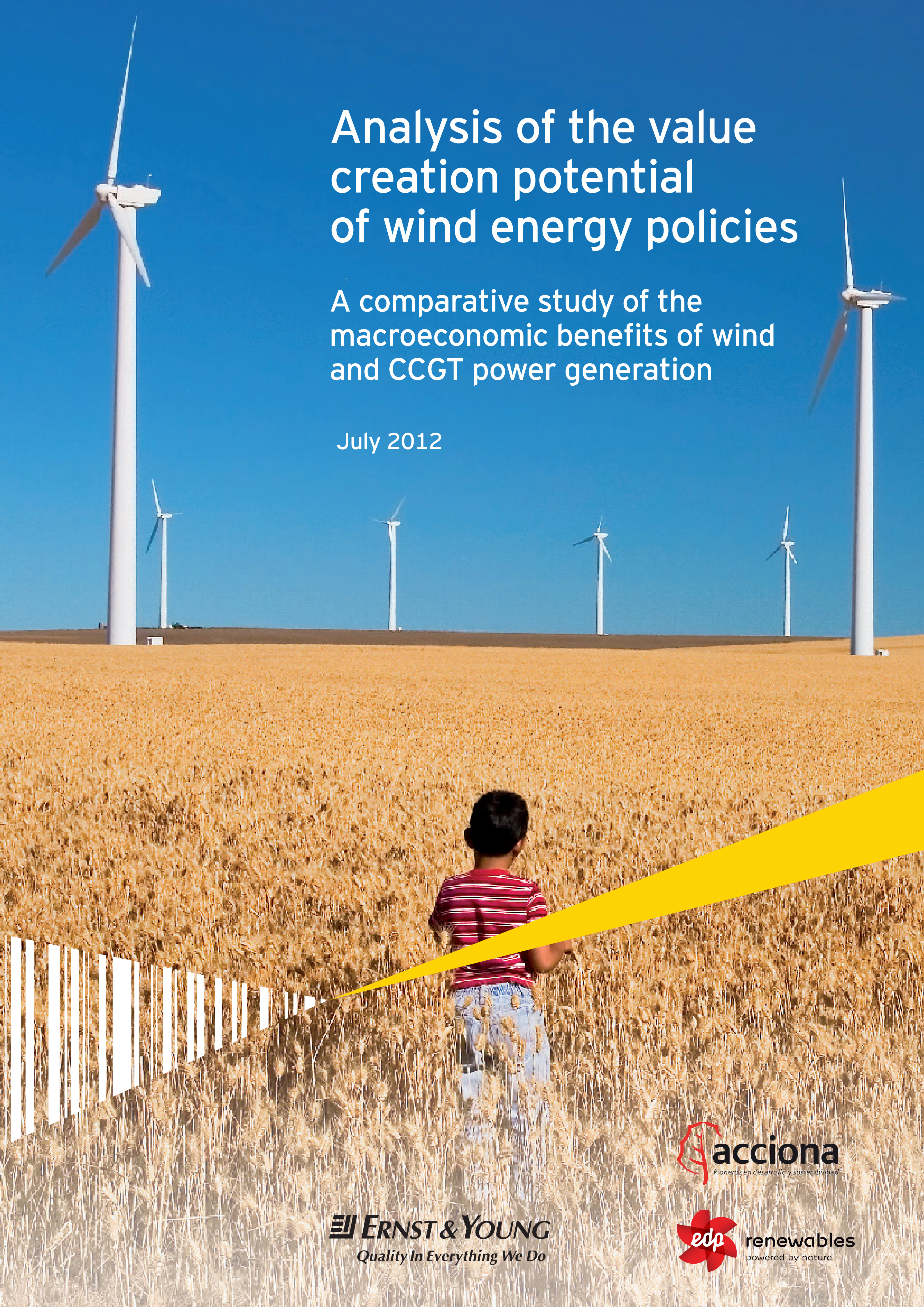
Analysis of the value creation potential of wind energy policies

A comparative study of the macroeconomic benefits of wind and CCGT power generation

July 2012



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Foreword

Policy makers increasingly need to make informed decisions on the opportunities to support renewable energy generation. In most cases, choices are based on a comparison of the respective Levelized Cost of Energy (LCOE) of technologies but seldom include a comprehensive analysis of the additional economic costs or benefits. On the basis of the LCOE analysis, renewable energy technologies such as wind power generation present in most cases a higher cost than fossil fuel based generation technologies. However, wind power also triggers returns for the domestic economy by generating local added value and job creation.

