UNECE

PATHWAYS
TO SUSTAINABLE ENERGY

Exploring Alternative Outcomes

UNITED NATIONS

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

PATHWAYS TO SUSTAINABLE ENERGY

EXPLORING ALTERNATIVE OUTCOMES

NEW YORK AND GENEVA, 2015

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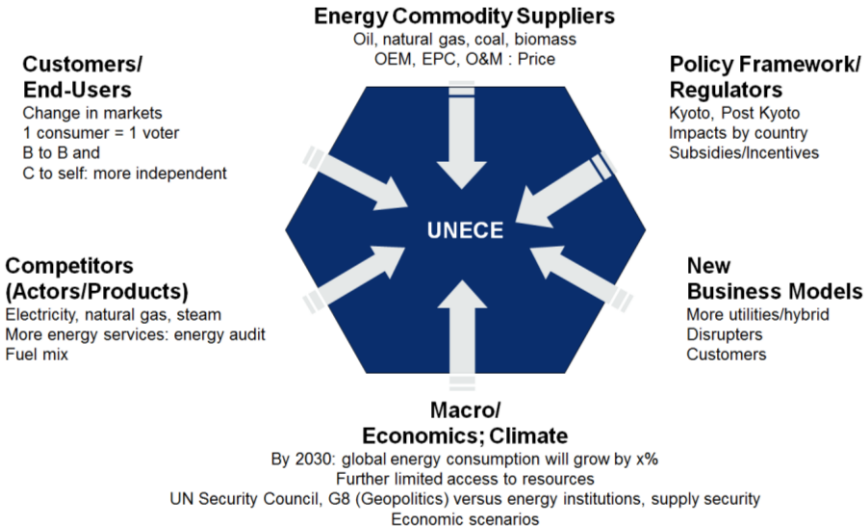
Introduction

In September 2015 countries agreed to a set of sustainable development goals. Attainment of all of the goals depends directly or indirectly on the availability of sustainable energy. Member States of the UNECE have asked how the region can attain its sustainable energy objectives.

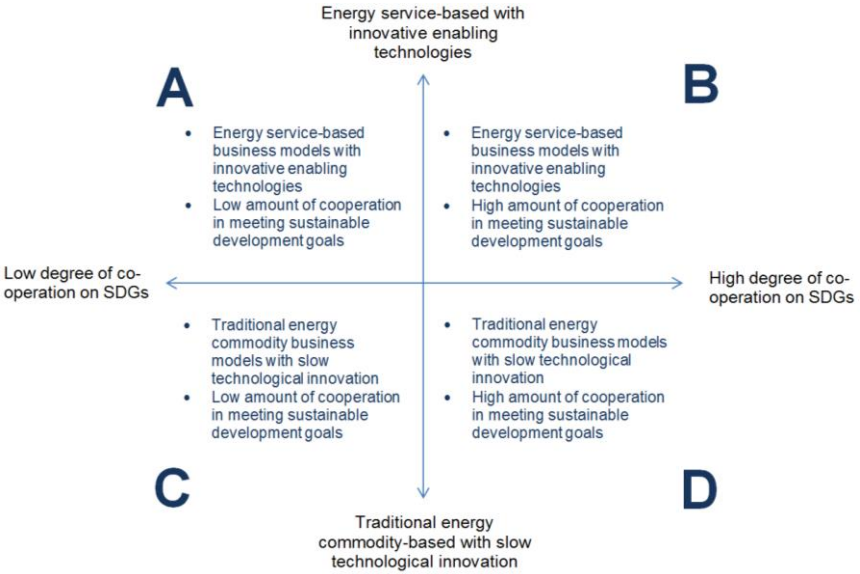


The response is complex given the diversity of the region and the range of forces and trends shaping the future. UNECE has undertaken an exploration of the factors shaping the future energy system and has developed four alternative scenarios of how the future might be. This document presents the first results of that work.

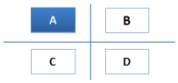
Expert interviews and interactive workshops led to the identification of 13 critical factors shaping the energy future (see last page). The results fell into three groups, namely (1) global

politics and economic situation, (2) technology, and (3) energy policy and market development.

Among the critical factors, the experts chose "degree of cooperation on Sustainable Development Goals" and "advanced technology and business models" as the two most important, uncorrelated factors shaping the future. These two factors define a matrix of four scenarios as shown below.



