

Executive Summary

The overall objective of the study is to provide reliable information on key factors affecting the economics of electricity generation using a range of technologies. The report can serve as a resource for policy makers and industry professionals seeking to better understand generation costs of these technologies.

The study was carried out by an *ad hoc* group of officially appointed national experts. Cost data provided by the experts were compiled and used by the joint IEA/NEA Secretariat to calculate generation costs.

Cost data were provided for more than 130 power plants. This comprises 27 coal-fired power plants, 23 gas-fired power plants, 13 nuclear power plants, 19 wind power plants, 6 solar power plants, 24 combined heat and power (CHP) plants using various fuels and 10 plants based on other fuels or technologies. The data provided for the study highlight the increasing interest of participating countries in renewable energy sources for electricity generation, in particular wind power, and in combined heat and power plants.

The technologies and plant types covered by the present study include units under construction or planned that could be commissioned in the respondent countries between 2010 and 2015, and for which they have developed cost estimates generally through paper studies or bids.

The calculations are based on the reference methodology adopted in previous studies, i.e., the levelised lifetime cost approach. The calculations use generic assumptions for the main technical and economic parameters as agreed upon in the *ad hoc* group of experts, e.g., economic lifetime (40 years), average load factor for base-load plants (85%) and discount rates (5% and 10%).

Electricity generation costs calculated are busbar costs, at the station, and do not include transmission and distribution costs. The costs associated with residual emissions – including greenhouse gases – are not included in the costs provided and, therefore, are not reflected in the generation costs calculated in the study.

The cost estimates do not substitute for detailed economic evaluations required by investors and utilities at the stage of project decision and implementation that should be based on project specific assumptions, using a framework adapted to the local conditions and a methodology adapted to the particular context of the investors and other stakeholders.

Moreover, the reform of electricity markets has changed the decision making in the power sector and led investors to take into account the financial risks associated with alternative options as well as their economic performance. In view of the risks they are facing in competitive markets, investors tend to favour less capital intensive and more flexible technologies. The used methodology for calculating generation costs in this study does not take business risks in competitive markets adequately into account.

The introduction of liberalisation in energy markets is removing the regulatory risk shield where integrated monopolies can transfer costs and risks from investors to consumers and taxpayers. Investors now have additional risks to consider and manage. For example, generators are no longer guaranteed the ability to recover all costs from power consumers. Nor is the future power price level known. Investors now have to internalise these risks into their investment decision making. This adds to the required rates of return and shortens the time frame that investors require to recover the capital. Private investors' required real rates of return may be higher than the 5% and 10% discount rates used in this study and the time required to recover the invested capital may be shorter than the 30 to 40 years generally used in this study.

Main results

Coal-fired generating technologies

Most coal-fired power plants have specific overnight construction costs ranging between 1000 and 1500 USD/kWe. Construction times are around four years for most plants. The fuel prices (coal, brown coal or lignite) assumed by respondents during the economic lifetime of the plants vary widely from country to country. Expressed in the same currency using official exchange rates, the coal prices in 2010 vary by a factor of twenty. Roughly half of the responses indicate price escalation during the economic lifetime of the plant while the other half indicates price stability.

At 5% discount rate, levelised generation costs range between 25 and 50 USD/MWh for most coal-fired power plants. Generally, investment costs represent slightly more than a third of the total, while O&M costs account for some 20% and fuel for some 45%.

At 10% discount rate, the levelised generation costs of nearly all coal-fired power plants range between 35 and 60 USD/MWh. Investment costs represent around 50% in most cases. O&M cost account for some 15% of the total and fuel costs for some 35%.

Gas-fired generating technologies

For the gas-fired power plants the specific overnight construction costs in most cases range between 400 and 800 USD/kWe. In all countries, the construction costs of gas-fired plants are lower than those of coal-fired and nuclear power plants. Gas-fired power plants are built rapidly and in most cases expenditures are spread over two to three years. The O&M costs of gas-fired power plants are significantly lower than those of coal-fired or nuclear power plants. Most gas prices assumed in 2010 are ranging between 3.5 and 4.5 USD/GJ. A majority of respondents are expecting gas price escalation.

At a 5% discount rate, the levelised costs of generating electricity from gas-fired power plants vary between 37 and 60 USD/MWh but in most cases it is lower than 55 USD/MWh. The investment cost represents less than 15% of total levelised costs; while O&M cost accounts for less than 10% in most cases. Fuel cost represents on average nearly 80% of the total levelised cost and up to nearly 90% in some cases. Consequently, the assumptions made by respondents on gas prices at the date of commissioning and their escalation rates are driving factors in the estimated levelised costs of gas generated electricity. The current gas prices are on a relatively high level. The gas price projections in 2010 of some of the respondents in the study are higher than the current level and a few are lower than the current level. The IEA gas price assumptions given in *World Energy Outlook 2004* (IEA, 2004) are markedly different.

