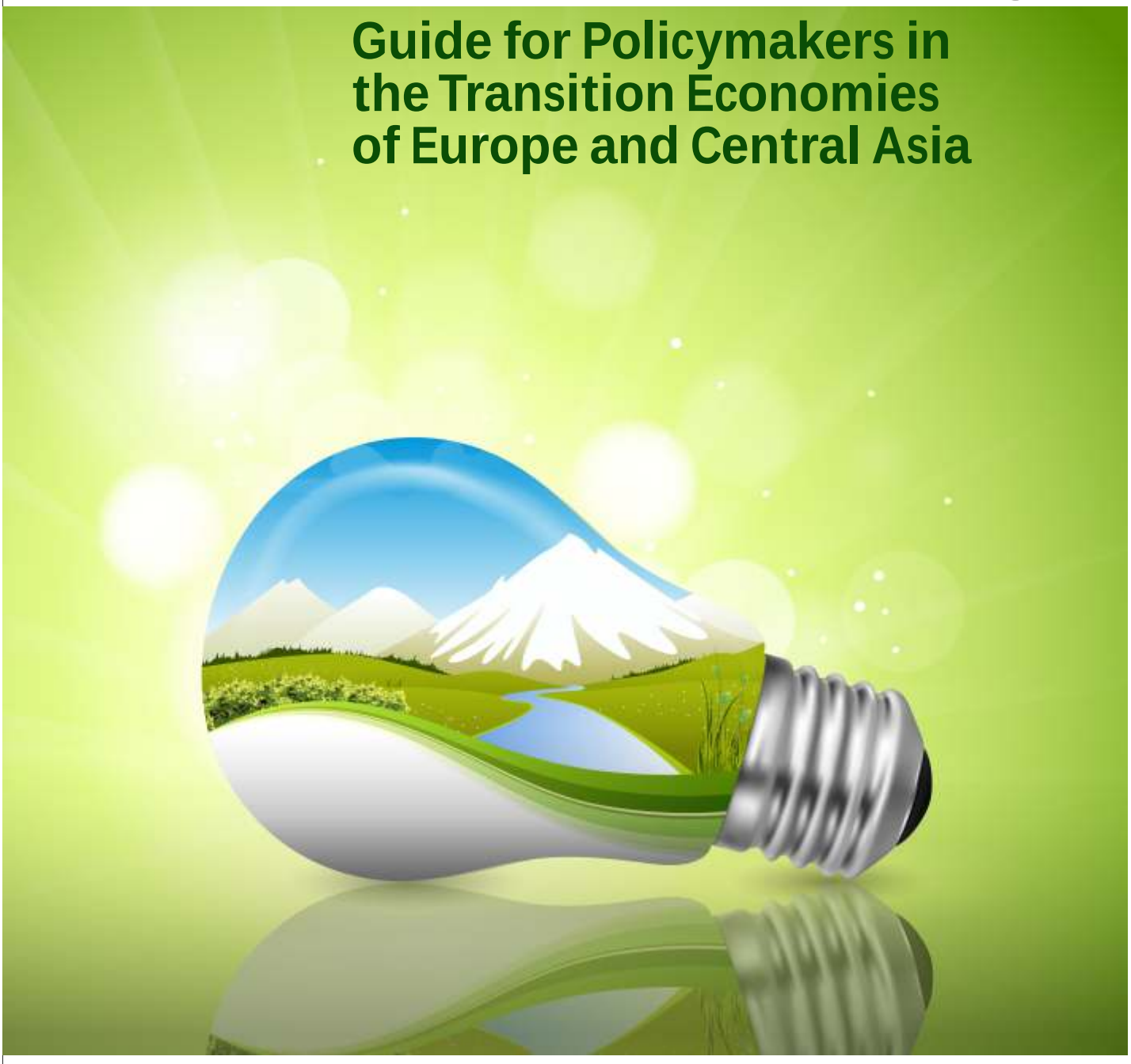
UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

Innovation Policy for Green Technologies

Guide for Policymakers in the Transition Economies of Europe and Central Asia



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UNITED NATIONS
New York and Geneva, 2013

NOTE

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FOREWORD

Many transition economies in Europe and Central Asia are endowed with rich natural resources and biodiversity. At the same time, global climate change and associated extreme weather events are already affecting these countries, with serious economic and social consequences.

These countries are now seeking new ways to accelerate the use of green technologies as a measure for adapting to the effects of the changing climate. For them to be successful in this effort, they need to put the right conditions in place to support the take-up and diffusion of green technologies. This will require tailor-made innovation policies that integrate and reflect each country's environmental concerns. Countries will need to strengthen the capacity of their policymakers for designing and executing these integrated policies in order to ensure suitable infrastructure, better access to external knowledge, and an enabling business environment..

This Guide reflects the findings of assessments on innovation policy—with special reference to green technologies—that were conducted by the UNECE for Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan in 2012 and 2013. It can be used as a textbook for group training or for self-learning.

At the UNECE, we are strongly committed to building the innovation capacity of our member States, as an important tool for reaching policy objectives in areas such as economic development and climate change adaptation. This guide is another important element in our "toolbox" for assisting national policy makers - one with a specific focus on supporting the adoption and implementation of green technologies. We look forward to working with countries on its application, and to seeing the results.

Sven Alkalaj
Executive Secretary
United Nations Economic Commission for Europe

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ABREVIATIONS

SUBREGIONS AND COUNTRY CODES

SOUTH-EASTERN EUROPE (SEE)

Albania (ALB)
Bosnia and Herzegovina (BIH)
The former Yugoslav Republic of Macedonia (MKD)
Montenegro (MNE)
Serbia (SRB)
Turkey (TUR)

EASTERN EUROPE, CAUCASUS, AND CENTRAL ASIA (EECCA)

Armenia (ARM)
Azerbaijan (AZE)
Belarus (BLR)
Georgia (GEO)
Kazakhstan (KAZ)
Kyrgyzstan (KGZ)
Republic of Moldova (MDA)
Russian Federation (RUS)
Tajikistan (TJK)
Turkmenistan (TKM)
Ukraine (UKR)
Uzbekistan (UZB)

NEW EU POST-COMMUNIST MEMBER STATES (NMS)

Bulgaria (BGR)
Croatia (HRV)
Czech Republic (CZE)
Estonia(EST)
Hungary (HUN)
Latvia (LAT)
Lithuania (LTU)
Poland(POL)
Romania (ROU)
Slovakia (SVK)
Slovenia (SLO)

EU ADVANCED INDUSTRIAL ECONOMIES (EU-15)

Austria (AUT)
Belgium (BEL)
Denmark (DNK)
Finland (FIN)
France(FRA)
Germany (DEU)
Greece(GRC)
Ireland(IRE)
Italy (ITA)
Luxembourg (LUX)
Netherlands (NLD)
Portugal (PRT)
Spain (ESP)
Sweden (SWE)
United Kingdom (GBR)

OTHER ECE MEMBER STATES

Andorra (AND)
Canada (CAN)
Cyprus (CYP)
Iceland (ISL)
Israel(ISR)
Liechtenstein (LIE)
Malta (MLT)
Monaco (MCO)
Norway (NOR)
San Marino (SMR)
Switzerland (CHE)
United States (USA)

Note: Transition Economies in Europe and Central Asia (TECA) = SEE + EECCA + NMS.

