Briefing
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European Parliament

Understanding energy efficiency

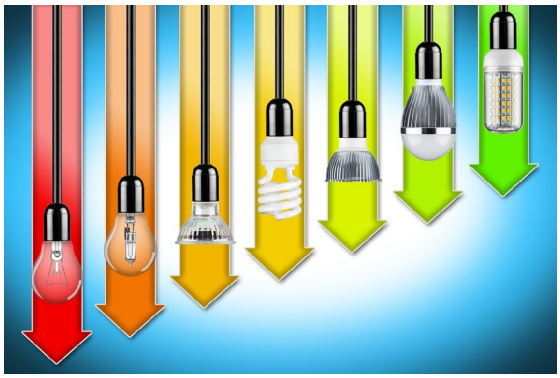
SUMMARY

The European Commission considers energy efficiency as a strategic priority for the Energy Union, and promotes 'energy efficiency first' as a principle. It proposes to rethink energy efficiency fundamentally, and treat it as an energy source in its own right. By using energy more efficiently, energy demand can be reduced, leading to lower energy bills for consumers, lower emissions of greenhouse gases and other pollutants, reduced need for energy infrastructure, and increased energy security through a reduction of imports. Worldwide, energy efficiency has contributed to substantial savings in energy consumption.

The implementation of energy efficiency policies is challenging, and the full potential of energy efficiency is far from realised, for financial, behavioural and regulatory reasons. Obstacles include high upfront investment costs, access to finance, lack of information, split incentives and rebound effects.

The EU has set energy efficiency targets and a set of regulations to promote energy efficiency across the economy. As part of the Energy Union strategy, the European Commission plans to propose specific strategies for heating and cooling, and for the transport sector. Key pieces of energy efficiency legislation are to be reviewed in the coming two years, and implementation of the existing framework enforced. Finance for energy efficiency will be given special attention.

The European Parliament has repeatedly called for stronger EU energy efficiency targets and policies, and is current preparing own-initiative reports on the Energy Efficiency Directive and the Energy Union strategy.



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Issue definition

Fundamental concepts

In general terms, energy efficiency refers to the amount of *output* that can be produced with a given *input of energy*.

Most commonly, **energy efficiency** is measured as the amount of *energy* output for a given energy input and listed as a percentage between 0% and 100%, for example the amount of mechanical energy that an electric motor produces for a given input of electrical energy.[1]

However, other kinds of output can also be used. The EU Energy Efficiency Directive uses a very broad definition:

> *'energy efficiency' means the ratio of output of **performance, service, goods or energy**, to input of energy.*

To illustrate these kinds of output, thermal comfort in a building is an example of *performance*; transport of persons or of information is a *service*; a smartphone is a *good,* the production of which requires energy.

For an economy-wide measure, GDP is often compared to energy use, to give the **energy intensity** (measured for example in kilowatt-hours per euro).[2]

Energy savings are the reduction of energy use, without reference to output produced.

The **efficiency of the overall energy system** is another issue. For example, peaks in electricity demand require spare power plants and extra transmission capacity that make the energy system less efficient.[3] **Efficient use of energy** can be understood in terms of using energy in such a way as to obtain the maximum benefit, but can also imply shifting energy consumption to times when energy is abundant and cheap (for example at night, or during sunny and windy periods when renewable energy sources produce more energy).

Assessing energy efficiency

Energy efficiency can be assessed at different levels, from economy-wide and sectoral energy intensity to individual units of activity, such as cooking. The International Energy Agency has produced guidelines for developing and using energy efficiency indicators for policy-making.

At European level, the ODYSSEE-MURE project performs comprehensive monitoring of energy consumption and efficiency trends, as well as an evaluation of energy efficiency policy measures by sector. The ODEX composite indicator is calculated as a weighted average of sectoral indices. It is used by the European Environment Agency to assess progress on energy efficiency in Europe.

Finally, energy is required for the production of energy, for example the drilling of oil wells or the construction of wind turbines. **Net energy** is the energy produced after deducting the energy used in the process.[4] Net energy analysis is also applied to measures intended to save energy. Housing insulation, for example, can save 120 times more energy than is used for the production of the insulating materials.

