural areas, with findings specific to fuel and location: some studies show that taxes are less regressive (or more progressive) in urban areas, where welfare losses are generally lower; others find that it is low-income groups in urban areas that are affected the most.
- other non-price variables must be taken into account, including housing characteristics (notably energy efficiency) and household composition;
- financial support for energy efficiency does not always reach low-income groups, which is why specifically targeted programmes exist in many countries;
- there is little evidence of real product price increases relating to EELS schemes which in fact significantly reduce lifecycle costs, but low-income households may not benefit because they usually use older (sometimes second-hand) appliances;
- taxes on transport fuels are progressive in most countries, except for specific situations (notably the working poor in high-income countries with high car ownership and limited public transport options); this is also true of charges such as congestion charges;
- transport fuel taxation becomes more progressive as average national income decreases; nevertheless, in most countries, it is generally middle-income households that are the most affected by tax rises;
- other important factors influencing the distributional effects of transport taxes include availability of public transport, lifecycle group and geographical location (not only urban vs. rural but also peri-urban).

12. There are several areas where research is lacking: the indirect impact of carbon policies is not fully covered, since prices changes in non-energy goods due to increases in energy-related taxes have not been modelled. Only a few studies look beyond effects on expenditure and income at impacts on household welfare, mobility, health and social exclusion, which are more difficult to quantify. Also much of the early effort to identify distributional effects focused on the transport sector, with a research bias towards car owning households in advanced economies. At a time when there is a trend away from car use in some cities (for instance in Europe) while car ownership is increasing rapidly in others (notably in emerging economies), a broader range of situations needs to be examined and impacts on public transport costs more fully assessed.

Countering regressive impacts: unlocking the third dividend

13. The analysis above shows that some of the measures available to drive the low-carbon transition have distributional effects, although they are not systematic and where they exist, they are generally limited in scale. The main issue is to avoid a situation in which carbon reduction measures without a redistributive mechanism could effectively amount to financing a public good, namely climate stability, through regressive taxation. It is therefore important to consider policy measures that can prevent these negative impacts at an early stage.

14. G20 countries are in a position to limit the distributional effects of low carbon policies with a familiar toolbox, because most energy end-use distributional issues and related mitigation policies pre-date carbon reduction efforts. For instance energy taxation has evolved largely to meet revenue raising requirements rather than equity or environmental imperatives, with strong distributional effects. Energy pricing (including subsidies) has significantly affected household energy use with distributional effects in some cases. There is considerable policy experience with instruments to alleviate energy and fuel poverty, on the part of governments as well as utilities. For instance in Brazil where half of residential electricity consumers benefitted from a social tariff in 2011, utilities are required to invest 0.5% of their annual revenue in energy efficiency programmes, of which 50% must

be devoted to low-income households. Applying such instruments to the changes brought about by low-carbon policies will nevertheless require a fresh assessment of their potential to ensure they are consistent with a broad range of policy objectives, and deliver robust and lasting results.

15. Many of the measures for a low-carbon transition raise tax revenues. Recycling these revenues to help alleviate their impact on low-income households presents policymakers with a significant opportunity to address distributional concerns. A review of more than 120 studies notes that if all or a sufficient part of revenue from energy taxes is handed back to the consumer, it is possible to eliminate negative distributional effects. Such revenue recycling would use the same path as existing programmes to address energy and fuel poverty; cash transfers (lump-sum transfers and fuel payments), increased benefit payments, social tariffs and support for public transport.

16. There is already substantial experience with recycling carbon-related tax revenues in several countries (Kennedy et al., 2015). For instance, Switzerland recycles revenue from a carbon tax on hydrocarbon fuels to taxpayers as reductions in health insurance premiums and California recycles some of the revenue from its emission allowance auctions back to households as rebates on electricity bills. In addition, special provisions to protect low-income households have been incorporated into carbon pricing policies around the world. California's cap-and-trade scheme is accompanied by a requirement that at least 25% of revenues be directed to programmes that benefit disadvantaged communities, with a first round of funding of US$272 million allocated to investments in public transit, housing improvements, renewable energy, cleaner vehicles and urban forestry (Greenlining Institute 2014). In Canada, British Columbia's carbon tax is required by law to be revenue-neutral. As part of this requirement, in the 2013-14 fiscal year, 16% of carbon tax revenue (US$194 million) funded a specific tax credit that offsets the burden of the carbon tax on low-income households, making the carbon tax highly progressive (Beck et al., 2015).

17. While revenue recycling targeted at low-income households can limit negative distributional effects, these revenues would not then be available for other purposes. This concern is related to the idea of the "double dividend" of environmental tax reforms: carbon taxation brings a first (environmental) dividend by reducing emissions, and tax revenues being recycled to foster economic growth bring a second (economic growth) dividend. Generally, the revenue recycling envisaged is a reduction in labour or company taxes, which might be economically efficient but would not make the taxation more progressive. Using tax revenues to support low-income households is an effective way to ensure an equitable outcome, but may not be as efficient at generating economic growth. Furthermore, low-income support provides only temporary relief: while it increases the purchasing power of these households temporarily, it does not lift them out of energy or fuel poverty in the longer term. This can only be achieved if financial support is targeted at changing the factors that underlie energy and fuel poverty: access to cleaner and more efficient fuels, better energy efficiency of domestic appliances and housing, and improved public transport options. By addressing the causes of energy and fuel poverty rather than just the symptoms, the economic benefits of such support are much more significant. Recycling revenues from carbon taxation into household and transport energy efficiency programmes targeted at low-income households would provide a "triple dividend":

- *an environmental dividend*, by reducing household and transport energy use and therefore emissions, above and beyond reductions achieved through carbon taxation;
- *an economic dividend* through direct and indirect non-energy economic benefits ranging from reduced expenditure on social support and health (which can account for as much as 75% of the total return on investment), to economic activity generated by energy efficiency work; analysis of GDP changes from large-scale energy efficiency policies shows annual economic growth benefits ranging from 0.25% to 1.1% and a job creation potential of 8 to 27 job-years per EUR 1 million invested (IEA, 2014);
- *an equity dividend*, as shown by existing energy efficiency programmes aimed at low-income households; experience in many countries clearly shows that such programmes are effective in reducing fuel poverty because they permanently lower energy use in low-income households.

1. Introduction

18. The vast majority of governments around the globe (189 countries representing 96 percent of global greenhouse gas (GHG) emissions and 98 percent of the world's population) have committed to reducing their GHG emissions and adapting to climate change (World Bank, 2016). The urgent priority now is for governments to ensure implementation of these commitments, requiring sustained efforts to influence investment and consumption decisions made every day by firms and households.

19. Action for climate and growth needs to be inclusive. The success of the transition towards a low-carbon future depends on the costs and benefits being distributed across society in a fair and transparent manner, particularly in a context of rising inequality in a majority of G20 countries (OECD, 2015a). The public acceptability of low-carbon policy instruments partially depends on how distributional effects are addressed. Understanding the distributional effects of the low-carbon transition is essential for a better informed public debate and for the design of effective policies to counter negative distributional effects.

20. A substantial amount of work has been devoted to measures that could limit adverse distributional effects that could result from low-carbon policies: there is much to learn from bringing together what is already known about household energy and transport affordability, the distributional effects of energy and transport policies, and tools used to address these effects. From this knowledge base as well as the growing experience of G20 countries with carbon-related policies, it is possible to anticipate impacts on lower income households and identify good practice to prevent or manage distributional issues as the transition to a low-carbon economy progresses. This report provides an overview of research into the distributional and household effects of this transition and draws lessons from experience across the G20 addressing and limiting these effects.

