

Lloyd's Register Technology Radar – Low Carbon



Moving towards a low carbon future

With a global agreement in place on the reduction of climate change, the conditions have never been better for low carbon power. Sure enough, despite the low oil price, clean energy attracted \$325 billion in investment in 2015 – a record year.

Technological developments, meanwhile, are making a low carbon future increasingly viable. The Lloyd's Register Technology Radar – Low Carbon examines the outlook for low carbon power generation – and the technologies that are likely to have the most impact.

Deployment continues to be a major barrier for innovation – more standardisation is needed (particularly in the Nuclear sector)

Energy storage

- Electrical technologies will transform storage – eg, supercapacitors, which will rapidly speed up charging times for large batteries

Grid / infrastructure

- Software advances will be most significant in short term
- Blockchain could change the way we think about transmission and distribution

Renewables

- Most believe there is now grid parity with fossil fuels
- Solar cell advances are likely to be the most disruptive in the short / medium term

Nuclear

- One of the most economical generation sources (taking into account lifecycle)
- SMRs unlikely to be disruptive, but modularisation technologies will have a major impact



By supporting a new generation of low carbon energy, LR is actively working towards global carbon reduction targets

We do this though:

- Supporting the production of energy with zero or low carbon emissions (wind, wave, tidal, nuclear, solar, energy storage, grid)
- Reducing the carbon emissions from existing sources
- Driving the development and adoption of Carbon Capture and Storage technologies
- Knowledge sharing, research and qualification of innovative technology
- Supporting clients at every stage of the asset / project lifecycle



About the research

The research is published in the form of two companion reports: one, *Lloyd's Register Technology Radar – Low Carbon*, provides an overview report, covering renewables, energy storage, grid/infrastructure and nuclear. The sister report, *Lloyd's Register Technology Radar – The Nuclear Perspective*, offers a detailed look at the nuclear power sector.

- The research is based on the opinions of 583 total respondents from across the low carbon sector. Of these, 154 identified themselves as operating in nuclear, and 323 as operating in renewables.
- The makeup of our 583 respondents is as follows: 44% are energy utilities; 24% are supply-chain manufacturers; 14% are distribution system operators; 9% are other companies in the supply chain, such as engineering or service providers; and 9% are operators. Meanwhile, 22% of respondents come from the Middle East; 23% from North America; 22% from Asia Pacific; and 32% from Europe. And 40% are C-level, with the remainder occupying other senior positions.
- Respondents were asked to rate a number of technologies in terms of their potential impact, the amount of time it would take for these technologies to hit the market, and how likely they are to be adopted once they do.
- They were also asked to reflect on the pace and success of innovation in their sector - and what they see as the major drivers and blockers.

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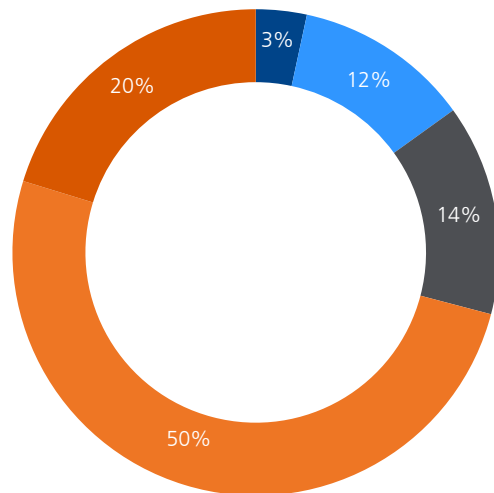
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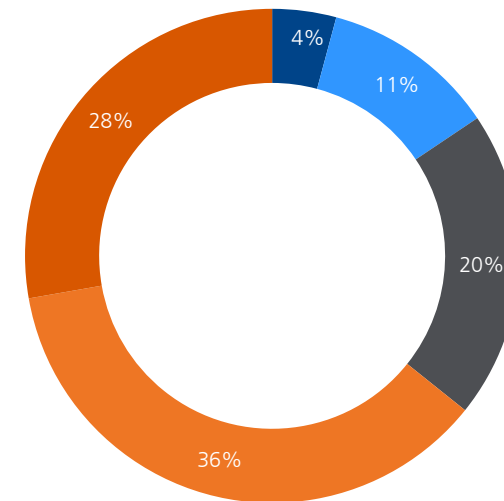
1. Low carbon generation technologies are cost competitive

To what extent do you agree or disagree that renewable energy sources are reaching cost parity with fossil fuels across the industry?



■ Strongly Disagree
■ Disagree
■ Neither agree nor disagree
■ Agree
■ Strongly Agree

To what extent do you agree or disagree that nuclear energy sources will continue to be a necessary source of energy supply?

