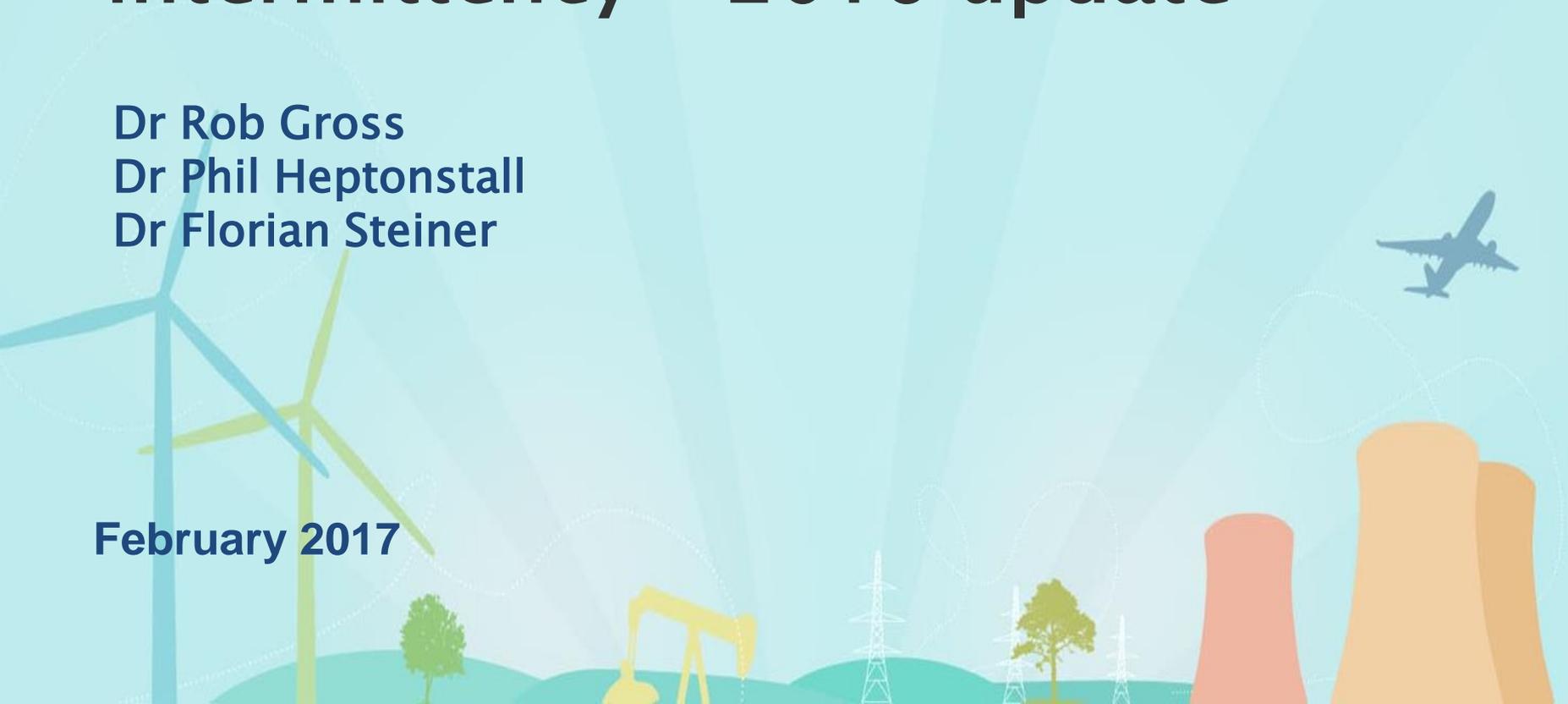


The costs and impacts of intermittency – 2016 update

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Presentation overview

- Project background and research approach
- The research questions
- Reminder of findings from the 2006 report
- 2016 findings, by categories of impact
- Conclusions
- Q & A

Background and approach

- Project updates UKERC 2006 report through a systematic review of the post-2005 evidence
- Many countries have much more ambitious renewables targets than a decade ago
- Evidence drawn from academic journal papers, reports by government research labs, publicly available industry analyses
- Input from an Expert Group representing industry, academia, policymakers
- Extensive review and commentary, and peer review by international experts

Research questions

What new evidence has come to light since UKERC reviewed the costs and impacts of intermittency in 2006 and what does the available evidence now suggest about the costs and impacts of intermittent generation (including relatively high penetrations of 20% and above)?

- What are the full range of impacts and associated costs of intermittency that are identified in the literature, and how do these impacts and costs compare to the evidence that was available in 2006?
- Has the reported range of impacts expanded, and if so, why?
- Which categories of impact are the focus of interest?
- To what extent is there a consensus within the current body of evidence on the size and range of the cost and impacts of intermittency?

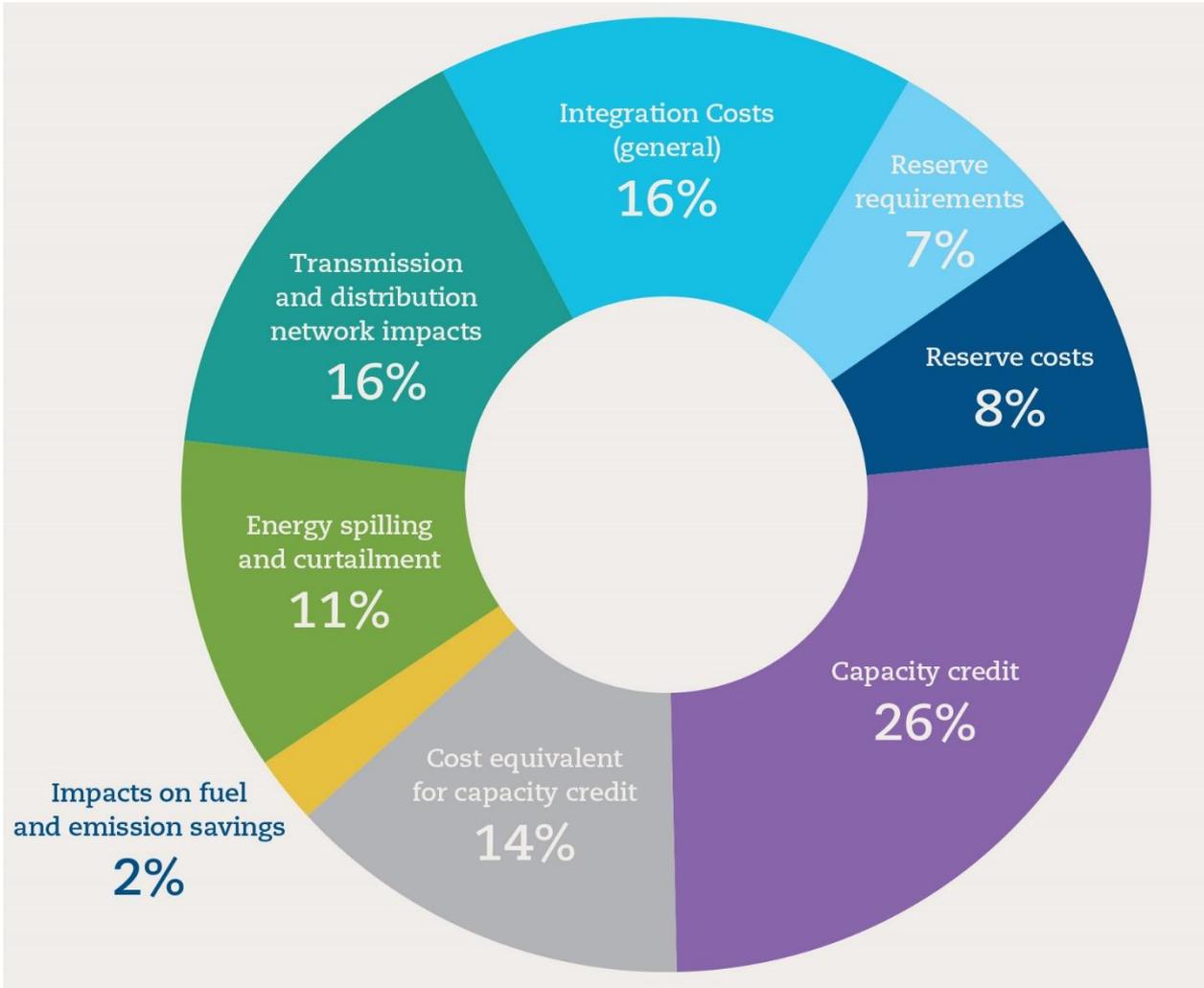
Reminder of the 2006 report's key findings

