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Towards a low carbon growth strategy for Ukraine

Key policy steps

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Executive Summary

Ukraine is one of the most energy-intensive economies in Europe. New impulses are needed to overcome traditional production structures that are no longer efficient and unsustainable in social and environmental terms. This paper identifies the key areas in terms of potential to reduce greenhouse gas (GHG) emissions and derives the corresponding policy actions needed to foster low carbon growth.

We argue that growth can only be sustained by fundamentally shifting the Ukrainian economy away from its current carbon-intensive path to a form of growth that is less dependent on the heavy use of natural resources, especially coal.

For a successful transition to low carbon growth, government intervention is indispensable. Firstly, private investments into clean technologies can only be induced by increasing the cost of emitting GHG, for example through carbon pricing or the introduction of an Emission Trading System (ETS). Secondly, the Ukrainian government needs to promote research and development into innovative clean technologies. Thirdly, in order to profit from possible financial assistance and technology transfers from abroad, the Ukrainian government may need to enter into further international commitments and guarantee a more ambitious reduction target in the level of emissions.

The main obstacles for a transition to low carbon growth in Ukraine are the lack of diversification of the economy, heavy reliance on expensive fossil-fuel imports, outdated and inefficient production capacities and unsustainably high subsidies in energy pricing. This implies a dire need for the government to increase competition, introduce market-based prices and to improve energy efficiency across all sectors.

The sectors with the greatest potential in terms of emission reductions are the industrial sector, the energy sector including energy resources as well as electricity and heat production, the transport sector and the residential sector. Promising sectoral policies include the modernization of the capital stock in the industrial sectors, the liberalization of the energy market, deregulations in the heating and electricity sectors as well as improved heat containment in residential buildings and the introduction of fuel taxes for private transport.

1. Introduction

From 2000 until the beginning of the economic crisis in 2008, the Ukrainian economy had been growing significantly, however at the expense of excessive depletion of natural resources and degradation of the ecosystem. Due to the heavy reliance on cheap energy, especially coal, and the production of steel, the economic structure of Ukraine is highly carbon intensive. Today, Ukrainian policy makers are facing the challenge to decrease GHG emissions without restricting economic activity. But how can the Ukrainian government tackle emission reductions and climate change while at the same time maintaining further growth, even in the short run?

This paper discusses the policy framework needed to enable sustainable investments in clean technologies. We outline concrete steps and recommendations for the Ukrainian government in the uptake of a low carbon growth strategy.

The paper is structured as follows. Section 2 provides a brief overview of the general economic structure, pattern of trade and carbon intensity in Ukraine and identifies the economic sectors with the greatest potential for emission reductions. Section 3 discusses the framework conditions needed for the successful implementation of a low carbon strategy and outlines a specific policy mix aimed at the different economic sectors identified in section 2. Section 4 concludes with a summary of the main policy recommendations established throughout this paper.

2. The structure of the Ukrainian economy

2.1 Ukraine's economic structure and pattern of trade

Although Ukraine's economy had been growing significantly until the crisis in 2008/2009, this is not a blueprint for future development. The significant growth in the years before the crisis relied to a considerable extent on the abundant availability of rather cheap energy resources. The pre-crisis economic model relied heavily on cheap energy imports mainly from Russia and high export volumes of ferrous and non-ferrous metals (see Tables 1 and 2).

Ferrous and nonferrous metals account for a third of total exports while the import share of mineral products (including mineral fuels such as oil and gas) is even more than one third of

total imports. With a negative trade balance the current economic model triggers high trade and current account deficits and will not be sustainable anymore.

Table 1: Ukraine's export structure (2010-2012)

	2010	2011	2012
In million USD			
Agricultural products	9,935	12,804	17,881
Mineral products (incl. mineral fuels)	6,237	9,608	6,945
Chemicals	4,658	6,980	6,763
Timber and wood products	1,768	2,184	2,193
Industrial goods	1,309	1,621	1,543
Ferrous and nonferrous metals	**17,333**	**22,114**	**18,890**
Machinery and equipment	9,183	11,895	13,284
Other (incl. informal trade)	1,768	2,212	2,313
Total (million USD)	52,191	69,418	69,812
% of total			
Agricultural products	19.0	18.4	25.6
Mineral products (incl. mineral fuels)	11.9	13.8	9.9
Chemicals	8.9	10.1	9.7
Timber and wood products	3.4	3.1	3.1
Industrial goods	2.5	2.3	2.2
Ferrous and nonferrous metals	**33.4**	**31.9**	**27.1**
Machinery and equipment	17.5	17.1	19.0
Other (incl. informal trade)	3.3	3.2	3.3
Total (%)	100	100	100