ACRONYMS

ADB	Asian Development Bank
CAD	Canadian Dollar
CAREC	Central Asia Regional Economic Cooperation
CBA	Cost-benefit analysis
CDM	Clean Development Mechanism
CIS	Commonwealth of Independent States
CO_2	Carbon dioxide
EBRD	European Bank for Reconstruction and Development
ECE	Economic Commission for Europe
EEA	European Environment Agency
EU	European Union
FDI	Foreign direct investment
GDP	Gross domestic product
GHG	Greenhouse gases
GII	Global Innovation Index
GNI	Gross national income
GNI	Gross national income
HDI	Human development index
HEI	Higher education institution
ICT	Information and communications technology
IDA	International Development Association (member of the World Bank Group)
IEA	International Energy Agency
IFC	International Finance Corporation (member of the World Bank Group)
IGES	Institute for Global Environmental Strategies
IPRs	Intellectual property rights
ISO	International Organization for Standardization
MSMEs	Micro, small and medium-sized enterprises
NGO	Non-government organization
NIS	National innovation system
OECD	Organisation for Economic Co-operation and Development
OSCE	Organization for Security and Co-operation in Europe
PES	Payment for ecosystem services
PISA	Programme for International Student Assessment
R&D	Research and development

ACRONYMS (CONTINUED)

SMEs	Small and medium-sized enterprises
SPECA	Special Programme for the Economies of Central Asia
TECA	Transition economies in Europe and Central Asia
UKCIP	UK Climate Impacts Programme
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USD	United States Dollar
WHO	World Health Organization
WTO	World Trade Organization

MODULE I

INTRODUCTION

My Notes

INTRODUCTION

This module introduces key concepts that will enable you to gain a broad understanding of the challenges posed by unsustainable growth and what can be done to address them. Topics that are covered include:

- Sustainable development;
- Green growth;
- Carbon emission trends ;
- Energy efficiency trends;
- Ecological footprint and human development;
- Climate change adaptation and mitigation;
- Stages of the climate adaptation process;
- Invention, innovation and diffusion of innovations; and
- Green innovations.

Upon completion of the module, you should be able to:

- Identify the dimensions of sustainable development;
- Understand the need for a transition to green growth;
- Distinguish between climate change adaptation and mitigation;
- Understand the concepts of innovation and eco-innovation;
- Explain why policies are needed to support eco-innovation;
- Understand the discussion questions appearing in the final section; and
- Answer correctly all questions in the multiple choice quiz.

The main references utilized for the module include publications of international organizations (OECD, UNECE, UNIDO) and international financial institutions (EBRD, World Bank) that are listed in the reference page at the end of the module.

GREEN GROWTH AND SUSTAINABLE DEVELOPMENT

UNSUSTAINABLE GROWTH

The industrial revolution has unleashed unprecedented economic growth over the last two and a half centuries, mobilizing massive resources and improving the standard of living in many parts of the world. However, this progress has been uneven, with billions of people still mired in abject poverty, and it resulted in increasing pressures on the natural environment.

In particular, air, water and the biosphere have long been regarded as public goods, owned by no-one in particular, and available free of charge as resources and as pollution receptacles. Since individual producers and consumers are typically not being charged the true cost to society of using these resources, they tend to disregard this cost in their production and consumption decisions. As a result, traditional industrial production and consumption patterns have become environmentally unsustainable. In the outcome document "The Future We Want" of the United Nations Rio+20 Conference on Sustainable Development, world leaders recognized the need to change unsustainable, and to promote sustainable, patterns of consumption and production as

an essential requirement for sustainable development. They also emphasised that adaptation to climate change represents an immediate and urgent global priority, and considered the green economy in the context of sustainable development and poverty eradication as one of the important tools available for achieving sustainable development.

TOWARDS SUSTAINABLE DEVELOPMENT

Sustainable development entails three interdependent components – economic development, social development and environmental protection. This type of development implies sustainable consumption of natural resources and a high level of human development.

The objective of sustainable development has a broad support of international community. Governments of the UN member states have made broad commitments to environmental sustainability and poverty eradication since the early 1990s. It is expected that global leaders will strengthen such commitments in the UN post-2015 development agenda.

GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE

Rising levels of air and water pollution became a major public concern in industrialized countries since the 1950s. This concern was reflected in government policies aiming to protect health of the public and natural environment. Since the 1970s most of these countries had environmental protection agencies or ministries that were tasked to formulate evidence-based policies and implement them with the aid of various standards and regulations. This type of government intervention was based on the insight that clean air and water are public goods (analogous to national defence or public health) that are unlikely to be provided well by markets.

Despite the initial success of environmental policies that improved air and water quality, the uninterrupted increase in greenhouse gas (GHG) emissions and loss of biodiversity indicate that economic activity has continued to be unsustainable. A large majority of climate scientists agree that climate change and global warming, caused to a large extent by human activities, are inevitable unless the GHG concentration in Earth's atmosphere can be stabilized. Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. Since the beginning of the industrial era in the middle of the 18th century the concentration of carbon dioxide in the atmosphere has increased by 44 per cent and continues to grow. According to the latest available data, global CO_2 emissions are about 50 per cent over the 1990 level and rising (Olivier et al, 2013). China emits 29 per cent of global emissions, followed by the United States (16 per cent) and European Union (11 per cent). Figure 1 shows that territorial CO_2 emissions of Europe, Central Asia and North America have declined somewhat since 1990 while increasing strongly in other parts of the world.

Figure 2 shows that the share of Europe, Central Asia and North America in global CO_2 emissions decreased from 61 per cent in 1990 to 42 per cent in 2008. The decrease of the share of transition economies in Europe and Central Asia from 16 per cent to 7 per cent over the same time period is exceptional, reflecting the impact of the transition recession in the early 1990s as well as a reduction in carbon intensity of production resulting from economic restructuring and technical progress. Table 1 shows that territorial CO_2 emissions declined in most economies of the region between 1990