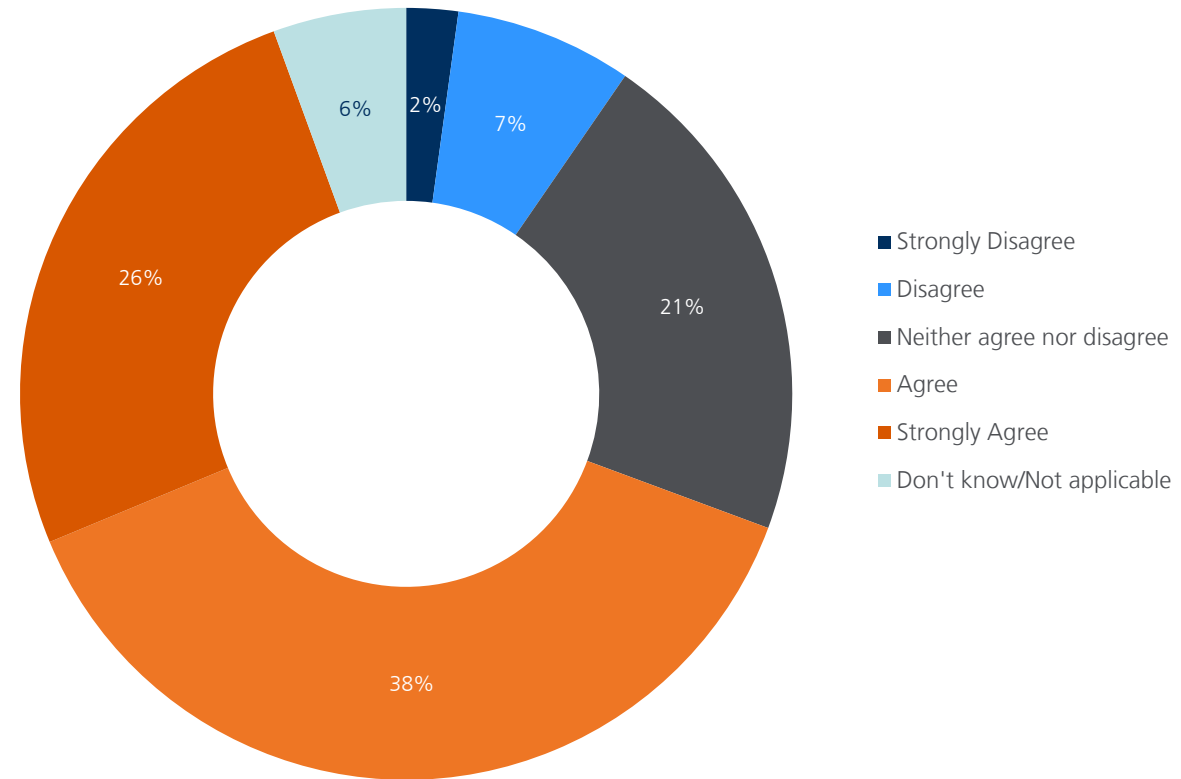


- The World Economic Forum estimates that in more than 30 countries renewables have already reached cost parity without subsidies, and that two-thirds of the world should get there in the next few years.
- When costs are levelised across the lifecycle, nuclear is one of the most cost-effective methods for power generation. Indeed, OECD research shows that nuclear is the lowest levelised cost option for power generation for all OECD countries under certain capital cost projections.

2. COP21 has had a serious impact on the adoption of renewables

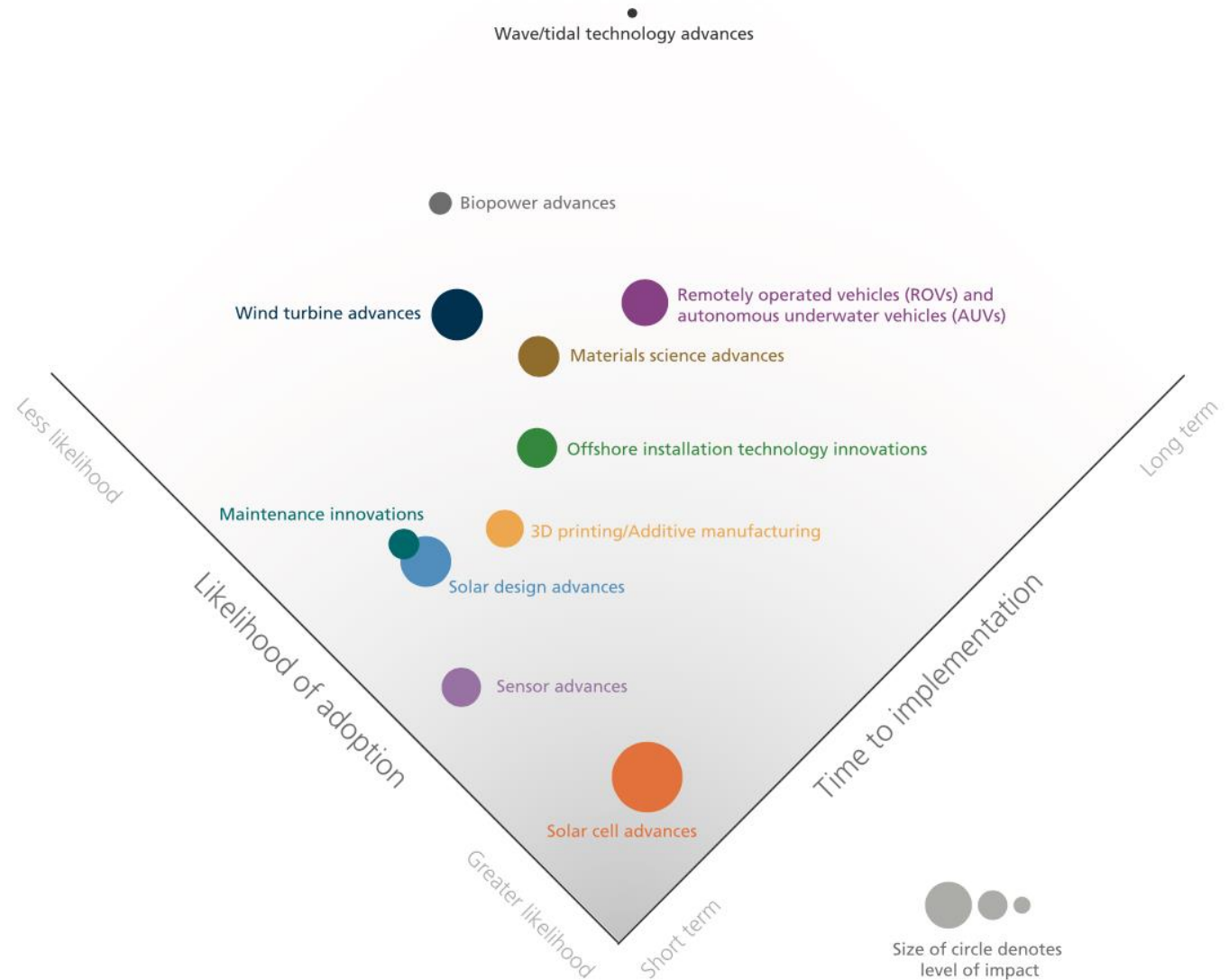
The outcome of the COP21 meeting has had a serious impact on my country's attitude towards the adoption of renewable technologies