Energy efficiency can be improved at all points in the chain from energy production to energy consumption. Combined-cycle gas turbines can convert gas to electricity with efficiencies of up to 60%. Waste heat from power generation can be supplied to households and industry (combined heat and power). High-voltage direct current (HVDC) transmission lines can reduce energy losses in the grid. Smart grids and enhanced grid interconnections improve system-wide efficiency by making best use of the grid to connect electricity producers and consumers. Smart meters can promote more efficient use of energy by encouraging consumers to reduce energy consumption, especially at times of peak demand. In the building sector, insulated walls and windows

can help reduce energy use without compromising thermal comfort. Condensing furnaces or heat pumps can reduce energy consumption in the heating sector. LED technology has dramatically improved the efficiency of lighting. In the transport sector, lightweight materials, aerodynamic design and efficient engines can improve the fuel efficiency of vehicles.

Costs and benefits of energy efficiency

Improved energy efficiency is expected to bring a number of benefits. First of all, by reducing energy usage, energy bills should be reduced for industrial consumers, thereby improving their competiveness. For households, lower energy bills reduce the risk of energy poverty[5] and increase spending power. Reduced energy demand also means that energy imports can be decreased[6] (contributing to energy security), and energy infrastructure (such as power plants or transmission lines) requirements reduced. Lower energy demand should also lead to a reduction in greenhouse gas emissions, making an essential contribution to climate protection and decarbonisation of the economy. Reduced energy use can contribute to improved air quality and reduced health impacts, as well as lower environmental impacts from energy extraction and use. Finally, the implementation of energy efficiency measures can create new jobs in industry and energy services.

Improvements in energy efficiency require an initial investment (and possibly recurrent costs), and generate a return over the lifetime of the investment in the form of energy savings.[7] An energy efficiency measure is said to be cost-effective when the return achieved exceeds the costs.

The International Energy Agency (IEA) advocates an approach that takes multiple benefits into account when evaluating the cost-effectiveness of energy efficiency projects and policies. The Institute for European Environmental Policy has reviewed the performance of various energy efficiency programmes in Germany, Ireland and Sweden and found that the benefits consistently exceed the costs.

In addition to financial costs, there are 'hidden costs' arising from the effort of identifying, evaluating and implementing energy efficiency measures.[8]

Rebound effects

In many cases, improvements in energy efficiency result in lower energy savings than expected, and can even lead to an increase in energy use.[9] The reason may be that consumers do not simply replace an old product with a more efficient one with the same specifications, but upgrade to a larger product. For example, they may replace a small but inefficient fridge with a larger, more efficient one, that offers more space, but has similar or even higher energy consumption. Even if a product is replaced with a more efficient one, lower energy bills mean that consumers have more money to spend on goods and services. This is generally a desirable social and economic outcome, but often involves additional energy consumption that negates part of the energy savings. An analysis of EU data shows that 11 Member States experienced rebound effects over 50%, with six of these over 100%.

Realising the potential of energy efficiency

Energy efficiency is a substantial market. The IEA estimates, in its energy efficiency market report, that global investment in energy efficiency was between US$310 billion and US$360 billion in 2012.[10] Nonetheless, many opportunities for investment in energy efficiency are missed, although they would appear to be economically advantageous. There are various explanations for this 'energy efficiency gap'.

First, there are cases of 'split incentives' where the investments in energy efficiency do not directly benefit the investor, but another party. An example is when the landlord invests in improving the energy efficiency of a building, but the savings go to the tenant. Likewise, utilities, whose income comes from selling gas or electricity, may have no inherent incentive to encourage their customers to save energy.

Secondly, high upfront investment costs may discourage energy efficiency investments, and access to finance can be difficult for smaller projects. Moreover, investor confidence can be dampened by uncertainty about the amount of energy savings and the illiquidity of most energy efficiency investments which prevents an easy or quick exit.

Thirdly, behavioural obstacles include inertia, short-term thinking, uncertainty, lack of information and the effort required in obtaining information. Rebound effects (see box) can diminish or even negate the energy savings resulting from energy efficiency measures.

A 2013 study by Fraunhofer ISI estimates that realising the EU's cost-effective energy efficiency potential can lead to 41% energy savings by 2030, taking benefits other than fuel savings into account and under the assumption that barriers such as lack of information or split incentives are removed. A 2014 study on behalf of the European Commission estimates the economic potential from a macro-economic perspective at 37% final energy and 40% primary energy savings by 2030.