- First full meta-analysis of topic, high impact and widely cited
- Two major categories of impact:
 - System balancing – costs £2–£3/MWh*
 - Maintaining reliability – costs £3–£5/MWh*
- Most of the evidence did not look beyond 20% contribution from variable renewables
- Renewable resource and system characteristics key determinants of costs
- Other impacts very small (and much less data available)
- Terminology not always consistently used



* In 2015 values, equivalent to approximately £2.4-£3.6/MWh and £3.6-£6/MWh respectively

Overview of 2006–2015 data



A lot more data than for the 2006 project

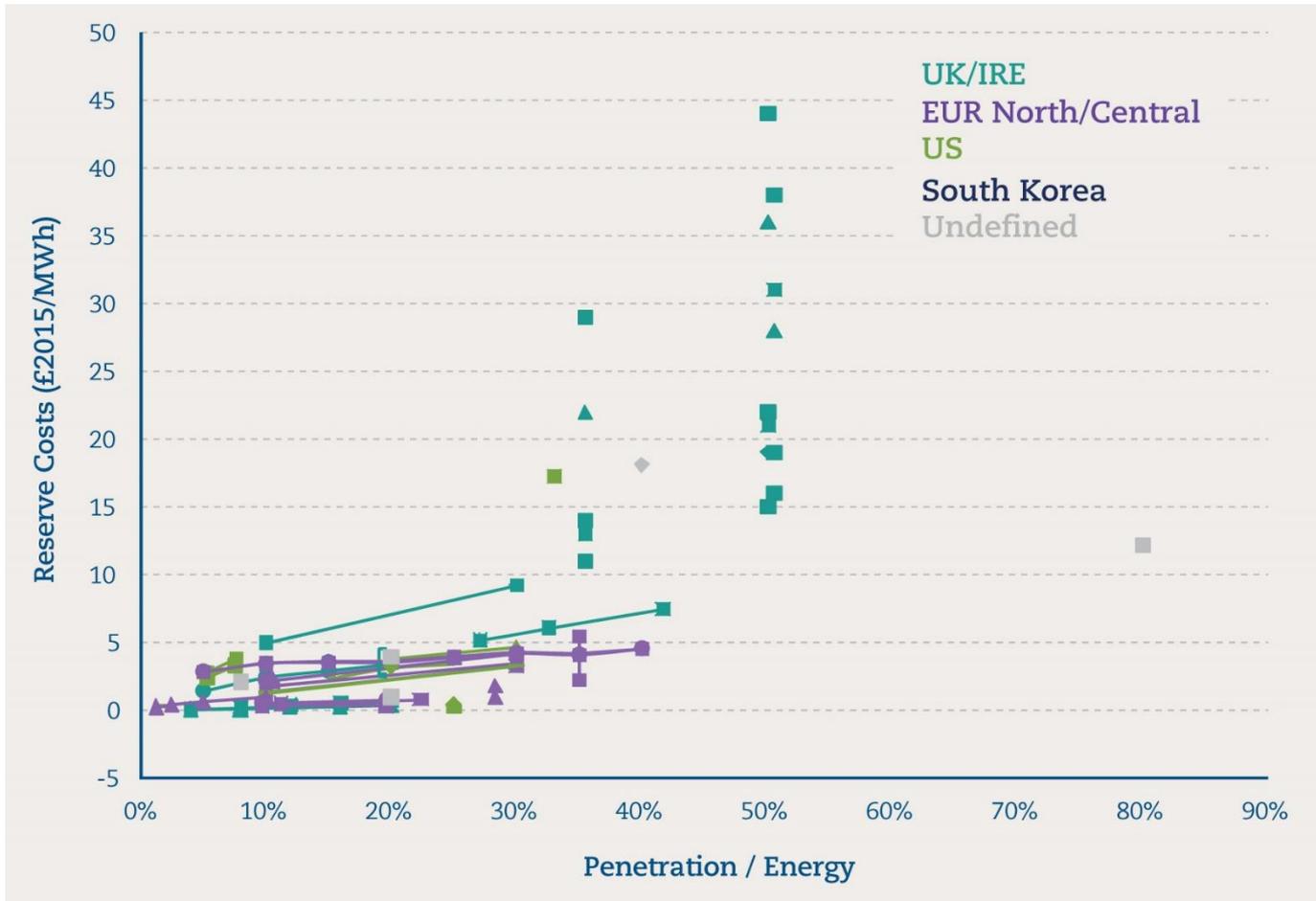
approx. 200 paper/reports

2000+ data points across eight categories of impact

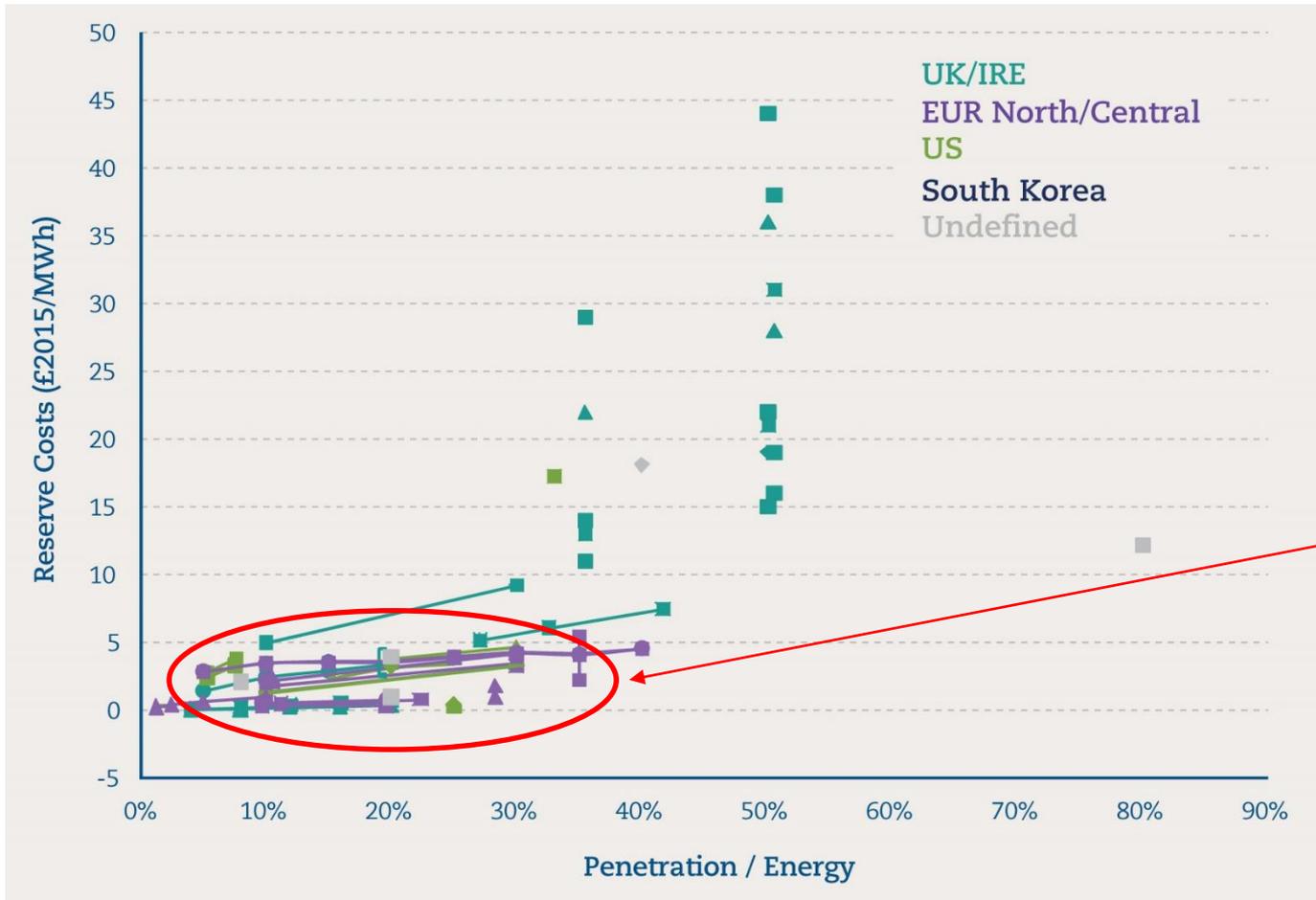