- Regionally, the Middle East is the least likely to share the COP21 sentiment: only 49% of respondents agree or strongly agree that it played a major role.
- Compare this with respondents in Asia Pacific (72%), Europe (71%), and North America (68%).
- Our survey was in-field during COP22 and the US presidential election.



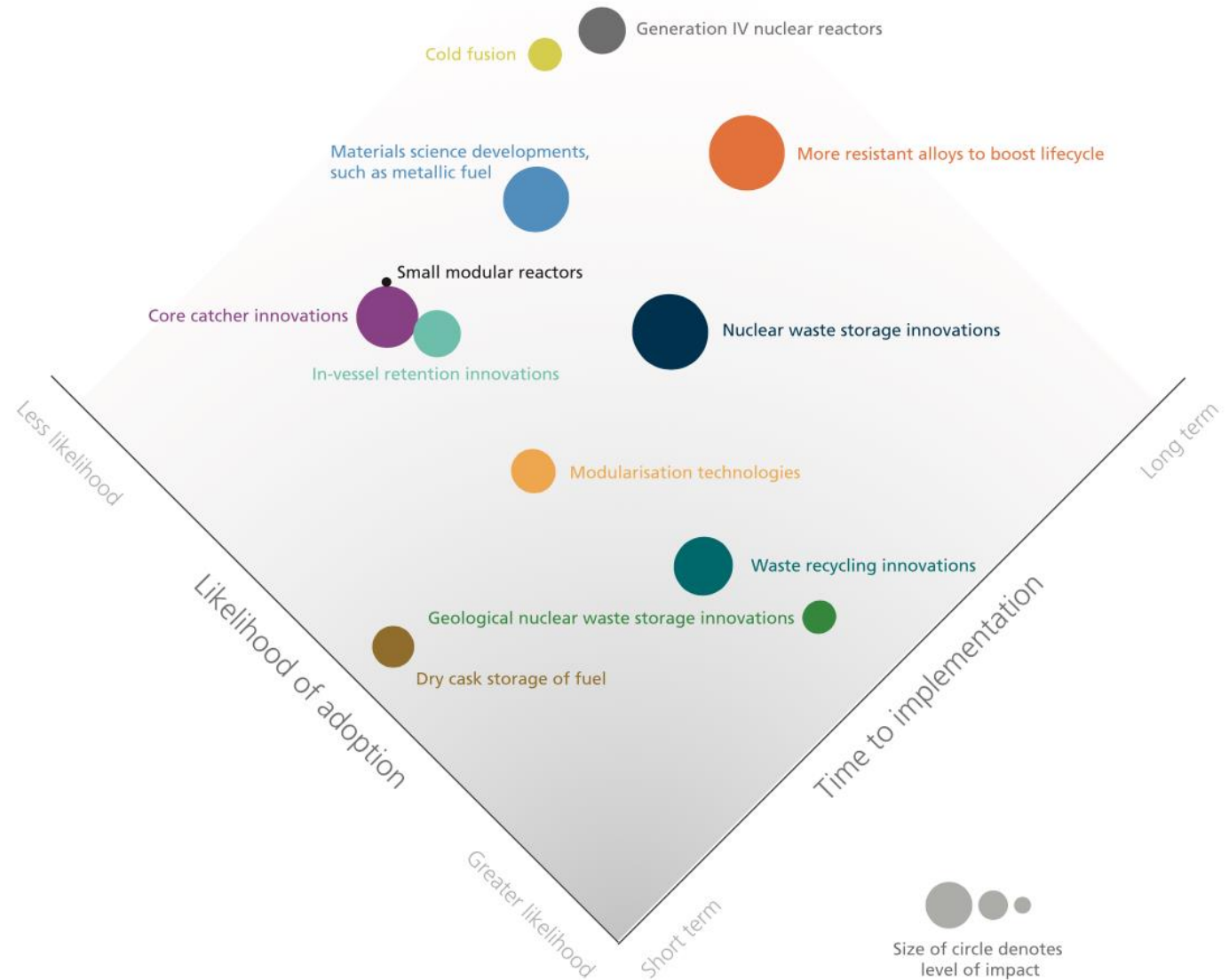
3. Renewables: Solar cell technology is likely to have a major impact, and soon

- For Renewables, respondents are most optimistic about the potential of advances in solar cell technology - and the likelihood of adoption.
- Survey respondents also view advances in wind turbine technology favourably.
- However, despite respondents believing that these developments will have a high impact, they are less sure about how long they will take to get to market, and how likely they are to be adopted.
- The survey was in the field prior to the Swansea Bay Tidal Lagoon announcement