Financial Institutions

The Energy Efficiency Financial Institutions Group, convened by the European Commission and UNEP Finance Initiative, published its final report in February 2015. The report points out the strategic importance of energy efficiency improvements. It identifies the critical success factors, policies, market instruments and financing solutions to increase energy efficiency investments in Europe in the buildings, industry and SME sectors. The report concludes that investments must increase if Europe wants to meet its targets and estimates that a five-fold increase in private energy efficiency investments in European buildings is required by 2030. Clearer documentation of the full benefits of energy-efficient renovation of buildings, improved provision of relevant data to decision-makers, standardisation of the energy-efficiency investment process, and use of EU funds to leverage investment through public-private financial instruments are recommended.

EU policy and legislation

The EU is committed to a 20% energy efficiency improvement by 2020 and a 27% improvement by 2030 – this means energy savings compared to projections of future energy use. Energy efficiency is one of the dimensions of the Energy Union strategy.

Energy efficiency targets for 2020 and 2030

In 2007, the European Council stressed the need to increase energy efficiency, and endorsed a target of 20% energy savings compared with projected energy use for 2020. Along with targets for 20% reduction of greenhouse gas emissions and 20% market share for renewable energy sources, this target is part of the headline targets for the Europe 2020 strategy.

In July 2014, the European Commission adopted a Communication on energy efficiency, in which it proposed an energy efficiency target: by 2030 energy consumption should be 30% lower than expected under the 'business-as-usual' projection made in 2007. The Communication was accompanied by an impact assessment, which calculated the cost-effectiveness of various energy efficiency targets based on energy-economic modelling.[11] The Commission's Energy 2050 roadmap, published in 2011, concludes that improvements in energy efficiency are essential in all scenarios analysed.

The October 2014 European Council endorsed an indicative EU-wide target of 27% energy efficiency improvement by 2030, to be reviewed in 2020 with a 30% target in mind. The target will not be broken down into national targets.

Energy Union

Energy efficiency is one of the five pillars of the Commission's Energy Union strategy published in February 2015, and endorsed in March 2015 by the European Council. Commission Vice-President Maroš Šefčovič considers energy efficiency as the cornerstone of energy security, and advocates an 'energy efficiency first' principle; that is, considering the potential of energy efficiency before expanding infrastructure for generation, transmission and imports. On 15 September 2015, the Commission outlined a new Strategic Energy Technology Plan, which includes energy efficiency as one of the priority areas for research and innovation.

Energy Efficiency Directive

The Energy Efficiency Directive 2012/27/EU (EED) establishes a framework of measures for the promotion of energy efficiency in the EU and aims to help remove barriers and overcome market failures that hinder efficiency in the supply and use of energy. The EED sets a non-binding target of 20% energy efficiency improvements by 2020. This means that EU primary and final energy consumption in 2020 should be 20% below the projected energy consumption under a 'business-as-usual' scenario.[12] Member States are to set their own indicative national energy efficiency targets.

The EED requires Member States to take measures to achieve final energy savings of 1.5% per year between 2014 and 2020 by energy efficiency obligation schemes or other policy measures. Large firms are required to undertake energy audits. Member States must renovate 3% of the floor area of buildings owned and occupied by the central government, each year, starting in 2014, to meet minimum energy performance standards. Alternatively, Member States may take cost-effective measures to achieve an equivalent amount of energy savings. Twenty Member States have notified the Commission that they will implement alternative measures.

Implementation of the EED is expected to lead to a 15% reduction in primary energy consumption compared to the 2007 baseline scenario, with an additional 2% reduction expected to come from the transport sector.

Directive on the energy performance of buildings

The buildings sector has great potential for improved energy efficiency, as buildings account for 36% of EU energy consumption, and 75% of the EU housing stock is not energy efficient. The Energy Performance of Buildings Directive 2010/31/EU (EPBD) sets out a common framework for calculation and certification of buildings' energy performance, requires regular inspection of heating and air conditioning systems, and obliges Member States to set minimum energy performance standards for new buildings, major renovations and the replacement or retrofit of building elements. It introduces the concept of 'nearly zero-energy building', which is to become the obligatory standard for new public buildings in the EU after 2018, and for all buildings constructed after 2020.