Source: National Bank of Ukraine (2013), own calculations

Table 2: Ukraine's import structure (2010- 2012)

	2010	2011	2012
In million USD			
Agricultural products	5,762	6,346	7,520
Mineral products (incl. mineral fuels)	**20,707**	**29,396**	**27,077**
Chemicals	10,524	12,961	13,519
Timber and wood products	2,000	2,230	2,182
Industrial goods	3,355	3,508	4,465
Ferrous and nonferrous metals	4,128	5,695	5,238
Machinery and equipment	12,689	20,018	22,433
Other (incl. informal trade)	1,414	5,516	7,870
Total (million USD)	60,579	85,670	90,304
% of total			
Agricultural products	9.7	7.4	8.3
Mineral products (incl. mineral fuels)	**34.3**	**34.3**	**30.0**
Chemicals	17.4	15.1	15.0
Timber and wood products	3.3	2.6	2.4
Industrial goods	5.5	4.1	4.9
Ferrous and nonferrous metals	6.8	6.6	5.8
Machinery and equipment	20.7	23.4	24.8
Other (incl. informal trade)	2.3	6.4	8.7
Total (%)	100	100	100

Source: National Bank of Ukraine (2013), own calculations

Relying on energy intensive production technologies, Ukraine's heavy industry also causes high emission rates of GHG. For instance, steelmaking in Ukraine requires four times more energy in Ukraine than in China (OECD 2012). In a separate paper, we estimate the annual potential of reducing GHG emissions for the Ukrainian metal industry to reach a level of 52 Mt per year in terms of CO_2 equivalent if switching to efficiency based technologies available today (see DIW econ 2012c).

The Ukrainian economy is lacking competition and transparency in the energy sector, especially in the gas market, causing rent seeking behaviour and economic inefficiencies. The funds spent on subsidies in the energy sectors place a heavy strain on the government budget, decrease the funds available for other policy measures and increase the tax burden.

A serious drawback is the focus of economic investments on the recommissioning of already existing but outdated production capacities, thereby impeding the real increment in more efficient production capacities and technologies. Furthermore, innovations – essential for sustainable growth – do not play an important role as a growth determinant in Ukraine. The

growth of Ukrainian GDP is driven much less by Research and Development than in other nations (see Technical Paper, DIW econ 2013[1]).

In the past five years, economic growth in Ukraine slowed down significantly. This is mainly due to the following reasons:

- A declining demand for Ukrainian exports. In particular China has switched in recent years from a net-importer to a net-exporter of ferrous and non-ferrous metals by building up its own production capacities.
- The gas crisis: Since 2005 import prices for Russian gas have been increasing significantly. Today Ukraine is paying one of the highest gas prices in Europe.
- The economic and financial crisis in 2008/2009 and the political turmoil in the Mediterranean and North Africa (MENA) region have led to a further drop in demand for Ukrainian exports.
- Ukraine is lacking behind with regards to foreign direct investments; the investment environment is rather poor and has significantly deteriorated in the recent past. The combination of widespread corruption and weak investor protection with a flawed judiciary has left Ukraine 152nd out of 183 countries in the World Bank's most recent Ease of Doing Business ranking.
- Furthermore, the Ukrainian economy suffered repeated financial bottlenecks.

In conclusion, the present Ukrainian economic model is exhausted and will not generate any further economic growth. Instead, new reform impulses are needed to overcome traditional production structures that are no longer efficient, internationally not competitive, and unsustainable in environmental and social terms. Ukraine needs a structural change in order to achieve a realigned, sustainable growth path.

2.2 Ukraine's carbon record

Along with increasing international efforts to reduce GHG emissions, the average carbon intensity of GDP has been falling in the EU-15 countries, the United States as well as in China (EBRD 2011). Even previous transition economies in Europe and Asia, for example Poland (World Bank 2011) and Kazakhstan (DIW econ 2012a), have drafted and implemented ambitious programmes to decrease the carbon content of their GDP. Ukraine on the contrary lags far behind these international developments.