Evolving methodologies

- As penetration levels rise, assessing system impacts becomes more complex
- A ‘whole system’ simulation approach is required at higher penetration levels
 - More accurate assessment of costs but less straightforward interpretation and presentation
- Separate categories of costs are not directly additive
 - Interaction and overlap between impacts
 - Risk of double-counting costs
- But individual cost & impact assessments still widely used...

Short term system balancing – reserve costs

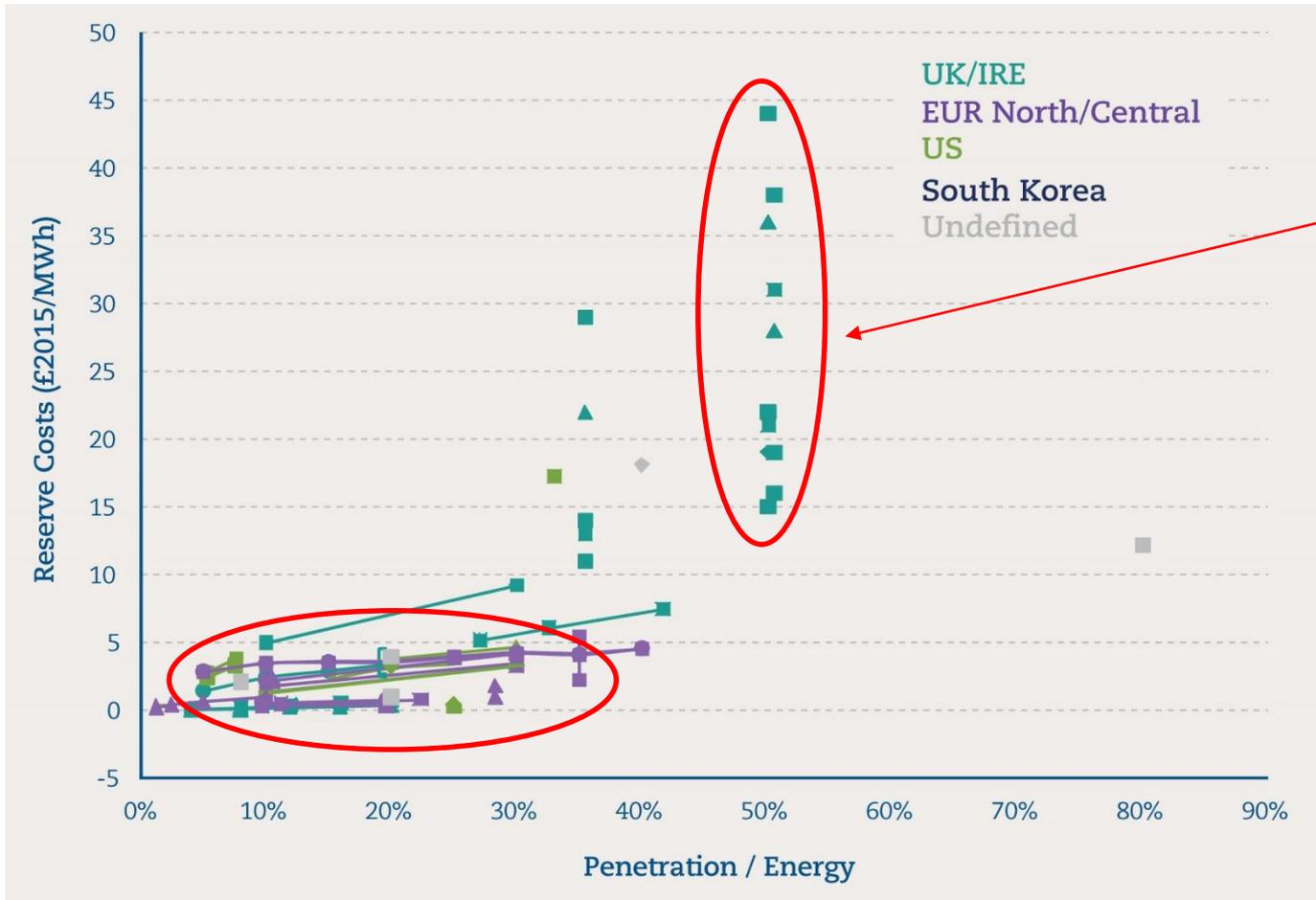


Short term system balancing – reserve costs



Up to a 30% penetration level, majority of results are £5/MWh or less

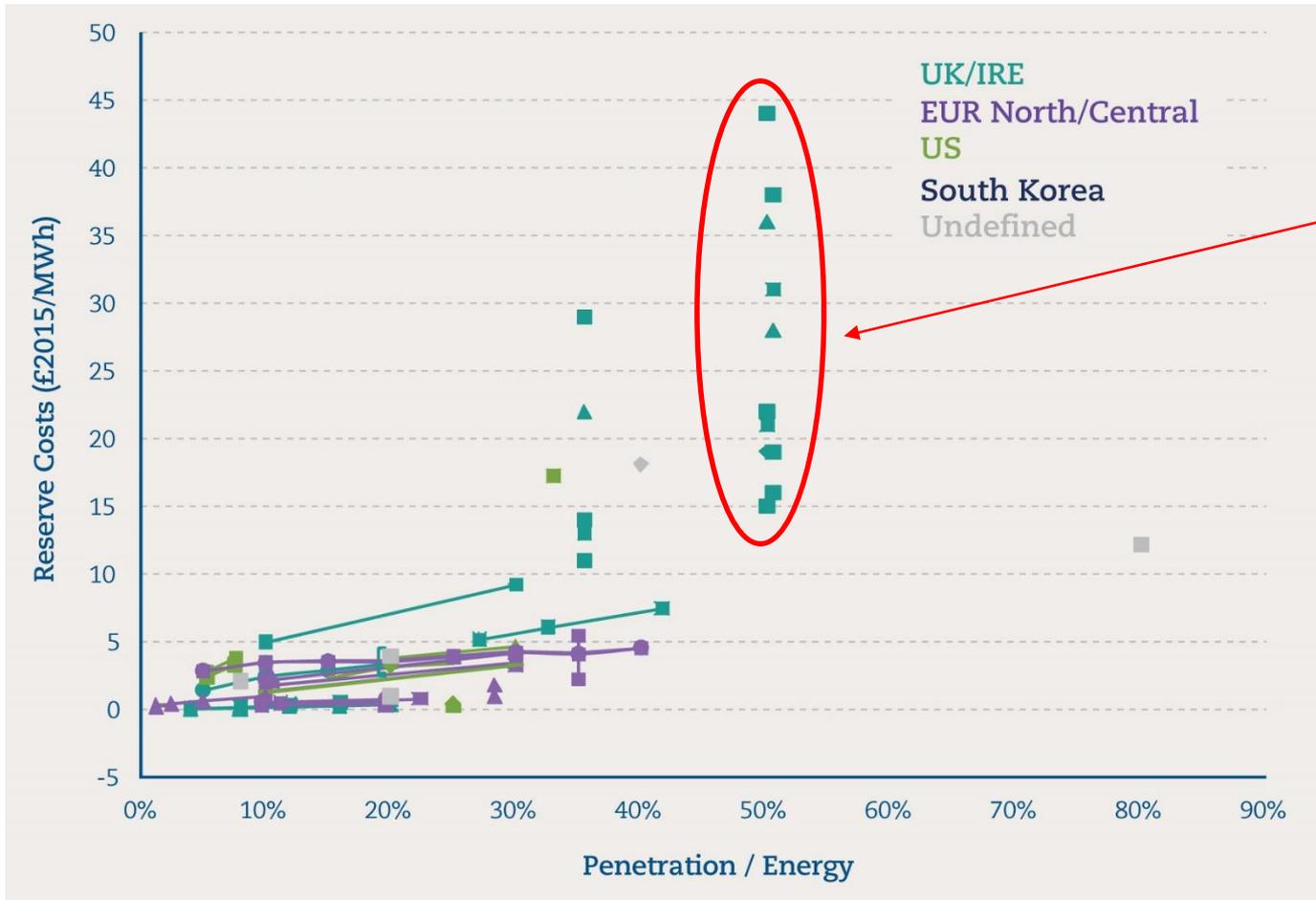
Short term system balancing – reserve costs