Ecodesign, performance standards and energy labelling

Ecodesign requirements address the supply of energy efficient products, while energy labelling addresses the demand side by providing clear information to consumers.

The Ecodesign Directive (2009/125/EC) aims to remove inefficient energy-related products from the market by regulating the minimum energy performance of products. Ecodesign requirements apply to many products, including computers, cooking appliances, dishwashers, heaters, lighting products, refrigerators, televisions, vacuum cleaners and washing machines.

Certain ecodesign requirements – for example bans on inefficient light bulbs and vacuum cleaners – have given rise to controversy in some countries, where they have been presented as examples of excessive EU regulation that restricts consumers' freedom of choice. In April 2015, Member States decided to postpone a ban of inefficient halogen lamps by two years, to September 2018.

The Energy Labelling Directive (2010/30/EU) aims to help consumers assess the energy efficiency of products by means of a standardised energy label. It applies to products such as lamps, dishwashers, washing machines, dryers, refrigerators, televisions and vacuum cleaners.[13] Energy efficiency is indicated on a scale that originally ranged from G (least efficient) to A (most efficient) and has subsequently been extended to A+++ to account for the introduction of more energy-efficient products.

A 2015 evaluation of the Energy Labelling and Ecodesign Directives found that the Ecodesign Directive is effective and does not need revision at present, but that the Energy Labelling Directive requires improvement. On 15 July 2015, the Commission proposed to replace Directive 2010/30/EU with a new Regulation on energy labelling that would restore the original labels, with A being the most efficient, in order to make energy labels easier to understand for consumers.

In the automotive sector, Directive 1999/94/EC requires car manufacturers to provide consumers with information about the energy efficiency (fuel economy) and CO_2 emissions of new passenger cars. Regulation (EC) No 443/2009, amended by Regulation (EU) No 333/2014, sets CO_2 emission performance standards for new passenger cars, which can promote the construction of more energy-efficient cars. Directive 2009/33/EC requires energy efficiency and other environmental criteria to be taken into account in public procurement of road transport vehicles.

Smart meters

The Electricity Directive (2009/72/EC) requires the roll-out of smart metering systems in the Member States, subject to a positive economic assessment of costs and benefits. By providing detailed information about energy use, smart meters can encourage consumers to make energy savings. Smart meters also enable the dynamic pricing of electricity according to supply and demand. Such dynamic pricing can contribute to a more efficient use of energy by discouraging consumption at times of peak demand (demand response), thereby reducing the necessity to provide spare generation or transmission capacity.

EU emissions trading system (ETS)

The ETS Directive (2009/29/EC) sets quotas for greenhouse gas emissions in electricity generation and industry, and establishes a system for trading emission allowances. The Directive can encourage energy efficiency investments if these are the most cost-effective way to reduce emissions, taking into account the price of allowances. Reform of the system is under way, with the introduction of a market stability reserve, and a proposal for post-2020 rules for free allocation, carbon leakage and support for low-carbon innovation.

A 2013 study on energy efficiency and the ETS concluded that there are only limited interactions between the ETS and the Energy Efficiency Directive, which concerns mostly non-ETS sectors.

Financing of energy efficiency

According to the Commission, more than €100 billion (including around €89 billion in the housing sector and €19 billion in industry) needs to be invested every year to achieve the 2030 energy efficiency target – twice the current levels.

The EU provides funding for energy efficiency measures through the European Structural and Investment Funds, the research and innovation programme Horizon 2020, the European local energy assistance programme (ELENA) and the European Energy Efficiency Fund (EEEF). The EEEF is a public-private partnership focused on financing projects carried out by, or on behalf of, local and regional authorities. The EIB's Private Finance for Energy Efficiency (PF4EE) instrument provides long-term financing for energy efficiency investments, backed up by the LIFE fund for credit risk protection and expert support services.

Energy efficiency measures are among the investments that can be supported by the European Fund for Strategic Investments (EFSI), which aims to attract €315 billion in private investments.

The Investor Confidence Project (ICP) Europe, supported through the EU Horizon 2020 programme, aims to establish a market for 'investor ready energy efficiency projects' by reducing transaction costs, risk, and engineering overheads for building renovation projects. ICP standardises the process by leveraging best practices for building renovations and subjecting projects to third-party review.