2. Defining and measuring household distributional effects in G20 countries

2.1 Household energy and transport costs

21. For most countries and income groups, the average share of energy and transport costs in household budgets is large, with a broad spectrum of specific situations. For instance it can be as low as 5% for the top income quintile in the United States, while it can account for over half the income of some households such as the working poor in peri-urban areas, with an average of 22% for the lowest income quintile (Bureau of Labor Statistics, 2016).

22. For the so-called "base of the economic pyramid" households across G20 countries, energy (excluding transport) ranks third in household expenditure, behind food and housing, with the exception of India where it ranks second. Energy expenditure averages 10% of total expenditure for these households, with great variation in patterns of energy use, and between rural and urban areas (Hammond et al., 2007). In India it averages 12.2% and in Indonesia 8.8% (Bacon et al., 2010). In European countries, the poorest 20% of households spent an estimated 9% of their budget on domestic energy services in 2014 (European Commission, 2015).

23. Transport costs also represent a large share of household income in many G20 countries, often an average of 15% in advanced economies with high rates of car ownership such as Australia (ABS, 2011). Low-income households in such countries can be "forced" into car ownership they can ill afford, with transport representing as much as 50% of household expenditure (AIFS, 2011). In many other advanced and emerging economies where car ownership is lower, public transport expenditure typically averages 10% to 12% of income for poor households (Venter, 2011).

24. Affordability is a key concept in understanding how these costs translate into social and economic reality and how they affect development and welfare. In the context of carbon-related policies, it is essential to define and measure levels of and changes in both energy affordability and transport affordability. These related concepts are largely context-dependent and require a range of approaches to measurement.

2.2 Energy affordability

25. An accepted definition of energy affordability is a household's ability to pay for necessary levels of energy consumption within normal spending patterns (Milne, 2004). There are two main terms that are commonly used to define low energy affordability: energy poverty and fuel poverty, which are determined not only by income levels but also by the broader socio-economic context. In both cases, low energy affordability has consequences that contribute to households finding themselves in a "poverty trap".

26. Energy poverty refers to situations where households lack access to modern energy services. This access is often physically limited: for instance even where national statistics show an electrification rate of over 90%, there are areas where connected households may not be able to use their electrical appliances or benefit from street lighting due to power outages and voltage fluctuation. Energy poverty then means that limited availability of modern energy services acts as a constraint on essential access to clean water, sanitation and healthcare, as well as efficient lightning, cooking, heating, transport and telecommunications. Indicators used by such organisations as the World Bank and the International Energy Agency measure energy poverty as outputs (e.g. access to electricity) rather than outcomes (e.g. electricity consumption and associated welfare gains) which are more difficult to estimate.

27. Fuel poverty refers to households which have access to modern services but cannot afford to make full use of them to the point where it affects their welfare: there is no physical constraint on access to energy services, but they are under-used, essentially for economic reasons. Such fuel poverty is often identified by its symptoms: low indoor temperatures leading to respiratory and cardiovascular diseases and mental stress; use of inappropriate sources of energy for heating, cooking and lighting with associated risks of accidents, fire and CO poisoning, and poor indoor air quality leading to respiratory problems, including asthma and allergies.

28. There is a continuing controversy over what constitutes energy poverty and how it differs from income poverty. Like income poverty, energy poverty can be defined by a threshold value needed to sustain life, but unlike income poverty, it is difficult to determine the minimum amount of energy needed for living. Household survey data from urban and rural India show that although energy consumption rises with income, at the lower end of the income profile, growth in energy consumption remains flat at first even as income rises because energy use beyond a basic level remains a luxury (Khandker et al., 2010). This translates into significant differences between income and energy poverty, particularly in rural areas, where some 57% of households are energy poor, when only 2% are income poor. For urban areas the energy poverty rate is 28%, compared with 20% that are income poor. The energy poverty line can therefore be defined as the threshold point at which energy consumption begins to rise with increases in household income.

29. An issue often debated in the literature on fuel poverty is whether it is a distinct problem or simply a manifestation of a more general poverty issue. Research shows a clear link between fuel poverty, poor housing conditions and low disposable income (Hill, 2012). Low energy affordability is also clearly related to high energy prices as well inadequate energy efficiency (for instance poor insulation and inefficient appliances). Nevertheless, getting the measure of fuel poverty is not straightforward: when looking at household energy use, it is not possible to know whether energy was purchased because the household could afford it, and how many sacrifices were made elsewhere in order to do so. What is known is that households face very different costs to achieve the same level of comfort, largely due to the varying energy efficiency of their homes and appliances. As a result, households living in or close to poverty face extra costs compared with wealthier households, notably for heating and refrigeration. These costs are largely outside the control of poorer households because of the investment required to reduce them.

30. There are three types of indicators for energy affordability (Heindl and Löschel, 2014):

- The TPC, which defines fuel poverty as spending over of 10% of disposable income on energy;
- The 2M, which considers adequate budgets for several groups of goods for different household types (an approach used to calculate social benefit entitlements in some countries) with fuel poverty occurring when expenditure exceeds twice the median fuel expenditure as a proportion of income;
- a third type of indicator which compares expenditure to the poverty line: the "Low-Income, High-Cost" (LIHC) indicator considers whether energy expenditure exceeds a median value and whether disposable income after energy expenditure is below the poverty line, while the "Low-Income, High-Cost-Share" (LIHCS) indicator considers the TPC value and whether disposable income after energy expenditure is below the poverty line.

31. These indicators are used for policy purposes in many G20 countries: for instance the 2M indicator is commonly used in the European Union, and the TPC is referred to in policymaking in most countries. The United Kingdom, where fuel poverty has been on the political agenda for several decades, used the TPC until 2013, when England moved to the LIHC because it better identifies households that face enduring affordability problems, for example due to a poorly insulated home (Hills, 2012). In France, the TPC and the LIHC indicators are used together (Bureau, 2011).

32. Researchers and policymakers are generally aware that these indicators have specific limitations when measuring the number of households facing fuel poverty and how this number changes as a result of energy price increases:

- indicators using income rather than expenditure do not take account of the fact that households may be saving or be savings-rich;
- a relative indicator of energy expenditure responds less strongly to energy price changes than one that uses a threshold value such as the TPC;
- the 2M does not account for the higher heating needs of some types of households (such as the elderly or the disabled, or families with young children);
- indicators that rely on a relative expenditure threshold such as the LIHC will not classify as fuel poor a household which spends nearly its entire income on energy, but whose overall spending on energy is below the median.

33. While the choice of indicator can significantly modify estimates of energy and fuel poverty, whatever the indicator used, an overview of studies on energy and fuel poverty points to large numbers of households facing energy affordability issues across G20 countries.

34. In 2016 there were an estimated 244 million people without access to electricity in India, 41 million in Indonesia and 8 million in South Africa (IEA, 2016a). In these countries, energy poverty is largely a rural problem: for instance in India 44% of rural households lack access to electricity, compared with only 7% of urban households. In China where electrification rates are high, energy poverty is usually taken to mean that solid fuels (dung, wood, charcoal or coal) are used for cooking (rather than liquid fuels or gas), often on primitive cooking stoves, with associated health risks due to indoor pollution. This is the case for just under half of Chinese households (accounting for 612.8 million people, of which 490 million live in rural areas), where these fuels are also generally used for heating. About 6% of households use only dung or wood, with wide regional variations (Tang and Liao, 2014). In Indonesia, some 156 million people, or 72% of the population, still rely on biomass as their primary fuel for cooking, and in Brazil the figure reaches 23 million people (13% of the population).