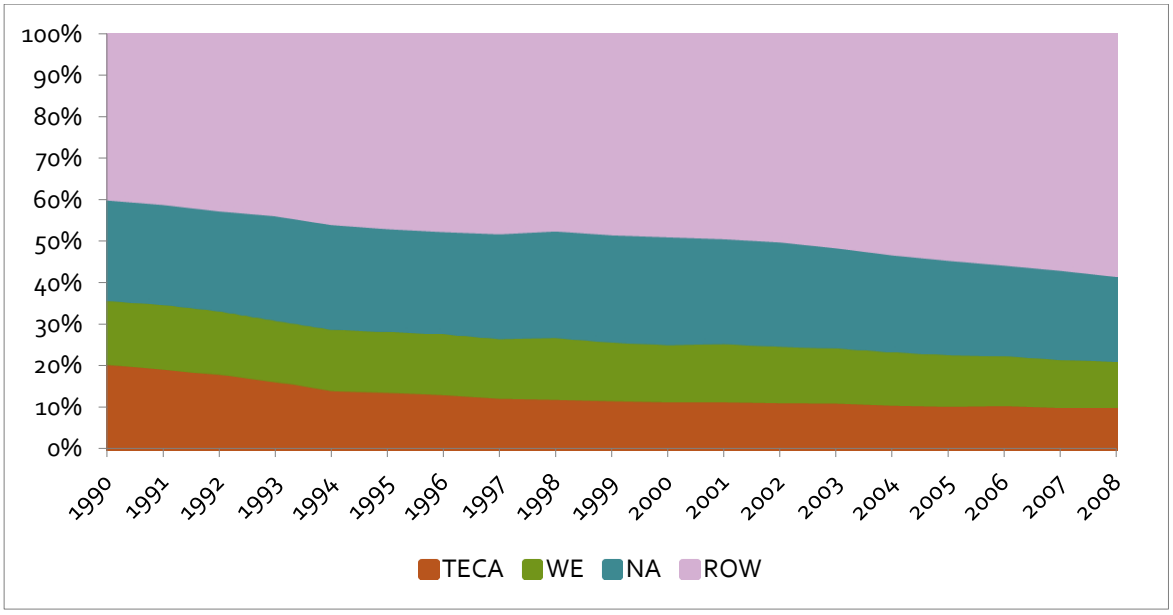
and 2008 with the exception of countries with relatively fast economic and population growth such as Turkey or the United States. However, the carbon emissions embodied in intermediate and final consumption increased in 29 countries over the same time period. This reflects to some extent the outsourcing of carbon intensive production to emerging economies outside the region. Thus sustainability remains an elusive target for the region and further emission cuts are needed in order to cope with climate change.

THE ECOLOGICAL FOOTPRINT AND HUMAN DEVELOPMENT

Following the pioneering work of the Global Footprint Network (an international think tank of scientists based in the United States, Switzerland and Belgium), environmental sustainability is often assessed by the size of the ecological footprint that corresponds to the demand placed by economic activity on biosphere (measured by the area of land and water required to produce resources and absorb waste), given the state of technology and resource management. To ensure international comparability, ecological footprint is expressed in units of world-average biocapacity area referred to as global hectares (Borucke et al, 2013). The sustainable level of ecological footprint was estimated to be 1.8 global hectares in 2007.

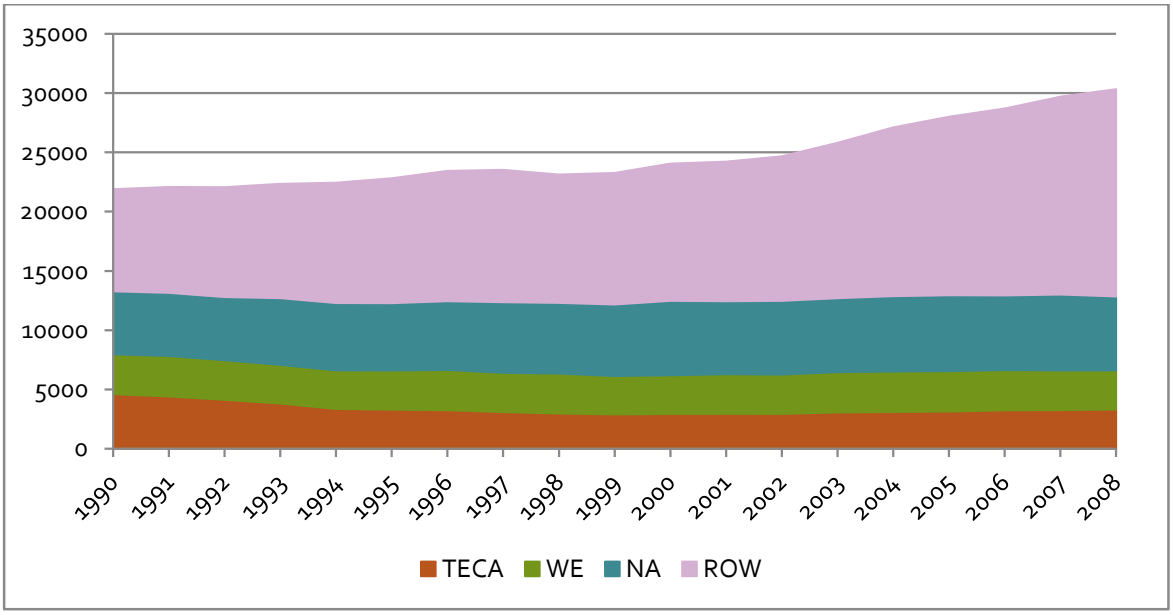
Figure 3. shows that countries with a high level of human development have unsustainable levels of resource usage. And vice versa, countries with environmentally sustainable levels of resource usage (Albania, Azerbaijan, Armenia, Georgia, Kyrgyzstan, Moldova, Tajikistan and Uzbekistan) have not yet reached a high level of human development and are likely to generate heavier carbon footprints as their per capita income and consumption levels increase over time. A similar result could be obtained with alternative measures of sustainability such as carbon dioxide emissions or material consumption per capita (see UNIDO, 2012).