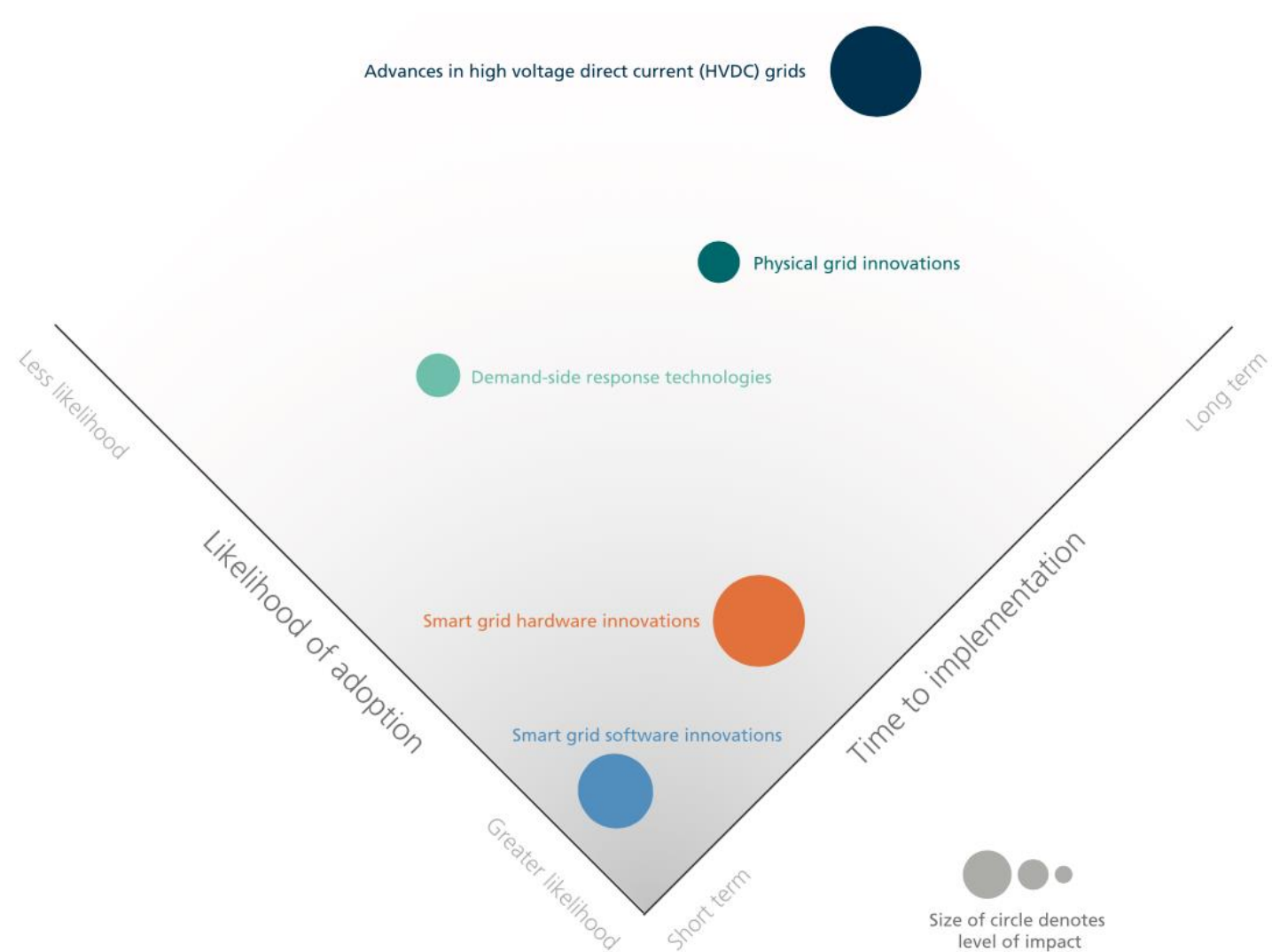
4. Nuclear: Contribution of SMRs is unclear at this stage, but modularisation technology seen as having a major impact

- Respondents to our survey predict that SMRs have a low likelihood of eventual takeup, and will have a minimal impact when they do arrive.
- Modularisation technologies, respondents predict, will hit the market sooner than fully fledged SMRs.
- They also see these technologies as more likely to be adopted, and expect them to have a much larger impact on the sector.



