EWEA Technology Workshop

Post Construction Yield Analysis Techniques – An industry survey

Full Results

2nd July 2012

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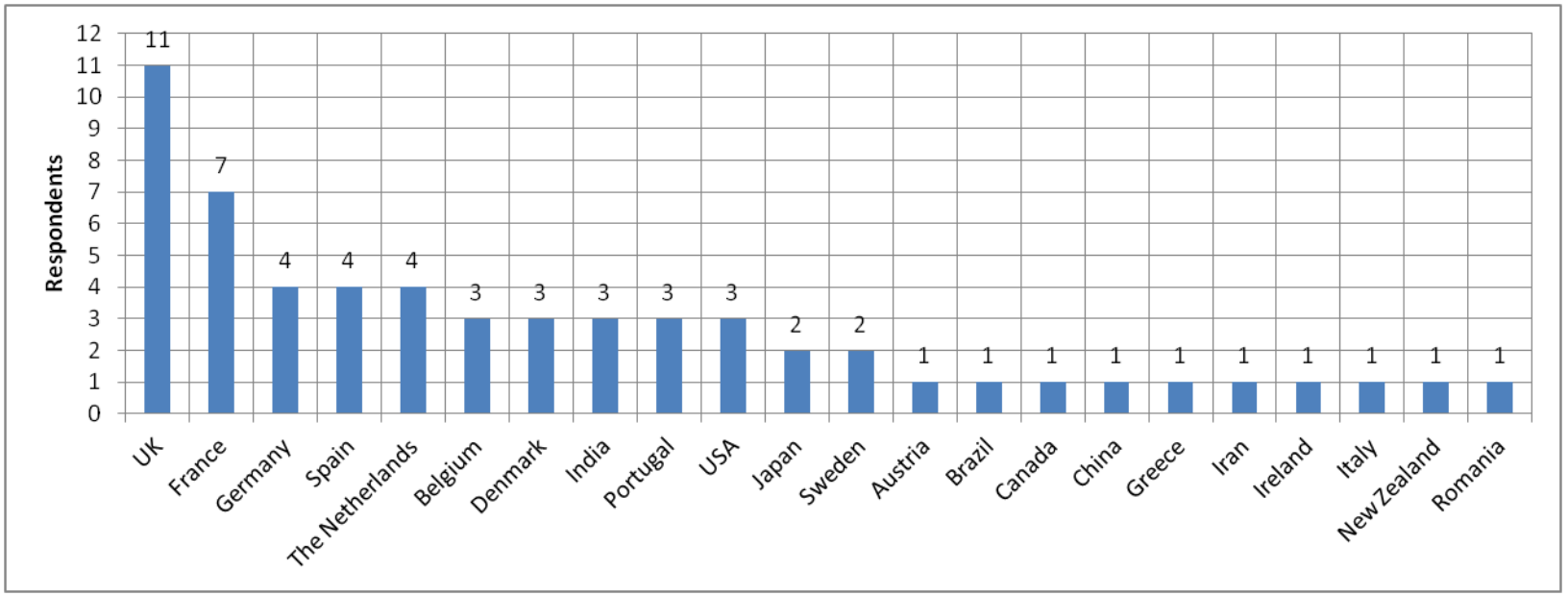
THE EUROPEAN WIND ENERGY ASSOCIATION

Section 1 – Industry Experience

Participants

- 59 respondents
  - 48 completed some or all of the questions
  - 42 answered all questions
- Respondents were from 22 countries



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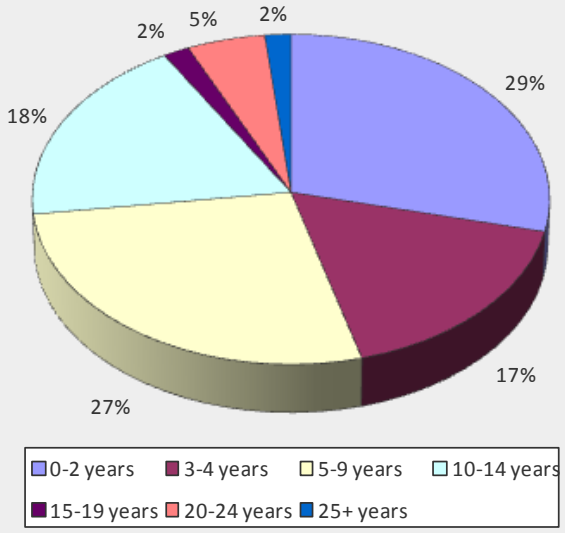
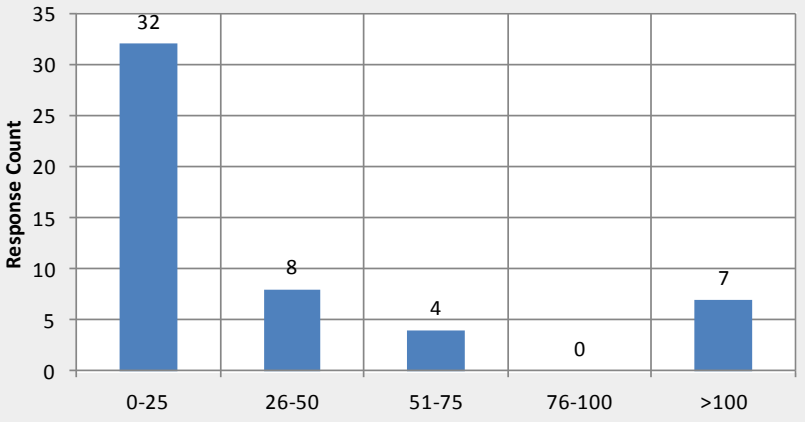
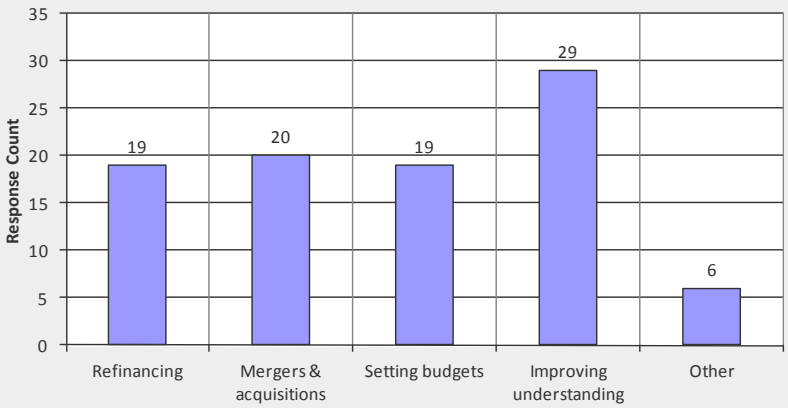
How long have you been employed in the wind industry?



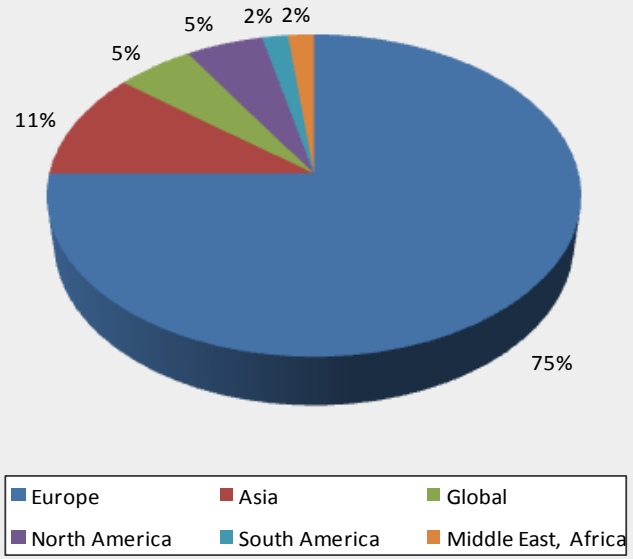
How many EPAs for operating projects has your organisation undertaken?



What are the key drivers for undertaking long-term energy production forecasting for operational wind farms?



What is your primary market?



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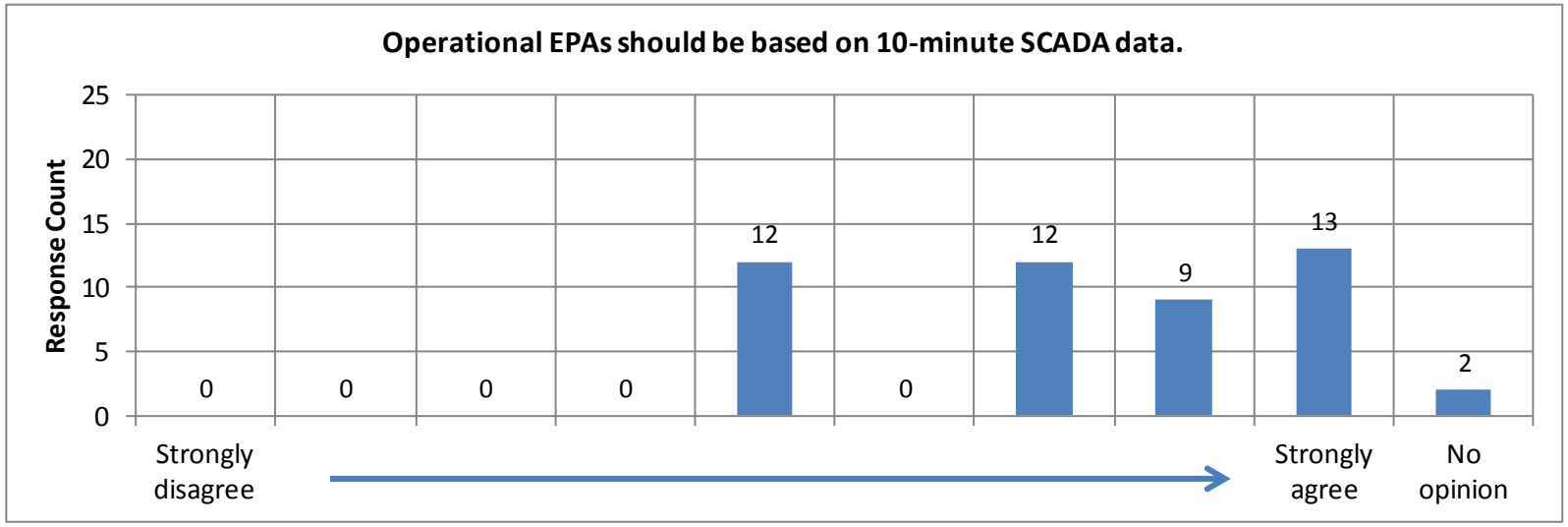
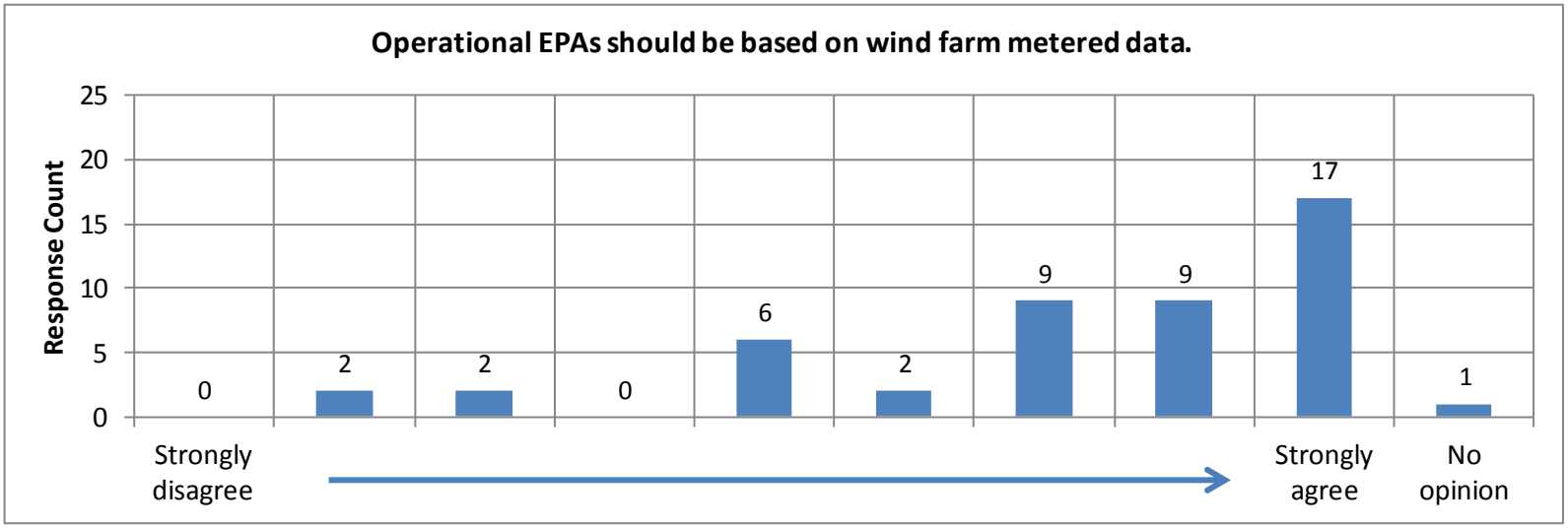
Section 2 – General Techniques



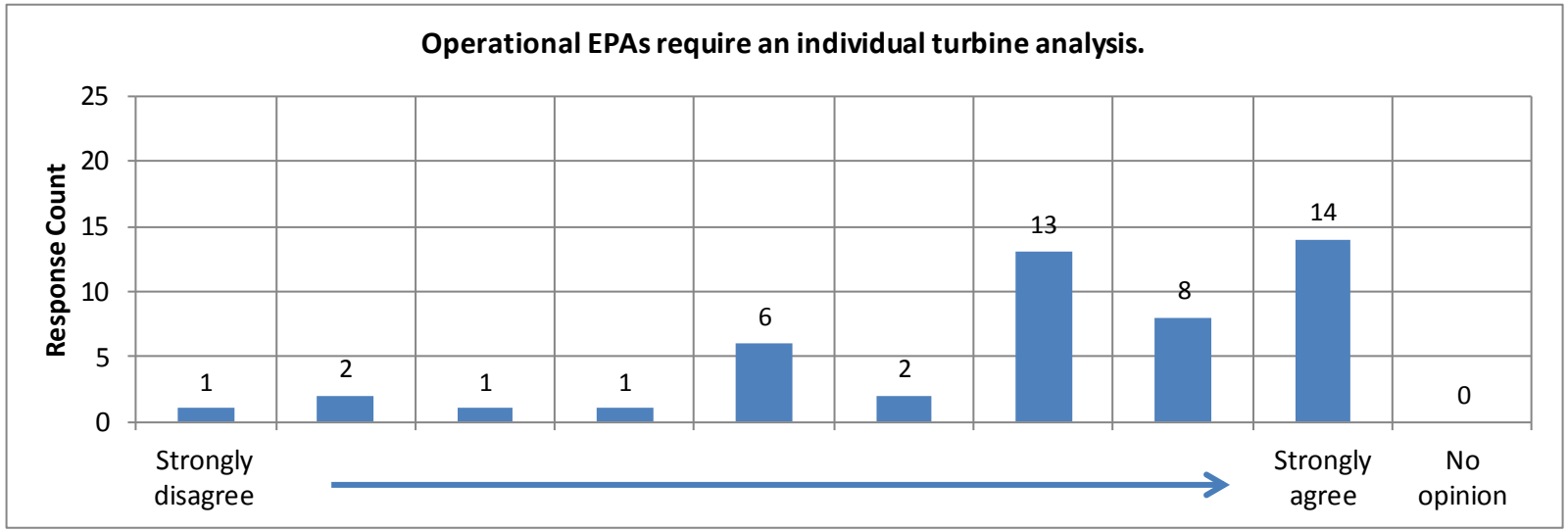
Selected comments

- *For a project financing where the reasons for over/underperformance don't matter, 10-minute SCADA data is not useful, but for a detailed dive into project operations it is necessary*
- *The only reason to use production data from 10-min SCADA is if a per turbine breakdown is needed*
- *Sometimes monthly [data] can be sufficient for an overview*
- *10-minute SCADA data are preferred but not essential*



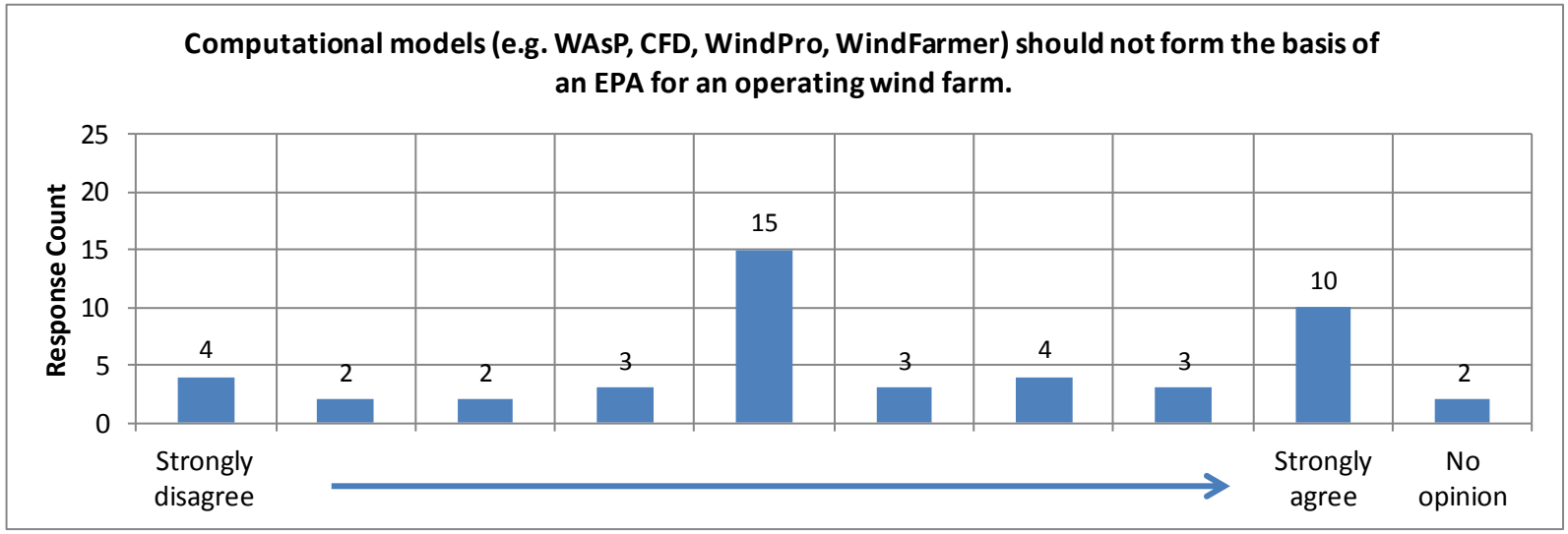
Selected comments

- *This is the ultimate measure*
- *To be used in conjunction with availability from SCADA data & knowledge of power curves*
- *Wind farm metered data are the most accurate and relevant for the purpose of assessing the performance of the entire project*
- *Metered data is good for an assessment of losses from turbine to metered output, but doesn't allow for individual turbine performance assessment*