At the request of Acciona and EDP, Ernst & Young conducted a study aimed at presenting an integrated analysis of the value creation potential of wind energy, in order to support energy policy decisions. The approach consists in comparing two energy technologies, Combined Cycle Gas Turbine (CCGT) and wind energy generation, by taking into account their direct costs (micro-economic analysis) as well as their impacts on the economy (macroeconomic analysis), such as job creation, contribution to the GDP, energy security, grid integration costs, CO_2 emissions and impact of wind power on electricity pool prices. For illustrative purposes, a comparison of the discounted costs and benefits over the lifetime of standard projects for each technology is presented in the report, but does not constitute a full assessment of all impacts of both alternatives.

The analysis undertaken has included several parameters that are not usually covered by the economic analysis of wind projects, though the work carried out should not be considered as fully comprehensive as some other impacts could also be taken into account, such as the impacts on the competitiveness of the economy of electricity price evolutions due to wind energy generation. Grid integration costs are included in the scope of the analysis but would require further investigations in order to provide precise results. These costs are related to the fact that wind energy is intermittent and requires back-up capacities to compensate for the variability of wind, balancing and network investments.

Combining cost items used in the LCOE calculation with the additional economic benefits which are reflected by the GDP creation, a "net cost" has been calculated for each technology. The model established for the study, based on publicly available information sources and average input data, indicates that in most countries analysed, any euro spent on wind energy will produce returns to the domestic economy, in terms of Gross Value Added, job creation and also in terms of energy security. This value creation potential is not sufficiently identified today by decision makers. This report aims at highlighting some of the advantages of wind energy which are not systematically included in energy planning.

Context and objectives of the study

The challenge of matching low carbon policies to economic growth

When looking at the most significant challenges facing Europe today, two trends are ascendant: fiscal austerity and economic growth. On the one hand, many European governments have little choice but to reduce spending, following their extensive bailouts and stimulus packages. On the other hand, they need to be mindful of the impact of their policies on prospects for growth.

As the world shifts to a resource-efficient and low-carbon economy to address the rising consumption of energy and raw materials, many countries are embracing national renewable and low carbon strategies to position themselves in economic competitiveness and growth. For reasons ranging from creating jobs, to incubating high-value industries, to achieving energy security or combating environmental degradation, many governments are making innovation and adoption of new low carbon technologies a top priority. While each country is pursuing a different path to renewable energy deployment, government's strategies and business investment will play pivotal roles in both the sector's and the broader economic development.

Renewable energies are continuing to expand both in terms of investment, projects and geographical spread. In doing so, they are making an increasing contribution to combating climate change, countering energy poverty and energy insecurity. Overall new investment in renewable energy reached a record of $260 billion in 2011, over 5 times the level of 2004 ($52 billion), according to *Bloomberg New Energy Finance*. The Directive 2009/28/EC on the promotion of the use of renewable energy sources (RES) sets the overall target to reach 20% of renewable energy in gross final energy consumption in 2020. Reaching this target will require a huge mobilization of investments in renewable energies in the coming decade. According to a study carried out by Ernst & Young (in association with Ecofys, the Fraunhofer Institute and the University of Vienna) for the European Commission in 2010, a gross estimate of the financial gap to be considered in addition to existing financing sources reaches approximately €35 billion per year on a 10-year period up to 2020, i.e. roughly €350 billion over the next decade.

In addition, the integration of wind and solar electricity leads to an increased variability of power supply. When a few percentage of power supply is produced by variable renewables, the existing electricity system is able to cover additional variability. However, when the share of variable renewable will reach the significant levels as expected by low carbon policies, a holistic approach will be necessary to ensure that power system integrity will be safeguarded, involving investment in network, balancing and back-up capacities.