FIGURE 1. TERRITORIAL CO_2 EMISSIONS BY REGION, MILLION TONNES



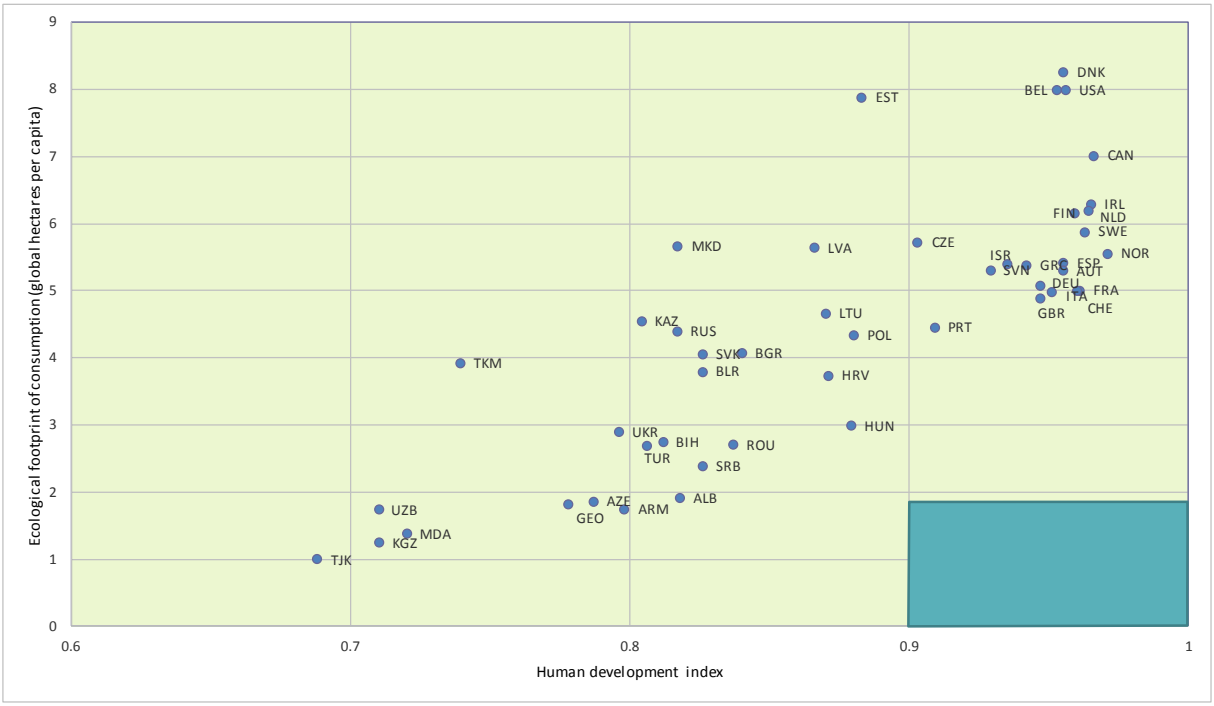
Note: TECA = Transition economies in Europe and Central Asia, WE = Western Europe, NA = North America, ROW = Rest of world.
Source: UNECE calculations.

FIGURE 2. TERRITORIAL CO_2 EMISSIONS BY REGION, PERCENTAGE SHARES



Note: TECA = Transition economies in Europe and Central Asia, WE = Western Europe, NA = North America, ROW = Rest of world.
Source: UNECE calculations.

FIGURE 3. THE ECOLOGICAL FOOTPRINT OF CONSUMPTION AND HUMAN DEVELOPMENT IN THE ECE MEMBER COUNTRIES, 2007



Source: Results from National Footprint Accounts 2010 edition, www.footprintnetwork.org. Extracted on October 13, 2010; UNDP (2009).

TABLE 1. CHANGE IN ANNUAL LEVELS OF CO_2 EMISSIONS, 1990 – 2008

Change in annual levels of CO2 emissions, 1990-2008				
Country	Territorial Emissions		Consumption Emissions	
	million tonnes	per cent	million tonnes	per cent
Eastern Europe, Caucasus and Central Asia				
Armenia	-1.1	-20.4	2.0	63.5
Azerbaijan	-21.3	-40.3	1.0	3.6
Belarus	-37.5	-35.9	5.0	8.2
Georgia	-2.9	-34.7	4.0	74.3
Kazakhstan	-51.2	-19.1	-73.0	-29.4
Kyrgyzstan	-3.5	-38.7	3.0	46.5
Moldova, Republic of	..	..	..	..
Russian Federation	-850.4	-34.8	-361.0	-21.5
Tajikistan	..	..	..	..
Turkmenistan	..	..	..	..
Ukraine	-262.1	-45.8	-146.0	-36.4
Uzbekistan	..	..	..	..
South-Eastern Europe				
Albania	-3.2	-42.3	-1.4	-20.7
Bosnia and Herzegovina				
Montenegro	..	..	..	..
Serbia	..	..	..	..
The former Yugoslav Republic of Macedonia	..	..	..	..
Turkey	147.0	100.6	117.1	55.6
EU 28				
Austria				
Belgium				
Bulgaria	-26.9	-35.0	-42.8	-45.0
Croatia	-2.0	-6.0	4.4	16.7
Cyprus	3.2	68.0	1.3	13.7
Czech Republic	-50.6	-30.9	-61.6	-37.7
Denmark				
Estonia	-11.1	-38.7	4.2	24.8
Finland				
France				
Germany				
Greece				
Hungary	-5.7	-9.1	4.2	5.6
Ireland				
Italy				
Latvia	-5.4	-41.9	7.2	100.8
Lithuania	-8.8	-37.2	-18.3	-48.3
Luxembourg				
Malta	0.3	13.2	3.5	126.9
Netherlands				
Poland	-17.6	-5.1	-64.1	-18.4
Portugal				
Romania	-69.4	-43.7	-74.5	-43.0
Slovakia	-16.2	-29.9	-10.1	-18.6
Slovenia	-2.1	-12.0	1.0	5.5

TABLE 1. CHANGE IN ANNUAL LEVELS OF CO_2 EMISSIONS, 1990 – 2008 *(continued)*

Change in annual levels of CO2 emissions, 1990-2008				
Country	Territorial Emissions		Consumption Emissions	
	million tonnes	per cent	million tonnes	per cent
EU 28 (*continued*)				
Spain	117.2	51.2	160.2	57.1
Sweden	-3.7	-7.2	-11.6	-12.7
United Kingdom	-28.1	-4.9	101.6	16.8
Other high income countries				
Canada	113.4	25.2	145.4	31.9
Iceland	..	..	..	..
Israel	..	..	..	..
Norway	8.7	27.7	2.5	3.7
Switzerland	-2.1	-5.0	8.0	8.0
United States	809.4	16.6	1215.1	24.6
.. - data not available				

Source: UNECE calculations based on G. Peters et al (2010).

HUMAN DEVELOPMENT INDEX

The level of human development is measured by a composite human development index (HDI), consisting of three components: the standard of living (measured by Gross National Income per capita), health status (measured by life expectancy at birth), and educational achievement (measured by years of schooling). More details on the measurement are provided in annual HDI reports of the UNDP.

The maximum value of the human development index is equal to one. A number of high-income countries have reached a high level of HDI that exceeds 0.9. Sustainable development is represented by the blue rectangle in Figure 3. The rectangle is empty, illustrating that no country in Europe, Central Asia and North America has been able to achieve high HDI and environmental sustainability. In fact no country in the world has been able to accomplish this feat yet.

GREEN GROWTH AND ENERGY EFFICIENCY

Sustainable development could be supported by a transformation of the traditional economic growth model into a green growth model that achieves high employment and equitable income distribution without an irreversible destruction of natural assets and biodiversity (UNECE, 2012a). The concept of green growth assumes that economic growth objectives can be reconciled with distributional and environmental objectives. Green growth can be viewed as one of the mechanisms for achieving objectives of sustainable development (OECD, 2012).

Is the green growth model feasible? Yes, providing that energy efficiency can be improved in a major way. The energy sector accounts for about two-thirds of CO_2 and other GHG emissions. Energy is essential for economic development and for improving the quality of life. Ensuring sufficient, reliable and environmentally responsible supplies of energy is a major challenge for the countries of Europe and Central Asia and globally.