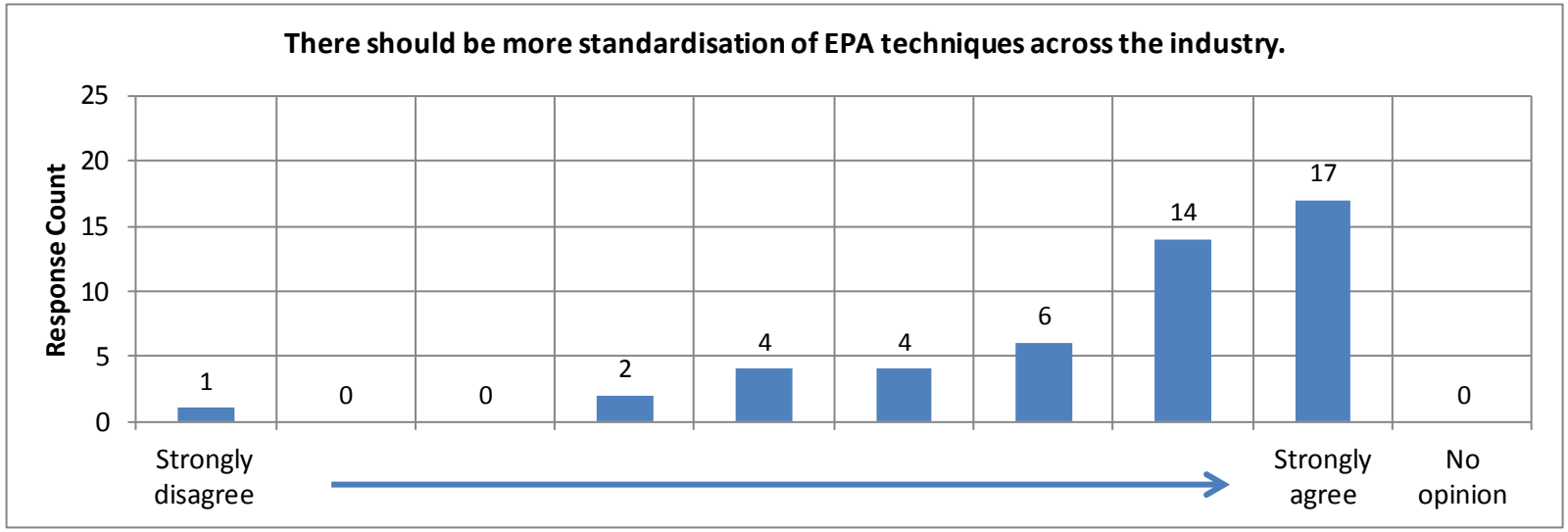
Selected comments

- *It depends on the depth of the assessment*
- *For some analyses it is not helpful, for others it is mandatory*
- *The [SCADA] data are most useful for identifying problems in the performance of individual turbines, which can lead to performance improvements.*



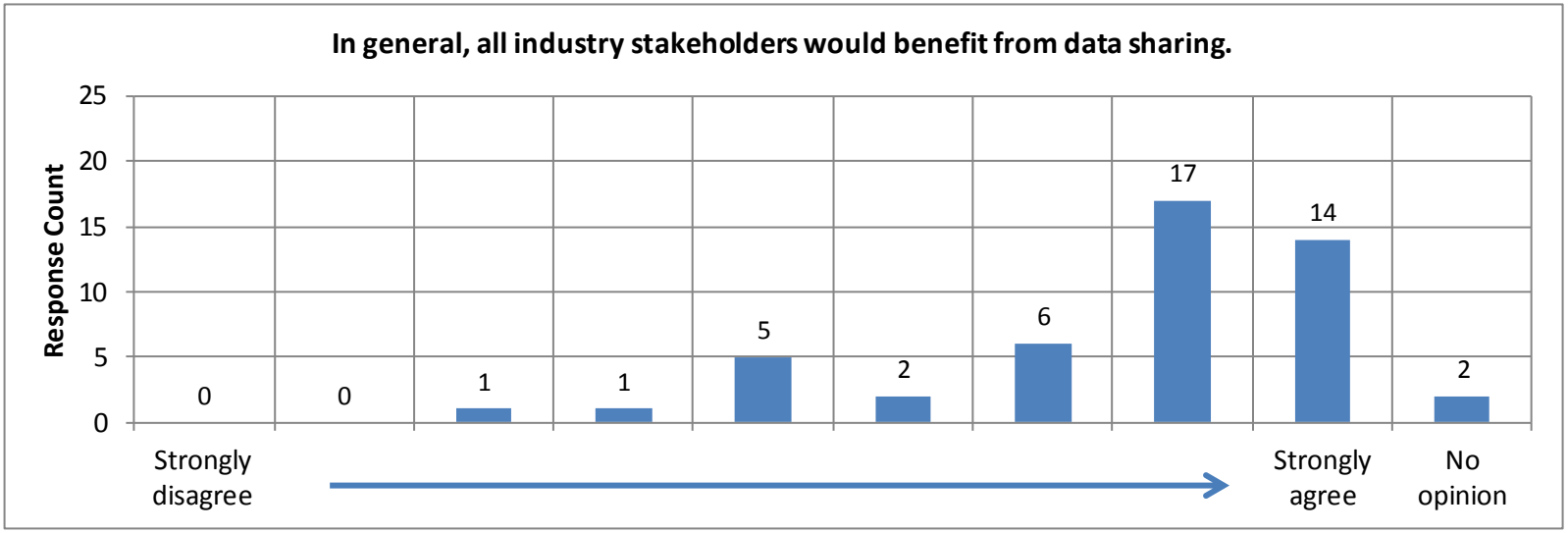
Selected comments

- *Basically, we should use measured SCADA data.*
- *These models should be used in conjuction with other assessment methods and only advanced users of these models should use them.*
- *In some cases [models] can be useful – e.g. assessing the potential production increase under modified software control settings or to assess the impact of new neighbouring wind farms.*
- *[Models] should be calibrated and used to improve the Energy assessment of future wind farms (nearby the actual project, for example)*



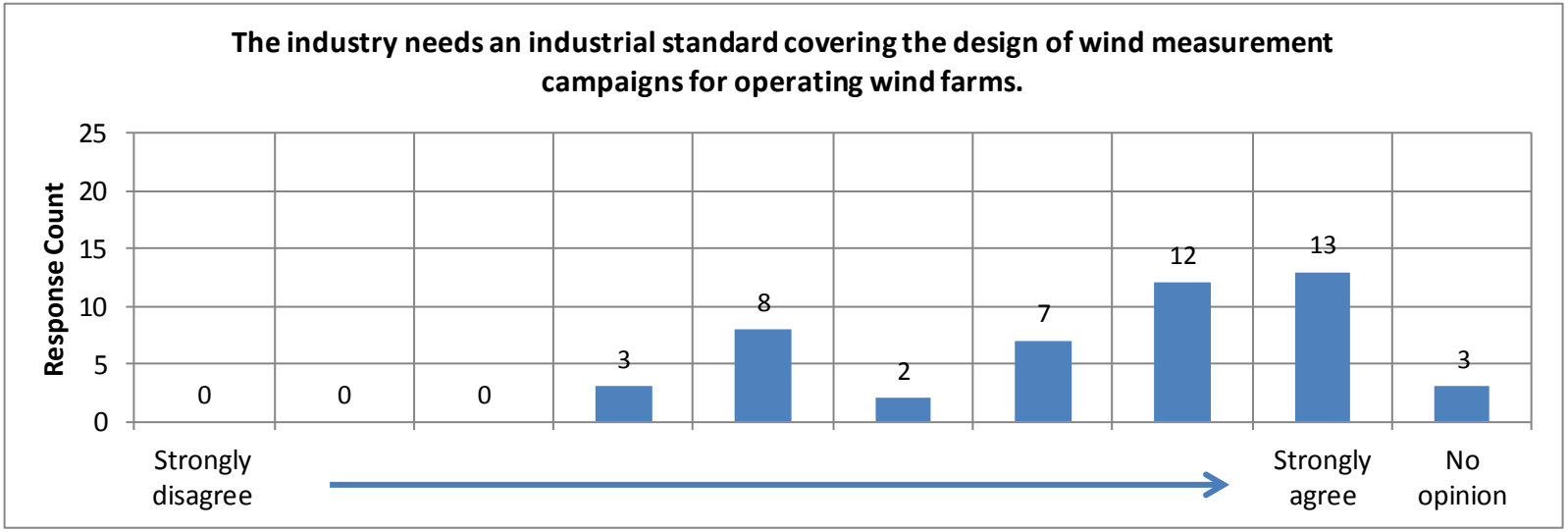
Selected comments

- *There are several methods, which have different strengths. A set of best practice guidelines which take that into account would be more useful than standardisation of methods.*
- *This is the way we will be able to demonstrate our competence in a) getting yield assessments right, and b) gaining investor's confidence.*
- *Improvement of wind flow and energy models first.*
- *There should be standardisation of terminology used, but not mandated analysis techniques*
- *This standardisation is difficult but necessary.*
- *Not sure how standardisation could practically be achieved.*



Selected comments

- *I believe the industry in general would benefit greatly by being less protective of data fields.*
- *[We] are currently working on a shared database on availabilities/defects/etc.*
- *With few exceptions, the industry would benefit greatly from increased data sharing. For example, this could improve the accuracy of pre-construction energy production estimates.*
- *Within the limitations of confidentiality.*
- *As long as it is not misused for negative marketing...*



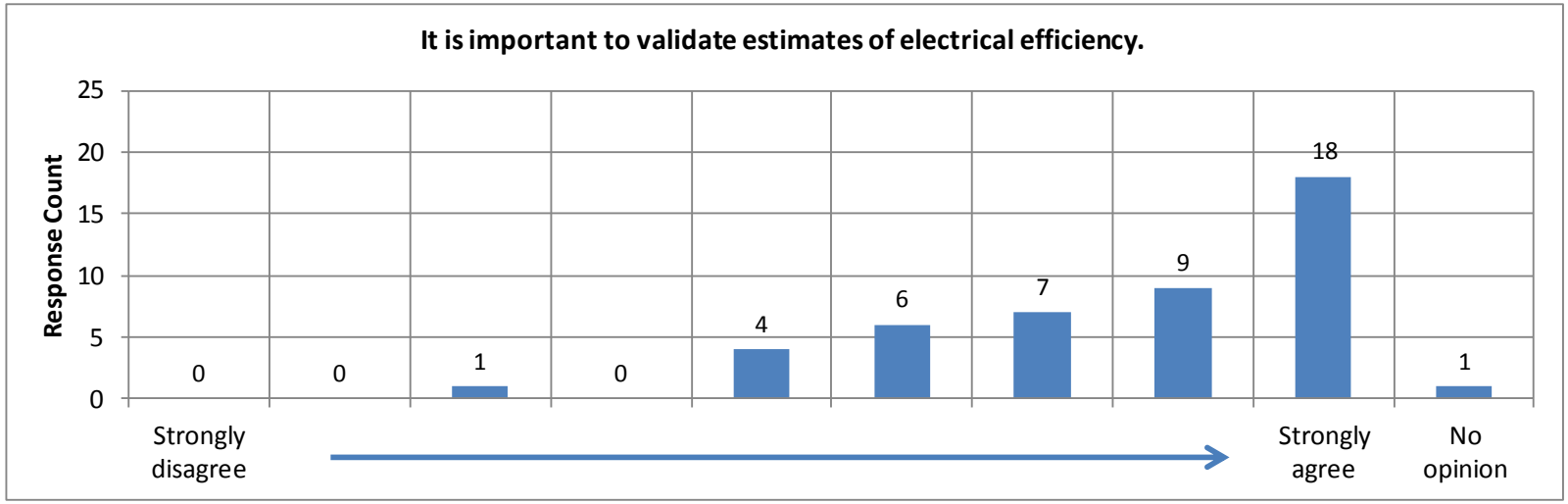
Selected comments

- *Already existing (IEC61400-12 standards)*
- *A standard is not a good idea for a topic as complex and site-specific, but guidelines documents would be good (and are under development)*
- *Current methods (of highly biased nacelle measurements combined with poorly maintained and sited permanent met masts) are clearly inadequate for the sort of complex sites we're now dealing with.*
- *Easier said than done...*

What other concepts should be developed by the industry in order to improve accuracy and reliability of EPAs for operational wind farms?

- Consensus on how to adjust production data for curtailment.
- Use of an 'Operational' availability including all event that cause downtime(except environmental eg high wind) rather than a contractual availability which may not include certain events (e.g. grid).
- Development of uncertainty models.
- Better understanding and use of wind turbine anemometers
- We should collect accuracy data for assessment of operational wind farm
- good and convenient software.
- Combination with remote sensing device (on nacelle and on the ground)
- improve quality of nacelle mounted anemometers
- information provided about the nacelle transfer function
- Nacelle-mounted lidars, providing wind speed profile in front of the turbine
- Multiple simulations
- make available simple on the shelf model in order to boost common approach of major issues
- Standard meteo site data acquisition up to hub height independently from the turbines in order to have comparable data from site to site
- Wind speed measurements or power shown by the meter at a few locations include very little complexity of the atmosphere. There is only one way to address this limitation by treating the atmospheric processes comprehensively. "Participant 042a" perfected a wind energy assessment technology that takes the atmosphere into consideration, for a decade.
- Obtaining consistent data series of 10-minute wind measurements for a period of at least: starting 1 year before starting Construction stage, and finishing at least 1 year after O&M stage begins. Consistent means: a met mast measuring wind at approximately hub height, keeping the same sensors configuration during the whole period, and in a particular position as close as possible to the wind turbine positions, but not affected by their wakes, according to IEC standards.
- The major consultants should break down their reconciliation studies into sub studies - for example, geographic area or forested sites etc
- Impact of climate variables in turbine performance
- Power curve tests, Site calibration, Reference WF Meteorological Masts, Remote sensing campaigns.
- Standardized measurement of the wind speed
- Standardized understanding of availability
- IEC 61400-12-3 Wind Farm Performance
- Emphasize importance of high SCADA and meteorological data recovery and quality
- SCADA Data filtering standard
- We use a concept called "fuel availability", expressed as a percentage, which is essentially "idealised wind farm energy based on measured wind speed at site"/ long term representative energy. This concept allows us to evaluate "windiness" of a given month compared to our budget, and therefore to provide more meaningful comparisons to budget on a monthly basis.
- This needs to be debated in an appropriate forum with key stake holders. Several concepts can emerge.
- Better flow modelling in complex terrain;
- Common consensus on use of indirect wind measurement data
- Wind resource variation over the time. reference time of extrapolation (1,10,20,30,50 years...). Seasonal prediction with index compared to a average
- In certain parts of the world there is no easy way to get reliable wind data for those farms that do not justify the expense of a dedicated met mast. Development of datasets that permit Measure, Correlate, Predict using long term weather history and short term production are needed.
- Operational wind farm power curve testing
- Definition of availability to be standardized.
- A database of accessible, QC'd operational production data along with plant specifications would be highly useful for consultants and developers to be able to fine tune their models and methods. This would not necessarily require the use of proprietary data, e.g., in the US, the EIA reports monthly production from most wind projects. However, the data have errors.
- Use of standard operational state codes by the turbine manufacturers. Clear distinction between different operational state codes.
- independent meter reading technology

Section 3 – Estimating Operational Losses


It is important to validate estimates of electrical efficiency.
Response Count
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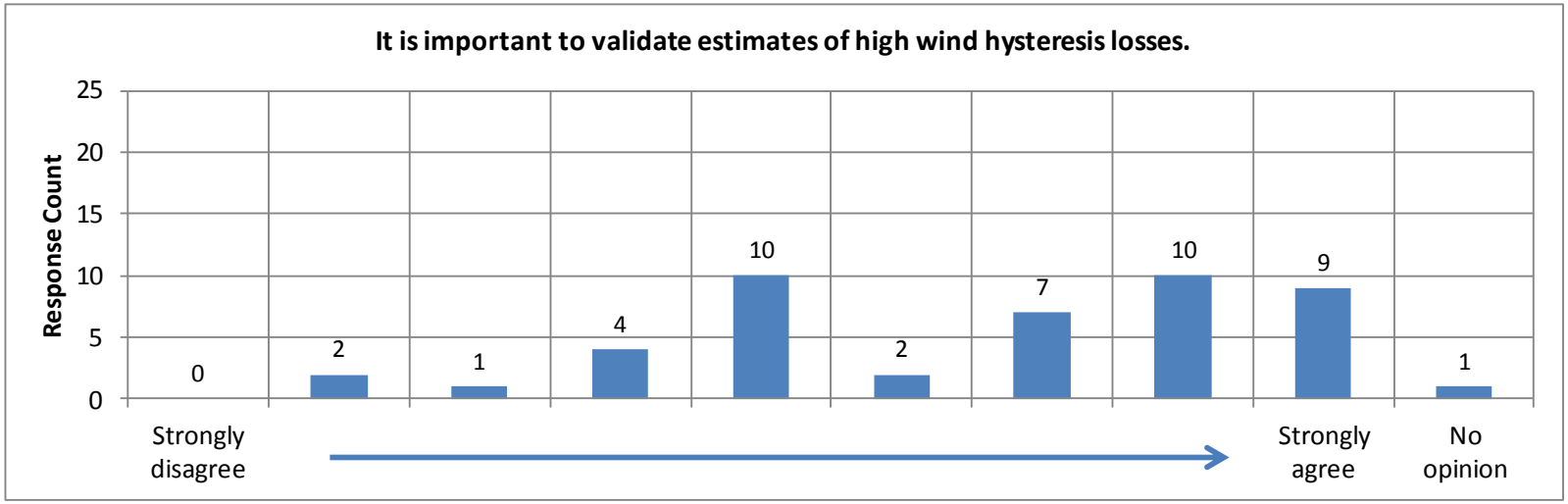
Strongly disagree
Strongly agree
No opinion


