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Global Tracking Framework: UNECE Progress in Sustainable Energy

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Foreword

The attainment of sustainable energy targets is not on track either globally or in the UNECE region. Unless there is a significant acceleration of efforts and outcomes to ensure quality access to energy that is affordable and that meets the environmental, social, and economic imperatives of the 2030 development agenda, the world will fall short of its ambitions and its commitments. These are the blunt conclusions of the 2017 Global Tracking Framework report prepared by the World Bank and the International Energy Agency with the support of a host of organizations and UN agencies including the regional commissions. The Economic Commission for Europe has prepared this report to provide more detail and background for the parent report, and it lays out a number of stark conclusions.

A holistic approach must be adopted to ensure a sustainable energy future that reconciles a tight emissions pathway with development by exploring synergies and partnerships between low and no carbon alternatives and traditional fuels in terms of technology, policies, market structure, and best practices. Framework conditions are needed to mobilize investments that align with the objectives of the 2030 agenda and that enable the needed transition. Rational economics and systemic improvements in efficiency throughout the energy chains lie at the heart of the sustainable energy agenda.

Decision-makers will be better informed with a broader range of forward-looking indicators that cut across the 2030 agenda for sustainable development from an energy perspective. Sustainable Development Goal No. 7 is the energy goal, but energy is intrinsically linked to the success of many other goals, and progress needs to be tracked across all energy-related goals. UNECE has cooperated with our sister regional commissions to prepare these analyses for our respective regions as a complement to the global report.

With the energy issues and country responses presented in this report, it becomes clear, that there is not a single pathway to the future energy system. Each country has its own starting point and a distinct set of options for how to proceed. It is essential for countries to explore their options, to consider collectively how the objectives of energy for sustainable development might be achieved, and to establish an early warning system of signposts to send an alert if the objectives are not being met. This report is a first step in that process, and a first alert has been issued.

Olga Algayerova

Executive Secretary

United Nations Economic Commission for Europe

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I. INTRODUCTION

In 2017 the third edition of the Global Tracking Framework (2017 GTF) was published with the intent to provide the international community with an assessment of progress on the three pillars of sustainable energy: energy access, energy efficiency, and renewable energy. The findings in the report clearly portrayed that the pace of progress on sustainable energy is falling well short of what is needed to meet global objectives by 2030.

Part 2 of 2017 GTF provided regional analyses of progress on sustainable energy. The five geographical regions in the report were aligned to the five United Nations (UN) Regional Commissions (RCs): the Africa region (UN Economic Commission for Africa – ECA); the Western Asia/North Africa region (UN Economic and Social Commission for West Asia - ESCWA); the Asia–Pacific region (UN Economic and Social Commission for Asia and the Pacific - ESCAP); the Europe, North America, and Central Asia region (UN Economic Commission for Europe - UNECE); and the Latin America and Caribbean region (UN Economic Commission for Latin America and the Caribbean - ECLAC). Part 2 was designed to delve into regional trends that explain the global results and to highlight individual country experiences. Part 2 was prepared in collaboration with the UN RCs.

This document has been prepared by UNECE as a complement to Part 2 of 2017 GTF. Its intent is to explore the findings of the main GTF report, to consider alternative data sources that may offer further insights, and to reflect on alternative indicators for a more robust assessment of progress toward energy for sustainable development. The report attempts to establish a systematic perspective on the energy system in the UNECE region to highlight the interconnections among demand, supply and extraction and the policies and pricing mechanisms that shape their ability to deliver society's energy needs sustainably. The underlying logic of this perspective is that people's needs for comfort, health, shelter, mobility and the like lead to demand for energy services that help meet those needs. The demand for energy services by consumers in turn drives energy system value chains through to development of primary energy resources. Regardless of energy system paradigms, prices or policies, the electrons in the electricity system, cubic meters of gas in pipelines, oil in tankers and coal output from mines have been produced in response to consumer demand.

There are further opportunities for improved capital and operational efficiencies through better application of energy efficiency and renewable energy throughout the energy system but especially at end-use where consumer utility can be improved and energy poverty addressed with economic investments in energy efficiency and renewable energy. There are equally opportunities to reducing the carbon footprint of fossil fuel based energy to master the transition towards a sustainable energy system of the future. These opportunities include policy options such as energy subsidies and a price on carbon, as well as technology< solutions along the fossil fuels value chain to improve greenhouse emission management.

The challenge faced by all governments is in understanding which options and policy choices can deliver improved sustainability and improved consumer utility, productivity and economic resilience. This report explores the issues, potentials, and successful applications of policies and prospects across the energy value chain in order to highlight opportunities for action.

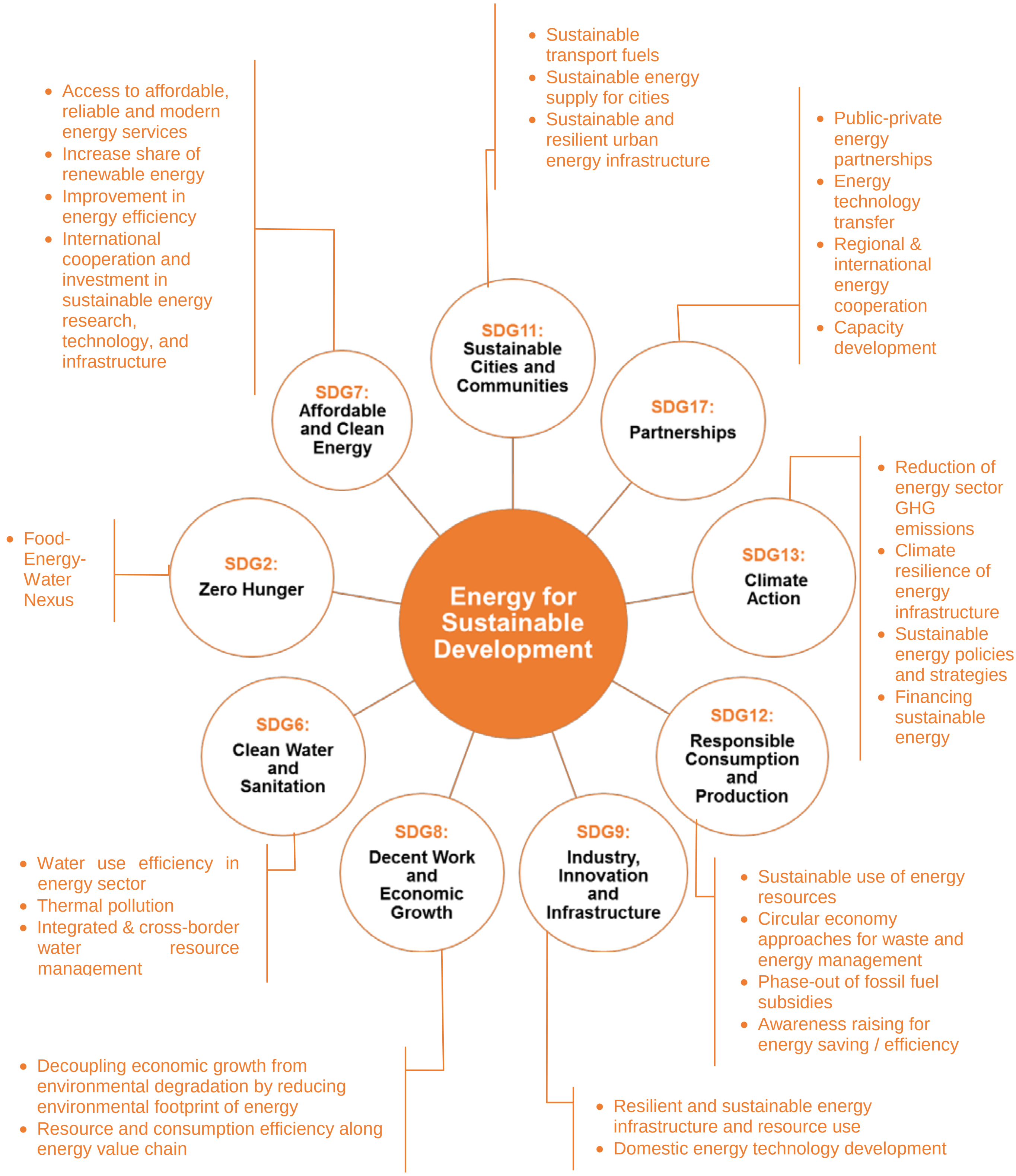
This report complements the 2017 GTF by extending beyond the current core indicators of progress to explore the status, potentials, and prospects for sustainable energy in the UNECE region. The first section briefly summarises the observations from 2017 GTF, then explores a range of perspectives on energy use and sustainability across the UNECE region. While the scope of the report does not allow presentation of complete data for all proposed indicator categories, it is meant to demonstrate that a broader perspective on energy for sustainable development can be useful to measure success and point out challenges for the diverse UNECE membership.

1.1. The Sustainable Development Agenda

On 1 January 2016, the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development (2030 Agenda) officially came into force. The SDGs call for action by all countries to promote prosperity while protecting the planet. They recognize that ending poverty must go hand-in-hand with strategies that grow economies, address the range of social needs, and tackle climate change and environmental protection.

If the world is to develop sustainably, it will be necessary to ensure access to affordable, reliable, sustainable, and modern energy services, as set forth in SDG7, while reducing greenhouse gas (GHG) emissions and the carbon footprint of the energy sector. Energy is the golden thread that weaves throughout the 2030 Agenda and is at the core of meeting the world's quality of life aspirations. The 2030 Agenda represents an imperative for profound and immediate changes in how energy is produced, transformed, traded, and consumed. Unfortunately, the rate of improvement in energy efficiency, of deployment of net low carbon energy solutions, and of provision of sustainable access to modern energy services are insufficient. Energy's contribution to the 2030 Agenda will falter in the absence of concrete measures to improve energy productivity, rationalize energy use, optimize energy resources, and deploy both new energy technology and sustainable energy infrastructure. Figure 1.1 shows a mapping of the energy-related SDGs.

Figure 1.1: Mapping of Energy-Related Sustainable Development Goals.



1.2. UNECE Region Overview

The UNECE region comprises 56 countries with a total population in 2015 of 1.3 billion, representing 18% of the world's population[1]. UNECE subregions[2] include North America, Western and Central Europe, Southeast Europe, Eastern Europe, Caucasus and Central Asia, the Russian Federation, and Turkey and Israel (Figure 1.2).

Figure 1.2: Map of 56 UNECE member States.

Caucasus
Azerbaijan, Armenia, Georgia
Central Asia
Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan
Turkey
Eastern Europe
Belarus, Republic of Moldova, Ukraine
Israel
North America
Canada, United States of America
Russian Federation
Southeast Europe
Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Montenegro, Romania, Serbia, The former Yugoslav Republic of Macedonia
Western and Central Europe
Andorra, Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands, Norway, Poland, Portugal, San Marino, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom of Great Britain and Northern Ireland

The region is diverse, with high and low-income nations, countries in economic transition, countries that are energy rich, and others with few indigenous energy resources. In 2014, the region accounted for 42% of the world's GDP[3], 40% of the world's total primary energy supply (TPES)[4], and 34% of the world's CO_2 emissions from fossil fuel combustion.[5]

The UNECE region has been shaped prominently by the reconstruction and development that followed World War II that drove the large scale infrastructure and technological development that persist in today's energy, industrial and transport systems. The development left a level of industrialisation and technological progress ahead of other regions, but nevertheless created enduring legacy systems.

Further influencing the region's energy systems are factors such as population density and per capita Gross Domestic Product (GDP). Almost half a billion (492 million) people live Western and Central Europe, with another 356 million people from North America. The remaining third of UNECE population resides largely in the Russian Federation (144 million) and Central Asia (including Turkey, 146 million). The smallest subregion in terms of population is Caucasus with 16 million, followed by Eastern Europe with 67 million.

Western and Central European countries Luxembourg (101,449 current USD), Switzerland (80,945), and Ireland (61,133) enjoy the highest per capita GDP, which is in stark contrast to the countries of Central Asia, Eastern Europe as well as Caucasus that feature much lower averages, including Tajikistan (926), Kyrgyzstan (1,103), and Moldova (1,848).

Population density figures (people per square km) also vary, with Iceland and Canada having the smallest density figures (3.3 and 3.9, respectively), and Monaco (18,865), Malta (1349), and San Marino (530) with the largest.

More complete socio-economic data for the region are presented in Annex I.

II. TRACKING SUSTAINABLE ENERGY PROGRESS IN UNECE

2.1. Overview

Tracking mechanisms like the GTF and the annual SDG reports measure progress towards the objectives of the 17 SDGs. The current pace of progress on the SDG7 targets (universal access to electricity, growth in the share of renewable energy and improvements in energy intensity) will not meet 2030 targets according to the 2017 GTF:

- The rate at which people are getting access to electricity is slowing**.** While UNECE officially has achieved 100% access to power networks, there remain significant quality and affordability issues to be addressed as well as access to other energy networks such as natural gas.
- It is estimated that annual renewable energy investments need to double or triple. Even though the UNECE region is the only region with an increasing share of renewable energy in TPES, subregions with low investment rates remain a challenge.
- Only energy intensity improvements have been progressing towards objectives, with global energy savings during the 2012-2014 GTF reporting period enough to supply Brazil and Pakistan combined. Nevertheless investments in improvements in energy efficiency will need to increase by a factor of 3 to 6.

The 2017 GTF results are a wake-up call for greater effort on a number of fronts, including increased financing, bolder policy commitments, and a willingness to embrace new technology on a wider scale.[6]

2.1.1. Energy for Sustainable Development

If the world is to develop sustainably, it will be necessary to secure access to affordable, reliable, sustainable, and modern energy services while reducing GHG emissions and the carbon footprint of the energy sector. Energy is a fundamental need as it provides the essential services of cooking, heating, cooling, lighting, mobility, and operation of appliances, information and communications technology (ICT), and machines in every sector of every country. Doctors use energy to provide healthcare services in clinics, it provides lighting for children to study, and when it is unavailable women (most often) are obliged to gathering wood to burn for cooking (which then degrades indoor air quality).

Energy is the common thread that weaves throughout the 2030 agenda, and it is at the core of meeting the world's quality of life aspirations. Energy was not included explicitly as one of the Millennium Development Goals but has assumed a prominent place in the 2030 agenda. SDG7 - the energy goal - aims to *ensure access to affordable, reliable, sustainable and modern energy for all*, and hereby importantly links sustainability in energy to the other 16 social, economic and environmental goals.

SDG7 has five targets[7]:

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services,

7.2 By 2030, increase substantially the share of renewable energy in the global energy mix,

7.3 By 2030, double the global rate of energy efficiency improvement,

7.A By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology,

7.B By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small-island developing States, and land-locked developing countries, in accordance with their respective programmes of support.

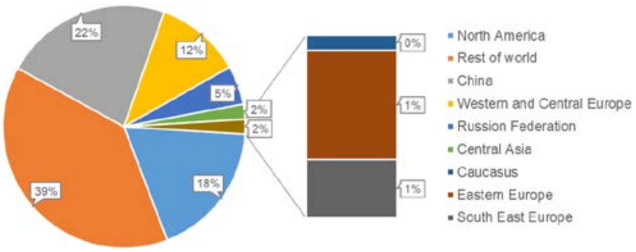
While these targets are central to energy's role in the 2030 Agenda, a broader perspective on the contribution energy will make to sustainable development is that international cooperation, availability of clean fossil fuel technology, investment, and the climate intensity of the energy sector play a role alongside energy efficiency, renewable energy and access. SDG7 enables attainment of the wider set of SDG goals with improved energy productivity, lesser emissions and sustainable access to energy services. Energy considerations are important for attainment of many of the SDGs (see figure 1.1 above). A wide set of energy indicators is needed to describe and track energy for sustainable development to paint a more complete picture of sustainable energy.

2.1.2. Energy in the UNECE Region

The following sub-chapters give an overview to the energy situation on national level, on energy trade and infrastructure, as well as existing energy cooperation.

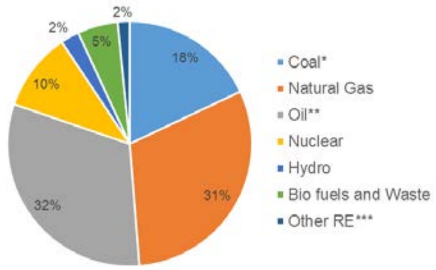
Figure 2.1 shows the balance of the UNECE subregions' [8] shares of global TPES compared to China and the rest of the world in 2014. The UNECE region utilizes 39% of TPES, with North America having the main share of 18% globally, followed by the 33 countries of Western and Central Europe with 12%.

Figure 2.1: UNECE Regional Shares of Global TPES (%, 2014).



Similar to the global value of 81%, the UNECE region's share of fossil fuels in TPES is 80%, from which 18% is coal, 31% natural gas (natural gas), and 32% oil. Figure 2.2 gives the overview of the full energy mix of the UNECE region.

Figure 2.2: UNECE Energy Mix (% of TPES, 2014).



*Includes Coal, peat and oil shale
** Includes Crude, NGL and feedstocks and secondary oil products
***Geothermal, solar/wind/other, heat, electricity

2.1.2.1. Regional Energy Trade, Infrastructure and Collaboration

The UNECE region includes some of the world's most significant energy exporting countries and some of the world's most significant energy trade routes. Each country's TPES, TPES/capita intensity, and energy own production is summarized in a table in Annex II. The own production index is calculated by dividing total energy production by TPES and is a simple indication of a countries energy balance ➔ below 1 is a net energy importer, above 1 is a net energy exporter.

As the analysis shows, the different UNECE subregions vary significantly between net energy importers and exporters. Azerbaijan's oil exports drive a high rate of 4.1, which is second highest for the whole UNECE region. Only Norway has a higher index value with 6.2, due to its high domestic use of hydro and significant oil exports. A summary of the countries with the highest and lowest own production index values in the UNECE subregions is provided below (Table 2.1).

Table 2.1: UNECE Regional Ranges for Own Production Indices.

2014	Southeast Europe	Caucasus	Central Asia	Eastern Europe	Western and Central Europe
Average	0.73	2.81	1.22	0.55	0.60
High	Albania (0.86)	Azerbaijan (4.10)	Turkmenistan (2.29)	Ukraine (0.73)	Norway (6.83)
Low	FYR of Macedonia (0.48)	Armenia (0.29)	Turkey (0.26)	Moldova (0.10)	Average Lowest 5 (0.11)

Figure 2.3 shows the development of the indices over the different UNECE-subregions from 1990-2014. A country with energy requirements that are declining (as a result of improving energy efficiency or economic restructuring) or energy production/exports that are rising (or both) will feature a rising own production index.

The subregions Eastern Europe, Western and Central Europe, and Southeast Europe are net energy importers. Over the past decade, North America has gradually increased its exports, so that it is expected to become a net exporter between now and 2025, mainly due to the reduction of petroleum liquid imports and the increase in natural gas exports.[9] The Russian Federation, and Central Asia subregion are net energy exporters. The Caucasus subregion became a net energy exporter in 1998, mainly driven by Azerbaijan's oil and gas exports. Georgia and Armenia have an index below 1.

Figure 2.3: Own Production Index for UNECE Subregions (1990-2014).

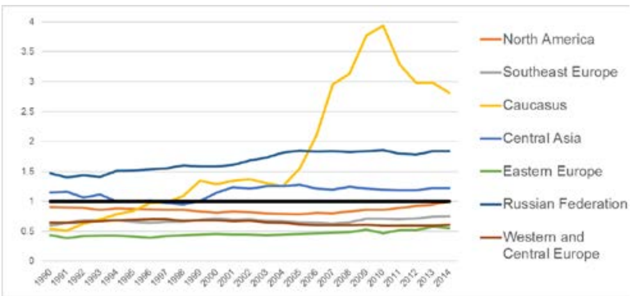
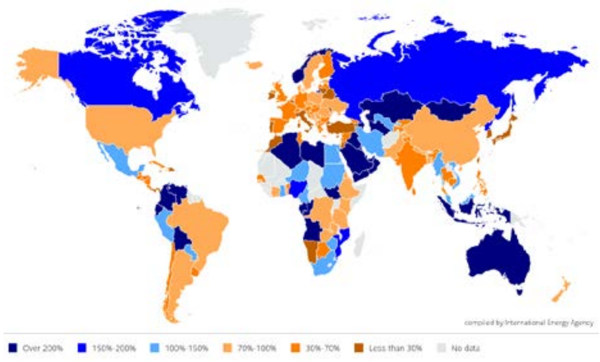


Figure 2.4 is a global map highlighting the own production index values. Countries with an index over 1 are shaded blue, while countries with an index below 1 are shaded orange.[10] Norway is the only exception among the countries of Western, Central, Eastern and Southeast Europe which are all net importers. Within Central Asia, Kyrgyzstan and Tajikistan are net importers, even though the subregion is overall an energy exporter.

Figure 2.4: National Own Production Index for UNECE Region (2014).

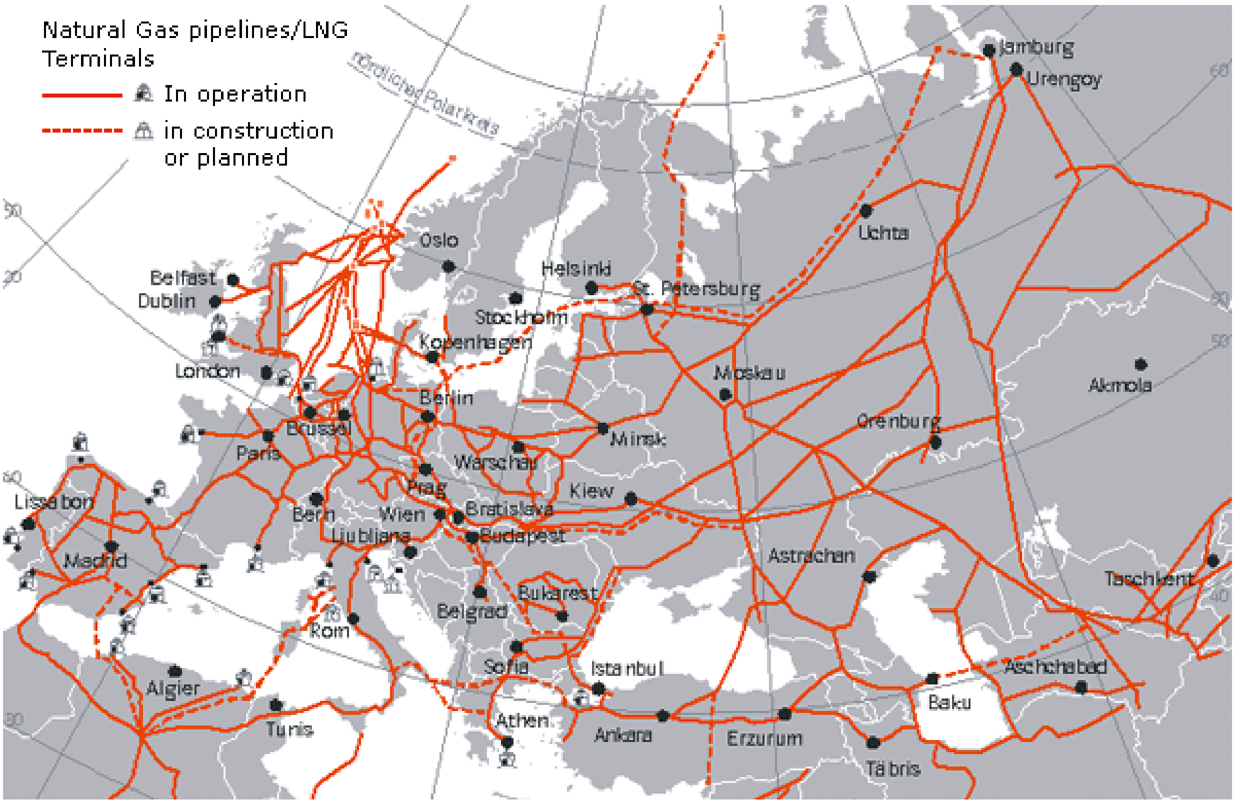


Source: IEA (2017c).

Regional Energy Infrastructure

UNECE member States feature a complex network of connected energy infrastructure and trade. Figure 2.5 shows the natural gas distribution system in Europe, including the gas trade infrastructure across the Caspian and Black Sea region. The map highlights the issues of trade routes that cross multiple borders, with significant flows of gas from Russia and Central Asia across the region to Europe. A similar density of infrastructure occurs to the North as the Yamal pipeline crosses Belarus from Russia through Poland. With growing energy trade with Asia, the energy infrastructure in the region is extending.

Figure 2.5: Natural Gas Distribution System in Europe including the Commonwealth of Independent States (CIS).



Sources: SManalysis (2009).

2.1.2.2. Critical Energy Issues for the UNECE Region

There is no common understanding in the UNECE region of what sustainable energy is or how to attain it. Divergent economic development, resource availability and energy mixes are embedded in today's national energy strategies. Each country sets its national energy strategy based on its perspectives on sustainable development, environmental protection, poverty alleviation, climate change mitigation, quality of life, and the like. As a consequence, multiple national approaches and outcomes can be found.

While many of the energy challenges in the region are similar to those elsewhere in the world, the region has specific climatic, economic, environmental and political circumstances and the implications are found in inefficient use of energy, power cuts, increasing energy costs, and unsustainable and unaffordable heating in winter. The region features universal household electrification in terms of physical access, but ageing infrastructure, a lack of supply diversity and increasing tariffs lead to poor power quality and, for some, energy poverty[11]. This situation is particularly acute during the cold winter months, and disproportionately affects poor and rural populations. Some consumers have reverted to local sources of solid fuels for cooking and heating, and others to electricity with off-grid diesel generators.

Many of the countries in the eastern part of the UNECE region have high carbon footprints due to a legacy of high energy intensity and energy inefficiency in industry and buildings. Energy losses from old infrastructure and dilapidated networks are significant. At present, some countries export large quantities of fossil fuels and feature some of the world's highest rates of energy intensity. Others struggle to provide reliable and affordable energy for their own citizens. Numerous market barriers, often linked to subsidised energy prices, impede the introduction of new, efficient energy technology. Lack of access to basic energy services and frequent disruption of power supply are of particular concern in Central Asia and the Caucasus.

Although the region as a whole has tremendous untapped potential for almost all forms of renewable energy, so far renewable energy sources contribute only a limited amount to TPES.

Key challenges for the region include:

- Energy security concerns impede improvements in technical, environmental, and economic efficiency, often by promoting energy independence or self-sufficiency instead of more efficient integration of energy markets.
- Fossil fuels dominate the region's energy mix and underpin today's energy access. The locked-in dependency on fossil fuels is neglected in conversations about energy efficiency and renewable energy, which slows attainment of objectives. Even under a climate change scenario that meets a 2° target, fossil energy will still represent 40% of the energy mix in 2050 and must be addressed whether through efficiency improvements or through emissions abatement.
- Certain options for improving the overall performance of today's energy system are excluded for reasons of public perception, politics, imposed market distortions, or legitimate but possibly solvable concerns of safety or environment (e.g., nuclear power, carbon, capture and storage (CCS), shale gas, natural gas in transport).
- Truly transforming the energy system will require a shift in policy and regulation to treat energy as a series of services rather than as a series of commodities. In many countries, the current political, regulatory, and industrial infrastructure is not ready for such a transformation.

2.2. SDG7 Pillars

The following sections present indicators and data for the three SDG7 pillars of energy efficiency, renewable energy, and energy access.[12] While indicators and data as presented in the 2017 GTF report are included in this presentation, further information beyond the core indicators of energy intensity, share of renewable energy in total final energy consumption (TFC)[13], physical electricity access and clean cooking fuels access is also provided. While the data from the 2017 GTF presented here focus on both the overall time period from 1990-2014 including an interpretation of the tracking period 2012-2014, other data are more recent or are presented in a different format. The intent is to enrich analysis of progress within these three pillars, and to initiate a discussion on a broader set of indicators to track energy for sustainable development across the 17 SDGs.

A summary of indicators used in the 2017 GTF, the UNECE Regional GTF, is provided in Annex V. The list is complemented by the recommendations from stakeholder consultations to provide the basis for further discussion on indicators to track energy for sustainable development.

2.2.1. Energy Efficiency

> *According to SE4forALL: "Energy efficiency can bring SDG7's renewable and access objectives within reach if energy consumption can be stabilised at current levels through efficiency gains".[14]*

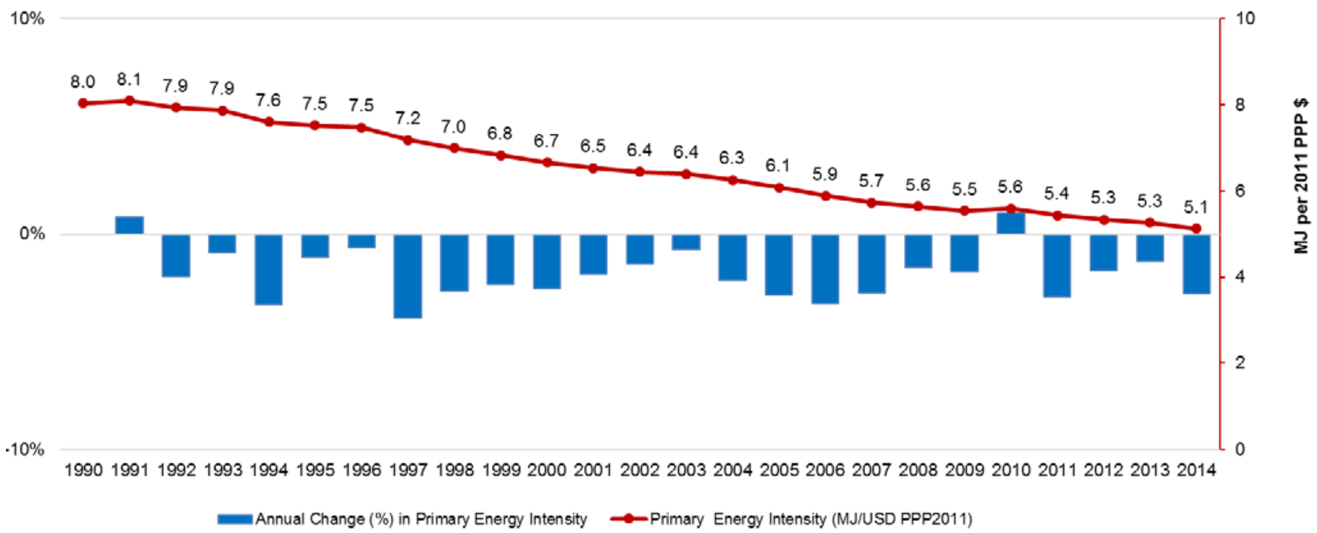
Energy intensity is often used as a proxy for energy efficiency. The two are not equivalent, and energy intensity in itself does not account for differing economic structures, resource bases, activity levels or climatic drivers for energy use. High energy intensity may directly result from a country extracting and exporting energy intensive mineral products in a cold climate (e.g., Canada, Sweden, or Russia), and low intensity from high levels of service industries (e.g., Switzerland). In neither case does energy intensity offer insight into the underlying energy efficiency of the economy, the historical development paths undertaken, and improvements in energy efficiency achieved, or the opportunities for further energy efficiency improvements.

Energy efficiency is a key component of energy productivity: reducing the energy required for economic output in the context of the capital, labour and other material resources in an economy improves energy productivity. That result is distinct from stopping an energy-intensive activity, though both outcomes would improve the energy intensity of an economy.

SDG7 Indicator: Energy Intensity

Energy intensity in the region has been improving since 1990. Over the period 1990-2014, primary energy intensity[15] declined at the fastest rate globally (1.9% compound annual growth rate (CAGR)), from 8.0 MJ/USD to 5.1 MJ/USD in 2014 (see Figure 2.6)[16]. From 2012 to 2014, the UNECE region avoided 3.9 exajoules (EJ) of TFC – corresponding to 33% of globally avoided energy globally, and nearly equivalent to the 2014 TFC of Spain and Czech Republic combined. The CAGR within the tracking period declined by -2.01%, almost equal to the global rate of 2.1% but short of the 2.6% needed over 2010-2030 to meet the SDG7 objectives.

Figure 2.6: Steady Improvement in UNECE Energy Intensity from 1990 to 2014.



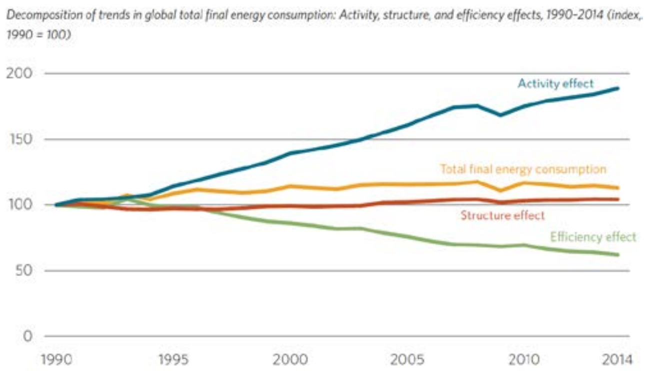
Energy intensity by economic sector

In the industrial sector, energy intensity declined continuously across all periods. Energy intensity in the agricultural sector also improved in recent years, dropping by 6.4% annually. Energy intensity in the services sector and the residential sectors dropped significantly in 2010-2012 before returning to more modest trends in 2012-2014.

Decomposition of energy end-use trends considers three main components over a given time period: activity change, sectoral structure shifts, and the energy efficiency improvements. In the UNECE region there has been a relative decoupling of energy consumption from GDP growth in the region, which began in the early 1990s, as GDP increased while energy demand remained stable (Figure 2.7).

There was little change in the region's aggregate economic structure, except for the countries of the former Soviet Union. These countries saw a substantial shift away from heavy industry to lighter industry, agribusiness and services. For example, Belarus' share of manufacturing in total GDP fell from 42% in 1991 to 32% in 2000, and 24% in 2014, similar to the Ukraine's which fell from 44% in 1992 to 19% in 2000.[17]

Figure 2.7: UNECE Region Achieved Relative Decoupling of Energy from GDP Growth.



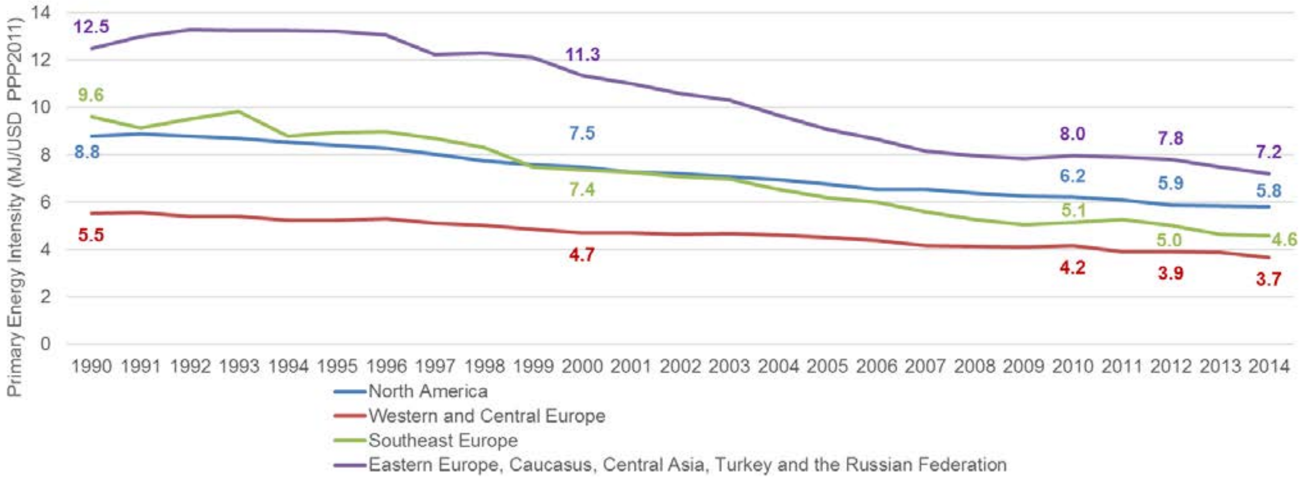
Source: World Bank et al. (2017).

Subregional Energy Intensity Trends[18]

Energy intensity has been declining in all subregions in the period 1990-2014, and the declines accelerated over the tracking period 2012-2014 except in North America (see figure 2.8 below) where the rate of decline slowed recently. There is a wide variance of energy intensities across the region from 18 MJ/USD in Iceland with its high reliance on geothermal energy[19] to about 2 MJ/USD in Switzerland with a large services industry and hydroelectric power.