Objectives of the study

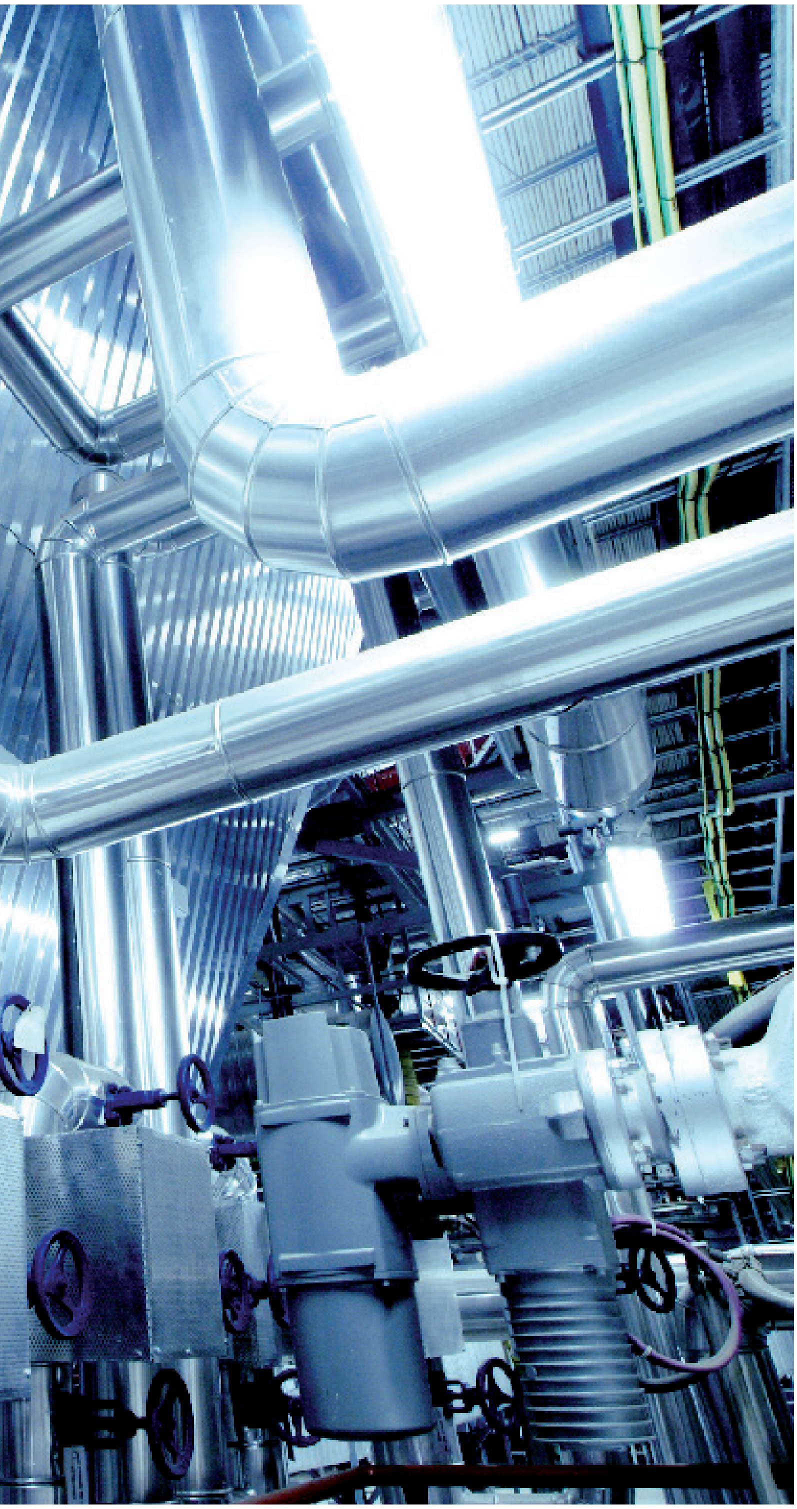
Despite ambitious renewable energy targets, developing renewables has become a challenge for budget-constrained governments. In this context, it is of paramount importance for policy makers to analyse the complete range of costs and benefits associated with increasing renewable energy generation. This study provides insight on costs and benefits of renewable energy policy measures, which are currently not systematically taken into account in the decision-making process:

- Job creation (direct and indirect) of policy measures in the renewable energy sector
- Contribution to the GDP and additional tax revenues
- Energy security
- Integration of wind capacities in the network
- Environmental externalities (CO_2 emissions)
- Impact of wind power on electricity pool prices

Wind technology was selected as the reference renewable energy source in this study and is compared here to Combined Cycle Gas Turbine (CCGT). This is based on the idea that natural gas is progressively becoming a significant source of electricity generation due to lower CO_2 emissions compared to other fossil fuels and to its price competitiveness. The analysis presented in this report could be extended to other renewable or conventional energy sources.

The methodology and model used in this study have been reviewed by the Catholic University of Porto.

Main findings



Wind energy provides a high contribution to GDP in most European countries

The macroeconomic analysis shows that wind generates more Gross Value Added per MWh produced than CCGT. For instance, in Spain, the costs required to produce 1 MWh from wind will generate €56 of Gross Value Added, against €16 for 1 MWh produced from CCGT. In the end, for equivalent services provided (production of 1 MWh of electricity), and in comparison with CCGT, wind energy will generate more economic benefits for the domestic economy.

This result can be explained mostly by the fact that for CCGT, a large share of the costs relates to fuel costs. As natural gas is in a majority of European countries imported to a large extent, these expenditures generate very limited benefits for the domestic economy.

Also, the industries and services involved in the entire value chain of wind energy have, in global terms, more local added value than in the case of CCGT.