It is important to validate estimates of high wind hysteresis losses.
Response Count
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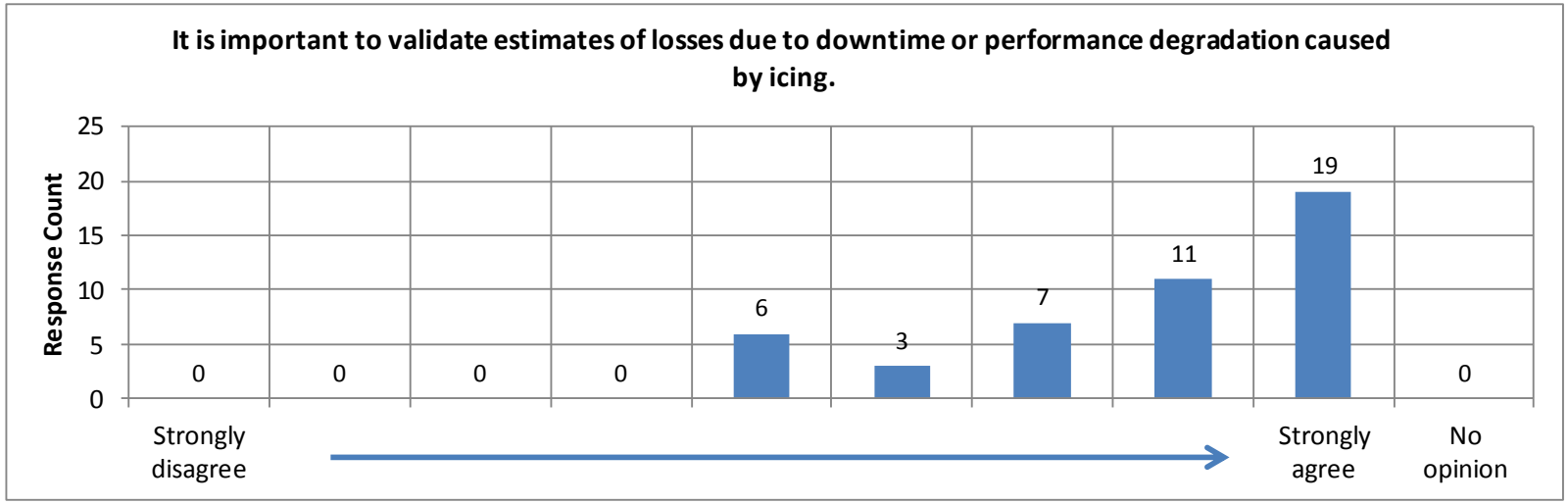
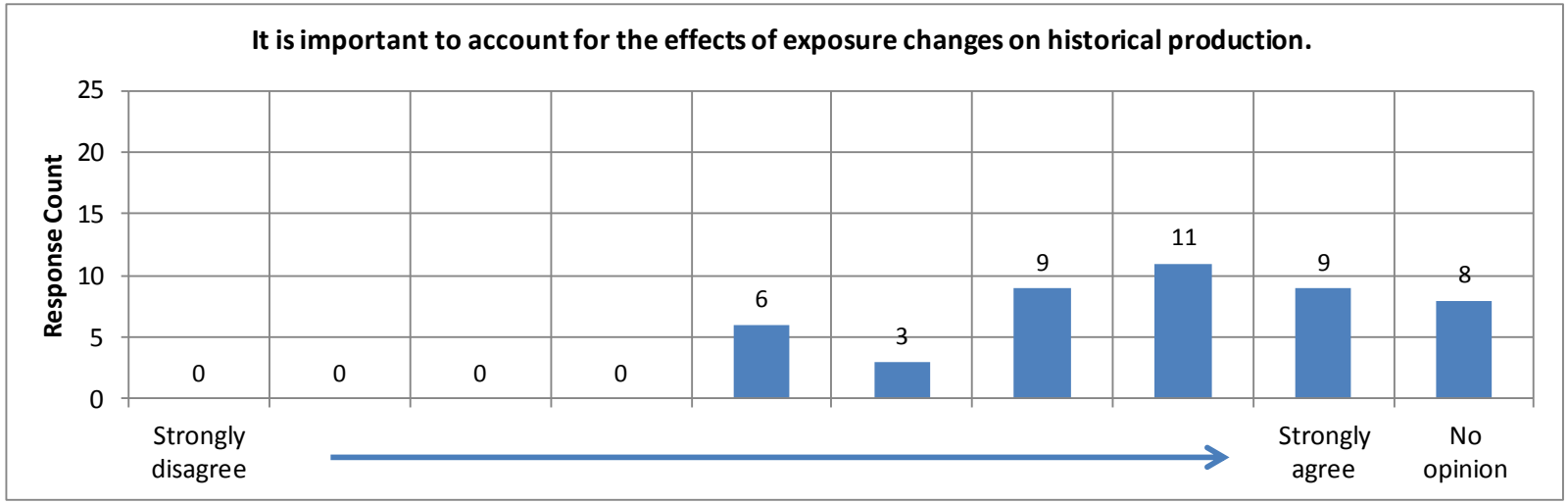
Strongly disagree
Strongly agree
No opinion

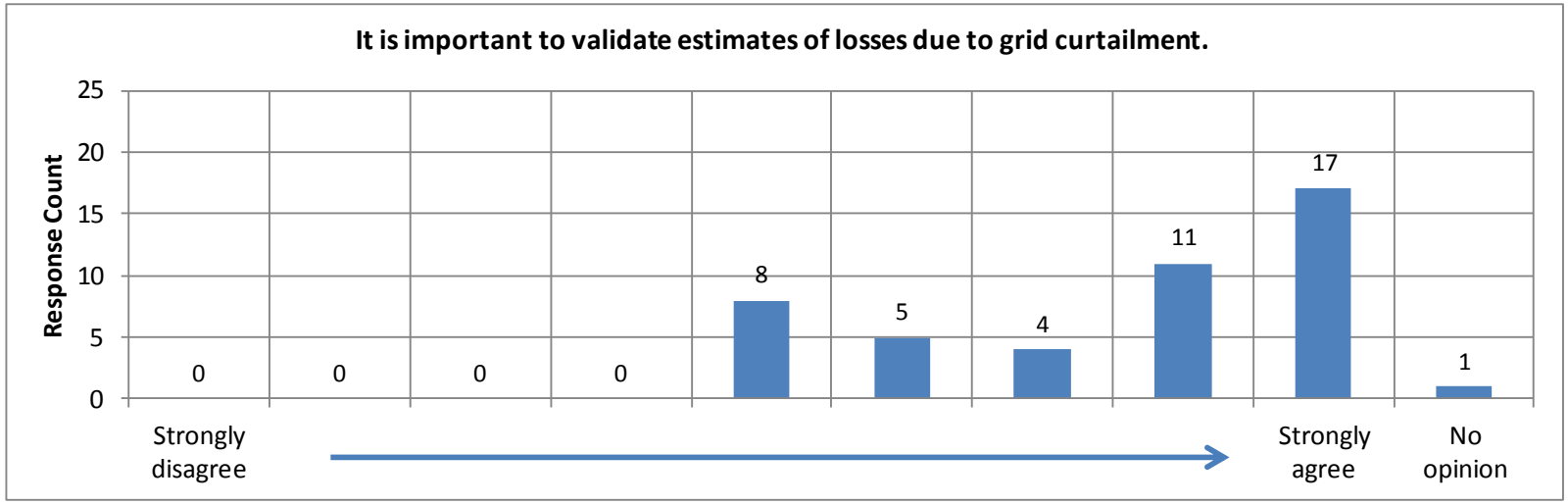


Selected comments

- *Information on the relationship between anemometer icing and blade icing... would be highly beneficial to correlating the preconstruction measurement data to operational experience.*
- *Need to make a reasonable assumption for future availability levels.*
- *This topic becomes more and more important since icing can lead to extended unplanned downtimes which is very costly in markets where you have to sell the electricity on the market (no feed-in tariff).*
- *This is the most challenging part. 10min SCADA data will pose limitations...*

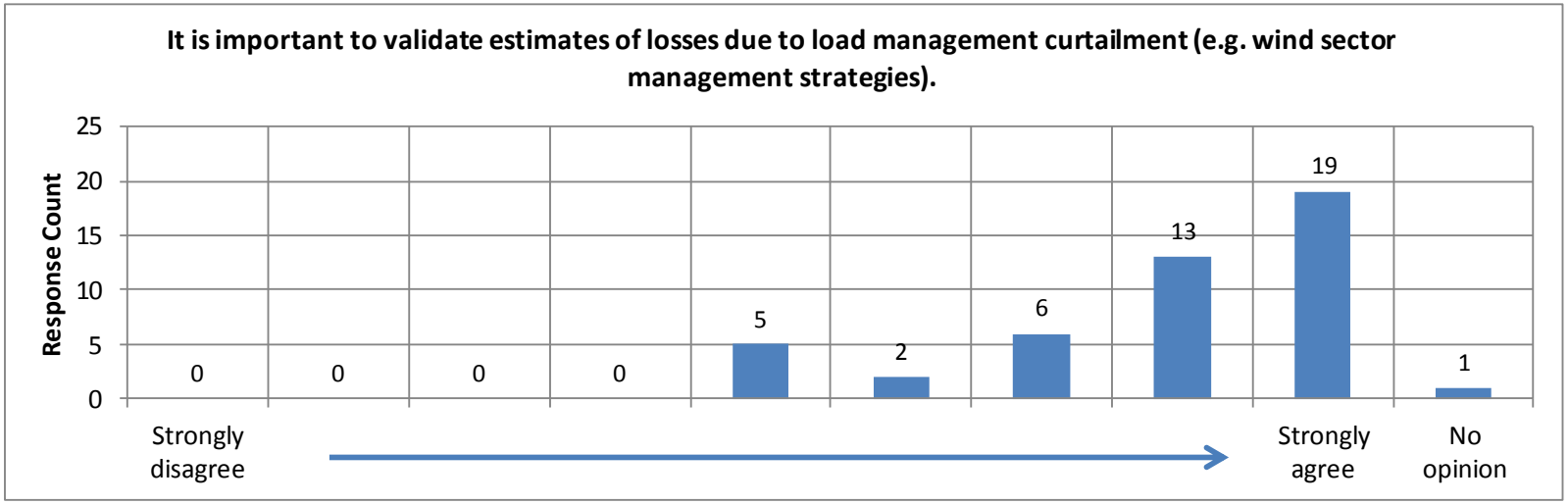


- Some apparent confusion over what “exposure changes” are.
- These refer to changes in the nature of roughness elements, obstacles & neighbouring wind farms over the operational period under consideration.



Selected comment

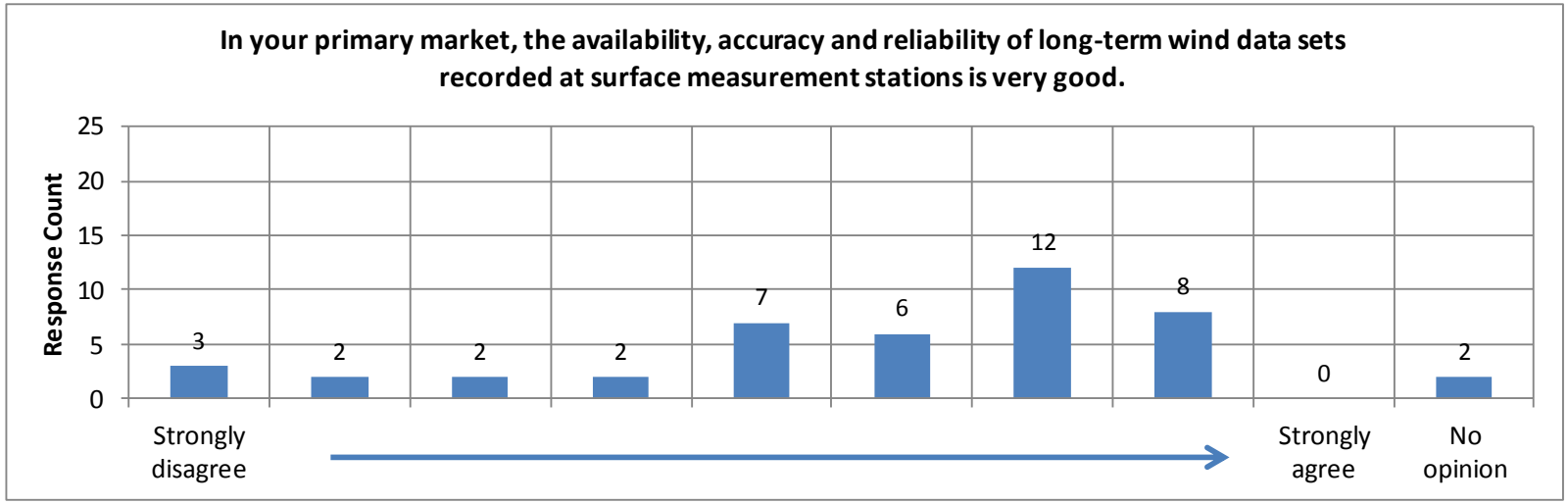
- *This depends on whether we're estimating production for financial or technical reasons... it's important to track this, but its priority depends on other considerations.*



Which other losses do you regard as being important?

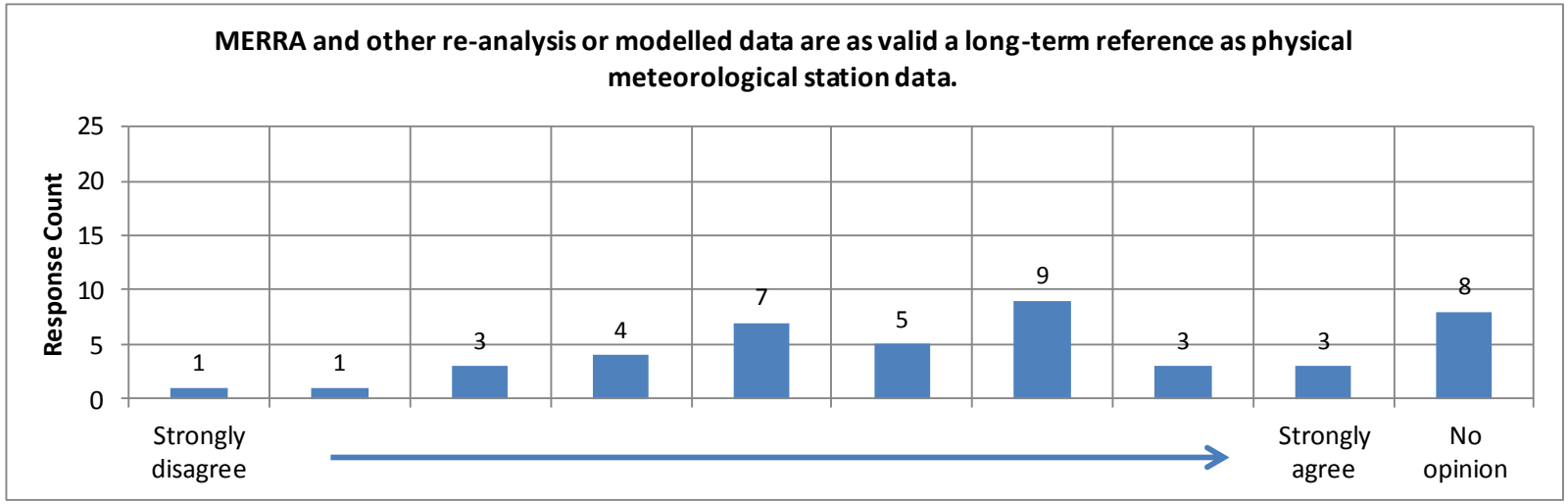
- Losses due to switching noise modes.
- wake losses
- those ones due to noise management, more and more important in France
- Availability losses
- Untwisting, vibrations, shadows
- terrain profile of the wind farm
- Noise / Shadow curtailment
- unavailability covered and not covered by LTMA contract
- blade degradation
- curtailment strategies (noise, shadow, bats...)
- Combined with turbine failure that could be prevented
- losses due to early aging of major components compared to original busyness case
- The largest uncertainty in the current energy production estimates for past or future projects results from the near total negligence of the complex atmospheric processes. When such processes are included, the secondary loss estimates (e.g., wake/array losses) can be significantly improved as well. I describe this situation using the dollars-and-cents analogy. The atmospheric approach solves the energy production estimate issue on the dollars level while the secondary loss improvements methods deal with the issue on the cents level. In other words, I say the atmospheric approach, that is lacking in the current methods, is of utmost importance.
- Those due to maintenance of wind turbines and/or the rest of the wind farm installation (LV/MV lines, electrical substation).
- The loss associated with the discrepancy between sales power curves and on-site power curves.
- Turbulence and wake losses
- Power reductions due to noise, bats, birds, shadow flicker etc.
- Losses due to non-accessibility of the site
- Estimate of Long Term WEC and WF availability
- Partial performance, High temperature, Technical standby, Scheduled maintenance, corrective actions.
- Noise reduction (resp. cut-off)
- other environmental issues (e.g. due to bats)
- Grid Downtime
- Blade degradation and power performance degradation, control settings
- There are many parameters - Wake turbulence, atmospheric stability, variation in wind shear..etc. that can affect performance...
- wake losses, validation of the turbine performance
- Planned maintenance, unplanned maintenance, serial defects
- Wake losses !!! Probably the most important in order to get better understanding
- Wake losses
- grid code compliance

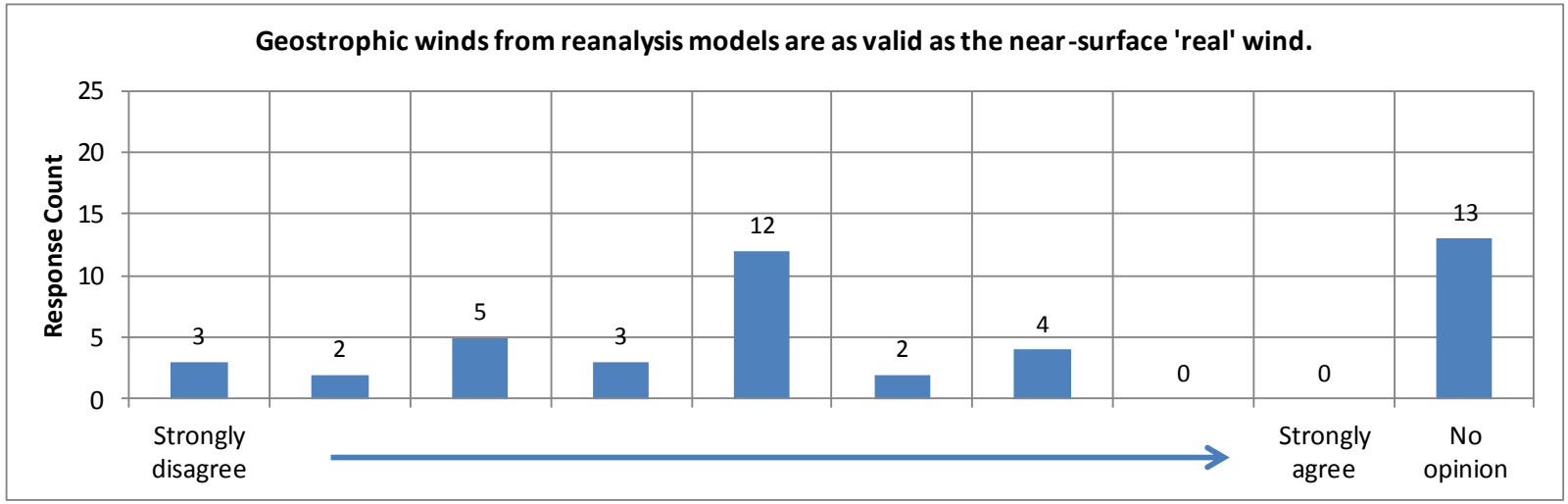
Section 4 – Defining long-term wind speed trends



