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Economics of nuclear and renewables ☆

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HIGHLIGHTS

- Renewables are increasing their energy share.
- Renewables system cost is higher than their production cost.
- Nuclear share is not increasing and their costs are not reduced.
- Discount rate and subsidies are important in economics of renewables and nuclear.

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ABSTRACT

This paper provides an assessment of the economic challenges faced by both nuclear power and "new" renewable electricity technologies. The assessment reflects the need to incorporate new renewables into power grids and issues faced in dispatching power and their effect on traditional electricity technologies as well as the need for transmission extension and/or grid reinforcement.

Wider introduction of smart grids and the likely demise of nuclear in some OECD countries are bound to enhance the future prospects for new renewables. However, their immediate future expansion will depend on continued subsidies, which are becoming difficult to sustain in present economic circumstances. Development of large energy storage facilities and carbon pricing could significantly enhance future renewable energy prospects. Correspondingly, expanding renewable energy, in spite of their popularity with some governments and sections of the public, is likely to face challenges which will slow their present rapid progress.

Nuclear is now shied away from in many industrialized countries and having mixed prospects in developing economies. In many instances, it suffers from high initial costs, long lead times and often excessive construction delays. Nuclear power also faces challenging risks – investment as well as regulatory. In contrast to renewables, its share of global energy consumption is declining.

1. Introduction

New renewables (NR: wind; solar; modern biomass and biofuels; tidal, wave and ocean energy) are widely claimed to be clean, indigenous and sustainable sources of energy. Therefore, they are favoured by many governments and the public as a whole. However, their present contribution to global energy consumption is still limited, about 3% in 2013 (IEA, 2015), since their economics are not yet favourable. In most instances, they need to be supported by state subsidies and regulations. They suffer from high investment costs and, as a result of the intermittent and diffused nature of wind, solar, and tidal, relatively low-utilisation factors. Incorporating new renewables into power grids poses challenges due to dispatching problems and potential needs for transmission extensions, grid reinforcements or investments in energy storage.

Wider introduction of smart grids and the likely demise of nuclear in some OECD countries (in the short and medium term, at least) will enhance the future prospects for new renewables. However, their immediate future expansion will depend on continued subsidies, which are becoming difficult to sustain in present economic circumstances. Development of large energy storage facilities and carbon pricing could significantly enhance future NRs prospects as indicated earlier. Correspondingly, NRs, in spite of

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their popularity with some governments and sections of the public, are likely to face challenges which will slow their present rapid progress.

Nuclear power plants face different challenges and prospects, being now shied away from in many industrialized countries and having mixed prospects in developing economies. In many instances, they suffer from high initial costs, long lead times and often excessive construction delays. Nuclear power also faces challenging risks, investment as well as regulatory. As will be discussed below, the investment risks in competitive power markets essentially rule out nuclear power unless there are government guarantees, or, in the future, the experience in building current generation light water reactors provides assurances that nuclear power plants can be built on schedule and under budget. Regardless of the technical progress in building current generation reactors, regulatory changes and legal challenges are likely to continue to make this an unlikely prospect except in countries where the state essentially controls its power industry.

In future years, the development and diffusion of small modular reactors (SMRs) could substantially change this picture. Under the SMR scenario, power investors would be able to purchase a turnkey nuclear plant that would essentially “plug in” to a power station campus. The SMR manufacturer would bear the technical risk and, if successful, be able to deliver a relatively small nuclear reactor (relative to typical light water designs) at a known cost with minimal lead time before the SMR would be generating power. As discussed in Budnitz (2015), there could well be non-proliferation and waste disposal features that would make SMRs attractive relative to current options.

The challenges are compounded by safety and proliferation considerations and a lack of technical skills in many countries as discussed in an earlier section. In contrast to renewables, their share of global energy consumption is declining, though nuclear electricity generation will continue to grow in absolute terms. Whereas NRs significantly increased their contribution to global electricity generation to over 6% by 2013, nuclear power's share of electricity generation has declined from as high as 18% in 1990 to only 12% in 2013, – a percentage that is not likely to improve significantly in the near future.

