The effects of meshed offshore grids on offshore wind investment – a real options analysis

Schröder, Sascha Thorsten; Kitzing, Lena

Publication date:
2012

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Schröder, S. T., & Kitzing, L. (2012). The effects of meshed offshore grids on offshore wind investment – a real options analysis. Poster session presented at EWEC 2012 - European Wind Energy Conference & Exhibition, Copenhagen, Denmark.

PO. 43

The effects of meshed offshore grids on offshore wind investment – a real options analysis

Sascha T. Schröder, Lena Kitzing
DTU Management Engineering

Abstract

Offshore wind farms in future meshed offshore grids could be subject to different regulatory regimes[1,2]. Feed-in tariffs would absorb market risk from wind farm operators, whereas price premium mechanisms leave operators exposed to market price signals. In this case, it plays a decisive role which price applies to a node in an offshore grid.

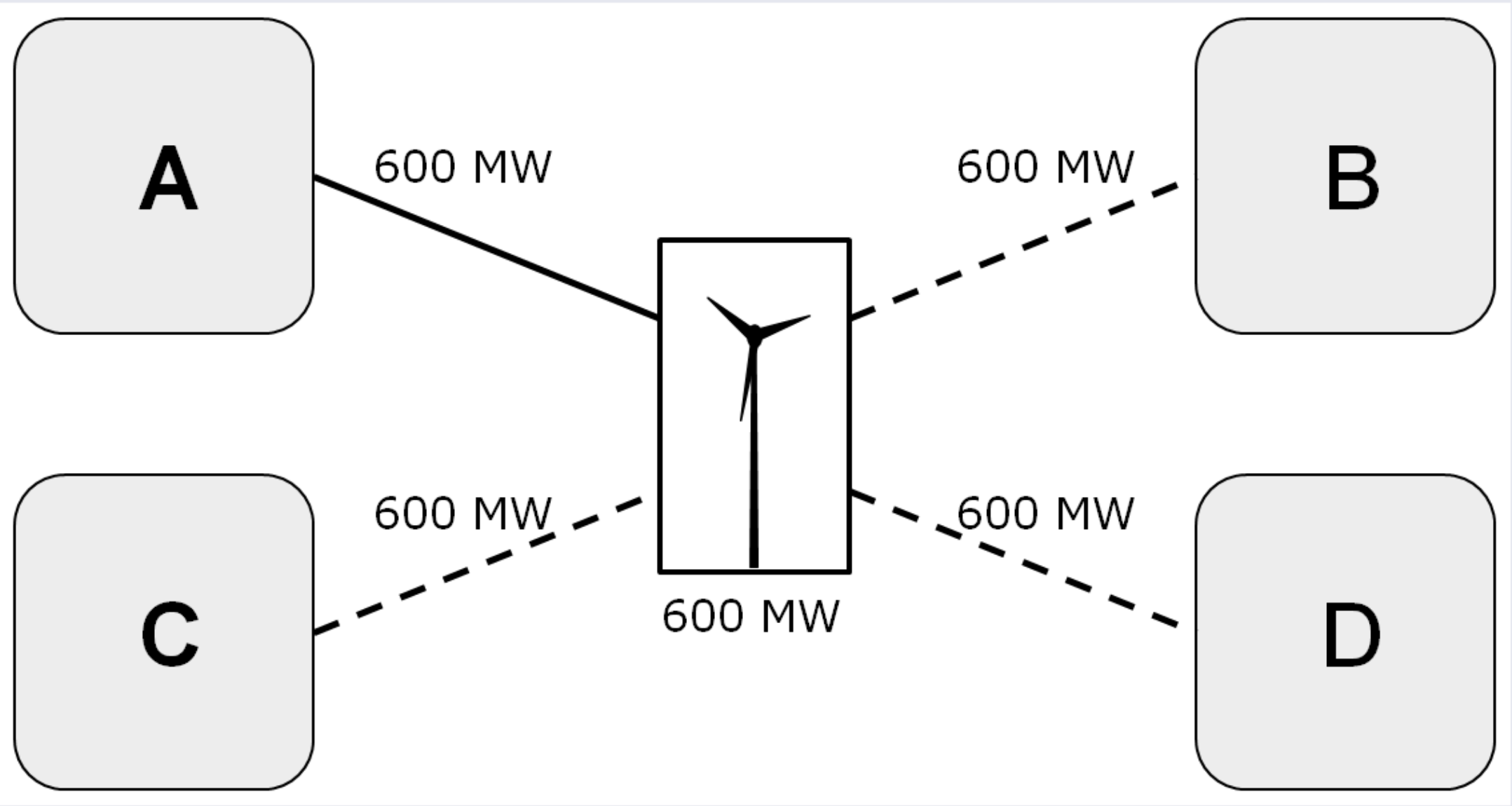
The offshore node will either be integrated into any of the neighbouring markets, with access to the respective maximum price, or be subject to separate nodal pricing[3]. We investigate the different regulatory regimes for connections to one to four countries based on a stochastic model capturing uncertainties in prices and line failures.