Selected comments

- *The quality of the measurements are generally less good than we measure ourselves. Masts are lower, there are no back-up instruments, and discretisation (e.g. 10° direction bins) is common.*
- *The reliability of long-term wind data sets could be improved*





Selected comments

- *We've found good agreement with masts from mesoscale modelling.*
- *Unknown at present - more research is required*
- *Can be used to provide relative comparisons (e.g. wind index) but not as direct input for simulations as wind is poorly modelled close to the ground.*

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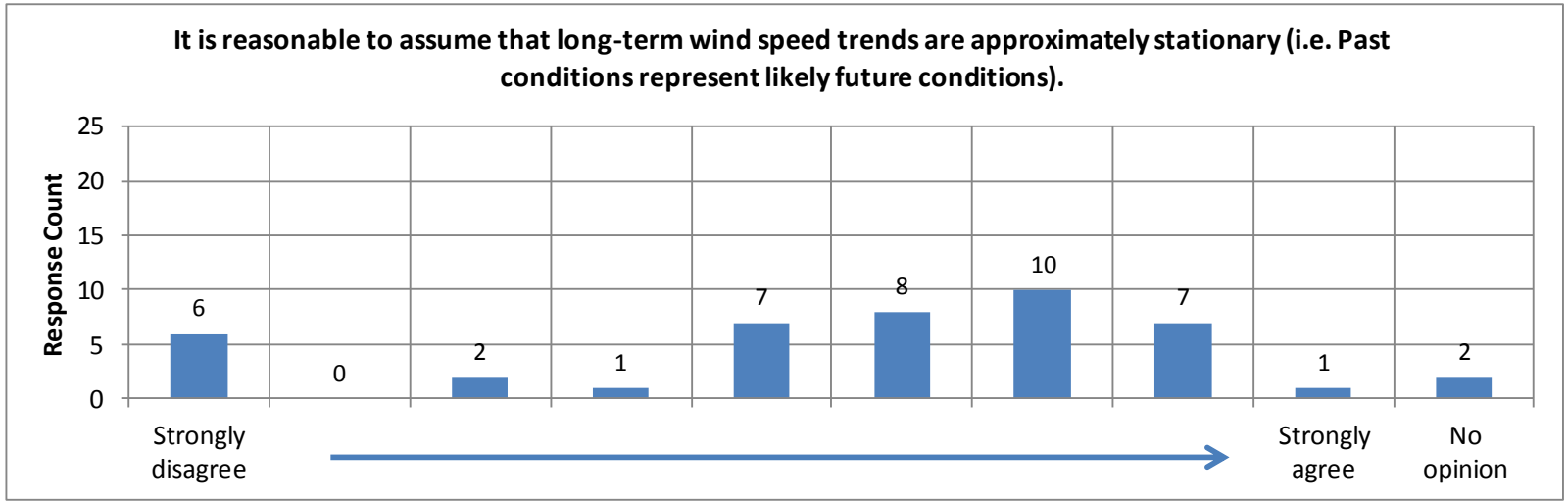
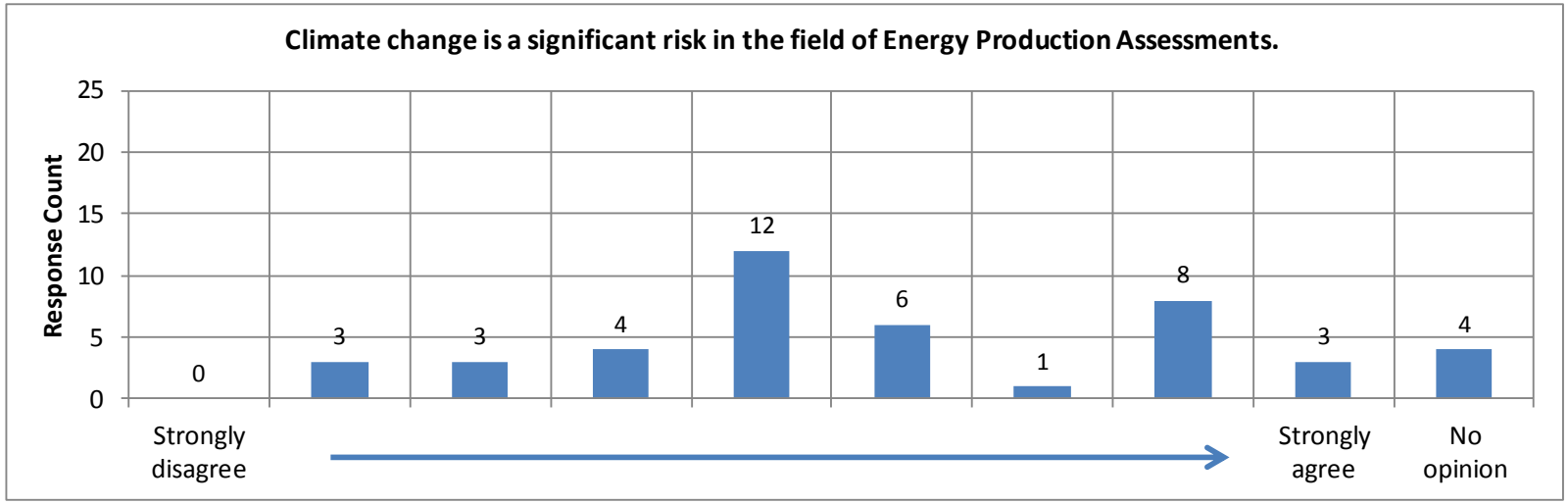


Selected comments

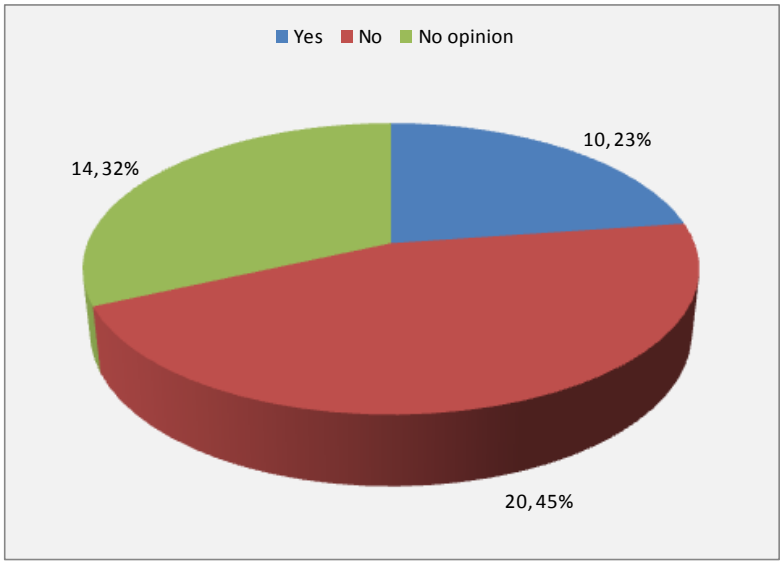
- *We have no other choice to use such an assumption.*
- *the selection of the long-term period has a very large influence*
- *Yes, but the scale of variation is probably bigger than we generally look at. So if you look at a 10-year dataset you're not likely to capture the length of historical variation.*



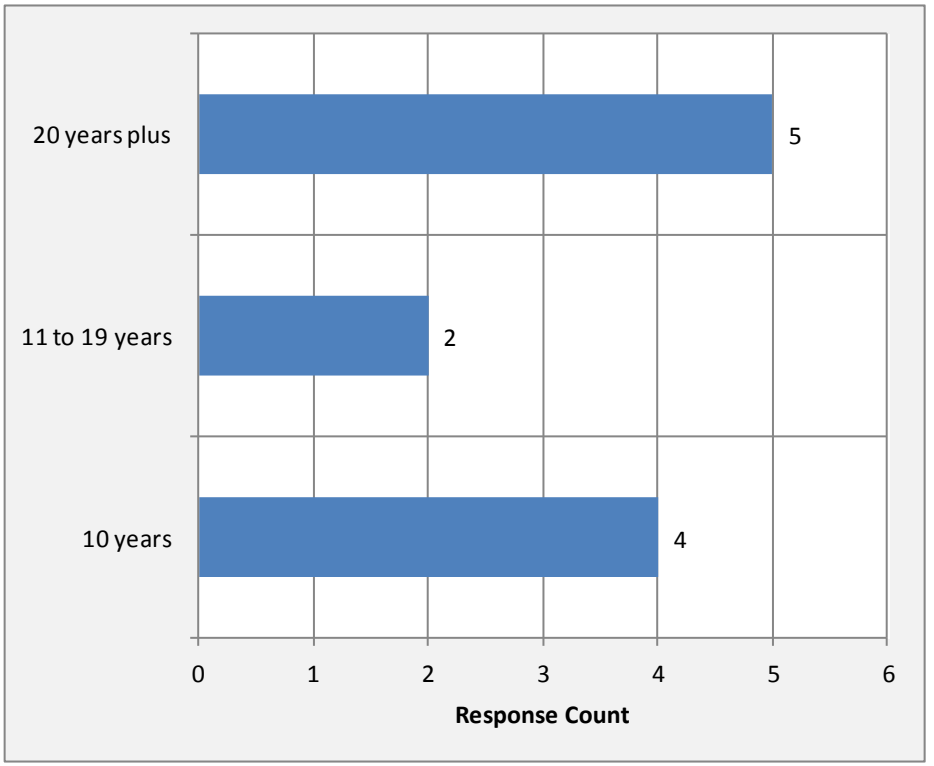
Selected comments

- *Robust atmospheric process models can address the climate change issue.*
- *I don't think long term climate is as big a risk as long term weather patterns.*
- *Climate appears to be changing faster than the life of a wind farm.*
- *It has to be investigated*
- *Probably but in fact, no one knows....*

Is there an 'ideal' period on which to base the long-term reference wind speed trend?



If “yes”, what is that period?



Selected comments

- *As long as possible, assuming data is reliable and consistent.*
- *There is still research to do on this issue.*
- *To be decided based on the financial structuring of the project.*

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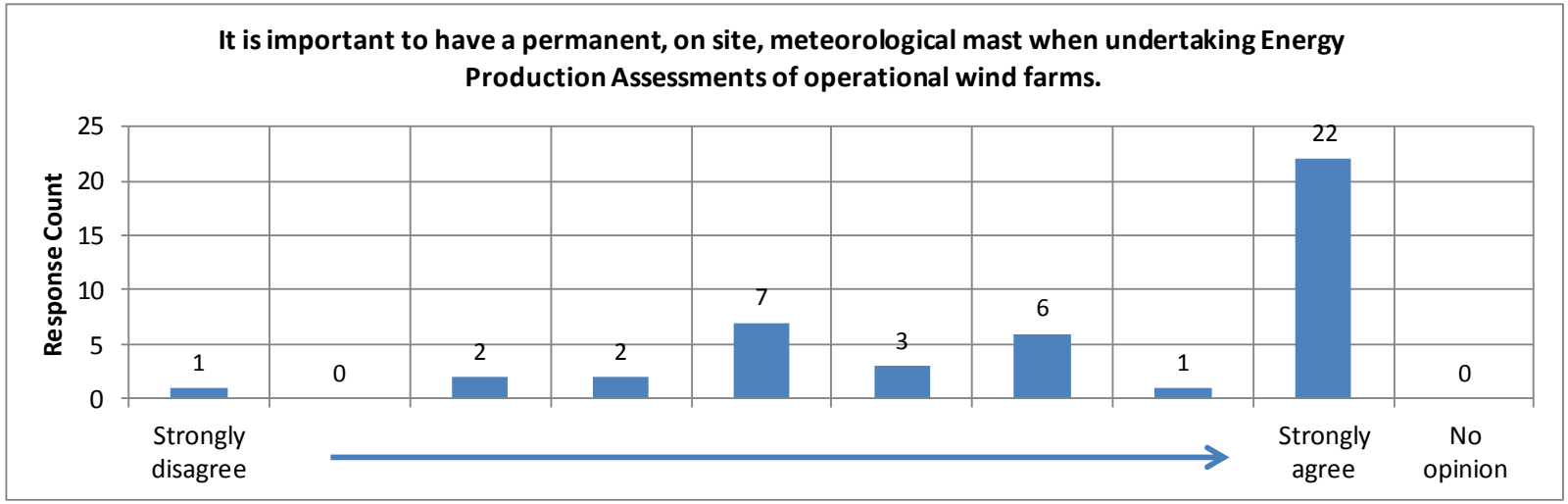
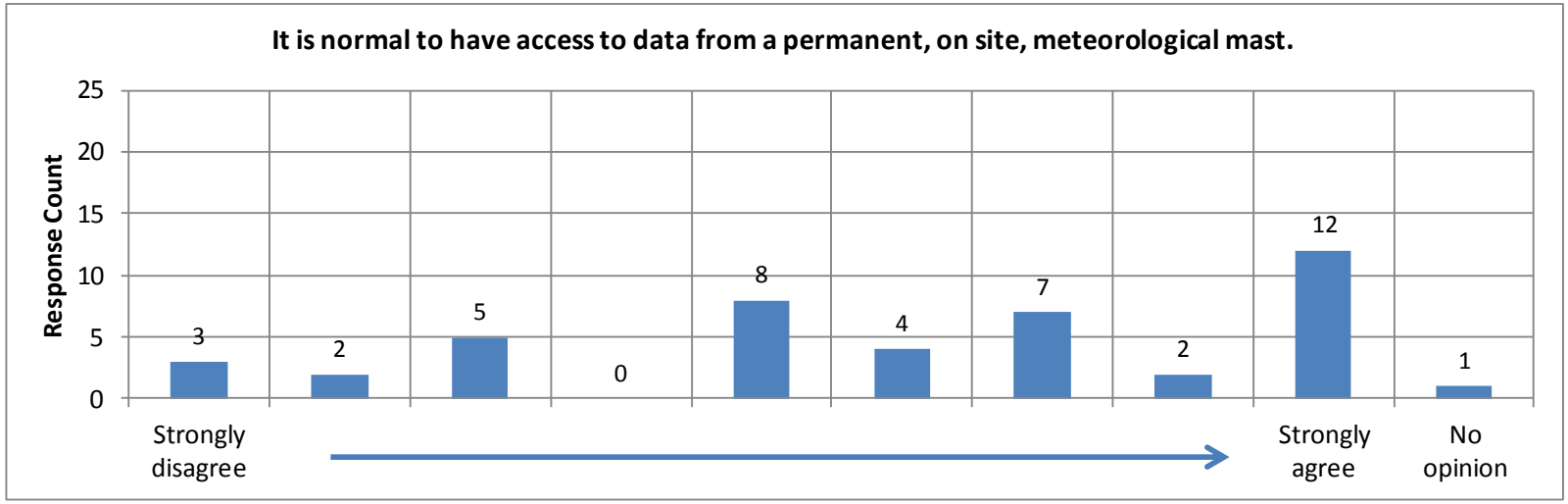
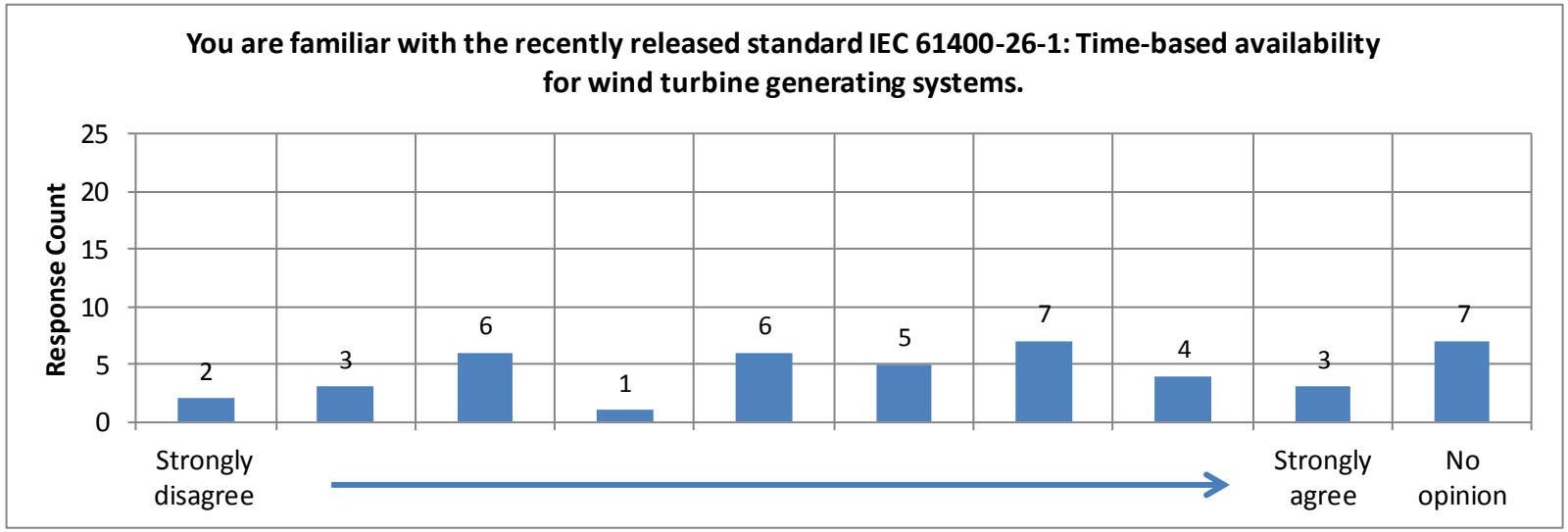
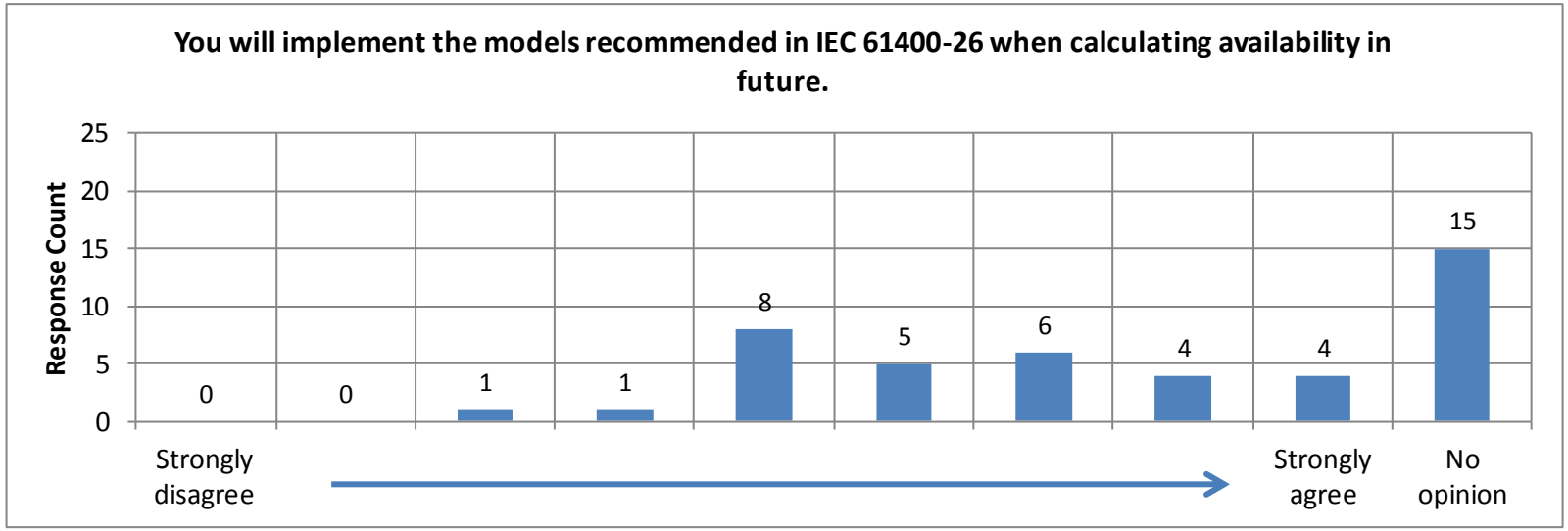
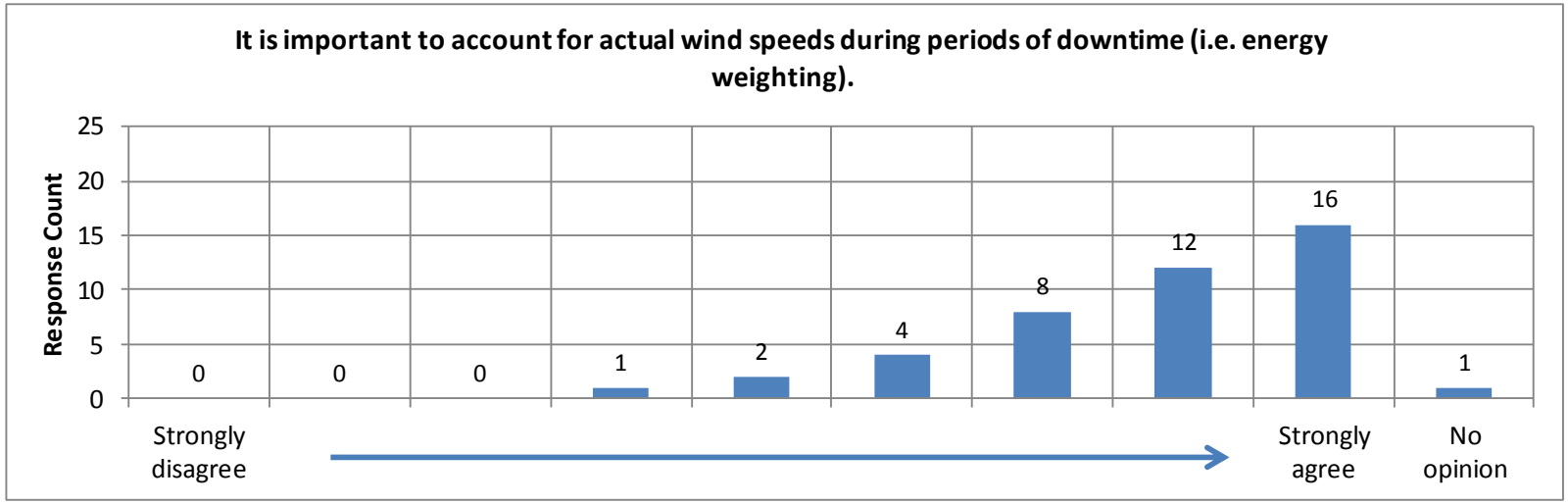