North America had the third highest energy intensity in 1990 at 8.8 MJ/USD, which fell to 5.8 MJ/USD by 2014 as economic growth decoupled from energy demand. In 2010–12, the pace of improvement accelerated, driven by cost-reflective energy prices and energy efficiency policies. In the power sector, the shift to natural gas enabled efficiencies in new electricity and heat plants that displaced older coal-fired plants. Yet activity in energy-extractive industries recorded significant growth. Canada's cold climate and mineral extraction industry resulted in energy intensity of 7.7 MJ/USD, higher than the United States' 5.6 MJ/USD.

Figure 2.8: UNECE Subregions Achieved on-going Declining Energy Intensity from 1990-2014.



In **Western and Central Europe**, energy intensity declined continuously in 1990–2014, from 5.5 MJ/USD, the lowest in the region, to 3.7 MJ/USD, driven by a combination of cost-reflective energy prices and consistent, comprehensive, and aggressive energy efficiency policies and commitments. The EU Renewable Energy Directive 2009 set an energy efficiency target for 2020 as a 20% reduction in energy demand relative to a business-as-usual projection. All EU countries were mandated to shape National Energy Efficiency Action Plans (NEEAP) requiring durable efficiency improvements along the whole energy value chain. The plans should largely achieve the 2020 targets, in part due to the global financial crisis.[20] The EU 2020 target was originally set at 18.6% below projected primary energy consumption of 1,542 Mtoe (million tonnes of oil equivalent), or 64EJ (exajoules), but primary energy consumption was revised downward to 1,527 Mtoe (63EJ), a 17.6% reduction.[21] Higher-productivity countries in Western and Central Europe reported very low energy intensity, but Iceland's was the highest in 2014 as its economy featured high energy-intensive aluminium smelters and a primary energy resource of low grade geothermal energy with high transformation losses.

In **Southeast Europe**, sharp improvements in energy intensity were made in the 1990s when conflict in Croatia, and Bosnia and Herzegovina caused energy demand to drop faster than economic output. During the 2000s, innovations in productivity contributed to further improvements. The pace of energy intensity improvements in Southeast Europe picked up in 2012–14, and energy intensity reached 4.6 MJ/USD in 2014, on the back of underlying structural shifts to lower-intensity services and recovery of GDP to 2008 levels. Still, significant annual variations in energy intensity suggest that the subregion has yet to implement firm policies on cost-reflective energy prices and energy efficiency. The subregion's northern neighbours have more challenging climates but often have lower energy intensity, pointing to further scope for energy efficiency action in Southeast Europe. Energy intensity in Southeast Europe is converging slowly toward the levels in the rest of Europe.

In **Eastern Europe, Caucasus, and Central Asia** energy intensity declined in 1990–2014 from 12.5 MJ/USD - the highest in the region – to 7.2 MJ/USD. As in Southeast Europe, variations suggest that prices and policies have still to mature into durable drivers. Changes in structure lie beneath the reported changes in many countries. In Tajikistan, for example, the declining trend was interrupted in 2011, and energy intensity increased as industries grew following long stagnation after the 1992–97 civil war. Israel's energy intensity was low in 2014, 3.7 MJ/USD, as was Turkey's, 3.5 MJ/USD; both benefited from low-energy-intensity industries and mild climates. Most countries in the subregion still have energy intensities above 5MJ/USD. Limited policy action, monitoring and evaluation, and data and compliance, coupled with energy price subsidies, slowed gains after 1998.

Additional Indicator: Supply Side Efficiency in Electricity Generation

More than half the primary fossil energy used to generate electricity is wasted as thermodynamic losses in the boilers and turbines of the region's power plants. Simply put, only a limited amount of the energy available in the primary fuel is transformed into electricity. Supply side efficiency (generated power output / primary energy input) in electricity generation in the region improved from 36% in 1990 to 41% in 2014. This improvements was driven primarily by investment in high efficiency combined cycle gas turbines, which improved overall gas-fired generation efficiency from 37% to 49% over the period. Transmission and distribution losses dropped from 8.2% in 1990 to 7.2% in 2014, reaching the lowest levels in the world. Natural gas transmission and distribution losses decreased from 1.2% to 0.6% during the same period.

2.2.2. Renewable Energy

> *Renewable energy sources are set to represent almost three quarters of the $10.2 trillion the world will invest in new power generating technology until 2040 because of rapidly falling costs for solar and wind power, and a growing role for batteries, including electric vehicle batteries, in balancing supply and demand.*[22]

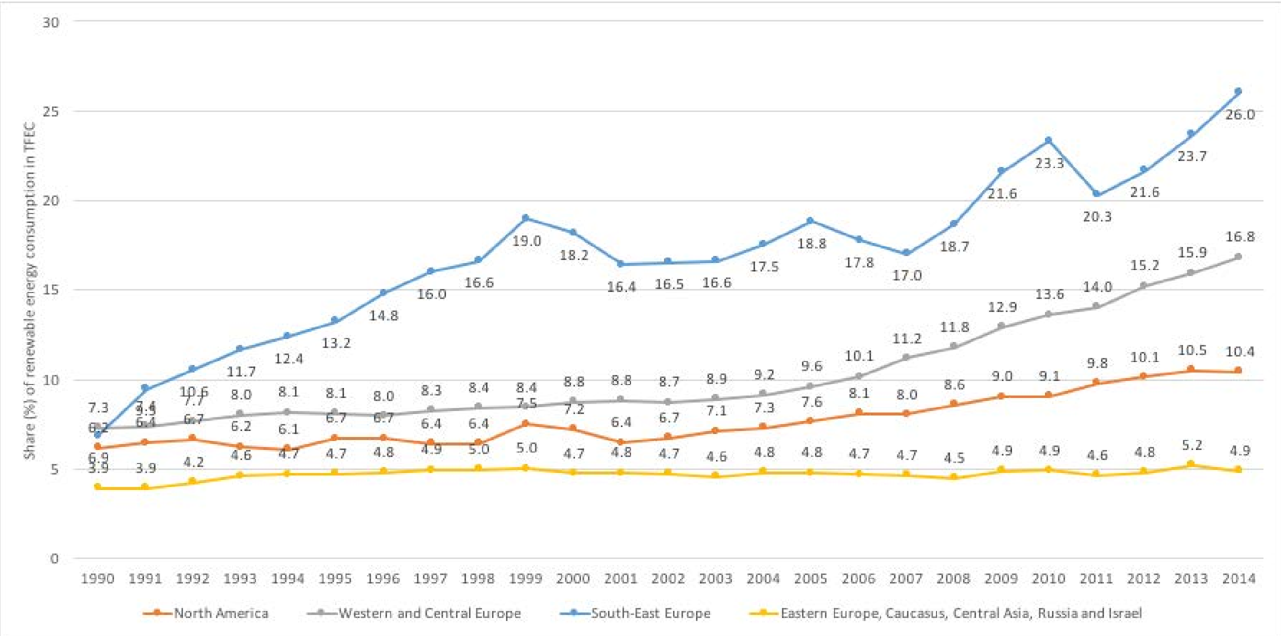
SDG7 Indicator: Share of Renewable Energy in Total Final Energy Consumption

The development of hydroelectric power in the region underpinned a high rate of electricity access. More recent renewable energy developments have been for the most part in large wind and solar farms, reflecting a central supply focus. Within the UNECE region, most investments in renewable energy occurred in Western Europe and North America as a result of strong price supports and policies such as Feed-in Tariffs (FiTs), auctions and tax incentives.

The UNECE region was the only region that consistently increased its share of renewable energy in the mix over the tracking period, and the rate of growth accelerated recently. It was also the only region to report flat growth in TFC over the period 1990-2014. The share of renewable energy in TFC increased from 6% in 1990 to 11% in 2014, with growth fastest in Southeastern Europe (Figure 2.9). The share of modern renewable energy reached 11%, the second highest globally, as traditional biomass consumption is negligible in the region.[23]

Among renewable energy sources, the share of modern solid biofuels consumption was the highest in 2014 at 38%, followed by hydropower at 28%, and modern liquid biofuels at 14%. In 2012-2014, wind and solar power production grew fastest, reaching shares of 9.5% and 4.3% respectively.

Figure 2.9: Growing Renewable Energy in all UNECE Subregions (Share of renewable energy in TFC, in %).



Subregional Renewable Energy Trends[24]

As shown in Figure 2.9, all subregions showed an increasing share of renewable energy over the tracking period, albeit from a very low base.

North America reported the second lowest share of renewable energy in 2014 at 10%. In 2014, however over half of renewable energy came from modern biofuels, and another 26% from hydropower. From 2012 to 2014, wind and solar power reported the strongest growth, reaching shares of 9.2% and 2.5% respectively.

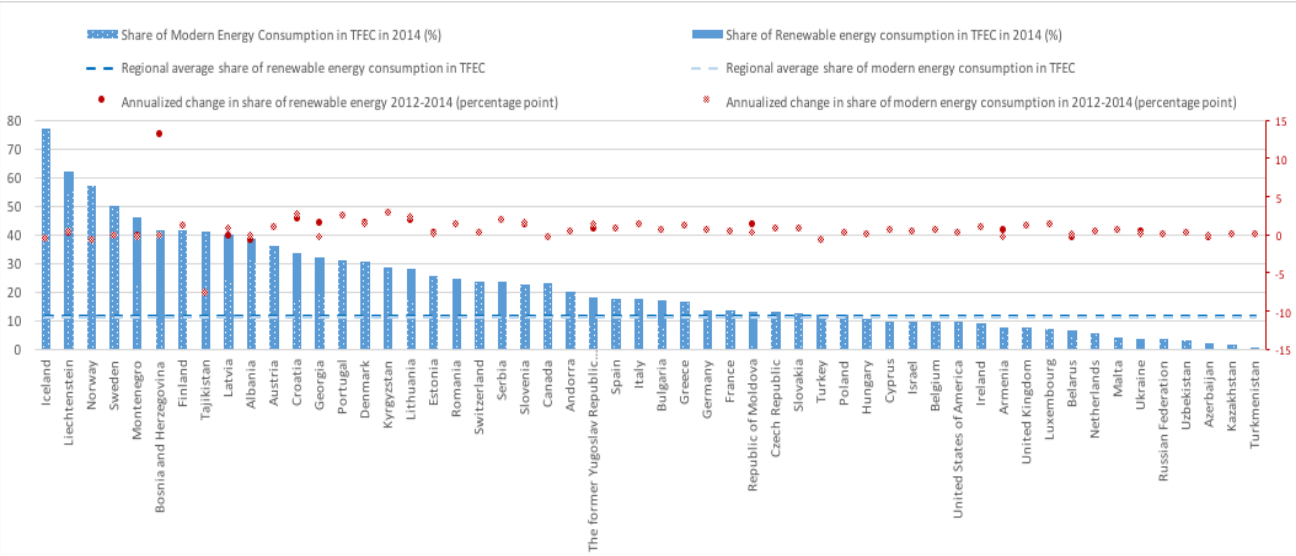
In Western and Central Europe, the share of renewable energy in TFC increased from 7.3% in 1990 to 17% in 2014. FiTs and the EU's Renewable Energy Directive 2009 supported strong growth in installed renewable energy capacity. The Directive mandates a binding target that 20% of energy use be provided from renewable energy sources by 2020. The Directive also set a target of 10% for renewable energy use in transport by 2020. The objectives are to be met through measurable national targets and policies set by each country. Over half of renewable energy consumption in 2014 came from modern biofuels and another 23% from hydropower. Since 2010, wind and solar power reported the strongest growth, reaching shares of 11% and 5.6%, respectively, in 2014. Iceland, Norway, and Liechtenstein reported the highest shares of renewable energy use, at 76%, 62% and 57%, respectively. Iceland and Norway have long histories in hydropower and geothermal energy, and Liechtenstein leads globally in solar photovoltaic energy per capita. In each case the high share of renewable energy is driven by the availability of the resource and commitment by the government.

Southeast Europe reached 26% of renewable energy in TFC in 2014, the largest share in the region, with over half in traditional biomass. Montenegro, Bosnia and Herzegovina, and Albania, reported the highest shares of renewable energy in TFC, at 46%, 42% and 39%, respectively. Southeast Europe also has the largest share of hydropower in the region, led by Romania, Croatia and Serbia. In 2012-2014, wind and solar power production showed the strongest growth, reaching 8.0% and 3.3%, respectively, of TFC.

The Eastern Europe, Caucasus, Central Asia, Russian Federation, Turkey and Israel subregion presented the smallest share of renewable energy in TFC in the region, at 4.8% in 2014, and investments in the subregion were focused largely on hydropower. Modern solid biofuels accounted for 20%, having decreased sharply from 1990 to 2014. Hydropower dominated the renewable energy mix with a 62% share in 2014, led by Tajikistan. In 2012-2014, liquid biofuels and wind power recorded the strongest growth, reaching 0.7% and 7.0% shares, respectively. Ukraine reported the fastest growth in wind power in the subregion, almost doubling the share of wind power in TFC from 16% in 2010 to 29% in 2014.

Figure 2.10 summarises the share of renewable energy for each country, and the change rates from 2012-2014.

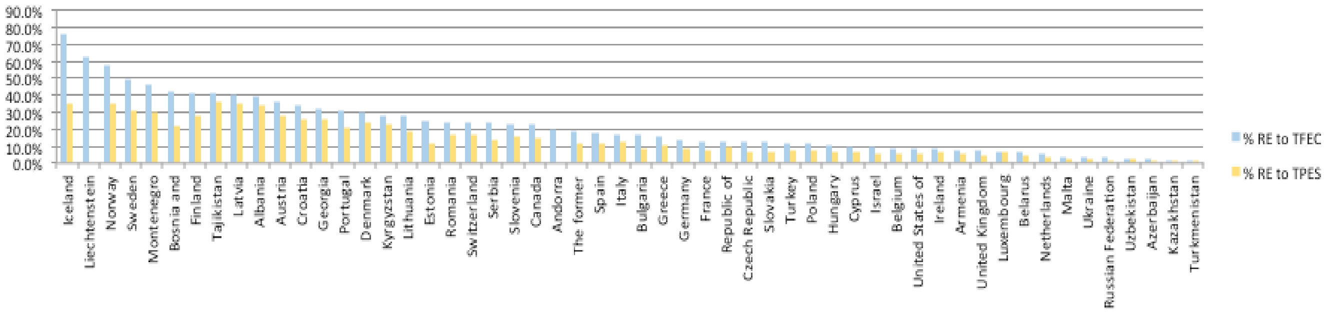
Figure 2.10: Country Proportion of Renewable Energy and Change Rates.



Additional Indicator: Share of Renewable Energy in Total Primary Energy Supply

Measuring renewable energy as a share of TPES is an indicator of progress in reducing global GHG and local pollution sources, country progress in developing and utilising available resources sustainably, and improving sustainability over the entire energy value chain. For the UNECE region as a whole, renewable energy from wind, solar, and geothermal accounted for only 1.6% of TPES in 2014. Including hydropower, biofuels and waste, renewable energy accounted for 9% of primary energy supply compared to a global share of 14%[25]. Figure 2.10 gives shows renewable energy as a share of both TFC and TPES for each country in 2014. The difference between renewable energy as a share of TFC and renewable energy as a share of TPES is most obvious in Figure 2.11 in countries with high shares of renewable energy, (e.g., Iceland, Norway, Sweden, and Montenegro) where there is an obvious transformation efficiency gap for renewable energy, but the renewable energy transformation effect is less in Tajikistan, Latvia, Luxembourg. As hydroelectric power's "conversion efficiency" is 100% that is not the case for other forms of renewable energy. While both indicators are useful, the need to understand primary energy options and implications is important. Further, measuring renewable energy as a share of TFC ignores the 6-8% transmission losses that are incurred through the high voltage network, whereas measuring renewable energy as a share of TPES does not reflect losses incurred in the combustion of fossil fuels.

Figure 2.11: Share of Renewable Energy in TFC and TPES in 2014 in UNECE Countries (2014).



Additional Indicator: Renewable Energy Generating Capacity Additions

Between 2000 and 2015, the UNECE region witnessed growth in renewable energy[26] generating capacity by 434 Gigawatt (GW) to 860 GW. This growth amounted to 38% of all global additions of renewable capacity, a capacity growth consistent with the region's share of global capacity. Non-hydro additions accounted for 86% of total renewable energy generating capacity, or 372 GW of the capacity growth, indicating a progressive shift away from hydro to investment in solar PV, wind and bioenergy. Hydro's share remains high with 57% of total renewable energy installed capacity[27].

Over the period 2000-2015, Western and Central Europe led growth in renewable energy with 23% of capacity additions, followed by North America at 11%. The balance was in Central Asia at 2%, Southeast Europe at 1%, and Russian Federation at 1% (see Figure 2.12). The latter countries represent a small part of the UNECE's total population and GDP base and have the least attractive climate and renewable energy resources for economic capacity development. Ideally progress would be measured against a scale of economically realisable renewable energy potential capacity in a country or region. Comparing this chart with a more recent period, the UNECE subregions which contributed most to renewable energy installed capacity additions were again Western and Central Europe (15%) as well as North America (12%) (see figure 2.13). Notably, the growth in capacity additions in North America is stronger, fuelled mainly by the U.S. which increased its annual additions from 192 GW in 2013 to 219 GW in 2014, making it the country with the most additions in 2015 in the region.

Figure 2.12: Renewable Energy Capacity Additions (2000-2015).

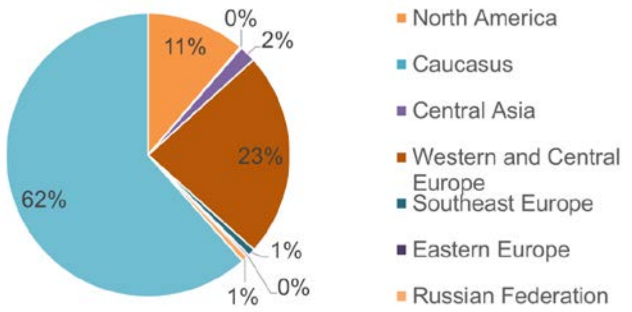
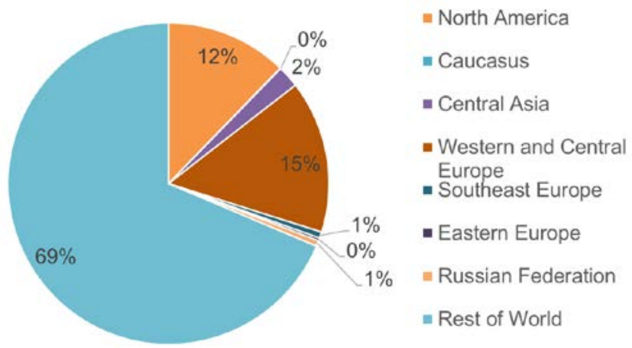


Figure 2.13: Renewable Energy Capacity Additions (2013-2015).



2.2.3. Energy Access

Energy is essential for sustainable development and poverty eradication. In 2015 about 2.8 billion people had no access to modern energy services and over 1.1 billion did not have electricity.[28]

SDG7 Indicator: Universal Electrification: Physical Electricity Access.

Historically high levels of industrialization provided a high level of physical electricity access in all countries. The electrification rate in the UNECE region was 99% in 1990, and reached 100% in 2010. In 2014, all countries reported electrification above 99.9%. In rural areas, universal access at the regional level was achieved in 2010. All countries showed a rate of rural electrification above 99.7% in 2014. North America and Western and Central Europe had universal access in 1990. South East Europe and Eastern Europe, Caucasus, Central Asia, Russian Federation, and Israel collectively achieved 100% between 2007 and 2010. In 2014, 12,500 people across Kyrgyzstan and Tajikistan did not have access to electricity.

Additional Indicator Area: Affordability, Reliability and Quality of Electricity Access

Despite 100% physical access to electricity, countries of the UNECE region are challenged by affordability, quality of access, and service. Part of the legacy of post-World War II industrialization is that many of the infrastructure assets are old, and substantial renewal and redevelopment is required to improve reliability and quality of supply.

Power supply in Central Asia and Caucasus is less reliable where infrastructure maintenance and age reduce supply reliability. In Tajikistan, for example, 70% of the population endure frequent power outages. Five areas within the region were reported with inadequate grid access: Villages in Kraiina and Eastern Bosnia in Bosnia and Herzegovina; 130 largely seasonal residences in rural settlements in Georgia; 20 settlements in the Batken region in Kyrgyzstan, where traditionally power was supplied from outside Kyrgyzstan; 1,500 remote settlements in Uzbekistan; and Tajikistan where the power grid covers 96% of the country, but 10% of the population in remote mountainous regions do not have access. These examples have supply constraints from remoteness, seasonal occupancy, or as a result of conflicts, but in each case, efforts are underway to address access.[29]

Affordability issues are not only a problem seen in the eastern countries of the region. With one of the highest end-consumer electricity prices in the EU (29.8 euro-cent per kiloWatt-hour (kWh) in the second half of 2016)[30], German suppliers reportedly cut electricity to 130,000 households in 2015 due to unpaid electricity invoices. [31] In Spain, there were more than 7000 deaths related to energy poverty in 2014, and Great Britain more than 15,000 in 2015. This is mainly explained through elderly who do not heat their houses sufficiently.[32] The World Health Organisation (WHO) estimates that 40% of unnecessary winter mortalities are caused by insufficient living conditions in the European region.[33]

Additional Indicator Area: Heat Demand, Access and Quality

The region's countries circle the arctic, and cold continental climates across most of the region create the highest demand for heating services in the world. The region has a legacy of older, often poorly insulated buildings with old inefficient central or unitary heating systems. Affordability and service quality of heat services are a particular challenge with lock-in of older fossil based heat infrastructure and poor insulation remaining an important issue in all countries.

Affordability of heating services is a growing challenge. All countries have at least part of their household population in energy poverty, which is generally acknowledged as more than 10% of household income spent on energy. For example, in the Russian Federation 29% of households spend more than 10% of income on energy, while in four other countries more than 40% of households spend over 10% of their income on energy (Albania 46%, Moldova 52%, Serbia 49%, and Tajikistan 60%).[34] Security of operation continues to rely on decades-old infrastructure in power systems, district heating networks, and and the natural gas network with low efficiency and high losses. Further barriers include a lack of transparency and trust in tariff setting, poor cost recovery and metering, and affordability.

SDG7 Indicator: Clean Fuels and Technology for Cooking

The UNECE region achieved 98% access to clean fuels and technology for cooking in 2014, up from 95% in 2000. With 75.8%, Southeast Europe was the subregion that did not achieve universal access. Nonetheless, 23.3 million people still relied on traditional fuels for cooking in 2014. They mostly lived in remote regions, and relied on locally-gathered fuel wood. The fuel is typically burnt in a controlled combustion wood stove or a traditional high mass combined space heater and/or cooking oven. Traditional stoves offer users reliable heat from low or no-cost local resources at reasonable efficiencies[35] and are therefore a preferred option in situations where access to commercial energy sources is impractical or expensive.

2.3. Beyond SDG7: Energy for Sustainable Development

As is noted elsewhere in this report and as recognised by analysts generally, energy is the golden thread that weaves throughout the 2030 Agenda for Sustainable Development. Addresses the net carbon intensity of the energy system is an essential part of meeting the climate challenge. Assuring energy access and affordability connect directly to poverty, hunger, health, education, gender equality, water, economic development and employment, infrastructure, inequality, and sustainable cities. Attaining the objectives of the 2030 Agenda will require full engagement of industry to transform energy. As a consequence, it is essential to monitor progress on energy for sustainable development in ways that reflect the cross-cutting interconnections among the SDGs.

2.3.1. Fossil Fuels

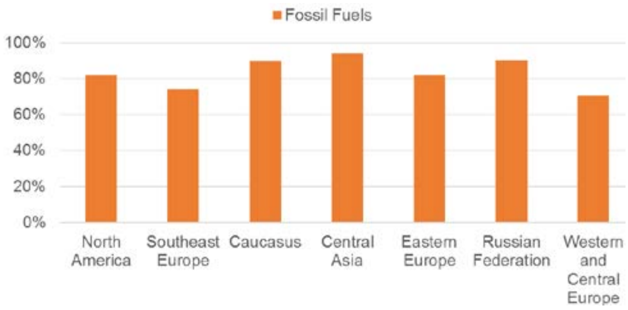
The energy transition towards a clean, affordable and sustainable energy system will require solutions for the use of fossil fuels in the upcoming decades. To achieve net zero emission by the second half of this century, the region's historical dependency on fossil fuels needs to be reduced. The share of fossil fuels within the energy system is one indicator to measure progress towards a low-carbon future. Other indicators could include the efficiency of fossil fuel based power generation capacities, methane emissions along the energy value chain, among others. Some data are provided below.

Additional Indicator: Share of Fossil Fuels in TPES

In 2014 80% of UNECE's TPES came from fossil fuels, equivalent to the global share of 81%. The balance was made up of 10% nuclear and 9% renewable sources of energy including hydro, biofuels and waste, as well as geothermal, solar and wind. Figure 2.14 gives an overview of the share of fossil fuels in the different subregions.

The figures vary across the UNECE sub-regions from 71% in Western and Central Europe to 94% in Central Asia. For more analysis on the role of fossil fuels in the UNECE region, please see Issue 1 in Chapter 5.3.

Figure 2.14: Fossil Fuel Shares in TPES of UNECE Subregions (2014).



2.3.2. Climate Commitments

Mitigation scenarios reaching atmospheric concentration levels of about 450 ppm CO2eq by 2100 include substantial cuts in anthropogenic GHG emissions by mid-century through large-scale changes in energy systems and potentially land use. These scenarios are also characterized by more rapid improvements in energy efficiency and a tripling to nearly a quadrupling of the share of zero- and low carbon energy supply from renewable energy, nuclear energy and fossil energy with carbon dioxide capture and storage (CCS), or bioenergy with CCS (BECCS) by the year 2050.[36]

Energy plays a crucial role in combating climate change and reducing emissions. According to the Intergovernmental Panel on Climate Change (IPCC), the CO2 emissions from fossil fuel combustion and industrial processes contributed about 78 % of the total GHG emission increase from 1970 to 2010.[37] According to the IEA, 80% of global CO2 emissions come from the energy sector, while it contributes a third to global GHG emissions.[38]

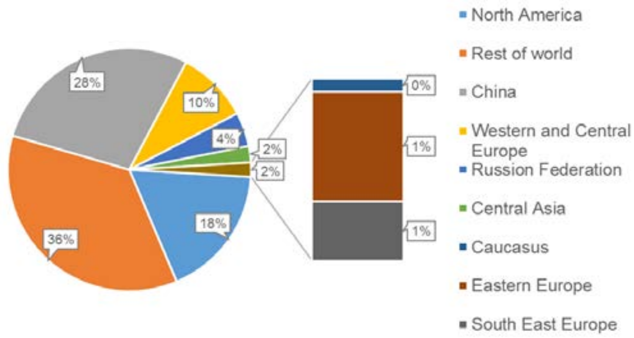
The Global Goals are closely linked to the climate objectives stated in the Paris Agreement as result of UNFCCC's 21st Conference of the Parties (COP) meeting in 2015, which aims to limit global warming well below 2°C. Meeting the climate change challenge necessarily involves fundamental transformation in how energy is produced, transformed, transmitted, and used. At the same time energy is at the heart of the 2030 Agenda. It will be necessary to meet both objectives in an integrated manner, which requires clear understanding of both the climate-related impacts of energy and the development-related opportunities that energy represents. The two most relevant GHGs are CO2, mainly from the combustion of fossil fuels, as well as methane emissions along the coal and gas value chains. Three indicators are suggested to track progress towards a less-carbon intensive energy sector.

Additional Indicator: CO2 Emissions from Fuel Combustion

According to the IEA, over the 1990-2010 period, total CO2 emissions from fossil fuel combustion increased about 45% globally. In 2010, CO2 contributed 76% of global GHG emissions (one third from the energy sector), CH4 about 16%, N2O about 6% and the combined F-gases about 2%.[39]

Looking at the UNECE region, the 56 member States contributed 36% of global CO_2 emissions from the combustion of fossil fuels in 2014 (see figure 2.15)[40], which is about 11 Gt CO2 out of the total global 32 Gt CO2 emitted. While global trends saw a small increase of emissions less than 1% compared to 2013, CO2 emissions in the UNECE region saw a reduction in 2014 compared to the previous year. North America makes the largest share at 18%, Western and Central Europe at 10%, the Russian Federation 5%, Central Asia 2%, Eastern Europe and Southeastern Europe 1% each. In light of commitments made under the Paris climate agreement, UNECE countries need to address energy's GHG emissions.

Figure 2.15: Global and UNECE Share of CO2 Emissions from Fossil Fuel Combustions (2014).

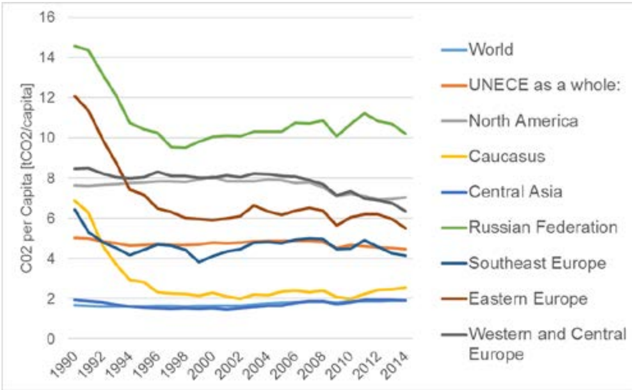


Country sizes vary considerably, and while emissions must be tackled at an absolute emission level, normalizing emissions by factors such as population, geographical area or economic activity offers useful insights into the scope and capacity for change.

On a per capita basis there is considerable range between the carbon intensity of fossil fuel energy[41] (in t CO2/capita) in UNECE subregions (see figure 2.16). With 9.1 t CO2/capita in 2014, the UNECE average is two times higher than the global average of 4.5 t CO2/capita. Figure 2.16 shows the time series for CO2 emission per capita for the UNECE subregions.

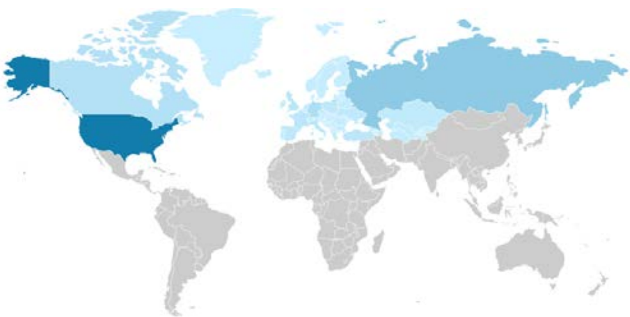
Since 1990, most subregions have moved toward the world average, the regions within the former Soviet Union countries, Russian Federation, Caucasus, and Eastern Europe, moving in the years after the dissolution. Central Asia has tracked the world average closely, while Western Europe and North America showed later progress as their post-millennial energy efficiency, renewable energy and climate policies took effect. Figure 2.16 shows that UNECE countries have higher per capita fuel combustion CO_2 emissions to address.

Figure 2.16: Fossil Fuel Combustion related CO_2 per Capita for UNECE Subregions (2014).



In addition to IEA data, the U.S. Energy Information Administration (EIA) publishes data for total CO2 emissions from the consumption of energy.[42] Figure 2.17 provides an overview map of the high emitting countries within UNECE, shaded in dark.

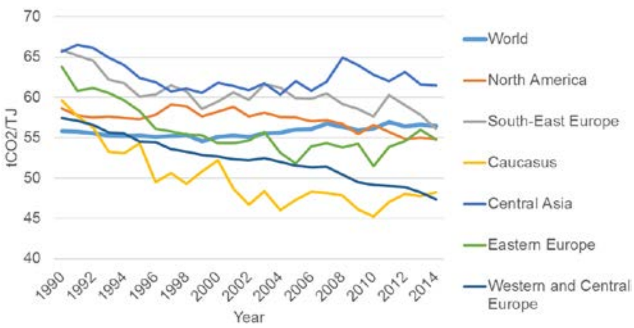
Figure 2.17: Total CO2 Emissions from the Consumption of Energy (2014).



Additional Indicator: Carbon Intensity of Primary Energy and Final Energy Consumption

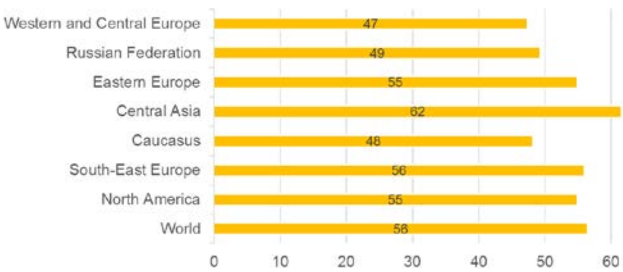
The carbon intensity of primary energy divides all net CO2 emissions from fuel combustion by TPES (t CO2 / TJ), the one for final energy consumption by TFC (tCO2 / TJ).

Figure 2.18: CO2 Emissions per TPES in UNECE (1990-2014, in tCO2/TJ).



According to IEA data, the global carbon intensity of primary energy in 2014 was 56.6 tCO2/TJ, averaged over all energies including fossil fuels, nuclear and renewables. Figure 2.18 shows the development of this indicator for the different UNECE subregions from 1990 to 2014. The carbon intensity of primary energy differs significantly across the regions. Central Asia and Southeast Europe's development remains above absolute numbers of global carbon intensity, however, a down ward trend might be visible since 2012.

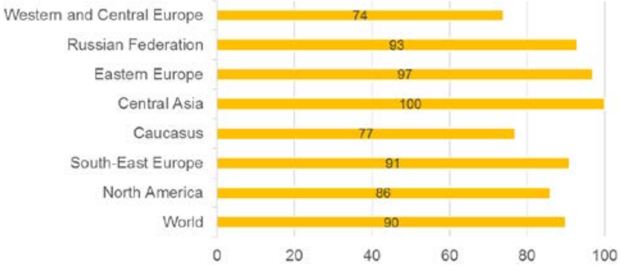
Figure 2.19: CO2 Emissions from Fuel Combustion per TPES for UNECE Subregions (2014, in tCO2/TJ).



Western and Central Europe has witnessed a continued decline of carbon intensity. In 2014 the sub-region reported 47 tCO2/TJ, well below the global carbon intensity of 56 tCO2/TJ.

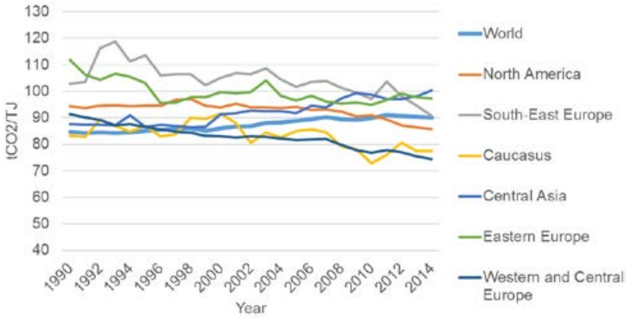
Figure 2.19 gives a detailed overview of the 2014 carbon intensities at subregional level. The highest national carbon intensity figures for TPES in the region are Malta, Poland, Estonia and Kazakhstan with 72, 71, 70, and 70 tCO2/TJ, respectively.

Figure 2.20: CO2 Emissions from Fuel Combustion per TFC for UNECE Subregions (2014, in tCO2/TJ).



Similarly, the carbon intensity trends for 1990-2014 and 2014 figures for TFC are given in Figure 2.20 and Figure 2.21. Only the subregions of North America, Caucasus and Western and Central Europe are below the global figure of 90 tCO2/TJ. The highest national carbon intensity for final energy have Estonia and Kazakhstan with 150 and 149 tCO2/TJ, respectively.

Figure 2.21: CO2 Emissions from Fuel Combustion per TFC for UNECE Subregions (1990-2014, in tCO2/TJ).



Additional Indicator: Greenhouse Gas Intensity of the Energy Sector

In 2010, CO2 emissions from the energy sector were 76% of global GHG emissions. Other GHGs such as CH4, N2O, and the combined F-gases accounted for about 16%, 6% and 2% of global emissions, respectively.[43] In order calculate the GHG intensity of the energy sector, additional data sources are required. [44] Energy-related emissions [45] are communicated as part of the United Nations Framework Convention on Climate Change (UNFCCC) processes that are the official national emission inventories provided. Figure 2.22 shows data for GHG emissions per TPES in tCO2/TJ for those countries for which data was available from the UNFCCC. As some countries only reported energy emissions data in 2012 or 2013, the timeframe 2012-2014 is presented.