National funding for energy efficiency aims to overcome barriers for potential investors. For example, in Germany, the public bank KfW provides low-interest loans and grants for energy efficiency investments in the residential sector, municipalities and industry. Among other measures, the UK offered a reduced VAT rate for the supply and installation of energy-saving materials in buildings. However, The Court of Justice of the EU ruled in June 2015 that this practice violates the VAT Directive.

Ongoing and planned initiatives

The Commission's work will focus on ensuring that the current legislative framework is fully implemented by the Member States and that investment in energy efficiency increases, notably as part of the European Structural and Investment Funds for regional policy and the European Fund for Strategic Investments. The Commission aims to strengthen the targeted use of financial instruments to support investments in energy efficiency, for example in the proposed 'smart financing for smart buildings' initiative.

The Commission plans to review all EU legislation related to energy efficiency in the coming years. A review of the ecodesign legislation is in progress. In July 2015, the Commission launched a consultation on a new energy market design.

A review of the Energy Efficiency Directive and the Energy Performance of Buildings Directives is planned for 2016. In 2017, various initiatives for the transport sector are envisaged, including a review of Directive 2009/33/EC on the promotion of clean and energy efficient road transport vehicles.

In 2015, the Commission intends to develop an EU strategy for heating and cooling, a sector that accounts for almost half of primary energy consumption in Europe. By the

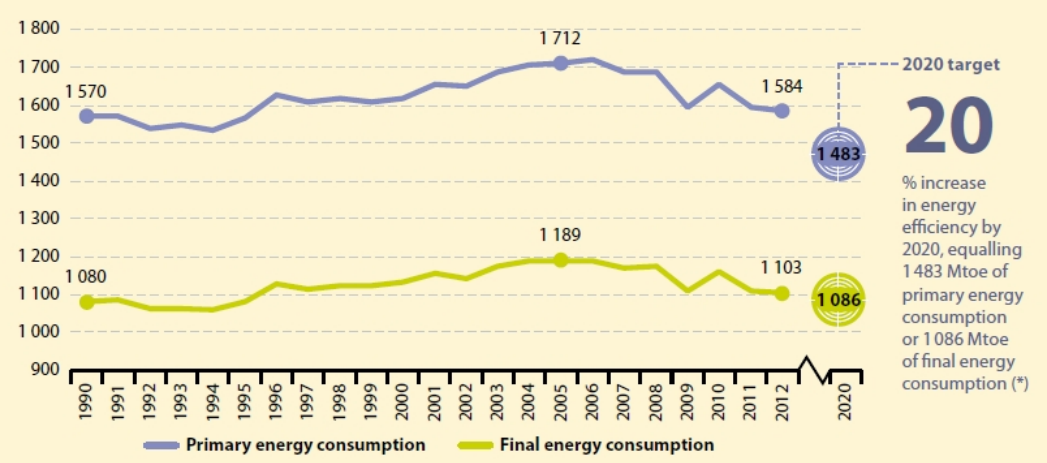
end of 2015, all Member States must submit an assessment of the potential for application of high efficiency combined heat and power and efficient district heating and cooling to the European Commission.

Implementation and challenges

Implementation of energy efficiency is challenging because it involves many different levels, including households, industry, national governments, regional and local authorities.

Studies indicate that the EU is likely to miss the 2020 energy efficiency target unless additional efforts are made. A September 2014 study on behalf of the European Commission projects a three percentage point shortfall for primary energy savings, and four points for final energy savings.

Figure 1 – Primary and final energy consumption in the EU 28, 1990–2012



Million tonnes of oil equivalent (Mtoe). Source: Eurostat.

Weak implementation at Member State level has been cited as one of the reasons for this shortfall. In 2015, the Commission referred Hungary and Greece to the EU Court of Justice for failing to transpose the Energy Efficiency Directive, and issued a final warning to Germany. All Member States, except Malta, received a letter of formal notice for failing to fully transpose the Directive by the June 2014 deadline.

Tania Zgajewski (Egmont Institute) considers that the EU approach to energy efficiency has failed to reach its objectives and lacks coherence. Her 2015 analysis of energy efficiency in the building sector concludes that the energy performance of buildings and the rhythm of renovation remain extremely weak, while Member States appear unwilling to transpose and implement the legislation properly and in a timely manner.