It is important to have a permanent, on site, meteorological mast when undertaking Energy Production Assessments of operational wind farms.
Response Count
25
20
15
10
5
0
1
0
2
2
7
3
6
1
22
0
Strongly disagree
Strongly agree
No opinion


It is normal to have access to data from a permanent, on site, meteorological mast.
Response Count
25
20
15
10
5
0
3
2
5
0
8
4
7
2
12
1
Strongly disagree
Strongly agree
No opinion

Section 5 – Availability analysis

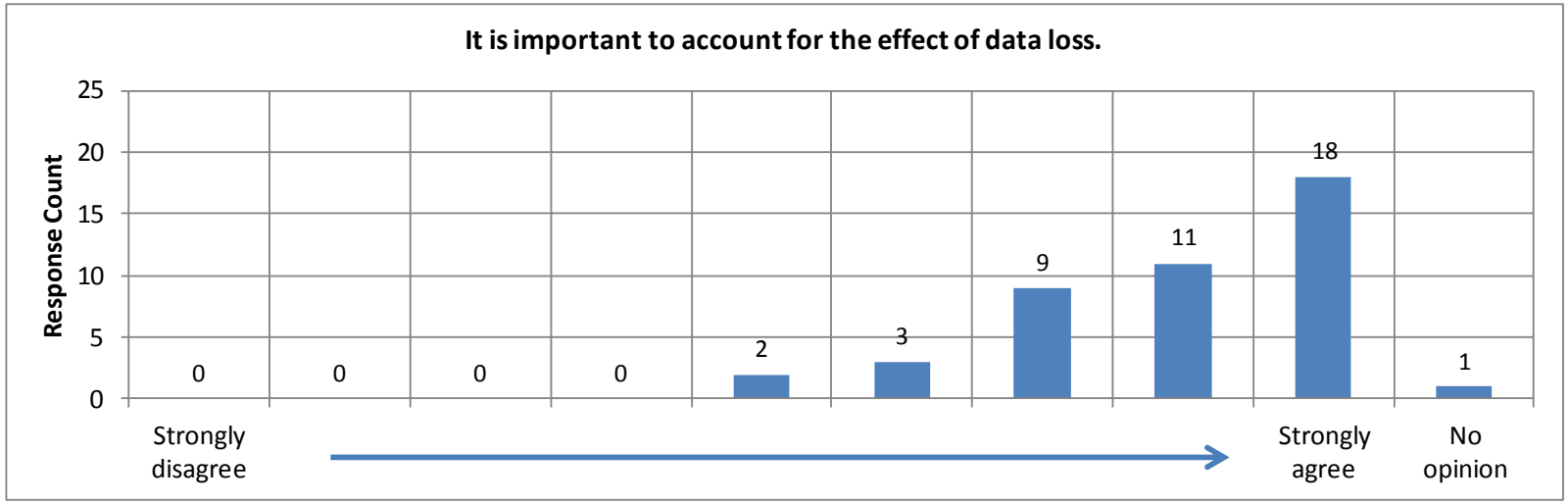

You are familiar with the recently released standard IEC 61400-26-1: Time-based availability for wind turbine generating systems.
Response Count
25
20
15
10
5
0
2
3
6
1
6
5
7
4
3
7
Strongly disagree
Strongly agree
No opinion


You will implement the models recommended in IEC 61400-26 when calculating availability in future.
Response Count
25
20
15
10
5
0
0
0
1
1
8
5
6
4
4
15
Strongly disagree
Strongly agree
No opinion

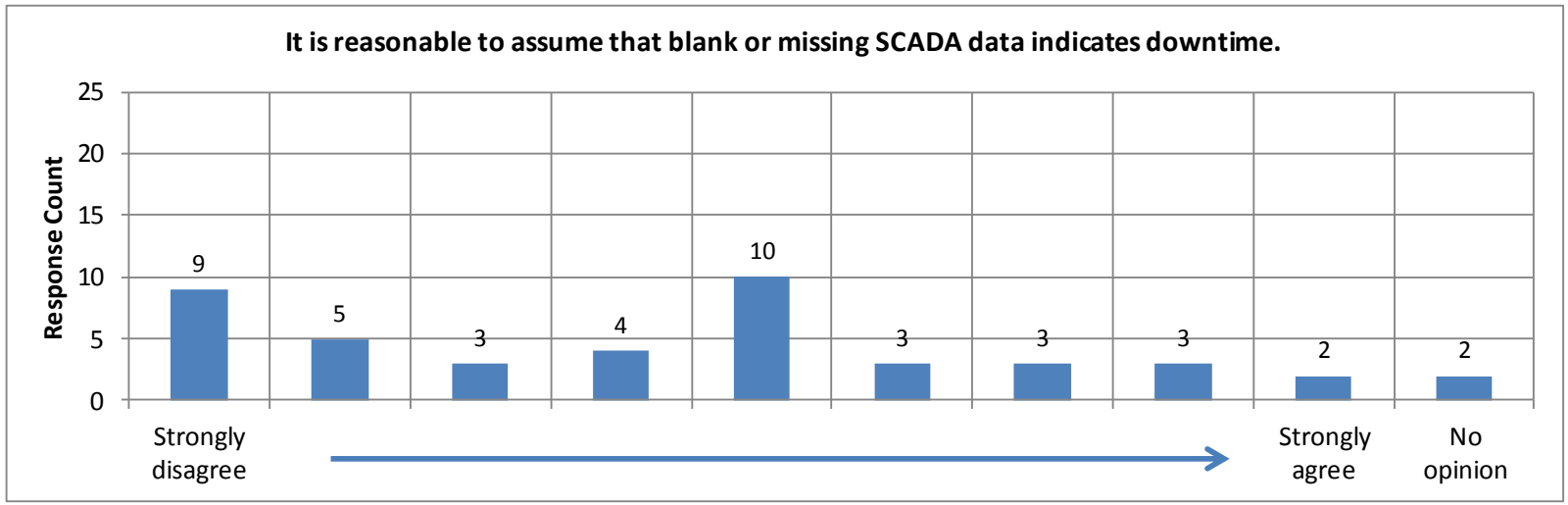


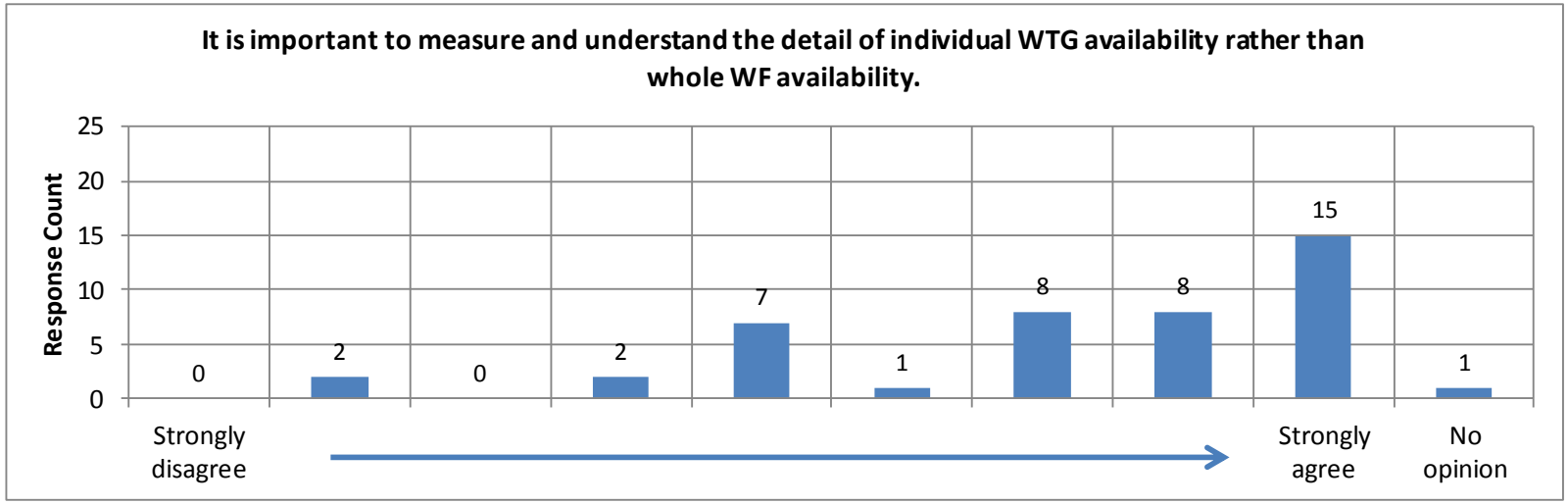
Selected comments

- *It is very important but also challenging. Energy weighting is a better method than linear scaling, but the best method is based on actual 10-minute data.*
- *Key when lots of down time in windy months*



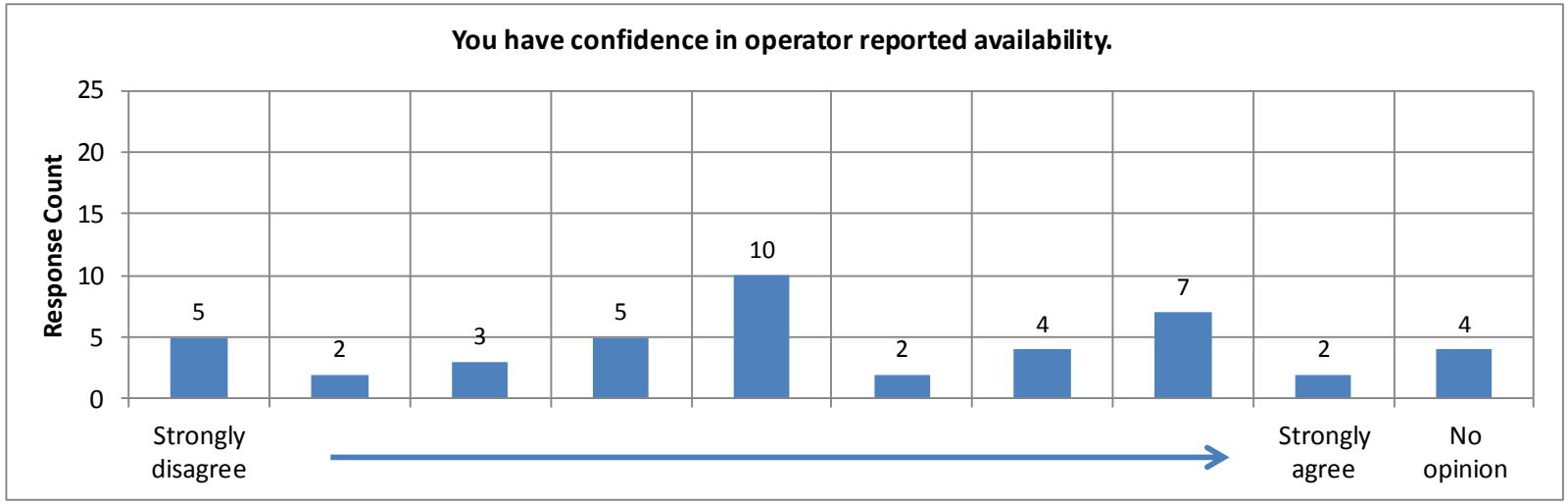
- *Is there much point in agreeing that something is important when it is so difficult to do with any accuracy? The thing about data loss is that there's no data to go on.*





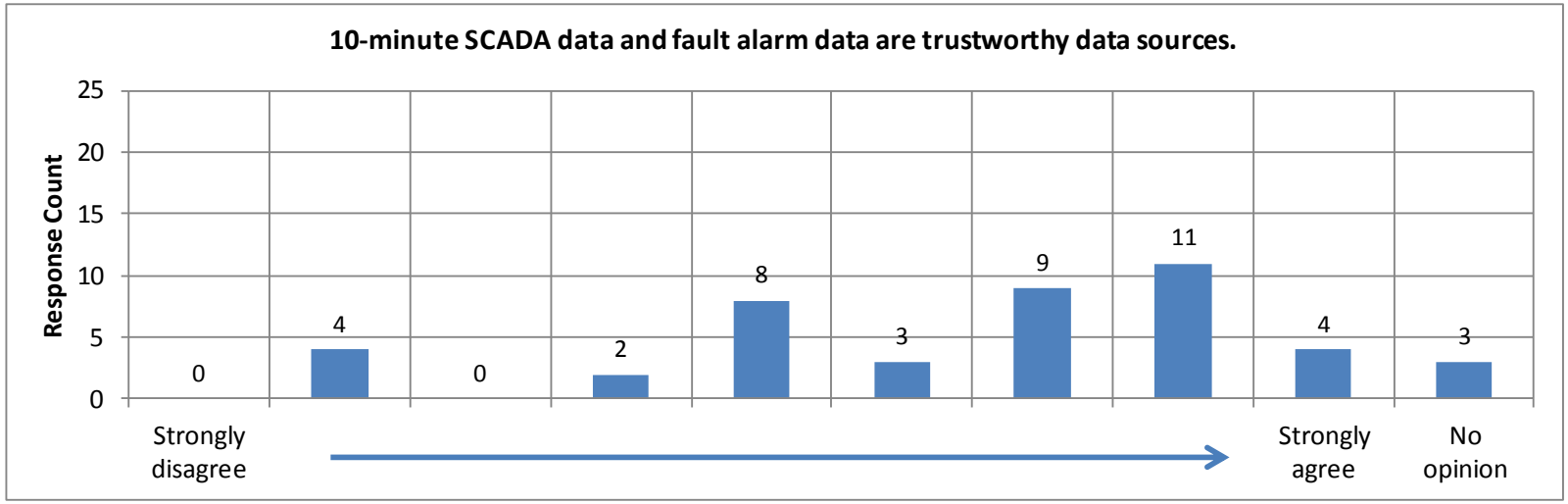
Selected comments

- *Once you understand the individual turbine production, it is rather straight forward to get the aggregate production.*
- *This is good operational practice but discretion may be used during energy yield assessment.*