Figure 2.22: Greenhouse Gas Intensity in TPES in UNECE countries (2012-2014).

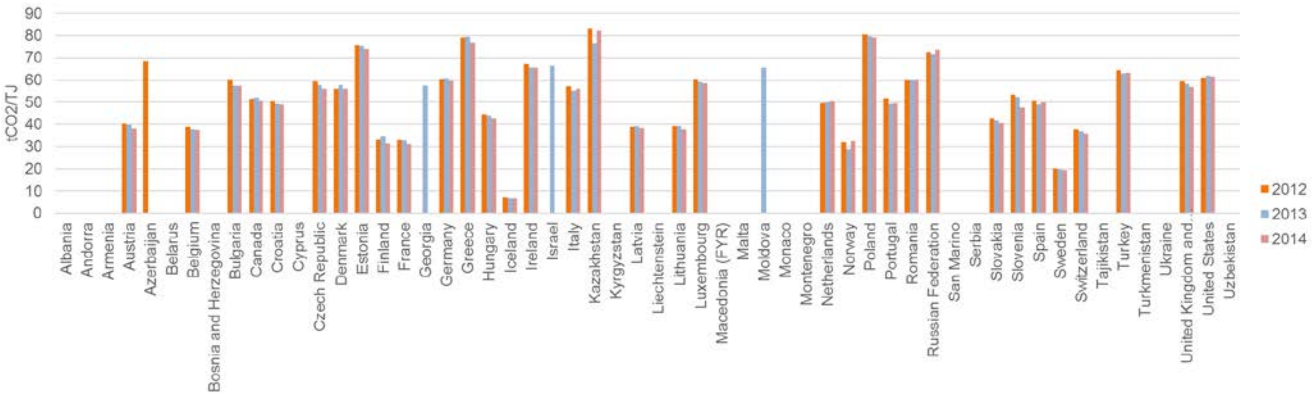


Figure 2.23 shows the GHG emissions per TFC. Countries with a large share of fossil fuels in their energy mix have higher intensities such as in the case of the Russian Federation and Poland, compared to countries with a large-share of low-carbon energy solutions such as nuclear and renewable energies such as in the case of France and Norway. Compared to the carbon intensity of TPES, the carbon intensity of TFC reflects conversion efficiencies as well as the GHG emissions and energy content from energy production. For comparison, total GHG emissions by country (not only the energy sector) for 2012 is shown below in figure 2.24.[46] According to this data source, the UNECE region contributed 32% or 17 Gt CO2eq of total global GHG emissions in 2012, compared to the global total of 54 Gt CO2eq.

Figure 2.23: Greenhouse Gas Intensity in TFC in UNECE Countries (2012-2014).

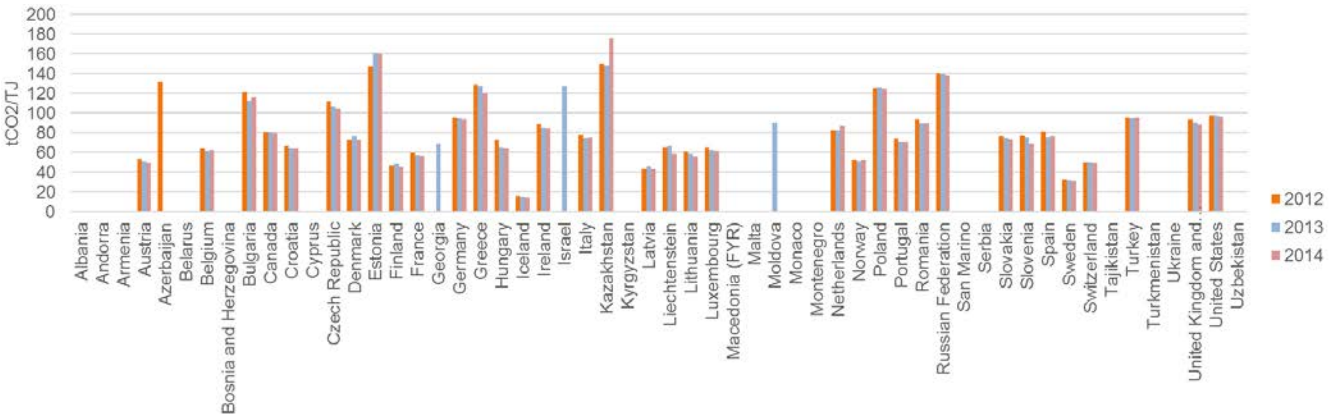
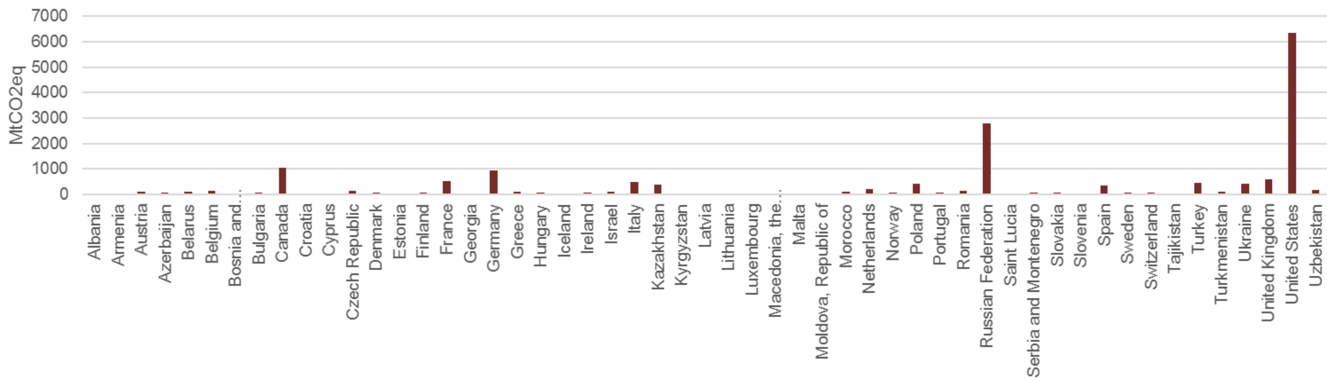


Figure 2.24: Total Greenhouse Gas Emissions of UNECE Countries in (2012-2014).



2.3.3. Energy as a Service Rather Than Energy as a Commodity

Additional Indicators: Quality of Service versus Cost of Service; Energy Intensity of Energy Services

As noted above, energy is the golden thread that weaves throughout the 2030 Agenda and is at the core of meeting the world's quality of life aspirations.

The challenge is reconciling a tight emissions pathway with these aspirations. The 2030 Agenda represents an imperative for profound and immediate changes in how energy is produced, transformed, traded, and consumed as the energy sector accounts for about two thirds of total global GHG emissions and 80% of CO2 emissions[47]. To avoid exceeding the amount of carbon that can be emitted and to set the stage for future GHG emission reductions, all options for reducing net CO2 emissions must be developed and pursued urgently to reduce energy's net carbon intensity.

The energy industry has succeeded in raising quality of life around the world, most notably in the advanced economies but even in the developing world. The issues of access and affordability, as discussed previously, remain challenges. The energy industry today is a commodity business that produces and delivers of cubic meters of natural gas, litres of petrol, kWh of electricity, tons of coal. Energy industry players earn returns by producing and selling more. The existing infrastructure, including the physical, regulatory, policy, and organizational infrastructure of the energy industry, is shaping the decisions about the future inasmuch as today's structures are expected to evolve only incrementally in the future. In fact, what is needed for true sustainability is to reconceive the energy industry as a complex of service industries. Such a reconfiguration would unleash innovation and energy productivity as has been witnessed with the revolution in telecommunications. It is not energy that consumers demand and use. They consume the services provided by energy, such as lighting, mobility, heating, and so forth. If energy could be transformed the way telecoms have, then business models that deliver quality of life sustainably will spur the investments needed for transformation of our energy system. New approaches will allow those without access to energy to leapfrog existing technology and systems, with much greater emphasis on distributed generation, renewable energy, and price responsive demand. Many readers will assume this approach is found in the ESCOs, or energy service companies, of today, whereas the proposed reconfiguration is much deeper and more aligned with the deregulation of banks, airlines, and telecoms.

Households and businesses use energy for their well-being and productivity when:

- Energy technology that meets needs, and reliable energy supplies are available
- Proposed energy services are better, cheaper or more reliable than other means
- New levels of service, comfort, wellbeing, status or productivity are achievable
- New services or synergies are possible – video recording, cell phones, mobility, and the like.

Consumers moderate their demand for energy services when needs are satiated, but there are a number of corollaries:

- Consumers will maximize their utility by making trade-offs between service levels in alternative (a dinner out) and competing services (drive a car/take a bus/telecommute)
- If basic service needs are not being met, there is little scope for reducing energy demand or improving efficiency as any improvements will be redirected to other needs.
- If energy consumption has been subsidized, there is little or no incentive for consumers to improve the sustainability of the energy services they use.

To consumers energy represents an ability to access and enjoy diverse services at higher levels of ease and utility. Although an energy utility's bills must be paid, energy does not represent a commodity or physical artefact to most consumers. Utilities can supply energy services, but so can non-traditional players. With the anticipated pressure on energy prices, it may make economic sense to provide services at certain quality levels rather than energy commodities. Breakthroughs in e-mobility, energy storage, and new transmission technology (including wireless) could make it more advantageous to sell services. Changing the industry to a service configuration involves changing a utility's (or service provider's) business model to one of maximizing the margins between the revenues received for services provided (for example, indoor comfort or mobility) and the costs of providing the services (through, for example, efficiency investments).

Where energy services are constrained or unaffordable the above corollaries still apply. For example, a household in energy poverty struggling to get necessary services will trade off food for heat or other expenses to maximize their constrained utility. This juggling of basic needs is a significant issue in a number of UNECE countries where, despite universal access to energy through utility connections, many household struggle to afford energy or have inefficient homes and appliances and cannot achieve needed levels of comfort from the available energy resources.

Generally the demand for energy services is expanding with novel services including not only home appliances and communications, but also electrification in industry and transport including e-mobility. The penetration of intelligent devices throughout the economic system, including energy, creates an enormous opportunity for transformational investment. Realizing the potential will require careful reconsideration of and readiness to revisit the existing regulatory, policy, technical, and organizational infrastructure of energy.

III. SUSTAINABLE ENERGY IN UNECE: SELECTED ISSUES AND COUNTRY CASE STUDIES

In this part of the report, country experiences that underpin the data reported in Part 2 are explored. The perspectives in this section seek to highlight systemic challenges and recognise that the elements of the energy system are connected: human needs drive demand for services, which in turn drives demand for energy technology, and in turn drives supply investments and resource demand. Chapter 3.1 introduces a typology of the different elements in a sustainable energy system and is used as the framework for this report. Chapter 3.2 to 3.7 provides information about specific issues and case studies within each of the energy system elements.

3.1. A System Perspective on Sustainable Energy

Figure 3.1 highlights that consumer service needs drive energy demand. This perspective is founded on the logic that the demand for energy is derived from society's demand for services: cooked food, industrial production, mobility, and the like, to enable quality of life and wellbeing for citizens. This consumer-driven demand for energy in turn drives investments in energy distribution, transmission and the production of consumer energy products like electricity, gas, heat, and ultimately the demand for primary energy resources. Inefficiencies in each of the stages in this energy value chain ensure that primary energy demand is much greater than the energy demanded by consumers. Importantly, efficiencies achieved throughput the chain, reduce costs throughout the chain, thereby minimising costs to consumers.

Figure 3.1: A System Perspective on Energy Sustainability.

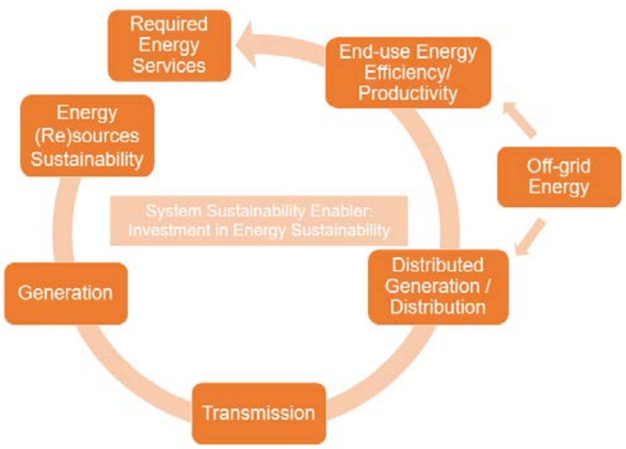


Figure 3.1 shows how consumer's service needs drive end-use energy efficiency. Typically demand for energy services is moderated by competitive offers, the costs of technology, cost-reflective prices and clear information. The demand to improve energy efficiency is driven by a need for both improved or increased service and the need to manage energy costs. Energy efficiency policies and measures deliver both improved services and a reduction in demand for energy; the balance between these is based on consumer's utility-maximising response to the energy efficiency intervention.

A diversity of distributed and centrally supplied energy as well as off-grid energy supplies consumers. The supply system consists of primary energy production, transformation, generation, and transmission / transportation and its capacity to adapt to changing technology and resource options, and motivate efficient investments in both demand and supply is central to enabling end use efficiency and distributed and centralized supply.

The available resources for energy supply are a reflection of energy resource endowment, technology for extraction, and use constraints (land use, water and air quantity and quality), options for trade, and social concerns. All determine collectively available supply and sustainability. Optimising the elements of this system improves economic and environmental sustainability and in turn lowers costs to consumers. Underpinning the whole system are the investments in energy sustainability along the energy value chain.

3.1.2. Drivers of Energy Policy-Making

The energy system in Figure 3.1 also forms the basis of a system logic that draws on the policy drivers to improve the sustainability of the energy system. An overarching policy capability and integrated framework is required, to ensure each element in the system is optimised according to local conditions in order to achieve the most economical outcomes.

The following sub-chapters look at the issues, potentials and prospects for each element of the energy system outlined in Figure 3.1. Where possible, case studies are used to offer examples of change ensuring a practical exploration of options for change.

Table 3.1 gives an overview of the issues explored and case studies used for each of the elements of the energy system.

Table 3.1: Issues and Case Studies in this Report.

Energy System Element	Selected Issues	Country Responses	Chapter
Required Energy Services	Issue 1: Heat services: A Critical Service with Substantial Quality and Sustainability Challenges.	Case Study: The vast heat service challenge in UNECE. Case Study: District Heating. Case Study: European Union's Policy Actions for Heating.	3.2.1 pg. 29
	Issue 2: Quality of Supply Challenges Despite Universal Electricity Access.	Case Study: A nexus of inadequate service, waste and vulnerable consumers.	3.2.1 pg. 31
	Issue 3: Energy Affordability Despite Universal Access.	Case Study: Community–led Sustainable Energy in the UK.	3.2.1 pg. 32
End-use Energy Efficiency / Productivity	Issue 1: Pollution and energy waste from low efficiency heating systems and poor insulation.	Case Study: Local and global harm from poor fossil fuel heating and building inefficiencies.	3.3.1 pg. 36
	Issue 2: Buildings: A Lack of Energy Efficiency Building Codes and Slow Retrofitting.		
	Issue 3: Improving Appliance and Equipment End-Use Efficiency.	Case Study: Appliances and Equipment Energy Efficiency: The EU Eco-Design Directive. Case Study: Appliance Energy Efficiency Market Transformation process in Turkey.	3.3.1 pg. 38
	Issue 4: Improving Transport Sustainability and Service Quality.	Case Study: The Global Fuel Economy Initiative's Activities in Georgia, the FYR of Macedonia, and Montenegro.	3.3.1 Pg. 40
	Issue 5: Improving Industrial Productivity with Energy Efficiency.	Case Study: Industry-Government Agreements for Industrial Energy Efficiency. Examples from Canada and the Netherlands. Case Study: ISO50001 Energy Management Systems.	3.3.1 pg. 41
Distributed Generation / Distribution	Issue 1: Integration of Variable Renewable Energy: Market Design Challenges.	Case Study: Integrating Variable Renewables into Grids. Case Study: Assigning Responsibility for Managing Increasing Variability of Supply.	3.4.1 pg. 48
	Issue 2: Distributed Renewable Energy for Remote Communities.	Case Study: Wind Turbine Cooperatives in Denmark. Case Study: Distributed Renewables: Croatia's High Share of Traditional Renewable Energy.	3.4.1 pg. 49
Transmission and Generation	Issue 1: A Continued High Reliance on Fossil Fuels		3.5.1 pg. 52
	Issue 2: Inadequate Progress in Supply Sector Efficiency of Fossil Fuel based Generation.		3.5.1 pg. 52
	Issue 3: Integration of Variable Renewable Energy: Policies to Support Renewable Energy Uptake.	Case Study: A shift from Renewable Energy Feed-In Tariffs to Auctions? - An Example of Off-Shore Wind Energy in Germany.	3.5.1 pg. 54
	Issue 4: Diverging Concepts of Energy Security: Energy Self-Sufficiency versus Energy Interdependence.	Case Study: European Energy Security: Improving Import Dependency.	3.5.1 pg. 55
	Issue 5: The Difficulty of an Energy Transition Paradigm Shift.	Case Study: To Renewables via Gas: The U.S. Fossil Fuel Transition. Case Study: Power Sector Reform Experiences in Russia.	3.5.1 pg. 57
Energy Resources Sustainability	Issue 1: Commitments to Reduce Energy Sector Greenhouse Gas Emissions.	Case Study: The European Union's Nationally Determined Contributions.	3.6.1 pg. 59
	Issue 2: Management of Methane Emissions From Fossil Fuel Extractive Industries.	Case Study: Coal Seam Methane Recovery: Examples from Poland and the Ukraine.	3.6.1 pg. 61
	Issue 3: The Energy-Water-and Nexus.	Case Study: Drina River Basin Energy-Water-Land Nexus Solutions Assessment.	3.6.1 Pg. 63

3.2. Improving Required Energy Services

The need to improve consumer service is a significant challenge. Despite the high levels of access reported by the GTF indicators, for many consumers connection to a utility network bears little relation to the services actually received through the connection.

Much of the infrastructure in the UNECE region derives from mid-20th century, it is old, less than reliable, and faces important quality of supply challenges. Discrete pockets of remote settlements with limited access to grid power remain.

3.2.1. Selected Issues and Country Responses

The level of service quality achieved by households and businesses is a combination of three aspects of consumer end use.

Access to energy
At a naïve level, access is indicated by connections to electricity, gas or heat networks. The capacity, consistency and quality/reliability of supply can vary considerably in established networks even with 100% connections for households and businesses.

Affordability of energy
In all countries lower socio-economic groups struggle to afford to purchase energy they need. Typically, less well-off households and businesses make trade-offs, compromising quality and quantity of food, clothing or health care to maximize utility from a limited service capability while maintaining basic levels of comfort for health.

Access to efficient end-use technology
Poor access and an inability to invest in efficient end-use appliances and equipment restrict low-income households and business to energy inefficient usage patterns, abnormally high energy consumption and costs with poorer quality of service.

Issue 1: Heat services – A Critical Service with Substantial Quality and Sustainability Challenges

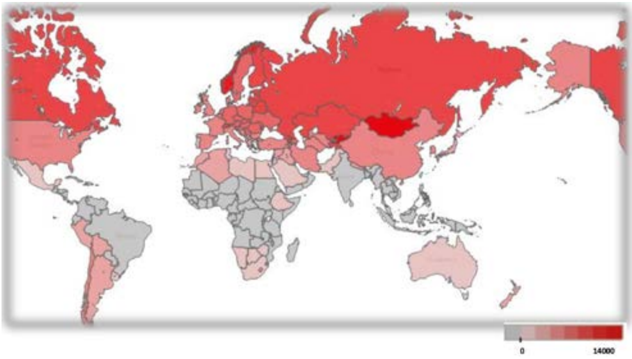
While consumers need diverse energy resources, heat services stand out in the UNECE region as a critical resource due to the prevalence of extreme cold.

The region's countries circle the arctic, and cold continental climates over most of the region create the highest demand for heat services in the world in almost all ECE countries except those bordering the Mediterranean and the southern states of the USA (Figure 3.2).

While consumers and policy makers can influence a number of variables, weather and climate are givens. Cold climates oblige more energy use to ensure human health and wellbeing. The extent of heating demand can be described by Heating Degree Days – the cumulative number of degrees over a year that daily average temperatures are below 18°C, a recognized temperature below which buildings need to be heated. UNECE region countries face a higher demand for heat services than any other region.

The region has a legacy of older (often poorly insulated) buildings with old, inefficient heating systems. The historical high dependence on fossil fuels for centralized heat services creates a locked-in dependence on fossil fuels often with poor efficiencies and a perception of heat security based on indigenous (typically fossil) energy resources. There is enormous scope for improvement in the adequacy of heat services in the region, including both their efficiency and their affordability.

Figure 3.2: Heating Degree Day Distribution.



Source: KAPSARC (2016).

Heat services in buildings and industry represent over 40% of final energy consumption in the UNECE region. In Western Europe, the Russian Federation and United States of America, energy for cooking is less than 4% of total heat services. Generally cooking is undertaken with commercial cooking fuels (gas and electricity). Exceptions occur in remote areas where controlled combustion wood stoves provide heating and cooking services. 13 million people in 17 countries still rely on solid fuels for cooking. Bosnia & Herzegovina and Georgia stand out with 42% and 54% access, respectively, to non-solid fuels for cooking. [48]

Case Study: The Vast Heat Service Challenge in the UNECE Region.

The UNECE average share of final energy consumed for heat services stands at 40%, but there is significant various around this average. The EU consumes 23EJ or 56% of its TFC for heating services; the Russian Federation, 18.5EJ or 56% of its TFC%; and the USA, 22EJ or 35% of its TFC on heat services.[49]

Uzbekistan stands out as a country with high space heating energy use. Residential, commercial, and public buildings account for 65% of final consumption of natural gas, and most of the consumption is for space heating. The average specific heat consumption of residential buildings in Uzbekistan is about 290 kWh/m2, compared with 95 kWh/m2 in the Netherlands, despite being similarly dependent on natural gas for primary and final energy consumption, relying heavily on individual gas boilers for space heating, and with a slightly colder and longer winter than Uzbekistan.[50]

In the Russian Federation, 70% of the population's heating requirements are met by district and local heating.[51] Although the network is extensive, it is very old and it is estimated that 60% of the network requires major repairs or replacement.[52] Resulting inefficiencies mean frequent service interruptions for some urban populations[53] and 29% of households spend more than 10% of their income on energy.[54]

Quality of life issues dominate many of these systems that were based on abandoned collectivist policies. With new distributed energy efficiency and renewable options available, a substantial rethink of heat and power supply systems is possible.

Four key aspects of heat service access and service quality warrant attention.

I. Legacy systems: Many buildings and energy systems in Eastern Europe, Central Asia, date to post-war reconstruction. Upgrading or replacing infrastructure to improve service quality across the eastern subregions of the region is a much larger task than provision of access to the remaining areas with poor access. Both are priorities and require an underlying policy base that ensures investment is allocated efficiently to achieve service and access quality improvements and a simultaneous economic transition to distribute renewable energy. Ensuring affordability and access to quality of service merit further exploration.

II. Adequacy of heat service, efficiency and affordability remain challenges in most countries. A high level of energy access, measured as connections to final energy systems, does not measure service quality. Those countries that recognise energy poverty (the inability of households to maintain safe indoor temperatures without undue burden on their income) face complex barriers of built–in inefficiencies, capacity to pay and access to modern efficient technology.

III. While the generators and engines in power generation and transport fleets require liquid or gaseous fossil fuels, heat services are still highly dependent on fossil fuels. The institutional and technological infrastructure was designed to use historically available fossil fuels, and it is difficult to upgrade and convert to renewable energy operation. There is a locked-in dependence on fossil fuels. Primary transformation processes in power generation, and energy provision also face locked-in dependence on fossil fuels with often poor efficiencies. The transition is neither obvious nor easy.

IV. Many countries maintain a focus on security based on indigenous (typically fossil) energy resources. While many UNECE countries are major exporters of energy resources to global markets, strong regional and cultural behaviours lock in an on-going reliance on indigenous resources.

An integrated approach to energy efficiency in buildings is especially important in addressing heating needs, and economically optimising investments in end-use energy efficiency and renewable energy. Supportive policy frameworks need a long term perspective: integrating building owners, the building sector and financiers in substantial retrofits. Heat services remain an imperative for health, safety and productivity in the region. Reticulated gas and district heating systems tend to exist in cities. Smaller settlements and rural areas are much more likely to depend on solid fuels for heat services and cooking.

A chance to re-think the sustainability of heat?
Lower costs for distributed renewable energy and better insulated homes and high costs for updating ageing central district heating systems is enabling a shift from economically unsustainable subsidised heat supply systems. Many district heating systems operate within a municipal mandate that required connection, were built without heat metering, and have struggled under central control economics to update as societal demands evolved.

Case Study: District Heating.

Globally, 15.8 EJ were used in 2010 (2.6 % of global TPES) to produce nearly 14.3 EJ of district heat for sale by CHP (44%) and heat-only boilers (56 %) After a long decline in the 1990s, district heat returned to a growing trajectory in the last decade, rising by about 21 % above the year-2000 level (IEA, 2012a). This market is dominated by the Russian Federation with a 42% share in the global heat generation, followed by Ukraine, United States, Germany, Kazakhstan, and Poland. Natural gas dominates in the fuel balance of heat generation (46%), followed by coal (40%), oil (5%), biofuels and waste (5%), geothermal and other renewables (2.4%), and a small contribution from nuclear.

Development of intelligent district heating and cooling networks in combination with (seasonal) heat storage allows for more flexibility and diversity (combination of wind and CHP production in Denmark) and facilitates additional opportunities for low-carbon technology (CHP, waste heat use, heat pumps, and solar heating and cooling).[55] In addition, excess renewable electricity can be converted into heat to replace what otherwise would have been produced by fossil fuels.[56]

Statistically reported average global efficiency of heat generation by heat-only boilers is 83%, while it is possible to improve it to 90–95% depending on fuel used. About 6.9 % of globally generated heat for sale is lost in heating networks. In some Russian and Ukrainian municipal heating systems, such losses amount to 20–25 % as a result of excessive centralization of many district heating systems and of worn and poorly maintained heat supply systems.[57]

The promotion of district heating and cooling system should also account for future technology developments that impact the district heating sector (building heat demand reduction, high-efficiency single-housing boilers, heat-pump technology, cogeneration reciprocating engines, or fuel cells, etc.), which may allow switching to more efficient decentralized systems.[58] District heating and cooling systems could be more energy and economically efficient when heat or cold load density is high through the development of tri-generation, the utilization of waste heat by communities or industrial sites, if heat (cooling) and power loads show similar patterns, and if heat-loss control systems are well-designed and managed.[59]

Distributed renewable energy is now competing directly with fossil fuel options and taking market share in new plant construction. When used in conjunction with modern low-energy construction techniques, distributed renewable energy is also starting to challenge district heating systems, particularly older smaller systems with often marginal operational economics.

Communities need to now ask whether distributed renewable energy options replacements for the less economic parts of a district heating system offer a lower life-cycle cost to consumers and governments than ongoing system costs of existing district heating.

Below case study provides information on the EU's policy actions for heating.[60]

Case Study: European Union Policy Actions for Heating.[61]

Article 14 of the EU Energy Efficiency Directive 2012/27/EU issues comprehensive guidance on: identifying and implementing adequate measures for efficient district heating and cooling infrastructure, the development of high-efficiency cogeneration, the use of heating and cooling from waste heat and renewable energy sources, where benefits exceed the costs. Procedures for operators of electricity generation installations, industrial installations and district heating and cooling installations to ensure that they carry out an installation-level cost-benefit analysis on high-efficiency cogeneration and/or the utilization of waste heat and/or connection to a district heating and cooling network when they plan to build or refurbish capacities above 20 MW thermal input or when they plan a new district heating and cooling network.

Issue 2: Quality of Supply Challenges Remain, Despite Universal Electricity Access

High levels of industrial and power sector development, and access to electro-technology over the 70 years of post-WWII reconstruction and industrialisation have led to the observed high level of electrification. Electrification rates (the ratio of electricity connections to number of households) across the entire UNECE region have been reported at 100% since 2012. Only Armenia, Azerbaijan, Bosnia & Herzegovina, Kazakhstan, FYR of Macedonia, Moldova and Ukraine had electrification access levels below 95% in 1990[62] and these have since achieved 100% electricity access. Countries in the UNECE region meet the objective for electricity access in the sense of connections to networks, but there are still aspects of this objective that warrant policy attention. There are still 'pockets' of remote settlements where access to electricity remains a challenge:[63]

- Small villages in Bosnia & Herzegovina face abnormally high costs to reinstate electricity distribution systems damaged during the 1990s conflict. The Government, supported by the United Nations Development Programme (UNDP), is developing distributed renewable power solution projects for these communities.
- A 2012-2016 Georgia rural electrification programme, supported by US AID, has connected 29 off-grid villages.
- The Kyrgyzstan Government and Islamic Development Bank are redeveloping supply to 20 settlements in the Balkan region, including supply from Tajikistan.
- In Uzbekistan 1500 settlements (predominantly in the Republic of Karakalpukstan) have no commercial electricity supply. Solutions underway include residential scale solar systems and government promoted mini hydro.
- In Tajikistan, the electricity grid covers 96% of the country, but remote settlements still have no grid connection. A more significant issue is that 70% of the population face outages from reduced winter hydro inflow.

Case Study: A Nexus of Inadequate Services, Vulnerable Consumers and Climate Change.

Synergies among policies to advance social wellbeing and energy poverty and to address climate change are possible, but not achieved in practice. A number of studies warn that unless strong energy efficiency measures are put in place, climate change policy can increase the risk of energy poverty, mainly due to the funding of carbon reduction programmes through utility bills. Experts have been warning that this way of financing the energy transition is highly regressive, because an increase in energy prices affects the poor more than those who are better off. In addition, the poor face a 'double penalty', since they pay for renewable energy subsidies through their energy bills but cannot benefit from producing renewable energy themselves because of high up-front investment costs. A solution could be to improve the energy efficiency of their homes and appliances, but without financial aid these improvements are usually out of reach of the energy poor.

In its March 2013 resolution on the Energy Roadmap 2030, the European Parliament warned that the de-carbonisation strategy could in some Member States cause 'a massive increase in energy poverty' and therefore the situation of these countries should be taken into account. It asked the Member States to protect households from rising energy bills, and suggested that one of the ways to address energy poverty would be combining energy efficiency measures and renewable energy solutions for heating and cooling.[64]

Issue 3: Energy Affordability

Affordability is a growing challenge. All countries have at least part of their household population in energy poverty; widely agreed as more than 10% of household income spent on energy. The UNECE region is particularly challenging in heat services. For example in the Russian Federation 29% of households spend more than 10% of income on energy, in 4 UNECE countries more than 40% of households spend over 10% of their income on energy (Albania 46%, Moldova 52%, Serbia 49%, and Tajikistan 60%).[65]

In reality each of these issues combine together, those that struggle to purchase energy, also struggle to afford and get access to the efficient appliances that will lower their dependence on constrained access to energy, and lower their energy costs.

A service quality affordability problem.

Six UNECE countries have aggregate energy intensities below the 1.5mtoe/capita: Bosnia & Herzegovina, Tajikistan, Turkmenistan, Uzbekistan, Kyrgyzstan, Montenegro, and Georgia. While these countries can improve their energy efficiency and expand the current crop of economic renewable energy, their prospects for productivity and development would improve by increasing energy access to levels of energy intensity achieved by developed countries. These countries warrant attention from access initiatives, and might set 2.0mtoe/capita of lower carbon energy sources as an objective for energy for sustainable development.

There is no comprehensive study on energy poverty across the UNECE, but insights from the EU and other countries show both universality to energy poverty and huge variety in experiences. Any country will have a share of its population struggling to pay energy bills or heat their homes. Examples include:

- The Building Performance Institute Europe estimates 54 million people cannot afford to heat their homes in winter, and 50 and 125 million persons live in energy poverty in the European Union.[66]
- Energy poverty is more prevalent in central and Eastern Europe, where it rose dramatically with the end of state subsidies for energy and increased poverty in general in the 1990s. More than 40% of people in Bulgaria were not able to keep their homes warm in 2014, and 32.9% were behind with their bills. The impacts can be disproportionate. According to the European Fuel Poverty and Energy Efficiency project, groups most at risk are retired and unemployed people, the working poor, those on welfare, elderly and disabled people and single parents.[67]
- The award winning Cold@home website explores the impact on the lives on individuals struggling with energy poverty in documentary form.[68]
- A UK study showed that 87% of low-income households kept up with their bills, but typically they cut back on non- essentials, food and heating. 65% of those who saved on heating were also saving on food, and 59% of those who saved on food were economising on heating.[69]
- A study in Vienna identified that the ways of handling this problematic situation vary greatly and that people follow different strategies when it comes to inventing solutions for coping with the restrictions and finding ways of satisfying at least a part of their basic energy needs.[70]

The impact on humans is real and flows on to unnecessary health and welfare costs to society. The consequences of energy poverty are numerous: an excess number of winter deaths, respiratory problems, increased hospitalisations, greater incidences of mental diseases, as well as negative effects on social life, relationships and education of children.

Energy efficiency is central to addressing energy poverty

Without representative studies of energy services needs, and energy poverty we can only rely on cases studies to explore the scope for improving services. A number of solutions alleviate energy poverty: social welfare payments, progressive tariffs for energy, policies limiting disconnections, information and consumer protection policies. These all work and address the symptoms of poor service. Some measures may produce progressive outcomes, others may create distortions – subsidising one attribute of welfare at the expense of another. Only energy efficiency goes to the heart of the problem addressing the underlying failure of efficient service delivery. A 2010 European Commission paper considers energy efficiency one of the most effective long term measures for lifting people of energy poverty.[71]

The regional profile includes examples where consumers in some countries face poor service quality. There is a growing understanding of energy poverty and the implications that poor access to efficient end-use services has on the lives of individuals. REN21 and Cold at Home http://www.coldathome.today/ highlight in different ways the scale and human impact of inadequate energy services. While consumers may struggle to improve their situation, the role that governments and utilities can play by enabling downstream investments in energy efficiency and renewable energy that simultaneously deliver improved consumer services and an economic return to utilities by minimizing upstream system costs is a significant opportunity in all countries.

Case Study: Community-led Sustainable Energy Programmes in the UK.

The UK government's Community Energy Strategy empowers local government to act on identified energy access and poverty challenges and develop local sustainable energy resources by: Generating electricity or heat; Reducing energy use through energy efficiency and behaviour change; Managing energy by balancing supply and demand; Purchasing energy in collective purchasing processes or switching suppliers to reduce costs (21,000 households switching energy suppliers through the Cheaper Energy Together scheme making an average costs saving of £131).

At least 5,000 community energy groups have been active across the UK since 2008. Community energy projects are currently focused on renewable electricity generation, with the most prevalent technology being solar PV and onshore wind. At least 60MW of community-owned renewable electricity generation capacity is currently in operation. While this remains a small fraction of installed renewable electricity generation capacity, it is located close to communities and there is significant potential for growth. Energy regulators, local authorities, power project developers are required to work with communities. The government is establishing a dedicated Community Energy Unit to act as the Department's policy lead on community energy and to take forward implementation of the strategy.[72]

3.2.2 Opportunities and Prospects

Increasingly, consumers are finding ways to cooperate and address energy service problems and household sustainability themselves. Many cities have community level household sustainability and home weatherization co-operatives that make measurable improvements to vulnerable households despite limited resources. Community-led action can often tackle challenges more effectively than government alone, developing solutions to meet local needs. Putting communities in control of the energy they use can; improve energy security, tackle climate change, help people save money on their energy bills, improve resilience of communities, and deliver social and economic benefits.

Committed action by central government is an effective way to drive improvements in energy service and address energy poverty. Below box provides, provides an effective overview of the multiple benefits from household energy efficiency programmes.

Opportunity: Health and Wellbeing Impacts of Energy Efficiency.