35. In many advanced economies the long- term incidence of fuel poverty ranges from 10% to 20% (with spikes during cold winters and when energy prices are high) with higher rates among lone parents and pensioner households. There are an estimated 150 million people in fuel poverty in the European Union alone, with the highest rates found in Southern, Central and Eastern Europe (Bouzarovski, 2013). Fuel poverty in Russia is also widespread, aggravated by the poor quality of

housing (Zagrebina et al., 2011). In 2014, the number of households in fuel poverty in England was estimated at around 2.38 million, representing approximately 10.6% of all households (UK National Statistics, 2016). In France an estimated 3.1 million households are officially defined as fuel poor (OPE, 2015).

2.3 Transport affordability

36. Accessibility is a key element in ensuring social sustainability. It can be defined as the ease of reaching goods, services, activities and destinations. Accessibility to opportunities such as employment, education, health and social activities plays an important role in the well-being of both urban and rural populations. Transport generally represents a large share of household expenditure and providing transport facilities requires significant public resources, the allocation of which involves tradeoffs between different equity objectives (Littman, 2002):

- horizontal equity concerns individuals and groups considered equal in ability and need who should receive equal shares of resources, bear equal costs, and in other ways be treated the same. It means that transport policies should avoid favouring one individual or group over others and that consumers should "get what they pay for and pay for what they get" in fees and taxes;
- vertical equity, also referred to as social inclusion, concerns individuals and groups that differ by income or social class. By this definition, transport policies are equitable if they favour economically and socially disadvantaged groups in order to compensate for overall inequities.

37. These approaches often overlap or conflict. For example, horizontal equity requires that users bear the costs of their transport services, but vertical equity often results in subsidies to improve accessibility for the disabled, the elderly, students and families with young children.

38. The affordability of transport is central to the lives of low-income households across G20 countries and is directly relevant to transport and urban planning policies. Yet transport affordability has attracted less policy and research attention than fuel poverty, despite the fact that lower-income populations suffer more from restricted transport options and travel under worse conditions (in terms of safety, security, reliability and comfort). The affordability definitions used for energy cannot be transferred to transport, as travel needs are highly individualised and context-specific, and it is difficult to define what transport is "required". For instance in South Africa the TPC indicator is applied to evaluate transport affordability but has been found to be inadequate because of the wide variation in consumption trade-offs between households in different locations (Venter, 2011). This complicates the identification of households actually spending disproportionate amounts on their transport and therefore likely to be under-spending in other essential areas.

39. A variety of concepts are used to grasp the many facets of transport poverty, which affects both car owning and zero-car households in different ways. For instance in countries where car ownership is high and vital for accessibility, transport affordability indexes have been developed to track household transport costs. In urban areas public transport affordability indices measure the impact of transport costs on income. Such indices can be a simple ratio of expenditure over income, or more complex indices that also take into account housing costs since these are directly relevant to transport expenditure options (Guerra and Kirschen, 2016). For instance in many cities it is the peri-urban households that incur the highest combined housing and transport costs, putting other items of expenditure (health, education or home-ownership) out of reach.

40. Nevertheless these indicators do not reflect the situation of low-income households that curtail the number of trips that they make, are forced to walk or cycle long distances (options that do not incur a direct cost), or live in undesirable locations to minimise transport costs (Carruthers et al., 2005). In South Africa for instance, more than half the poorest people walk long distances to work because other transport options are beyond their means (Venter, 2011).

41. Recent research estimated that in 2014, 9.2% of UK households (i.e. 2.5 million households) were in car-related economic stress, defined as having to curtail spending in other areas in order to be able to own and run a car (Mattioli, 2016). Both the geographical and social characteristics of car-related economic stress are important, with certain types of households (e.g. the working poor) and certain areas (peri-urban and rural) being more vulnerable. The number of households finding it difficult to afford transport across G20 countries is likely to be much higher than this, as it would include those unable to afford a car and those struggling with the cost of public transport.

3. Overview of low-carbon policy instruments with potential distributional effects

3.1 Energy, transport and carbon taxation

42. Some climate change policy instruments are meant to re-direct energy use and choices. They therefore have the potential to affect household spending and impact the affordability of energy and transport services. There is strong evidence that taxation is one of the most cost-effective ways to integrate the costs of environmental damage and change behaviour in the transition to a low-carbon economy. By the end of 2016, about 100 countries (accounting for 58 percent of global GHG emissions) were considering carbon taxation, though a much smaller number had introduced carbon taxation or emission trading schemes (Institute of Climate Economics, 2016, and World Bank, 2016).

43. A systematic analysis of effective tax rates on energy use in 41 countries taxation (OECD countries taken together with Argentina, Brazil, China, India, Indonesia, Russia and South Africa accounting for 80% of global energy use and 84% of carbon emissions in 2009) shows that, with very few exceptions, taxes on energy use do not fully reflect its negative environmental side-effects (OECD, 2015b). The economy-wide level of energy taxation ranges from just over EUR 0 per GJ in Indonesia and Russia to EUR 6.58 per GJ in Luxembourg. Countries with higher per capita GDP tend to tax energy use at higher effective rates, which correlate with lower carbon intensity. Taxes on transport energy are consistently higher than those on other types of energy use. Oil products are taxed more frequently and heavily than other fuels. Taxes on natural gas are usually lower than on oil products, and those on coal are often low or zero.

44. This overview of 41 countries also calculates an effective carbon rate (ECR) by converting current energy taxes (including explicit carbon taxes and emission trading schemes) into CO_2-equivalent taxes. Because of their limited coverage and low rates, explicit carbon taxation and emission trading schemes currently contribute only modestly to ECRs, which are primarily driven by excise taxes on energy. Some 90% of emissions are priced below the low-end estimate of the climate cost of CO_2 emissions, taken as EUR 30 per tonne, with 70% of CO_2-emissions priced below EUR 5, implying there is hardly any policy-driven price incentive to reduce these emissions.

45. Road fuel taxes often represent a large share of the end-use price and are an important source of government revenue: for instance in EU countries they account for about 80% of revenue from excise duty on energy (NERA, 2014). In some countries, they are earmarked (at least partially) for transport infrastructure investment and can be seen as a type of user charge. Taxes on vehicles serve a range of policy roles, notably environmental, though differentiation of rates according to vehicle characteristics. Purchase taxes (also called registration taxes) for new cars are common and can represent a significant share of the vehicle purchase price in some countries. Purchase taxes that are differentiated according to fuel types and emission levels have been shown empirically to have substantial effects on vehicle purchase decisions, though it has proven difficult to forecast the effects of specific policies. Vehicle ownership taxes can also be differentiated by fuel type, weight and emissions, including CO_2 emissions. While increasing the ownership tax has no immediate effect on CO_2 emissions, it can reduce emissions in the long-run if a CO_2-differentiated ownership tax makes car buyers choose more fuel efficient cars.

3.2 Subsidy and pricing reform

46. Non-tax instruments have an impact on household end-use energy prices and are therefore relevant to the shift towards a low-carbon economy. Altering energy prices through price regulation

can be motivated by policies that seek to limit or avoid abuses of market power, and also by a political choice to keep prices below market levels or production costs. Price regulation can take the form of regulation, price freezes and direct price controls.

47. Net subsidies for energy production and use can be motivated by concerns over competitiveness or inflation, or a broader objective of stimulating economic development, or poverty alleviation. Consumption subsidies can take the form of subsidies to energy providers, so that households pay tariffs below the cost recovery level. They can also be provided as direct subsidies to end-users. They are a significant burden on government budgets, particularly when international prices rise, and can lead to overconsumption by end-users. For instance energy subsidies in Indonesia represented 2.5% of GDP in 2010 (Olivier et al., 2013).

