Executive Summary

Energy security and climate change mitigation are two key objectives of governments. Which policies can achieve and maximise the realisation of both of these goals? This report offers an analytical approach to quantify which measures are effective under varying conditions.

The study reviews interactions between energy security and climate change mitigation policies. It does not determine whether the extent or the type of government action towards either climate change or energy security is justified or not. Rather, the study focuses on interactions given stated policy objectives and foreseen policy choices. It proposes, to the extent possible, the use of quantitative tools to assess the effects of government intervention in a context of multiple energy policy objectives. It ultimately intends to help guide policy-making towards policies that achieve both energy security and climate change mitigation objectives as efficiently as possible.

Results from the country case studies reflect a generally worsening trend in terms of CO_2 emissions and energy security and highlight the linkages between these energy policy concerns. The various policy cases investigated underline that policies deemed acceptable either to reduce CO_2 emissions or to improve energy security may no longer hold when considered through the prism of an integrated climate-security energy policy. It is the IEA's hope that countries will start undertaking a systematic review of the energy security implications of their climate policy initiatives and vice versa. The tools elaborated in this report should shed interesting, objective light on challenges and opportunities that lay ahead for countries seeking to develop sustainable energy policies.

The various aspects of energy security policy

Carbon dioxide emission trends are commonly used as a tool to assess efforts to mitigate climate change, yet there is no similar approach for energy security. Historically, the assessment of energy security has been almost exclusively based on expert judgment, making unwieldy any systematic appraisal of policy interactions under various scenarios. This report proposes a pragmatic approach to assess energy security policies.

Energy insecurity stems from the welfare impact of either the physical unavailability of energy, or prices that are not competitive or overly volatile. In practice, however, such impacts are difficult to gauge and, therefore, so is the magnitude of an appropriate policy response.

There are several kinds of government actions addressing energy security. First, a distinction can be made between government actions to mitigate the short-term risks of physical unavailability in case of a supply disruption and efforts to improve energy security in the long-term.

In the first case, actions include establishing strategic reserves. For oil, the International Energy Agency co-ordinates the use of member countries' emergency oil stocks. Governments may also seek to establish contingency plans to curtail consumption in order to mitigate the magnitude of physical unavailability.

In the second case, policies tend to focus on tackling the root causes of energy insecurity, which can be separated into four broad types:

- **Energy system disruptions linked to extreme weather conditions or accidents:** Government policies are generally precautionary in nature. Governments notably have an important role in preparing contingency arrangements for the management of, and recovery from, such incidents after they happen.

- **Short-term balancing of demand and supply in electricity markets:** To ensure the security of electricity systems, governments establish independent transmission system operators (TSO) responsible for the short-term balancing of demand and supply.
- **Regulatory failures:** Government action aims to monitor the effectiveness of regulations and to adjust regulatory structures when inefficiencies are detected.
- **Concentration of fossil fuel resources:** Government action aims to minimise the exposure to resource concentration risks in fossil fuel markets and includes moving away from fossil fuels, or diversifying supply routes and means.

This typology of energy security policy helps identify areas of potential overlap with policies and measures to reduce energy-related greenhouse gas emissions. Policies addressing concerns linked to resource concentration may have the most significant implications for climate change mitigation and vice versa: both policies are likely to affect fuel and associated technological choices. In contrast, interactions with policies correcting for regulatory failures may have only secondary effects on greenhouse gas mitigation policies in the energy sector. Finally, energy security measures responding to the risks of short-term physical disruptions and the balancing of electricity grids have very limited interactions with climate mitigation efforts. This work therefore focuses on resources concentration as a driver of longer-term energy security.

Measuring resource concentration as a driver of energy security

Instead of trying to determine in quantitative terms the welfare losses resulting from resource concentration, we define indicators that focus on measuring the cause of energy insecurity. These indicators address the two components of energy security independently: the price and the physical availability of energy.

A measure of the price component of energy security is useful in markets where prices are allowed to adjust in response to changes in demand and supply. In such cases the risk of physical unavailability is reduced to extreme events. The prevailing energy security concern is related to prices not set competitively or that are overly volatile. The international oil and coal markets can be included in this category.

The energy security indicator for this price component (ESI_{price}) is based on a measure of market concentration (ESMC) in each international fossil fuel market. For a given country, ESI_{price} weighs the relative importance of each ESMC value based on the exposure of the country to each fuel. The more a country is exposed to high concentration markets, the lower is its energy security.