The stochastic analysis shows that there is a significant option value from the operational flexibility to accessing several markets: The wind farm's IRR increases by up to 40% in the analysed (fictive) cases when connected to four neighbouring countries. This is however only with access to the respective maximum price. For nodal pricing, the wind farm will have to cope with lower IRRs when connected to more than one country. This should be considered when designing the regulatory regime and level of support in the offshore grid.

Objectives

The core objectives are to assess the financial impacts of different regulatory regimes on an offshore wind farm in a meshed offshore grid. This covers both the expected Internal Rate of Return (IRR) and the risk exposure.

We conduct our analysis on a generic offshore node based on four archetypical markets with similar characteristics for an exemplary 600 MW offshore wind farm with connections of 600 MW capacity to a different number of countries:



Methods

The price processes are modelled as plain mean reverting Wiener processes.

$$dx = \kappa * (x^* - x)\, dt + \sigma\, dW_t$$

where:

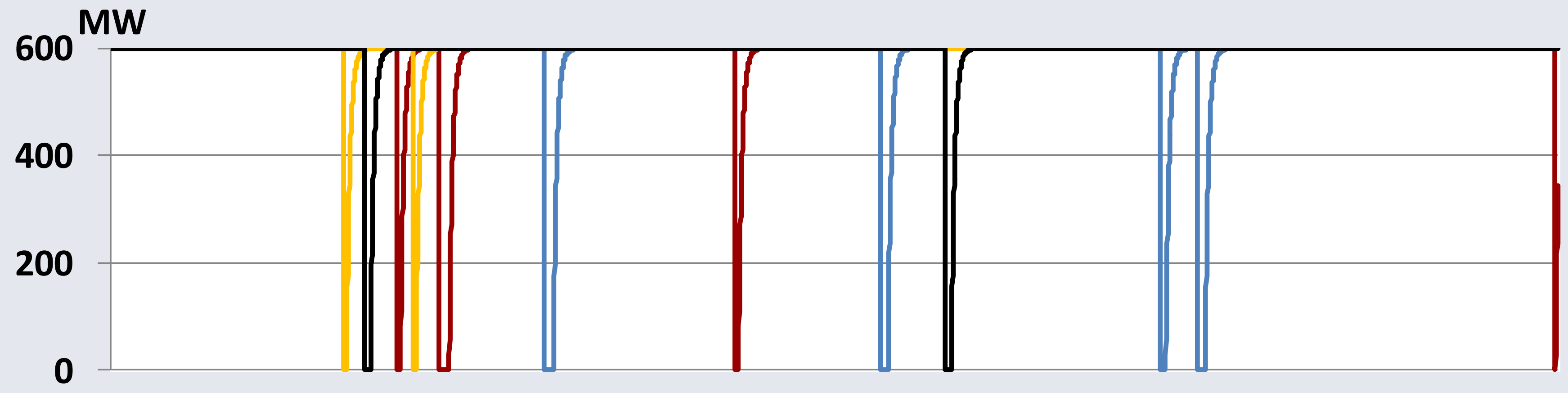
W_t	is a Wiener process with independent increments at $W_t - W_s \sim N(0;t-s)$, for $0 \leq s < t$
κ	is the mean reversion factor of the market (exogenously given)
σ	is the standard deviation of the market (exogenously given)
x*	is the 'normal' level of the price x_t, to which it tends to revert

The stochastic line failures are modelled with a Poisson-distributed occurrence and a normally distributed duration. After a failure, an exponential recovery process leads back to the nominal capacity illustrated in the 1-year figure below:

$$y_t = \hat{y} - \hat{y} * i_{(t,\varepsilon)} - \left(\hat{y} * j_{(t,\theta)} + (e^{-\kappa} - 1) * y_{t-1} + y_{t-1}\right)$$

where e.g.:

y_t	is the value of available interconnection capacity, being restricted to $0 \leq y_t \leq \hat{y}$
$\hat{y}$	is the nominal capacity
$i_{(t,\varepsilon)}$	is the binary variable that activates the line failure, with
ε_t	is a Poisson distributed random variable with mean of λ, $\varepsilon_t \sim Pois(\lambda)$
λ	reflects the expected number of line failures per year
$j_{(t,\theta)}$	is the variable that activates the recovery process after an outage