The global population will rise from 7 billion today to 9 billion by 2050. It will be necessary to reduce greenhouse gas emissions by 50 per cent to avert a climate change disaster while supporting economic development with the aid of secure, affordable, and sustainable energy supply. Improving energy efficiency from source to use is key to meeting this challenge.

The relatively low ecological footprint of lower income economies of transition economies in Europe and Central Asia reflects mainly low levels of consumption and in some cases (e.g. Kyrgyzstan and Tajikistan) also the high share of hydropower (a low-carbon technology) in energy supply. The energy use per unit of production tends to be comparatively high in a number of economies, which implies that their transition to higher levels of income and consumption would be environmentally unsustainable unless energy efficiency improves in a major way. Table 2 shows the evolution of energy efficiency during the 1990-2010 time period. The remarkable progress of transition economies reflects both economic restructuring and improved production efficiency. Nevertheless, resource-rich transition economies in Eastern Europe and Central Asia are still among the most energy-intensive countries in the world.

TABLE 2. ENERGY USE (KG OIL EQUIVALENT) PER CAD 1,000 GDP (CONSTANT 2005 PPP CAD)

Energy use (kg oil equivalent) per $1,000 GDP (constant 2005 PPP $)					
Country	1990	1995	2000	2005	2010[a]
Eastern Europe, Caucasus and Central Asia					
Armenia	739.0	297.0	284.0	199.0	175.0
Azerbaijan	771.0	896.0	571.0	368.0	156.0
Belarus	695.0	578.0	425.0	322.0	243.0
Georgia	422.0	448.0	260.0	180.0	167.0
Kazakhstan	628.0	730.0	442.0	385.0	396.0
Kyrgyzstan	676.0	424.0	326.0	299.0	271.0
Moldova, Republic of	582.0	646.0	472.0	416.0	264.0
Russian Federation	470.0	547.0	491.0	384.0	335.0
Tajikistan	338.0	373.0	359.0	243.0	180.0
Turkmenistan	1428.0	1621.0	1388.0	819.0	572.0
Ukraine	602.0	816.0	736.0	543.0	435.0
Uzbekistan	1129.0	1278.0	1261.0	897.0	673.0
South-Eastern Europe					
Albania	207.0	117.0	120.0	119.0	72.0
Bosnia and Herzegovina	0.0	281.0	235.0	214.0	217.0
Montenegro	0.0	0.0	0.0	167.0	140.0
Serbia	220.0	311.0	272.0	253.0	208.0
The former Yugoslav Republic of Macedonia	156.0	199.0	184.0	185.0	153.0
Turkey	120.0	120.0	122.0	108.0	115.0

TABLE 2. ENERGY USE (KG OIL EQUIVALENT) PER CAD 1,000 GDP (CONSTANT 2005 PPP CAD) *(continued)*

Energy use (kg oil equivalent) per $1,000 GDP (constant 2005 PPP $)					
Country	1990	1995	2000	2005	2010[a]
EU 28					
Austria	126.0	122.0	112.0	123.0	111.0
Belgium	193.0	199.0	188.0	174.0	159.0
Bulgaria	435.0	402.0	321.0	262.0	202.0
Croatia	138.0	149.0	139.0	128.0	118.0
Cyprus	127.0	130.0	132.0	117.0	119.0
Czech Republic	293.0	257.0	236.0	215.0	178.0
Denmark	133.0	132.0	110.0	105.0	110.0
Estonia	622.0	448.0	313.0	232.0	247.0
Finland	246.0	258.0	228.0	212.0	211.0
France	158.0	157.0	147.0	145.0	137.0
Germany	171.0	148.0	135.0	132.0	121.0
Greece	122.0	121.0	122.0	112.0	99.0
Hungary	211.0	214.0	179.0	161.0	150.0
Ireland	156.0	132.0	108.0	89.0	93.0
Italy	109.0	111.0	109.0	111.0	104.0
Latvia	366.0	375.0	230.0	185.0	182.0
Lithuania	377.0	353.0	232.0	192.0	180.0
Luxembourg	209.0	159.0	123.0	137.0	121.0
Malta	143.0	112.0	84.0	102.0	87.0
Netherlands	167.0	161.0	136.0	138.0	136.0
Poland	331.0	286.0	197.0	176.0	154.0
Portugal	104.0	115.0	114.0	117.0	102.0
Romania	342.0	283.0	236.0	189.0	148.0
Slovakia	317.0	306.0	259.0	216.0	158.0
Slovenia	174.0	191.0	163.0	155.0	138.0
Spain	117.0	122.0	121.0	119.0	103.0
Sweden	224.0	231.0	184.0	175.0	160.0
United Kingdom	160.0	155.0	130.0	113.0	101.0
Other high income countries					
Canada	279.0	283.0	252.0	240.0	212.0
Iceland	320.0	340.0	369.0	336.0	514.0
Israel	138.0	136.0	125.0	125.0	110.0
Norway	153.0	142.0	131.0	122.0	135.0
Switzerland	108.0	107.0	100.0	97.0	89.0
United States	240.0	229.0	204.0	184.0	171.0

[a] 2010 or latest year available.

Note: Energy use per GDP (Constant 2005 PPP $) is the kilogram of oil equivalent of energy use per gross domestic product converted to 2005 constant international dollars using purchasing power parity rates. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.
Source: UNECE Regional MDG Database.

CLIMATE CHANGE ADAPTATION AND MITIGATION

CLIMATE CHANGE IMPACTS

Global climate change and associated extreme weather events are bound to affect a number of goods-producing industries (such as agriculture, construction, energy and water utilities) as well as services (such as health, transport and tourism) and urban areas with large populations and infrastructure networks. In a few comparatively cold countries such as Canada or Russia the beneficial effects of rising average temperatures may exceed adverse effects of climate change. However, in most countries negative impacts tend to predominate (UNECE, 2012a). The available projections of local and regional climate changes imply that such impacts are likely to be considerable.

National reports on the implementation of the UN Framework Convention on Climate Change show that countries of transition economies in Europe and Central Asia are already experiencing serious climate change consequences, including warmer temperatures and a higher frequency of extreme weather events such as heat waves and floods. E.g. in 2010, a heat wave in Russia may have caused more than 50,000 deaths. In 2012, droughts destroyed over 50 percent of crops in Kazakhstan, 25 percent in Russia, and 20 percent in Ukraine. In 2013, extreme floods caused widespread damage in the Czech Republic and Russia. These weather events may well reflect adverse impacts of climate change and are expected to occur more frequently in the future. Within the region, countries of the Caucasus and Central Asia are particularly vulnerable to climate change effects (World Bank, 2009). At the same time the adaptive capacity and readiness to improve climate resilience tend to be weaker in these countries than in high-income economies.

CLIMATE POLICIES

Given the potentially devastating impacts of climate change, an interesting question is whether policy responses should focus on a mitigation of its rate and magnitude by reducing carbon emissions of economic activity or an adaptation to its inevitable consequences (e.g. by enhancing the resilience to extreme draught, heat waves and other adverse weather impacts). Climate change mitigation policies aim to reduce greenhouse gas emissions of economic activity. Climate change adaptation policies aim to enhance the capacity to cope with the effects of climate change.