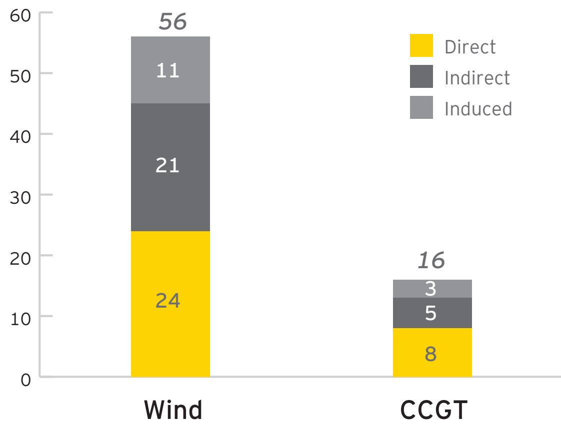


Figure 1: Gross Value Added in euros discounted per MWh produced in Spain

The contribution to GDP of wind and CCGT varies according to national energy contexts

In all European countries covered by the analysis, wind has a higher contribution to GDP compared with CCGT. However, results vary significantly from one country to another depending on the share of imports in the natural gas consumed by CCGT plants.

In particular, investing in a wind power plant has a much stronger impact on GDP in countries where natural gas is mostly imported. In countries where fossil fuels are mostly imported, fuel expenditure is directed to gas producing countries and consequently does not benefit the national economy.

For example, the UK and France have significantly different shares of domestic gas used in their respective economies.

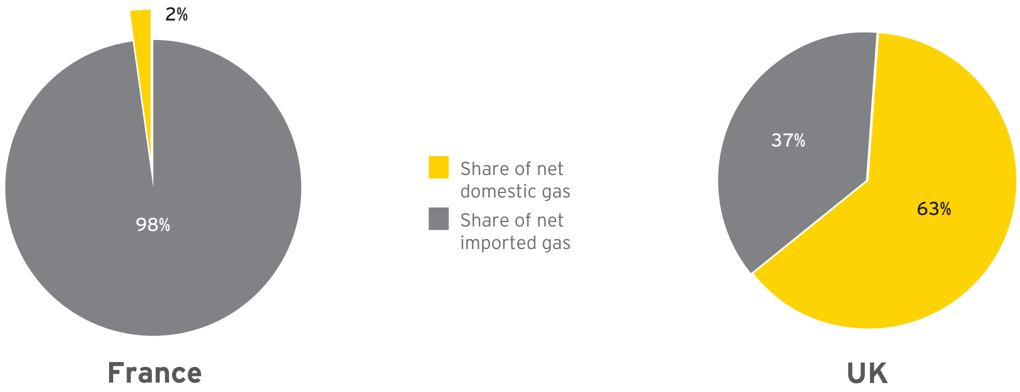


Figure 2: Origin of natural gas consumed in the UK and France

This explains the difference between the UK and France in terms of additional GDP creation of wind compared to CCGT as shown below:

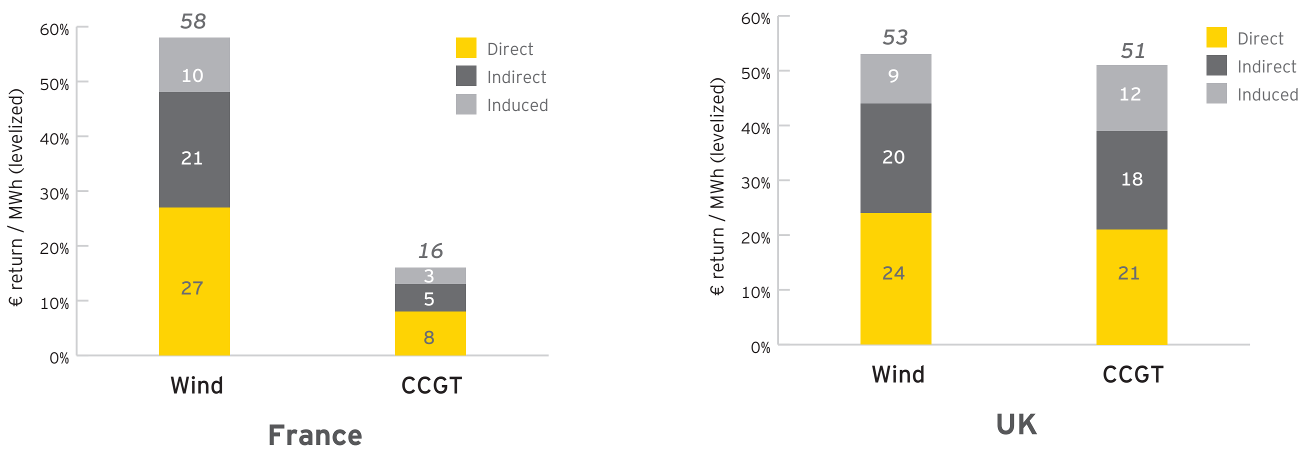


Figure 3: GDP creation from Wind and CCGT energy in France and the UK

Main findings

When all external costs and benefits are included, the "net" cost of wind is lower than the equivalent cost for CCGT