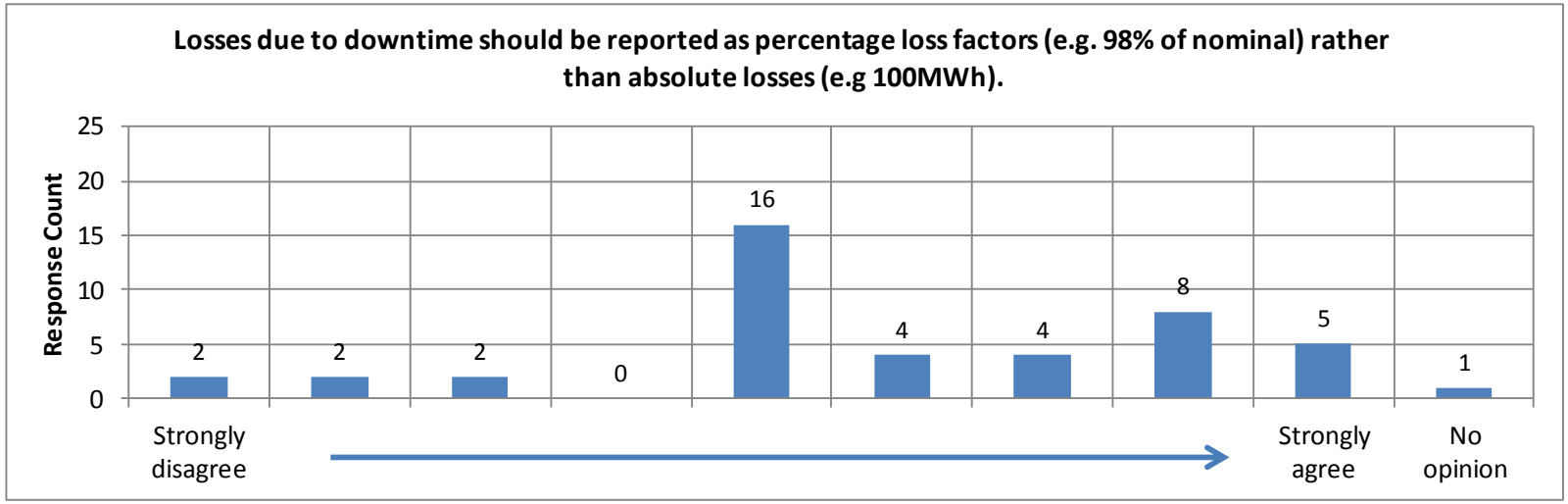
Selected comments

- *These are often contractual availabilities and do not represent all downtime.*
- *Contractual and technical availabilities are often very different, and contractual availability is rarely linked to any performance indicator*
- *Depends on the operator and the reporting!*
- *It's not a matter of trust, but of what you call "availability"... operator availability is defined to advantage the manufacturer.*



Selected comments

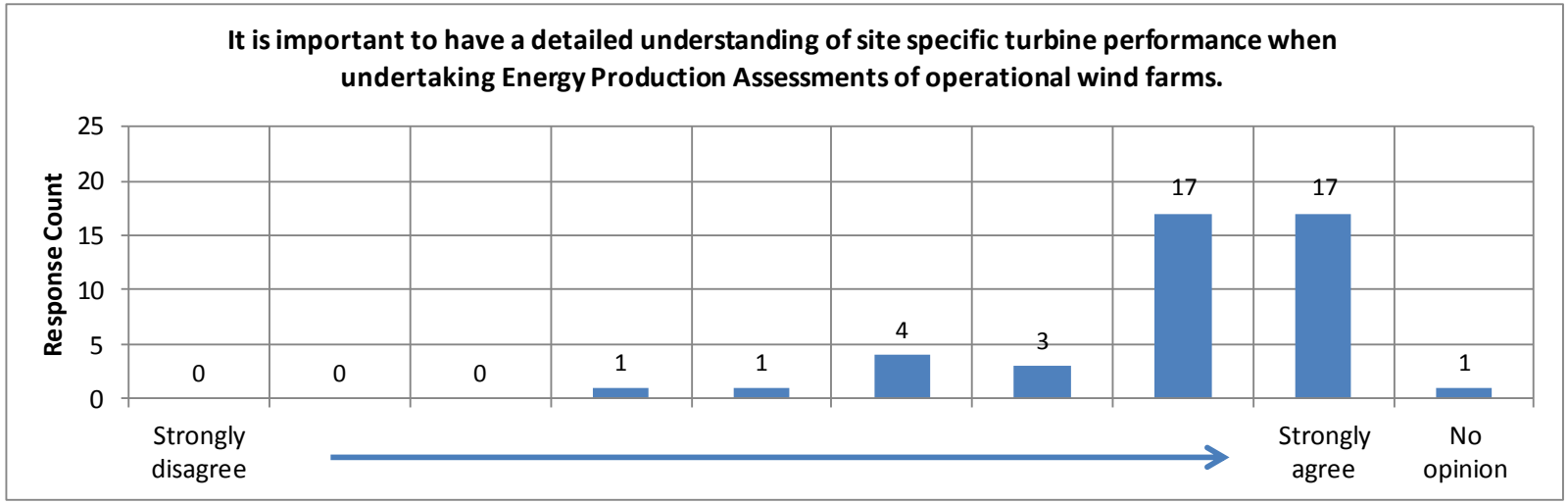
- *Generally yes, although I've used systems that seemed dubious.*
- *Wind speed measurements are notorious in SCADA systems for being poorly recorded*
- *Raw databases are trustworthy - excel and csv files can be more easily manipulated*
- *One can't generalize like the above. It depends on how things are at that particular wind farm.*
- *Detailed description of alarm codes is often not provided*

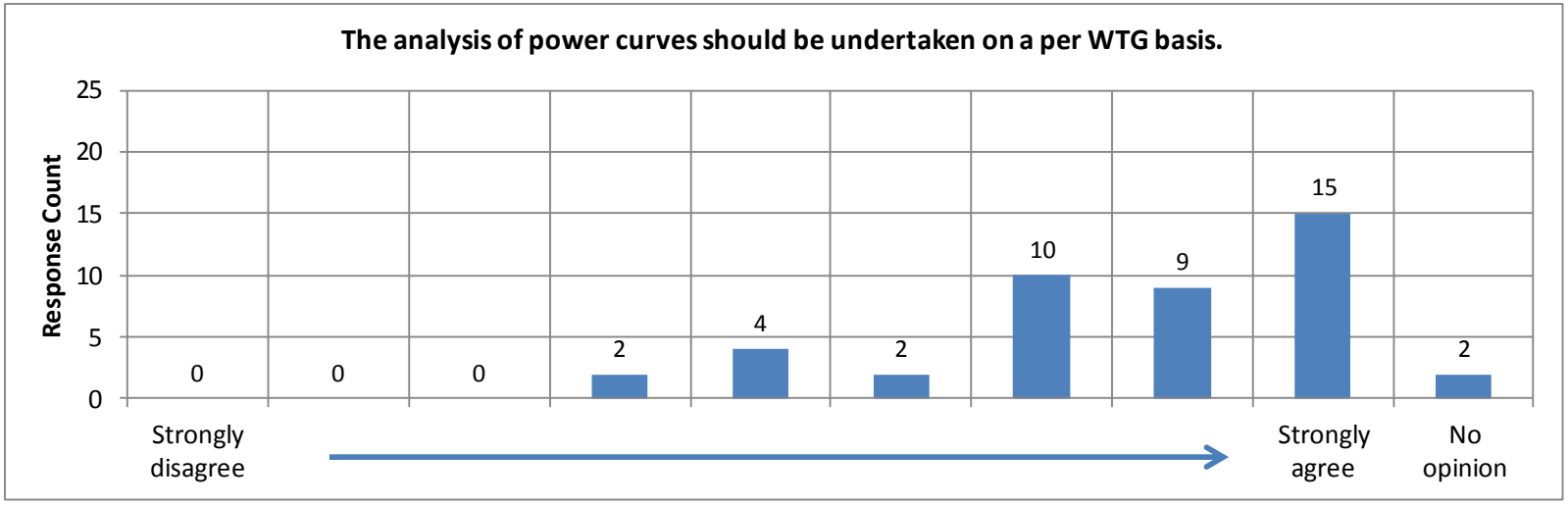


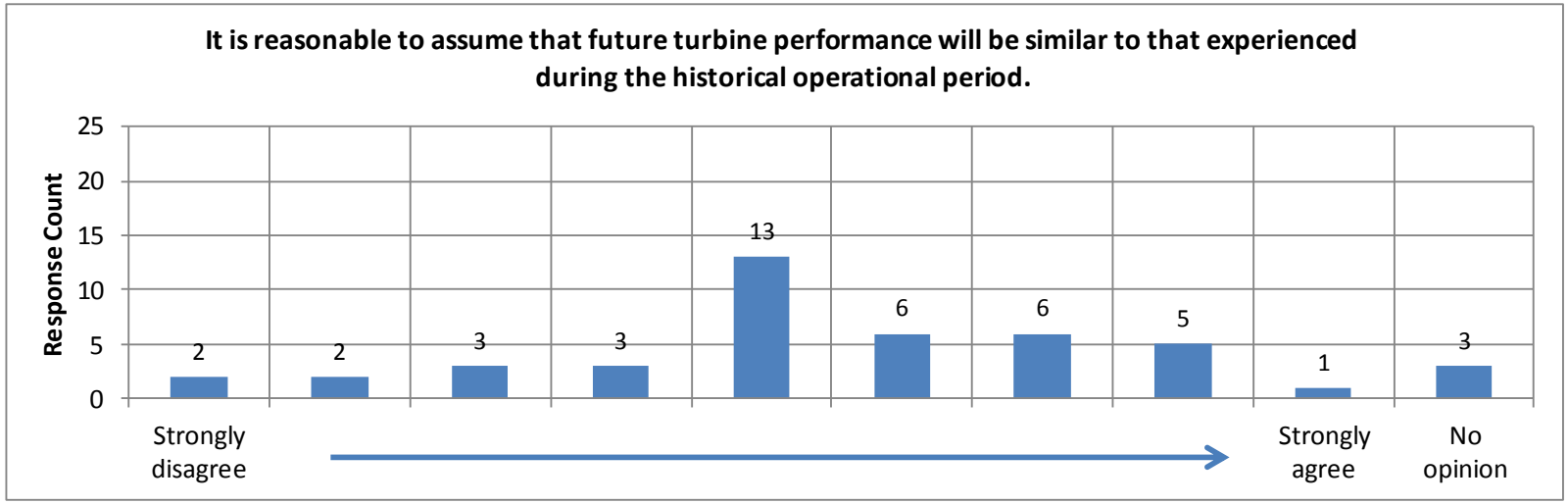
Selected comments

- *Why not both?*
- *Either way is fine, as long as they are telling the same story consistently.*
- *Methodology of loss calculation needs to be transparent to use absolute loss data.*

Section 6 – Power Curve Analysis

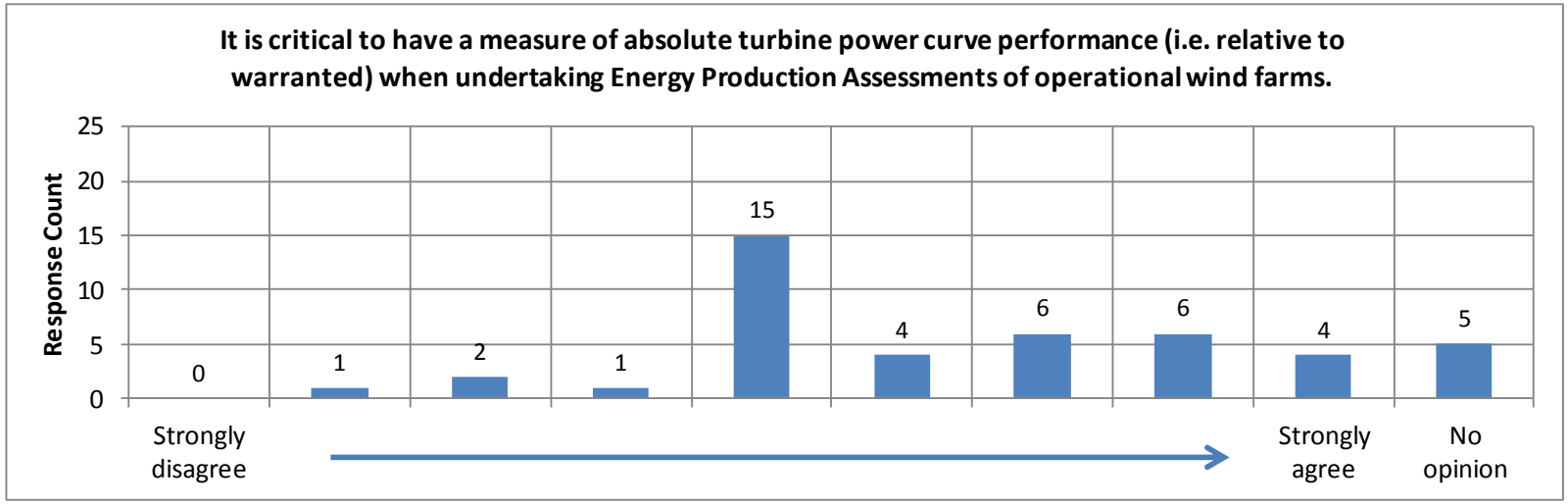

It is important to have a detailed understanding of site specific turbine performance when undertaking Energy Production Assessments of operational wind farms.
Response Count
25
20
15
10
5
0
0
0
0
1
1
4
3
17
17
1
Strongly disagree
Strongly agree
No opinion


The analysis of power curves should be undertaken on a per WTG basis.
Response Count
25
20
15
10
5
0
0
0
0
2
4
2
10
9
15
2
Strongly disagree
Strongly agree
No opinion



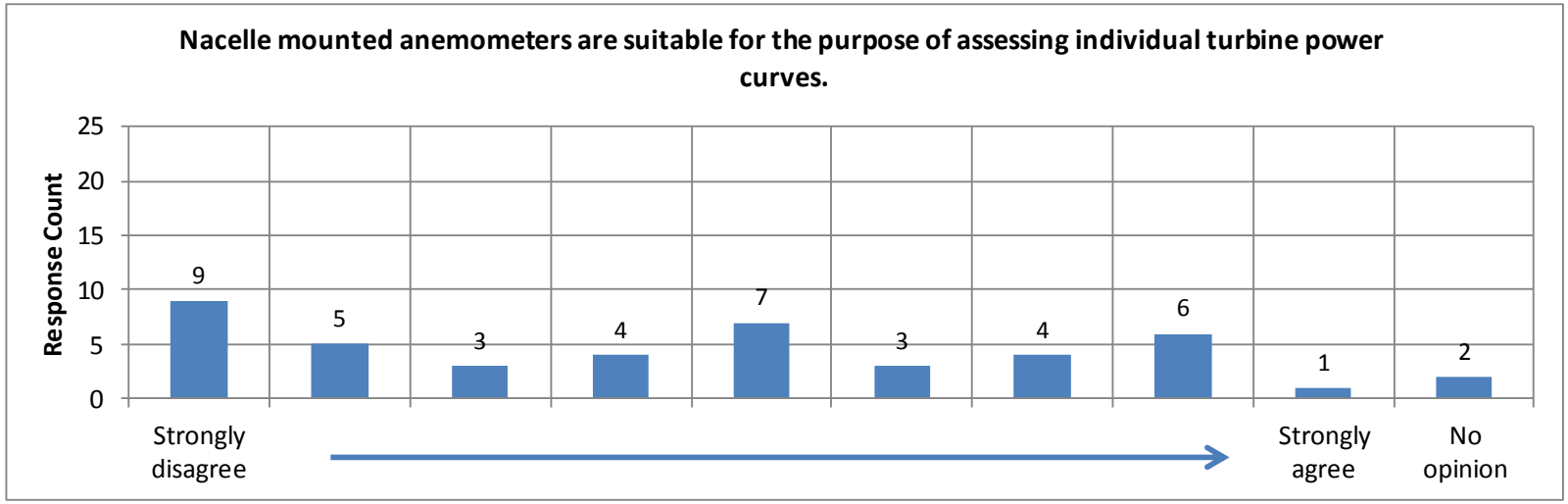
Selected comments

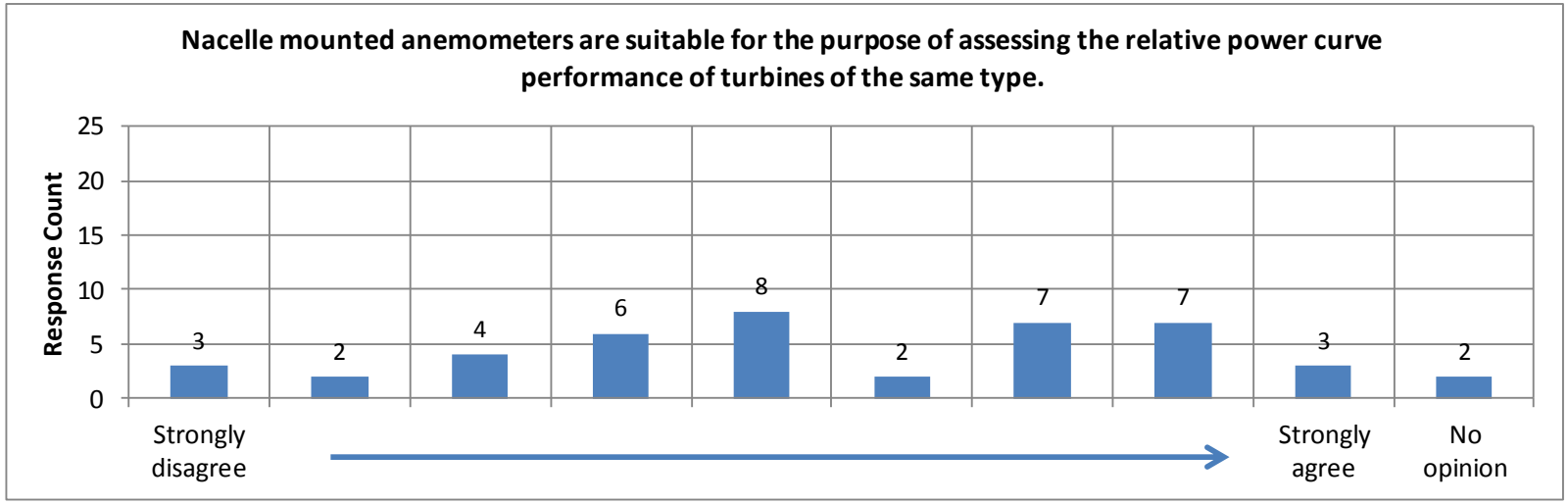
- *Although this is never a reasonable assumption, it is usually the only assumption feasible to make an assessment.*
- *There should be an assumption that turbine efficiency and availability will decrease as components wear over time.*
- *Should be informed by the site operator.*
- *Degradation due to soiling could be added, depends on maintenance aspects.*
- *Depends on the age of the turbine.*