A measure of the physical unavailability component of energy security is useful in markets where prices are regulated or pegged on other commodities. In such cases the price cannot contribute to balance supply and demand – an excess demand for gas, when such gas is indexed on oil prices, will not result in a price adjustment, and therefore not trigger the appropriate supply response. The principal concern, in such cases, is that of physical unavailability as markets then lack a crucial adjustment mechanism. The gas markets in most European countries and in several Asian countries where gas is indexed to oil fall in this category.

We find that the energy security indicator focusing on physical unavailability (called ESI_{volume}) is mostly useful for gas trade transiting through pipelines. ESI_{volume} measures a country's share of total energy demand met by oil-indexed, pipe-based gas imports. The higher this share, the less secure the country's gas supply.

When gas is indexed to oil, in addition to a risk of physical unavailability occurring, gas consumption is also exposed to the price risk of the oil market. Gas therefore links the price and physical availability components of energy security.

Case studies

Five IEA countries have volunteered to participate as case studies in this analysis of energy security and climate change policy interactions: the Czech Republic, France, Italy, the Netherlands, and the United Kingdom. The quantitative assessment was undertaken following a "reference" energy projection. It provides insights on how energy-related CO_2 emissions, ESI_{price} and ESI_{volume} evolve between now and 2030, without significant efforts to abate CO_2 emissions.

In a second step, a number of discrete policy measures that reduce CO_2 emissions are applied to these energy projections. These policy cases change the trend of energy security indicators and allow gauging the interaction between specific CO_2 reduction measures and energy security goals.

While the analysis undertaken was based on five OECD European countries, the framework defined may be applied to any country, including non-OECD countries. It does require, however, a projection of fossil fuel supply, broken down by key regions or countries.

Results from the reference scenario

For our five case studies, reference scenarios generally show a worsening trend in CO_2 emissions, ESI_{price} and ESI_{volume}. However, differences in fuel mixes and the organisation of the gas sector lead to significant variations in the five countries.

Compared to 2004, CO_2 emissions are projected to decrease by 27% in 2030 in the Czech Republic, by 3% in 2020 in the UK, while they increase by up to 38% in France. ESI_{price} increases by 6% by 2030 in the Czech Republic, 15% by 2020 in the UK and up to 42% in France. ESI_{volume} grows by 12% in 2030 in the Czech Republic and 31% in France, while it emerges as a new concern in the UK starting between 2004 and 2010 and in the Netherlands between 2020 and 2030.

The price indicator defined here (ESI_{price}), though it is difficult to appreciate in absolute terms, allows gauging trends and undertaking cross-cutting comparisons. This is particularly useful in assessing market concentration. For example, when OPEC countries are considered as a single participant in the market, the oil market is twice as concentrated as the coal market throughout the 2004-2030 period. When OPEC countries are considered as individual participants, however, the oil market is in fact characterised by less than half the level of concentration of the coal market.

If OPEC countries are considered as a single participant in the international oil market, the measure of market concentration (ESMC) is projected to increase by approximately 30% between 2004 and 2030. Over the same period, concentration in the coal market grows by some 22%, remaining much lower than that of oil.

Market concentration in the gas market only captures volumes traded on gas-based terms (e.g. Henry Hub and National Balancing Point contracts). Nevertheless, comparing concentration levels in the gas market to those in the oil or coal market also provides some useful insights. In 2004, when the gas market is geographically restricted, it is 18% more concentrated than the coal market. By 2030, when the gas market is assumed to be global thanks to the growth in LNG trade, the market concentration in gas is 60% lower than that of coal.

The gas sector is unique in this assessment as it links the price and the physical availability components of energy security. By considering both a case of unchanged price structures in Europe, where oil-indexation of gas continues to be the norm (case 1), and a case of a gradual switch from oil-indexed contracts to gas-based pricing (case 2), we quantify the impact of changing gas price structures in the European context on security concerns. Gas market concentration remains roughly unaffected by considering either case 1 or case 2. Importantly, however, gas market concentration is significantly lower than that of the oil market. Oil-indexed gas pricing, therefore, exposes gas importers to a market characterised by higher concentration than if gas were purchased on gas-indexed terms. In addition, oil-indexed pricing creates important physical availability concerns, as reflected in the evolution of the ESI_{volume} indicator described above.