48. The need to phase out inefficient fossil fuel subsidies has been recognised in the OECD's Declaration on Green Growth that 42 countries have signed, and by the G20 leaders (G20, 2009). A significant amount of support is provided through tax reductions in or exemptions from energy taxes, so that subsidy reform is closely linked to the taxation changes that will be necessary to support the transition towards a low-carbon economy. A country where producer prices are in line with production costs and which does not levy taxes on energy use may send stronger environmental price signals to end-users than a country which does levy taxes on energy use but adds them to producer prices that are well below marginal production costs (OECD, 2015c).

3.3 Support for renewable and low-carbon energy

49. Decarbonising the electricity sector is at the heart of the low-carbon transition. The central issue is the capital-intensive investment needed in generation and transmission to increase the share of renewable and zero-carbon sources which can be more expensive than traditional forms of electricity production. Many countries have adopted ambitious targets for generation based on renewable energy and introduced measures to support their development, notably advantageous feed-in tariffs (FIT) which have proven to be effective in stimulating rapid and large-scale development of new and renewable energy. Some form of FIT is currently applied in about 70 countries (Cox and Esterly, 2016). Any additional costs are either covered by government incentives provided to utilities (as is the case in the United States for instance) and therefore funded by taxpayers, or passed on to consumers, sometimes through a surcharge added to energy bills. These surcharges have similar distributional effects to energy taxes. For instance, renewable electricity generation subsidies in Germany are financed by a surcharge that represents about 20% of the average residential retail tariff (Mormann et al., 2014). China has consistently set targets for increasing renewable electricity generation in five-year energy plans, notably through the development of wind power. Since the enactment of the Renewable Energy Law in 2006, this growth has been primarily funded through a national surcharge on electricity consumption added to the price of each kWh of electricity sold through the grid.

50. Global subsidies for biofuels were estimated to have reached US$ 23 billion in 2014, with biofuels providing about 4% of transport fuel (IEA, 2016b). Double-digit global production growth observed pre-2010 has slowed to a modest 2%. While support for biofuels remains a carbon reduction policy option, the lifecycle GHG performance of biofuels is under scrutiny with many countries adding sustainability criteria to biofuels policies. Biofuel subsidies have been funded by taxpayers through government subsidies with no impact on pump prices for households. There has been concern that substitution of agricultural land to produce biofuels rather than food was causing an increase in food prices and bringing hardship for vulnerable groups notably in developing and emerging economies. Recent studies on this topic assessing plausible futures for agricultural markets, large-scale biofuels use and global food security are contradictory and the distributional effects of biofuel support cannot be identified precisely (OECD, 2015b).

3.4 Energy efficiency programmes

51. Global investment in energy efficiency in buildings (including envelope, heating and cooling, appliances and lighting) was estimated at UDS 388 billion in 2015 (IEA, 2016c). There is considerable

experience in G20 countries with household energy efficiency programmes that have brought substantial energy savings and emission reductions under a great variety of economic, climatic and social conditions. Despite a long term trend towards reliance on market-based approaches and regulations, many programmes have involved financial support. Distributional effects are not negligible in that (as is the case with many support programmes) these programmes can turn out to benefit higher rather lower income households. In addition, low-income households face specific financial and social barriers to energy efficiency that mean that they often live in less energy efficient homes and use less efficient appliances. The existence of these issues is widely recognised which is why many countries have designed energy efficiency programmes and policies aimed specifically at low-income households.

52. Financial support for energy efficiency at household level often takes the form of tax rebates and credits. These can only benefit households that earn enough income to pay the taxes from which they can claim the rebate or credit. Energy efficiency investments require some form of upfront investment, and subsidised loans and grants are meant to address the issue of the capital outlay needed, but lower income households may not be able to access even part of the cash needed. In addition, they generally live in rented accommodation and change dwellings more frequently than middle income households. This means that even when programmes target landlords, lower income households may not be in position to benefit from housing quality improvements. These limitations hold true not only for major investments such as wall insulation or window retrofitting, but also for energy efficient domestic appliances, which are still more expensive than standard appliances. Furthermore, lower income households often use second-hand appliances which are less energy efficient. In the case of refrigerators for instance, the energy consumption difference between an old inefficient model and a new top-rated efficient model can be as much as 30%, which can represent a considerable share of household expenditure considering that a refrigerator is often the most energy intensive household appliance, accounting for as much as 25% of a low-income household electricity bill.

53. Though energy prices and taxes are the focus of much of the concern about the distributional effects of policy changes because of their visible effect on energy prices and expenditure, many other policies can directly or indirectly affect household energy use patterns. Prescriptive energy efficiency standards and labelling (EESL) programmes applied to dwellings, appliances and vehicles have played a central part in improving energy efficiency over several decades and are indispensable to the low-carbon transition that lies ahead. They are in place in at least 80 countries around the world. Over the last ten years alone in advanced and major emerging economies appliance EESL have seen improvements ranging from 16% for refrigerators to 23% for room air conditioners (IEA, 2016c). Based on evidence from a wide cross-section of countries, the energy efficiency of major appliances has increased at more than three times the underlying rate of technology improvement (IEA, 2017). One-off improvements of more than 30% have been observed when new EESL programmes are introduced into a market where few energy efficiency programmes had existed previously (Molenbroek et al., 2015).

3.5 Transport planning and management

54. Current transport systems rely largely on fossil fuels and impose high environmental costs, particularly in urban settings. There is a widespread consensus that policy intervention is needed to provide more energy-efficient and less carbon-intensive mobility. Many of these issues are currently addressed through energy and vehicle taxation and standards. There are also pricing measures that are particularly relevant to households, notably with respect to public transport and transport demand management. While public transport subsidies can be found in all G20 countries, pricing of scarce road capacity is still limited to parking charges (which are significant in some cities) and a few road congestion charge schemes. Fundamentally, sustainable transport policies depend on integrated urban and transport planning to ensure that the impact of property development on transport demand is properly accounted for, and that environmental and equity concerns are considered alongside economic development priorities.

4. Findings from studies of distributional effects

4.1 Overview

55. The work that has gone into defining and measuring energy affordability has been applied in a broad range of modelling and empirical studies of the distributional effects of energy policy measures across G20 countries. Many concentrate on the impact of a single measure on expenditure and income, with many focusing on the impact of a change in energy prices for different socio-economic groups. Empirical evidence regarding the distributional effects of environmental taxation is often based on static analysis, which does not take into account behavioural changes. When the price of a commodity is increased by a tax, consumers normally reduce their consumption of the commodity (depending on the availability of substitutes), with behavioural changes reflected in price elasticities which measure short-term adjustment as well as longer term shifts. Few studies consider not only effects on expenditure and income but examine impacts on household welfare, mobility, health and social exclusion, which are more difficult to quantify.

56. The distributional effect of a tax on different socio-economic groups is usually assessed according to whether a tax or price change can be considered progressive, regressive or neutral. For instance in the case of an energy tax, if the portion of household income or expenditure devoted to the tax rises as income rises, then the tax is progressive, whereas if those on lower incomes are devoting larger portions of their income or expenditure to the tax than those on higher incomes, then it is regressive. An overview of the distributional effects of consumption taxes in 20 OECD countries shows that excise tax burdens are almost always regressive when measured as a percentage of income, and in most cases are either regressive or neutral when measured as a percentage of expenditure (OECD and Korean Institute of Public Finance, 2014). In interpreting these results, the report argues that an income-base approach may be of particular interest in analysing the immediate distributional effects of consumption taxes, especially if household consumption patterns are not strongly affected by borrowing and saving, while an expenditure-based approach will provide a more reliable measure of lifetime distributional effects.