At 50% penetration level, costs range between £15 and £45/MWh

Up to a 30% penetration level, majority of results are £5/MWh or less

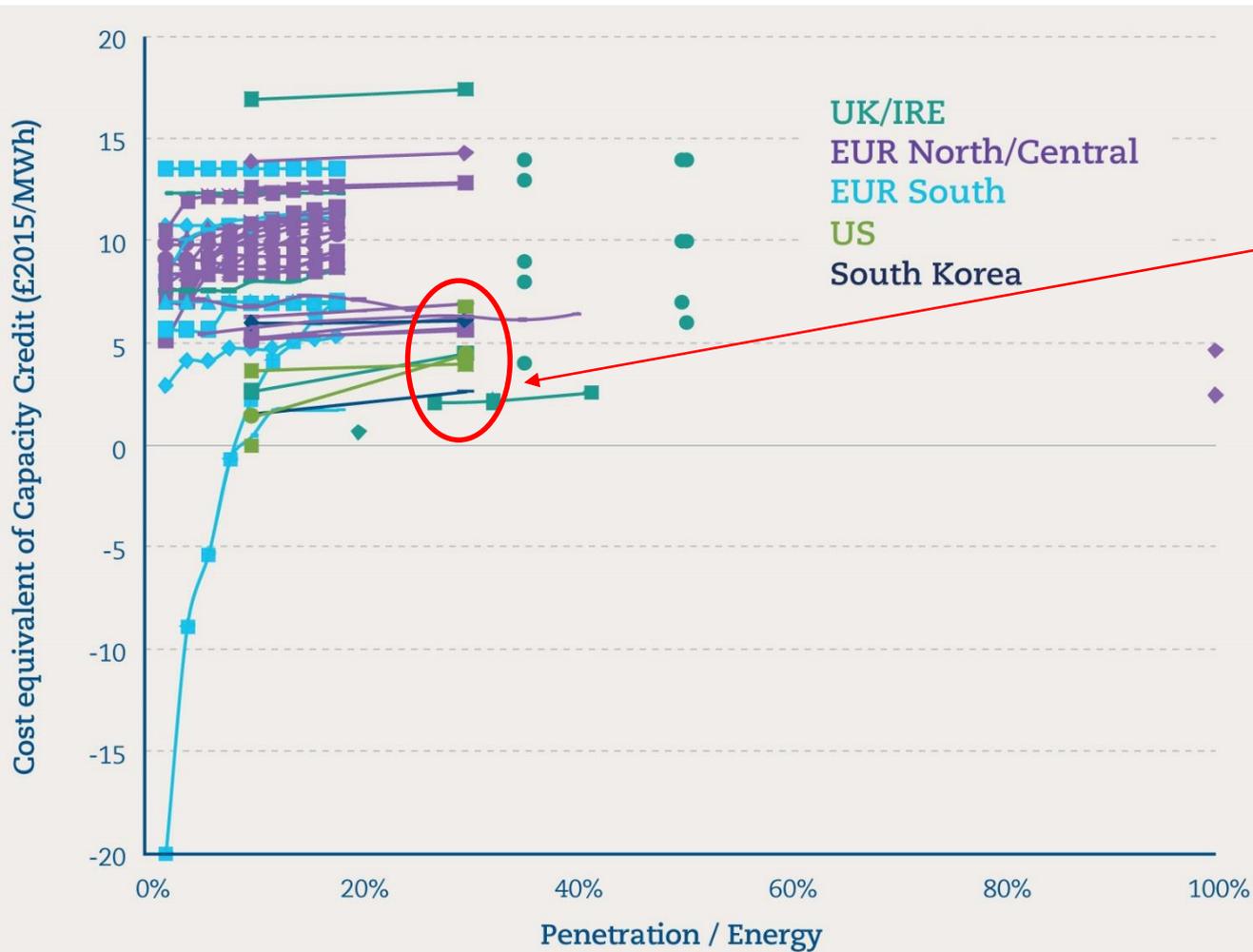
Short term system balancing – reserve costs



What's going on here?

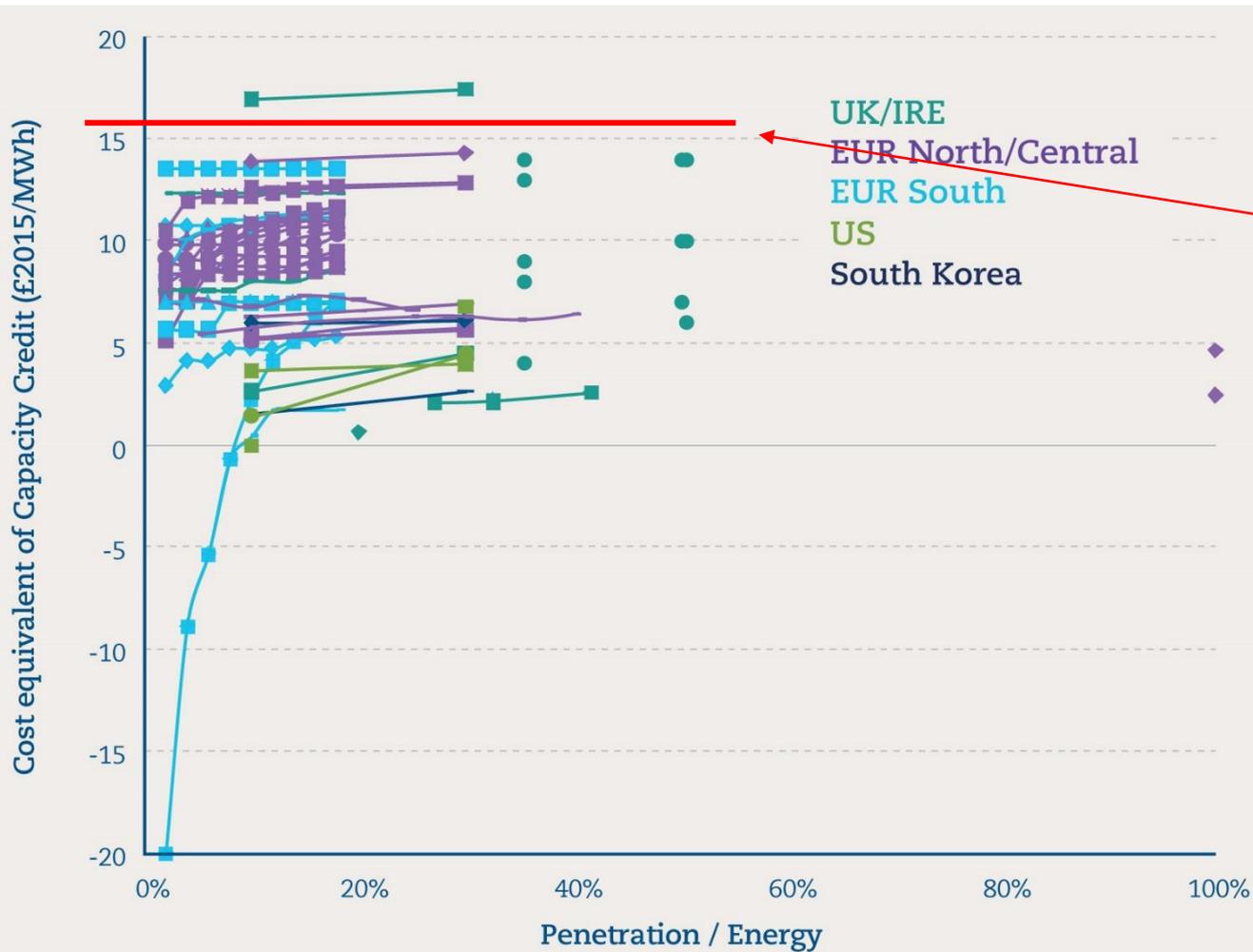
These results explore the range of flexibility and different mixes of wind and solar