Selected comments

- *The power curve performance level can usually be assumed representative of the future level and is inherent in the data.*
- *No it is not critical as this would mean power curve measurement of every turbine which is impractical. Much can be done without this.*
- *We tend not to use warranted power curves due to nacelle bias.*
- *This can help identify where there are opportunities to improve and where there is a trend of reducing efficiency*
- *It is useful, but not critical*





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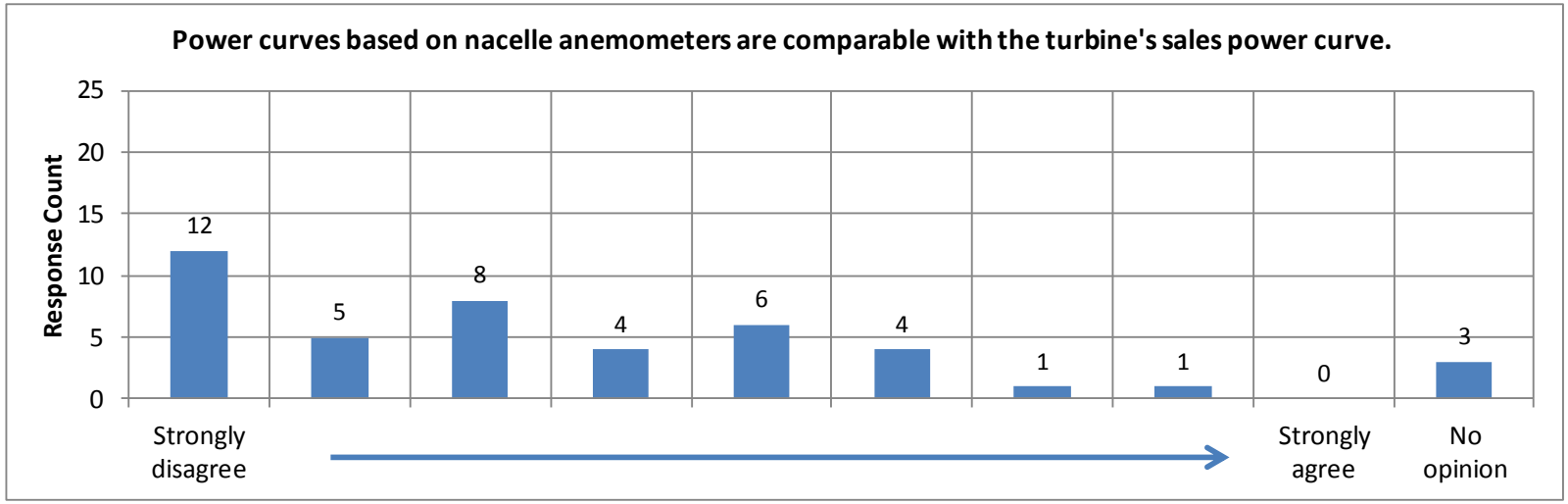
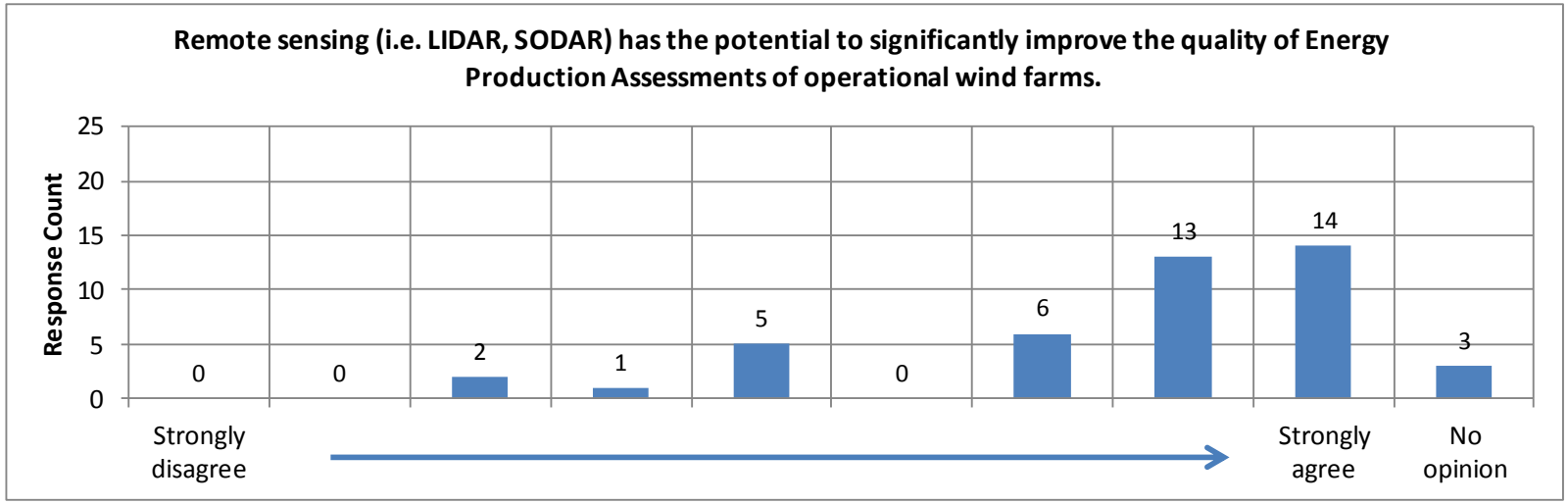


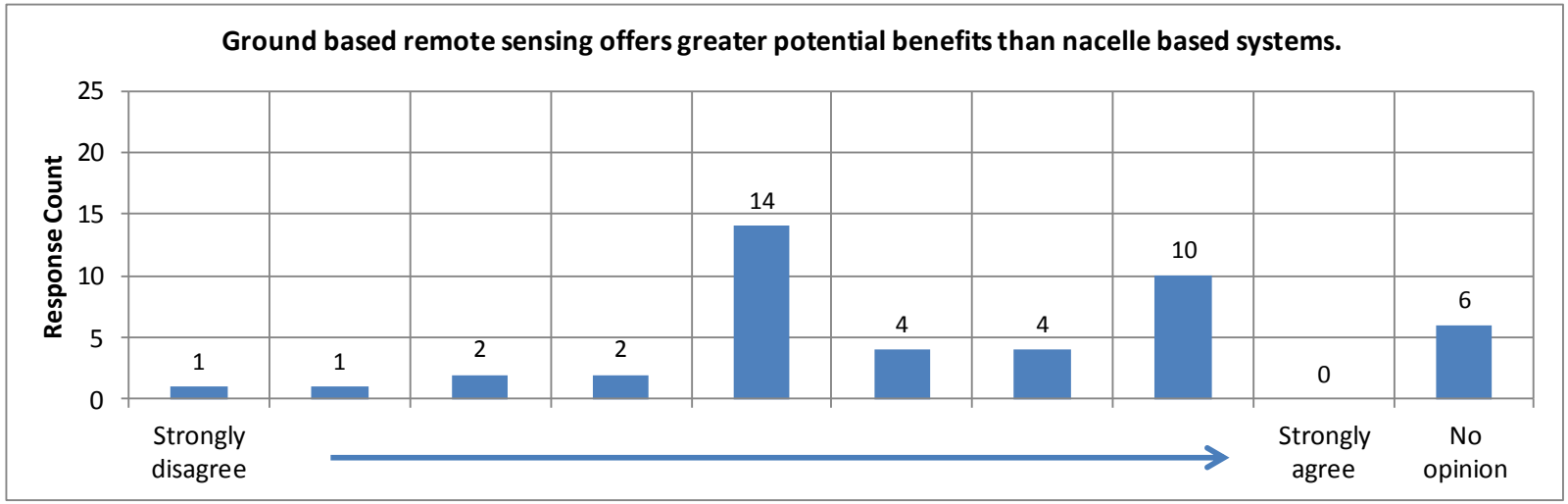
Selected comments

- *This is never the case as turbine's sales power curves are based on idealized environmental conditions.*
- *Depends greatly on the accuracy and validity of the correction applied.*
- *On some turbine yes, others no*



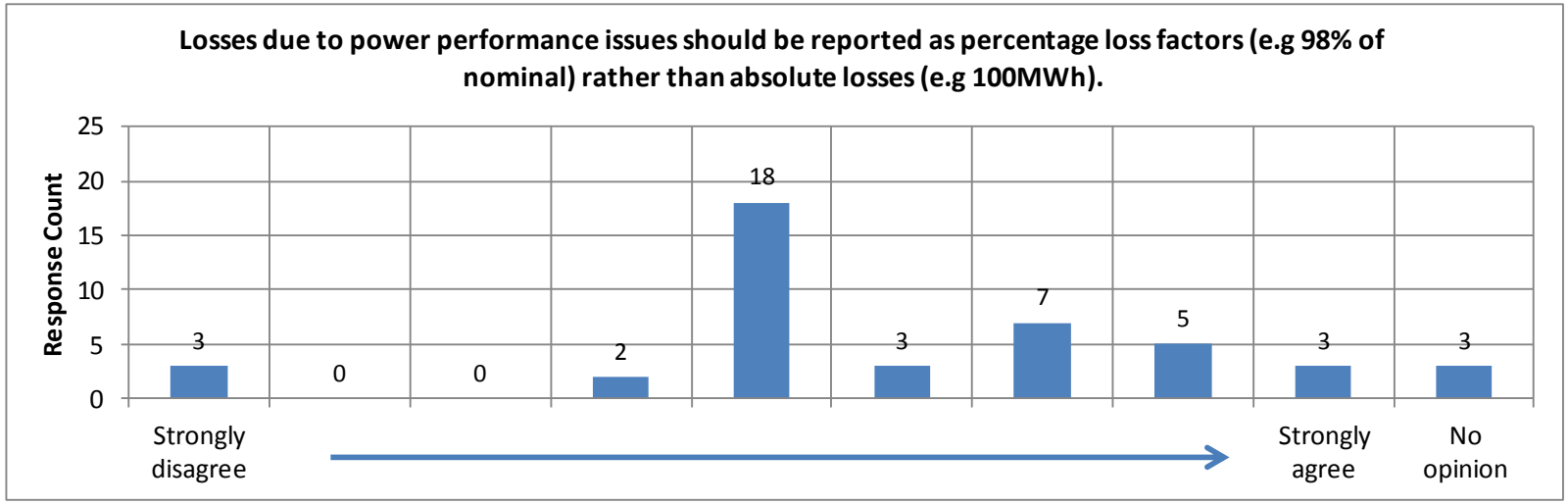
Selected comments

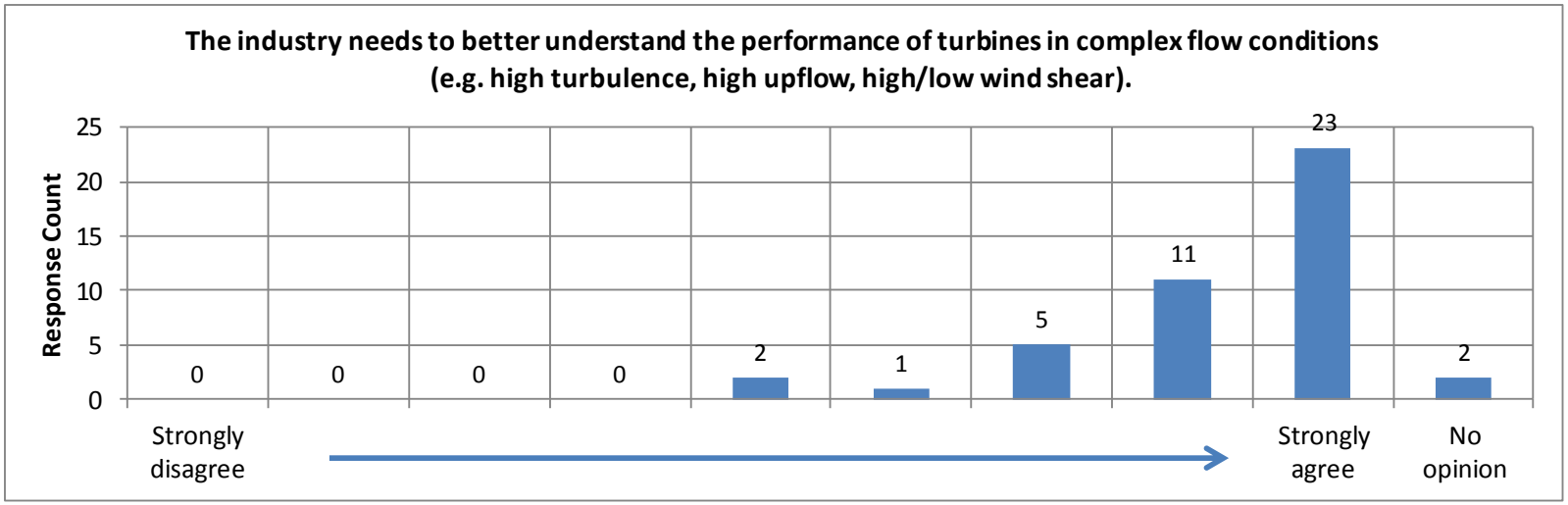
- *They should be used most before setting up the project. Their use within an large operational wind farm has large uncertainties...*
- *This technology can help. For a small farm the cost of renting a LIDAR and SODAR might be justified. But for a medium/large farm with met mast it is unlikely to be.*
- *Too expensive at present*



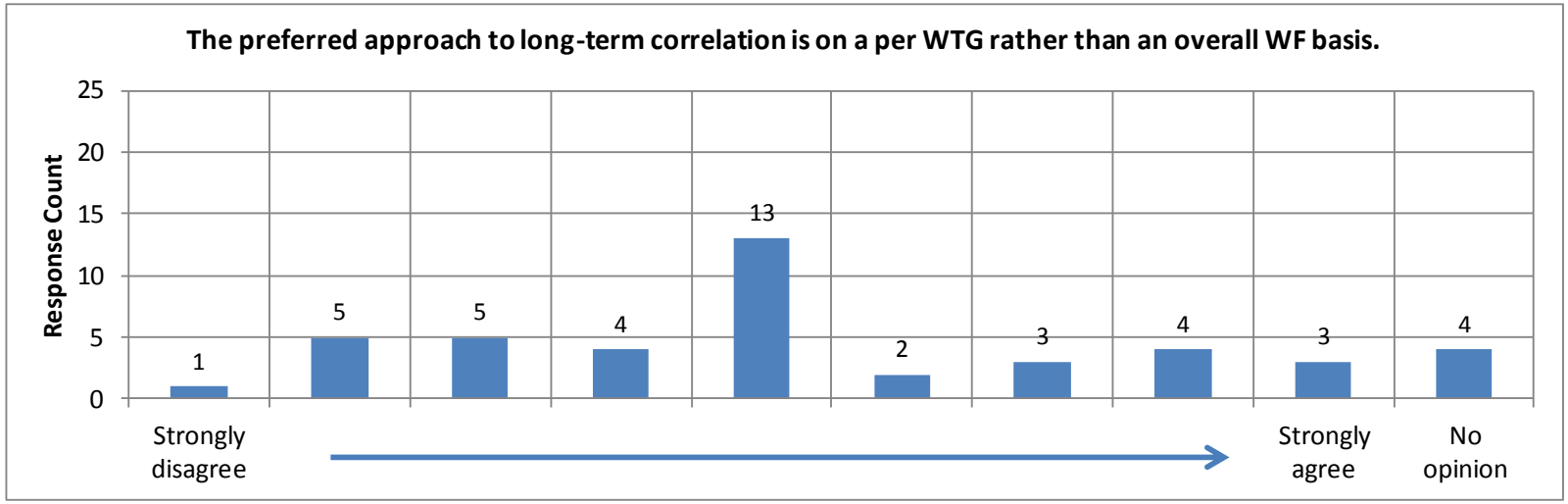
Selected comments

- *They are complementary.*
- *The nacelle based system averaging method reduces information about wind shear upstream compared to a ground-based measurement.*
- *Some nacelle based remote sensing systems can avoid nacelle based problems.*


Losses due to power performance issues should be reported as percentage loss factors (e.g 98% of nominal) rather than absolute losses (e.g 100MWh).
Response Count
25
20
15
10
5
0
3
0
0
2
18
3
7
5
3
3
Strongly disagree
Strongly agree
No opinion

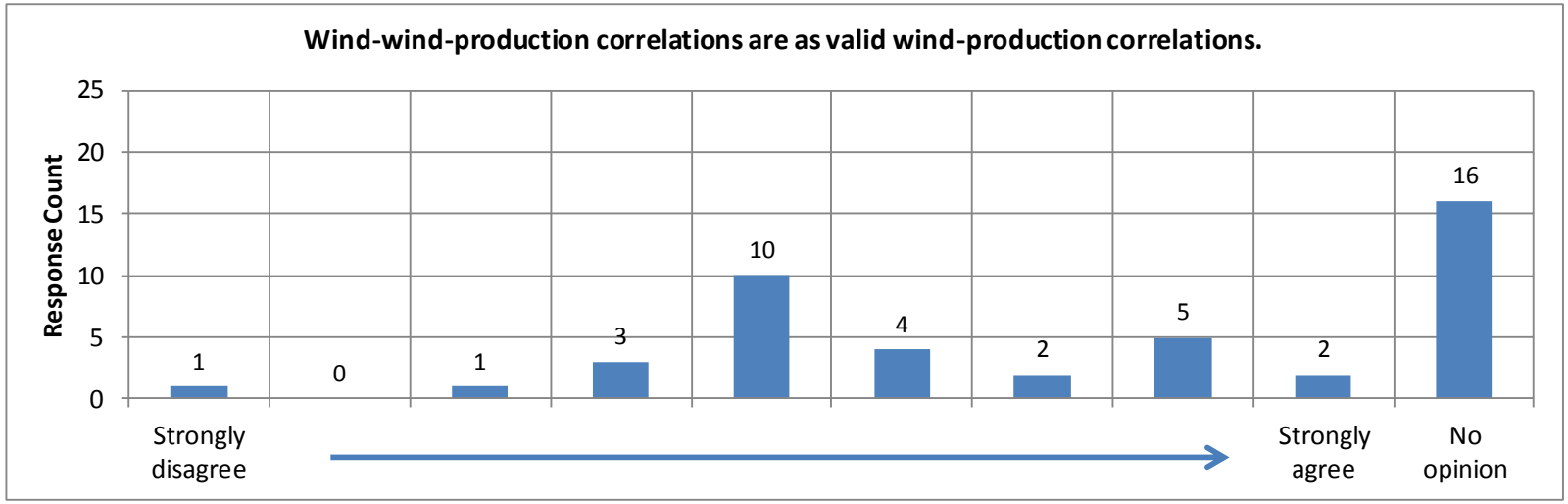

The industry needs to better understand the performance of turbines in complex flow conditions (e.g. high turbulence, high upflow, high/low wind shear).
Response Count
25
20
15
10
5
0
0
0
0
0
2
1
5
11
23
2
Strongly disagree
Strongly agree
No opinion