57. A recent review of work addressing the social implications of green growth found over 120 studies worldwide, including many empirical studies that considered the ex-post distributional effect of low-carbon policy measures (Heindl and Löschel, 2014). Most modelling studies rely on economic micro-simulation which, providing data are available, produces a higher degree of detail than computable general equilibrium or input-output models.

58. There are several areas where research is lacking: the indirect impact of carbon policies is not fully covered, since prices changes in non-energy goods due to increases in energy-related taxes are not modelled. Also much of the early efforts to identify distributional effects focused on the transport sector, with a research bias towards car owning households in advanced economies. At a time when there is a trend away from car use in some cities (for instance in Europe) while car ownership is increasing rapidly in others (notably in emerging economies), a broader range of situations needs to be examined and impacts on public transport costs more fully assessed.

4.2 Distributional effects of measures relating to domestic energy use

59. Domestic energy consumption covers very different end-uses (heating, cooking, lighting, cooling and domestic appliances) and energy forms (liquid fuels such as kerosene, solid fuels such as biomass and coal, as well as metered gas and electricity) in different climates and geographical locations. There are nevertheless some common factors that detailed studies of the distributional effect of energy taxation have been able to pinpoint: distributional effects measured as a percentage of income across income deciles are more regressive (or less progressive) than when measured as a share of expenditure, while results measured as a percentage of income across expenditure deciles are less regressive (or more progressive) than when measured as a share of expenditure. As is the case with calculating energy affordability indicators, the borrowing and saving behaviour of households has a

strong impact on the outcome of distributional effects so that both income and expenditure need to be considered.

60. To achieve maximum emission reduction potential, carbon taxes would need to target energy uses that show most elasticity, whereas revenue raising would prioritise those energy uses that are most inelastic. Elasticities are therefore an important consideration in the design of taxes because they have major implications for environmental effectiveness as well as revenue recycling. Elasticities are also a key determinant in energy affordability and therefore distributional and household effects.

61. Using a range of indicators, a recent OECD study found that there is no clear relationship between energy affordability and average energy prices across countries (OECD, 2016). This points to households adjusting to higher energy prices over time by reducing their energy use. The extensive literature on energy price elasticities indeed shows that demand falls as prices rise, although not always enough to keep expenditure constant (Espey and Espey, 2004). Meta-studies suggest mean estimates of price elasticities close to one, although there is much variation depending on method and data. Studies that control for many, potentially endogenous, factors or rely mainly on variation across short time horizons typically find lower estimates than studies that rely on cross-sectional studies and control only for factors that are not endogenous in the long-term, when the results reflect a long-run equilibrium that includes all the adjustment that has taken place. Controlling for some endogenous factors, such as appliance energy efficiency, implies also estimating a short-term elasticity. It is plausible that higher energy prices reduce energy demand by almost enough to keep expenditures constant over the long run. Should higher energy prices also increase wages, the reductions in energy demand needed to keep energy expenditure as a share of income constant are accordingly lower. These findings do not imply that energy taxes and prices can be increased without affecting households at all; in fact adjustment costs can be large. Furthermore, energy affordability indicators do not fully measure the impact of energy prices on household welfare or well-being.

62. Moving away from wood and other traditional fuels increases vulnerability to price fluctuations, notably for products such as kerosene and LPG which are used for cooking in countries such as India, Brazil and South Africa. Studies show that price elasticities for commercial fuels used for cooking are generally high in these countries (Kohlin and Gundimeda, 2008). For kerosene, elasticity depends on the use: urban households use kerosene only as a cooking fuel, while 35% of rural households also use it for lighting. As a result, demand for kerosene is responsive to price especially in rural areas, with elasticities ranging from -0.7 for the rural rich to -0.5 for middle-income households, while a tax on kerosene used for cooking is regressive in both urban and rural areas (Datta, 2008). In China, differences between urban and rural areas also play a large part in distributional effects; carbon taxation on all fuels would likely affect urban households the most, while distributional effects in rural areas would be moderate (Cao, 2009). In the case of India, the elasticity of gas is close to unity, ranging from -0.92 for the urban rich to -1.05 for the urban poor (Komives et al., 2009). A tax on gas for cooking is found to be strongly progressive in rural areas though it is regressive for urban middle-expenditure groups. The findings of a survey of studies of the distributional effects of subsidy reform are also relevant in this respect; a survey of single-country modelling found that it is usually low-income urban households who depend on commercial fuels that are most affected. The poorest in rural areas would be little affected by fossil-fuel subsidy reform as they utilise non-commercial fuels (Ellis, 2010).

63. In a recent review of 120 studies, some regressivity was found for taxes on heating fuels in many countries while taxes on electricity are found to be regressive in all countries analysed (OECD and Korean Institute of Public Finance, 2014). A detailed study of the distributional impact of hypothetical carbon taxes in Russia found them to be clearly regressive, especially for coal, electricity and gas, because poorer households spend more on these energy forms than richer households, which spend more on petroleum products (due to higher car ownership and use) (Orlov, 2012). In addition there are other important, non-price variables to take into account. For instance, for many households, the demand for heating is highly correlated with the characteristics of dwellings, but demand for electricity is driven by household composition.

64. Prescriptive EESL schemes aim to decrease operating costs and make energy bills more affordable for consumers. Energy prices, product prices, disposable income levels and usage patterns combine to influence the life-cycle costs and benefits of these schemes. In countries with low energy prices, the efficiency level at which least life-cycle cost is achieved will be lower than in countries with higher energy prices because the economic value of each unit of energy saved is lower. With several decades of experience in implementing EESL, policymakers are well aware of the potential distributional effects of tightening and extending standards. Costs to end-users are generally examined in detail prior to their implementation and affordability is already a key consideration in setting EESL requirements: for instance the United States and EU Member countries explicitly take this consideration into account, ensuring that requirements are set at the levels that impose the least life-cycle costs for the average end-user, and a similar approach is applied in China.

65. There is little empirical evidence of significant product price increases from EESL: a recent international overview of relevant empirical work found little evidence of product price increases, and significant evidence of reduced lifecycle costs and substantial net savings for end-users over the full product lifetime (European Commission, 2015). While EESL programmes may have caused small changes in prices at the initial implementation of new energy efficiency standards, they appear to have had little long-term impact on appliance price trends (Hollander and Roser, 2012). Few affordability problems are anticipated for products produced for global markets and integrating existing EELS, notably consumer electronics, and information and communication technology goods. Products whose costs are strongly linked to material costs, such as electric motors, LEDs or transformers, could see some cost increase from additional material requirements. Locally tailored products of relatively small production volumes may also see larger price increases. Affordability issues are most likely in countries with low energy prices and low disposable incomes.

66. In some cases, the reduced energy costs resulting from EESL programmes may be used by householders and companies to purchase additional energy services (this is known as the rebound effect). In advanced economies, this is likely to be limited to heating and cooling, and to a lesser extent lighting, mainly in low-income households. In many cases, this increased comfort level may be an intended outcome of EESL programmes, especially those targeted at low-income households. Even when a rebound effect has been found to occur, EESL programmes have still demonstrated a net energy saving and overall cost-effectiveness (Gillingham et al., 2014).

4.3 Distributional effects of transport-related measures

67. There is an extensive literature on the equity effects of transport-related prices and taxes. Research has focused almost exclusively on direct effects on household income, expenditure and affordability. Indirect impacts such as transitional effects on various markets (for instance used cars) as well changing property prices have been little studied (Fullerton, 2011).