- Aside from potential energy demand reductions, improving energy efficiency in buildings creates conditions that support improved health and wellbeing for occupants. Positive health outcomes are consistently strongest among vulnerable groups, including children, the elderly and those with pre-existing illnesses.
- The most prominent health impacts associated with energy efficiency improvements include reduced respiratory disease symptoms and lower rates of excess winter mortality (EWM) in cold climates. Fewer deaths from dehydration are reported in heat extremes.
- Recent evidence shows that chronic thermal discomfort and fuel poverty have negative mental health impacts; energy efficiency improvements can improve mental wellbeing.
- Health improvements at the individual level generate indirect social impacts and relieve pressure on public health budgets. Modelling of a high energy efficiency scenario showed that reduced indoor air pollution could save the European public health budget USD 99 billion per year in 2020.
- Overlaying proven metrics and assessment methods from epidemiological disciplines with financial metrics can generate market values for identified health benefits, enabling these outcomes to be built into robust policy assessment frameworks.
- When quantified health and well-being impacts are included in assessments of energy efficiency retrofit programmes, the benefit-cost ratio can be as high as 4:1, with health benefits representing up to 75% of overall benefits.
- The body of evidence linking improved health and wellbeing to energy efficiency measures has prompted several governments to make addressing fuel poverty a central element of energy policy, often optimising investments by targeting vulnerable groups.[73]

The scale of energy poverty is significant in a number of UNECE countries and warrants a more effective evaluation. Until the scale and impact on human welfare from the three aspects of energy service are quantified, energy poverty will remain a poorly recognized and diffuse policy challenge.

Upgrading or replacing infrastructure to improve access across the Eastern subregions of UNECE is a larger task than provision of access to the remaining areas with poor access. Both are priorities and both require an underlying analytical and policy base that ensures investment is efficiently allocated to achieve service and access quality improvements, releases multiple social benefits and a transition to renewables.

The overall pace of adoption of clean fuels and technology for cooking remains slow. A continuation of current trends would mean that only six additional countries would achieve universal access by 2030[74] (Azerbaijan, Latvia and Ukraine by 2020, and Estonia, Croatia and Moldova by 2030). Albania, Bulgaria, Kazakhstan, Romania and Uzbekistan are expected to reach 100 % access by 2040, and the Kyrgyz Republic by 2050. The remaining six countries are not expected to reach universal access before 2050. Again this is an area that deserves evaluation in order to better understand the barriers and options for progress.

Consumer norms are not static. Changes in technology stimulate change in energy culture: new heating devices and new insulating technology shift perceptions and accepted norms about warmth and comfort, leading to new material cultures (thermal curtains, better insulation, new heating systems, LED lighting, better refrigerators) and practices (closing curtains, heating bedrooms, tracking electricity consumption).

3.3 End-Use Energy Efficiency

Energy efficiency improvements have a clear impact on consumers: reducing energy costs, boosting business performance and delivering more services for household consumers. Energy efficiency is represented by better cooling and heating systems, more efficient appliances, and advanced vehicles. Investing in energy efficiency is crucial to meeting future energy demand growth and mitigating climate change. It improves productivity and leads to reductions of local pollutants and GHG emissions.

Energy Productivity and per-capita consumption

Energy productivity is the ratio between the value added (and GDP) of a country or sector, and its total energy consumption. It measures the amount of GDP that can be produced with one unit of energy. Energy productivity is not a perfect energy efficiency indicator because it does not reflect differences between countries such as their economic structure, size, or climate. Nevertheless, as an index it can provide useful information when plotted against energy availability measured as TPES per capita intensity. Adjusting energy consumption by the number of citizens makes it possible to compare countries despite differences in population. Per capita energy consumption reflects the wealth of a country, the structure of the economy and the efficiency of energy use. However, countries that are structurally similar can differ in terms of energy use per capita because of differences in size or climate.

Plotting shifts in energy productivity and availability over a period of time illustrates patterns of energy consumption based on economic structure and climate zones. Similar countries exhibit similar trajectories of productivity and per-capita consumption over time, which can inform expectations about how rapidly they might progress to greater productivity and efficiency.

From 2001 to 2012 most UNECE member countries improved their energy productivity despite variances in energy availability (Figures 3.3a-d). Countries with high per capita consumption are prone to reduce energy demand while improving energy productivity. Many European countries show an intense decline in per capita consumption and improvement in productivity over the analysed period.

Most of the Balkan countries are still developing their energy availability. Some countries like Azerbaijan or Tajikistan have made major shifts in productivity, bud still have low levels of energy intensity or low energy availability. In contrast, other countries like Kazakhstan or Turkmenistan have massively increased per-capita consumption but achieved moderate improvement in productivity.

Figure 3.3a: Productivity Trends 2001-2012 in North America and Europe.

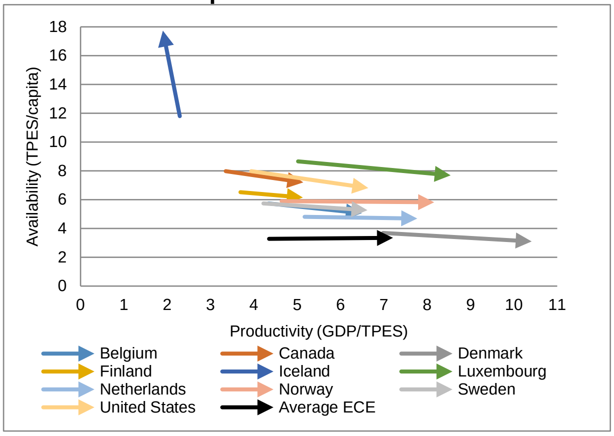


Figure 3.3b: Productivity Trends 2001-2012 in Europe.

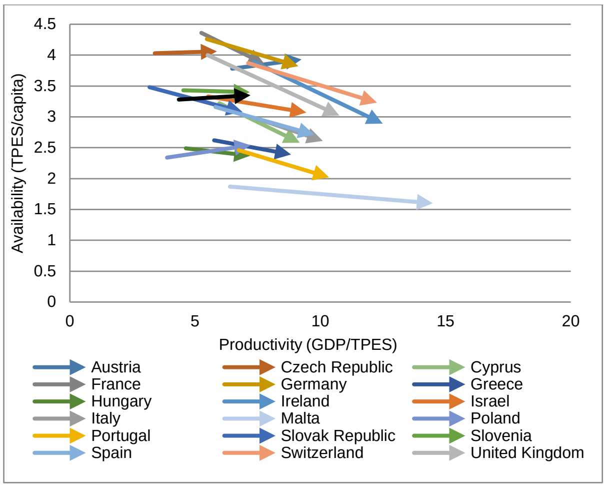


Figure 3.3c: Energy Productivity Trends 2001-2012 for Southeast Europe.

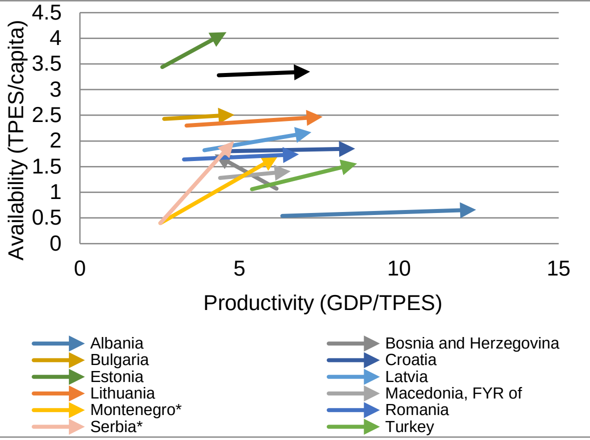
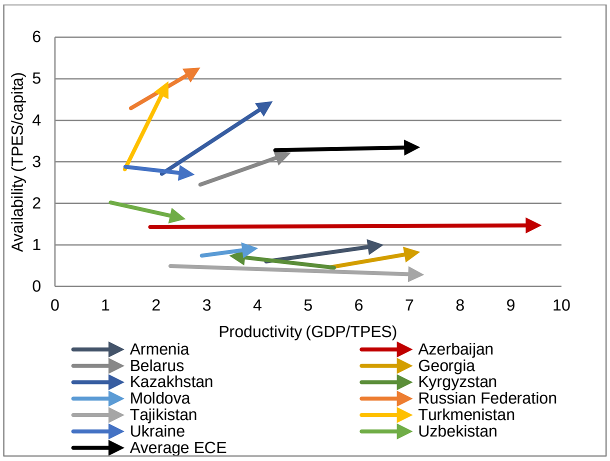


Figure 3.3d: Productivity Trends 2001-2012 in Eastern Europe, Caucasus, and Central Asia.



Note: Due to data gaps, countries not included in calculation: Andorra, Liechtenstein, Monaco, and San Marino). Data for 2001 is given for Serbia and Montenegro as one country.*
Source: IEA (2016g).

Energy efficiency improvements deliver reductions in energy demand, and increased utility to consumers (better light, warmer homes, higher production, public budget reductions, and supply side cost reductions). This important aspect is often undervalued in policy making and investment decisions, but delivers a range of micro and macroeconomic outcomes. [75] The multiple benefits of energy efficiency can be worth much greater than the value of avoided energy demand.

A key issue for policy makers is that the full range of outcomes need to be understood when developing investment options and designing climate mitigation policies.[76] For example, rebound effects may reduce the contribution of energy efficiency improvements to climate change mitigation. Such effects could alter the relative priority of different CO2 abatement policies. Efficiency rebounds can reach 60%, with rebound in developing countries likely much higher than in rich countries.[77]

Drivers for Improving Energy Efficiency

Key drivers for energy efficiency improvements include cost-reflective prices and consistent, enduring energy efficiency policies. Both drivers are required to drive enduring energy intensity improvements. They influence end-use efficiency and utility efficiency investments notably in North America. Long running energy efficiency policies like minimum energy performance standards (MEPS), corporate average fleet efficiency standards (CAFE), and building codes work in a context of competition to improve productivity, displace inefficient production and drive energy efficiency innovations such as electric vehicles and advanced ICT systems.

Achieving absolute energy efficiency improvements requires prices and policies that redefine the energy system as an interconnected cost-reflective system, rather than a supply dominated system. An 'end-use energy efficiency first' demand side led approach also minimizes demand on upstream systems and fossil fuel transition costs, enhances the contribution of renewables investments, and optimizes socio-economic and environmental outcomes.

3.3.1. Selected Issues and Country Responses

Activity growth and static energy demand in the UNECE region reduced average energy intensity from 8.0 MJ/USD in 1990 to 5.1 MJ/USD in 2014. Energy intensity is however not the same as energy efficiency. Changes in activity levels (number of homes, population, GDP etc.) and structure (size of homes, industry activity mix, etc.), and fuel mix changes, confound the clear measurement of energy efficiency and need to be isolated using decomposition techniques. So while energy intensity is used as a prime indicator for energy efficiency, it is only a proxy and is subject to significant extraneous drivers.

Reducing energy intensity has led to significant reductions in energy consumption. UNECE regional energy intensity improvements since 1991 have reduced energy demand in 2014 by 131EJ below what would have been required if energy intensity had been held at 1990 levels. There is much scope to continue this trend.

Improvements in energy intensity are happening, but not fast enough. The average compound annual growth rate (CAGR) of energy intensity in the UNECE region was -1.9 % for the period 1990-2014, while the objective is to attain a -2.6 % rate for the period 2010-2030. Although the UNECE region collectively has reduced energy intensity in industrial, transport and service sectors, the rate of improvement has regressed since 1990 and is uneven as some countries make slower progress than others, despite the attractive economics of energy efficiency.

Table 3.2 summarizes the global investment requirements for energy efficiency and benefits in form of fuel cost saving opportunities.

Table 3.2: Global Energy Efficiency Investment Requirements and Fuel Cost Saving Potential (2012-2035).

	OECD			Non-OECD		
Sector	**Additional investment** ($ trillion)	**Energy savings** (Mtoe)	**Fuel cost savings** ($ trillion)	**Additional investment** ($ trillion)	**Energy savings** (Mtoe)	**Fuel cost savings** ($ trillion)
Industry	0.4	668	1.2	0.7	3 482	2.2
Transport	1.6	1 121	3.0	3.2	2 731	2.7
Buildings	3.2	3 478	5.9	1.4	3 704	1.7
Total	**5.3**	**5 267**	**10.0**	**5.2**	**9 917**	**6.6**

Note: Early retirement of industrial facilities before the end of the technical lifetime by five years is assumed in the Efficient World Scenario and is included in the investment figures.
Source: IEA (2012).

Issue 1: Pollution and Energy Waste from Low Efficiency Heating Systems and Poor Insulation

With a high need for heat services and a high dependence on fossil fuels, both local and global pollution are a significant issues in some countries where locked in reliance on coal, poor heating system efficiency and poor insulation compound to create abnormal air quality problems (see case study below). The choice is stark – either provide heating for human safety and comfort with dangerous levels of air pollution, or suffer inadequate heating.

Effecting change requires a coordinated effort on insulation, heater efficiency and emission controls and access to alternative non-polluting fuels. Industry and transport offer significant opportunities for improved wellbeing, economic performance, and air quality. This requires central government action on improved heating appliances, improve insulation in buildings, improved industrial energy efficiency, cleaner and more efficient transport options. Below case study provides more information on the harm from poor fossil fuel based heating.

Case Study: Local and Global Harm from Poor Fossil Heating and Building Inefficiencies.

The clean fuels and fuel wood heaters that dominate heating services across most of the UNECE region can provide heat with relatively low levels of pollution. However where heating services rely on coal, local as well as global emissions are a significant challenge. It is difficult to burn a complex fuel like coal at low particulate emission levels. Some 400 cities in Europe exceed the daily norms for PM10 levels (50mg/m^3 24hr concentration), with 6 of the 10 most polluted cities in Poland and the remainder in Bulgaria. In Poland, 70% of single-family homes in Poland are heated with coal, with 60% with manually controlled heaters. Despite monitoring and EU fines for exceeding standards, the problem is not going away. There are no standards for coal heaters and 140,000 new coal heaters are installed every year adding to a stock of 3million uncontrolled coal burners. The problem is exacerbated by the 3.6 million homes (70%) that have little or no insulation and only 1.37million with average or better insulation. Market research indicates that 51% of households would be prepared to take up subsidies and loans for energy efficiency improvements.[78]

Issue 2: Buildings: A Lack of Energy Efficiency Building Codes and Slow Retrofitting of Buildings.

Between 1990 and 2014, residential energy intensity across the UNECE region increased from 25 to 26MJ/capita. Residential energy intensity increased from 36 to 37 MJ/capita in North America. In Southeast Europe intensity increased from 15 to 16 MJ/capita, and in Eastern Europe, Caucasus, Central Asia, Turkey and Israel it increased from 19 to 21 MJ/capita. Only in western and central Europe subregion did residential energy intensity improve from 25 to 22MJ/capita.

Energy use in commercial buildings in the services sector is a function of the activities undertaken in the building. In the services sector, between 1990 and 2014, energy intensity across the UNECE region improved from 0.9 to 0.7MJ/USD. Services energy intensity fell from 1.1 to 0.86 MJ/USD in North America, and western and central Europe it declined from 0.7 to 0.59 MJ/USD. In Eastern Europe, Caucasus, central Asia, Turkey and Israel it improved from 1.1 to 0.9 MJ/USD. In southeast Europe service energy intensity increased from 0.1 to 0.57 MJ/USD.

Most UNECE countries have building efficiency regulatory programmes. While an overview cannot assess the suitability, compliance or effectiveness of codes, it can highlight the range of climates, code requirements that exist, and the role that supporting labelling, performance tests and incentives have in complementing codes in countries where policies have matured. Furthermore, the existence of regulation does not imply the degree of application and enforcement of it, and few countries have effective compliance management.

Table 3.3: Summary of Building Codes and Related Policies in the UNECE Region.

Country	Residential Building PJ	Residential Regulatory Policies	Commercial Building PJ	Commercial Regulatory Policies
Austria	289	Austrian Institute of Construction Engineering OIB guideline 2011. Passive House, ZEB incentives for hi efficiency, renovations. 66kWh/m^2/year.	118	Austrian Institute of Construction Engineering OIB guideline 2011
Belgium	375	EPB Flanders 2012, PEB Brussels, PEB Wallonia. Energy certificates, renovation grants 2007, tax incentives 2009.	211	EPB Flanders 2012
Canada	1297	National Building Code of Canada 2010 and state codes. ecoENERGY retrofit (2007)	1054	National Building Code of Canada 2010 and state codes. LEED.
Czech Republic	277	Energy Performance Certificate. Building retrofit subsidies.	131	
Denmark	205	Building regulations (2010). Energy performance certificates, Passive House. ZEB. Tax incentives.	90	Building regulations (2010). Energy performance certificates,
Finland	241	National building Code of Finland 2012. Energy Performance of Building undergoing renovation or alteration. Energy performance certificates, Nearly ZEB. Repair and energy grants.	82	National building Code of Finland 2012. Energy Performance of Building undergoing renovation or alteration. Energy audits.
France	1844	Reglementation Thermique (2012) Diverse tax instruments.	980	Reglementation Thermique (2012)
Germany	2600	EnEV 2012 Energy performance certificates, Passive Haus. ZEB Extensive programme of KfW grants for energy efficiency.	1344	EnEV 2012 Extensive programme of KfW grants for energy efficiency.
Greece	194	KENAK (2010) residential. Energy performance certificates, Passive House ZEB. Energy saving at home 2010.	82	KENAK (2010) non residential
Hungary	240	OTEK National code, energy performance certificates, ZEB. Climate friendly homes (2010)	131	
Ireland	133	Conservation of Fuel and Energy: Dwellings (2011). Energy ratings, Passive House, CO_2 neutral buildings. Better Energy National upgrade, and Warmer Homes scheme.	71	Conservation of Fuel and energy: Buildings other than Dwelling (2008).
Italy	1314	Italy National Building code (2011) Energy Performance certificates, Passive House, Funding in 4 regions.	710	Decree for energy efficiency in requirements in buildings (2015)
Luxembourg	20	Reglement grand-ducal modifie la performance energetique des batiments (2008). Energy Performance Certificate ZEB. Finance aid	17	Energy Performance of Functional Buildings 2010 District heating and energy conservation in public buildings.
Netherlands	482	Bauwbesluit 2015 Chpt 5. Meer met Minder 2008, incentives.	406	Bauwbesluit 2015 Chpt 5.
Norway	181	The Planning and Building Act 2016) Energy Performance Certificate, Enova Fund 2001.	127	The Planning and Building Act 2016), Energy Performance Certificate, Enova Fund 2001
Poland	879	Act of 29 August 2014. The Energy Performance of Buildings Law	358	Act of 29 August 2014. The Energy Performance of Buildings Law
Portugal	120	Regulation characteristics of Thermal Performance of Buildings 2010. New and existing residential. Energy efficiency fund.	86	Energy certification of buildings 2013 non residential
Russian Federation	4666	Thermal Performance of New Buildings 2003. 6 climate zones. 2.1 - 5.6m^2.K/W.	1550	
Slovak Republic	97	Act 555-2005, new residential and energy performance certificates. 2008 ZEB and Passive house. Govt insulation programme and energy efficiency finance facility.	88	
Spain	688	Codigo Tecnico de la Edification (2009) residential, energy efficiency certificates, passive house.	424	Codigo Tecnico de la Edification (2009), non-residential,
Sweden	316	Building Reg's BBR10 (2012). EPBD energy performance certification, ZEB, incentives	208	Building Regs 2010.
Switzerland	270	MoPEC – MuKEn Harmonised energy requirements for the Cantons 2009 36-58kWh/m2/yr depending on building.	153	MoPEC – MuKEn Harmonised energy requirements for the Cantons 2009 36-58kWh/m2/yr depending on building.
Turkey	940	Bep-TR (Regulation of energy performance of buildings) 2010. 4 climate zones	238	Bep-TR (Regulation of energy performance of buildings) 2010. 4 climate zones
United Kingdom	1867	Building regulations, England & Wales 2010, Scotland 2011, Northern Ireland 2010. Supported by BREEAM, Passive House and ZEB labels. Carbon Emissions Target CERT, Community Energy Savings Prog. (CESP2009,	626	Building regulations, England & Wales 2010, Scotland 2011, Northern Ireland 2010. BREEAM Non-domestic.
Ukraine		Ukraine Thermal Insulation of Buildings 2006, New residential		Ukraine Thermal Insulation of Buildings 2006, New residential
USA	11232	IECC (2009) Residential enacted as State codes, supported by ENERGY STAR for new homes, Home Energy Rating schemes and labeling in various states.	8622	IECC (2009). Commercial, and ASHRAE 90.1 (2010) enacted as state codes supported by LEED

Building codes tend to apply to new buildings and the existing under-insulated building stock is not addressed. Finland's Decree (4/13) on improving the energy performance of buildings undergoing renovation or alteration is one of the few regulatory codes that address existing buildings by providing minimum standards for improving energy performance of buildings in renovations and alterations. Within federations, national building codes provide a framework, typically with individual states undertaking state codes consistent with the national code, but responding to state level climatic and other drivers.

The UNECE publication "Good practices for energy-efficient housing in the UNECE region" outlines a range of policy and measures identified to improve occupant comfort and health and reduce energy demands. [79] An UNECE-led initiative on *Framework Guidelines for Energy Efficiency Standards in Buildings* seeks to disseminate transformational, principles-based performance guidance for building energy standards. [80] The effectiveness of regulatory measures is improved by complementary measures. Some UNECE member countries implement non-regulatory measures that fall into three policy classes:

- Controlled consumer information: energy performance certificates, home energy rating schemes, voluntary labelling (e.g., ENERGY STAR ratings for the energy efficiency of new homes),
- Design tools; Passive house and Zero Energy requirements as voluntary codes,
- Fiscal and financial incentives; tax breaks for energy efficient homes, tax deductions for energy efficiency equipment, funds or grants for energy efficiency retrofit programmes,

Other areas that deserve further review include compliance management monitoring and evaluation, carbon certification and targets for buildings (like the UK Carbon Energy Targets CERT), benchmarking different financial assistance and grant schemes to identify best practices.

Issue 3: Improving Appliance and Equipment End-Use Efficiency.

With current information systems, an evaluation of appliance and equipment efficiency is not possible as energy consumption and costs are not accounted separately from building costs.

National energy efficiency standards and labelling programmes including Minimum Energy Performance Standard (MEPS) have been in existence since the 1970s and now operate in more than 80 countries around the world, covering more than 50 different types of appliances and equipment in the commercial, industrial and residential sectors. Table 3.4 summarizes the existence of appliance and equipment regulatory programmes in the UNECE region.

Table 3.4: Appliance and Equipment Regulatory Programmes in UNECE Countries.

Country	Number of Appliances / Equipment	Appliance Regulatory Policies
Canada	54 MEPS 69 labels	MEPS and labelling aligned with US market and international standardization processes. Energuide initiated in 1978 is the oldest energy label. Canada is an ENERGY STAR partner country.
European Union	62 MEPS 35 Labels	EU Ecodesign of Energy-related Products Directive 2009/125/EC and Energy Labelling Directive 2010/30/EU operate across all member states with a system of supranational independent institutions in what is a single market for appliances and equipment. The mandatory EU energy label rates energy efficiency classes ranked from A- G. The directives will lead to energy demand reductions across the EU of 195TWh by 2020. The EU is an ENERGY STAR partner.
Israel	7 MEPS 9 Labels	
Russian Federation	8 MEPS 9 Labels	The Federal Law on Energy Efficiency obliges producers to indicate the class of energy efficiency. Decree N1222 On Types and Characteristics of Goods which should contain information about class of energy efficiency and labelling', Government of the Russian Federation, 31.12.2009 defines product classes.
Switzerland		Switzerland is an ENERGY STAR partner country.
Turkey	25 MEPS 24 Labels	EU Ecodesign of Energy-related Products Directive 2009/125/EC and Energy Labelling Directive 2010/30/EU transposed to Turkish law.
Ukraine	3 MEPS 6 Labels	
USA	47 MEPS 40 Labels	The US Appliance and Equipment Standards Program targets 30% reduction in energy intensity per square foot of building area by 2030. U.S. Department of Energy (DoE) and Environmental Protection Agency (EPA) operate ENERGY STAR internationally.

Sources: IEA (2015) and CLASP

The design and coverage of energy efficiency standards and labelling programmes vary according to national circumstances. Based on evidence from a wide cross-section of countries with energy efficiency standards and labelling programmes, the energy efficiency of major appliances have improved three times faster than the underlying rate of technology improvement.

Case Study: Appliances and Equipment Efficiency: The EU Eco-Design Directive.

The EU Eco-design Directive sets MEPS for 23 classes of energy using products. Ecodesign legislation, which sets minimum energy efficiency requirements, applies to many everyday products sold in the EU, such as dishwashers, fridges and heaters. Some types of product must also display energy labels which show how efficient they are.

EU Eco-design Directive. Four of the most energy intensive industrial products (electric motors, circulator pumps, fans and water pumps) are regulated to minimize energy costs and environmental impacts over their respective life cycles and will lead to energy demand reductions across the EU of 195TWh by 2020. The policy has been accompanied by significant technology development and has initiated EU and global standardization processes. [81]

By 2020, use of energy efficiency labels and Ecodesign requirements is projected to lead to energy savings of around 165 Mtoe (million tonnes of oil equivalent) in the EU, roughly equivalent to the annual primary energy consumption of Italy. In relative terms, this represents a potential energy saving of approximately 9% of the EU's total energy consumption and a potential 7% reduction in carbon emissions. In 2030, this saving is projected to grow to 15% of the EU's total energy consumption and 11% of its total carbon emissions. [82] [83]

Minimum Energy Performance Standards and Labelling

One-off improvements of more than 30% have been observed when new energy efficiency standards and labelling programmes are introduced to a market where few energy efficiency schemes existed previously. These substantial efficiency improvements for individual appliances and equipment have translated to national energy savings and reductions in CO_2 emissions. The most mature national energy efficiency standards and labelling programmes cover a broad range of products and are estimated to save between 10% and 25% of national or relevant sectoral energy consumption. In all of the energy efficiency standards and labelling programmes reviewed by the 4E programme, the national benefits outweighed the additional costs by a ratio of at least 3 to 1.

Energy efficiency standards and labelling programmes deliver energy and CO_2 reductions while also reducing total costs. Appliances and equipment covered by energy efficiency standards and labelling programmes have not only dramatically improved in efficiency over the past 20 years, but are also cheaper to purchase. While energy efficiency standards and labelling programmes may have caused small changes in prices close to the implementation of new energy efficiency measures, they appear to have had little long-term impact on appliance price trends. [84]

Case Study: Appliance Energy Efficiency Market Transformation Process in Turkey. [85]

The most important component and starting point for a successful market transformation is the improvement of regulatory framework in agreement with local manufacturers. In the case of Turkey, Customs Union and the presence of worldwide reputable manufacturers in Turkey became an important driving force for an accelerated market transformation. These facts led Turkey to adopt MEPS more rapidly, and ensured completion of transformation of products on the market within about 1.5 or 2 years and, considering the average service life of appliances, it is expected to achieve full market transformation within 10 years. The costs and benefits of transformation depend on many factors like whether the country has a significant appliance manufacturing industry, size of manufacturing industry, international trade relations, level of awareness of supply chain and consumers.

The MEPS and Labelling regulatory framework, adoption of internationally consistent standards via transposition of EU Directives, pro-active market surveillance, laboratory inventory, and training and communications projects contribute a market transformation effort. Results provide energy savings of 730 GWh corresponding to a GHG reduction of about 450,000 tCO2 by the midway of the project implementation. These figures are expected to reach about 3700 GWh and 2.4 $mtCO_2$ respectively by the end of the project.

The Market Transformation of Energy Efficient Appliances in Turkey is a good example for other countries where no or little energy efficiency related legislation is in place and no market transformation movement has been launched so far.

Governments need to underpin energy efficiency efforts with a level playing field of energy efficiency regulations for industrial equipment. MEPS and labelling policies have widespread global impact and target essential energy intensive equipment such as electric motors. Use of international standardization ensures alignment and access to global appliance markets for local industry. Regulatory action is measurable and deliberate. Programmes have been assessed as providing up to 17:1 return on government investments. A regulated 'level playing field' enhances consumers and suppliers confidence to invest in higher efficiency products.

Issue 4: Improving Transport Sustainability and Service Quality

Transport energy intensity

Between 1990 and 2014 transport energy intensity across the UNECE region improved from 20.4 to 12.3MJ/USD. Transport energy intensity fell from 31 to 17 MJ/USD in North America and from 14 to 8.1 MJ/USD in Western and Central Europe. In Southeast Europe transport energy intensity fell from 8.8 to 8.0 MJ/USD. In Eastern Europe, Caucasus, Central Asia, Turkey and Israel it improved from 15 to 10 MJ/USD.

The subregional comparisons highlight how different transport productivity can be in different countries. North American energy intensity in 2014 was 17

MJ/USD while Western Europe's was under half this energy intensity at 8.1 MJ/USD. Geographic differences make up much of this, as European cities and countries are closer and more compact with higher population densities and economic structures than their North American counterparts. Southeast Europe and Western Europe have nearly identical transport/GDP energy intensities, but the economic structures and transport systems are vastly different.

Vehicle fuel economy

Global transport uses 93% of oil production, the balance of transport energy being electric rail and urban rail or electric bus systems. Apart from cities in Western Europe, most countries in the UNECE region are reliant on conventional fossil fuelled light duty vehicles for passenger transport, and fossil fuelled heavy-duty road vehicles for freight. Even with high levels of access to vehicles, mobility may still be constrained for some citizens. Affordability of efficient vehicles or fuel, limits to transport option and networks, and climatic extremes all limit mobility.

While the average fuel economy of vehicles continues to improve, the rate of progress has slowed in recent years. The average amount of fuel required to travel 100 km improved by 1.1% in 2014 and 2015, down from 1.8% between 2005 and 2008. The change reflects the composition of global car sales, as Light Duty Vehicles sold in OECD countries use less fuel than those sold in non-OECD countries, and suggests a technological gap in engine technology between the two regions. However due to the popularity of large, heavy and powerful vehicles in the United States America and Australia, total fuel use per kilometre travelled in these countries remains greater than outside the OECD. [86]

Fuel economy improvements in non-OECD countries outpaced those in OECD countries. This is a major change from the trends observed in previous assessments. There are two major reasons for this: trends occurring within specific markets, and effects attributable to market changes within OECD and non-OECD country groupings.

Case Study: The Global Fuel Economy Initiative's (GFEI) Activities in Georgia, the FYR of Macedonia, and Montenegro. [87]

GFEI is working with UNECE countries from Eastern Europe, Southeast Europe the Caucasus, the United States and the European Union to promote improved fuel economy. Three examples for in-country work is provided below:

FYR of Macedonia

A summary of the relevant automotive fuel economy-related EU Directives has been drafted and REC Macedonia, the local GFEI implementing partner, is collaborating with the Ministry of Economy, which is responsible for EU approximation. The auto fuel economy baseline data collected and analysed to date with the Faculty of Mechanical Engineering includes data from 2005, 2008 and 2013. FYR Macedonia's vehicle stock of total registered vehicles has seen modest growth, with just over 350,000 vehicles total stock in 2013. The energy efficiency of the average vehicle improved over the years surveyed, from over 200 g CO2/km in 2005 to below 150 g CO2/km by 2013.

Montenegro

A first working group meeting has been held. The roles and responsibilities of the work group members have been allocated to: a) provide a review of national legislation and current policy (including taxation) related to fuel economy issues; b) identify key stakeholders and potential barriers to implement fuel economy policy; c) analyse the relevant EU Directives that set vehicle emission standards; and d) set up a roadmap for transposition of these EU Directives to national legislation.

Georgia

Georgia has completed a baseline (2008-2012), and a white paper on taxation has been submitted to government. The white paper stresses the need for taxation reform in order to improve the fuel economy of the automotive fleet. Analysis of the Georgian car fleet (both imported new and used vehicles) from 2008, 2010, 2011 and 2012 using the GFEI Fuel Economy Policies Impact Tool (FEPIT) has been carried out and a list of actions was produced that will inform the development of a national car fuel economy improvement plan in Georgia.

Recent trends

From 2014 to 2015, OECD countries improved their average fuel economy by 0.5%, compared with 1.8% from 2012 to 2013. This rate decline resulted from the combination of a weakening improvement trend in North America, a trend reversal in Japan, continued improvements taking place in Europe, and market shares that have not experienced major changes in 2015.

- The United States achieved only a small 0.5% annual improvement in average fuel economy, marking a slowdown in improvement compared with the 2.3% average improvement over the 2012-13 time period. This reflects a tendency towards an increase in the average power of new vehicles and is consistent with the fall in oil and petroleum fuel prices.
- Most European OECD countries experienced average annual fuel economy improvements of 2% to 3%, which are much closer to the 3.6% improvement rate needed to meet the 2030 target of the Global Fuel Economy Initiative (GFEI) [88], but still falling short of it. The continued improvement in fuel economy in Europe in 2015 is coherent with the weaker impact of changes in oil prices (due to the high fuel taxation regime applied in all European countries, changes in oil prices result in a lower percentage change in fuel prices).[89]
- In 2015, new LDV registrations in the Russian Federation totalled 3 million. The on-road stock of LDVs is estimated at 34 million in the same year. LDV ownership attained nearly 0.24 LDVs per capita, which is much higher than the average for other countries with comparable levels of personal income. Fuel economy is not regulated in the

Russian Federation. However, the Russian Federation levies an annual circulation tax on vehicle owners, which increases progressively with vehicle power. From 2010, large vehicles experienced improving specific fuel consumption, with stagnation between 2012 and 2015. Medium-sized LDVs have seen a continuous decrease in specific fuel consumption since 2005, in line with the total average fuel economy. Newly registered small LDVs saw a deteriorating average fuel economy for most of the years since 2005. However, from 2012 onward this trend reversed, with a minor move towards improvement. Specific fuel consumption by powertrain also demonstrated contradicting trends. While diesels saw improving fuel economy, hybrid vehicles worsened. The trend seen in gasoline LDVs was reflected in total specific fuel consumption due to their high market share. [90]

Issue 5: Improving Industrial Productivity with Energy Efficiency

As global populations and economies grow, the demand for energy intensive materials (metals, plastics, cement, pulp and paper) is expected to increase by between 45% and 60% by 2050, from 2010 levels. [91] Many factors of production are at local resource or waste sink limits. Whereas GHG emissions present a global physical limit to increasing production with current technology and methods. Productivity Improvements are needed that simultaneously minimise resource and environmental impacts and address the needs of growing economies.

Between 1990 and 2014, industrial energy intensity across the UNECE region improved from 7.5 to 4.9MJ/USD. Industrial energy intensity fell from 7.8 to 5.6 MJ/USD in North America, and from 4.7 to 3.5MJ/USD in Western and Central Europe. In Southeast Europe industrial energy intensity fell from 5.3 to 4.1 MJ/USD. In Eastern Europe, Caucasus, Central Asia, Turkey and Israel it improved from 10 to 6.7 MJ/USD.

The Institute of Industrial Productivity estimates that energy management can reduce direct energy costs of individual businesses by 10-30%. [92] Most industrial energy efficiency investments pay back in less than 3 years, largely because industry is focused on short-term risk and opportunities. For emerging economies, energy efficiency offers a strategic route to improved industrial productivity, an important driver for increasing wealth and welfare.

Industry energy efficiency contributes or 35% (3452Mtoe) of the total estimated energy savings from 2012 to 2035 in the IEA's Efficient World Scenario. Additional investments of USD0.7Tn is required over this period but results in USD2.2Tn in fuel cost savings.[93]

Recognising the private ownership and competitive markets that most business exist in, a number of governments have developed industry – government voluntary partnerships to realise the potential for energy efficiency in industry. Two examples from UNECE countries, Canada and the Netherlands highlight the nature and scope for energy efficiency improvement from energy management programmes.

Case Study: Industry-Government Agreements for Industrial Energy Efficiency – Examples from Canada and the Netherlands.

CIPEC, Canada

5-year change in energy consumption solely attributable to the CIPEC program has been assessed by analysis of covariance to remove key extraneous factors that could potentially mask the program's true impact. A direct link between energy-related decisions and participation in the CIPEC program is evident. Results also demonstrate that participants utilize a range of program elements to varying degrees. After extraneous factors are removed, analysis shows that the adjusted mean 5-year change in energy consumption among CIPEC program participants is an increase of only 2.2%, which is 2.4 times lower than the adjusted mean increase of 5.2% among non-participants. Isolating the effects of the CIPEC program. Analysis reveals that participation in the program reduced energy consumption changes over 5-years by more than half on a total facility basis. [94]

Long Term Industry Agreements, Netherlands.