[1] DIW econ (2013): "Assessing the innovation potential in Ukraine – Recent track record and implications for low-carbon development". Low Carbon Ukraine – Technical Paper No.1.

With an aggregate GHG emission of 383 million metric tons of CO_2 equivalent (UNFCC 2012a)[2], Ukraine is placed among the twenty countries with the highest emissions worldwide (European Commission 2011). Table 3 shows a comparison between CO_2 emissions from energy use (per unit of GDP) in Ukraine and other previous transition economies.

Table 3: Carbon intensity in selected Eurasian economies[3], 2010

	Ukraine	Kazakhstan	Russia	Poland
Carbon intensity (kg CO_2 / $ of GDP)	3.03	2.44	1.82	0.79

Source: own calculations

As illustrated in Table 3, Ukraine needs more CO_2 emissions to produce one unit of GDP than other countries in the region. This is all the more remarkable given the fact that Kazakhstan and Russia are sizeable producers of oil and natural gas, which usually is connected with high emissions from extraction operations. The carbon intensity of Ukrainian exports is far above that of all other countries in Europe, East Asia and the Commonwealth of Independent States (CIS) and is more than six times higher than world average (EBRD 2011).

The sectoral distribution of emissions in Ukraine is shown in Table 4. This is a preliminary account, splitting total GHG emissions in Ukraine according to the major emitting sectors of its economy. While a more detailed investigation of these sectors will be provided during the course of the current project “Capacity Building for Low Carbon Growth”, this overview offers a useful starting point.

More than half of total Ukrainian emissions are accounted for by fuel combustion in industries and industrial processes as well as by the generation of electricity and heat production. Among the industrial sectors, the majority of emissions (17.8 percent) stems from the metal industry, followed by the chemical industry with 3.9 percent.

The extraction, transport and processing of oil, natural gas and coal constitute another major source of emissions (13.3 percent). The transport and residential sector account for 10.4

[2] Value for 2010, excluding emissions from land use and land use change (LULUCF) (UNFCCC 2012a).

[3] Carbon Intensity for 2010 in metric tons of Carbon Dioxide from energy use per thousand U.S. Dollars of GDP, 2005 prices and market exchange rates (EIA 2011).

percent of total emissions each. Out of the emissions in the transport sector, 75 percent are attributable to the use of road vehicles, corresponding to 7.7 percent of total emissions.

Table 4: Green house gas emissions[4] in Ukraine by sector, 2010

Sector	CO_2 equivalent (in 1000 metric tonnes)	Percent of total emissions
Industrial processes and fuel combustion in industry	105 510	27.5
Industry: metals	68 278	17.8
Industry: chemical products	14 896	3.9
Industry: mineral products	9 323	2.4
Industry: other	5 743	3.4
Electricity and heat production	94 370	24.6
Production, transport and processing of energy resources (oil, gas & coal)	50 842	13.3
Energy: natural gas fugitive emissions	19 814	5.2
Energy: coal mining	19 675	5.1
Energy: other	11 353	3.0
Transport sector	40 025	10.4
Transport: road vehicles	29 431	7.7
Residential sector	39 921	10.4
Other (incl. agriculture, waste)	52 513	13.7
Total	**383 182**	**100.0**

Source: UNFCCC 2012a, own calculations

3. Towards low carbon growth in Ukraine

The alternative to the current carbon intensive growth in Ukraine is the adoption of an innovative low carbon growth[5] strategy. Low carbon growth strategies comprise two broad sets of policies: (i) framework policies and (ii) sectoral policies. The implementation of such policies necessarily implies the decoupling of energy consumption and GHG emissions from economic development (Low Carbon Growth). Climate policies should be not regarded as a burden to economic development but rather as a chance for further sustainable growth

[4] All Greenhouse Gases included, emissions from LULUCF excluded.
[5] In general, low carbon growth refers to conventional economic growth at increased efficiency with respect to GHG emissions and the use of natural resources (DIW econ 2012).

opportunities. In fact, greening policies can induce many positive development outcomes such as enhanced productivity and innovation, the creation of new jobs and markets as well as fiscal revenue generation.

There are first signs that this awareness is starting to be reflected in Ukrainian policies. Ukraine has already undertaken some first measures to green its economy (MEP 2006). One example is the discussion of the introduction of an Emission Trading System (ETS), possibly preceded by a carbon tax.