The development of scenarios that explore the range of plausible alternative futures is the first step to consider and test different approaches that the region might consider to attain sustainable energy. Each scenario sets forth a distinct response to a set of existential questions: energy demand, energy prices, energy policies and regulation, technological innovation, business models, and carbon pricing schemes.



Scenario A: Eagles

This scenario is characterized by low cooperation in meeting sustainable development goals, but high innovation in the energy sector with the growth of service-based business models and innovative enabling technologies.

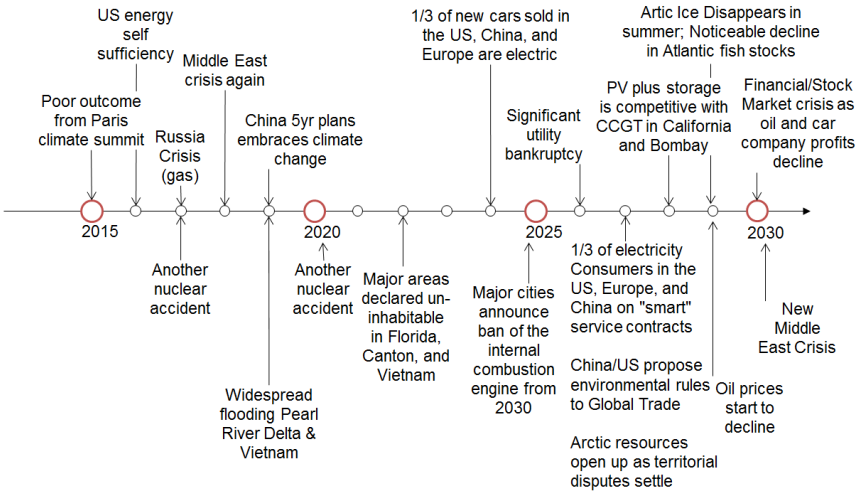
Global Political and Economic Situation

There is continued recovery of the wider global economy and energy demand growth continues strongly in developing countries. Global wealth continues to migrate to Asia. The US and Europe, especially Germany, continue to play leading roles, but with an increased influence from China.

Global warming has a growing economic and social impact around the world: new trade routes emerge, uninhabitable land areas expand, and the number of climate migrants swells. While there is high-level agreement in Paris, there is poor follow-up and failure to implement an effective top-down climate agenda. Poorer developing nations get limited support for resource management and development of capabilities.

Some countries and regions including the US, China, and Europe show domestic leadership in implementing low carbon policies. In 2027 China and the US propose new environmental rules for global trade. By 2025, New York, Los Angeles, Beijing, Shanghai, and many big European cities ban the internal combustion engine within city limits. A new generation of mega-city dwellers, sensitive to local pollution and climate change, adopt a “sharing” economy that marks the start of a revolution in personal transport. By 2024 one third of all new cars sold in the US, China, and Europe are electric. By 2027, Arctic fossil fuel resources open up as territorial disputes are settled.[1]

[1] The timelines for Scenarios A, B, and C still need to be extended to 2050.



Technological and Market Developments

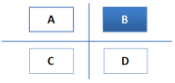
By 2028 PV plus storage is competitive. Third generation bio starts to make an impact, as do marine energy technologies, and there is good progress on energy storage, electric batteries, heat pumps, smart metering, and IT applications in the energy sector generally. Carbon Capture and Storage (CCS), however, remains on the shelf, while nuclear power challenges for a leading role in baseload power. Energy efficiency flourishes in areas where energy costs are high.

Overall, financial support for renewables and for energy efficiency is variable. Innovative businesses transform the power industry. By 2027 one third of electricity consumers in the US, Europe, and China are on smart service contracts to optimise their energy use through use of smart appliances. Governments continue to regulate the power industry as an infrastructure play. Some utilities experience difficulties, and there is a significant bankruptcy in 2026.

In Germany, government promotion of renewables and progressive cost reductions continue to undermine the profitability of the grid and of large scale traditional plants. Some developing countries have rapid population growth with a strong increase in energy demand, making them attractive markets for renewables.

Energy Policy and Cost Developments

Oil prices continue to decline, exacerbating instability in some oil producing regions. Some oil producing countries seek to diversify, including promoting renewables. Economic growth drives rising total energy demand and fossil fuels remain competitive in the absence of carbon pricing. Eventually, however, the reduction in costs and market penetration of renewables leads to a sharp decline in fossil fuel prices.