Wind energy shows a higher levelized cost per MWh (LCOE) than CCGT with around €81 per MWh generated compared to €74 per MWh (including €5,25 of CO_2) for CCGT. This is mainly due to higher CAPEX requirements.

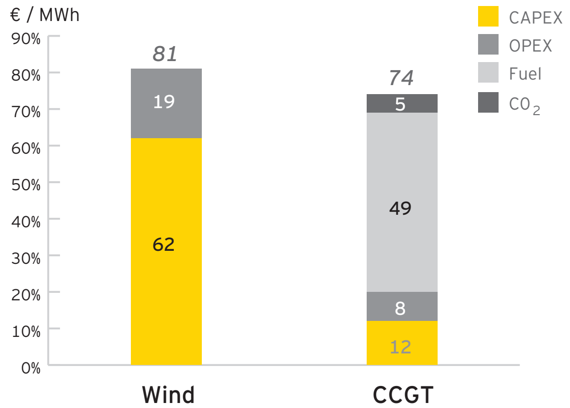


Figure 4: Levelized costs of Wind and CCGT per MWh produced

These CAPEX and OPEX costs for wind have a significant contribution to GDP creation in the domestic economy. In order to take these economic benefits into consideration, a "net cost" has been calculated. It consists in combining the cost items used in the LCOE calculation with the additional economic benefits which are reflected by the GDP creation. This approach seeks to provide a comprehensive vision of costs and value creation from the perspective of a domestic economy. For the 27 countries of the European Union (EU27), the result shows that by including the environmental and social costs and benefits of each technology, the integrated (or net) cost of wind generation is significantly lower than CCGT.

The results of the analysis for Spain are typical for most European countries. The difference between CCGT and wind energy in the initial electricity price (LCOE) is compensated by a much higher GDP creation for wind. At the end, the "net cost" of 1 MWh from CCGT is more than twice that of wind.

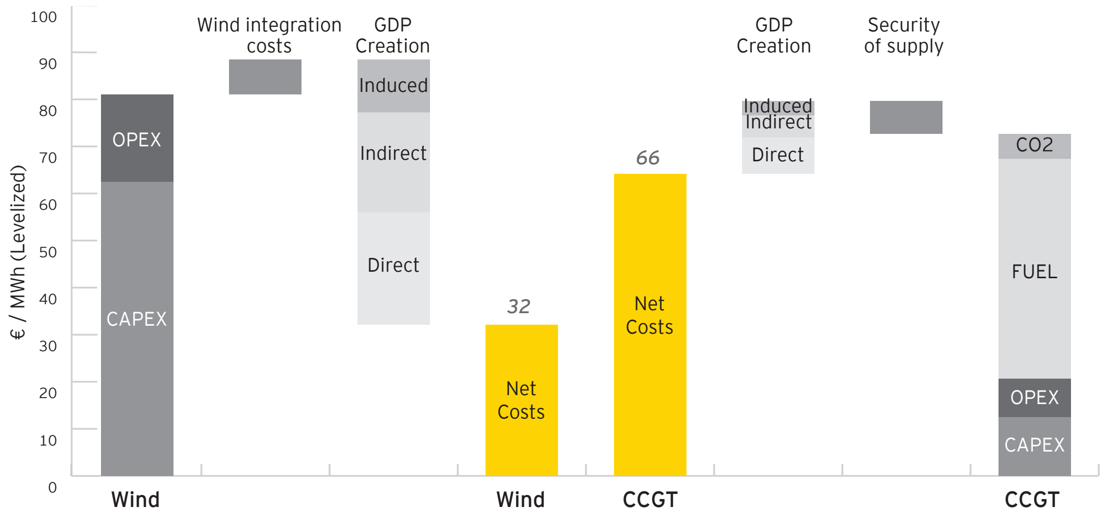


Figure 5: Global profit and loss analysis for Spain

France shows results very similar to Spain with virtual the same GDP creation potential for wind and CCGT.