3.1 Framework conditions for low carbon growth

3.1.1 The role of the Ukrainian government

For a successful transition to low carbon growth, government intervention is indispensable. The main task for the government consists in redirecting market forces towards cleaner production and investment. This is achieved by narrowing the cost gap between brown and green technologies, by pricing in the costs of GHG emissions. Such measures include the phasing out of unsustainable brown subsidies, reforming policies, redirecting public investments and enforcing market-based mechanisms. As soon as the cost of brown technologies exceeds the cost of clean technologies, investments in specific abatement technologies will be more attractive yielding positive returns for investors.

The two major instruments for the government to price in GHG emissions in order to redirect market forces towards low carbon investments are a carbon tax or the introduction of an Emission Trading System (ETS).[6]

- A tax on carbon emissions increases the cost of carbon intensive production and thereby provides a financial incentive for firms and private investors to reduce GHG emissions. A tax may institutionally be easy to administer in Ukraine, but determining the optimal tax rate is not a trivial matter. Too low tax rates may not trigger any significant cuts in GHG-emissions, while prohibitive tax rates endanger industrial competitiveness (NECU 2011). In general, it is hard to reach a specific reduction target by using a tax on carbon.
- At present, the Ukrainian government plans to introduce a cap-and-trade system for CO2 emission certificates. Trading systems, such as the European Union ETS, are based on setting a maximum ceiling on emissions. Enterprises that emit less GHG than their cap can sell unused emission allowances to firms that are likely to emit more carbon. Such a

[6] A more detailed analysis of these instruments and their implementation possibilities is to follow in a further policy paper in the course of the current DIW econ project “Capacity Building for Low Carbon Growth in Ukraine”.

carbon market does not require any further environmental standards to be enforced since firms will seek to emit less GHG to avoid having to purchase more allowances. It does, however, require sound economic judgment in setting the level of the cap (DIW econ 2012b) and needs additional efforts to set up a market place for CO2.

Apart from increasing the relative price of dirty to clean technologies, innovation is crucial for the realisation of low carbon growth. As Aghion et al. (2009) point out, "governments (...) need to influence not only the allocation of production between clean and dirty activities, but also the allocation of research and development between clean and dirty innovation." In the absence of government intervention to redirect technological development towards clean innovations, innovations tend to be biased towards already existing dirty technologies (Aghion et al. 2009). Hence an optimal policy combines carbon pricing (or carbon permits) with strong support in clean-innovation R&D. In practice, these subsidies in R&D can be financed through the receipts form carbon pricing.

In Ukraine, research and development is not sufficiently developed. From 2005 to 2011, spending in R&D measured as a share of GDP decreased from 0.14 per cent to 0.08 per cent (DIW econ 2012).[7] However, Ukraine has a comprehensive network of higher education institutes[8] and possesses a rather well developed industrial base capable of manufacturing complex machinery. These factors, in theory, form a sufficient basis for the development of domestic research in clean technologies. Hence there is a strong need for the government to engage in the promotion of domestic research and development.

Possible measures are the promotion of cutting-edge scientific research in natural and economic sciences and specific training aimed at developing new skill sets needed for green jobs. This may be supported by administering specific research subsidies[9]. Policies should also encourage the cooperation between enterprises, think tanks and universities in the framework of a National System of Innovation (OECD 1997).

» **To encourage private investment in clean technologies, public intervention is indispensable. Public policies should combine measures that increase the**

[7] For a more detailed discussion on the innovation potential of the Ukrainian economy see DIW econ (2013): "Assessing the innovation potential in Ukraine – Recent track record and implications for low-carbon development". Low Carbon Ukraine – Technical Paper No.1.

[8] For example, Ukraine outscores other countries in the region, as well as France and the United Kingdom, on the 2011 education index compiled by the United Nations Development Programme (UNDP), which takes literacy and schooling years into account (UNDP 2011).

[9] Domestic research subsidies for green technology may, apart from accumulating domestic knowledge, also lower the final price of green products, or decrease their time to market. This in itself may have positive effects on the uptake of these technologies and thus on climate change mitigation (Acemoglu et al. 2012).

relative cost of dirty to clean technologies, e.g. through carbon pricing or the introduction of an ETS, with direct subsidies in clean-innovation R&D.