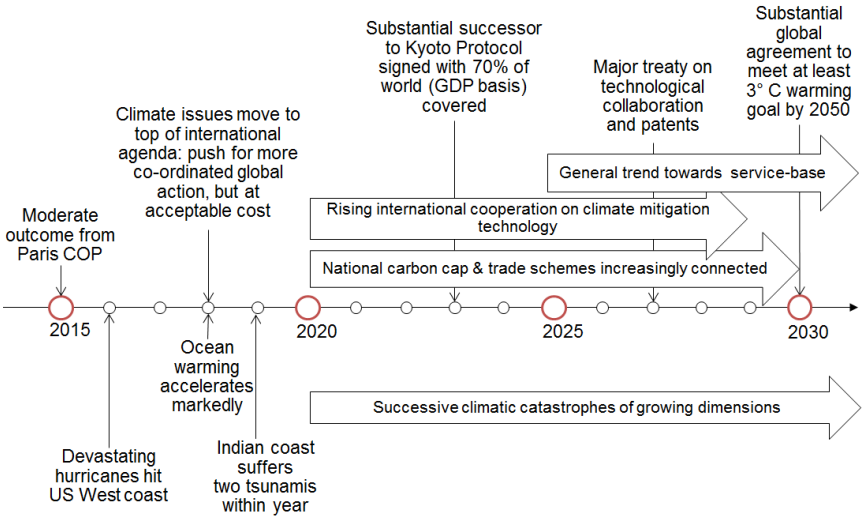


Scenario B: Flamingos

In this scenario energy systems develop through energy services-based business models with innovative enabling technology. There is a high degree of international cooperation to achieve sustainable development goals.

Global Political and Economic Situation

This scenario is shaped by a rising number of increasingly intense climate catastrophes. The signs of global warming continue unabated and climate concerns rise to the top of the international agenda. There is balanced leadership from the USA, Europe and China supported by a global consensus. High emphasis is placed on cost-effectiveness because of the need to address all of the SDGs. Despite various measures to reduce energy consumption in transport, a lack of upstream investment from 2015 to 2018 coupled with a rising global population and overall strong economic growth drive oil prices by 2020 to around $70/bbl.



Gas prices decouple from oil prices and there is continued strong supply of gas. The overhang of coal production capacity against the declining demand for a range of environmental reasons keeps the price low.

Technological and Market Developments

By 2025 populations think in terms of the service they use (transport, heat, light, food storage) rather than concerning themselves with procuring input commodities (energy) and owning the capital equipment needed to deliver such a service. The shift to a service orientation leads to better use of capital stock through wider deployment of cold and thermal storage and smart demand management. The focus on climate change leads to unprecedented technological cooperation at international levels with very rapid innovation and cost-reduction of localised energy-supply enabling facilities. In addition there is a strong push to increase energy access for those without, and the emphasis is on local, often PV or biomass-driven supplies. There are important break-throughs in battery storage by 2025.

The result is that by 2030 in the more economically advanced UNECE countries 70% of energy for small consumers is procured based on the end-product (heat, light, “integrated household/office requirements”) and/or local production whereas in the rest of the region the equivalent figure is 50%. Many non-traditional service providers enter the market. Information and communications technology along with smart grids and smart systems form the backbone of the new energy system.

Centralised technologies are under pressure due to the wide range and decreasing prices of distributed generation technologies. Also, fossil plants are pressured by the rising cost of their CO2 emissions. Nevertheless, regions with high quality, low-cost coal use Carbon Capture and Storage (CCS; commercially competitive and available from 2030). As part of the international

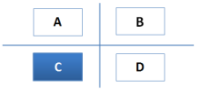
collaboration to produce zero-carbon energy, enormous efforts are made to improve the contribution of nuclear power. There is a specific emphasis on the human and institutional factors associated with nuclear safety risks, and as a consequence, in most countries the technology is accepted.

Energy Policy and Cost Developments

Rational economics broadly underpin energy policy, which translates into a focus on removing market distortions such as subsidies, enabling market participation by innovators, and ensuring that prices reflect competitive market interplay. The current low oil price era provides a convenient opportunity to eliminate the subsidies of fossil fuels. Research and development of low-carbon technology is supported by focussed subsidies, but governments are unwilling to provide long-term support for uneconomic technology.

Overall energy supply, energy efficiency, and environmental policies are well-integrated with the range of sustainable development goals and minimise costs while meeting range of needs. Markets function extremely well and spur innovation. There are good international trade and patent protection agreements, and a high degree of technical standardisation.