Most studies conclude that the global cost of mitigating climate change is significantly lower than the cost of adapting to higher temperatures and extreme weather events (Shelburne, 2009). Nevertheless, there seems to be a growing consensus in the countries of transition economies in Europe and Central Asia that preventative actions including both mitigation and adaptation measures must be undertaken sooner rather than later because delays are bound to escalate the costs (UNECE, 2012a).

ADAPTATION MEASURES

How does one adapt to climate change? One option is to do nothing until the impacts of climate change materialize and then rely on standard disaster management. Another option is to anticipate such impacts and prepare for them with a view to reducing costs of climate disasters in the future. Figure 4 illustrates stages of a forward-looking adaptation process.

Adaptation measures aim to improve the climate resilience of infrastructure and preparedness for extreme weather events. An interesting example of adaptation measures is provided by the disaster risk-reduction activities undertaken in the Caucasus and Central Asia (Box 1).

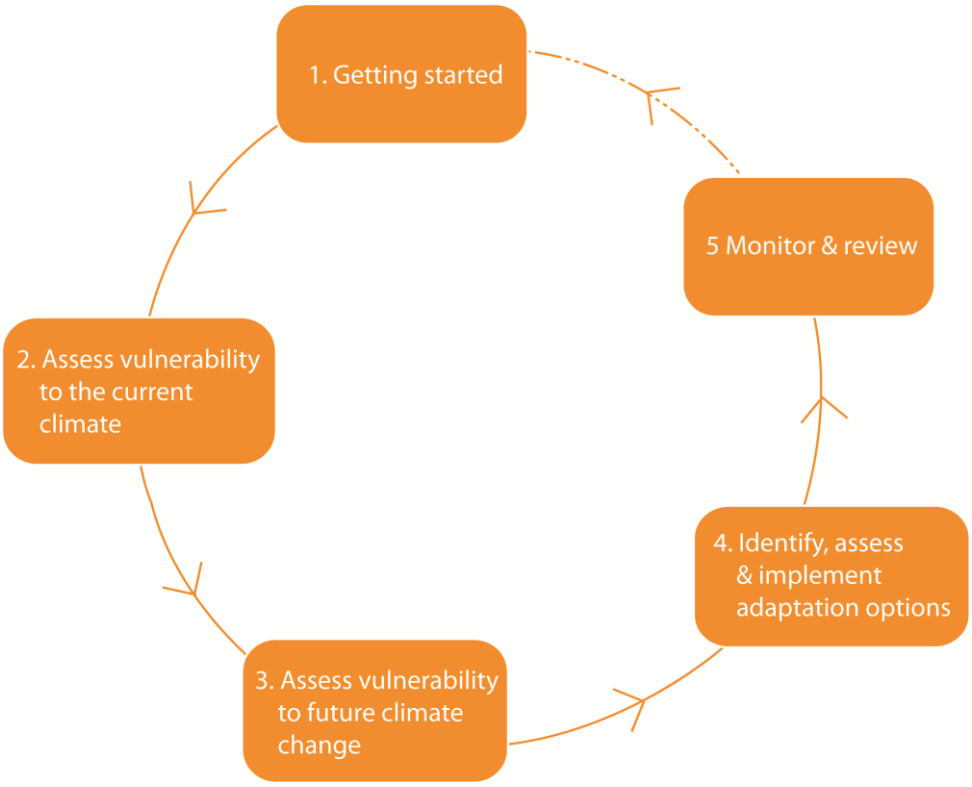
BOX 1. SUPPORTING DISASTER RISK REDUCTION IN THE CAUCASUS AND CENTRAL ASIA

The governments of Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan are implementing disaster risk reduction and disaster preparedness activities at schools. These activities focus on vulnerable communities and institutions, and include:

- Addressing of needs and concerns of children while promoting a culture of safety;
- Strengthening capacities of local and national authorities in disaster preparedness and risk reduction;
- Identification and dissemination of good practices to all disaster risk reduction stakeholders;
- Incorporation of elements of disaster preparedness and risk reduction into education policies and strategies; and
- Improved ability of schools and preschools to undertake disaster preparedness and risk reduction.

Adapted from UNECE (2012a)

FIGURE 4. STAGES OF THE CLIMATE ADAPTATION PROCESS



MITIGATION MEASURES

So far most climate policies and measures have aimed to mitigate climate change by reducing greenhouse gas emissions of economic activity. Despite ongoing mitigation efforts, carbon dioxide emissions from fossil fuel combustion are increasing, owing to investment in high-carbon infrastructure and increasing worldwide demand for energy and transport. These two sectors are responsible respectively for one-half and one-quarter of such emissions. At the same time, climate change impacts on energy networks and transport infrastructure have intensified, disrupting both local operations and global supply chains. Mitigation measures focus mainly on improvements in energy efficiency and fuel efficiency of motor vehicles. Despite a significant progress achieved by such measures, the total energy use and distance travelled by motor vehicles tend to increase more rapidly than efficiency improvements so that the volume of carbon emissions produced by energy and transport sectors continues to rise.

In the final analysis, production grows in response to effective demand for consumer goods and services. An inspection of Figure 3 implies the following question: why not improve sustainability by reducing consumption in high-income countries? Although some might prefer more leisure with less consumption to the opposite, it is extremely unlikely that a majority of people in these countries would be prepared to sacrifice their material standard of living for sustainable development (Georgescu-Roegen, 1976). It is also hard to see why most people living in low-income and middle-income countries would give up voluntarily their ambitions for higher living standards.

CLIMATE CHANGE SOLUTIONS

Mitigation measures are cheaper than adaptation measures. However, benefits of mitigation are likely to materialize only in the long term and at the global level. By contrast, benefits of adaptation usually materialize in the short run or medium term at the local or regional level. This poses a problem because there are obvious incentives to renege on mitigation commitments. From a selfish local or national point of view, it would make sense to spend little on climate mitigation (while benefiting from mitigating actions of others) and invest more in adaptation with the aim to reducing negative local effects of climate change or taking advantage of positive effects (if any). Given the predominantly local nature of competitive politics, the reluctance of voters (and taxpayers) to finance measures that may benefit mainly other countries is understandable.

One possible solution to this free-riding problem is provided by international cooperation in the UN framework. In spite of diverse national interests, governments agreed at the Rio+20 conference in 2012 on a process leading towards the adoption of sustainable development goals that would become part of the UN post-2015 development agenda. The ongoing negotiations may well result in a balanced package of measures that strengthen the existing climate mitigation and adaptation pledges from UN member States and ensure increased accountability.

Even though the eradication of extreme poverty, better education, lower fertility and changing social norms may eventually reduce demand for consumer goods and services, for the time being climate change solutions will have to rely mainly on low-carbon innovations that reduce harmful environmental effects of production and consumption activities. Otherwise it is hard to see how sustainable development could be achieved by any country in the foreseeable future.