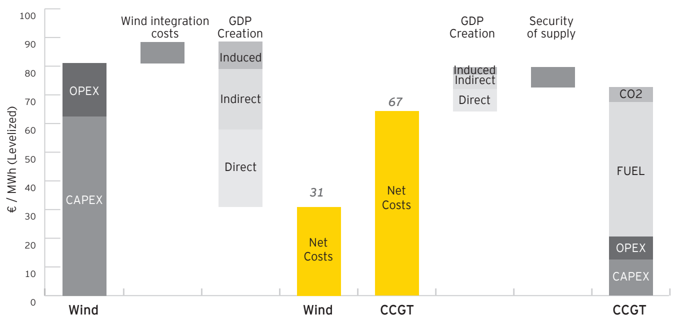


Figure 6: Global profit and loss analysis for France

The case of the United Kingdom provides many interesting insights in how wind achieves better wealth creation in most European countries. With a significant share of fuel being produced locally, the UK has similar GDP creation for CCGT and wind.

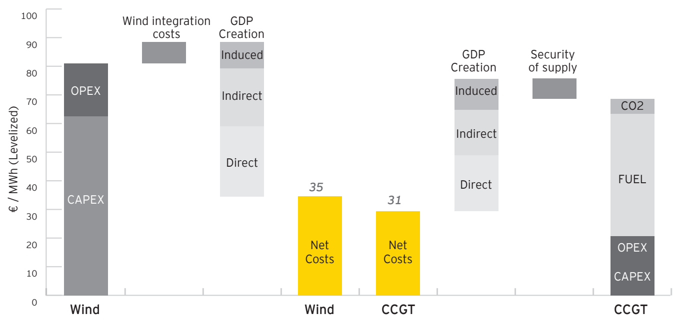


Figure 7: Global profit and loss analysis for the UK

Germany has the best results of all European countries in GDP creation for wind. With a high level of imports for natural gas, GDP creation is again low for CCGT. In total, the difference between the "net costs" is the highest of all the countries studied: wind's net costs are nearly 2,5 times lower than CCGT's.

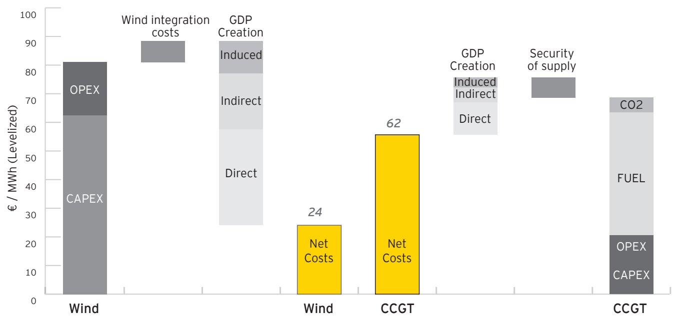


Figure 8: Global profit and loss analysis for Germany

Portugal's GDP creation through investments in wind and CCGT are among the lowest in this study. But, due to the low domestic share of natural gas, net costs of wind are in the end lower than those of CCGT.

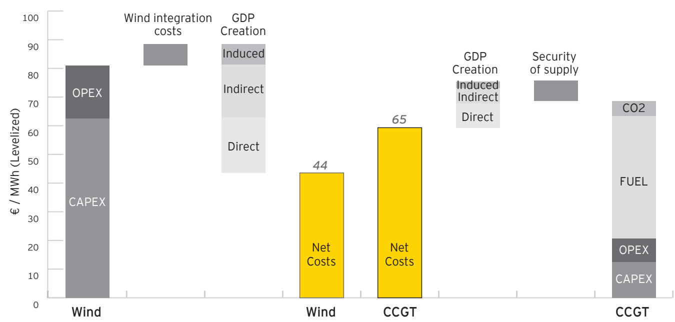


Figure 9: Global profit and loss analysis for Portugal

This highlights the fact that any euro spent on wind energy in the EU will provide significant returns to the domestic economy, in terms of Gross Value Added, job creation and also in terms of energy security.

Main findings

Wind has a significant job creation potential

The results shown above for GDP creation also apply to local job creation. Indeed, jobs are generated in domestic companies providing goods and services related to the capital (turbines, for example) and operational expenditures (direct jobs for operation and maintenance), in supplying companies (indirect jobs) and in the economy in general due to the additional income generated in the entire supply chain (induced jobs). Job creation is presented in "job.year" (which corresponds to one full time equivalent job during one year) per M€ invested (discounted value) in order to show the efficiency of the investments in terms of job creation. In Spain and France, wind creates twice more jobs than CCGT per M€ invested as shown below:

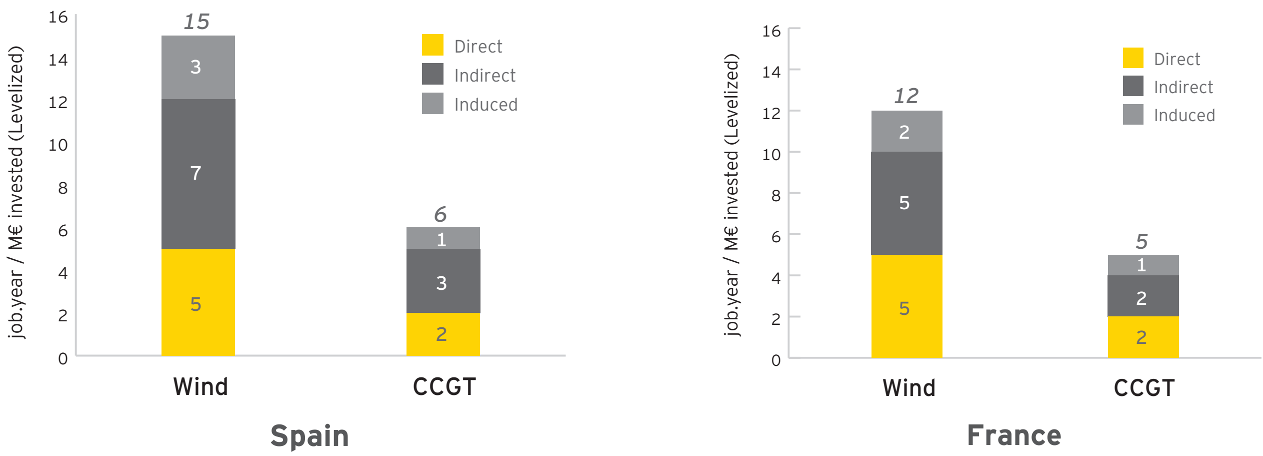


Figure 10: Job creation for wind and CCGT in Spain and France

In EU27, wind creates 21 job.years per M€ invested, compared to 13 for CCGT. Similarly to GDP, this difference in job creation can be explained by the fact that a high share of the costs of generating electricity with CCGT is "exported" through fuel costs, thus not benefiting the domestic economy. Most jobs are created indirectly by the projects.

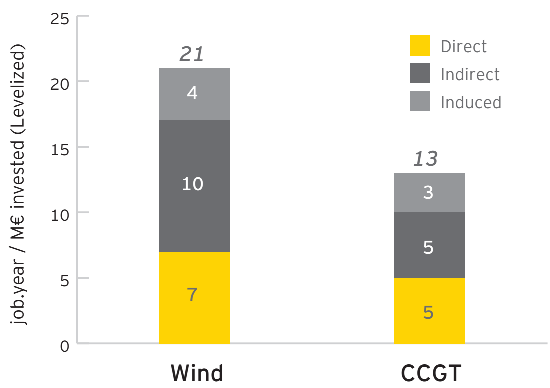


Figure 11: Job created by wind and CCGT in EU27

Wind electricity generates more tax revenues than CCGT

By creating local value and local jobs, both energy sources will generate tax revenues for governments and local authorities. The model calculations show that €1 spent on electricity from wind generates between €27 and €52 cts of tax revenues in Europe depending on local tax policies. In particular, the "tax return" is above €50 cts in France and Germany.

The tax revenues mostly come from VAT and corporate taxes. Depending on domestic tax policy, social taxes can also be a significant source from employees and employers.

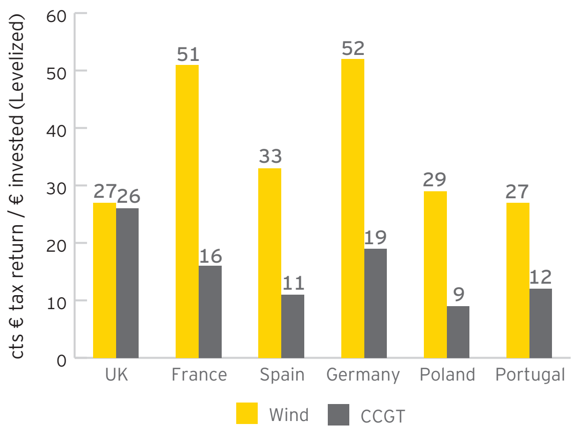


Figure 12: Tax return rate for wind and CCGT in 6 European countries

Conclusion

The results of the study show that despite a higher up-front cost in €/MWh, wind technology triggers higher returns for the domestic economy by generating local added value and job creation. In the end, combining the cost and benefit items from the LCOE (initial costs) and the GDP contribution (return on costs) shows a lower "net cost" of wind compared to CCGT for most European countries studied and at EU27 level.