A real price on carbon is established through cap-and-trade schemes that are established around the world and that couple progressively. The traded carbon price in around 25% of the world (measured by GDP) reaches $40/t (real) by 2025 and rises to $60/t by 2030 in 50% of the world.

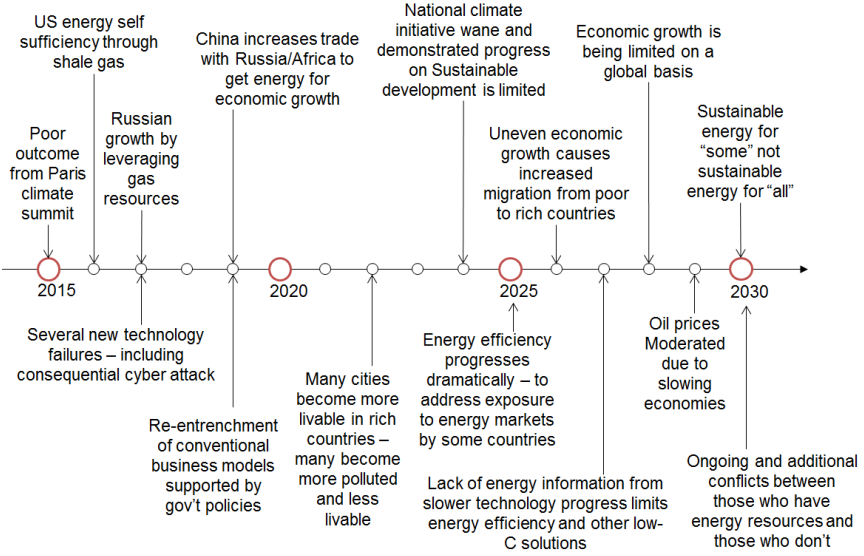


Scenario C: Ostriches

In this scenario the energy sector is characterized by slow technological innovation and low cooperation in meeting sustainable development goals.

Global political and economic situation

Leadership across countries will be less about global concerns, but rather re-entrenchment in national priorities. Conventional and/or indigenous energy sources will be prioritised over low-carbon policies. Countries and regions with stable governments and stable indigenous energy resources (such as US, Canada and Norway) will continue to have strong economies. Developed economies will see energy demand remain flat, whereas emerging economies will grow using indigenous resources. Countries highly dependent on energy imports will be exposed to global energy price fluctuations. Climate commitments will exist, but will focus on "low-hanging fruit" or well established paths.



Technological Developments

Despite significant technological innovation in many industries, innovation in the energy sector is limited due to stagnation of energy prices at 2015 levels and a lack of commitment on how to meet SDGs. The slow introduction of new technology in energy has resulted in ad hoc national or regional efforts to make the energy system more sustainable. Policy makers continue to deploy targeted approaches such as subsidies and favourable tax treatments of specific technologies.

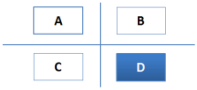
Technology will continue to develop but on an incremental basis. Existing technology will progress, albeit at a slower rate, as the most cost-effective applications, with a reduced vision of large-scale deployment of variable renewables and supporting technologies. Progress on electric vehicle development as well as storage technology development and supporting business models is also slow. Carbon Capture and Storage (CCS) takes longer to progress towards cost-effectiveness due to less international cooperation. By 2030 there will not be sufficient cost reductions for the scale of deployment needed to meet long term climate goals.

Several large scale events involving technological failures and internet-based sabotage reinforce traditional energy actors. Advanced business models based on energy services will not progress, but rather managed markets will continue. The use of information and communication technology (ICT) or other advanced systems based approaches such as super-grids or mini-grids will slow, and will result in slower progress to address access to electricity for many regions. This trend to centralized commodity based energy systems will favour centralized technologies such as Carbon Capture and Storage (CCS), but delays in innovation investment will limit progress.

Energy efficiency is one technology area that continues to progress, largely driven by simple necessity of many energy importing countries. During times of high prices, energy efficiency will be highly supported but during times of low prices, energy efficiency will be largely ignored. The net results will be that overall progress in energy efficiency will not offer the potential productivity gains shown in other scenarios.