Reliably meeting peak demand – capacity costs



At a 30% penetration level (where wind analyses dominate) most results are £4-7/MWh

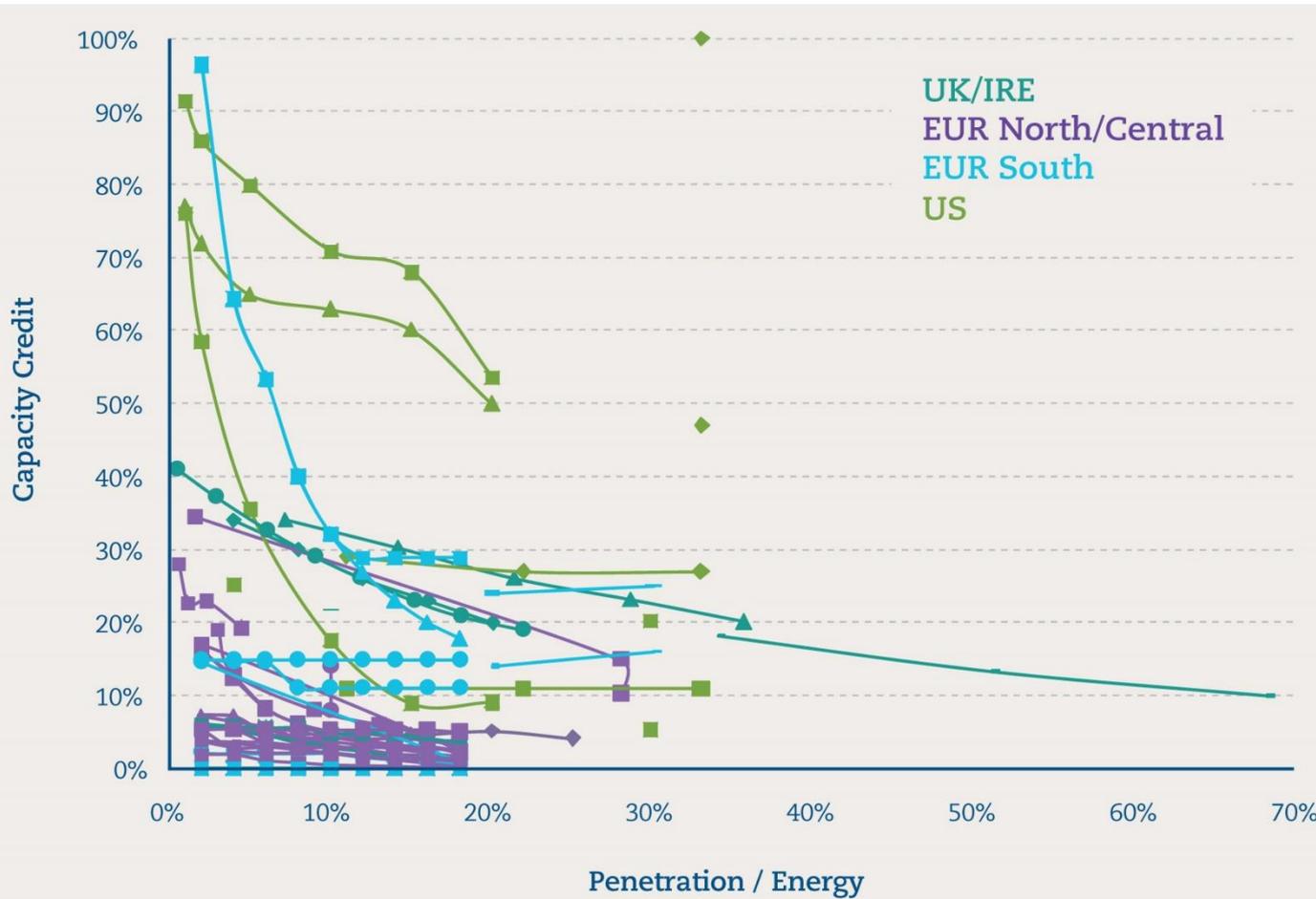
Reliably meeting peak demand – capacity costs



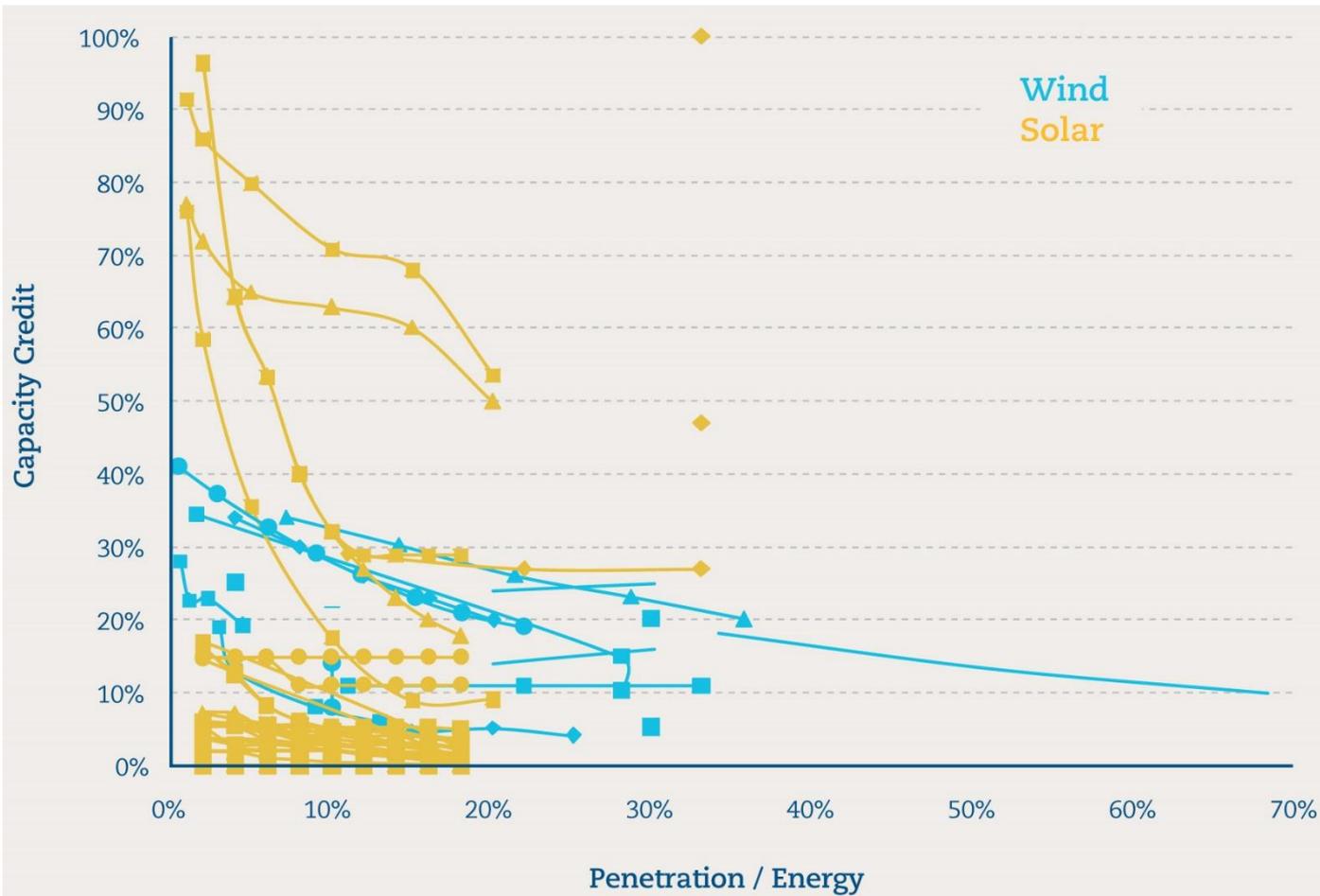
Almost all results are less than £15/MWh, even at 50% penetration level