This effect can be explained by the fact that a significant part of the expenditure related to producing electricity from CCGT is transferred to gas producing countries, mostly outside Europe. Therefore the choice facing decision makers when assessing opportunities to support renewable energy generation can be summarized as whether the benefits for the domestic economy compensate for higher initial costs.

It should however be clear that energy challenges facing European economies will require a diverse mix of electricity generation. In this perspective CCGT and wind energy generation both have strong development perspectives, and both provide significant advantages, such as load factor and price competitiveness for CCGT.

Appendix: methodology

This study aims at comparing two energy technologies, CCGT and wind turbines, by taking into account their direct costs (microeconomic analysis) as well as their impacts on the economy (macroeconomic analysis). Several studies have analysed the respective Levelized Cost of Energy (LCOE) of these two technologies but did not include a comprehensive analysis of their additional economic costs or benefits. The main steps of our approach are presented below:

1. The first phase of the analysis consists in calculating the LCOE for each option. For CCGT, the construction expenses (CAPEX), operation and maintenance expenses (OPEX), fuel costs and CO_2 are summed and discounted throughout the duration (construction and plant lifespan) of a reference CCGT project. For wind energy, the same principle is applied to a reference wind turbine project. This methodology allows computing LCOE in euros per MWh produced for wind power generation and for CCGT.
2. In the second phase of the analysis, CAPEX, OPEX and fuel costs were considered as input in the national economy, thus generating local output, creating added value and employment. To quantify them, each cost item of CAPEX (development, turbine, foundations, etc.) and OPEX (labour or non-labour) is considered as an expenditure made in a given segment of the domestic economy. A multiplier model, based on input-output data, allows to assess the effect of 1 euro spent in each industry or service segment in terms of turnover, Gross Value Added (GVA) and jobs created.
3. The direct, indirect and induced effects are thus calculated by taking into account the interdependencies between different sectors (services or industries) and the share of imports within the economy. The turnover and GVA created every year were then summed and discounted on the entire project's lifetime to obtain the levelized GVA and turnover created per MWh produced by each project. Regarding employment, the number of jobs created is summed for the entire duration of the projects and then divided by the number of years to get an average number of job.years created per year.
4. The last phase of the analysis is to estimate the amount of taxes collected due to the economic activity generated by both projects and compare them. This estimation includes income taxes from employees, corporate tax from the companies, Value Added Tax and social taxes and charges. Regional and specific taxes were also taken into account when identified in a given country. All the tax revenues generated during the construction and the operation of the plants are then summed and discounted over the lifespan of the project.

In the end, the approach described above allows to obtain, for each technology:

1. The total levelized cost per MWh of the project
2. The total levelized Gross Value Added created by the project
3. The average number of job.years generated every year
4. An estimation of the total taxes collected in euros invested (through project costs).

By subtracting the discounted value created to the amount of expenditure (project costs), a net comparison of the effects of both technologies at a macroeconomic level is carried out. Two additional economic effects are also taken into account in this comparison:

- Security of supply: the deployment of wind energy will contribute to reduce the fossil fuels dependency (which are in many cases imported) and will avoid economic losses due to price fluctuations. This security of supply effect is monetized in our calculations.
- Grid integration costs: renewable energies are intermittent and require back-up fossil fuels to compensate for the variability of wind, balancing and network investments.
- Our analysis also covered the impacts of wind energy generation on electricity prices.

Main limitations

The model used in the analysis described previously is built on validated sources and uses average input data. The main objective is to produce comparable figures between wind and CCGT energy: all the costs, benefits and productions are thus discounted over the project's lifespan. For some input data, which are the most subject to variation, different scenarios have been tested and stress tests have been performed. The analysis conducted has favoured conservative assumptions when validated data was not available.

The main limitations of the model and of the analysis are presented below:

- The macroeconomic effects of both technologies rely on the computation of national multipliers from Eurostat input-output tables. Thus allocation of the investments in CAPEX and OPEX to the various sectors of the economy (industry or service) highly depends on the precision of the tables available. As the level of detail varies between data sets from one country to another, comparison between countries should be made cautiously.
- The methodology assumes the same average domestic share for both wind and CCGT sub-sectors, defined in the Eurostat classification (electrical machinery, for instance). For this reason, this approach might underestimate the domestic share of specific wind components in countries with a strong wind industry (Spain, Germany in particular). A detailed analysis of the supply chain for wind and CCGT would be required for each country to capture precise data on these issues. At this stage, and based on existing studies, it has been assumed that when taking into account the entire supply chain (including second and third rank suppliers), a similar share of components and services have similar domestic shares for both technologies.

The methodology and model used in this study have been reviewed by the Catholic University of Porto.

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