3.1.2 The role of International Cooperation

In many sectors, private investment may be limited to financial constraints and may depend on technology[10] transfers from abroad. Fortunately there exist several possibilities of external assistance (OECD 2012), for example within the framework of the UNFCCC or international organisations. Since European, North-American and Asian companies currently operate at the technology frontier with respect to GHG emission reductions, the Ukrainian economy may profit significantly from technological spill over effects from abroad.

Some of the publically supported channels include:

- The Global Environmental Facility (GEF), mandated by the Conference of the Parties to the UNFCCC to support technology diffusion in developing and transition economies. Projects include renewable energy, energy efficiency, sustainable transport, and innovative financing initiatives (GEF 2010);
- The Framework for Implementing Agreements, administered by the OECD and the International Energy Agency (IEA), to share research on breakthrough energy-related technologies and to assist with deployment programmes in member and non-member states (IEA 2003);
- Technical assistance provided by foreign governments or the European Union, i.e. the EU project PROMITHEAS aimed at fostering cooperation among research institutes and universities of the Black Sea littoral states with a focus on renewable energies;
- Multilateral financial institutions such as the European Bank for Reconstruction and Development (EBRD) or the World Bank may give access to large scale loans. The World Bank has been active in financing energy efficiency investments in the building sector of Eastern European countries through targeted loans to its governments (World Bank 2008). Similarly, the EBRD has been financing projects within its Ukrainian Energy Efficiency Programmes (UKEEP).

To fully gain access to financial and technological transfers from abroad, a number of steps are necessary. Firstly, the potentials of specific technologies to reduce GHG emissions as well as their economic cost need to be assessed for all economic sectors within the framework of Technology Needs Assessments (TNAs). Secondly, Ukraine may need to enter

[10] The term technology does not only refer to equipment, but also includes know-how and organisational methods suited to cutting emissions associated with particular economic activities (IPCC 2000).

into further commitments with multilateral financial institutions or foreign governments. Such commitments may involve a firm assurance by the Ukrainian government to promote low carbon growth policies and to set an ambitious reduction target in the level of GHG emissions.

» **In order to gain access to financial assistance and technology transfers from abroad, Ukraine may need to enter into further international commitments and to guarantee a more ambitious target in the level of emission reductions.**

3.2 A sectoral policy mix

In the following section we discuss sector specific policy measures to be applied in the emission-intensive sectors identified in Section 2.1. Following the structure of Table 4, these sectors include the industry, energy, transport and residential sector and are listed in decreasing order in terms of their share of total GHG emissions.

3.2.1 Industrial Sector

As illustrated in Table 4, industrial processes and fuel combustion in industry constitute the highest share of emissions in Ukraine (27.5%). This is due to the fact that manufacturing activity in Ukraine is dominated by energy-intensive steel production. The key reason for the energy intensity is an ageing capital stock with outdated and inefficient production technologies that remain in use across the entire region. Smelting one tonne of steel in obsolete open-heart furnaces in Ukraine consumes almost four times more energy than smelting one tonne of steel in the European Union countries or China (OECD 2012).

Hence the industrial sector and in particular the metal industry present much potential for the reduction of GHG emissions.[11] This however can only be achieved if the capital stock, especially outdated infrastructure and production capacities, is modernized. Promising energy efficiency measures include the improvement of energy management systems, heat recovery, the replacement of electric apparatus, improved cooling systems as well as the replacement of furnaces and kilns in the metals and cement industries (UKEEP 2012).

In order to provide incentives to implement such technologies, regulatory standards for production technologies should be tightened and coupled with reinforced penalties for their violation.

[11] For a detailed discussion of low carbon growth potentials in the metal industry, see DIW econ (2012c): “Benchmarking for sustainable and economically viable technology options – The case of the metal industry in Ukraine”. Green Growth Policy Paper No. 2.

» **The main requirement for emission reductions in the industrial sector is the improvement of energy efficiency. This implies the modernization of the capital stock, especially of deteriorate infrastructure and outdated production capacities.**

3.2.2 Energy Sector

In order to put Ukraine on a low carbon growth path, much effort has to be directed into the energy sector. The Ukrainian energy sector, especially the gas market, is characterized by "dirty" technologies, high levels of inefficiencies and corruption, rent-seeking behaviour, and misleading incentives by distorted prices.