68. The perception that fuel taxes are regressive can be traced back to studies using US gasoline consumption data (Poterba, 1991). However, the United States has specific characteristics, including high average income, high car ownership rates (even for households in lowest income quintile, it averages 0.9) and long commuting distances with limited public transport options (Bureau of Labor Statistics, 2016). A review of relevant work from over two dozen countries concludes that while these taxes can be regressive in some high-income countries, transport fuel taxation is generally progressive, particularly in low-income countries (Kosonen, 2012). Taxes on gasoline in particular are more progressive as average national income decreases (Sterner 2012, and Flues and Thomas, 2015). In low-income countries such as India, taxes on transport fuels are generally considered to be highly progressive in both urban and rural areas (Datta, 2008).

69. Transport fuel taxes will directly affect car-owners, while zero-car households can also be affected to some extent if price increases are passed on to public transport fares, though most studies do not consider this indirect distributional effect. In many emerging economies, few low-income households own a car: for instance in Indonesia car ownership averages 7% nationally and less than 1% for low-income families (Oxford Business Group, 2015). It is also lower for these groups in

advanced economies: for instance only a third of the lowest spending 10% of households own cars in the United Kingdom, compared with 77% of those on middle incomes (Department of Transport, 2016). In addition, for households that do own cars, mileage tends to be considerably lower for poorer households. This explains why numerous studies find it is middle-income households that are most affected by fuel price increases (Santos and Catchesides, 2005). This has been shown to be the case in a range of countries, notably a number of European countries, as well as South Africa (Slunge and Sterner, 2012) and Mexico (Sterner and Lozada, 2012).

70. There are fewer studies of geographic distributional effects, though research that distinguishes between urban and peri-urban/rural households suggests that welfare losses are substantially lower in urban areas. In most G20 countries, decades of urbanisation have depopulated and impoverished parts of the countryside. Many countries have as a result implemented regional policies aimed at supporting rural, sparsely populated and remote areas, and addressing associated distributional issues. An analysis of the extent to which such areas are actually worse affected by increases in fuel and vehicle taxes needs to distinguish rural vs. urban areas, as well as metropolitan areas vs. medium/small urban areas, and central vs. remote areas. There are also differences in lifecycle groups that are largely unrelated to income levels and physical isolation: groups that generally have the highest car use (middle-aged couples with children) drive between two and three times more than the groups with the lowest car use (the young without children or without a partner), especially in large cities.

71. A recent Swedish study that is relevant to many advanced countries as well as a number of emerging countries examines the distributional effects of an increase of fuel tax, a kilometre tax and a CO_2-differentiated vehicle ownership and car purchase tax with respect to income, lifecycle group and location (Eliasson et al., 2016). All the taxes are found to be progressive over most of the income distribution, and slightly regressive if the highest and lowest incomes are included. In fact these tax increases are clearly regressive for lower income groups.

72. The degree of adaptation to price changes can be assessed by studying elasticities, notably country-specific and individual elasticities for each income decile. A meta-analysis shows that while there are significant cross-country differences, poorer households in all countries respond more to price increases, which reduces regressivity, especially in the long run (Goodwin et al., 2004). For instance in the case of India, while transport fuels have been found to be inelastic in the short run, demand responds to price changes in the long run with elasticities ranging from -0.84 to -0.42 (Sterner, 2007, and Ramanathan and Geetha, 1998, respectively). How these households respond to price increases depends on how they trade expenditure across a range of goods and services. For instance in India, surveys conducted amongst low-income residents of Pune and Delhi show that poor households trade items to balance their budget, with the exception of education expenditure (Darshini et al., 2013). In many high-income countries where transportation expenditure is highest as a portion of net (after tax) income for lower-income car owners, households are also trading accessibility against other factors, with a choice between cheaper suburban housing with higher transportation costs, and more costly urban housing with lower transportation costs.

73. Differences in the regressivity of transport fuel taxes can also be related to the quality of public transport. Good public transport could make a private car less of a daily necessity and more of a luxury good, the use of which would increase strongly with income level, making any increases in transport fuel taxes progressive rather than regressive. This finding is illustrated using micro-level survey data and estimated short-run and long-run fuel demand elasticities to examine the distributional effects of China’s 2009 fuel tax reform, which showed the increase in fuel prices to be strongly progressive in cities where public transport availability was good (Cao, 2009).

74. Insight into the distributional effect of energy price changes is also provided by studies of subsidy reform which simulate the impact of increasing the price of gasoline and diesel. For instance in the case of Indonesia the reform is found to be strongly progressive, with higher income households experiencing a greater decline in welfare than lower income households, the reason being that higher income households tend to spend more intensively on vehicle fuel (Yusuff et al., 2011). It should be

noted that in 2007, prior to the introduction of subsidy reforms, an estimated 70% of transport fuel subsidies were captured by the wealthiest 40% of households (Durand-Lasserve et al., 2015).

75. Road and parking pricing, and distance-based fees, can increase horizontal equity by making prices more accurately reflect the costs imposed by a particular trip, reducing cross-subsidies. Pricing reforms can also benefit lower income households if they reduce negative impacts on disadvantaged neighbourhoods or improve travel options for non-drivers. For example, congestion pricing can benefit lower income commuters and non-drivers by improving transit and rideshare services. The implementation of congestion pricing has nevertheless been limited, partly due to the fact that it has often been suggested that congestion pricing is regressive rather than progressive. A recent study of proposed congestion charges in four European cities indicates that high-income groups pay more in tolls, on average, in all cities, though since driving increases less than income, low-income groups tend on average to pay more tolls relative to their income (Eliasson, 2016). In countries with lower car ownership rates, the outcome would be different: for instance a study of the distributional consequences of a congestion pricing scheme under consideration in Beijing found that households most affected typically have higher incomes, reflecting the fact that those who drive into Beijing are relatively wealthy, so that overall the congestion charge would be slightly progressive (Linn et al., 2016).

5. Effectiveness of policy measures to limit distributional concerns

76. The analysis above shows that some of the measures available to drive the low-carbon transition have distributional effects, although they are not systematic and where they exist, they are generally limited in scale. Potential negative effects on the more vulnerable groups of society vary considerably depending on the geographical and socio-economic context. The main issue is to avoid a situation in which carbon reduction measures without a redistributive mechanism could effectively amount to financing a public good, namely climate stability, through regressive taxation. It is therefore essential to consider at an early stage policy measures that can prevent these negative impacts.

77. As described above, taxation has evolved largely to meet revenue raising requirements rather than equity or environmental imperatives, and can result in many (largely unintentional) distributional effects, all of which pre-date climate policies. Non-tax instruments such as pricing that have historically affected household energy use also have distributional effects in some cases. These issues have been the focus of much analysis and there is considerable policy experience with instruments that can address the distributional issues of energy use across G20 countries. Many of these instruments are part of established social and energy policies, and their costs and benefits are well known.

78. On the strength of this experience, countries are in a position to approach the issue of limiting the distributional effects of carbon reduction with a familiar toolbox. Applying these instruments to the changes brought in by low-carbon policies will nevertheless require a fresh assessment of their potential to making these policies both inclusive and compatible with sustainable growth. In some cases, this could in fact be an opportunity to address some pre-existing concerns relating to energy taxation, pricing and subsidy reform in terms of both equity and environmental effectiveness.

5.1 Recycling revenue from energy and carbon taxes

79. Many of the measures that are part of the low-carbon transition raise tax revenues. Recycling revenues from energy and carbon taxes or related sources such as cap-and-trade schemes and congestion charges to help alleviate their impact on low-income households presents policy-makers with a significant opportunity to address distributional concerns. As detailed in the previous section, energy affordability issues in G20 countries have long been addressed through financial support programmes. In addition to the increased funding that could be provided by low-carbon measures, such programmes would need to be designed so that they are consistent with environmental policy objectives, and deliver robust and lasting economic and social results.