In the Netherlands over 95% of industrial energy consumption is now covered by the third development phase of Long Term Agreements (LTA). The 1st phase was based on energy efficiency. The 2nd phase; LTA 2, (2001 – 2012) was based on Energy Management Systems (EMS). In 2006 90% of companies complied with EMS (or ISO 14001). LTA 3 (2009-2020): LTA 2 + all energy intensive companies using more than > 0.5 PJ) totals 1100 companies equals 95% of industrial energy consumption. Energy Efficiency improvement results for LTA-2 companies shows that they achieved twice the energy efficiency improvement of non-LTA companies. From 2001 to 2008, energy efficiency improvements achieved by Long Term Agreement members were 2.4% versus 1% for non-LTA industries. [95]

Because most of industrial growth will be in 'other industries', it will be important to extend analysis and policy beyond the historical focus on energy intensive large industrial processes. There is an urgent need to re-define energy efficiency in terms of energy productivity and business improvement objective functions if the global welfare and environmental improvements sought in the UN's Sustainable Development Goals are to be achieved.

Most governments are much more motivated to improve the country's social wellbeing, economic productivity and environmental impacts rather than "saving energy". Improving the country's GDP per unit energy productivity is a priority for a number of countries can all be enhanced or delivered by energy efficiency policies and measures. Table 3.5 summarizes the multiple benefits of increased productivity for different levels.

Table 3.5: Productivity Outcomes from Energy Efficiency Multiple Benefits in Industry

Energy Efficiency Impact	Economic Outcomes	Social Outcomes	Environmental Outcomes
The Business	• Profitability and productivity improvements can be 40 -250% of energy cost savings. • Technical energy efficiency improvements new processes and technology • Improved energy security. • Improved competitiveness. • Technology spill over & supply chain improvements. • New business opportunities.	• Safer working conditions. • Improved job satisfaction, better working conditions.	• Reduced local pollution air and water emissions. • Water conservation. • Reduced physical waste.
National Economy and Society	• Macroeconomic gains. • Increased employment. • Increased tax revenue from higher value services • Economic restructuring to higher value activities • Improved global competitiveness.	• Improved health from lower local pollution.	• Reduced local pollution, air and water emissions. • Water conservation. • Reduced physical waste.
Global Society and Environment	• New opportunities for trade in green technology and services.	• Less conflict over constrained resources and waste streams. • Higher value labour in energy productivity products and services	• Reduced demand on extraction of finite primary energy and physical resources. • Reduced GHG and other air and water emissions.

Sources: Derived from IPCC (2014a).

Energy Management is central to progressing energy efficiency in industry

All industrial processes can improve their energy productivity. ISO 50001 (like ISO9000, and ISO14000) establishes a framework for effective energy management processes so that businesses can identify, understand, and invest in energy efficiency projects that develop their businesses and improve productivity. After instituting cost-reflective energy prices, energy management is the most important and universally effective policy option for the industrial sector, as in identifies economic opportunities for energy efficiency and renewable energy regardless of processes, and enables capabilities to make these investments.

Case Study: ISO 50001:2011 Energy Management Systems. [96]

The ISO 50001:2011 Energy management system provides the requirements with guidance for use for a framework for organizations to:

- Establish an energy policy;
- Allocate resources and create teams to implement an energy management system;
- Conduct energy reviews;
- Identify opportunities for improving energy performance;
- Establish baselines and energy performance indicators for tracking progress;
- Set energy performance improvement targets; and
- Implement action plans to achieve those targets.

Central elements of the standard include energy performance in operations, procurement and design, as well as an internal audit process to determine how well the organization is doing in implementing the system and achieving its targets. A continuous improvement process includes management review. An energy policy and energy planning process institute implementation and operation checking and controls. Information systems underpin energy management, using internal audits of the energy management system, energy monitoring, measurement and analysis to identify non-conformities, correction, corrective and preventive action for energy use and productivity.

Energy Management Capacity building

To extend application of energy management systems and decision-making capacity for energy efficiency investments, more and more organisations focus on the improvement of capacities of energy managers within organisations as well as external energy auditors and advisors. For example, UNIDO supports countries to improve industrial productivity, with energy efficiency being a central theme alongside cleaner production environmental stewardship. It has developed an energy management system expert training that establishes a durable energy management capability in businesses. [97]

Furthermore, GIZ provides targeted trainings as well as train the trainer seminars for energy management, energy efficient buildings and performance, energy controlling and energy audit, in a range of countries including the Ukraine and Turkey. [98]

3.3.2 Opportunities and Prospects

Market transformation: Renovating the building sector to renovate the buildings

Construction sectors tend to be highly decentralized and fragmented: building owners, designers, multiple suppliers and constructors, many dwellings are built by small builders with little access to efficient production techniques or modern building components that enable energy efficiency. In rural areas there may be a large share of informal construction. Compliance with building codes is generally poor. These complex and uncoordinated markets are inherently more difficult to improve. Applying regulatory controls and energy efficiency standards for buildings is unlikely to be effective when industry capacity to respond is limited. UNECE has developed framework guidelines for energy efficiency in buildings and is undertaking a broad-based education and dissemination programme to address these challenges. [99]

Supply chains for more energy-efficient buildings and the compliance infrastructure are often underdeveloped. Although energy efficiency standards for buildings were introduced in many countries in the 1990's, compliance enforcement is underdeveloped, or may be effective only in larger apartments or commercial buildings. In many countries, poor management of energy efficiency features at the architectural design phase, and inconsistent implementation during construction means regulations may be largely ineffective by themselves.

Opportunity: Developing Supply Chain Capability for Renovation. [100]

Ramping up the innovation and competitiveness of the construction sector throughout the entire value chain increases the depth and rate of energy renovation. Successful programmes of deep energy renovation are feasible at a large scale if they are supported by policy measures, and more collaboration among actors. A set of ingredients must come together:

- Aggregation of demand; facilitators and integrators of technical solution packages;
- Advisory services that give power to customers; having "à la carte" options designed to fulfil users' needs and ambitious policy targets.
- Implementing support measures that encourage innovation and scaling up deep energy renovation
- Establishing a harmonised energy renovation target at the EU level and making public funding conditional on performance achieved is one of the key recommendations.
- Empowering frontrunners such as cities, regions or private initiatives to go beyond the set goals and lead by example accelerates the rate and depth of energy renovation.
- Public authorities should also lead by example and plan an integrated energy management approach to increase the energy performance of the building stock they own and occupy.

Building owners are not well informed about or motivate to ask for energy efficiency or comply with building energy efficiency standards. This is a general issue with new residential buildings. Only recently have commercial property owners started to recognise that the lower energy and operating costs and better rentals of energy efficiency buildings translate to increased capital value.

While much is made of the importance of energy efficiency building codes, they can achieve little in many countries without a deliberate effort to improve the capacity of the entire building value chain top deliver a substantially new outcomes. Programmes like the Netherland's EnergieSprong that focus on transforming the building value chain as a system, work with all the decision makers in the system.

Counting the benefits of building insulation

Many building retrofit programmes undervalue the multiple benefits of energy efficiency initiatives. Health benefits in terms of reduced hospital visits, doctor's visits, prescription costs, and reduced sick days, can exceed the energy cost reduction significantly in some cases by 400%. The challenge is that these benefits have not always been well evaluated or considered, and one country's drive for comfort and wellbeing in buildings differ from another's.

Opportunity: Transforming the Building Value Chain: EnergieSprong. [101]

Energiesprong uses the social housing sector in each market as the Launchpad for these solutions, with a view to later scale to the private home-owner market. The independent Energiesprong market development teams aggregate mass demand for high quality retrofits (and new built houses) in a market and create the right financing and regulatory conditions in parallel. With this structure in place, solution providers can go into a quick and transformative innovation process to deliver against this new standard.

The Energiesprong refurbishment standard implies a renovation is completed within one week, without residents having to vacate the home. Moreover, it comes with a 30 (or 40!)-year warranty covering both the indoor climate and the energy performance. The refurbishment is financed by combining the energy costs savings from the tenants, and the costs the social housing organisation saves on maintenance. Ultimately, residents get a better and more comfortable house without any additional monthly expenses.

In 2013, Energiesprong brokered the "Stroomversnelling" deal between Dutch building contractors and housing associations to refurbish 111,000 homes to Near Zero Energy. Two years later, the Stroomversnelling network consists of contractors, component suppliers, housing providers, local governments, financiers, TSOs and other parties. Its goals are to reduce the price of Near Zero Energy renovations, increase occupants' acceptance of these renovations and increase the momentum and growth pace of the NZE housing market itself. Energiesprong programmes are now underway in France, the UK, Germany and New York State.

Lessons learned.

- Fix on a clear objective: 'zero energy' in the case of Energiesprong.
- Ensure interventions deliver the full objective rather than incremental or partial changes
- Ensure energy performance guarantee refurbishments are financially more attractive than existing options.
- Employ a market transformation strategy to 'articulate initial mass-market demand using social housing stock. Use this to motivate:

- Regulators to lift observed and unforeseen barriers,
- Financiers to re-evaluate value propositions,
- Builders to invest in better concepts and industrialized refurbishment or new construction packages.
- Work though programs with scale, avoid stand-alone projects unless they show how to structurally improve market conditions for E= 0 programs
- Mobilize collaborative programs where builders and suppliers share knowledge and work together.

A key multiple benefit is the reduction in public budgets from reductions in health and energy subsidies resulting from energy efficiency. Governments can recognise the public benefit from energy efficiency projects account for energy cost reductions in terms of cost of new supply, or export prices and add this to the private benefits regardless of the level of energy subsidies.

Opportunity: The Economics of Building Energy Efficiency are more Compelling with a Societal Perspective. An example from Uzbekistan.[102]

Replacing nonstandard and inefficient (also known as ‘homemade’) gas boilers in detached houses and small commercial buildings with efficient modern gas boilers could reduce gas consumption by about 2.4 billion m3 per year, about 13 % of the total gas consumption in residential, commercial, and public buildings in 2013. Enforcing the current building energy efficiency standards in the construction of new detached houses, which account for 99 % of new residential construction, could cut heat energy demand of these new buildings by 50 percent, compared with those that do not implement the requisite energy efficiency measures. In schools and health care facilities, recent demonstration projects achieved over 40 % reduction in space heating energy use through comprehensive thermal retrofit of buildings. All these energy savings can be attained with domestically available technology, products, and materials. They remain largely untapped primarily due to financial, institutional, and informational barriers. Replacement of the current stock of nonstandard gas boilers with modern gas boilers would require investments of about Uzbekistani Som 3.2 trillion, or about US$1.2 billion at end of 2015 cost estimate and official exchange rate. The financial simple payback periods for residential and commercial consumers are about 6.6 and 5.2 years, respectively, based on the end of 2015 retail gas price. The simple payback periods are shortened to about 3.4 and 2.7 years, respectively, based on the end of 2015 export gas price.

The Avoid – Shift – Improve approach to transport efficiency

The Global Fuel Economy Initiative has a ‘100 to 50 by 50’ objective of doubling the average fuel economy of new cars by 2030 and all cars by 2050. While global average fuel economy improved by 1.0% on a yearly basis from 2014-15, this is 0.5% less than average improvement in fuel economy from 2010 to 2015 and around one-third of the improvement rate needed to meet the 2030 GFEI target. Of UNECE subregions only Western Europe was close to this range (2-3%). Most countries achieved less than 0.5% improvement. Small LDVs experienced deteriorating specific fuel consumption, while medium LDVs saw improving average fuel economy. Newly registered large LDVs gained weight between 2010 and 2015, but their average fuel economy did not change.

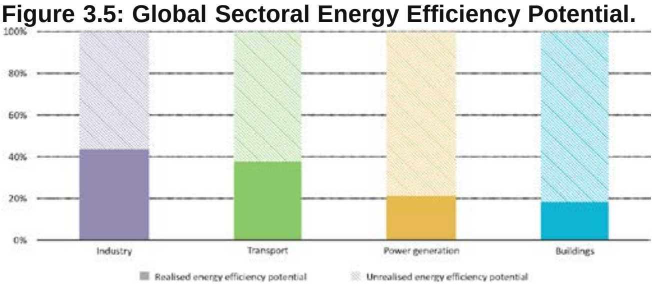
A combination of three strategies can limit transport energy growth to 5% above 1990 levels and reduce transport CO2 emissions by 28%: 1) avoiding the need for travel; 2) slowing travel energy demand growth with better urban planning and demand management and adopting higher fuel economy vehicle and modes; and 3) shifting to lower energy travel modes like public and active transport.

A shift to electricity-based transport could deliver huge improvements in drive train efficiencies and open a way for renewable energy to meet transport energy demand. Most countries are ‘takers’ rather than ‘makers’ of vehicles, and while they take what is produced, global fuel economy standards oblige the production of more efficient vehicles. Recent slowing of vehicle fuel economy progress shows how much consumer prices and policy choices can shape transport intensity. Of the end-use sectors, transport is often the most neglected. While residential, commercial, and industry sectors often have reasonably well developed policies, transport ministries are often distanced from the mainstream stationary energy efficiency efforts.

Developing energy efficiency policies for sustainability

No sector has reached even 50% of its efficiency potential. Between 60% and 80% of the global economic potential for energy efficiency is unrealized (see figure 3.5).

Figure 3.5: Global Sectoral Energy Efficiency Potential.



Note: Potentials based on efficiency scenarios to 2035.
Source: IEA (2012).

A range of policies have been developed and implemented within the UNECE region. Notably, the 2006 EU Directive on Energy End-Use Efficiency and Energy Services (Energy Services Directive) requires Member States to submit NEEAPs in 2007, 2011 and 2014. In the first NEEAP, each Member State should have adopted an overall national indicative savings target for end-use sectors of 9% or higher, to be achieved in 2016, and with an intermediate target for 2010. Table 3.6 summarizes the work to date in reviewing and developing energy efficiency policies and targets in UNECE member States.[103]

Table 3.6: Independent Reviews and Energy Efficiency Policies in UNECE Countries.

Country	Energy Efficiency Policy Review	National Energy Efficiency Action Plan (NEEAP) [104] or equivalent. / *Energy efficiency target.*
Albania	ECS Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA) 2013 ECS review 2008	NEEAP, 2011
Andorra		
Armenia	ECS PEEREA 2005 IEA 2015	National Program on Energy Saving and Renewable Energy, 2010
Austria	IEA IDR 2014	NEEAP, 2017
Azerbaijan	ECS PEEREA 2013 IEA 2015	No Strategy. *Target 20% energy efficiency improvement by 2020.*
Belarus	ECS PEEREA 2013 IEA 2015	37% GDP energy intensity reduction by 2035 from 2010' (by 2020 GDP energy intensity should be reduced by not less than 13%).
Belgium	IEA IDR 2016	NEEAP, 2017
Bosnia & Herzegovina	ECS PEEREA 2012 ECS review 2008	NEEAP, 2012
Bulgaria	ECS PEEREA 2008	NEEAP, 2017
Canada	IEA IDR 2015	Energy Efficiency Act 2009
Croatia	ECS review 2010	NEEAP, 2014 (2017 under consultation)
Cyprus		NEEAP, 2014
Czech Republic	IEA IDR 2016	NEEAP, 2017
Denmark	IEA IDR 2011	NEEAP, 2017
Estonia	IEA IDR 2013	NEEAP, 2017
European Union	IEA IDR 2014	European Commission Action Plan on Energy Efficiency 2006. Note 1.
Finland	IEA IDR 2013	NEEAP, 2017
France	IEA IDR 2016	NEEAP, 2017
Georgia	ECS PEEREA 2012 IEA 2015	NEEAP 2017 *pending government approval*
Germany	IEA IDR 2013	NEEAP, 2017
Greece	IEA IDR 2011	NEEAP, 2014
Hungary	IEA IDR 2011	NEEAP 2015
Iceland		
Ireland	IEA IDR 2012	NEEAP 2017
Israel		
Italy	ECS review 2009	NEEAP, 2014
Kazakhstan	ECS PEEREA IEA 2015	Energy efficiency programme 2020. *25% energy intensity reduction by 2020*
Kyrgyzstan	ECS review 2011 IEA 2015	Law on energy conservation and energy efficiency in Buildings 2013.
Latvia	ECS PEREEA 2008	NEEAP, 2017
Liechtenstein		
Lithuania		NEEAP, 2014
Luxembourg	IEA IDR 2014	NEEAP, 2014
Malta	ODYSSEE-MURE 2012 Energy Efficiency Watch (EEW) 2013	NEEAP, 2017
Republic of Moldova	IEA 2015	NEEAP, 2013. Reduce energy intensity by 10%, building energy by 20%.
Monaco		
Montenegro		NEEAP, 2014
Netherlands	IEA IDR 2014	NEEAP, 2017
Norway	IEA IDR 2011	Note 2.
Poland	IEA IDR 2016	NEEAP, 2014
Portugal	IEA IDR 2016	NEEAP, 2013
Romania	ECS PEREEA 2006 ODYSSEE-MURE 2012	NEEAP, 2014
Russian Federation	IEA IDR 2014 ECS review 2007	Federal Program to reduce energy intensity by 13.5% by 2020
San Marino		
Serbia		NEEAP, 2013
Slovak Republic	ECS PEEREA 2009 ECS review 2006 IEA IDR 2012	NEEAP, 2017
Slovenia		NEEAP 2014
Spain	IEA IDR 2015	NEEAP, 2017
Sweden	IEA IDR 2013	NEEAP, 2017
Switzerland	IEA IDR 2012	NEEAP, 2008

Tajikistan	ECS PEEREA 2013 IEA 2015	Law on energy efficiency and energy saving 2013.
The FYR of Macedonia	ECS review 2006 ECS PEEREA 2007	NEEAP, 2014
Turkey	ECS PEREEA 2014 IEA IDR 2016	NEEAP (under development)
Turkmenistan	IEA 2015	
Ukraine	IEA IDR2012/13/15 ECS 2013	Strategy to 2030 proposes 30% - 35% energy intensity reduction to 2030
United Kingdom	IEA IDR 2012	NEEAP 2017
United States	IEA IDR 2014	National Action Plan for Energy Efficiency (NAPEE) 2006
Uzbekistan	IEA 2015	Law on Rational use of energy updated 2003. *No targets.*

Source: IEA IDR (In Depth Reviews). IEA Policies and Measures Database. IEA (2015a) Eastern Europe, Caucasus and Central Asia, 2015. World Energy Council, Enerdata, Agence de l'Environnement et de la Maîtrise de l'Énergie 2015; Energy Efficiency Action Plans by country. European Commission 2015; Energy Community Secretariat 2015; Austrian Energy Agency 2015; A common Nordic end-user market: Consequences of the EED (Berit Tennbakk et al.); Nordic Council of Ministers 2014.

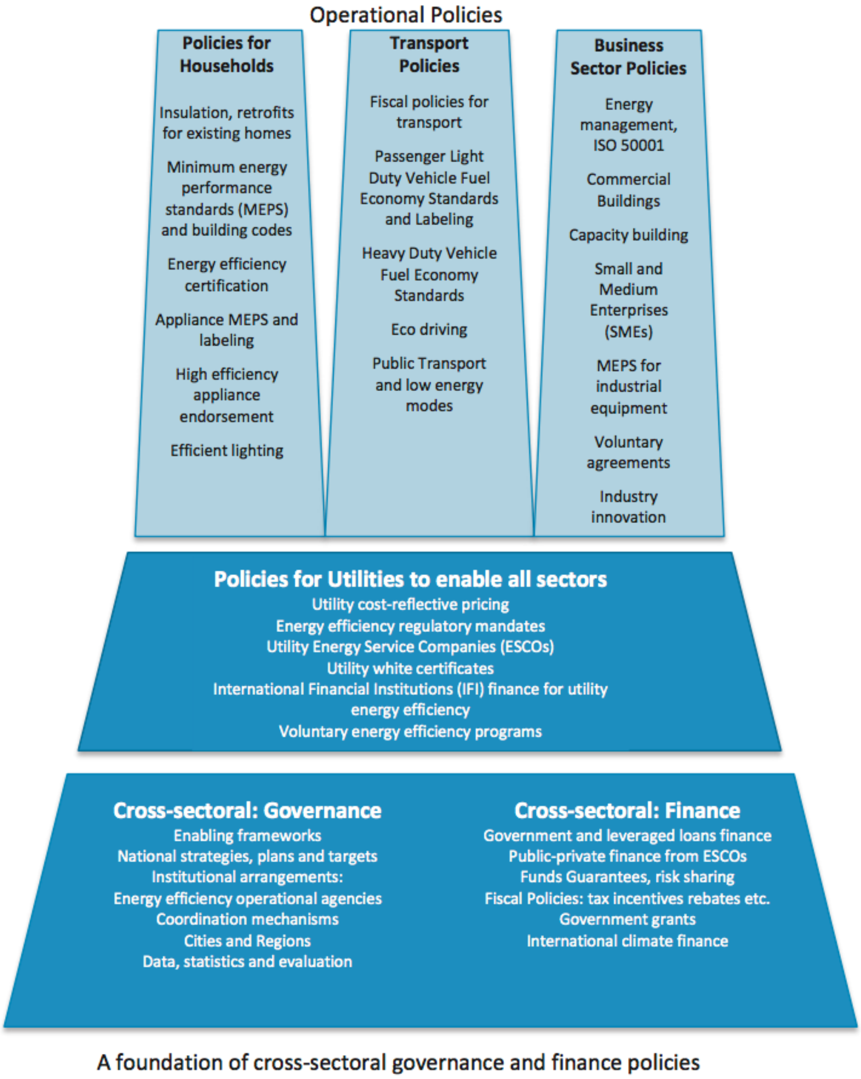
The 2006 Energy Services Directive requires Member States to submit NEEAPs that set out estimated energy consumption, planned energy efficiency measures and improvements individual EU countries expect to achieve. In the first NEEAP, each Member State should have adopted an overall national indicative savings target for end-use sectors of 9% or higher, to be achieved in 2016, and with an intermediate target for 2010.[105] ENOVA (Norwegian National Energy Agency), established 2001, works on energy efficiency improvement, production of energy from renewable energy sources, promoting new technology and enhancing general knowledge about the possibilities for using efficient, environmentally friendly energy solutions.[106]

Developing effective energy efficiency policies

To tap into the vast reserve of potential efficiency and renewable energy improvements, governments need to commit to sound governance, improved data, and enabling policy frameworks that lead to efficient investment decisions. An enabling framework of governance and financial policies remains the key challenge in most countries.

Figure 3.6 summarizes the scope of energy efficiency policies outlined in a UNECE report which highlights the need for a base of cross-sectoral policies as foundations for energy utility policies, an enabling finance system and operational policies in households, transport and business sectors.

Figure 3.6: A Best Practice Framework of Energy Efficiency Policies.



Source: UNECE (2015b).

Best practices in policies can only be effective if they are fully applied in a local context. Policies that have worked well in one setting do not automatically work well in another. The examples that are offered in this report are concrete examples of policies and measures that are best in the settings for which they have been designed. All countries should reflect carefully on their respective development needs, the local conditions that need to be recognized and motivated, and the priorities for tailored energy efficiency policy.

3.4. Integrating Distributed Generation

> *Rapid technology advancements and the convergence of multiple disparate trends have already disrupted many industries and businesses, and there are signals that the energy sector may be next in line. A big shift in the way we produce or consume energy could disrupt energy markets as a whole, starting with power markets and snowballing from there.* [107]

A new set of energy policies and practices are required to enable integration of distributed sustainable energy options. [108] [109] These options are typically renewable energy sources, mainly solar PV and wind but also biogas, biomass, small hydro, and geothermal energy, but can also include gas-fired microturbines. Many features of renewable energy make them difficult to integrate into existing energy infrastructure, which is true for both the national transmission grid as well as the more local distribution networks. In many countries, energy efficiency, renewable energy, access and affordability are treated as separate policy streams, often managed in separate agencies and budgets and separate from more mainstream energy policy and planning. New paradigms of demand and asset management, system optimisation, and integration are needed. SDG outcomes however anticipate significant multiple benefits and spill overs delivering broad socio-economic and environmental benefits.

3.4.1. Selected Issues and Country Responses

This chapter focuses on the integration of variable renewable energy which provides challenges for grid integration and challenges current power market design regimes. It further discusses the opportunities provided by distributed renewable energy for remote communities. Case studies are presented for the Ukraine, Denmark, Croatia, and Germany.

Issue 1: Integration of Variable Renewable Energy: The Need for Flexible Supply and Better Market Design

Integrating "variable" or "intermittent" renewable energy (VRE), notably solar and wind energy, into the energy mix ostensibly creates challenges for transmission and distribution. Countries are adapting to growing shares of VRE in their energy systems, notably Denmark, Germany, and Spain. Market design and operations are being adapted to enhance integration of VRE and provide needed balancing.

The existing institutional and technological infrastructure in most UNECE countries was designed to use fossil fuels. It is not obvious to upgrade and convert these systems to include renewable energy. One of the challenges is how existing energy systems, which assume fuel storage and on-demand availability, can adjust to accommodate VRE.

The role that distributed renewable energy can play in enhancing system resilience can improved access in countries that do not have sufficient energy resources for their development. While fuel wood and processed biofuels can be stored, most other renewable energy has diurnal or seasonal availability. VRE need backup, either supplied from the grid or a local battery or alternative generation system. The scale of the backup power supply depends on the size of demand peaks and their coincidence with the available VRE resources.

Case Study: Integrating Variable Renewables into Grids. [110]

VRE electricity deployment and integration develops over four stages; each with its own specific characteristics and operational priorities.

First, wind and solar plant output is are subsumed in the daily variations in power demand. Annual variable renewable electricity shares only reach up to around 3% in annual electricity generation. Second, operational practices such as intelligent forecasting of variable renewable electricity output are introduced. UNECE countries in this phase include the Netherlands, Sweden, Austria, and Belgium, with variable renewable energy electricity shares ranging from 3% to almost 15%.

In the third phase variability affects overall system operation including other power plants. This phase is when power system flexibility is paramount. The power system must accommodate substantial uncertainty and variability in the supply-demand balance. The two main flexible resources to date are dispatchable power plants and the transmission grid, but demand-side options and new energy storage technology are growing in importance. Countries in this phase include Italy, the United Kingdom, Greece, Spain, Portugal, and Germany, with VRE electricity shares ranging from 15% to 25% in annual generation.

The final phase sees "highly technical" and "less intuitive" challenges that require resilience in the face of events that could disturb normal operations on very short time scales. Only Denmark and Ireland can be considered to be facing these challenges, with variable renewable electricity share ranging from 25% to 50% in annual generation.

Countries with historically high hydro shares in their power systems like Norway have been early adopters of policies and market techniques that manage annual hydro variability.

Case Study: Assigning Responsibility for Managing Increasing Variability of Supply in the Ukraine. [111]

On 6 April 2017 the Ukrainian parliament submitted Draft Law No. 4493 of 21 April 2016. On Electricity Market (the "Electricity Market Draft Law"). The Draft Electricity Market Law introduces responsibility for generators for managing the hourly imbalances in the day-ahead market where they will sell electricity at "green" tariff rates.

It is planned that the responsibility for solar and wind will be introduced gradually with increase by 10% annually starting with 2021 until 2030 with 10% tolerance for wind and small hydro (the tolerance margin for small hydro will be valid until 2025) as well as 5% tolerance for solar. It also envisages the possibility of signing preliminary power purchase agreements before construction when a producer of electricity from renewables has executed title documents in respective lands, obtained a construction permit or executed a similar document under Ukrainian laws and signed a grid connection agreement.

The producers of electricity from renewables which have commissioned their power plants before the entry into force by the Electricity Market Draft Law are exempt from liability for imbalances until 2030.

Successful implementation of distributed renewable energy requires enabling energy market policies. Distributed generators should receive energy and capacity price signals that motivate economic investments in distributed renewable energy. The interaction of demand, and supply in real time are key drivers for distributed renewable energy, and are more durable signals for economic investments than typical renewable energy support polices like FiTs or renewable energy subsidies. Indeed to offer subsidies while investors receive poor price signals for energy used or generated can create perverse outcomes. The World Economic Council report The Future of Electricity highlights that achieving renewable energy requires clearer policies that encourage economic investments.

Issue 2: Distributed Renewable Energy for Remote Communities

Some of the first investments in renewable energy occurred in remote communities where communities addressed social needs and local development agendas with renewable energy despite constraints in traditional energy resources.

Over time, community-developed renewable energy supply expanded, and the concept of energy-independent villages evolved, particularly in Western and Central Europe. For example, a series of villages in Germany, most famously the 150-person village "Feldheim", produce sufficient amount of renewable energy to cover its own energy demand, while selling overproduced energy from the 122.6 MW wind, and additional solar and biomass capacities back to the national grid.[112] Essentially, rather than being off-grid, the energy dependence of these villages is enabled through the connection to the national grid, as it helps to compensate for the intermittency of VRE.

Another example comes from Denmark. With no significant energy resources by the 1970's the country became dependent on imported oil. Price shocks associated with the 70's oil embargo highlighted how dependent Denmark was on imported energy. Many of the wind turbines erected in the 1980s and early 1990s were and still are owned by local cooperatives, the first established in 1980 near Aarhus in Jutland. The case study below provides more details.

In 2015, Denmark produced 42% of electricity from wind, and plans to meet all its energy needs from renewable energy by 2050.

Case Study: Wind Turbine Cooperatives in Denmark. [113]

Jointly owned wind turbines in Denmark are organised as partnerships with joint and several liability. In practice, the risk of joint and several liability is minimised in that the partnership is unable to contract debt. This is ensured in the bylaws, which maintain that the partnership cannot contract debt, and that the turbines must be adequately insured. Partners own a part of the wind turbine corresponding to the number of shares you buy. Often one share is calculated corresponding to the yearly production of 1000 kWh from that particular wind turbine.

Private individuals and cooperatives have played an important role in the development of the Danish wind energy sector. 15 % of the Danish wind turbines today are owned by about 300 cooperatives.

Local acceptance of a wind turbine project is necessary. Public resistance against wind turbines in the landscape has been and still is and one of the largest barriers to the development of wind power. Opinion polls show a wide support in the population in favour of wind power in general. However, uncertainties and lack of information in the planning phase of future wind power projects often give raise to local scepticism. The experiences from a number of wind energy projects in Denmark show that public involvement in the planning phase and co-ownership increases the acceptance. Adding to this, two private offshore projects show that cooperative development and ownership is an option also in larger-scale projects.

The Middelgrunden Offshore Wind Farm (40 MW) close to Copenhagen was developed though cooperation between the municipality, an energy company, and, not least, a number of private individuals. Middelgrunden is the world's largest cooperatively owned wind farm with more than 8000 members of the cooperative. The Samsø project off the east coast of Jutland (23 MW) was developed by a cooperative with local people on the island of Samsø and the municipality as members.

Case Study: Distributed Renewables. Croatia's High Shares of Traditional Renewable Energy. [114]

The use of solid biofuel firewood in Croatia exemplifies the ongoing tradition of wood heating in many UNECE countries. Ease of fuel access is a key reason, especially in villages where many people own a small woodlot for reliable access to free fuel. In cities there are also multifamily houses that use firewood for heating, buy fuel wood before winter and store it for winter use. The unit price of fuel wood is much lower than other fuels,

Across the UNECE region there are many settlements where gas or district heating networks are simply not economic, and while electricity is everywhere, heat pumps are still too expensive for some or not practical, so people tend to use a mix of electricity and wood where economic for heating. These self-sufficient renewable options are important to address energy poverty, – often houses just heat a living room or one more extra rooms, the key challenges are to help insulate homes and improve the efficiency of traditional and modern wood burners.

The traditional masonry fuel wood stoves and cookers used throughout the UNECE region generally offer efficient use of a distributed sustainable fuel wood resource. They differ significantly from the poor efficiency and high emissions of cooking stoves of other regions and for many communities are a lower cost option than supply of gas or fossil fuelled district heat. The testing of solid fuel heaters is not well coordinated with differing local test procedures and actual performance is subject to operator skill. A limited number of combustion tests, point to efficiencies for traditional and modern masonry stoves that are similar to other controlled combustion wood stoves; efficiencies are generally above 60% and up to 72%.[115]

While widespread uptake of modern renewable energy is central to the necessary energy transition, traditional biofuels still play a key role in many UNECE countries. Policies should ensure traditional biofuels are a practical and enabled element of the energy transition.

3.4.2 Opportunities and Prospects

Some countries, despite their significant cost-effective fossil fuel reserves, have set ambitious goals for renewable energy. Their ability to pursue these goals hinges on power system and investment capabilities and on their available renewable energy resources. Not all countries are starting their energy transitions with an enabling set of renewable energy potentials.

Realising available renewable resources

Underlying climatic and geographical contexts are substantial considerations in a country's primary renewable energy resource potential. The UNECE region is characterised by a low insolation resource which stay in the 700 to 1200 kWh / kilowatt peak (kWp)[116] bracket for most countries. [117] The U.S. has the strongest potential, almost reaching 2000 kWh/kWp, followed by Central Asian countries, in particular Tajikistan, then Spain, Turkey, Italy, and Armenia. Even countries with low insolation levels such as Germany can install solar PV on a large scale. At the end of 2016, the total nominal PV power installed in Germany was 41 GW, distributed over 1.5 million power plants.[118]

Initiatives to track renewable energy source potentials exist, such as the Global Wind Atlas by the International Renewable Energy Agency (IRENA). [119] It indicates that there is ample potential in different subregions of the UNECE region, in particular in coastal areas along Western and Central Europe, as well as the North American coast. A similar global map for bioenergy does not exist yet, but many national assessments exist, such as the Biofuels Atlas for the U.S. provided by the National Renewable Energy Laboratory (NREL) [120] and a Bioenergy Simulator by IRENA.[121]

Some countries start from a very low base to pursue significant renewable energy targets. Kazakhstan for example has a 1% renewable electricity share and objectives of 3% by 2020, 10% by 2030, and 50% renewable energy by 2050. [122] As an oil and gas exporting country, a range of support mechanisms and investment incentives need to be put in place in order to utilize the country's renewable energy potential, such as for sustainable bioenergy, as well as wind, small and medium hydro and solar, which offer distributed clean energy solutions in particular for rural areas where 47% of the population live.[123]

On the other hand some countries with existing substantial renewable energy capacity face challenges to extend from their traditional central renewable energy systems to new renewable and necessarily more distributed energy opportunities. The ability to invest in renewable energy and trade renewable energy outputs across borders is therefore important for many countries and can liberate further economic improvements in renewable energy costs for some countries.

An electricity market evolving to meet the dynamic challenges of distributed power.

Electricity markets are already moving their focus towards consumers. [124] There is talk of the "prosumer" who not only consumes electricity but also produces it, for example through roof-top solar panels. The shift is important for network companies who must balance growing distributed VRE capacity while selling lower volumes of electricity.

One of the common paradigms to change is that the power system has been a technically determined system that requires a centrally designed planning system to operate effectively. The physics of power systems demand instantaneous response to changes in demand and supply. The reality is however that our ability to measure and understand system dynamics in real time has evolved in the past 30 years, and options have evolved away from a central plant investment model to distributed systems.

A distributed energy transformation, based on demand side energy efficiency and distributed renewable energy, will address access quality, affordability and system resilience for less cost and lower environmental impact than most supply security options.

New conventional energy supply has been perceived by policy makers as reliable and secure. However there is growing evidence that addressing end-use efficiency is not only cheaper than new supply options, but that it also delivers large social and economic outcomes or multiple benefits, at lower cost than new supply options. This is particularly so in countries with inefficient or unaffordable heating services, where improved comfort and reduced health costs exceed the value of reductions in energy demand costs, and energy efficiency investments reduce upstream costs in power and heat supply systems. Indeed in the coldest continental climates e.g. Kazakhstan and Russian Federation the demand for heat is highest and scope for renewable energy is limited.

A shift in thinking to a system value maximising approach rather than the current focus on lifecycle cost of renewable energy (and other) supply options is required for improved service provision, energy system economics, and energy resilience.

Opportunity: A Move from the Levelised Cost of Electricity to System Value. [125]

As legacy power systems face disruption from new technology and resource the underlying costs drivers start to shift from simple indicators to more complex metrics. The traditional focus on the levelised cost of electricity (LCOE) is no longer sufficient. Next-generation approaches need to factor in the system value of electricity from wind and solar power.