The European Court of Auditors found, in 2013, that Cohesion Policy investments in energy efficiency were often not cost-effective, and were carried out without a proper needs assessment. The Court recommends introducing a mandatory needs assessment, and to use transparent cost-effectiveness criteria for the selection of projects.

European Parliament

The European Parliament resolution of 5 February 2014 on the 2030 climate and energy framework advocates a more ambitious energy and climate policy. It calls for a binding EU energy efficiency target of 40%, to be implemented by individual national targets.

The Industry, Research and Energy (ITRE) Committee is preparing an own-initiative report on the Energy Union strategy. The draft report (Marek Józef Gróbarczyk, ECR, Poland) notes that energy efficiency on a cost-effective basis contributes to security of supply but cannot replace diversification of energy sources. It warns that over-prescriptive legislation could constrain national choices of energy efficiency measures. The Committee vote is expected for October 2015, and the plenary vote for November 2015.

The ITRE Committee is also working on an own-initiative report on the Energy Efficiency Directive (Markus Pieper, EPP, Germany).

The EPRS implementation appraisal of the EU energy efficiency legislation concludes that meeting the energy efficiency targets requires strengthened monitoring of existing legislation as well as consideration of additional measures, notably for the buildings and transport sectors, along with behavioural incentives.

Outlook

With the 'energy efficiency first' principle of the Energy Union and the planned overhaul of energy efficiency legislation, energy efficiency is going to remain on the political agenda for the coming years. Efforts are likely to focus on overcoming the obstacles that hinder the realisation of cost-effective energy efficiency measures, notably in the area of financing. The current environment of low energy prices (oil, gas, coal), combined with uncertainty about future prices, make this endeavour all the more challenging.

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Endnotes

[1] However, not all forms of energy have the same usefulness. For example, electricity has more uses than heat. Therefore, even if the efficiency of converting one form of energy to another is low, it can still bring benefits.

[2] Energy productivity is the converse measure, GDP output per energy input (e.g. euro per kilowatt-hour).

[3] This inefficiency occurs at two levels: on the one hand, money and energy are required for building and maintaining spare capacity to meet peak demand, and on the other hand the power plants kept in reserve for demand peaks are often older plants that are physically less efficient.

[4] Another measure is energy return on energy invested, the ratio between the energy produced and the energy used for its production.

[5] Energy poverty is a situation where individuals or households are unable to adequately heat their homes or provide other required energy services at affordable cost. The exact definition varies across Member States.

[6] According to the European Commission a 1% improvement in energy efficiency can reduce EU gas imports by 2.6% (based on energy-economic models).

[7] In order to account for the cost of capital and the time value of money, a discount rate is applied to the annual cash flows related to the investment and the payback. The choice of the discount rate has significant influence on cost-benefit calculations.

[8] These hidden costs may be accounted for in economic modelling by adjusting the discount rate.

[9] The rebound effect (also known as Jevons' paradox) was first described in William Stanley Jevons' 1865 book 'The coal question'. Jevons observed that coal use in England grew after James Watt's improvements of the energy efficiency of the steam engine, which enabled its widespread use in various industries.

[10] Energy efficiency investments were around half the size of upstream oil and gas investment, and larger than supply-side investment in renewable electricity or in fossil-fuel based electricity generation. In 2011, energy savings from the energy efficiency improvements of 11 IEA member countries equalled 1 337 million tonnes of oil-equivalent (Mtoe). The savings exceeded the total final consumption from any single fuel source in these countries, and was larger than the total 2011 final consumption for the EU from all energy sources combined.

[11] The modelling was carried out with the PRIMES energy model that simulates the European energy system and markets on a country-by-country basis and across Europe. The model was developed by E3M-Lab of the National Technical University of Athens and is used by various departments of the European Commission. Results indicate that a 40% target, as proposed by Parliament, would lead to a substantial increase in overall energy system costs.

[12] Primary energy consumption in the EU 28 should not exceed 1 483 Mtoe in 2020, and EU 28 final energy consumption should not exceed 1 086 Mtoe by the same year. The energy efficiency target is actually an energy savings target, as it does not relate to the economic output related to the energy input.

[13] In addition, Regulation (EC) No 1222/2009 requires the labelling of tyres with respect to fuel efficiency, as well as wet braking performance and rolling noise.

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