At a 10% discount rate, levelised costs of gas-fired plants range between 40 and 63 USD/MWh. They are barely higher than at the 5% discount rate owing to their low overnight investment costs and very short construction periods. Fuel cost remains the major contributor representing 73% of total levelised generation cost, while investment and O&M shares are around 20% and 7% respectively.

Nuclear generating technologies

For the nuclear power plants the specific overnight investment costs, not including refurbishment or decommissioning, vary between 1 000 and 2 000 USD/kWe for most plants. The total levelised investment costs calculated in the study include refurbishment and decommissioning costs and interest during construction. The total expense period ranges from five years in three countries to ten years in one country. In nearly all countries 90% or more of the expenses are incurred within five years or less.

At a 5% discount rate, the levelised costs of nuclear electricity generation ranges between 21 and 31 USD/MWh except in two cases. Investment costs represent the largest share of total levelised costs, around 50% on average, while O&M costs represent around 30% and fuel cycle costs around 20%.

At a 10% discount rate, the levelised costs of nuclear electricity generation are in the range between 30 and 50 USD/MWh except in two cases. The share of investment in total levelised generation cost is around 70% while the other cost elements, O&M and fuel cycle, represent in average 20% and 10% respectively.

Wind generating technologies

For wind power plants the specific overnight construction costs range between 1 000 and 2 000 USD/kWe except for one offshore plant. The expense schedules reported indicate a construction period of between one to two years in most cases.

The costs calculated and presented in this report for wind power plants are based on the levelised lifetime methodology used throughout the study for consistency sake. This approach does not reflect specific costs associated with wind or other intermittent renewable energy source for power generation and in particular it ignores the need for backup power to compensate for the low average availability factor as compared to base-load plants.

For intermittent renewable sources such as wind, the availability/capacity of the plant is a driving factor for levelised cost of generating electricity. The reported availability/capacity factors of wind power plants range between 17 and 38% for onshore plants, and between 40 and 45% for offshore plants except in one case.

At a 5% discount rate, levelised costs for wind power plants considered in the study range between 35 and 95 USD/MWh, but for a large number of plants the costs are below 60 USD/MWh. The share of O&M in total costs ranges between 13% and nearly 40% in one case.

At a 10% discount rate, the levelised costs of wind generated electricity range between 45 and more than 140 USD/MWh.

Micro-hydro generating technologies

The hydro power plants considered in the study are small or very small units. At a 5% discount rate, hydroelectricity generation costs range between some 40 and 80 USD/MWh for all plants except one. At a 10% discount rate, hydroelectricity generation costs range between some 65 and 100 USD/MWh for most plants. The predominant share of investment in total levelised generation costs explains the large difference between costs at 5 and 10% discount rate.

Solar generating technologies

For solar plants the availability/capacity factors reported vary from 9% to 24%. At the higher capacity/availability factor the levelised costs of solar-generated electricity are reaching around

150 USD/MWh at a 5% discount rate and more than 200 USD/MWh at a 10% discount rate. With the lower availability/capacity factors the levelised costs of solar-generated electricity are approaching or well above 300 USD/MWh.

Combined heat and power generating technologies

For combined heat and power the total levelised costs of generating electricity are highly dependent on the use and value of the co-product, the heat, and are thereby very site specific. The expert group agreed on a pragmatic approach of calculating the levelised costs of generating electricity for this study. At a 5% discount rate, the levelised costs range between 25 and 65 USD/MWh for most CHP plants. At a 10% discount rate, the costs range between 30 and 70 USD/MWh for most plants.

Other generating technologies

Levelised costs were also computed for the remaining technologies. Considering the low number of responses for these technologies the results cannot be used outside the context of each specific case.

Conclusions

The lowest levelised costs of generating electricity from the traditional main generation technologies are within the range of 25-45 USD/MWh in most countries. The levelised costs and the ranking of technologies in each country are sensitive to the discount rate and the projected prices of natural gas and coal.

The nature of risks affecting investment decisions has changed significantly with the liberalisation of electricity markets, and this has implications for determining the required rate of return on generating investments. Financial risks are perceived and assessed differently. The markets for natural gas are undergoing substantial changes on many levels. Also the coal markets are under influence from new factors. Environmental policy is also playing a more and more important role that is likely to significantly influence fossil fuel prices in the future. Security of energy supply remains a concern for most OECD countries and may be reflected in government policies affecting generating investment in the future.

This study provides insights on the relative costs of generating technologies in the participating countries and reflects the limitations of the methodology and generic assumptions employed. The limitations inherent in this approach are stressed in the report. In particular, the cost estimates presented are not meant to represent the precise costs that would be calculated by potential investors for any specific project. This is the main reason explaining the difference between the study's findings and the current global preference in reformed electricity markets for gas-fired technologies.

Within this framework and limitations, the study suggests that none of the traditional electricity generating technologies can be expected to be the cheapest in all situations. The preferred generating technology will depend on the specific circumstances of each project. The study indeed supports that on a global scale there is room and opportunity for all efficient generating technologies.