System value is defined as the overall benefit arising from the addition of a wind or solar power generation source to the power system; it is determined by the interplay of positives and negatives. Positive effects can include reduced fuel costs, reduced CO_2 and other pollutant emissions costs, reduced need for other generation capacity and possibly grid infrastructure, and reduced losses. On the negative side are increases in some costs, such as higher costs of cycling conventional power plant and for additional grid infrastructure, as well as curtailment of VRE output due to system constraints. System value provides crucial information above and beyond generation costs; in cases where system value is higher than the generation cost, additional VRE capacity will help to reduce the total cost of the power system.

As the share of VRE generation increases, the variability of VRE generation and other adverse effects can lead to a drop in system value. It is important to distinguish the short-term and long-term system value of VRE. In the short term, system value is strongly influenced by existing infrastructure and the current needs of the power system. For example, if new generation is needed to meet growing demand or retirements – as in South Africa – system value will tend to be higher. By contrast, the presence of large amounts of relatively inflexible generation capacity – as is the case in Germany – can lead to a more rapid system value decline in the short term. For long-term energy strategies, the long-term system value is most relevant. This accounts for both fuel savings and capital investments. In order to attract investments in VRE at least cost, policy mechanisms that provide sufficient long term revenue certainty to VRE investors are needed. In turn, such mechanisms need to be designed in a way that accounts for the difference in system of different generation technology. Existing policy practice already provides a number of ways in which the value of VRE can be boosted by facilitating system-friendly deployment strategies.

Opportunity: Next Generation Wind and Solar – From Cost to Value. [126]

As legacy power systems face disruption from new technology and resource the underlying costs drivers start to shift from simple indicators to more complex metrics. The traditional focus on the LCOE is no longer sufficient. Next-generation approaches need to factor in the system value of electricity from wind and solar power.

VRE brings new challenges to the fore. A systemic approach is the appropriate answer to system integration, best captured by the notion of transformation of the overall power system. This requires strategic action in three areas:

- System-friendly deployment, which aims to maximise the net benefit of wind and solar power for the entire system.
- Improved operating strategies, such as advanced renewable energy forecasting and enhanced scheduling of power plants.
- Investment in additional flexible resources, comprising demand-side resources, electricity storage, grid infrastructure and flexible generation.

Wind and solar power can facilitate their own integration by means of system-friendly deployment strategies. Six areas are most important:

- System service capabilities. Technological advances have greatly improved the degree to which variable renewable electricity can be forecasted and controlled in real time. With the right framework conditions in place, variable renewable electricity can help to balance supply and demand despite its dependence on the availability of wind and sunlight.
- Location of deployment. With the cost of solar PV and (onshore) wind power falling rapidly, deployment is becoming economical even in lower resource conditions. This gives a wider choice for developing diversity in power plants and allowing electricity to be produced closer to demand.
- Technology mix. The output of wind and solar power is complementary in many regions of the world. It can be complementary to other renewable energy, such as hydropower, deploying a mix of technology coincident to load can bring valuable synergies.
- Local integration with other resources. Distributed deployment of variable renewable electricity can open the opportunity to integrate generation resource directly with other flexibility options to form an integrated package. For example, solar PV systems can be combined with demand-side response or storage resources to achieve a better match with local demand and thus reduce the need for investments in distribution network infrastructure.
- Economic design criteria. The design of wind and solar plants can be optimised to facilitate integration. For example, a detailed modelling study that was carried out as part of this project highlighted that wind turbines with larger blades compared to generator capacity produce electricity in a less variable fashion, which reduces integration challenges.
- Integrated planning, monitoring and revision. The relative costs of VRE and other generation technology, as well as the cost of various flexible resources, are changing dynamically. Consequently, the optimal mix of flexible resources as well as system-friendly deployment strategies will change over time, prompting the need to adjust strategies.

Regardless of current energy market structure, renewable energy, whether centralised or distributed, require durable signals that give investors clearer insight in to the drivers for new capacity, and offer a reliable basis for investment evaluation and return over the life of the investment. This applies whether the investor is an urban householder, a farmer, a business or professional power plant investor, their motivation to invest is similar - a reliable return on the renewable energy installation.

3.5. Improving Supply-Side Sustainability in Generation and Transmission

Naive perceptions of security of supply persist in many countries. Security is perceived to be enhanced by self-sufficiency, often through new domestic supplies of fossil fuels, while energy trade is perceived as unreliable and renewable energy is perceived as variable and challenging to system stability (stability is different to security of supply). The institutional paradigms and policies that served well over the past 50 years are now challenged by a wider range of renewable energy and demand side products and services.

3.5.1. Selected Issues and Country Responses

Incumbents in any market have a historical position of strength, experience in the market place and a history of shaping and working with the policies and practices in the market. The incumbent experience represents inertia to change. The high reliance on fossil fuels and the associated infrastructure in many UNECE countries act as a centre of mass that is difficult to shift.

A range of issues are considered in this chapter including the high share of fossil fuels in power generation and the need to improve generating efficiencies. Other issues include the implications and opportunities of energy security driven policy making in the UNECE region, and upscaling grid-connected renewable energy.

Issue 1: A Continued High Reliance on Fossil Fuels

UNECE countries depend on fossil fuels for 80% of their energy supply. Coal provides 18% of TPES in the region, less than its global share of 29%. Compared to other fossil fuels, coal emits disproportionally more CO2 emissions, globally 46%, in addition to local pollutants. Natural gas represents 31% of TPES in the region compared to a global share of 21%.

Power generators and transport fleets require liquid or gaseous fossil fuels. Heat services are also highly dependent on fossil fuels. The institutional and technological infrastructure that shaped current energy resources and systems was designed to use available fossil fuels, and it is difficult to upgrade and convert to renewable energy operation. There is a locked-in dependence on fossil fuels, often with poor efficiencies. The transition is neither obvious nor easy.

Many fossil fuel based economies, including developed as well as emerging economies, rely heavily on energy resource imports. Germany (64%), Armenia (72%), Belarus (88%), Georgia (70%) and Moldova (90%) are reliant for more than 60% of their TPES on fossil imports. [127] Overall, fossil fuel shares remain high in countries, for example in Germany the share of fossil fuels in TPES remains high at 80%, despite the *Energiewende* efforts under way because fossil fuels are comparatively dense energy carriers and easy to trade both regionally and globally. Renewable energy does not have these attributes.

There is significant but aging fossil infrastructure in place in most countries that is a legacy of post-WWII development of available resources. Those countries that have managed to reduce their fossil-to-TPES ratio to date have had a number of aligned drivers in place for change:

- Economic and fiscal robustness enabling access to and investment in efficient plant to meet demand growth and replace aging plant,
- Competitive energy markets, with cost-reflectivity that rewards investment in improved efficiency,
- Policies to reduce environmental impacts,
- Alternative resources (gas, nuclear, renewables).

For countries with more than 80% fossil fuel share of TPES, one of more of these change drivers has been absent. In most cases countries can alter the first three drivers given time or use the global commitments to advance sustainable development but accessing alternative resources and technology, is a real constraint for many countries. While new renewable energy options enable further renewable energy growth, these tend to be distributed and require markets that incentivise consumers to adopt them. The transition from a fossil to a low carbon energy system is difficult and requires substantial effort across policy, structure, finance and technology.

Issue 2: Inadequate Progress in Supply Sector Efficiency of Fossil Fuel based Generation

The efficiency of conversion and transformation from primary to final energy is an important aspect of SDG7. The ratio of final to primary energy reflects overall energy efficiency in the supply sector obtained by dividing final end-use by total primary energy. A gradual reduction in this ratio has occurred globally from 72% in 1990 to 68% in 2010, which implies a reduction in conversion and transformation. In the UNECE region the indicator dipped by around 1.4% during the same time period, but it stayed higher at 71% than the world's average 68% in 2010. In 2015 the indicator was 68%.

In 2014, 41% of global electricity generation came from coal-fired power plants and 22% came from gas power plants.[128]

Efficiency of thermal power plants.

Changes in power production fuel mixes are driving reported average plant efficiencies. The share of coal in the global power generation mix will drop to 36% by 2021, down from 41% in 2014, driven by lower demand from China and the United States, along with fast growth of renewable energy and strong focus on energy efficiency.[129]

Coal is the dominant fuel (30%) for power production in the UNECE region, followed by gas (25%) and nuclear (21%) (See figure 2.2 above). Hydro power follows at 15%. Power generation is responsible for 40% of global CO_2 emissions, and the power sector in UNECE region contributes a substantial amount of the region's emissions. Coal's higher carbon intensity and the lower efficiency of coal power plants results in comparatively higher emissions. In 2014 coal accounted for 73% of global electric sector carbon dioxide emissions, and gas accounted for 20% of global power plant carbon dioxide emissions.[130]

The share of fossil fuels in the UNECE region's power generation sectors varies from 2% to 100%. 6 countries have less than 3% fossil fuel shares in their power systems (Albania, Norway, Switzerland, Tajikistan, all with large hydro resources, Iceland with geothermal, and France with nuclear). Denmark and Germany have achieved fossil fuel shares of 40% and 57% respectively. Eight countries have power systems based on more than 90% fossil fuels, including Kazakhstan 92%, Cyprus 93%, Azerbaijan 94%, Moldova 94%, Malta 97%, Israel 98%, Belarus 99%, and Turkmenistan 100%.[131]

The average power plant efficiency of electricity generation from of fossil fuels (coal, gas and oil) in the UNECE region improved from 36% in 1990 to 41% in 2014. Gas fired generators improved from 37% in 1990 to 49% in 2014 the highest amongst regions. [132]

Improving fossil fuel power plant efficiency in UNECE region: Scope and scale

Using in-house power plant data systems, GE evaluated the scope for power plant efficiency upgrades and the impact on emissions. Table's 3.7 and 3.8 outline the estimated technical (not economic) potential for efficiency improvements to coal and gas power plants in key UNECE member countries from GE's analysis.

Table 3.7: Coal Power Plants: Potentials for Efficiency Improvements and Emission Reductions.

Country	Coal generation (GWh) 2015	Average plant efficiency %	Potential efficiency with upgrades	Potential CO_2 reduction Mt	% Change in CO_2
World	8,920	34%	38%	924	11%
USA	1,356	37%	42%	296	9%
Russian Federation	173	25%	30%	37	16%
Germany	315	36%	41%	31	11%
Poland	134	34%	39%	16	12%
Ukraine	83	30%	36%	14	16%
UK	117	38%	44%	13	13%
Kazakhstan	73	30%	35%	11	14%
Czech Republic	45	28%	33%	8	15%
Turkey	80	34%	38%	8	10%
Canada	64	38%	43%	6	11%
Spain	55	36%	41%	6	12%

Source: GE (2017).

Table 3.8: Gas Power Plants: Potentials for Efficiency Improvements and Emission Reductions.

Country	Gas generation (GWh) 2015	Average plant efficiency %	Potential efficiency with upgrades	Potential CO_2 reduction Mt	% Change in CO_2
World	5,713	39%	43%	203	8%
Russian Federation	564	26%	30%	45	12%
USA	1,316	45%	48%	34	6%
Uzbekistan	41	28%	33%	4	13%
Turkey	134	45%	48%	3	6%
Belarus	34	28%	32%	3	13%
Italy	130	45%	47%	3	5%
Canada	73	41%	44%	2	8%
Turkmenistan	23	25%	29%	2	14%

Source: GE (2017).

In the fossil power generating UNECE countries, it would be possible to reduce CO_2 emissions by 542Mt through upgrades. 83% of the potential is in coal power plants. Two thirds of coal plant improvements are in turbine and boiler hardware upgrades, with the remaining third in operational data and software improvements. 55% of the gas plant improvement potential is in turbine and boiler hardware upgrades, 45% in data systems.

Transmission and Distribution

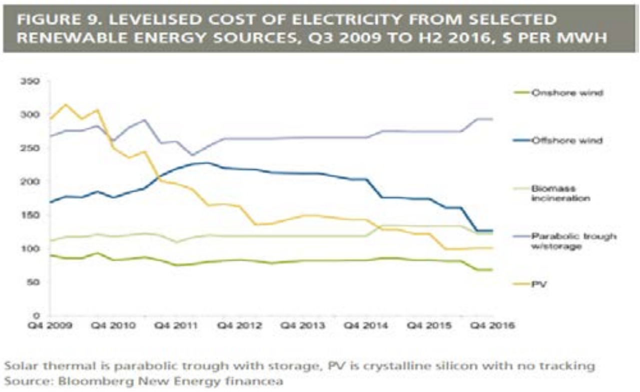
Losses in electricity transmission and distribution declined from 8.2% in1990 to 7.2% in 2014, the lowest amongst the regions. Natural gas transmission and distribution fell by half from 1.2% to 0.6%.[133]

Issue 3: Further Development of Policies to Support Renewable Energy Uptake

Despite the declining costs of renewable energy (Figure 3.7) and rapid growth in implementation, challenges exist to maintaining progress and realizing the potential of renewable energy. Key challenges include the continued lack of foundational long-term sustainable energy policies, lack of investments and support by domestic banks in many countries with less renewable energy implementation experience, capacity lacks for specialists, as well as geo-political factors that maintain conventional energy subsidies and constrain trade, combined with the lock-in of older inefficient fossil energy infrastructure.

Renewable energy support policies have evolved significantly over the past decades. While initial support mechanisms focused on FiTs guaranteeing a fixed tariff for supplied kWh over a fixed period of time, more effective and efficient support policies have developed over time. In particular the move to renewable energy auctions seeks to address the need for renewable energy to become competitive.

Figure 3.7: Price Trends for Renewable Energy (2009-2016).



A summary table of the renewable energy policies implemented within the UNECE member States is provided in Annex VI.

Most countries in the UNECE region have established renewable energy policies.

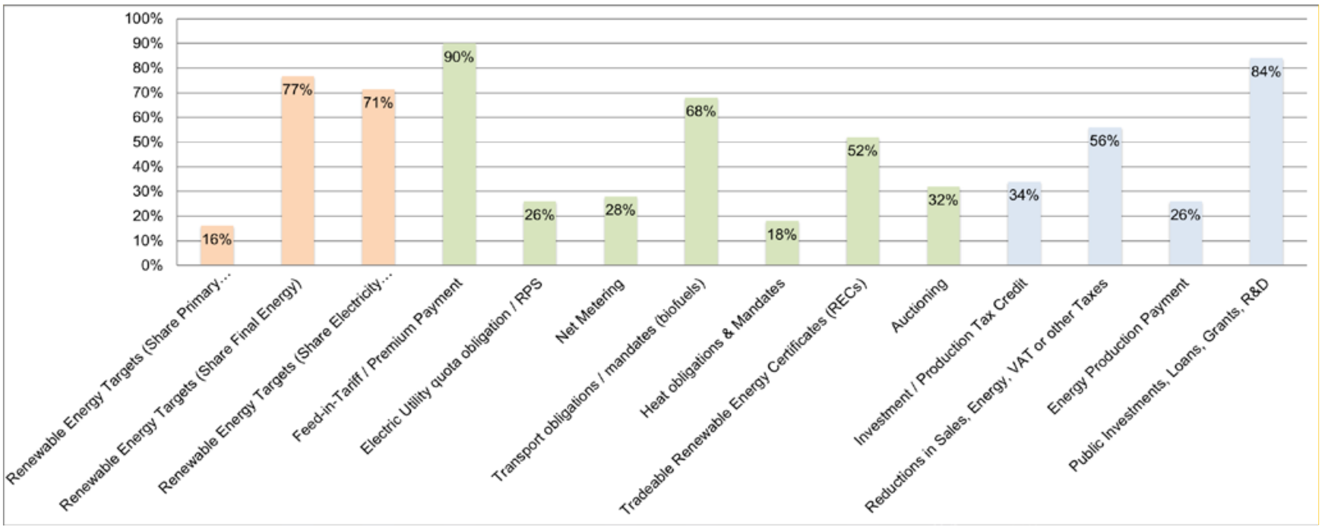
- Bulgaria, where the Energy from Renewable Sources Act (ERSA) and the Energy Act (EA) enables preferential prices for electricity from renewable sources.[134] The regulator set FiTs for electricity produced by new renewable electricity installations and for biomass. Renewable electricity can be sold at freely negotiated prices and/or into the balancing market.
- Ukraine's 2014 National Renewable Energy Action Plan aims to implement a series of renewable energy policies - such as preferential loans for alternative energy production, tax exemptions, accelerated depreciation, import duty waivers - as well as initiatives eliminating fossil fuel energy subsidies for residential users.[135]
- In 2015, the government of Belarus set new FiTs for renewable energy power fed to the country's grid. Tariffs range from 1.1 to 3.3US cents per kWh for the first 10 years to 0.45 US cents per kWh after 20 years. [136] In addition, based on a program with performance targets to increase biodiesel production from 2007-2010 by utilizing domestic resources, [137] liquid biofuels consumption increased from zero in 2007 to 0.0010 EJ in 2014.

Figure 3.8 provides the percentage share of policy types implemented across the 56 member States. Three quarters of countries have introduced renewable energy shares in final energy, and about two thirds have defined renewable energy targets as share in electricity generation.

Among regulatory policies, the most prominent mechanism remains the FiT or premium payment, despite its economic inefficiency, which 45 countries (re-)introduced for one or more types of renewable energy sources. Transport obligations for biofuels as well as tradeable renewable energy certificates were the second and third most common choices.

Less used are electric utility quota, net metering regulation, or heat obligations. The use of renewable energy auctioning increased. Sixteen countries introduced auction schemes for renewable energy. Notably Spain, which terminated its FiT scheme in favour of an auction scheme for different types of renewable energy. Also Germany is increasingly moving from FiT to auctions as shown below.

Figure 3.8: Type and Share of Renewable Energy Policies introduced in UNECE Countries (2015).



Source: UNECE (2017a) for 17 countries, otherwise from REN21 (2017).

Case Study: A shift from Renewable Energy Feed-In Tariffs to Auctions? An Example of Off-Shore Wind Energy in Germany.

In a public auction run by the *Bundesnetzagentur* (German Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway) in April 2017 both, the Danish company Dong Energy and the German company EnBW won rights to build three offshore wind projects in the German North Sea without government subsidies. The world's first subsidy-free offshore wind auction bids have been described as "a highly symbolic first for the industry", in particular when looking back on the large sums of money governments have spent subsidizing offshore wind projects in the hope of creating a clean source of energy that could eventually pay for itself. [138]

Whilst the April 2017 offshore wind auctions were the first of this type, Germany has moved ahead with the implementation of renewable energy auction policies to cover the whole renewable energy sector. In a reform of the German Renewable Energy Act (Erneuerbare Energien Gesetz) in January 2017, FiTs were replaced by an auction system for most renewable technology. Payments to renewables installations are now determined in competitive processes, instead of by the government's FiTs and premiums, with the advantage that costs for renewable power can be limited to the economically necessary level for each installation. Renewable energy auctions may unlock further cost reductions in renewable technology. [139][140]

Issue 4: Diverging Concepts of Energy Security: Energy Self-Sufficiency versus Energy Interdependence

The concept of energy security is diverse, and different interpretations exist. The IEA defines it as "the uninterrupted physical availability at a price that is affordable, while respecting environmental concerns". Different interpretations exist depending on national and regional circumstances, mainly driven by national resource availability and collaborative contexts. Kazakhstan's Nazarbayev University defines it for the Central Asian and Caspian Countries as security "to ensure secure transportation of oil and gas to the market through multiple pipeline network in geopolitical cooperation among producers and transit countries of the area, to keep a sufficient willingness to invest in the energy sector, and to reduce the risk of export concentration." [141]The European Union which depends on imports for more than half of its consumed energy defines in its Energy Security Strategy the aim "to ensure a stable and abundant supply of energy for European citizens and the economy". [142]

The case study below explores the energy import dependence of the European Union in more detail. It shows a shift to diversification in energy systems, energy efficiency and renewable energy are increasingly increasing elasticity in energy markets and mitigating supply security risks in Europe.

Case Study: European Energy Security: Improving Import Dependency.[143]

18 EU member States import more than 50% of their energy. Demand for energy is now more than 8% below its 2006 peak due to the GFC, structural changes, and efficiency improvements linked to policies of the past 10 years. Import dependency, reached more than 50% as European production declined after 2006, but stabilised thereafter with increasing renewable energy production and demand reduction. In 2012, oil was at 90% import dependency, gas at 66% import dependency and coal at 42%. Import dependency for uranium is 95% but it is a relatively small quantity.

Oil supply risks are off-set by high market liquidity and regulated 90-day stock holdings.

Gas import pipeline capacity is 8776 GWh/day, LNG terminals 6170 GWh/day. Long term pipeline gas contracts, nearly entirely with the Russian Federation, are estimated to cover 17-30% of market demand. Gas market and gas infrastructure (interconnectors, reverse flows and storage) developments are improving resilience. However the Baltic States, Finland, Slovakia and Bulgaria remain dependent on a single supplier and the Czech Republic and Austria have very concentrated imported gas supplies. A winter supply disruption through Ukraine transit routes would pose challenges for Bulgaria, Romania, Hungary and Greece.

Coal provides 17% of EU energy, used in electricity, CHP and district heating plants, with Germany, Poland, the UK and Greece being the top four consumers. Coal demand declined by 20% from 1995-2012 in nearly all Member States. Import dependency currently stands at 42% and has been increasing due to the closure of uncompetitive mines in a number of EU countries.

Global markets for oil, gas and coal have undergone profound change. All three commodities now trade at significantly lower prices than previously, while sustaining medium term volumes, and new market entrants. Media focus has shifted from the historical patterns of price volatility to discuss how long suppliers can sustain output and maintain historical patterns of investment in production operation and maintenance at prevailing prices. There had been a shift in market power from the supply side to the demand side in global fuels markets, as technological innovations allow new resources to be extracted and challenge established patterns of demand.

New domestic supply shifted the US from a net importer to a net exporter of energy, mainly due to its “shale gas and shale oil revolution”, combined with increased output from renewables. The U.S. EIA estimates that the United States has about 200 trillion cubic feet of proved shale gas resources in 2014. [144] In ‘Revolution Now’[145] the US Department of Energy describes the rapid price declines and uptake of wind, solar photovoltaic, LED lighting and electric vehicles as an “*historic shift to a cleaner, more domestic and more secure energy future is not some far-away goal. We are living it, and it is gaining force*”. In the United States, solar energy accounted for 32% of the nation’s new generating capacity in 2014, beating out both wind energy and coal for the second year in a row. [146]

Oil

From 2011 to 2015, oil prices were sustained on average over USD100/bbl, a sustained price level previously only seen as price peaks. Prices fell during 2015 to USD37/bbl, while OPEC held back production. Global production exceeded supply by an average 2mbbl/day during 2015.[147]

The US remained the largest consumer at 21%; Europe, 15%; Russia, 3.7%. Main net exporters of oil within the UNECE region are the USA, Norway, and Russian Federation.

Oil demand decreased 13% in the period 2005-2012 but continues to be 34% of the primary energy source used in the EU. 64% of final consumption of oil is used in transport where electric vehicles are now looking like a viable alternatives. Oil retains the highest import dependency, 88% (80% if only imports from outside the European Economic Area are taken into consideration), and significant import bill (EUR 302 billion in 2012).

Natural Gas

The European Union relies on natural gas imports for 66% of its gas supply**.** EU long-term contracts for pipeline gas supply cover 17-30% of EU market demand, are nearly entirely imports from Russia, and are sometimes covered by long term inter-governmental agreements, some of which extend to 2030. The total capacity of pipelines to the EU from supplier countries is 397 bcm/year. New projects under construction include the pipelines of the Southern Gas Corridor, which will allow by 2020 supplies to the EU markets of a further 10 bcm per year gas from Azerbaijan. The envisaged infrastructure in Turkey could transport up to 25 bcm per year to the European market allowing further gas volumes from Azerbaijan as well as Northern Iraq. (EC 2014) 130 underground gas storage facilities in Europe, including non-EU countries such as Turkey, comprising a combined capacity exceeding 90 bcm. (CEDIGAZ in EC 2014) Regasification capacity of liquefied natural gas (LNG) terminals in the Europe (excluding small scale LNG) is 200 bcm/year, half the EU’s annual gas imports of 400bcm in 2015. Further terminals are planned and their total capacity is planned to reach 275 bcm/year in 2022.The main net exporter of natural gas in the UNECE region are the Russian Federation, the USA, and Norway. While much of the UNECE regions gas is distributed by national and regional pipeline systems, the bulk of global trade is increasingly shaped by LNG system dynamics. Global LNG supply capacity is 300Mt / year but in 2016 only 268 Mt were traded. Buyers in Asia (which makes up 70% of global LNG demand) are shifting from fixed long-term contracts with a priority on security of supply, to more flexible group purchase of short term gas and spot contracts driven by power sector flexibility and deregulation. The US is likely to be the third largest supplier in 2018, and its flexible terms are likely to be attractive to Asian buyers. [148]

In Europe the 2013/14 winter supply outlook of ENTSOG noted that there were no big variations in Norwegian, Algerian or Libyan supplies, but that there were important decreases in LNG imports (- 32%). The drop in imports of LNG was a result of a divergence of gas prices between Europe and Asia, which led cargos to be redirected to Asia and reducing the arrival of spot cargos in Europe. The drop was replaced by draws on storage (+40%) and increased Russian imports (+7.5%, mostly Nord Stream flows). [149]

LNG export capacity is still growing (US and Australia) and stagnant demand is suppressing gas spot prices. European gas demand not covered by long-term supply contracts has a strong negotiating position.

Coal

Coal is a low cost, low-grade fuel and a rich chemical feedstock. In 2014, it provided 29% of the world primary energy, but created 46% of global GHG emissions and a disproportionate amount of local air and water pollutants. Disruptive streams of low cost gas (growing LNG supply and lower prices) and renewable energy are eating away at coal's share of demand, but it nevertheless remains locked in to its historical low cost paradigms and infrastructure. [150]

The IEA points to coal being 27% of global energy by 2021. US and European coal demand was 47% of global coal trade in 2000, but this has now dropped to 22%.[151] Coal's role in the developed world's existing power and heat infrastructure is declining. Lack of investments in CCS technology further hinders a further development of coal-based technology. However, coal remains the mainstay in many emerging economies.

The United States of America and EU are respectively the second and third largest coal-consuming regions in the world, using 25% of global coal production. US coal supply is almost entirely domestic, and coal consumption dropped 15% in 2015. [152] The EU meets only about one third of its needs for hard coal with indigenous production. Demand for solid fuels in the EU has declined by almost 20% since the mid-1990s. Following the slump in consumption in 2009, demand started recovering and 2012 was the fourth consecutive year of growth in solid fuel consumption.

A number of Member States have seen a double-digit growth in consumption between 2011 and 2012, in particular Portugal (+32%), Spain (+20%), France (+13%), Ireland (+12%) and the Netherlands (+10%). The decline in coal and CO_2 prices and high gas prices provided coal with a strong competitive advantage to gas in power generation.

The EU has a diversified portfolio of coal suppliers, with Russian, Colombian and US imports accounting for each for approximately a quarter of hard coal import quantities. Rising production costs of domestic hard coal and depressed prices on global coal markets have made imports an economically attractive option. International prices increasingly serve as leverage to negotiate price contracts with domestic coal producers.

Global coal markets are competitive and have not experienced the spikes or disruptions observed in the crude oil market or regional markets for natural gas. There is no minimum stock requirement in terms of coal inventories and stock changes almost daily.

The current global situation of low coal prices and stagnant global demand is contrasted with significant pressure and change in countries where coal is in a period of intense disruption. Countries carry individual accountability to reduce emissions, so they must improve the economics and efficiency of a vast stock of older coal-fired power plants. New investments in renewable energy challenge the underlying cost structures that have developed the current fleets of power and heat plants.

Issue 5: The Difficulty of an Energy Transition Paradigm Shift

An energy transition is under way and change in the global energy system is observable. Renewable generation grew x% in 2016 and represented y% of total global generation. Most additional generating capacity installed from 2012 to 2016 was based on renewable energy sources (x GW out of a total of y GW.

The overall increase in the world's nuclear net capacity last year was the highest since 1993, with new reactors coming online in China, the United States, South Korea, India, Russia and Pakistan. Conversely, Germany, France, and Sweden have announced their intention to withdraw from nuclear power. In the future capacity additions will be offset at least in part by retirements.

Coal demand fell worldwide but the drop was particularly sharp in the United States, where coal demand was down 11% in 2016 because of price competition with natural gas - electricity generation from natural gas was higher than from coal. In the European Union, emissions were largely stable last year as gas demand rose about 8% and coal demand fell 10%. Renewable energy also played a role. The United Kingdom saw significant coal-to-gas switching in the power sector, as a result of both cheaper gas and a mandated carbon price floor. [153]

Energy transition dynamics.

While current progress looks promising, there is much more to do before a durable energy transition is confirmed. The term 'energy transition' describes a shift over the medium term to a mix of energy efficiency, low carbon options and universal access to quality energy services.

Many countries focus on energy security based on indigenous, typically fossil, energy resources. While 10 UNECE countries are major exporters of energy resources to global markets, strong regional and cultural behaviours persist in an on-going reliance on indigenous resources. Developing a more sustainable energy system requires a shift in the view of security of supply. Economic trade in sustainable resources, increasing demand side focus and innovations in technology and skills will shape sustainable outcomes and produce a dynamic and resilient energy system.

The challenge is to discern investment pathways that enable an economically efficient transition. Countries, may have the financial wherewithal and the technology to deploy high-efficiency low-emission coal technology, but risk stranding investments if competitive gas and renewables displace new coal. Existing plants, however, can continue operating despite lower efficiencies because they impose low incremental costs. Their initial investment capital was amortised years ago and they can act as marginal operators. Many countries have already expended effort in 'priming' renewable energy with FiTs and have grown renewable energy from a negligible base, but they have yet to alter their vastly greater existing coal systems. A notable example is found in Germany where there has been little change in the efficiency and scale of coal fired capacity.

The transition will neither obvious nor easy but a process of moving power systems to high efficiency gas and renewable energy is doable both technically and economically. Placing a real price on carbon would reinforce the drivers and accelerate the transition.

Case Study: To Renewables via Gas: The North American Fossil Fuel Transition.

Currently a third of U.S. electricity is generated in gas-fired power plants. Nuclear plants produce about 20%, hydro 6%, and other renewables 7%. In 2015 solar made up 32% of all new electrical capacity, greater than wind and coal for the second year in a row.[154]

In 2015 U.S. coal production decreased for the fourth year in a row to 1,165 million (US) tons, a decline of 6.3% from the 2014 levels. U.S. coal production dropped 10.3% year-on-year to its lowest levels since 1986. Coal's share of total electricity generation, which was 50% in 2005 and 33% in 2015, is predicted to fall to 21% in 2030 and to 18% in 2040. Coal-fired generators capacity is expected to reduce one -third through 2030, to about 60 GW. [155]

Current LCOE for coal-fired power plants with CCS are USD65-139/MWh. Gas-fired plants have a cost of USD58/MWh; nuclear USD103/MWh; onshore wind USD64.5/MWh and solar USD85/MWh and hydroelectric USD68/MWh.[156] The shale revolution in the US clearly sharpened the competitive edge between coal and gas in US power markets, and the progressive reduction in the costs of renewable energy is making them increasingly competitive with both coal and gas even without financial support.

Restructuring

Markets for energy and utilities that are transparent, competitive and facilitate efficient cost-reflective price formation) are a pre-condition for delivering timely, innovative and least cost responses to achieve public policy goals.

Russia is undertaking one of the most ambitious electricity reform programmes in history making impressive progress by international standards, transforming the sector into a key driver of longer-term economic prosperity. Russia unbundled and privatised its generation infrastructure (USD30Bn generation assets were unbundled and privatised from 2005), instituted incentive-based economic regulation, and established an investment obligation mechanism targeting new investment.

Case Study: Power Sector Reform Experiences in Russia. [157]

The wholesale energy market was fully liberalised in 2011 and covers much of European Russia, the Urals and Siberia. Since then most power has been sold and bought on a competitive basis through the central wholesale spot market. Energy prices generally reflected movements in underlying supply-demand fundamentals and short run marginal production costs driven largely by changes in upstream fuel costs. The Federal Antimonopoly Service provides independent objective and consistent supervision with incentive based economic regulation. Open access arrangements are in place for transmission and distribution networks. The Federal Grid Company has a major network development program that will improve regional power flows by 2020, but this is now informed by real detailed regional and grid exit point power flows, enabling solid projections of demand and a better basis for investment decisions.

Competition and innovation. Although Russia's very successful 2008 privatisation brought several new entrants, the government still has considerable scope to diversify ownership and wholesale competition through further divestment as well as virtual power auctions or similar mechanisms to sell rights to the output of publicly owned generators. It can also strengthen market integration and effective competition supervision. Russia's competitive wholesale spot market is one of the most successful components of the reform implemented to date.

Competitive retail markets are in an early phase of development in Russia. Although still concentrated in outmoded retail market structures, Russian policy makers have taken positive steps towards establishing the market rules and regulations needed to develop competitive and innovative retail markets. But much still depends on how effectively these rules and regulations are translated into commercial incentives and practical processes. While progress has been made to rebalance consumer tariffs since 2001, 10% of revenues are still subject to cross-subsidies concentrated in a relatively small part of total load. Residential tariffs still need to increase by 50-70% to address this.

Price reform remains essential for success. Russia has made considerable progress in rebalancing tariffs, but there is more to do, especially for regulated residential consumers. The presence of dominant 'Guaranteeing Suppliers' with local regulated residential consumers and universal supply obligation franchises remain an inherently unsustainable element. Price increases could be linked to growth in user capacity to pay while direct government welfare payments to regulated users should replace user-funded energy subsidies. At the same time, the government needs to keep pursuing supply-side reforms to help reduce the level of cost-reflective prices.

3.5.2 Opportunities and Prospects

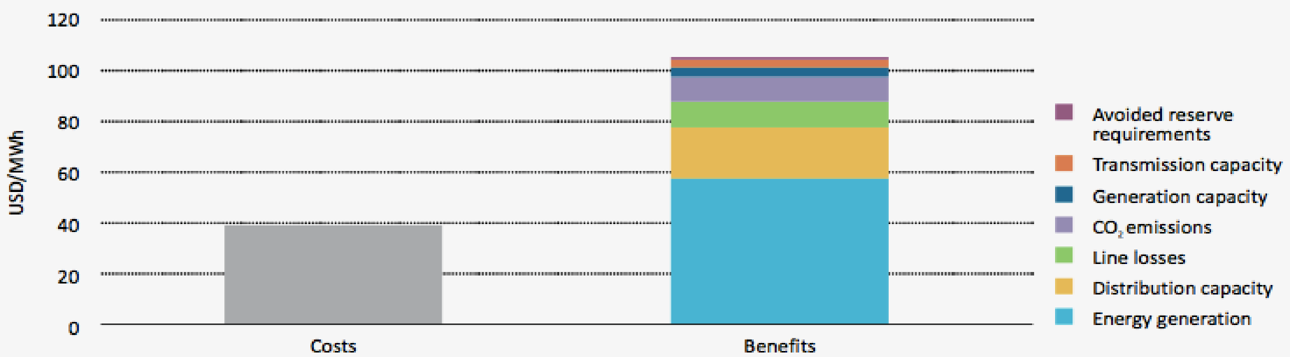
Integrating consumer energy efficiency with supply side

North American utilities typically work in a regulated market context in which regulators oversee investments and operational performance including the performance of utility demand side management activities. Documents like the Californian Standard Practice Manual set out methods for evaluating the energy efficiency programme costs and both the energy and other benefits that accrue to consumers.

Opportunity: Utility Benefits from Consumer Energy Efficiency. [158]

Efficiency Vermont's energy efficiency programmes reduced energy demand by 110GWh over a 10 year average measure life at a total cost of USD33Mn and at a levelised energy cost of USD39/MWh. The energy efficiency measures in turn provided measured benefits 2.4 times greater, over USD104/MWh, comprising: avoided generation costs worth USD57/MWh, avoided distribution costs of USD20/MWh, avoided lines losses of USD10/MWh, avoided CO_2 of USD9.4/MWh at USD20/tCO_2. Figure 3.12 summarizes the multiple benefits in a chart.

Figure 3.9: Power System Upstream Multiple Benefits.



Note: Values are expressed as levellised USD/MWh.

Source: Efficiency Vermont (2012), *Annual Report 2010*, Efficiency Vermont, Burlington, www.efficiencyvermont.com/docs/about_efficiency_vermont/annual_reports/2010_Annual_Report.pdf.