80. There is considerable policy experience with mechanisms designed to help vulnerable households with their energy expenditure. In most cases support to low-income households is funded

out of general public budgets rather than revenue from earmarked taxes. For instance the United Kingdom has introduced a flat rate payment to help pensioners and low-income households pay their fuel bills in winter, with additional payments in areas with exceptionally cold weather. Another form of compensation is to adjust electricity and gas tariffs for different households and income groups. The United Kingdom used such a mechanism to target pensioners, with about a quarter of low-income households covered. In France the social electricity and gas tariffs applied to 2.27 million low-income households is being replaced by a lump-sum transfer to all low-income households so that a broader range of households can be reached (notably those who do not use electricity or gas for heating) with lower administration costs. The main lessons from these programmes can be summarised as follows:

- though they are deemed to be effective, such schemes are expensive: for example in 2010 the United Kingdom provided US$5 billion in winter fuel and cold weather payments to low-income households, and the French scheme of lump-sum payment is estimated to cost about EUR 500 million annually;
- fuel poverty is such a widespread issue that it is not necessarily fully addressed by current policy measures: for instance it is estimated that only half of the 150 million households in fuel poverty in EU countries receive fuel- poverty assistance such as fuel payments or subsidised tariffs (EPEE, 2009);
- compensation is difficult to dose precisely since it cannot take into account factors such as the energy efficiency of dwellings, urban-rural differences and commuting distances;
- where schemes are in place to protect lower income households, the leakage to other groups of energy users is such that it can absorb some of the funding, a shortcoming that it is often impossible to avoid entirely.

Nevertheless it is generally considered that energy and fuel poverty issues are too important not to be addressed, even if the tools that are available have limitations.

81. A review of over 120 studies notes that if a sufficient part of revenue from energy taxes is handed back to the consumer it is possible to avoid negative distributional effects (OECD and Korean Institute of Public Finance, 2014). Such revenue recycling would take the same path as existing programmes to address energy and fuel poverty:

- cash transfers (lump-sum transfers or fuel payments for qualifying households);
- increased benefit payments, using existing social support schemes;
- targeted social tariffs for energy utility billing.

A specific issue with carbon tax revenue recycling is that if a carbon tax achieves its purpose (reducing emissions) then in the longer term revenue from the tax will decline, so that there will be less revenue available for recycling. This means that cutting other taxes permanently could become a burden on government expenditure and should be factored into the choice of recycling scheme from the outset, by choosing payments to low-income households that are more directly related to energy expenditure for instance. On the other hand, a major advantage that is immediately apparent is that such revenue recycling can improve the public acceptability of new carbon taxation (providing the recycling is carefully targeted).

82. Regular payments to households to offset the increase in commodity prices resulting from a carbon tax (known as "fee-and-dividend") have the advantages of fairness and simplicity. By dividing carbon-tax revenues equally amongst all consumers, they ensure that lower income households receive at least as much revenue as they pay in tax. A model simulation using US data examined three different ways of distributing auction revenues in a cap-and-trade scheme (which has the same effect as an energy/carbon tax): (1) reduction of personal income tax (by equal percentage of household income), (2) distribution of revenues on an equal per capita basis (lump-sum transfers) and (3) distribution of revenues in proportion to income. The first was found to have the lowest welfare costs, but it would be regressive, while lump-sum transfers would have higher welfare costs but a progressive impact. The third option is progressive at the lower end of the income scale, but highly regressive thereafter (Rausch et al., 2011).

83. Concerning transport energy use, taxes are geernally progressive, with exceptions in some countries where even low-income households need to run cars. For zero-car households, where public transport is well developed, energy tax rises have a limited direct distributional effect. Recycling revenues from transport-related carbon taxes into public transport funding would be coherent with broader transport and urban planning objectives that are part of the transition to a low-carbon economy, as well as benefitting low-income households the most. This is also true of instruments such as road use charges, as shown by a study of the proposed congestion charging scheme for Stockholm. It concluded that the net equity impact of congestion pricing depended on how revenues are used; if they are used for improving public transport, low-income groups benefit the most, whereas if they are used for tax cuts, the net benefits accrue to high-income groups (Eliasson and Mattsson, 2006).

84. The revenue from carbon taxes can also be used to mitigate the unintentional effects of taxation changes; for instance in some emerging countries, any increase in taxes on kerosene causes the poor to substitute towards fuel wood, which has strong adverse health implications and can lead to deforestation. This is the case in India, where every percentage increase in kerosene price increases fuel wood use by 0.7% for the rural poor and 0.4% for the urban poor (Gundimeda and Kohlin, 2006). Such negative environmental and health impacts could be addressed by cross-subsidies, for instance by channelling revenues from carbon taxes towards targeted support for the use of LPG and electricity for cooking and lighting by these households.

85. Another lesson from existing schemes is that some of the poorest households cannot always be reached because they may not be part of the institutional, legal and fiscal system. For instance in the case of Brazil, a recent study of the distributional effect of a carbon tax found that any negative impact on low-income households can be compensated by the revenue being recycled to improve the social security system. It also notes that some of the poorest households may not be able to access this compensation because they belong to the country's large informal sector (Grottera et al., 2017).

86. There is already substantial experience with recycling carbon-related tax revenues in several countries (Kennedy et al., 2015). For instance since 2008, Switzerland has recycled revenue from a carbon tax on hydrocarbon fuels applied to all individuals and to those companies that do not participate in the national cap-and-trade programme. Revenue is redistributed to taxpayers as reductions in health insurance premiums for individuals, and to companies as a percentage of their total payroll tax. California is recycling some of the revenue from its emission allowance auctions back to households as semi-annual rebates on electricity bills. The revenue comes from a reverse auction of allowances that were distributed to investor-owned utilities under cap-and-trade rules.

87. In addition, special provisions to protect low-income households have been incorporated into carbon pricing policies around the world. Since 2012, California's cap-and-trade scheme has been accompanied by a requirement that at least 25% of revenues be directed to programmes that benefit disadvantaged communities in areas with high levels of pollution, poverty and unemployment, and low levels of educational attainment (Sanchez 2015). The first round of funding allocated US$272 million to investments in public transit, affordable housing, home weatherisation, renewable energy, cleaner vehicles and urban forestry (Greenlining Institute 2014). In Canada, British Columbia's carbon tax is required by law to be revenue-neutral, so revenue generated must be used to offset other taxes. As part of this requirement, a specific tax credit has been designed to offset the burden of the carbon tax on low-income households. It is based on household size and adjusted net income, so that it decreases as household income increases. In the 2013-14 fiscal year, about 16% of carbon tax revenue (US$194 million) was directed toward such low-income tax credits, making British Columbia's carbon tax highly progressive (Beck et al., 2015).

5.2 Low-carbon sustainable and inclusive growth: unlocking the "triple dividend"

88. While revenue recycling targeted at low-income households can limit negative distributional effects, these revenues would not then be available for other purposes. This concern is related to the idea of the "double dividend" of environmental tax reforms: carbon taxation brings a first (environmental) dividend by reducing emissions, and tax revenues being recycled to foster economic

growth bring a second (economic) dividend. Generally, the type of revenue recycling producing a second dividend involves a reduction in labour or company taxes rather than income transfers to low-income households.