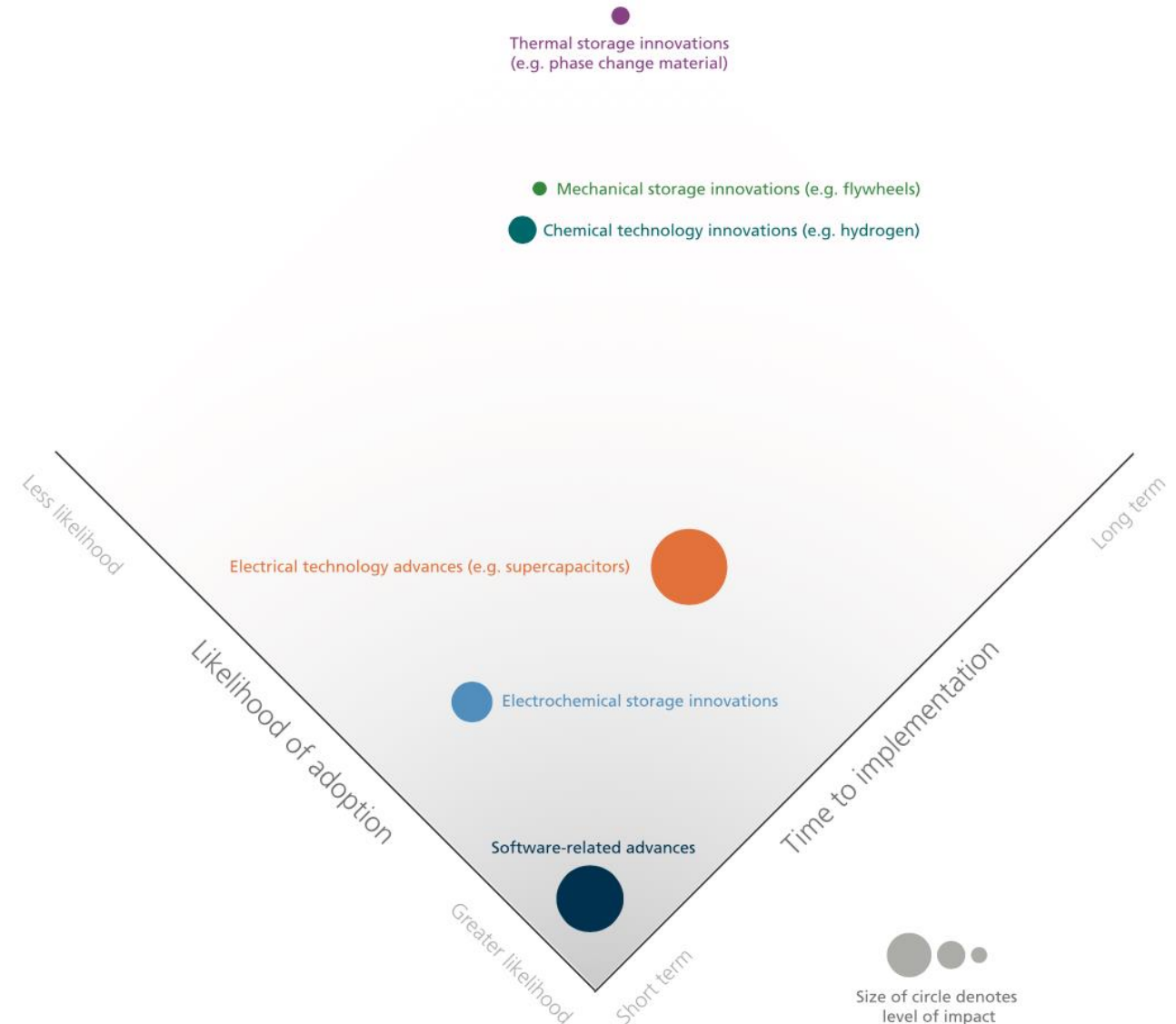
5. Transmission & Distribution: Software advances will be instrumental

- Smart grid software innovations are seen by respondents as the technology that will be the quickest to arrive and the most likely to be adopted.
- Indeed, blockchain could reshape the way we think about the transmission and distribution of power by enabling a new era of peer-to-peer low carbon generation.



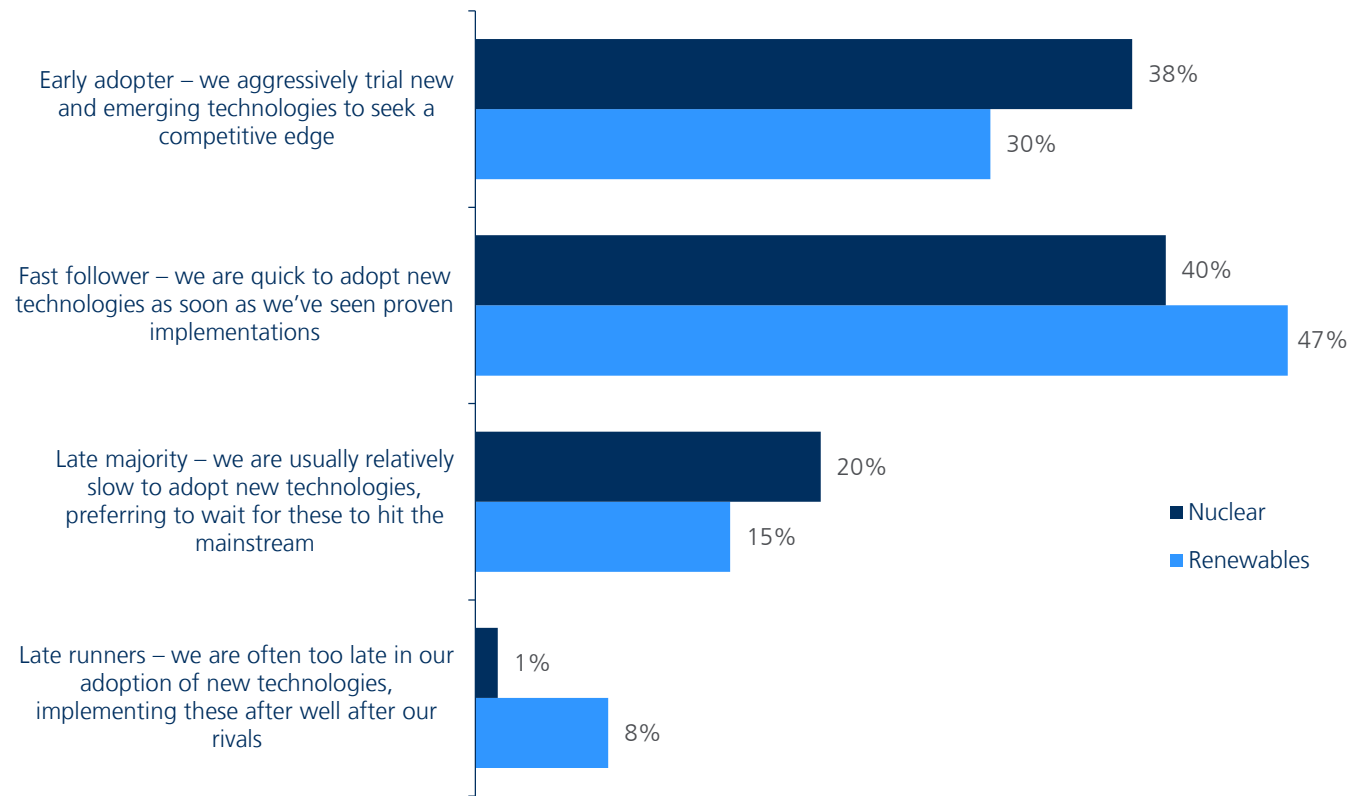
6. Energy Storage: Electrical technologies will transform storage, rather than mechanical or chemical innovations