3.6. Energy Resource Sustainability

Energy resource sustainability addresses a range of issues, including the cleaner use of fossil fuel resources including its extraction, production, generation, transmission, and consumption. The increased use of renewable energy sources has implication to other sectors and resources including water, food, and land use, among others so that a sub-chapter on nexus issues was integrated. As mentioned elsewhere in this report, energy and climate objectives are closely linked, and a summary of the climate commitments of UNECE countries submitted under the Paris Agreement is presented in this section.

3.6.1 Selected Issues and Country Responses

Issue 1: Commitments to Reduce Energy Sector Greenhouse Gas Emissions

CO2 emissions from energy contributed 76% of total greenhouse gas emissions globally in 2010. In 2012, the UNECE region emitted 31.5% of global GHG emissions. [159] At 32.1 Gt of CO2 emitted, global energy-related CO2 emissions were static for a third straight year in 2016. The global economy grew 3.1% in this same year, signalling a medium term decoupling of emissions growth and economic activity. This decoupling resulted from switches from coal to natural gas, improvements in energy efficiency, and structural changes in the global economy, and increasing renewable power generation. [160]

CO2 emissions declined in the U.S. and China (the world's two-largest energy users and CO2 emitters), offsetting increases in most of the rest of the world, and were stable in Europe. The biggest drop came from the United States, where CO2 emissions fell 3%, or 160 Mt, while the economy grew by 1.6%. The decline was driven by a surge in shale gas supply and renewable power displacing coal. Emissions in the U.S. last year were at their lowest level since 1992, yet the economy has grown by 80% since then. [161]

Prior to COP21 in 2015, countries submitted their intended nationally determined contributions (INDCs) to define their voluntary contributions to mitigate climate change. These commitments are diverse, as they reflect local conditions and capabilities, and vary in scope, pledged pathway, conditionality, and additionality. Within the outcome document of COP21, the "Paris Agreement", countries agreed to reduce

GHG emissions to well below 2°C. As of 22 August 2017, 165 INDCs[162] covering 192 parties (out of 197), and 155 parties have submitted their Nationally Determined Contributions (NDCs)[163] to the UNFCCC Convention. The NDCs represent 96% of the Parties to the Convention, including the EU and its member countries as one regional entity. [164]

Within the UNECE region, as of 19 April 2017, all member States have submitted INDCs. Table 3.9 provides a simple overview of each member States' submission of (I)NDCs, the status of ratification, the reduction targets, and an analysis of energy key words.

Table 3.9: (Intended) Nationally Determined Contributions ((I)NDCs) of UNECE Countries.

UNECE Member State	Date of Ratification	(I)NDC Submission*	Key word mentioned**				Per Capita Emissions in 2015***	Base-year	Reduction target (by year)
			Energy	Renewable energy	Energy efficiency	Energy Access			
Albania	9/21/2016	First NDCs	1	0	0	0	1.53	BAU	11.5% (2030)
Andorra	5/24/2017	First NDCs	1	0	0	0	N/A	BAU	37% (2021-2030)
Armenia	3/23/2017	First NDCs	1	1	1	0	1.51	2010	633 million tCO2 eq (2030)
Azerbaijan	1/9/2017	First NDCs	1	1	1	1	3.36	1990	35% (2030)
Belarus	9/21/2016	First NDCs	0	0	0	0	6.82	1990	28% (2021-2030)
Bosnia & Herzegovina	3/16/2017	First NDCs	1	1	1	0	6.47	1990	3-23% (2030)
Canada	10/5/2016	Rev. Sub. 11/05/2017	1	1	1	0	15.45	2005	30% (2030)
European Union	****	First NDCs (EU)	1	0	1	0	N/A	1990	40% (2030)
Georgia	5/8/2017	First NDCs	1	0	1	1	1.8	2013	15% (2021-2030)
Iceland	9/21/2016	First NDCs	1	1	0	0	11.76	1990	40% (2030)
Israel	11/22/2016	First NDCs	1	1	1	1	5.16	2005	26% (2016-2030)
Kazakhstan	12/6/2016	First NDCs	1	1	1	1	15.2	1990	15-25% (2021-2030)
Kyrgyzstan	not yet ratified	INDCs	1	0	0	0	1.19	BAU	11.49-13.75% (2020-2030)
Liechten-stein	not yet ratified	INDCs	1	0	1	0	N/A	1990	40% (2021-2030)
Monaco	10/24/2016	First NDCs (EU)	1	1	1	0	N/A	1990	50% (2021-2030)
Montenegro	not yet ratified	INDCs	1	1	1	0	6.69*****	1990	30% (2030)
Norway	6/20/2016	First NDCs	1	1	0	0	8.27	1990	40% (2021-2030)
Republic of Moldova	6/20/2017	First NDCs	1	1	1	1	1.86	1990	64-67% (2021-2030)
Russian Federation	not yet ratified	INDCs	1	1	1	0	12.27	1990	25-30% (2020-2030)
San Marino	not yet ratified	INDCs	1	1	1	0	N/A	2005	20% (2030)
Serbia		INDCs	0	0	0	0	6.69*****	1990	9.8% (2021-2030)
Switzerland	not yet ratified	INDCs	1	0	0	0	4.83	1990	50% (2021-2030)
Tajikistan	3/22/2017	First NDCs	1	1	1	0	0.54	1990	65-70% (2021-2030)
The FYR of Macedonia	not yet ratified	INDCs	1	1	1	1	4.71	BAU	30% (2030)
Turkey	not yet ratified	INDCs	1	1	1	1	4.54	BAU	21% (2021-2030)
Turkmenistan	10/20/2016	First NDCs	1	1	1	0	17.54	2000	1.7 times less than 2000 level (2030)
Ukraine	9/19/2016	First NDCs	1	1	1	0	5.1	1990	>40% (2021-2030)
United States of America	9/3/2016 ******	First NDCs	1	0	1	0	16.07	2005	26-28% (2020-2025)
Uzbekistan	not yet ratified	INDCs	1	1	1	0	3.67	2010	10% (2020-2030)

* First INDC means the NDC is equal to the INDC submitted before COP21, but it has been ratified by the party.
** 1= key word mentioned in (I)NDC)
*** Source: European Commission Joint Research Center (2016): *CO2 time series 1990-2015 per capita for world countries*. In: Emission Database for Global Atmospheric Research. http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts_pc1990-2015
**** Dates of ratification vary depending on the Member States. As of July 2017 two EU Member States, Czech Republic and The Netherlands, have not yet ratified the Paris Agreement.
***** Data only available for Serbia and Montenegro together.
****** Withdrawal announced on 1 June 2017.

From the (I)NDC submission by member States all except two countries (Belarus and Serbia) mention energy within their (I)NDC. Two thirds mention renewable energy, and almost three quarters emphasize energy efficiency. Energy access is only mentioned by a quarter of the (I)NDCs, reflecting the comparatively lower urgency of energy access within the UNECE region. In terms of emission reductions, the EU and its member states have already reduced their emission by 19% on 1990 levels while GDP has grown 44%. Per capita emissions have fallen from $12tCO_{2eq}$ in 1990 to $9tCO_{2eq}$ in 2012 and are projected to fall to around $6tcCO_{2eq}$ in 2030. [165]

Case Study: The European Union's Nationally Determined Contributions.[166]

The EU and its 28 Member States are committed to a binding target of at least 40% absolute domestic reductions in GHG emissions by 2030 compared to 1990 base year. The NDC is to be fulfilled jointly, as set out in the conclusions by the European Council of October 2014. The NDC covers emissions from Energy, Industrial processes and product use, Agriculture, Waste, Land Use, Land-Use Change and Forestry (set out in Decision 529/2013/EU)

The target represents a significant progression beyond its current undertaking of a 20% emission reduction commitment by 2020 compared to 1990 (which includes the use of offsets). It is in line with the EU objective, in the context of necessary reductions according to the IPCC by developed countries as a group, to reduce its emissions by 80-95% by 2050 compared to 1990. The NDC plans no contribution from international credits.

Domestic legally-binding legislation is already in place for the 2020 climate and energy package. The existing legislation for land use, land-use change and forestry (EU Decision 529/2013) is based on the existing accounting rules under the second commitment period of the Kyoto Protocol. Legislative proposals to implement the 2030 climate and energy framework, both in the emissions trading sector and in the non-traded sector, to be submitted by the European Commission to the Council and European Parliament in 2015-2016 on the basis of the general political directions by the European Council, taking into account environmental integrity..

The Paris Agreement is a success that nearly all countries submitted (I)NDCs based on the concept of "common but differentiated responsibilities", as defined by UNFCCC.[167] Since their submission, a range of analysis papers have been published to assess if (I)NDCS are sufficient to limit global warming to 2°C, or even 1.5°C. Results indicate that the combined mitigation actions in country submissions would only limit global warming to between 2.5 and 2.8°C (compared to current policies projections of 3.3 to 3.9°C).[168] The analyses conclude that greater efforts are required by the global community to achieve the stated objectives. This conclusion is particularly true for the UNECE region with high emitting countries and subregions, particularly North America and Western and Central Europe, which needs to be reflected in future sustainable energy strategies.

Climate Action Tracker analysed if selected countries can achieve the commitments announced in their (I)NDCs.[169] For example, it is expected that Canada, under its current policies, will miss its 2030 NDC target to reduce GHG emissions by 30% below 2005 levels in 2030 by a wide margin. However, the implementation of a national mandatory carbon-pricing plan that was announced in 2016, would represent a major step towards policies that could change this adverse outlook. With its current policies, the EU is expected to come close in range of meeting its target of reducing emissions by 40% below 1990 levels by 2030. However, as mentioned above, this will not be sufficient to limiting warming to below 2°C. From the eastern part of the UNECE Region, Kazakhstan is recognized for its plans to transit into a greener future, though currently its implemented policies are not yet sufficient to meet its INDC target to reduce GHG emissions by 15% below 1990 levels by 2030.

Issue 2: Management of Methane Emissions from Fossil Fuel Extractive Industries

Methane emissions are a serious climate problem as their greenhouse warming potential is 28-84 times greater than the greenhouse warming potential of CO_2.[170] Methane also represents a significant safety risk as it easily forms explosive mixtures with air. The corollary of this risk is that if methane can be managed and captured it becomes a high quality fuel resource and safety is improved.

Energy sector non-CO_2 emissions are the second largest source of non-CO_2 emissions, accounting for approximately 25% of non-CO_2 emissions in both 1990 and 2005. Emissions from the energy sector increased 14% between 1990 and 2005 (from about 2,500 to 2,800 $MtCO_2e$), driven by a 21% increase in emissions from natural gas and oil systems, which represented the largest part of emission sources, accounting for 55%

of energy-related emissions. The next largest emissions source in this sector were coal mining activities, accounting for 19% of energy related emissions in that year. From 2005 to 2030, energy sector emissions are projected to increase 42% (to about 4,000 MtCO2e). It is estimated that around 8% of total worldwide natural gas production is lost annually to venting, leakage and flaring, resulting in substantial economic and environmental costs. Russia alone represents 19% of world's oil and gas methane emissions in 2015.[171]

The Global Methane Initiative (GMI) maintains a database of country Coal Bed Methane (CBM) and Coal Mine Methane (CMM) information. The U.S. Environmental Protection Agency (EPA) currently lists over 200 coal methane management projects. [172] Of this list 143 projects are in UNECE member countries, achieving over 5,401 $MtCO_2e$ reduction in 2014. Where data exists, these are summarised for UNECE countries in table 3.10.

Table 3.10: Coal Bed Methane (CBM), Coal Mine Methane (CMM) and Mine Methane Reduction Projects in the UNECE Region.

Country	Estimated CBM resource (1)	CMM emissions Mm^3/yr (2)	GHG emissions $MtCO^2e$ in 2010 (3)	Number of Projects	Project types and scale
Belgium				1	Hydrocarbon permit "Hainaut" covering 443 km^2 for exploration of CBM/CMM
Bulgaria	195Bnm^3	101Mm^3 2010			NA
Canada	>5TnM^3	66Mm^3 2010			NA
Czech Republic				21	23MWe of CHP. 200+ km pipeline network using CMM (~77 million m3/year) and AMM (32 million m3/year) Interconnected system amongst many mines. AMM %Ch4=~75; CMM %CH4=50-55. Recovery by OKD DBP started in 1997.
EU					NA
France	28Bnm^3	Gazonor 72Mm^3 Lons le Saunier 83Mm3		3	Gazonor. Abandoned mine methane used as diluting fuel for boilers and in an ash dryer. Operating at least since 2005, also Fuel for coke oven. Operating at least since 2005, Pipeline injection into Gaz de France network.
Georgia	11Bnm^3	0.25Mm^3			NA
Germany	3Tnm^3	195Mm^3		37	113MWe CHP projects totalling over 406 $MtCO_2e$ reduction in 2014
Hungary	>150Bnm^3	1.4Mm^3			NA
Italy		1.4Mm^3			NA
Kazakhstan	>650Bnm^3	995Mm^3		1	25Mm^3 CH_4 utilised. 1.4MWe CHP project at Lenina Mine 21.5 $MtCO_2e$ reduction in 2014
Poland	425Bnm^3 - 1.4Bnm^3	482Mm^3		15	CHP projects totalling over 105 $MtCO_2e$ reduction in 2014 from over 210 million m^3/yr methane gas.
Romania		191Mm^3		2	6-10Mw Caras-Severin CHP and 35MW thermal Lupeni Mine.
Russian Federation	48-80Tnm^3	3,424Mm^3	51$MtCO_2e$ Coal 418$MtCO_2e$ Oil and Gas	9	Over 13MW CHP projects totalling over 324$MtCO_2e$ reduction in 2014
Slovakia				2	Hornonitrianske Mines Bohumin 2 and 3. 2 x 1.2 MW CHP from over 2.4 million m^3/yr methane gas.
Spain		46Mm^3			NA
Turkey	3Tnm^3	135Mm^3			NA
Ukraine	1.7Tnm^3	1,325Mm^3	31$MtCO_2e$	22	Diverse flaring, thermal and extraction processes incl. 83MW generation totalling over 1734 $MtCO_2e$ reduction in 2014
Uzbekistan			107$MtCO_2e$ Oil and Gas		NA
UK	2.45Tnm^3	191Mm^3		46	Over 115MW CHP projects totalling over 543$MtCO_2e$ reduction in 2014
USA	495Bnm^3	5,318Mm^3 2013	78$MtCO_2e$ Coal. 313$MtCO_2e$ Oil and Gas.	35	NA

Sources: U.S. EPA (2016); GMI (2017); U.S. EPA (2017).

It should be noted that data sets on methane in both the Coal and Oil & Gas sectors are incomplete and different analyses offer different values for CBM and CMM.

Technologies for detecting and quantifying methane emissions, as well as standard national/regional methods for reporting them are available. [173] However, their implementation is not always harmonised and in some cases it may be complicated to make comparisons of the data. [174]

With changing commitments following COP21, all data sets and projections need to be reviewed and updated in light of the current policies. However two conclusions can be drawn: (1) the scale of Coal Bed Methane in UNECE is vast, exceeding 12Tnm^3, and (2) CMB and CMM offers, if properly managed, an access to abundant valuable resources and provide an opportunity for easily obtainable emission reductions.

Case Study: Coal Seam Methane Recovery: Examples from Poland and the Ukraine.

Poland[175]: 24% of mine methane is currently being captured by methane management systems in Poland. Nevertheless, 110 million m^3 of methane was still vented to the atmosphere in 2014. Methane utilization has dropped slightly from 68% in 2013 to 66% in 2014.

With 930 Mm^3/year methane bearing capacity, and 338 Mm^3/year methane drainage, a potential 680 million m^3 VAM (including 110Mm^3 that is ready to manage Since 2010 there has been support for electricity produced from high efficiency cogeneration Primary Energy Saving> 10%).

Ukraine[176]: In 2015, 35Mt of coal was mined in Ukraine (less than half the 2014 antebellum levels) with 562Mm^3 per year of coal mine methane, of which 404Mm^3 are extracted with ventilation and 28% or 158Mm^3 by outgassing. In 2015 methane capture was undertaken in 2 mines.

Issue 3: The Energy - Water - Land Nexus

Energy has significant connections to agriculture, water, and climate. The process of extracting and processing natural energy resources, the subsequent generation of power, and transmission and distribution via grids and pipelines has a significant impact on a variety of other economic and environmental processes and activities. These connections offer an opportunity for synergies to increase sustainability, but they could negatively affect competing sectors. Water captured for a hydropower dam may not be available for irrigation downstream and could impact river ecosystems. Warm water discharge from thermal power plants impacts fisheries and wildlife. The production of biofuels may lead to land competition for food production, and binds water resources, and leads to mono-cultures. On the other hand, agriculture is an energy-intense sector, with 4% of global electricity and 50mtoe of energy currently being used in irrigation pumping and desalination.[177] Over the next 25 years, the amount of energy used in the water sector will more than double, mostly because of desalination projects that will account for 20% of water-related electricity demand by 2040. Large-scale water transfer projects and increasing demand for wastewater treatment also contribute to the water sector's rising energy needs.

The connections and synergies between sectors are described as a nexus. A nexus offers opportunities to minimize resource input and waste, emission, and energy leakage by narrowing material and energy loops. [178] The energy-water-agriculture nexus is highly relevant for the energy sector. Trans-boundary water basins represent a particular governance challenge – there are over 270 trans-boundary river basins in the world, covering approximately 60% of the globe's freshwater flow and roughly 40% of the population. [179] Additionally, there are an estimated 600 aquifers that are shared by two or more nations. [180] How a river or aquifer is managed or used in one location can drastically affect other locations further up or downstream. The case study below on the Drina Basin, covering six UNECE countries, including Bosnia-Herzegovina, Montenegro, and Serbia, provides an analysis on the energy-food-water nexus and its challenges and opportunities for more sustainable resource management.

Case Study: Drina River Basin Energy-Water-Food Nexus Solutions Assessment.[181]

The Drina River, located in the Western Balkans and shared by Bosnia and Herzegovina, Montenegro and Serbia, is the main tributary of the Sava River, and groundwater represents the main source of water supply for communities in the basin. Surface water resources also support significant power generation (both hydropower and thermal power) that is key for the energy security of the three countries and also produces revenues from exports.

A participatory assessment of the intersectoral links, trade-offs and benefits in the water-food-energy-ecosystems nexus involving the energy, agriculture, water and environmental authorities of the three countries and other key stakeholders was carried out under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes. The interactions of energy with other sectors, relevant for resource management, were jointly identified. Selected examples for each group of interlinkages are given below to illustrate possible solutions related to policy or technical measures, also determined in the process.

Water-Energy *(selected)*

- *Interlinkages*: Water needed for hydro- and thermal-power production, altered river flow due to uncoordinated hydropower operations, Pumped storage playing a key role in integrating RE in the grid.
- *Solutions*: Harmonize legislation related to water resources use for energy generation (i.e. regulate the practice of hydropeaking, pumped storage, implementation of feed-in tariffs for the promotion of non-hydro renewables, legislation on concessions in order to overcome investments barriers) and to permitting of hydropower projects and utilities; Utilize the potential of non-hydro RE to reduce dependence on coal and on water resources from the basin.

Food/Land-Energy

- *Interlinkages*: Potential new land use for non-hydro RE (solar and wind); Potential for biofuels in the region.
- *Solutions*: Implement/continue implementing land consolidation policies (making larger clusters, swapping, farm cooperatives), restoring unutilised land; Develop practice in SE or sustainability impact assessment in land use planning.

Ecosystems-Energy

- *Interlinkages*: Potential for installation of small scale renewables in the agricultural and eco-touristic sectors; Potential for biomass production associated to the wood industry.
- *Solutions*: Promote the use of renewable energies in eco-tourism (for instance, solar on rooftop of buildings), especially in remote areas.

Energy-Food/Land

- *Interlinkages*: Ecosystems compromised by expansion of small hydropower (also in protected areas).
- *Solutions*: Transboundary collaboration on gathering and sharing information on the status of biodiversity, development and enforcement of common regulations (including those related to the siting of small hydropower facilities), and the establishment of transboundary protected areas (notably the Tara-Drina).

The assessment demonstrates various potential benefits from cooperation, to countries and utilities from potential increases in electricity production (e.g. by optimising water release regimes), but also at the regional level through increased energy trade and integration, and energy security.

A related modelling exercise shows that cooperative operation of hydropower dams could deliver more than 600 GWh of electricity over the 2017-2030 period. Setting aside 30% of the dam capacity for flood control would have a cost, through a change in the energy mix, of about 4% of the operational cost of the whole electricity system in the three countries. Pressure on hydropower generation could be reduced by increasing energy efficiency – by as much as 4.1 TWh in the combined Drina Basin – and would also deliver significant reductions in GHG emissions (from 38 Mt in 2017 to about 28 Mt in 2030) representing about 21% of the combined emissions of the three countries in 2015.

3.6.2 Opportunities and Prospects

Increasing international cooperation to increase ambitions to reduce greenhouse gas emissions

If countries do not act faster in the period to 2030 they will be obliged to make much greater reduction efforts in the period after 2025 to hold the temperature rise below 2 °C above pre-industrial levels. [182]

Currently policies for sustainable energy tend to work in a disaggregated way. Separate energy efficiency, renewable energy and climate policies are led by different operational agencies. There is a need to integrate GHG mitigation potentials with the potentials for energy efficiency and renewable energy to develop a clearer understanding of the trade-offs and economically optimal investment paths available to countries in the UNECE region.

Exploring technology options to decarbonize fossil fuel based power generation

If the world is to constrain CO2 emissions to levels consistent with a less than 2°C rise in global temperatures, then Carbon Capture and Storage (CCS) will need to contribute about one-sixth of needed CO2 emission reductions in 2050, and 14 per cent of the cumulative emissions reductions between 2015 and 2050 compared to a business-as-usual approach. It is the only technology option other than energy efficiency and shifting the primary energy mix to lower carbon fuels that can deliver net emissions reductions at the required scale. The IPCC's AR5 Synthesis Report estimated that without CCS the cost of climate mitigation would increase by 138%.

Global CO2 storage levels of at least one billion tonnes per year by 2030 need to be in place, and more thereafter. Delivering such an outcome will require collective commitment by governments and industry alike to fund CCS demonstration projects and development efforts in power and industrial applications at levels commensurate with the required abatement outcomes. Ensuring the availability of CCS will require regulatory and legislative support at all levels of government and international cooperation at project level so the necessary financing can be unlocked.

In order to facilitate this transition, UNECE developed Recommendations on CCS and on carbon capture, utilisation and storage (CCUS), which were submitted to UNFCCC before the COP20 in Lima and were well received.

Opportunity: How carbon capture and storage in cleaner electricity production and through enhanced oil recovery could be used in reducing greenhouse gas emissions.[183]

The UNECE Group of Experts on Cleaner Electricity Production from Fossil Fuels Coal Mine Methane (CMM) prepared recommendations for how Carbon Capture and Storage (CCS) and CCS for Enhanced Oil Recovery (EOR) should be treated in a Post-Kyoto Protocol Agreement. After the approval of the recommendations by the UNECE Committee on Sustainable Energy, they were transmitted to the UNFCCC in 2014. The recommendations covert the following items:

- Policies on CCS/CCUS should have parity with other no carbon/low carbon technology regarding their climate mitigation potential, commensurate with the state of technological and infrastructure development.
- Governments should consider a broad array of fiscal instruments to encourage CCS/CCUS until carbon is properly and adequately priced. Capturing and storing CO2 from all industrial sectors will be essential to reach climate goals. CCS/CCUS deployment will accelerate if governments work together to financially sponsor demonstration projects.
- Developed countries should be encouraged to invest in CCS/CCUS in developing countries.
- CCS developments need to be monitored and tracked globally so best practice guidance on CCS can be developed and disseminated.

Improved Methane Management in Coal, Oil and Gas Sector

According to the EPA, coal mining accounted for 8% of total global anthropogenic methane emissions in 2010, and these emissions are projected to increase by 33% to 784 million metric tons of carbon dioxide equivalent (MtCO2e) by 2030. The global abatement potential is projected to be 50 to 468 tCO2e, or 6 to 60% of baseline emissions, in 2030. The cost-effective abatement potential ($0 break-even price) is 77.7 tCO2e, or 10% of baseline.

The technological maximum potential ($100 + break-even price) is 467.6 tCO2e, or 60% of baseline.

The technological maximum for emissions reduction potential in oil and gas is 1,219 million metric tons of carbon dioxide equivalent (MtCO2e), approximately 58% of projected emissions in 2030. Because of the energy value of the methane captured, EPA estimates that 747 MtCO2e, or 40% of the baseline emissions, can be cost-effectively reduced. Over 26% of total abatement potential is achieved by adopting abatement measures in the oil and gas production segments.[184]

Significant programmes to reduce the flaring of associated gas from oil extraction founded the global natural gas industry during the 1970s. Recovered coal seam methane can be used as a fuel and extraction methods for methane for coal, oil and gas extraction processes are mature; options to recover methane from coal seams include:

- Coal Bed Methane processes extract methane from un-mined coal seams. The coal seams may still be mined in the future but this is largely dependent upon geological factors, such as coal depth and quality;
- Coal Mine Methane processes extract methane during mining activities as the coal is in the process of being extracted and thus emitting significant quantities of the gas;
- Abandoned Mine Methane processes recover methane from mines that have been closed as significant amounts of methane may remain trapped in the mine or may continue to be emitted from openings.

There is significant scope to transform fugitive methane emissions into useful energy resources while mitigating methane GHG. Many countries have coal seam methane management regimes in place. US EPA modelling outlines global marginal abatement cost curves for methane management but there is no up to date comprehensive evaluation of the potential for methane management programs and their capabilities yet.

The extensive switching of power production from coal to gas and solar in the US highlights the role that methane resources could play in the energy transition. The increasing utilization of gas has raised the issue of fugitive emissions of methane from both conventional and shale gas production.

Taking into account revised estimates for fugitive methane emissions, recent lifecycle assessments indicate that specific GHG emissions are reduced by one half (on a per-kWh basis) when shifting from the current world-average coal fired power plant to a modern natural gas combined-cycle (NGCC) power plant.[185] This reduction is the result of the lower carbon content of natural gas (15.3 gC/MJ compared to, e.g., 26.2 gC/MJ for sub-bituminous coal) and the higher efficiency of combined-cycle power plants.[186]

The priority for methane management is to monitor and record emissions accurately using the best monitoring and measurement technology and to assess the best solutions to minimize leaks and emissions. More efficient and effective methane management will offer direct economic benefits which include: decreasing negative health impacts, increasing workers' safety and reducing global warming. However, more work is needed to demonstrate how methane options can advance the energy transition.

Recent progress in fracking technique, and methane management, Degasification and Ventilation Air Methane (VAM), alter the economics of gas and unconventional oil extraction, and the scope for methane application to power generation suggest the potentials methane management need to be revisited. [187]

In this context the UNECE Secretariat in consultation with the secretariats of the International Gas Union, the World Coal Association and the World Petroleum Council and other industry experts, has prepared and executed a survey on techniques and measures currently undertaken to measure, report, and verify (MRV) methane emissions in extractive industries. The data obtained from the survey shows that very few entities operating in the extractive industries do not monitor their gas emissions. Similarly, only few do not report the results, as such reporting is oftentimes mandated by law. However, the underlying reason for monitoring are diverse. While the primary purpose was “environment” and “law” for the oil and the gas industries, stakeholder forum the coal industry singled out “safety” as the main reason. More than half of all industries distinguish between methane and other hydrocarbon gases during the monitoring. In terms of continuity of measurements, results vary for sectors. 50% of coal mines measure continuously, as the gas in the mine is released into the working environment. For oil and gas (mid- and downstream), about a third of the companies measure continuously. Only the coal sector has a standardized approach on the control of CH4 emissions. Responses to question #17 (image 10) indicate that methods for CH4 emissions monitoring typically ARE mandated by law for global coal industry and are NOT for the other industrial sectors covered by the survey. Monitoring measures are not standardized across entities and sectors. [188] With a vast resource of coal bed methane and scope to increase The United Nations Economic Commission for Europe (UNECE) Committee on Sustainable Energy recommended that work be done to agree on common philosophies, standards, and technology for monitoring, recording, and reporting methane emissions at each stage of production, processing, storage, transmission, distribution, and use of fossil fuels, whether coal, oil, or natural gas, recognizing at the same time that case by case adaptation to specific situations might be necessary. Additionally, it was agreed there is a need to mitigate methane emissions, including identifying appropriate mechanisms for mobilizing needed resources, and to fund a detailed study on a common basis across the entire UNECE region. In response, the Committee requested that work be undertaken to assess baseline, benchmarking and scale of current methane emissions in the extractive industries, with the aim of giving clear guidance to practitioners and policy-makers.

Opportunity: Best Practice Guidance for Effective Methane Drainage and Use in Coal Mines. [189]

The UNECE Group of Experts on Coal Mine Methane (CMM) has released the second edition of the Best Practice Guidance for Effective Methane Drainage and Use in Coal Mines. Since the first edition was published in 2010, the industry practice and regulations have evolved, and the second edition captures the most critical developments. The second edition also includes additional case studies that illustrate the application of the best practices in coalmines worldwide. The principles-based second edition of Best Practice Guidance does not replace national or international laws and regulations. Rather, it complements them through a holistic approach to safer and more effective methane management practices.

Realizing Synergies in the Energy-Water-Land Nexus

Understanding the diversity and social, economic and environmental diversity and potentials is at the heart of solutions for eco-systems with energy-water–land use nexus challenges. Often the solution lies in better understanding the diversity of needs in the region around the eco-system and the breadth of benefits that can be drawn from the ecosystem. Communities can then find ways to enable that diversity of outcomes from better to management of the nexus relationships and dependencies in the eco-system.

To identify opportunities for increase resource sustainability while limiting negative impacts on connected sectors, a range of tools and approaches have been developed in the past. Tools like strategic environmental assessment (SEA) enable new insights into inter-sectoral synergies to address the trade-offs and externalities in resource utilisation and trans-boundary issues. Besides facilitating potential inter-sectoral conflicts (e.g. likely impacts resulting from hydropower development on water resources or agriculture soil in downstream sections), SEA also provides an opportunity for a wide range of stakeholders (environmental and health authorities, businesses, public) to provide their feedback on proposed development in a given sector or area. Thus, efficient application of SEA can streamline development and implementation of specific projects by addressing issues that are difficult to grasp at the project level (especially large-scale and cumulative effects); and by providing an early warning on problems to be solved when designing the projects and carrying out relevant permitting procedure including EIA. This in turn expands the scope of economic sustainable energy potentials and maximises system resilience by opening up multiple options for resources, rather than singular reliance on traditional resources and technology. Countries and regional communities can extract more value from a wider and more sustainable range of resource options, increase economic trade in resources, to improve system sustainability and resilience.

Several tools and approaches have been developed to assess intersectoral links and dynamics including energy at different scales and for different purposes, and could be considered for detailing a scoping level assessment of the kind applied in the river basins referred to in Box "Good Practices and Policies for Inter-Sectoral Synergies to Develop Renewable Energy: Opportunities in hydropower more sustainable". These include: (1) dialogues; (2) mapping; (3) scenarios; (4) extended systems analysis; and (5) institutional analysis. [190] Several more detailed nexus analysis tools and efforts focus on accounting for the inputs and outputs of resources when delivering services, indicating where and how resources are linked, as well as how those linkages will compound direct and indirect demands. Each have an explicit focus on water, energy and land-use activities and how those are linked, and the most appropriate one can be selected depending on the purpose of the analysis. [191]

An example of an integrated resource assessment tool is the INOGATE RESMAP Geospatial mapping for sustainable energy investment project, presented in below box. While this tool currently covers only Georgia. Armenia, Azerbaijan, Moldova, it highlights the scope for a richer understanding of options to fully deliver GHG reductions and SDG objectives and the scope of energy, industrial processes and product use, agriculture, waste, land use, land-Use change and forestry options that need to be understood and managed to deliver SDG objectives in full.

Opportunity: Geospatial Mapping for Sustainable Energy. [192]

The INOGATE RESMAP online geospatial mapping platform demonstrates the value at stake from wind and solar investment to stakeholders in Georgia, Armenia, Azerbaijan and Moldova. It enables assessment of the theoretical, ecological and economically viable wind and solar energy resource maps, using highly granular data (at least 10km square resolution). Infrastructure and constraint maps on a web-based 'GeoExplorer' map enable labelling, zoom, measurement functions, scroll down boxes and relevant information tools. This enables stakeholders (investors, policy makers, equipment suppliers) the location, amount (MW and GWh/year) and Net Present Value of the economically viable wind and solar resource available in their country, at different combinations of capital cost, investment discount rate and power purchase tariff, thereby determining the value at stake. Mapping existing reference projects, wind and solar resource will assist dialogue between policy makers, investors and other stakeholders and a better optimisation of resources constraints and objectives.

A series of policies and technology already exist that can help reduce water and energy demand, and ease potential chokepoints in the water-energy nexus. These include integrating energy and water policymaking, co-locating energy and water infrastructure, utilising the energy embedded in wastewater, using alternative sources of water for energy and improving the efficiency of both sectors. Below box presents suggested solutions for policy and technology options and cooperation opportunities based on the results of transboundary river basin energy-water-land nexus analysis from the Balkans (the Sava and its tributary the Drina), the Caucasus (the Alazani/Ganykh) and Central Asia (the Syr Darya).

Opportunity: Good Practices and Policies for Inter-Sectoral Synergies to Develop Renewable Energy: Opportunities in making hydropower more sustainable. [193]

Renewable energy could play a strong role in helping to achieve better management of resources within the water-energy-food-ecosystems nexus. The nexus approach itself presents an opportunity to strengthen the actions aimed at achieving the Sustainable Development Goals.

So far, four nexus assessments have been completed in the Alazani/Ganikh (Azerbaijan, Georgia), Sava (Bosnia and Herzegovina, Croatia, Montenegro, Serbia, and Slovenia), Syr Darya (Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan7), and Drina Basins (Bosnia and Herzegovina, Montenegro and Serbia).

The assessments provide the input to develop policy recommendations, including measures that could facilitate renewable energy deployment, which is more sustainable and accounts for the nexus trade-offs between the energy, water and food sectors and the ecosystems. The nexus assessments demonstrate that depending on the context, diverse solutions to externalities from hydropower development and making renewable energy more sustainable can be identified, ranging from technical measures to information and governance. Some selected examples about such solutions are given below (with a focus on energy sector measures):

The Sava and Drina River Basins - Develop hydropower sustainably and integrate other renewable energies; coordinate operation of hydropower plants (for flood control, for energy system benefits, ensuring environmental flow); and development of new capacities ideally with a basin-wide strategy, taking into account the trade-offs with other water uses and the environment;

The Alazani/Ganykh River Basin - Facilitate access to modern energy sources and energy trade; minimize impacts from new hydropower development; apply catchment management to control erosion to limit impacts on infrastructure;

The Syr Darya River Basin - Promote restoring the regional grid and vitalizing energy market; improve efficiency in energy generation, transmission and use; improve efficiency in water use (especially in agriculture).

The basin cases show that through regional and transboundary cooperation in both the energy sector and in water management – across sectors – negative intersectoral and environmental impacts can be reduced and synergic beneficial actions have more impact.

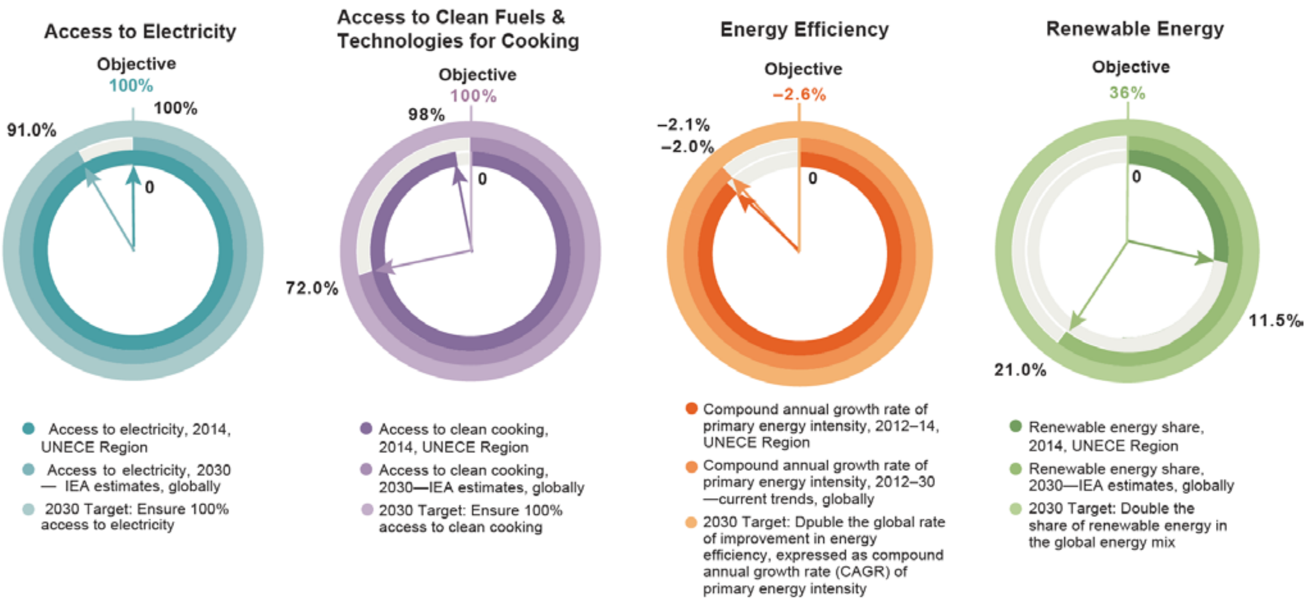
IV. CONCLUSIONS AND RECOMMENDATIONS

This report is a first step towards broadening the discussion about energy to tracking progress on energy for sustainable development. Energy underpins the Sustainable Development Agenda beyond SDG7. Progress must be measured using relevant indicators that reflect a more holistic approach.