3.2.2.1 Energy Resources: Oil, Natural Gas and Coal

Emissions in the energy sector mainly arise from the production, processing and transport of oil, natural gas and coal. The bulk of emissions (78 percent) originate in equal parts from the transport of natural gas and the mining of solid fuels, primarily coal. Both of these activities offer substantial scope for the reduction of GHG emissions, for example trough the modernisation and optimization of the gas transport system. Particularly promising measures include the reduction in greenhouse gas methane emitted from leakages in natural gas pipelines (NECU 2010).

Apart from investments in infrastructure, the key of reducing GHG emissions in the energy sector rests on encouraging market based competition. Specifically, we propose such efforts to include:

- Phasing out direct subsidies to coal mining (Handrich, Pavel and Naumenko 2009) and phasing out economically unfeasibly low tariffs for natural gas consumers. Currently, Ukraine's direct and indirect energy subsidies are the world's 8th largest in terms of economic value (UNEP 2008). This has become a significant strain on the national budget, a liability in relations with Russia as far as gas is concerned, and a major deterrent to energy efficiency (Opitz 2010);
- Restructuring of the gas sector through transparent regulation by independent authorities, unbundling and demonopolisation in the gas transport and distribution as well as in the oil and gas extraction sectors (Pavel and Poltavets 2005; Aslund and Paskhaver 2010).

These policy measures will lead to an increase in the price of fossil energy, as advocated in Section 3.1.1. Industries that rely on the input of fossil fuels will become less competitive,

while non-energy intensive industries, such as the agricultural sector, could profit. This brings about the need for structural change and diversification of the Ukrainian economy. In an international perspective, this will lead to changes in the comparative advantage of Ukraine. Steel and other heavy industries will display decreasing volumes of production, leading to a change in the pattern of foreign trade.

Apart from the structural change, Ukraine needs a stable and reliable macroeconomic policy permitting firms to predict the change of energy prices. Only if policy makers ensure in a credible way that the induced changes of relative energy prices are permanent, firms will make long term investments into energy efficiency and clean technologies.

» **The key to reduce GHG emissions in the energy sector lies in promoting market based competition. This involves phasing out direct subsidies to coal mining, phasing out unfeasible low tariffs for natural gas as well as the demonopolisation of the gas transport sector.**

3.2.2.2 Electricity and Heat Production

The overwhelming majority of heat in Ukraine (97 percent) is produced by burning natural gas. Natural gas also plays an important role in electricity generation with 8 percent of power stemming from this source. The most important fuel for electricity production is domestic coal (36 percent). Renewable energy sources, mainly large hydro stations, only generate 7 percent of electricity (IEA 2009).

The electricity and heat production sector is the largest fuel consumer in Ukraine after the industrial sector. Emissions from the production of electricity and communal heat account for about 25 percent of all GHG emissions in Ukraine (see Table 4). These emissions can broadly be divided into two categories: (i) Emissions deriving from the combustion of fossil fuels used for heat generation, (ii) emissions deriving from technical losses in heat and electricity generation and distribution.

Emissions from losses in heat and electricity generation and transmission hinge to a large degree on the state of current infrastructure and equipment (Pavel 2007). Both the natural gas transmission and distribution infrastructure as well as the storage and gas-fired units for district heating systems are in dire need for upgrade and renovation (IEA 2012).

The principal way to compel electricity companies and district heating providers to invest in infrastructure improvements lies in liberalising utility tariff rates and improving regulation

(Pavel and Chukhai 2005). There is a strong need for removing subsidies for private gas consumption and district heating systems and to adjust residential electricity tariffs to cost-reflective levels (IEA 2012). These must include the capital and replacement costs.[12]

With respect to renewable energies, investments in wind power, biomass and photovoltaic installations have experienced an increase recently (Trypolska 2012). Generous feed-in-tariffs for solar and wind energy generation and an obligation for state companies to connect new units to the grid, have given a boost to Ukraine's renewable energy development (IEA 2012). However, quantities are yet too small to account for an aggregate impact.

In order to further reduce Ukraine's dependence on fossil fuels, we propose to:

- Maintain the current system of feed-in tariffs guarantying access for electricity generated from renewable sources to the national grid;
- Clarify land rights, permit renewable energy installations for private households and increase the capacity of the grid to include green electricity;
- Support the construction of small biomass cogeneration plants in agricultural areas through preferential loans in order to decrease emissions from heat production and agricultural waste.