- Respondents predict that the next innovation to impact energy storage will be software-related.
- Respondents feel innovations in electrochemical storage will not have as much impact as improved economies of scale with existing batteries.
- The storage technology that respondents believe will have the biggest impact is electrical technology such as supercapacitors, which will rapidly speed up charging times for large batteries.



7. More fast followers than early adopters in low carbon

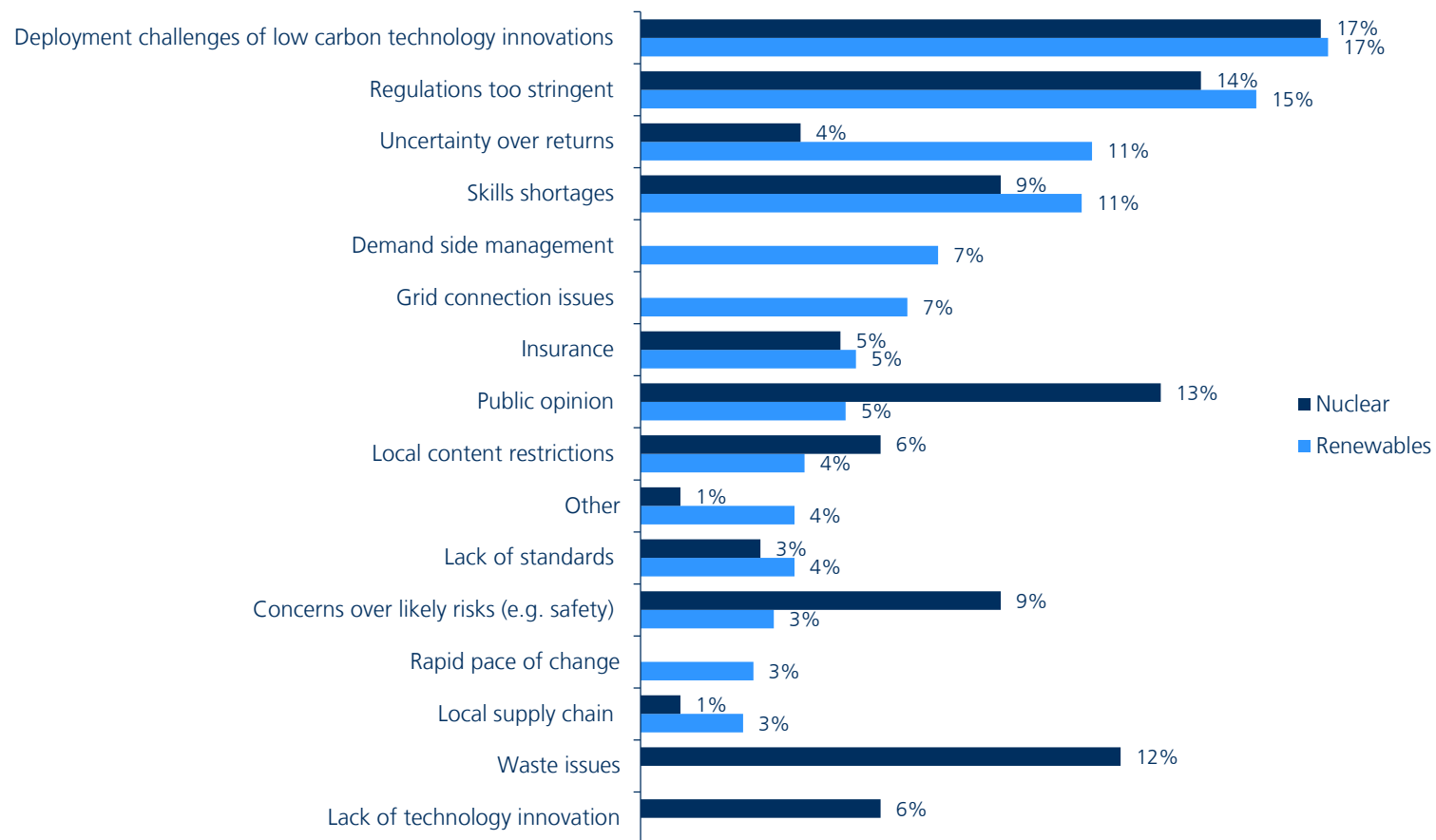
- Most of our respondents identify their company as a 'fast follower' rather than an 'early adopter'.
- This can be partially explained by project economics: only certain players can afford to take on the risks that come with testing new and emerging technologies, while securing sufficiently low borrowing rates.
- Nuclear respondents in Asia Pacific account for the most significant regional variation – only 16% consider their company to be early adopters, and 60% fast followers.