UKERC analysis suggests that UK-relevant costs would not exceed around £14/MWh, regardless of penetration level

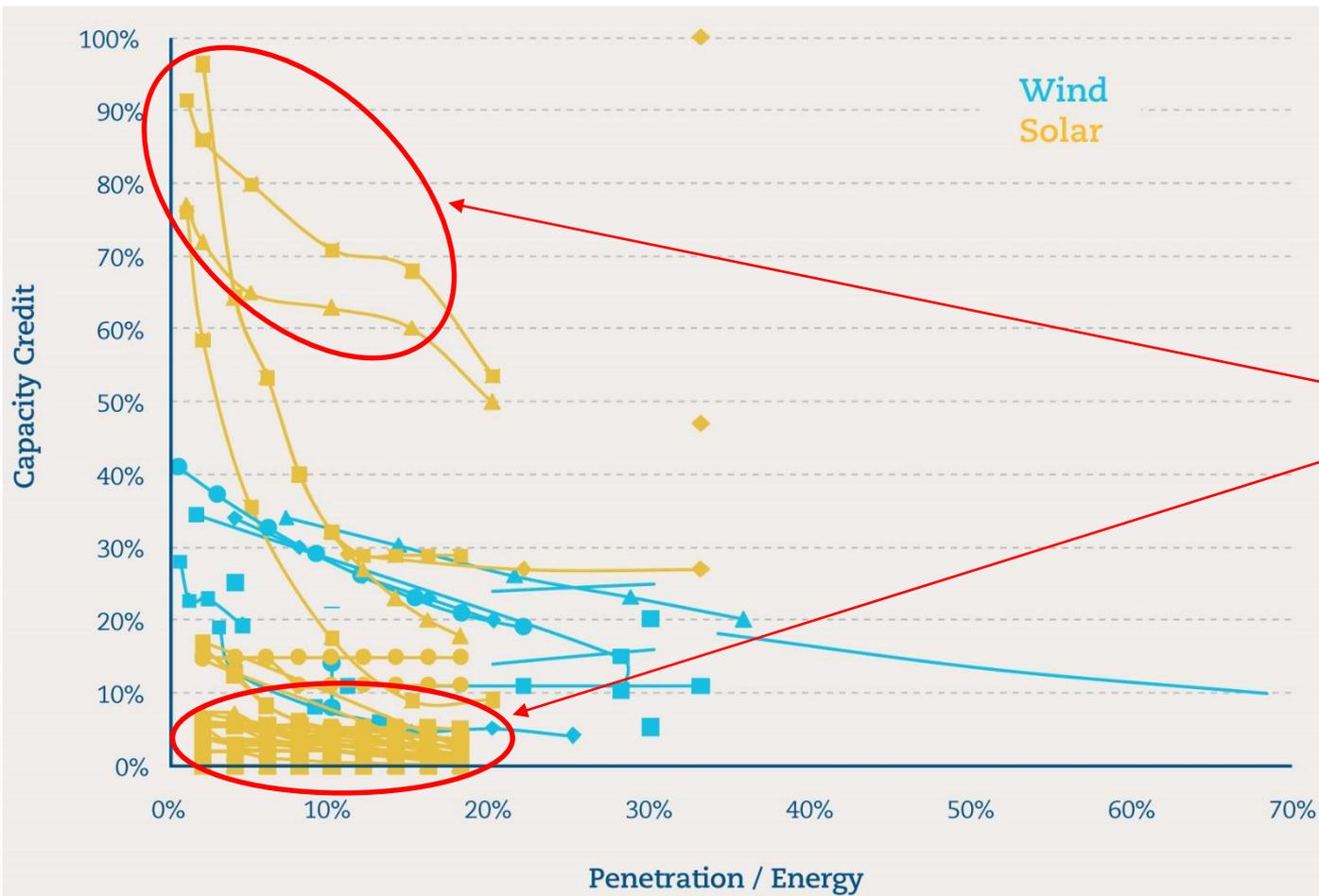
Understanding capacity costs – by region