Energy Policy and Cost Developments

A global carbon value will not exist and regional prices will decrease. Policy-based initiatives may proceed, but market-based initiatives will not. The result will be uneven growth that renders it difficult to meet SDGs homogeneously on a global basis. Reductions in energy intensity will be modest. Energy costs will be controlled through improvements in energy efficiency and the limits that higher energy prices put on economic growth. There will be continued reliance on fossil based sources. Scarcity will exist for those without indigenous resources, but those with indigenous resources will progress, creating tensions on resource availability.



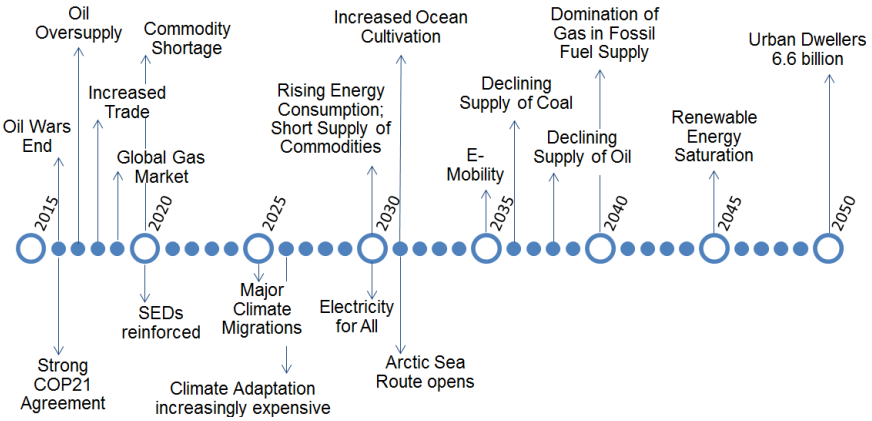
Scenario D: Hummingbirds

This scenario is characterized by high cooperation in meeting sustainable development goals, but low innovation in the energy sector with little development of new enabling technologies.

Global Political and Economic Situation

On a global scale, there is general willingness to support the SDGs, applying measures as prescribed, but with a limited view for their overall effect in achieving the intended goals. There is strong leadership from within and outside the UNECE managing to impose hard policy measures.

In the context of a high level of cooperation on global common goals, leadership becomes crucial in aligning interests. It will act as the main mechanism involving developing countries in the achievement of common goals. The world sees relatively low economic growth and only a modest increase in conventional energy demand growth. It will not be possible to fulfil global ambitions and remain economically efficient without extensive reforms of energy systems.



Technological and Market Developments

Technology does not flourish in application. The gradual development of existing and emerging technologies increases the supply of new energy resources. Energy demand is dampened by improving energy efficiency. Significant new resources are brought into play by virtue of technology transfer. The gas-to-oil ratio in the market will increase.

There will be little technology-based innovation of integrated energy systems. Renewable energy developments will continue in selected regions. They will be integrated into larger grids only where peak demands can be managed, i.e. with limited penetration, in combination with large cheap storage in the form of hydropower, and in areas with large enough interruptible demand. Grid scale batteries will not be deployed because of their cost. End user electrification will continue.

Energy efficiency measures will be applied within current systems. The current trend of falling global energy intensity will continue, even within a centralized system without smart grid and a radically new technology. Supplies become more affordable and abundant, driving energy consumption. As a result, energy efficiency measures will accelerate.

Energy systems will expand as they are today with limited adaptation to new Information and communication Technology (ICT). Source rock production will expand to all land based petroleum provinces and some that do not hold conventional reservoirs. Major common Carbon Capture and Storage (CCS) systems do not emerge. Carbon costs will remain a tool for transfer of economic rent from producers to consumers.

Energy Policy and Cost Developments

Current wars in producing countries give way to cooperation. Locally, some markets will be liberalized while others will be

regulated. Globally supply will be controlled as before, thus maintaining regional and global energy market regulation.

There is limited energy system reform on a national basis. Efforts to integrate energy systems across nations and regions do not meet stated objectives.

The lack of advanced technologies leads to higher prices for resources. It will by itself stimulate the growth and development of new energy resources and energy efficiency.

Renewables, and in particular photovoltaics will continue to come down in price, as will electricity storage. Fossil fuel production will see reduced costs. Emerging markets will benefit from cleaner technologies.

Carbon costs favour low carbon energy sources and Carbon Capture and Storage (CCS). Energy supply abundance allows conventional energy sources to compete at lower prices, resulting in an increased use. CO_2 storage will have fairly high costs.

Subsidies in their crudest form are removed. In the context of a lack of technology, gradual improvement of existing technologies through the subsidy mechanism is an important point to prevent a sharp rise in energy costs. Subsidizing effects of carbon price, of encouragements to adapt renewable energy and of regular fiscal measures remain.