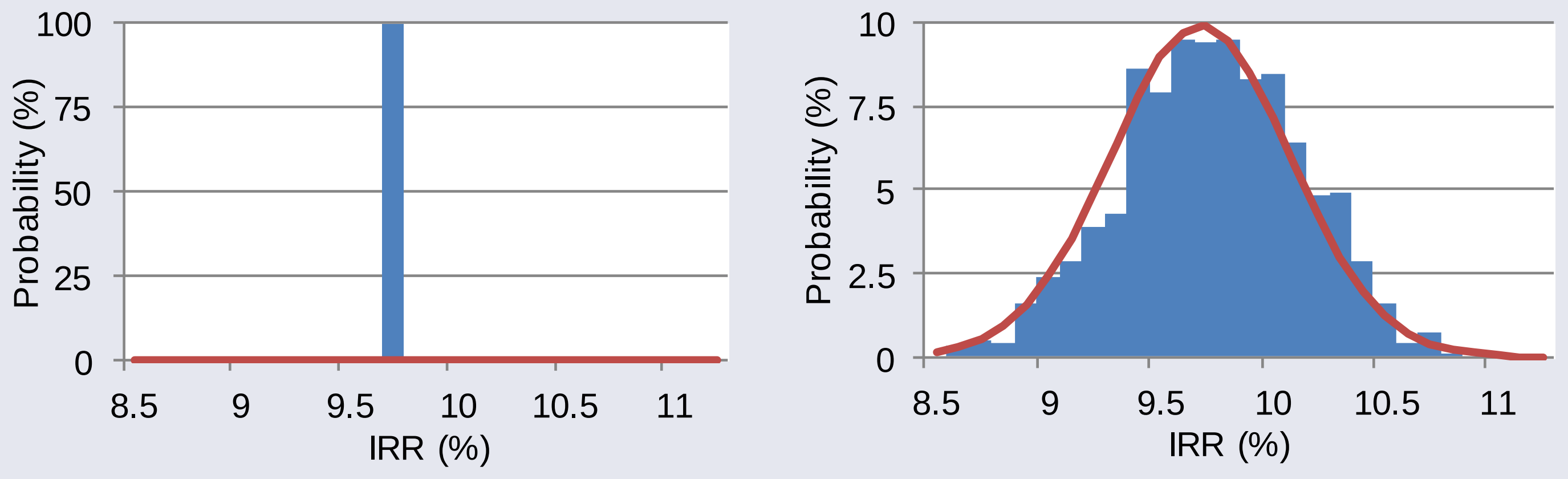


The wind farm specifics are based on wind generation from measured 2006 data from the FINO1 platform in the German North Sea and operational and cost data based on a Danish study[4].

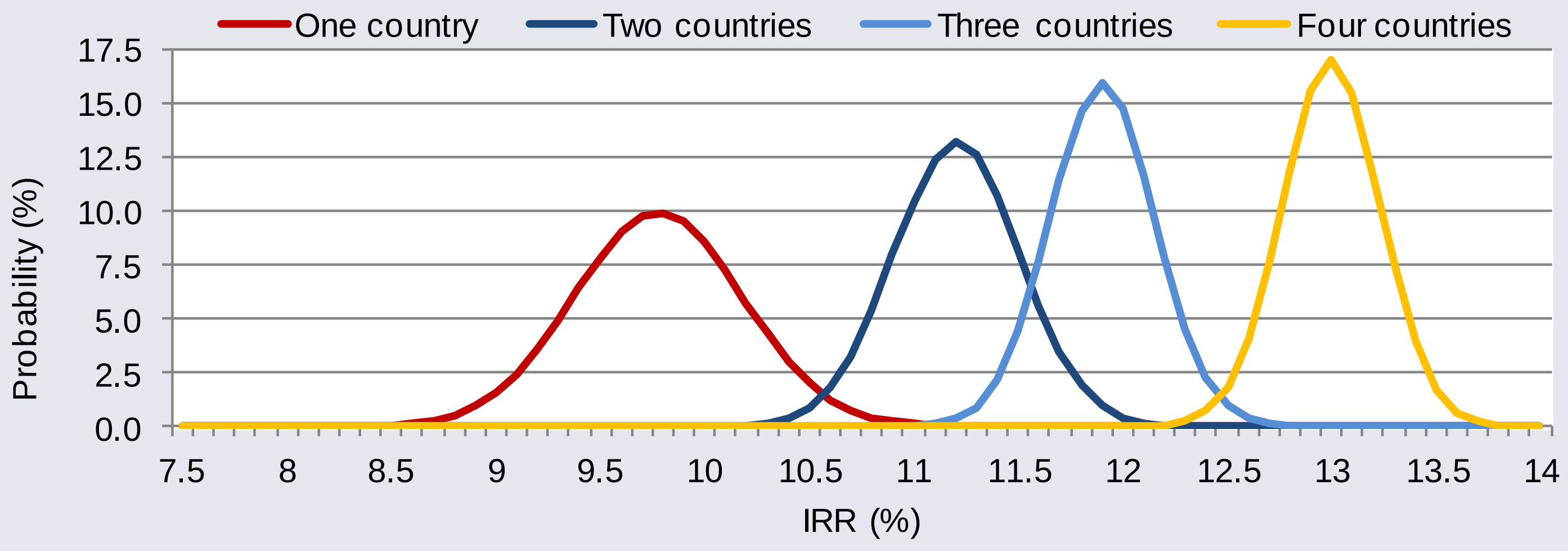
We subsequently attach a traditional Discounted Cash Flow calculation to the stochastic price process to determine the IRR and run a N=1000 Monte Carlo simulation for each regulatory regime and number of countries in the analysis.