A more comprehensive view of energy is the basis for a more informative assessment. Taking demand for energy services as the basis of such an approach a broader set of indicators naturally emerges. The analysis of challenges and progress within the different elements of the energy system, including end-use energy efficiency, distributed generation, transmission and generation related challenges, as well the sustainability of energy resources, helps to describe a country's status and prospects in achieving sustainable energy.

The following graphs summarizes the results of this tracking period for the pillars of energy efficiency, renewable energy, and energy access as described in SEforALL:

Figure 4.1: Summary of Achievement of the UN's Sustainable Energy Targets in the UNECE Region.



The following conclusions emerge from this report:

- Attainment of the objectives of SDG7 is falling short in the UNECE region, and countries need to accelerate the uptake of renewable energy, the improvement in energy efficiency, and the provision of energy access.
    - **Access Realities:** Despite the reported 100% access, some countries face limited power supply, outages, poor service quality, etc. Human comfort and safety depend on substantial heat services in most UNECE countries. A significant challenge exists to upgrade older un-insulated housing stock with locked-in fossil fuel dependence. Low-income households throughout UNECE make tradeoffs between heat, food, and other needs, and there is a measurable proportion of households that spend more than 10% of their income on energy. Addressing GHG emissions without improving energy efficiency would worsen energy poverty.
    - **Demand Side Energy Efficiency:** Most countries have National Energy Efficiency Action Plans, but show limited progress or compliance tracking. Improving building energy efficiency is slow, but there is solid appliance efficiency progress in North America and the EU. A largely untapped potential for industry energy management productivity exists. Outside of the EU, vehicle fuel economy is not progressing.
    - **Supply Side Energy Efficiency:** Fossil fuel (coal, gas and oil) power plant efficiency grew from 36% in 1990 to 41% in 2014. Gas fired generators improved from 37% in 1990 to 49% in 2014. Electricity transmission and distribution losses declined from 8.2% in 1990 to 7.2% in 2014, while natural gas transmission and distribution losses fell from 1.2% to 0.6%.
    - **Renewable Energy Integration:** Among the five UN regions, the UNECE region was the only one to improve the share of renewable energy in TFC. Development in introducing more competitive market-based support mechanisms such as auctions are increasingly applied, and there is substantial opportunity for sharing lessons learnt among the countries of the region. Further challenges exist regarding the market design to manage variability, and financial incentives to provide needed back-up.

- Consumer energy services are not adequately met. There is evidence of challenges in heating service affordability, reliability of aging systems and future resilience needs. Energy sustainability must focus on more than just environmental impacts and pursue integrated social, economic and environmental policies.
- Reports on progress towards achieving SDG7 need to include indicators not only on the three pillars of renewable energy, energy efficiency and energy access, but also on the financial indicators listed for targets 7.A and 7.B which track the mobilisation of funding, investments in energy efficiency, and foreign direct investments in infrastructure and technology.
- Energy for sustainable development goes beyond SDG7. Progress tracking reports need to include a broader set of energy indicators, making the linkages to other Sustainable Development Goals. As shown in this report, the World including the UNECE region is falling short with respect to attainment of relevant indicators such as the carbon intensity of the energy sector. However, without any UN-wide agreed carbon intensity targets measuring progress is difficult.
- All of the indicators, whether from a more narrow perspective of SDG7 or from a broader perspective of energy for sustainable development, are derived from the existing data gathering and reporting infrastructure that emerged from the energy system of the past. In order to inform policies to accelerate the transition to an energy system that can support sustainable development, it will not only be necessary to develop appropriate indicators of the system of the future but also to adapt data gathering systems and build the required capacities to collect, analyse, track and report data and indicators.
- There is a need for a process that can deliver a more comprehensive but at the same practical and manageable set of indicators. The SDG7 review is part of this larger process. The UN Regional Commissions can contribute by consulting with their member States in defining the indicators.

The challenge in most countries is to develop integrated programmes based on rational economics:

- An ‘energy efficiency first’ approach throughout the energy system to maximise multiple benefits to citizens and businesses while minimising costs and upstream demand for energy infrastructure;
- A generalised, equivalent treatment of low or no carbon alternatives;
- Integration of energy efficiency and renewable energy;
- A durable policy framework that address fundamentals like cost-reflective energy pricing, efficient energy markets, liberalised trade, open access, and valuing carbon.

The Eighth International Forum on Energy for Sustainable Development explored in detail how to implement the outcome of the 2017 Astana energy ministerial that set out broad lines for acting on energy efficiency from source to use, deploying advanced fossil technology, supporting low or no-carbon alternatives, and taking whole energy system perspectives in energy policy. As part of the Forum and the Energy Ministerial conference that took place in Astana in June 2017, ministers agreed to “participate on a voluntary basis in the development of methods for public data collection, and the gathering and dissemination of appropriate data and indicators related to energy for sustainable development”194. Participants of the Eighth Forum endorsed an outcome document that focused on “Improving data quality and indicators”, with a pledge to support future regional reports on tracking of progress on attainment of the Sustainable Development Goals, in particular on energy.[195] UNECE alongside the other four Regional Commissions stand ready to support their member States in addressing this action, and target activities to achieving this goal.

Key limitations of this report include the availability of data from all countries, not only for the agreed SDG7 indicators, but also as a basis to broaden the set of indicators to track energy for sustainable development. The report would further benefit from a more intensive consultation phase with member States. The data gathering and reporting infrastructure that exists today has emerged and evolved over many years, and changes and improvements to this system require extensive consultation, adaptation, and capacity development support. Furthermore, tracking important pillars such as the carbon intensity of energy, per capita carbon emissions, are difficult due to missing data or differences in reporting approaches, and are further complicated by the fact that no universally agreed targets exist to measure progress.

This report has suggested a number of new paradigms for indicators for the future, whether related to quality of service or holistic systems analysis. There is merit in considering what indicators would point to a future in which energy for sustainable development is assured. Once a concise set of indicators has been identified, it will be necessary to establish data gathering infrastructure to ensure that data are available to populate a new set of indicators credibly.

Acronyms and Abbreviations

AR5	IPCC Fifth Assessment Report
BECCS	Bioenergy Carbon, Capture and Storage
CAGR	Compound annual growth rate
CBM	Coal Bed Methane
CCS	Carbon, Capture and Storage
CEO	Chief Executive Officer
CH4	Methane
CIS	Commonwealth of Independent States
CMM	Coal Mine Methane
CO2	Carbon Dioxide
CO2eq	Carbon Dioxide equivalent
CSE	UNECE Committee on Sustainable Energy#
DOE	U.S. Department of Energy
ECA	Economic Commission for Africa
ECLAC	Economic Commission for Latin America and the Caribbean
EIA	U.S. Energy Information Administration
EPA	Environmental Protection Agency
ESCAP	Economic and Social Commission for Asia and the Pacific
ESCWA	Economic and Social Commission for West Asia
EU	European Union
EUR	Euro
FiT	Feed-in Tariff
GFEI	Global Fuel Economy Initiative
GHG	Greenhouse gas
GDP	Gross Domestic Product
GMI	Global Methane Initiative
GTF	Global Tracking Framework
HFC	Hydrofluorocarbons
ICP	Investor Confidence Programme
ICT	Information and communications technology
IEA	International Energy Agency
IEC	International Energy Charter
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
LCOE	Levelised cost of electricity
LNG	Liquefied Natural Gas
MEPS	Minimum Energy Performance Standard
N2O	Nitrous Oxide
NDC	Nationally Determined Contribution
NEEAP	National Energy Efficiency Action Plans
NGCC	Natural gas combined-cycle
NREL	National Renewable Energy Laboratory
PFC	Perfluorocarbons
PPP	Power purchasing parity
RC	Regional Commission
REN21	Renewable Energy Policy Network for the 21st Century

SDG	Sustainable Development Goal
SEforALL	Sustainable Energy for All
SEA	Strategic environmental assessment
F6	Sulfurhexafluoride
TFC	Total final energy consumption
TPES	Total primary energy supply
UN	United Nations
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFC	United Nations Framework Classification
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
USD	United States Dollar
VAM	Ventilation Air Methane
VRE	Variable Renewable Energy
WB	World Bank
WHO	World Health Organisation

Units of Measurement

°C	degree Celsius
bcm	Billion cubic metres
bt	Billion tons
EJ	Exajoules
gC	gramm carbon
GW	Gigawatt
GWh	Gigawatt-hour
kWh	Kilowatt-hour
kWp	Kilowatt-peak
MJ	Mega joules
Mt	Million tons
mtoe	Million tons oil equivalent
MW	Megawatt
PJ	Petajoules
t	tons
TJ	Terajoules
TWh	Terawatt hours

Glossary

Compound annual growth rate (CAGR), in %

CAGR of primary/final energy intensity between two years. Represents the average annual growth rate during the period. Negative values represent improvements in energy intensity (less energy is used to produce one unit of economic output), while positive numbers indicate declining energy intensity (more energy is used to produce one unit of economic output).

Energy Intensity, in MJ/2011 PPP$

Primary energy intensity is used as a proxy indicator for energy efficiency. It is calculated as the ratio of TPES to GDP measured at PPP in constant 2011 USD (MJ/2011 PPP$): Energy intensity is an indication of how much energy is used to produce one unit of economic output. Lower ratio indicates that less energy is used to produce one unit of output (GTF 2017 definition).

Gross domestic product (GDP), in 2011 PPP US$

GDP (in 2011 PPP US dollars) is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. GDP is measured at purchasing power parity at constant 2011 US dollars (GTF 2017 definition).

Kilowatt Peak (kWp)

Kilowatt peak stands for peak power. This value specifies the output power achieved by a solar module under full solar radiation (under set Standard Test Conditions). Solar radiation of 1,000 watts per square meter is used to define standard conditions. Peak power is also referred to as "nominal power" by most manufacturers. Since it is based on measurements under optimum conditions, the peak power is not the same as the power under actual radiation conditions. In practice, this will be approximately 15-20% lower due to the considerable heating of the solar cells. Source: SMA Solar Technology AG (2011).

Levelized Cost of Electricity (LCOE), in USD-Cents / kWh

Levelized cost of electricity (LCOE) represents the kilowatt-hour cost of building and operating a power generation plant over an assumed financial life and duty cycle (Solar Mango definition).

Own Production, as ratio +/-1

Dividing the total primary energy supply of a country by its energy production gives an indication on the level of self-sufficiency (or dependency) of a country (IEA Energy Atlas definition).

Total Energy Production

Production is the production of primary energy, i.e. hard coal, lignite, peat, crude oil, NGL, natural gas, combustible renewable energy and waste, nuclear, hydro, geothermal, and solar and the heat from heat pumps that is extracted from the ambient environment. Production is calculated after removal of impurities (e.g. sulphur from natural gas) (IEA definition).

Total Final Energy Consumption (TFC), in Mtoe

Sum of energy consumption by the different end-use sectors, excluding non-energy uses of fuels. TFC is broken down into energy demand in the following sectors: industry, transport, residential, services, agriculture, and others. It excludes international marine and aviation bunkers, except at world level where it is included in the transport sector (IEA definition)

Total Primary Energy Supply (TPES), in Mtoe

TPES is made up of: Production + Imports **-** Exports **-** International marine bunkers **-** International aviation bunkers +/- Stock changes (IEA definition).

Renewable Energy

Total Renewable Energy includes modern and traditional energy. Traditional energy stands for solid biomass when consumed in the residential sector in non-Organisation for Economic Cooperation and Development (OECD) countries. It includes the following categories in International Energy Agency (IEA) statistics: primary solid biomass, charcoal and non-specified primary biomass and waste. Modern Energy includes all types of technology including solar, wind, biomass, geothermal, hydro, liquid biofuels, biogas, marine, and renewable wastes (GTF 2017 definition).

Annexes

Annex I.

Overview: Socio-Economic Data for UNECE member States.

Table A.1: UNECE Country Populations, Population Density, and GDP per Capita in 2015.

Countries	Population (million)	Population Density (people per sq. km of land area)	GDP/Capita, PPP (current USD)
North America			
Canada	35	3.9	43,248
United States	321	35	56,115
Southeast Europe			
Albania	2.9	105	3,945
Bosnia and Herzegovina	3.8	74	4,249
Bulgaria	7.2	66	6,993
Croatia	4.2	75	11,535
Montenegro	0.62	46	6,406
Romania	19.8	86	8,972
Serbia	7.0	81	5,235
Former Yugoslav Republic of Macedonia	2.1	82	4,852
Caucasus			
Armenia	3.0	105	3,489
Azerbaijan	9.6	116	5,496
Georgia	3.7	64	3,795
Central Asia			
Kazakhstan	17.5	6.5	10,509
Kyrgyzstan	5.9	31	1,103
Tajikistan	8.5	61	926
Turkey*	78	102	9,125
Turkmenistan	5.4	11	6,672
Uzbekistan	31	73	2,132
Eastern Europe			
Belarus	9.5	47	5,740
Israel*	8.4	387	35,728
Moldova	3.6	124	1,848
Ukraine	45.2	78	2,115
Russian Federation	144	8.8	9,092
Western and Central Europe			
Andorra	0.07	150	N/A
Austria	8.6	105	43,774
Belgium	11.3	371	40,324
Cyprus	1.16	126	23,242
Czech Republic	10.5	136	17,548
Denmark	5.7	134	51,989
Estonia	1.3	31	17,118

Finland	5.5	18	42,311
France	66.8	122	36,205
Germany	81.4	234	41,313
Greece	10.8	84	18,002
Hungary	9.8	108	12,363
Iceland	0.33	3.3	50,173
Ireland	4.6	67	61,133
Italy	60.8	206	29,957
Latvia	1.9	32	13,648
Liechtenstein	0.037	234	74,950
Lithuania	2.91	46	14,147
Luxembourg	0.57	219	101,449
Malta	0.43	1349	22,596
Monaco	0.037	18,865	N/A
Netherlands	16.9	503	44,299
Norway	5.2	14	74,400
Poland	38	124	12,554
Portugal	10.3	113	19,222
San Marino	0.03	530	n/a
Slovak Republic	5.4	113	16,088
Slovenia	2.1	102	20,726
Spain	46.4	92	25,831
Sweden	9.8	24	50,579
Switzerland	8.3	209	80,945
United Kingdom	65	269	43,875
UNECE Total	1,318		

Note: In order to integrate Israel and Turkey in sub-country cluster analysis, Israel was assigned to Eastern European cluster, and Turkey to the Central Asian cluster. This clustering and assignment do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries. In particular, the boundaries shown on the maps do not imply official endorsement or acceptance by the United Nations.
Source: World Bank (2017c).

Annex II.

UNECE member States' TPES, TPES/capita and Own Production in 2014.

Table A.2: UNECE National TPES, TPES / Capita, and Own Production in 2014.

Member State	TPES PJ in 2014	TPES / Capita MJ/Capita 2014	Own Production Index*
North America	**104,505**	**7.04**	**0.99**
Canada	11,718	7.87	1.68
United States	92,787	6.94	0.91
Southeast Europe	**3,543**	**1.76**	**0.75**
Albania	97	0.80	0.86
Bosnia and Herzegovina	327	2.05	0.77
Bulgaria	749	2.48	0.63
Croatia	336	1.90	0.54
Montenegro	400	1.54	0.72
Romania	1,326	1.59	0.83
Serbia	555	1.86	0.71
Former Yugoslav Republic of Macedonia	109	1.26	0.48
Caucasus	**907**	**1.27**	**2.81**
Armenia	123	0.98	0.28
Azerbaijan	599	1.50	4.10
Georgia	183	0.98	0.31
Central Asia	**11,523**	**1.91**	**1.21**
Kazakhstan	3,209	4.43	2.17
Kyrgyzstan	158	0.65	0.50
Tajikistan	117	0.34	0.64
Turkey*	5,088	1.59	0.26
Turkmenistan	1,119	5.04	2.91
Uzbekistan	1,828	1.42	1.28
Eastern Europe	**6,675**	**2.39**	**0.55**
Belarus	1,161	2.93	0.13
Israel*	950	2.76	0.33
Republic of Moldova	138	0.93	0.10
Ukraine	4,424	2.33	0.73
Russian Federation	**29,763**	**4.94**	**1.84**
Western and Central Europe	**65,607**	**3.19**	**0.60**
Andorra	N/A	N/A	N/A
Austria	1,346	3.77	0.37
Belgium	2,209	4.73	0.24
Cyprus	82601	2.29	0.06
Czech Republic	1,725	3.91	0.71
Denmark	678	2.87	0.99
Estonia	252	4.57	0.97
Finland	1,420	6.21	0.54
France	10,158	3.67	0.56
Germany	12,814	3.78	0.39

Greece	968	2.12	0.38
Hungary	956	2.31	0.44
Iceland	245	17.8	0.89
Ireland	534	2.76	0.16
Italy	6,145	2.41	0.25
Latvia	181	2.185	0.58
Liechtenstein	N/A	N/A	N/A
Lithuania	293	2.39	0.25
Luxembourg	159	6.82	0.04
Malta	32	1.80	0.02
Monaco	N/A	N/A	N/A
Netherlands	3,054	4.33	0.80
Norway	1,203	5.59	6.83
Poland	3,936	2.44	0.72
Portugal	885	2.03	0.28
San Marino	N/A	N/A	N/A
Slovak Republic	667	2.94	0.41
Slovenia	279	3.24	0.55
Spain	4,796	2.46	0.31
Sweden	2,016	4.96	0.72
Switzerland	1,049	3.06	0.53
United Kingdom	7,511	2.78	0.60
UNECE Total	**222,525**	**4.46**	**0.99**
World	**573,555**	**1.89**	**1**

Note: The “own production index” is the same as IEA’s “self-sufficiency index”. Dividing the TPES of a country by its own energy production gives an indication of a country’s energy balance. TPES is the sum of production and imports less exports and stock change. A value above 1 indicates a net exporter, below 1 means a net importer.
Source: IEA (2017g).

Annex IV.

Energy for Sustainable Development Indicators and GTF Methodology.

History and Methodology: SDG7 (SEforALL) indicators used for the Global GTF Report.

The methodology applied for the Global GTF Report can be found at http://gtf.esmap.org/methodology

Beyond SDG7 Indicators: Information needs and challenges for Sustainable Development.

The energy systems structure used in this report is intended to complement the GTF SE4ALL reporting framework and extend from it to offer a structured set of insights into the challenges and opportunities to improving the sustainability, societal wellbeing, economic and environmental implications of energy systems in UNECE member countries. The content provided in this report goes beyond the SDG7 indicators in order to provide perspectives beyond aggregate framework indicators. The ability to do this rides on the quality and competence of underlying data systems.

Methodological issues

In many countries a number of agencies collect energy, activity and related social and environmental data.

Regional and global assessment like this report rely on the data gathering and management processes operated by a number of key agencies that have developed leading capabilities and relationships that enable consistency in data definitions, quality management, data warehousing and publication. The 'data specialisations' are recognized, and also characterized by cooperation and data validation across the data managing agencies: World Bank and OECD economic activity data; UN population and human activity data; WHO health and wellbeing data; IEA energy data. While individual countries, and agencies specializing on one or another aspect of global activities also publish data, their perspectives and data validation processes tend to occur within a limited perspective of the global data managers.

Data differences. Differences in data derive from three main areas:

- Data frameworks and definitional differences.
- Data sources with different perspectives.
- Accounting misalignments.

Consistent data standards IEA Stats, UN data definitions etc.: Where differences in data occur this is always an opportunity to explore the cause and nature of underlying differences in data systems.

Missing data. The data gathering and reporting infrastructure that exists today has emerged and evolved over many years. This report has suggested a number of new paradigms for indicators for the future, whether related to quality of service or holistic systems analysis. There would be merit in considering what indicators would point to a future in which energy for sustainable development is assured. Once a concise set of indicators has been identified, it will be necessary to establish data gathering infrastructure to ensure that data are available to populate a new set of indicators credibly.

Annex V.

Draft List of Indicators to Track Energy for Sustainable Development.

Table A.3: Draft List of Indicators and Areas for Possible Indicators to Measure Energy for Sustainable Development to Achieve the 2030 Agenda.

Pillars	Suggested Indicators (or areas for indicator formulation)
Energy Access	▪ Access to clean cooking fuels* ▪ Physical access to electricity* ▪ Affordability (share of household income spent on energy) ▪ Quality of Service o Number of hours of access to electricity per day (outage rates)*** o Technical quality (frequency, voltage) o Number of turnoffs by type of consumer*** o Number of households with access to main grid*** o Time required to fix disruptions*** o Number of households with generators o Loss of GDP through interrupted supply (VOLL)*** o Transmission losses*** ▪ Suggested areas to formulate additional indicators: o Affordability, reliability and quality of electricity access such as household money spent on energy**,*** o Heat demand, access and quality** o Include indicators for other energy services*** o Introduce/Improve measurements associated with the quality and affordability of services***
Renewable Energy	▪ Share of renewable energy in TFC* ▪ Share of modern / traditional renewable energy in TFC* ▪ Share of renewable energy in TPES**,*** ▪ Additions of renewable energy installed capacity**,*** ▪ Share of renewable energy in bus-bar energy (e.g. post combustion but pre transmission & distribution losses)*** ▪ Installed reliable renewable energy capacity per capita*** ▪ Sub-indicator that excludes traditional BM from total RE*** ▪ Type of renewable energy contribution (electrical vs. thermal), exergy ▪ Ratio of renewable energy electricity to total electricity (in terms of capacity, production / consumption)*** ▪ Share of renewable energy expressed in terms of Total Primary Energy Requirements (i.e., taking into account the actual non-renewable primary energy required to provide the same final RE).*** ▪ Number of people with access to RE*** ▪ Equitable access to networks*** ▪ Share of renewable energy in installed reliable capacity (versus generation)*** ▪ Cost of producing 1kWh from solar PV / Wind /other renewable energy (under consideration of distribution losses with a view towards improving the network)*** ▪ Cost comparison of unsubsidized renewable energy with unsubsidized fossil*** ▪ Suggested areas to formulate additional indicators: o Number of people with access to RE o Equitable access to networks o Share of renewable energy in installed reliable capacity (versus generation) o Cost of producing 1kWh from solar PV / Wind /other renewable energy (under consideration of distribution losses with a view towards improving the network) o Cost comparison of unsubsidized renewable energy with unsubsidized fossil
Energy Efficiency	▪ Ratio of TPES to GDP (MJ/USD)* ▪ Ratio of TFC to GDP (MJ/USD) ▪ Energy use in buildings (kWh per m^2 of used space ▪ Compound annual growth rate, or CAGR of TFC as well as of TPES* ▪ Supply side efficiency in electricity generation** ▪ Transmission losses ▪ Ratio of TPES to TFC net of imports and exports*** ▪ Re. SDG indicator 7.a.1: Replace "USD invested in energy efficiency" with "USD invested divided by energy saved over the life of the investment" *** ▪ Price elasticities of energy demand and supply*** ▪ Efficiency measured as the amount of energy needed to provide demanded energy services*** ▪ Suggested areas to formulate additional indicators: o Physical energy intensity indicators**** ▪ Specific energy consumption (SEC), defined as the amount of energy (in enthalpy) needed to execute a certain activity (e.g. the production of one tonne of steel), expressed in physical terms.
Other Energy Sources	▪ Share of Fossil Fuels in TPES*** ▪ Efficiency of fossil fuels in generation*** ▪ Methane emissions along the value chain*** ▪ Share of nuclear in TPES*** ▪ Bringing it all together, Fuel Mix in TPES; Fuel mix in Electric Generating Capacity; TFC by end-use
NEXUS:	
- **Climate**	▪ CO2 emissions from fossil fuel combustion (total and per capita) per TPES and per TFC**,*** ▪ GHG emissions of energy sector**

- **Water**	▪ Clean water treatment (sanitation, desalination volumes and efficiency, …) ▪ Water resource depletion (aquifer), intermittent energy supply ▪ Fracking and water use, chemical pollutions ▪ Water cooling systems in the energy world (evaporation losses, thermal losses through cooling) ▪ Transfer of water (system to system, transboundary), hydro, agriculture ▪ Impacts of large hydro development ▪ International water resource management ▪ thermal pollution in rivers / impact of water cooling systems in energy generation
- **Land**	▪ Land intensity of renewable energy (wind, solar, biomass)*** ▪ Deforestation caused by use of traditional biomass*** ▪ Suggested areas to formulate additional indicators: ▪ Land management in cities*** ▪ International land management***
- **Food**	▪ Food waste for biofuels / compost*** ▪ Fertilizer production*** ▪ Energy embodied in food exports / imports***
- **Environment**	▪ Energy use per passenger miles*** ▪ Suggested areas to formulate additional indicators: ▪ Air quality / health / exposure*** ▪ Waste as resource: Recycling; waste to energy***
- **Socio-Economic**	▪ Energy poverty / affordability: household money spent on energy*** ▪ Suggested areas to formulate additional indicators: ▪ Quality of building codes (does it cover humidity, indoor air quality)*** ▪ Embodied energy in materials and structures (cement, steel, use)*** ▪ Economic value added of energy exports (benefits in the receiving country)*** ▪ Corruption index associated for PPP energy***

*SDG7 indicator / indicator used in global 2017 GTF.
** Additional (limited) data for suggested indicators presented in the UNECE Regional GTF report.
*** Suggestions made in the context of a workshop “Tracking Progress on Energy for Sustainable Development: Data and Indicators”, held in Astana on 14 June 2017, as part of the Eighth Forum on Energy for Sustainable Development. See full set of recommendations here: LINK
**** Suggestion by expert reviser, based on E. Worrell et al. (1997): Energy intensity in the iron and steel industry: a comparison of physical and economic indicators. In: *Energy Policy*, Vol. 25, 1997.

Table A.4: Potential Indicators within the different elements of the energy system.

System Element	Insights	Potential Indicators
Consumer service quality	There is a need to move beyond simple notions of ‘access’ and ‘energy poverty’ to real metrics for end use service quality, entitlement and access in households and businesses, while accommodating diversity in resources, expectations and needs. Importantly how these contribute to SDG outcome goals.	Systematic tracking of: 1. Achieved end-use service quality against basic welfare norms. 2. Affordability of end use service quality (the cost of the service attained rather than the unit price of energy)
End-use efficiency	There is a need to move beyond naïve energy intensity to real energy efficiency indicators, with a concatenated structure of indicators that also highlight structure and activity within households and businesses.	Systematic tracking of: 1. Changes in household size, occupancy, and efficiency of key end use applications in households. 2. Changes in economic structure, end use efficiency and value added in industry and commerce. 3. Changes in modal and vehicle structure, activity and end use efficiency in transport.
Distributed cost-reflective utilities	There is a need to identify how utilities can better incentivise consumer demand responsiveness and end-use efficiency as T&D utilities shift from being energy distributors to become capacity managers of diverse central and distributed energy producers.	Systematic tracking of: 1. Changes in the actual performance of central supply systems, distributed and end-use renewable energy, within competent life cycle analytical frameworks.
Supply system innovation and sustainability	There is a need to understand how supply side policies and practices can evolve a more sustainable and economically efficient supply system.	Systematic tracking of: 1. Changes in supply system value and performance within competent life cycle analytical frameworks.
Resource sustainability	There is a need to understand how diversifying the resource mix, economic trade, and managing environmental nexus impacts can enable a more resilient and sustainable energy system.	Systematic tracking of: 1. Metrics for separate and integrated resource (energy water, land, and air) system resilience. 2. Changes in resource (energy water, land, and air) system value and performance within competent life cycle analytical frameworks. 3. Metrics for nexus dynamics.

Annex VI.

Overview: Current Status of Renewable Energy Policies in UNECE member States.

Table A.5: Overview to Renewable Energy Support Measures in UNECE Countries.

	Renewable Energy Targets (national and sub-national)			Regulatory Policies (national and sub-national level)							Fiscal Incentives and Public Financing (national and sub-national level			
	Renewable Energy Share in Primary Energy	Renewable Energy Share in Final Energy	Renewable Energy share in Electricity Generation	FiT / Premium Payment	Electric Utility quota	Net Metering	Transport obligations / mandates (biofuels)	Heat obligations / mandates	Tradable Renewable Energy Certificates (RECs)	Auctioning	Investment / Production tax credit	Tax Reductions	Energy Production Payment	Public investments / Loans / Grants / R&D
South-East Europe														
Albania	18% (2020)	38% (2020)	N/A	1	1		1		1		1	1	1	
Bosnia and Herzegovina	20% (2016)	40% (2020)	N/A	1			1			1				
Bulgaria	N/A	16% (2020)	20.6% (2020)	1			1							1
Croatia	N/A	20% (2020)	39% (2020)	1			1							1
FYR of Macedonia	N/A	28% (2020)	24.7% (2020)	1										1
Montenegro	N/A	33% (2020)	51.4% (2020)	1										
Romania	N/A	24% (2020)	43% (2020)		1		1		1					1
Serbia	N/A	27% (2020)	37% (2020)	1										1
SUM	2	8	6	7	2	0	5	0	2	1	1	1	1	5
%	**25%**	**100%**	**75%**	**88%**	**25%**	**0%**	**63%**	**0%**	**25%**	**13%**	**13%**	**13%**	**13%**	**63%**
Caucasus														
Armenia	21% (2020); 26% (2025)	N/A	40% (2020)	1		1							1	1
Azerbaijan	N/A	9.7% (2020)	20% (2020)										1	1
Georgia	N/A	N/A	N/A	1		1				1			1	1
SUM	1	2	2	2	0	2	0	0	0	1	0	0	3	3
%	**33%**	**67%**	**67%**	**67%**	**0%**	**67%**	**0%**	**0%**	**0%**	**33%**	**0%**	**0%**	**100%**	**100%**
Central Asia and Turkey														
Kazakhstan	N/A	N/A	3% (2020); 50% (2030)	1						1				1
Kyrgyzstan	N/A	N/A	N/A	1					1		1	1	1	1
Tajikistan	N/A	N/A	10% (N/A)						1		1		1	1
Turkey	N/A	N/A	30% (2023)	1			1			1				1
Turkmenistan	N/A	N/A	N/A											
Uzbekistan	N/A	16% (2030); 19% (2050)	N/A											
SUM	0	1	3	3	0	0	1	0	2	2	2	1	2	4
	0%	**17%**	**50%**	**50%**	**0%**	**0%**	**17%**	**0%**	**33%**	**33%**	**33%**	**17%**	**33%**	**67%**
Eastern Europe														
Belarus	N/A	28% (2015); 32% (2050)	N/A	1	1		1		1				1	
Israel	N/A	13% (2025); 17% (2030)	10% (2020); 17% (2030)	1			1	1	1	1		1		1
Moldova	20% (2020)	17% (2020)	10% (2020)	1								1		1
Ukraine	18% (2030)	11% (2020)	11% (2020); 20% (2030)	1		1						1	1	1
SUM	2	4	3	4	1	1	2	1	2	1	0	3	2	3
	50%	**100%**	**75%**	**100%**	**25%**	**25%**	**50%**	**25%**	**50%**	**25%**	**0%**	**75%**	**50%**	**75%**

Western and Central Europe														
Andorra	N/A	N/A	N/A	1									1	
Austria	N/A	45% (2020)	70.6% (2020)	1			1		1		1			1
Belgium	9.7% (2020)	20% (2020)	20.9% (2020)		1	1	1		1	1	1	1		1
Cyprus	N/A	13% (2020)	16% (2020)	1		1	1							1
Czech Republic	N/A	13.5% (2020)	14.3% (2020)	1			1		1	1	1	1		1
Denmark	N/A	35% (2020); 100% (2050)	50% (2020); 100% (2050)	1		1	1		1	1	1	1		1
Estonia	N/A	25% (2020)	17.6% (2020)	1			1						1	1
Finland	N/A	38% (2020); 40% (2025)	33% (2020)	1			1		1			1	1	1
France	N/A	23% (2020); 32% (2030)	27% (2020); 40% (2030)	1			1	1	1	1	1	1		1
Germany	N/A	18% (2020); 30% (2030); 45% (2040); 60% (2050)	40-45% (2020); 55-60% (2030); 45% (2035); 80% (2050)	1			1	1	1	1	1	1		1
Greece	N/A	20% (2020)	40% (2020)	1	1	1	1	1	1	1	1	1		1
Hungary	N/A	14.65% (2020)	10.9% (2020)	1			1			1		1		1
Iceland	N/A	64% (2020)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ireland	N/A	16% (2020)	42.5% (2020)	1			1	1	1					
Italy	N/A	17% (2020)	34% (2020)	1		1	1	1			1	1		1
Latvia	N/A	40% (2020)	60% (2020)	1		1	1					1		
Liechtenstein	N/A	N/A	N/A	1										
Lithuania	20% (2025)	23% (2020)	21% (2020)	1	1		1					1		1
Luxembourg	N/A	11% (2020)	11.8% (2020)	1			1							1
Malta	N/A	10% (2020)	3.8% (2020)	1		1						1		1
Monaco	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Netherlands	N/A	16% (2020)	37% (2020)	1		1	1		1		1	1		1
Norway	N/A	67.5% (2020)	N/A		1		1		1			1		1
Poland	12% (2020)	15.5% (2020)	19.3% (2020)	1	1		1		1	1		1		1
Portugal	N/A	31% (2020); 40% (2030)	60% (2020)	1	1		1		1			1		1
San Marino	N/A	N/A	N/A	1										
Slovak Republic	N/A	14% (2020)	24% (2020)	1			1		1			1		1
Slovenia	N/A	15% (2020)	39.3% (2020)	1		1			1	1	1	1		1
Spain	N/A	20.8% (2020)	38.1% (2020)				1	1	1	1	1		1	1
Sweden	N/A	50% (2020)	62.9% (2020)	1	1		1		1		1	1		1
Switzerland	24% (2020)	24% (2020)	N/A	1				1	1			1		1
United Kingdom and Northern Ireland	N/A	15% (2020)	N/A (Scotland: 100%)	1	1		1		1			1	1	1
SUM	4	28	24	27	8	9	24	7	19	10	12	21	5	25
%	**13%**	**88%**	**75%**	**90%**	**27%**	**30%**	**80%**	**23%**	**63%**	**33%**	**40%**	**70%**	**17%**	**83%**
North America														
Canada	N/A	N/A	N/A (4 provincial targets)	1	1	1	1			1	1	1		1
United States of America	N/A	N/A	N/A (29 state or municipal targets)	1	1	1	1	1	1		1	1		1
SUM	0	0	2	2	2	2	2	1	1	1	2	2	0	2
%	**0%**	**0%**	**100%**	**100%**	**100%**	**100 %**	**100%**	**50%**	**50%**	**50%**	**100%**	**100%**	**0%**	**100%**
Total UNECE Member States	**9**	**43**	**40**	**45**	**13**	**14**	**34**	**9**	**26**	**16**	**17**	**28**	**13**	**42**
%	**16%**	**77%**	**71%**	**90%**	**26%**	**28%**	**68%**	**18%**	**52%**	**32%**	**34%**	**56%**	**26%**	**84%**

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[12] SE4All tracking is replaced by SDG7 tracking which are the same indicators. The methodology and data sources for the GTF indicators can be reviewed in Annex IV.
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Another option are the emission data from the Global Carbon Project http://cdiac.ornl.gov/GCP/
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