Background

Sustainable Energy in the UNECE Region

Affordable, reliable and sustainable energy is a key to sustainable development and the transition to modern society. Energy remains crucial for social and economic welfare, ending poverty, ensuring healthy lives, and raising standards of living. The goal of creation of energy system of the future can be achieved through sustainable management of natural resources, ensuring innovative production and consumption patterns, and sustainable industrialization that further fosters building resilient energy infrastructure, as well as proper and coordinated planning of the overall system development.

2015 was a crucial year for framing international energy and climate objectives for the future. The Sustainable Development Goals were announced in September, with goal number 7 defining targets for “clean and affordable energy” for all. In addition, the results of the climate agreement in December 2015 will further shape national energy policies through a global climate change mitigation agenda.

However, there is no clear direction on how to achieve these important objectives. Countries do not have a common understanding of sustainable energy and what sustainable energy pathways could look like. In addition, national energy strategies today and in the future will reflect differing national priorities such as economic growth, environmental and climate concerns, energy access, energy security, resource efficiency, among others.

The ECE region with its highly diverse countries is symbolic for the ambiguous understanding of a sustainable energy future and how to achieve sustainable energy for all. The region is diverse, comprising high and low income countries, countries that are energy rich and energy poor, and countries that are in the midst of

economic transition. It plays a crucial role in achieving sustainable development and climate targets as fossil fuels comprise 60% of primary fuel, making the UNECE region one of the largest emitters of greenhouse gases, accounting for about half of global emissions. The region further produces 40% of the world's energy while consuming 45%, is home to important energy industries, generates nearly 50% of global economic output and is dominant in the world’s financial infrastructure.

There is an important opportunity today to explore the implications of different sustainable energy strategies for the region. The project supports this process by combining the modelling of sustainable energy pathways with a policy dialogue, and the development of a mechanism to track implementation of climate and sustainable development obligations.

The Scenario Building Process

The project was initiated to address uncertainties about a sustainable energy future and initiate a policy dialogue among ECE member states. The project could provide directions to the UNECE region and its member States on how to attain sustainable energy outcomes with the aim to provide an early warning system if activities are not on track, based on solid stories about various energy futures and building on a variety of views from global experts, and a list of actionable recommendations for Member States for energy strategy development. The brochure gives results for the first part of the overall project.

Scenario descriptors and variations

Group	Descriptors		
	No	Title	Variables (options)
Global Political and economic situation	1	Degree of cooperation on SDGs	Low
			High
	2	Key country leadership (US, China, EU, other)	Leadership by several or all
			Lack of Leadership
	3	Cost/availability of energy	High cost with low availability
			Low cost with high availability
	4	Food, water, energy and land Nexus	Abundance for all
			Scarcity across some or all
Technological Developments	5	Advanced technology and business models	Low technology improvements with conventional business model
			Advanced technology with services based business model
	6	Information and communication Technology (ICT) impact and grid development	Smart grid build out
			Dumb and constrained grids
	7	Storage	Low cost and broadly applicable
			High cost and region specific
	8	Carbon Capture and Storage (CCS) available at competitive prices	Competitive with carbon price
			Uncompetitive
	9	Broad range of competitive low carbon technologies	Few technologies available
			Many technologies (RE, Nuclear, CCS) available
Energy Policy Developments	10	Impactful Price of Carbon	$6/tonne
			>$300/ tonne
	11	Taxes/subsidies	Support for conventional energy
			Support for low-carbon energy
	12	Awareness of multiple benefits of energy efficiency	Disjointed energy efficiency and energy policy
			Integrated energy efficiency and energy policy
	13	Free or Managed Markets	Free markets
			Highly regulated markets

United Nations Economic Commission for Europe

Sustainable Energy Division

UNECE's work on sustainable energy is designed to improve access to affordable and clean energy for all and help reduce greenhouse gas emissions and the carbon footprint of the energy sector in the region. It promotes international policy dialogue and cooperation among governments, energy industries and other stakeholders.

The Committee on Sustainable Energy and its six subsidiary bodies carry out concrete and results-oriented activities with the aim to achieve the specific objectives identified for each priority area:

Areas of work

- Cleaner Electricity Production
- Coal Mine Methane
- Energy Efficiency
- Natural Gas
- Renewable Energy
- Resource Classification
- Energy Security

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