8. Deployment is seen as the greatest barrier to progress after cost

- While nuclear and renewables respondents both say that deployment challenges are their greatest barrier to progress, there are some differences in opinions on other challenges.
- While uncertainty over returns is not seen as a major issue in the nuclear industry, 11% of renewables respondents said it was their biggest barrier
- Public opinion is seen as a major challenge in some countries for nuclear, with 13% of respondents identifying it as their biggest barrier

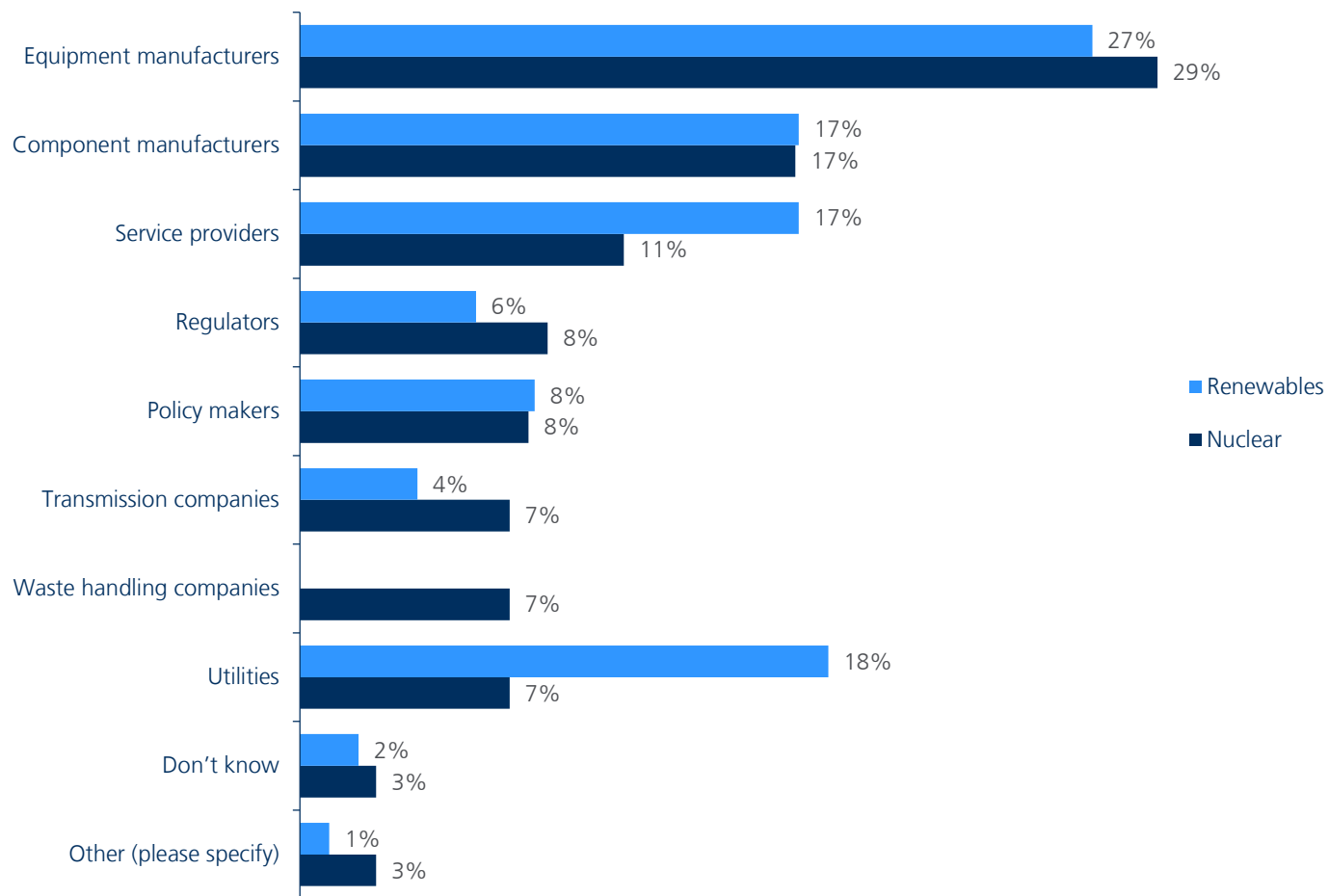
In your opinion, aside from cost, what do you think is the most important barrier to progress in introducing renewable/nuclear technologies?