Countries concerned about the political stability of exporting countries may wish to factor such considerations in their energy security analysis. This assessment includes an attempt to do so, through a combination of the measure of energy market concentration and a political stability rating applied to countries that supply the international fossil fuel markets. This new factor has a varying influence on the energy security rating of each fossil fuel market. The effect of factoring political risk in 2004 was nearly twice as large in the oil market when OPEC countries were considered as a single participant than in the coal market. In the case of oil, factoring political stability has a growing effect over 2004-2030 whether OPEC countries are considered a single market player or not. In comparison, gas and coal markets would record favourable evolutions.

Results from the policy cases

The adoption of a quantitative framework to assess policy impacts in terms of CO_2, ESI_{price} and ESI_{volume} allows identifying and gauging possible policy synergies and conflicts. This study illustrates how specific climate policy mitigation measures in the electricity and transport sectors could affect the energy security outlook of various countries. For the sake of simplicity, all policy measures considered are compared against an identical 5% reduction in countries' emissions from baseline by 2030. While measures are assessed individually, the framework could also be used to evaluate a mix of policy tools. Some interactions between various policies may emerge that are not reflected in these illustrations.

End-use efficiency improvements and an enhanced reliance on non-fossil fuel technologies (renewables or nuclear) in the electricity sector have positive impacts of similar magnitude on energy security. This reflects the similarity of the changes in fuel mix required to reduce emissions by 5%, essentially a reduction in coal- and gas-based electricity generation. Country specificities, however, imply different effects. For our assumed 5% reduction in CO_2 emissions, ESI_{price} in 2030 decreases by 2.5% to 4.3% from the baseline, while that of ESI_{volume} ranges from 2.3% to 38.1%. These results indicate an overall improvement in energy security indicators, when energy efficiency and non-fossil fuel generation are enhanced to reduce emissions from the power sector.

Achieving a 5% reduction in emissions through a switch from coal to gas, on the other hand, has a negative impact on both security indicators. The increase in ESI_{price} in 2030 ranges from 0.1% to 4.1%. This may seem a relatively small increase, but the resulting changes in traded energy also influence countries' exposure to the different market concentration levels. Indeed, the greater the difference between the efficiency of the new gas plant and that of the coal plant it is replacing, the smaller – on an energy basis – are the volumes of gas required compared to the volumes of coal displaced. In other words, there are conflicting effects. On the one hand, due to lower concentration levels in the coal market compared to that of the oil market[1] a switch from coal to gas induces a negative effect on ESI_{price}. On the other, it reduces energy volumes required which lowers the overall exposure to concentration risks and therefore induces a positive effect on ESI_{price}. In contrast, the impact on ESI_{volume} (the exposure to pipe-based, oil-indexed gas imports) is much more predictable: a switch from coal to gas leads to an increase in ESI_{volume} ranging from 4.4% to 87.1%.

Fuel efficiency improvements in transport lead to important benefits in ESI_{price}, ranging from a reduction of 4.6% to one of 8.2%. Again, differences depend on the respective role of oil in each country case study, with a greater benefit for countries where oil represents a greater share of total consumption. These benefits are more significant in all countries than those obtained through efficiency improvements in electricity end-uses, due to the importance of oil in driving ESI_{price} trends.

1. Remember that through oil-indexation gas is effectively exposed to the price risk of the oil market.

Switching from oil to biofuels in transport has complex implications for energy security, as one needs to account for the energy used in biofuel production. In this case, a switch from oil to biofuels lowers the ESI_{price} indicator in 2030 from between 3.5% to 6.4%. The underlying contributions to ESI_{price} are, however, conflicting. On the one hand, the drop in oil and coal consumption lowers the exposure to oil and coal market risks which contributes to lower ESI_{price}. On the other, the enhanced consumption of – oil-indexed – gas increases the exposure to oil risks, reflected in a higher ESI_{price}. At the same time, due to enhanced gas requirements, ESI_{volume} increases in 2030 by 3.5% to 44.9%, compared to baseline.

Conclusion

Any analysis based on the use of indicators rests necessarily on a number of simplifications. The energy security indicators developed here nevertheless provide a framework allowing a systematic, quantitative evaluation of energy security and climate change mitigation. The quantitative framework defined enables us to determine with precision how each indicator changes and why. Changes in indicator levels can entail conflicting effects which could not be identified without the tools defined in this report. As such, they can complement expert judgments on a matter where the complexity of policy interactions and their effects, inside and outside country borders, can rapidly blur the policy picture. The energy security indicators developed by the IEA should be viewed as a stepping stone for future elaboration and improvement.