» **Emission reductions in the heat and electricity sector are subject to the modernization of the gas transmission system and the renovation of depreciated heating equipment. These investments in infrastructure can only be induced if subsidies for gas consumption are eliminated and electricity tariffs are increased to full cost-recovery levels.**

3.2.3 Transport Sector

Sectors with comparatively low carbon intensity, such as the transport sector, provide great opportunities for emission reductions. With emissions accounting for 11 percent of total emissions in Ukraine, the energy intensity of transport in Ukraine is lower than that of the EU-27 average (UNECE 2010). However, this may change in future since incomes are growing and car ownership is increasing (Ernst & Young 2012). The challenge for policy makers consists in reducing present emissions and detaining future emissions from a potentially growing sector.

[12] To minimise the social impact of these reforms, the tariff increases may be carried out in a stepwise procedure (Opitz, Dodonov and Pfaffenberger 2004).

Measures such as the successive implementation of fuel efficiency standards and fuel taxes in the private transport sector may provide a starting point. These could be complemented by investments in public transport modes and the modernisation of the railway, urban tram and bus systems. With respect to road transport, improvements can be achieved by investments in better road infrastructure and by supporting the implementation of electric, hybrid and fuel cell electric vehicles (DIW econ 2011). However, more research on transport capacities in Ukraine is needed to determine the ecological and efficiency gains of these policy options.

» **Promising measures in the transport sector include the adoption of fuel efficiency standards and taxes, the improvement of road infrastructure and the modernization and expansion of the public transport system.**

3.2.4 Residential Sector

The residential sector offers great scope for improvement in energy efficiency, especially in the private household sector. The increase of electricity and utility tariffs to cost covering levels advocated in section 3.2.2.2 will give residents the incentives to save energy (Meissner, Naumenko and Radeke 2012). They may start to engage in energy efficiency investments such as heat containment in buildings through insulation of walls, windows and roofs. This does not only improve energy efficiency, but also reduces Ukraine's dependence on Russian oil and gas imports and creates jobs in the construction and handicraft sector.

A mix of measures that have been discussed in neighbouring countries with similar residential structures may prove fruitful (Opitz 2003):

- Enforce the deployment of metering and heat controls to supply residents with the tools to control and reduce their energy consumption;
- Improve the framework for the operation of Energy Service and Performance Companies;
- Sharpen the definition of residential property rights and support the formation of resident associations as methods to share investment outlays and risks;
- Advance the provision of financial support to households for energy efficiency improvements, possibly through co-financing or support from multilateral financial institutions (see section 3.1.2)

» **With respect to the residential sector, we advocate giving private residents the incentives and the tools to invest in heat containment and other energy efficiency measures.**

4. Policy Recommendations

This paper discussed the policy framework needed to enable investments in clean technologies and outlined concrete steps to assist the Ukrainian government with the implementation of a low carbon growth strategy. Low carbon growth strategies comprise two broad sets of policies: (i) framework policies and (ii) sectoral policies. Both of them call for a central role of the Ukrainian government.

There is a dire need for the Ukrainian government to implement an effective regulatory framework that increases competition and strengthens the efficiency of markets. Ideally, public policy should combine measures that increase the relative cost of dirty to clean technologies, for example through carbon pricing or the introduction of an ETS, with direct subsidies into clean-innovation R&D.

With respect to sectoral policies, we recommend a specific policy mix aimed at the economic sectors with the greatest potential for emission reductions. The most promising sectors identified in this paper are the industrial sector, the energy sector including energy resources and electricity and heat production, as well as the transport and residential sector.

1. The main requirement for emission reductions in the industrial sector is the improvement of energy efficiency. This implies the modernization of the capital stock, especially of deteriorate infrastructure and outdated production capacities.
2. The key to reduce GHG emissions in the energy sector lies in promoting market based competition. This involves phasing out direct subsidies to coal mining, phasing out unfeasible low tariffs for natural gas as well as the demonopolisation of the gas transport sector.
3. Emission reductions in the heat and electricity sector are subject to the modernization of the gas transmission system and the renovation of depreciated heating equipment. These investments in infrastructure can only be induced if subsidies for gas consumption are eliminated and electricity tariffs are increased to full cost-recovery levels.
4. Promising measures in the transport sector include the adoption of fuel efficiency standards and taxes, the improvement of road infrastructure and the modernization and expansion of the public transport system.
5. With respect to the residential sector, we advocate giving private residents the incentives and the tools to invest in heat containment and other energy efficiency measures.

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