9. Equipment manufacturers leading the innovation agenda across low carbon

- Manufacturers are seen to be driving innovation in both sectors
- There is opportunity for Government and regulators to do more to support technology development

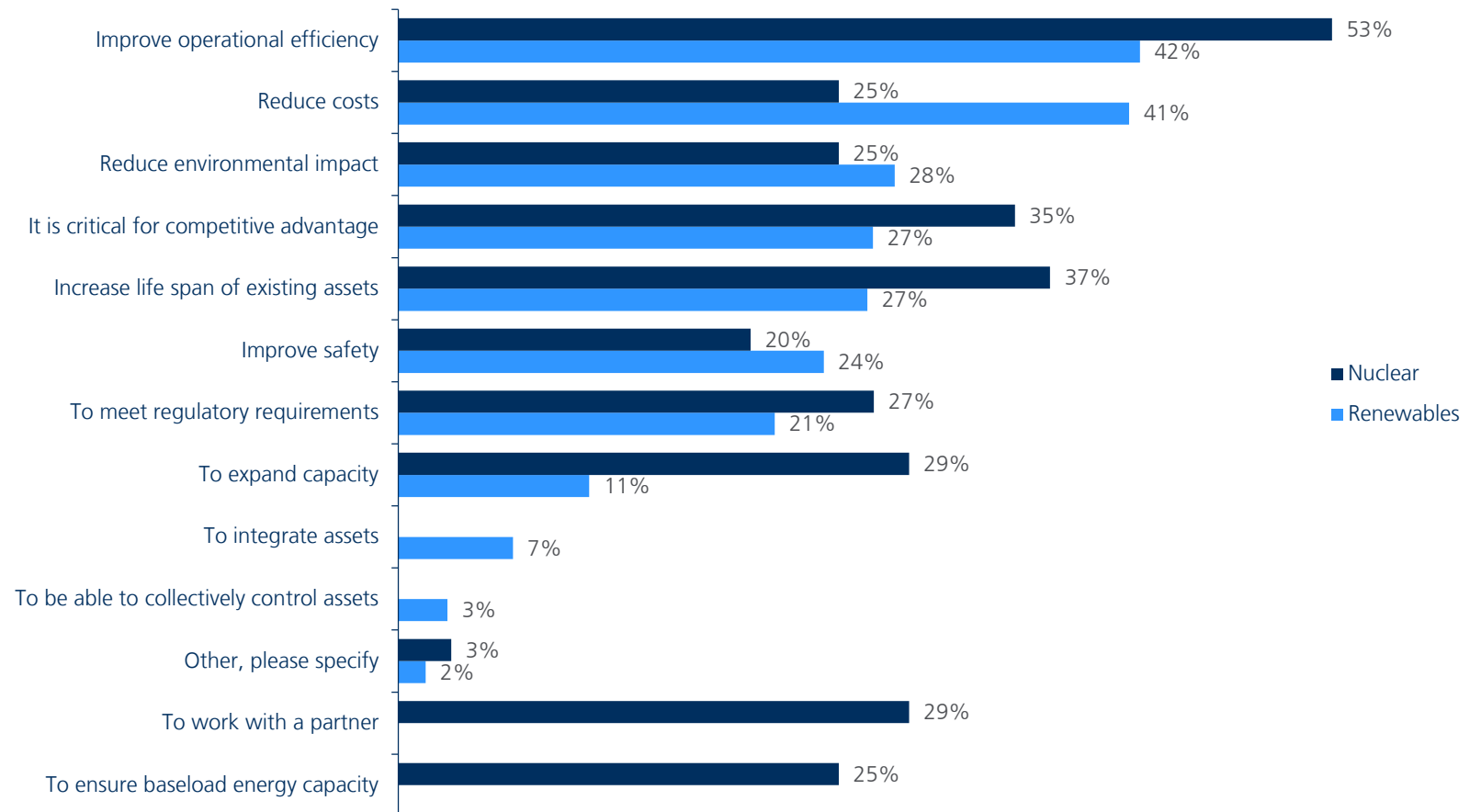
Thinking specifically about the segment in which you operate, where do you think the most innovation is happening in nuclear/renewable energy?



10. Improving operational efficiency is key driver for technology investment

What is your firm's primary driver for investing in renewable or nuclear technologies?

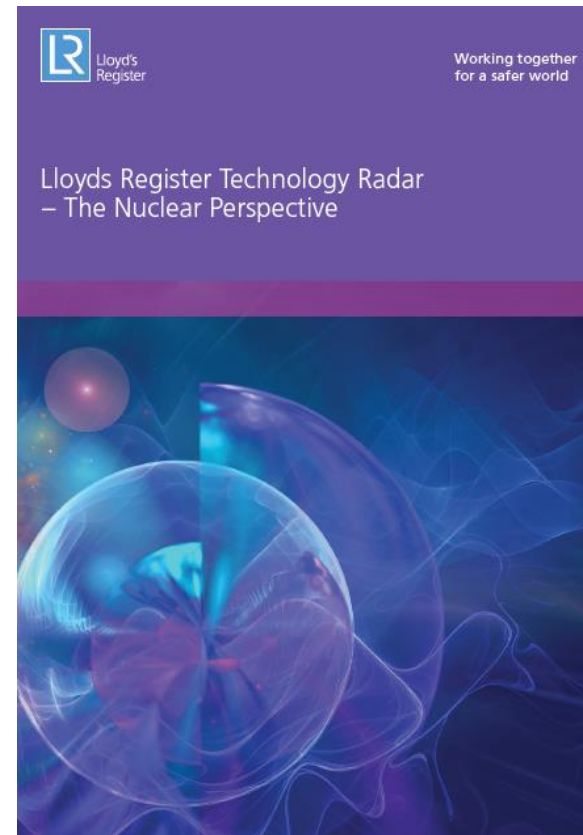
- For both sectors, operational efficiency is a key driver of innovation
- For renewables, there is a strong cost-reduction agenda as the sector strives for cost parity with fossil fuels
- For nuclear, asset life extension is an important driver



Thank you – any questions?

The research is published in the two companion reports, both accompanied by an Executive Summary in English, Chinese and Norwegian

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an overview report
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