Results

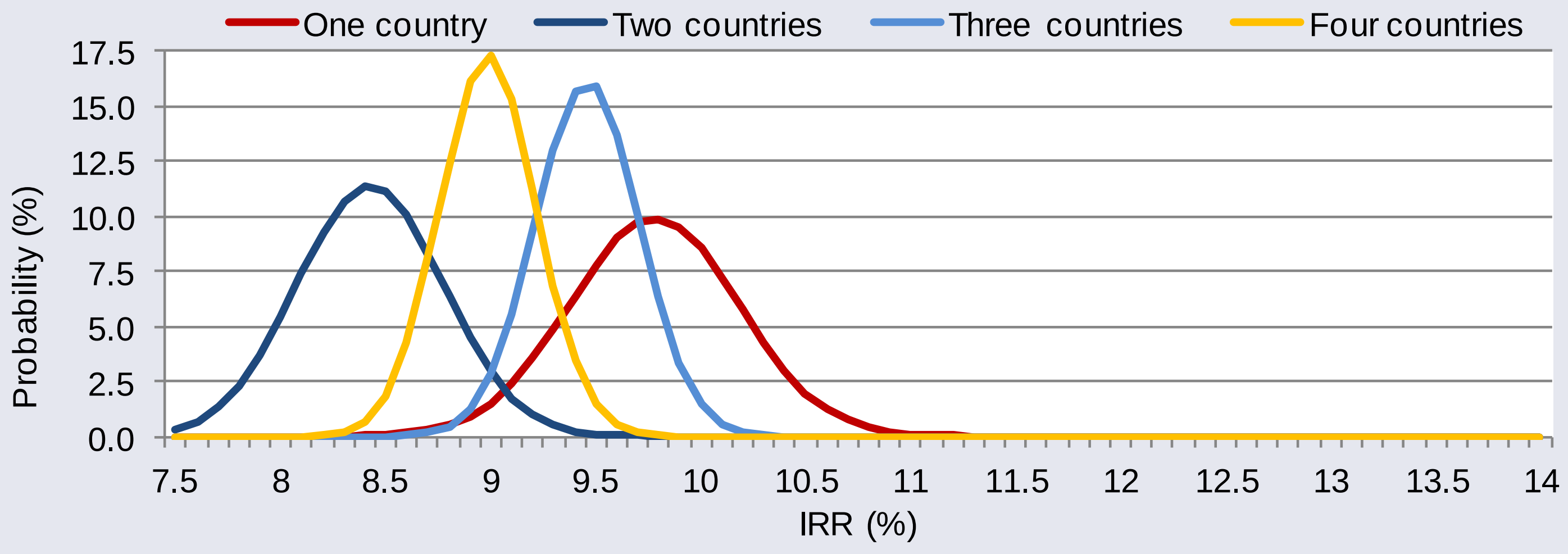
The one-country case serves as the benchmark case. In this case, the difference in risk exposure (here shown as standard deviation of IRR) of the feed-in tariff (left) and price premium schemes (right) becomes apparent:



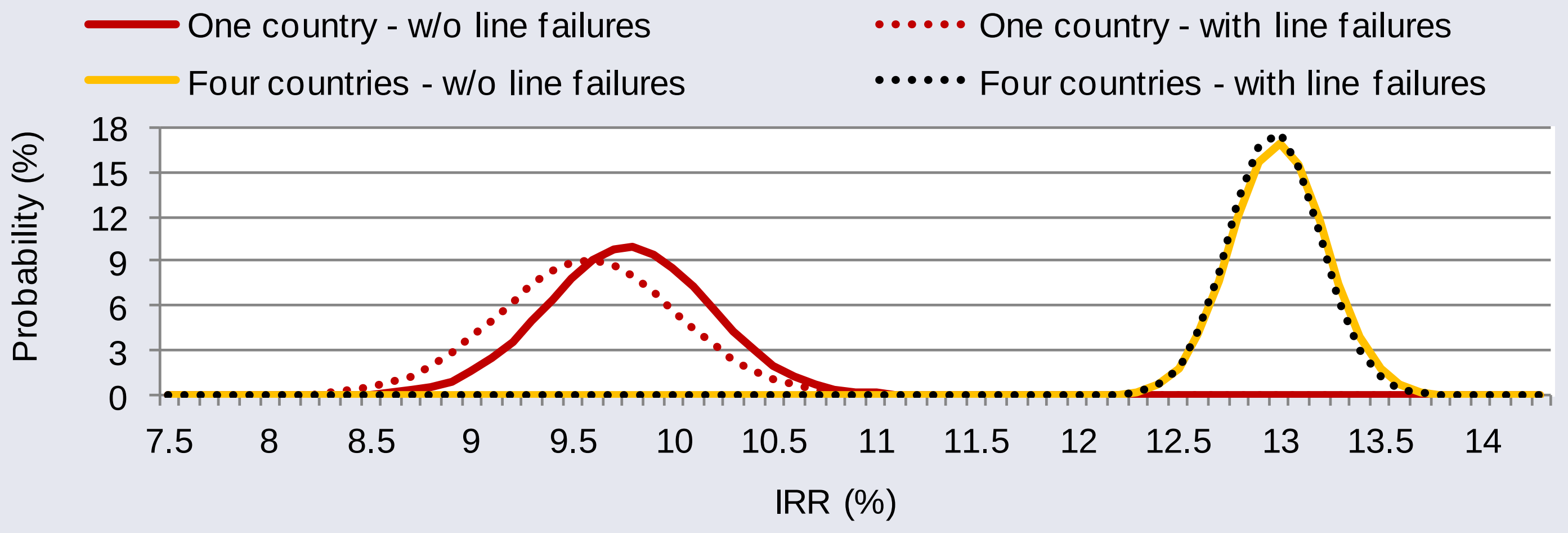
If the offshore wind farm is always remunerated at the maximum neighbouring price, the IRR increases with the number of countries while the spread decreases:



Under nodal pricing and identical interconnector capacities, additional cables can lead to a lower IRR due to congestion towards the high-price zones. However, the results cannot be generalised: an increase from two to three connections is beneficial for the offshore wind farm, but a further increase to four connections is not.



When considering stochastic line failures, the offshore wind farm faces a far higher risk if it has only one interconnector. The IRR results for the case with access to the highest-price market are as follows:



Conclusions

The regulatory framework in offshore grids has a decisive impact on the economics of an offshore wind farm. Policy makers and regulators should ensure to design the regulatory framework in a way that offshore wind farms are not facing the risk of a significantly lower IRR than in the benchmark case. Under price premiums, depending on the pricing scheme and the network topology, the support level may therefore have to be adjusted accordingly.

The option value of increased interconnection is up to 15% of the offshore wind farm's IRR per additional market under a price premium and maximum price access, whereas nodal pricing can decrease the IRR. From an integrated point of view, this implies that an offshore wind farm operator may have an interest to support or hamper the construction of new interconnectors, depending on the regulatory framework.

References

1. Roggenkamp MM, Hendriks RL, Ummels BC, Kling WL. Market and regulatory aspects of trans-national offshore electricity networks for wind power interconnection. *Wind Energy* 2010;13:483–491.
2. de Decker J, Kreutzkamp P (Eds.). Offshore Electricity Grid Infrastructure in Europe –a techno-economic assessment. 2011, OffshoreGrid final project report.
3. Schröder ST. Interconnector capacity allocation in offshore grids with variable wind generation. *Wind Energy* (forthcoming). doi: 10.1002/we.537.
4. Deloitte. Competition support analysis for large-scale offshore wind farms in Denmark. Study for the Danish Ministry of Climate and Energy, 2011 (in Danish).

EWEA 2012, Copenhagen, Denmark: Europe's Premier Wind Energy Event