Understanding capacity costs – by generation type

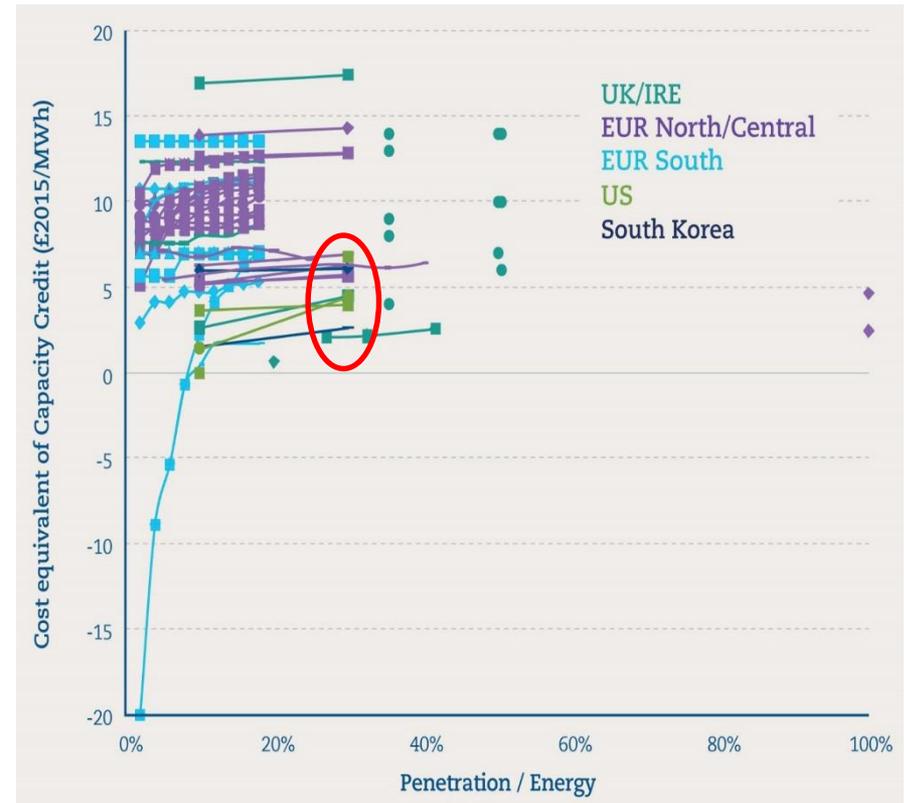
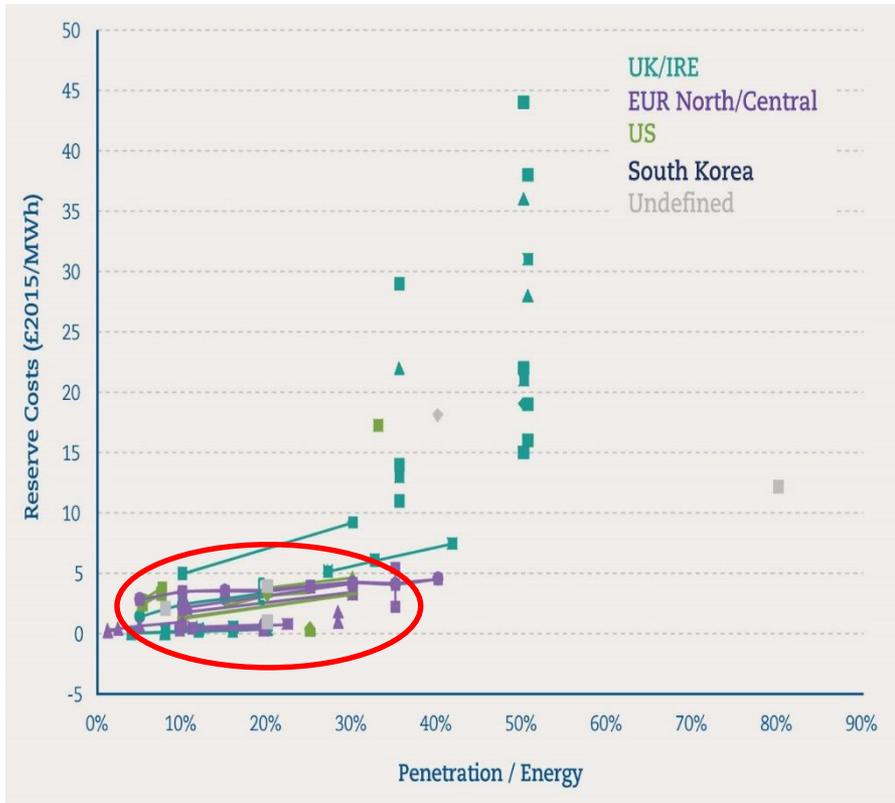


Understanding capacity costs – by generation type



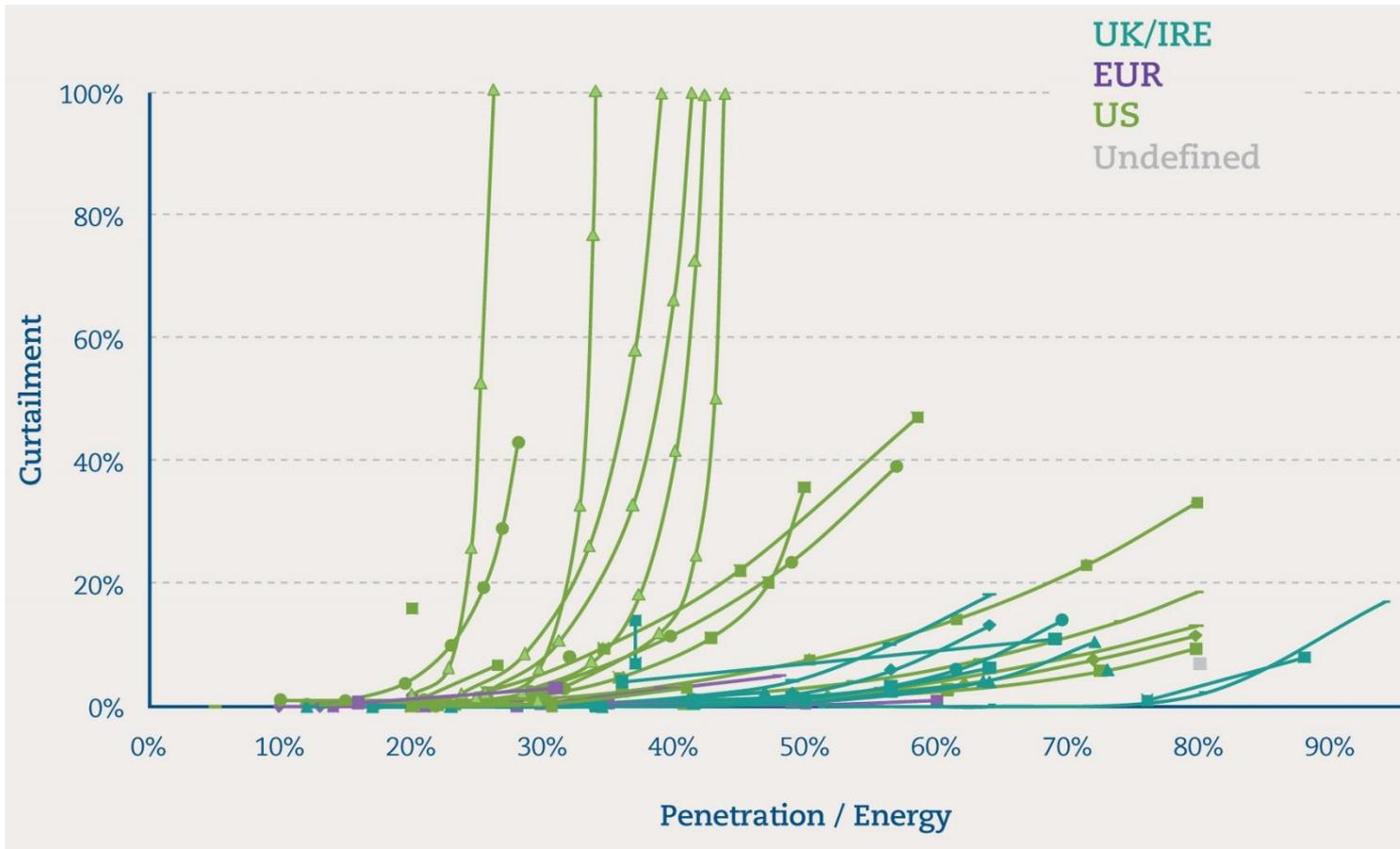
Results for PV dominate the upper and lower ends of the range, results for wind more closely grouped