INVENTION, INNOVATION AND DIFFUSION OF INNOVATIONS

FROM INVENTION TO INNOVATION

Classical economists such as Adam Smith in the 18th century and Karl Marx in the 19th century analyzed carefully business practices and changing production technology in various stages of industrialization. This tradition was further developed in the first half of the 20th century by Joseph Schumpeter, an Austrian economist who spent the final 18 years of his professional career at Harvard University. Schumpeter viewed new products and processes as the principal source of business cycles and introduced a useful analytical distinction between invention, innovation and diffusion of innovations.

Inventions (novel ideas or models) are generated in a more or less systematic pursuit of knowledge (technology) by various actors (university scientists, researchers in government or private laboratories, independent inventors acting on their own). A large number of inventions get patented every year and most of them never find any commercial use. Innovations are commercially viable applications of inventions, adopted by firms, households or governments. Innovations include product innovations (e.g. a smart phone), process innovations (e.g. a new manufacturing method), marketing innovations (e.g. internet advertising), and organizational innovations (e.g. team work systems). The diffusion of innovations throughout the economy is key for productivity growth and competitiveness. The capacity to absorb up-to-date knowledge and adapt imported technologies is essential for a transition of emerging market economies to innovation-based systems (UNECE, 2007).

THE ORIGINS AND EVOLUTION OF INNOVATIONS

While recognizing the importance of pioneering entrepreneurs for economic development, Schumpeter advanced a bold hypothesis that saw large firms with strong research and development (R&D) capabilities as the principal source of dynamic innovations and technical progress in capitalist economies. This hypothesis remains controversial until today because empirical evidence is rather inconclusive. Many major innovations were undoubtedly produced by large firms. For instance, successful innovations of Bell Labs in the United States include the transistor (late 1940s), solar cells (early 1950s), digital transmission of voice signals and communications satellites (early 1960s), mobile telephony (early 1970s), and digital signal processor (late 1970s). However, major innovations were also introduced by small start-ups created by enthusiastic young entrepreneurs. For instance, the microelectronic revolution was unleashed by Microsoft (Bill Gates and Paul Allen) and Apple (Steve Jobs and Steve Wozniak) in the mid-1970s and early 1980s.

Moreover, the overwhelming majority of inventions and innovations are incremental rather than fundamental and often take place during the diffusion process. Such incremental improvements can be discovered by large firms as well as small and medium-sized enterprises (SMEs). To understand the difference between fundamental and incremental innovations, picture technology as a large book of technical recipes. Fundamental innovations add new chapters to the recipe book. Incremental innovations entail small variations of existing recipes.

The evolution of diverse species of innovation is likely to be characterized by the continued dominance of incremental improvements. However, business leaders in 25 major economies expect that the following types of innovation will become increasingly important for the performance of their firms (Table 3):

- The development of new business models;
- The development of more sustainable processes, products or services;
- The development of entirely new products or services; and
- The development of new customer services.

TABLE 3. BUSINESS EXPECTATIONS OF INNOVATION TENDENCIES

What kind of innovations will/have contribute(d) the most to your company's performance?	In the past	Going forward	Change
The improvement of existing products or services	83 per cent	79 per cent	-4pts
The development of entirely new products or services	63 per cent	66 per cent	+3pts
The development of new business processes to improve profitability	61 per cent	63 per cent	+2pts
The development of more affordable new products and services	56 per cent	56 per cent	0
The development or improvement of products customized to local needs	55 per cent	53 per cent	-2pts
The development of new business models	46 per cent	52 per cent	+6pts
The development of more sustainable processes, products or services	44 per cent	48 per cent	+4pts
The development of new customer services	39 per cent	42 per cent	+3pts

Note: Based on responses of more than 3,000 executives from 25 countries.
Source: GE Global Innovation Barometer, January 2013, (http://files.publicaffairs.geblogs.com/files/2013/02/2013-GE-Global-Innovation-Barometer- -Results-Summary-3.pdf).

CAPACITY FOR KNOWLEDGE GENERATION, ABSORPTION AND DIFFUSION

The capacity for knowledge generation is clearly superior in advanced industrialized countries with excellent private and public research universities, laboratories and institutes that attract best domestic and foreign talent. Although the discovery of new technology is extremely important for knowledge-based competitiveness, it does not guarantee success in a globalized competitive economy. Even business firms with strong research departments can lose market share or even go bankrupt (e.g. General Motors or Kodak).

The capacity to absorb advanced technology and diffuse it throughout the economy is essential for competitiveness. It provides an opportunity for emerging economies to catch up to higher productivity and income levels of leading industrialized countries while their firms become increasingly integrated in global supply chains. The obvious example of a successful catch-up story is provided by the Republic of Korea although a number of transition economies in Europe and Central Asia have been also catching up since the late1990s.

In transition economies, technology transfer through the acquisition of patents, licenses and investment (both domestic and foreign) plays an important role in the catch-up process. It is important to note that the development of basic and specialized skills is needed for a successful absorption of advanced technology from abroad. In turn, the

diffusion of innovations depends on incentives of businesses, consumers and public institutions for their adoption.

FOSTERING GREEN INNOVATION: LEADERS AND FOLLOWERS

Some experts predict that the emerging green economy will unleash a new low-carbon industrial revolution that will see huge changes in production and consumption patterns. According to them, emerging market economies, especially those in Eastern Europe and Central Asia, should participate fully in this revolution if they are not to be left behind (EBRD, 2011). Other experts are more circumspect and emphasize the questionable legacy of some low-carbon technologies (e.g. nuclear power generation) as well as physical laws that limit energy-efficiency improvements to a much greater extent than improvements in computing power or mobile telephony. Therefore, multiple small-scale green innovations are more likely than major breakthroughs (Joint Project, 2009).

To date green innovations have not unleashed a self-sustaining and cost-reducing technical progress comparable to the ICT revolution (OECD, 2011). For instance, most innovative technologies for renewable energy generation could not survive in the market without massive government subsidies. However, this may change in the future as new and cheaper green products and processes become available.

Be that as it may, green innovations (also known as eco-innovations) are likely to be important for the success of the oft-invoked diversification of transition economies. Although a number of green innovations have been adopted successfully by business firms in high-income countries, such investments are seldom undertaken in less advanced transition economies for many reasons, including outdated regulatory frameworks, environmentally harmful subsidies, weak property rights, financing constraints, and weak competition (OECD, 2012).

WHAT CAN GOVERNMENTS DO TO SUPPORT ECO-INNOVATION?

Governments can support eco-innovation by funding research, providing grants for innovative start-ups, increasing demand for green technologies and improving the environment for doing business. Such policies will have to be coordinated across multiple domains to ensure the mainstreaming of sustainable development concerns in a variety of policy fields. The first step consists of developing a coherent national innovation programme or strategy that targets sustainable development. In this respect, Kazakhstan provides an example of good practice (Box 2).