2. The economic and financial evaluation of renewables and nuclear

The levelised cost of electricity (LCOE) (DECC, 2013), is the traditional method for assessing and listing dispatchable generating facilities according to their annual production costs, and it applies to assessment of the cost of nuclear. However, it does not directly apply to non-dispatchable technologies, like renewable, due to their intermittency. Developing the necessary algorithms for such a purpose, particularly in the case of wind energy, is not easy because of the difficulty in forecasting wind's intensity and duration. For example, account needs to be taken of capacity factors achieved by wind energy developments. In the UK, it has been confidently claimed that onshore wind energy developments achieve a capacity (or load) factor between 20% and 50%, with an average attained of 30%.[1] The official statistics demonstrate that for onshore wind energy developments in England, the rolling average capacity factor achieved to early 2014 has been barely 24%, and in 2010, nearly 60% of these developments failed even to achieve 20%[2] – yet capital costs will be similar wherever wind energy developments occur onshore regardless of mean wind speeds impacting performance. Solar and tidal forms of energy suffer from the same problem to some extent.

3. Assessing the returns on investment in renewables

To assess the viability and economics of NRs (particularly solar and wind), it is necessary to compute the future stream of the electrical system cost with NRs and compare it with the system cost without the incorporation of NRs. This calculation yields the estimated system cost of NRs.

Of course, a higher system cost of NRs can be fully or partially offset by the value of reduced carbon emissions and other beneficial externalities. The increase in system cost over levelised cost is not only caused by the need for back-up generation facilities, but also by the need for additional transmission facilities and grid reinforcement, These can be substantial in the case of wind technologies that are often more remote than conventional generation sources. In most cases, the electric system cost per kW h delivered with the presence of NRs is going to be higher than in the absence of NRs. The extra cost requires subsidies, such as feed-in tariffs, or regulations that impose the additional cost on the ratepayer. Calculating the present worth of system costs without NRs is straightforward. With the incorporation of NRs, there is a need for a more elaborate approach. Below we develop a simple, but effective, means to compute the financial and economic effect of incorporating NRs. We have, however, to distinguish between solar energy, which is more predictable in timing, duration and extent, and wind, which is less predictable. In addition, we need to take account, in the case of solar, for the levels of direct and indirect solar variation which will vary between locations – generally higher in lower latitudes and lower in higher latitudes. Also, we need to differentiate if the investment is done by a regulated utility which can pass the extra cost of renewable electricity to consumers or it is executed by independent investors selling in the spot market.

The economic evaluation of power generating technologies, including NRs, should estimate their impact on market value: the additional net revenue they generate. The market value of NRs is lower than their LCOE due to integration costs and associated increase in system costs. ‘System LCOE’ is a methodology to fully account for the impact of generation technologies on market value. It is composed of generation cost plus integration costs. System LCOE is the standard LCOE plus the indirect costs that occur at system level (Hirth, 2013) and (MacGill and Vithayasrichareon, 2013). The integration cost of NRs is additional system costs that are not direct generation cost of NRs. Integration costs of NRs have three cost drivers: variability, uncertainty and location. While it is true that all generation technologies have integration costs, it is more specific and pronounced in NRs due to the variability and unpredictability in dispatching and the need to locate NRs further away from demand centres.

The three components of the integration cost (variability, uncertainty and location) mentioned above are shown in the Fig. 5.1 and are defined as follows:

a) Profile (variability) costs occur because wind and solar PV are variable. In particular, at higher shares this leads to increasingly inappropriate load-matching properties. Backup capacities are needed due to variability of NRs. The full-load hours of capital-intensive dispatchable power plants decrease while these plants need to ramp up and down more often.
b) Balancing (uncertainty) costs occur because renewable supply is uncertain.
   Day-ahead forecast errors of wind or solar PV generation cause

[1] file:///C:/Users/lijenni/Downloads/B25_PPS22_Planning_and_Renewable_Energy_Companion_Guide.pdf.

[2] http://theconversation.com/its-advantage-scotland-when-it-comes-to-wind-power-15900.

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