89. The overview presented above suggests that the distributional impact of energy and carbon taxes depends crucially on how the revenues are used. Cutting labour or company tax rates without targeting low-income households, although economically efficient, would not make the taxation more progressive. Using tax revenues to finance lump-sum transfers (targeted or not) are effective ways to ensure an equitable outcome, and although they can provide an economic boost to domestic demand, they may not be as efficient at generating economic growth. Furthermore, it can be argued that low-income support provides only temporary relief: while it increases the purchasing power of these households at least temporarily, it does not lift them out of energy or fuel poverty in the longer term. This can only be achieved if the financial support is targeted at changing the factors that underlie energy and fuel poverty: access to cleaner and more efficient fuels, the energy efficiency of domestic appliances and housing, and public transport options. By addressing the causes of energy and fuel poverty rather than just the symptoms, the economic benefits of such support are much more significant. Carbon taxation would then generate three dividends: for the environment, for economic growth and for equity.

90. Though the impact of energy efficiency policies on macroeconomic performance still needs to be better understood, it is generally agreed that energy efficiency improvements deliver benefits across the whole economy, with direct and indirect impacts on economic activity, employment, trade balance and energy prices. Analysis of GDP changes due to large-scale energy efficiency policies (across all sectors) shows economic growth benefits ranging from 0.25% to 1.1% per year. The potential for job creation ranges from 8 to 27 job years per EUR 1 million invested in energy efficiency measures (IEA, 2014).

91. Like other energy efficiency support programmes, those targeted at low-income households have traditionally been evaluated on the basis of energy savings, though their non- energy co- benefits are increasingly noticed and are often cited by policy makers as a rationale for such programmes (Prevak et al., 2010). The co- benefits literature relating to energy efficiency programmes for low-income households is quite diverse, but most studies describe the following categories (IEA, 2011):

- direct financial co- benefits, including reduced outlays for energy assistance and rate subsidies, as well as other cost savings for utilities and ratepayers (e.g. avoided bad debt write- off; reduced carrying costs on billing arrears, reduced spending on notices, shut- offs and reconnections for non- payment);
- indirect economic co- benefits, including increased property values, economic activity (including jobs created by low- income energy- efficiency programmes), greater home and fire safety, and improved learning and earning capability of participants;
- social welfare and livelihood co- benefits, including improved health and comfort through improvement in housing quality and community appearance, as well as environmental benefits.

92. Co- benefits with a direct financial impact, such as reduced outlays for fuel assistance, can be measured using the same methods used to estimate energy benefits. Indirect economic benefits can also be estimated, assuming data are available and an estimation model can be developed. Social welfare and livelihood impacts are more difficult to measure, although cohort studies in several countries have positively linked improved health to low-income weatherisation programmes, with health improvements representing as much as 75% of the total return on the investment (IEA, 2014). More detailed understanding of such causal links and co-benefits will eventually provide much needed support for policies and decision-making in the low-carbon transition.

93. Experience in many countries shows that weatherisation and other energy-efficiency improvements (e.g. water heater and piping insulation; replacing old and inefficient appliances,

lighting and equipment) are effective in reducing fuel poverty because they permanently lower energy use in low-income households. For instance in the United States over 7 million homes have been weatherised over three decades via the Department of Energy's Weatherization Assistance Program, and in the United Kingdom, the Warm Front and Energy Assistance programmes have provided insulation and heating systems to over two million vulnerable households since 2001 (IEA, 2014).

94. Energy provider efficiency programmes are valuable tools for overcoming the problem of affordability since the most effective programmes targeted at vulnerable households are those which allow householders to upgrade home efficiency at no upfront cost, with investment paid back through bills. Replacing a piece of household equipment such as a boiler, an air conditioner or a refrigerator is a large expense that many low-income customers may not be able to absorb easily. In the United States in 2014, of the total ratepayer-funded utility programmes for residential energy efficiency, 18% of electric efficiency and 34% of natural gas efficiency spending went toward low-income programmes (low-income households make up roughly 33% of the U.S. population) (Cluett et al., 2016). Utilities have also been involved in energy efficiency programmes in countries where social tariffs subsidise energy services for lower income households. For instance in Brazil where as many as half of residential electricity consumers benefitted from a social tariff in 2011, utilities are required to invest 0.5% of their annual revenue in energy efficiency programmes, of which 50% must be devoted to low-income households through the Brazilian Electricity Public Benefit Fund.

95. Not all measures introduced to support the low-carbon transition directly raise revenue that can be recycled. This is the case of pricing and subsidy reforms which may have effects similar to direct energy taxation and impact lower income households. Concern about the potential impact of the removal of fuel subsidies on low-income households has been a barrier to subsidy reform in many countries. Yet addressing the social impacts of low-carbon strategies may be more complex where energy subsidies remain in place, because the benefits of energy subsidies are consistently captured by higher income households, in particular in developing countries, thus widening existing income inequalities (Berg and Ostry, 2011). For instance in India, 87% of electricity subsidy payments go to households above the poverty line and over half are directed to the richest two-fifths of households (which are the largest consumers). Such subsidies are strongly regressive and are not necessarily motivated by poverty alleviation concerns but their removal (as part of low-carbon or other policies) would need to take account of effects on the poorest households.

96. Tariff design is major driver of distributional outcomes and the use of "lifeline rates", which are targeted subsidies applicable to the first block of consumption that covers basic needs, can work to the advantage of low-income groups (Mayer et al., 2015). This is the opposite of the usual system of tarification, whereby rates per kWh of electricity consumed decline as consumption increases. Lifeline rates are usually funded through cross-subsidisation from larger consumers. Brazil introduced lifeline tariffs in 2002 and China has applied a block tariff system since 2012 (Goldemberg at al., 2004, and He and Reiner, 2014). International experience nevertheless points to social transfer programmes being more effective at addressing distributional concerns than keeping the price of energy low for poorer households even as prices rise for other consumers as a result of subsidy reform. In addition, social transfer programmes rather than subsidies allow carbon pricing signals to be fully felt by end-users, with better environmental outcomes.

97. Concerning renewable surcharges on electricity bills, the focus has been on protecting industrial competitiveness (especially for energy-intensive industries) rather than household distributional concerns. Nevertheless these concerns are recognised, for instance under EU rules, where provision has been made for Member States to grant partial compensation to low-income households to improve public acceptance of ambitious renewable energy support measures.

98. To conclude, this overview suggests that recycling revenues from carbon taxation into household and transport energy efficiency programmes targeted at low-income households would provide a "triple dividend":

- an environmental dividend by reducing household and transport energy use and therefore emissions, above and beyond reductions achieved through carbon taxation;
- an economic dividend through direct and indirect non-energy economic benefits ranging from reduced expenditure on social support and health to the economic activity generated by energy efficiency work;
- an equity dividend, as proven by existing energy efficiency programmes aimed at low-income households; experience in many countries clearly shows that such programmes(including wall, water heater and piping insulation, and replacing inefficient appliances, lighting and equipment) are effective in reducing fuel poverty because they permanently lower energy use in low-income households.

99. There is much to learn from bringing together what is already known about energy and transport affordability, the distributional effects of energy and transport policies, and tools that are used to limit any negative distributional impact on households. From this knowledge as well as the growing experience of G20 countries with carbon-related policies, it is possible to anticipate impacts on lower income households and identify good practice that can prevent or manage distributional issues as the transition to a low-carbon economy progresses. Pricing and subsidy reform can be designed so that it takes account of distributional effects at the outset, with a range of accompanying measures adapted to local and national specificities. Energy, transport and carbon taxation will play a central part in these policies, bringing tax revenue that can be used to harness the untapped potential of energy efficiency and protect the most vulnerable from energy and fuel poverty: revenue recycling through energy efficiency support targeted at low income households can provide a much needed "triple dividend" which, along with integration with sectoral policies (such as urban and transport planning), will ensure that climate, energy, economic and social objectives are aligned.

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* Includes expenditures for electricity, natural gas, other household fuels, and gasoline

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