BOX 2. THE STATE PROGRAMME FOR ACCELERATED INNOVATIVE INDUSTRIAL DEVELOPMENT

The State Programme for Accelerated Innovative Industrial Development of Kazakhstan for the 2010-2014 period specifies a number of investment priorities with a view to ensuring sustainable economic development through diversification and improved competitiveness. The Programme is embedded in the national Strategy for Industrial and Innovative Development (2003-2015) that targets sustainable development and transition to a diversified knowledge-based economy.

Adapted from UNECE (2012b)

Given the uncertainty about the nature of technological progress and innovation in the foreseeable future, it would be risky for governments and public authorities to

gamble on specific technologies for climate change adaptation and mitigation. Instead government and the business sector should complement one another. This is best done if governments create a framework that enables the business sector to deploy its technology, managerial know-how and finance to full capacity. Under the right framework conditions, innovative firms and investors will be in a position to produce the services needed by government and society effectively and efficiently. These ideas will be further elaborated in subsequent modules.

SUMMARY

1. Global emissions of greenhouse gases keep increasing and threaten to accelerate climate change with adverse effects on most countries. Emission trends are illustrated in Figures 1 and 2, and Table 1. Related energy efficiency trends are shown in Table 2.

2. Sustainable development implies sustainable consumption and a high level of human development. Figure 3 shows that no country achieved sustainable development to date. A transition from the industrial growth model to a green growth model can contribute to sustainable development.

3. Climate change mitigation can be achieved by measures that reduce greenhouse gas emissions. Climate change adaptation entails measures that improve climate resilience. Stages of the climate change adaptation process are illustrated in Figure 3.

4. The pursuit of knowledge results in inventions consisting of novel ideas or models. Some inventions find commercial use and become innovations. Innovations include new or improved products, processes, marketing methods or organizational forms. Most innovations are incremental improvements of existing technologies. Table 3 shows the future innovation trends expected by business leaders.

5. Green innovations or eco-innovations are less environmentally harmful than available alternatives. Advanced industrialized countries have generated and adopted green innovations extensively. Transition economies lag in this area due to a number of barriers to the absorption and diffusion of such innovations. Such barriers can be overcome with the aid of coherent policies that support eco-innovation.

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GLOSSARY

Climate change refers to a persistent change in the mean and/or the variability of climate properties.

Climate change adaptation refers to the adoption of policies and practices to prepare for the effects of climate change.

Climate change mitigation refers to the adoption of policies and practices that reduce greenhouse gas emissions of economic activity.

Diffusion of innovations refers to the way in which innovations spread, through market or non-market channels, to different consumers, countries, regions, sectors and firms.

Eco-innovation is an innovation whose use is less environmentally harmful than its alternatives.

Green innovation is an innovation whose use is less environmentally harmful than its alternatives.

Green growth is a type of economic growth that avoids unsustainable pressure on the quality and quantity of natural assets while achieving high employment and equitable income distribution.

Greenhouse gases refer to carbon dioxide, nitrous oxide, methane, ozone and chloro-fluorocarbons occurring naturally and resulting from human activities, and contributing to the greenhouse effect (global warming).

Human development index is a statistical tool used to measure a country's overall economic and social progress. The index value is determined by a weighted sum of the standard of living, health status, and educational achievement.

Innovation refers to new or significantly improved products, processes, marketing methods or organizational methods.

Invention refers to a new scientific or technical idea and the means of its embodiment or accomplishment. Most inventions are not economically feasible.

Small and medium-sized enterprises are independent firms with no more than 250 employees.

Technology refers to the state of technical knowledge.

Sustainable development is a process is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains two key concepts: the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

ADDITIONAL RESOURCES

The UK Climate Impacts Programme or UKCIP was established by the British government in 1997 with a view to supporting adaptation to the unavoidable impacts of a changing climate. UKCIP is based at the Environmental Change Institute at the University of Oxford and provides interesting materials pertaining to climate change adaptation without charge. These materials include climate adaptation news, case studies, tools and resources that can be accessed at http://www.ukcip.org.uk/.

A useful tool that can be downloaded at the same address is the UKCIP Adaptation Wizard that assists organizations with adapting to climate change through a 5-step process that has been introduced in figure 3. in an earlier part of this module. Look at the case studies of adaptations performed with the aid of the Wizard at http://www.ukcip.org.uk/wizard/wizard-case-studies/ and consider object lessons for your own country or organization.

QUESTIONS FOR DISCUSSION AND MULTIPLE CHOICE TEST

QUESTIONS FOR DISCUSSION

1. Would a green growth model be beneficial to your country? Who would be the potential winners and losers?

.....

.....

2. Consider the expected impacts of climate change in your country. Are negative impacts likely to be greater than positive impacts?

.....

.....

3. People adapted to climate change in the past mainly by migration. Do you think that there are better adaptation options available to people affected by warmer and more variable weather in your country? If so, what are they?

.....

.....

MULTIPLE CHOICE TEST

Check the best answer. *(Correct answers can be found on page 144)*

QUESTION 1

Sustainable development includes the following dimensions:

A. Economic dimension.

B. Environmental dimension.

C. Social dimension.

D. All of the above. Your answer:.....

QUESTION 2

Which of the following countries have reached sustainable development?

A. All 28 Member States of the European Union.

B. France, Germany and the Netherlands.

C. Kyrgyzstan and Tajikistan.

D. None. Your answer:.....

QUESTION 3

Figure 3 shows that in 2007 the level of consumption was environmentally sustainable in:

A. Kazakhstan.

B. Tajikistan.

C. Turkmenistan.

D. All of the above. Your answer:.....

QUESTION 4

The human development index is influenced by:

A. Per capita national income.

B. Level of education.

C. Life expectancy at birth.

D. All of the above. Your answer:.....

QUESTION 5

Effects of climate change mitigation policies are predominantly:

A. Local or regional.

B. National.

C. Global.

D. None of the above. Your answer:.....

QUESTION 6

Effects of climate change adaptation policies are predominantly:

A. Local or regional.

B. National.

C. Global.

D. None of the above. Your answer:.....

QUESTION 7

Climate change mitigation policies aim to:

A. Reduce greenhouse gas emissions.

B. Address local impacts of climate change.

C. Improve the distribution of national income.

D. All of the above. Your answer:.....

QUESTION 8

Climate change adaptation policies aim to:

A. Address impacts of climate change.

B. Improve climate mitigation technologies.

C. Reduce consumption levels.

D. None of the above. Your answer:.....

QUESTION 9

Innovations include:

A. Product innovations.

B. Process innovations.

C. Organizational innovations.

D. All of the above. Your answer:.....

QUESTION 10

The green growth model …

A. … is based on the assumption that economic growth objectives can be reconciled with equitable income distribution and environmental sustainability.

B. … can help achieve sustainable development.

C. Both A and B.

D. None of the above. Your answer:.....