Reserve and capacity costs

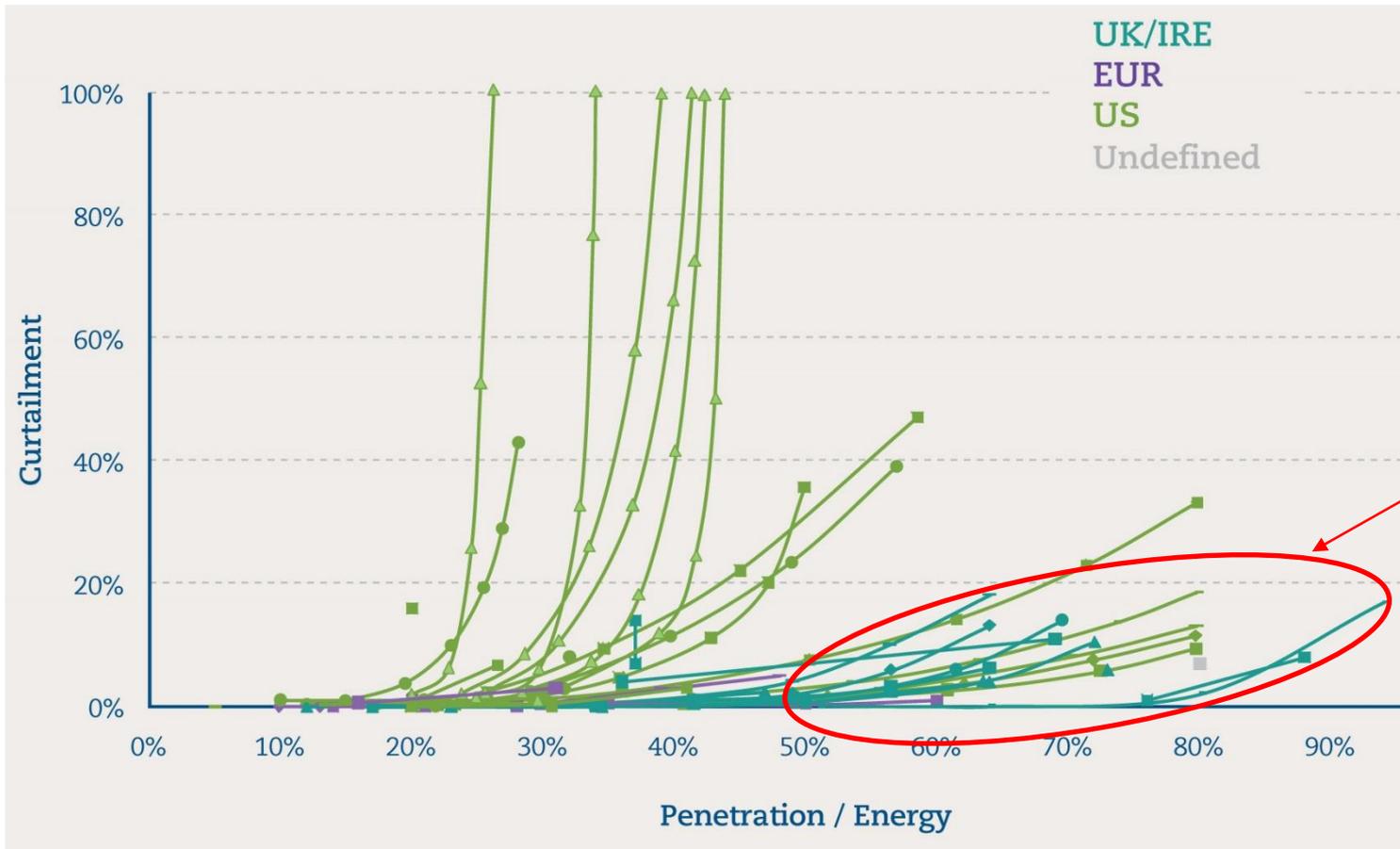


At 30% penetration level, combined balancing and reserve costs for UK-like, wind-dominated systems look to be of the order of approx. £10/MWh - but beware of this simplification!

Curtailment

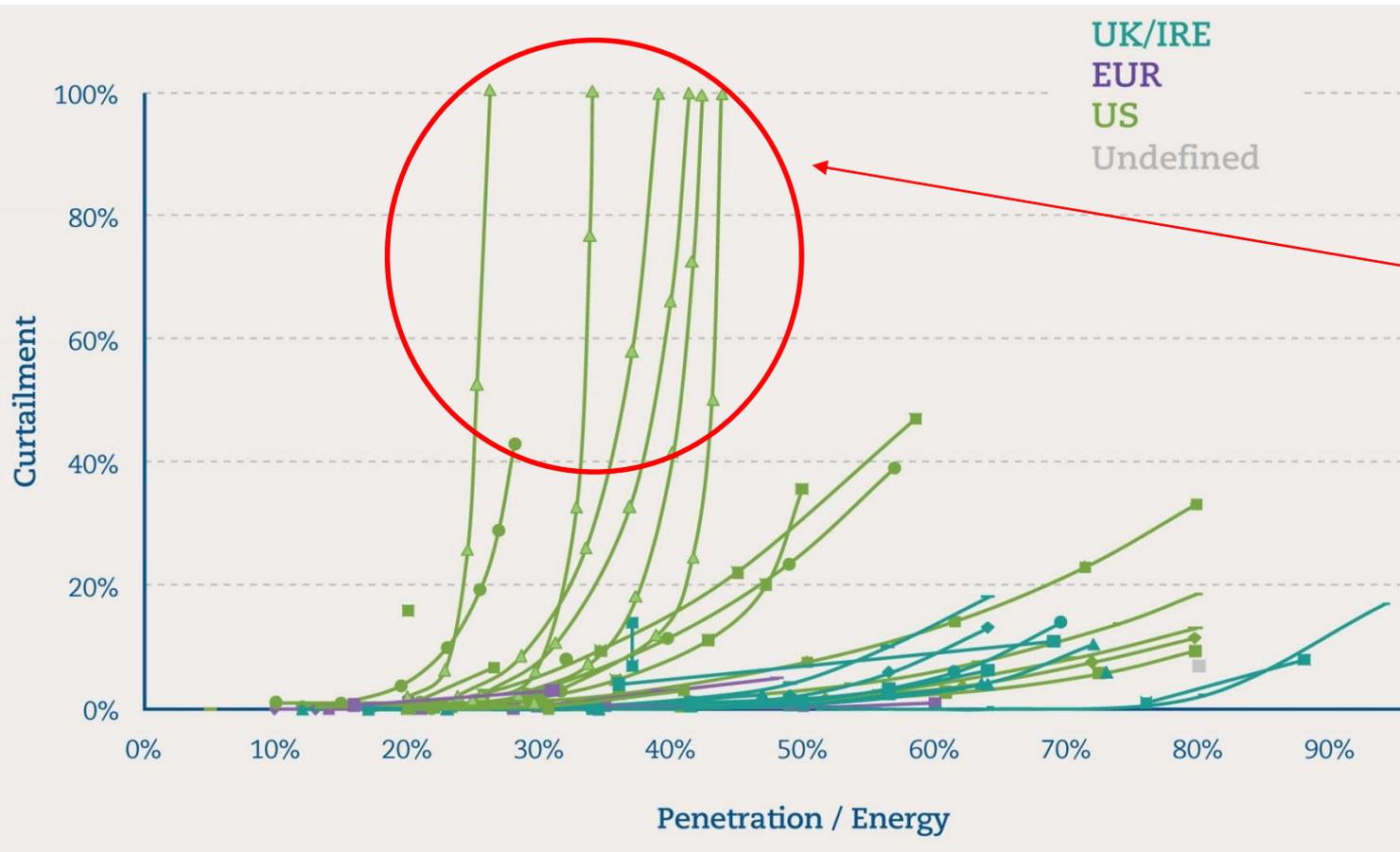


Curtailment



UK and European analyses suggest that levels are very low until over 50% penetration

Curtailment



What not to do
- extreme outliers can result from boundary-testing model runs

Other impacts / issues

- **Transmission and network costs:** up to 30% penetration level, evidence suggests that costs are in the range of £5–£20/MWh
 - But transmission reinforcement benefits the whole system, not just renewables
- **Thermal plant efficiency reduction:** very small at low penetration levels, but can increase as penetration levels rise
 - Imposes costs on remaining conventional generators
- **System inertia:** focus is on the technical challenges rather than costs, likely to only become significant at very high instantaneous penetrations
 - Particular issue for island systems with no/poor interconnection
- **Electricity markets:** significant reduction of the load factors of the remaining thermal plant on the system, and the economic value of output from intermittent generators declines as penetration levels rise

Conclusions

- At 30% penetration, UK-relevant balancing and reliability costs less than £10/MWh
- As the costs of renewables fall, system costs will become increasingly important
 - 10 years ago, renewable costs were relatively high, system costs were small
 - Now, renewable costs are lower, system costs likely to be higher
- Range of forecast integration costs is very wide but it is clear that flexibility is a key determinant of cost
 - Costs for flexible systems likely to be relatively modest, costs for non-flexible systems likely to be much higher
- Policy, regulation and markets must incentivise and reward flexibility
 - If they don't, costs may be much higher than they need to be
- 'Whole system' analytical approach will be essential

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