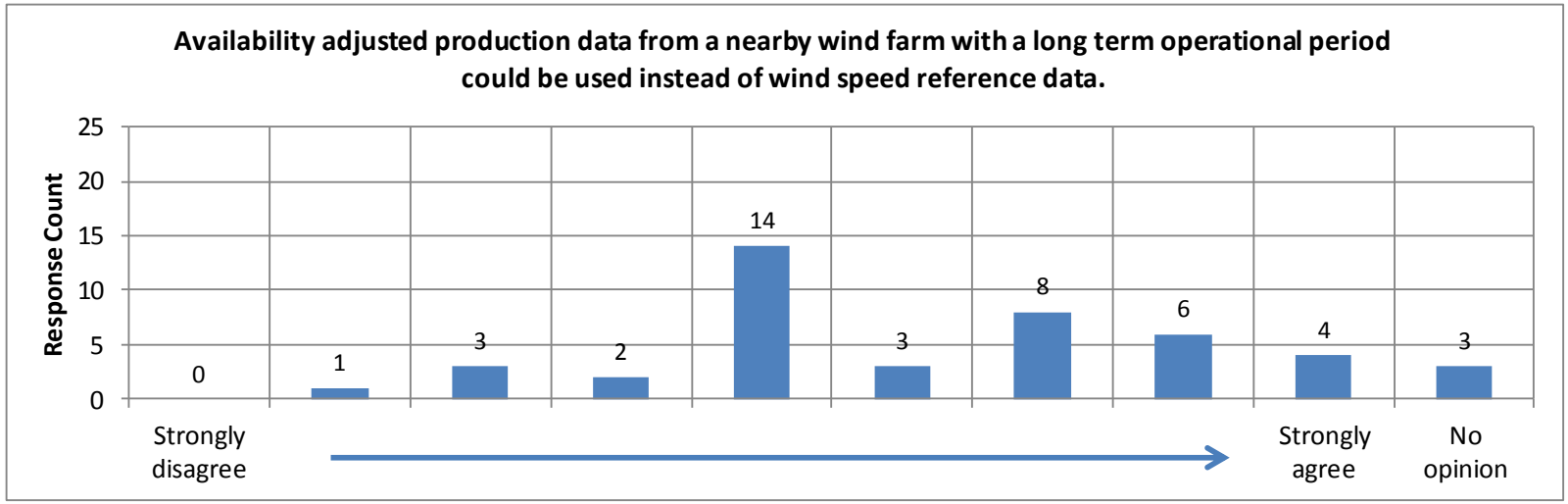
Section 7 – Long-term Correlation

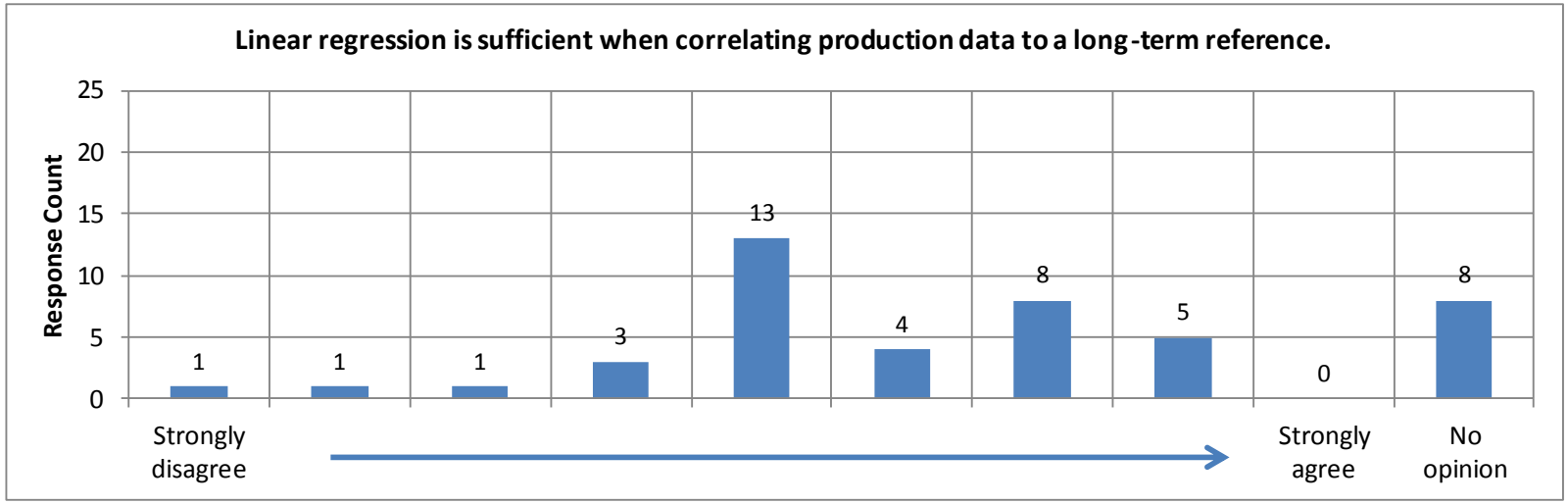


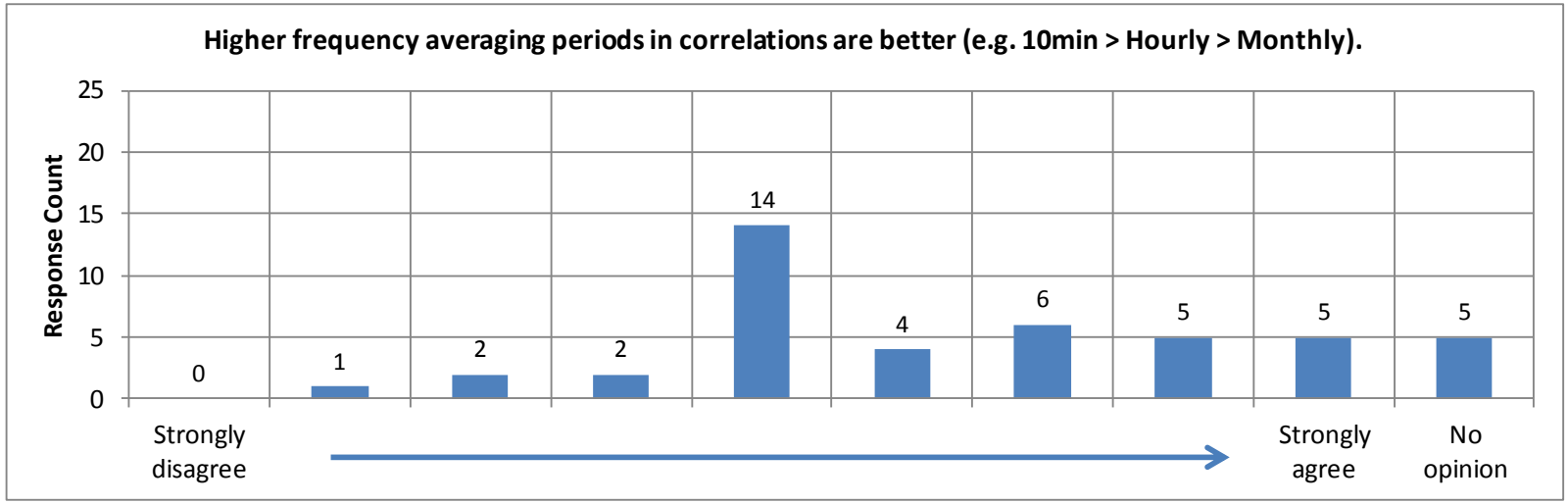
Selected comments

- *Would need to be confident in the production measurement at the individual turbines.*
- *Although, in theory, more correct, it is unlikely that this will be an applicable approach in most cases. Overall WF basis should be accurate enough.*


Wind-wind-production correlations are as valid wind-production correlations.
Response Count
25
20
15
10
5
0
1
0
1
3
10
4
2
5
2
16
Strongly disagree
Strongly agree
No opinion


Availability adjusted production data from a nearby wind farm with a long term operational period could be used instead of wind speed reference data.
Response Count
25
20
15
10
5
0
0
1
3
2
14
3
8
6
4
3
Strongly disagree
Strongly agree
No opinion





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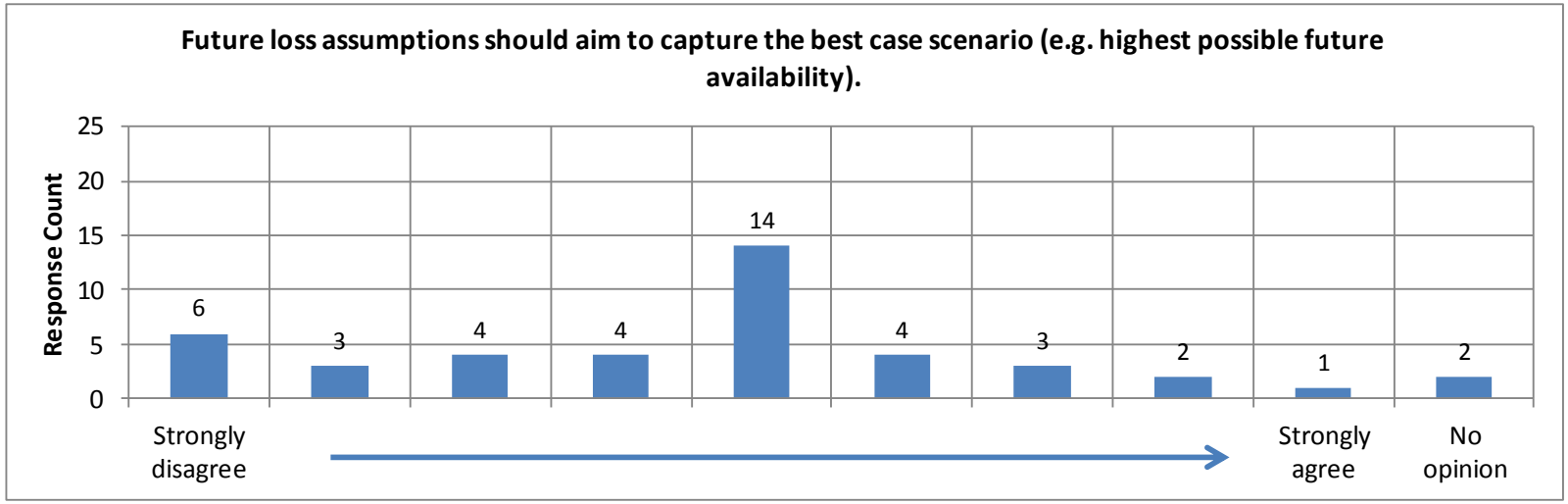
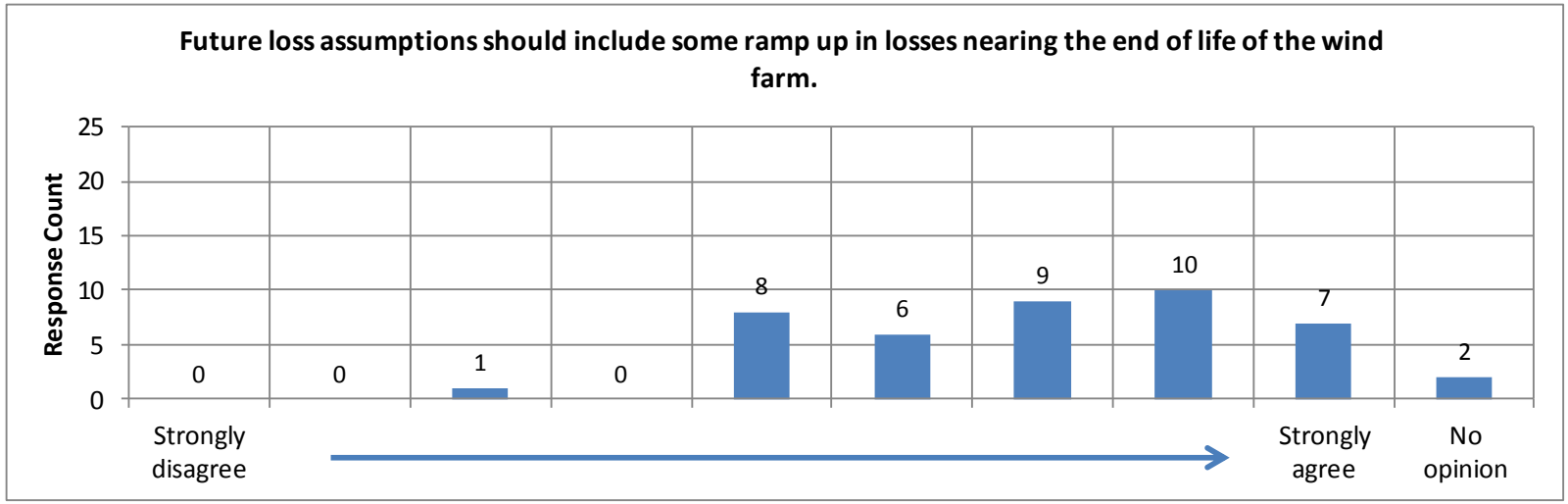
Section 8 – Future operational loss factors





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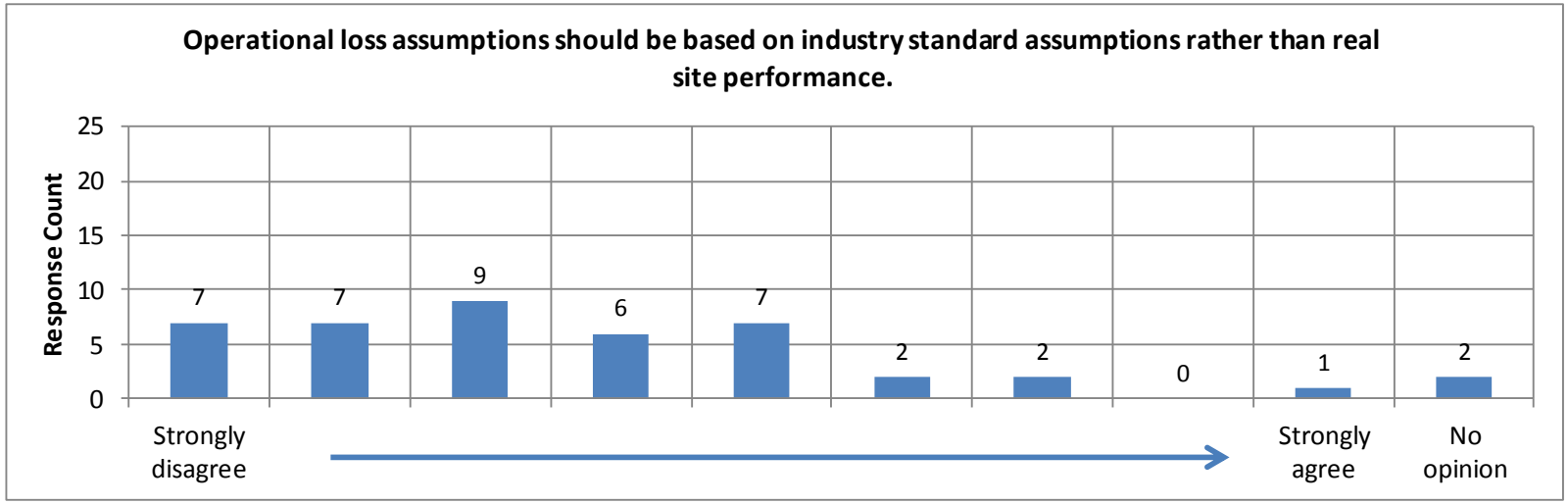

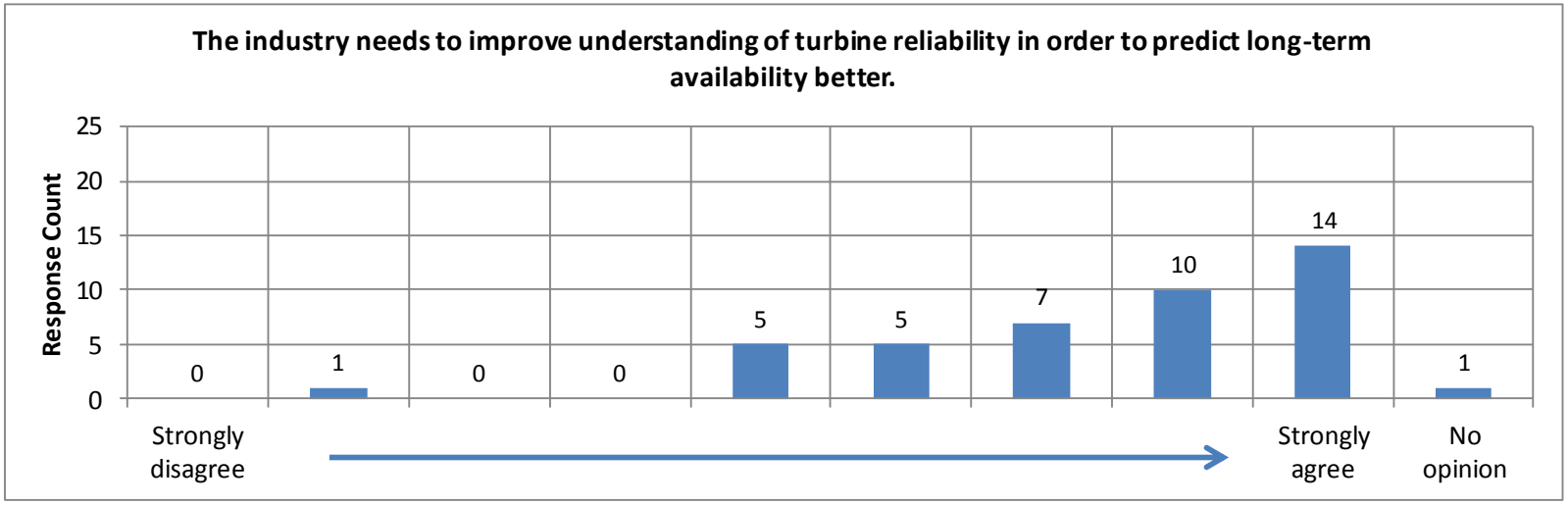

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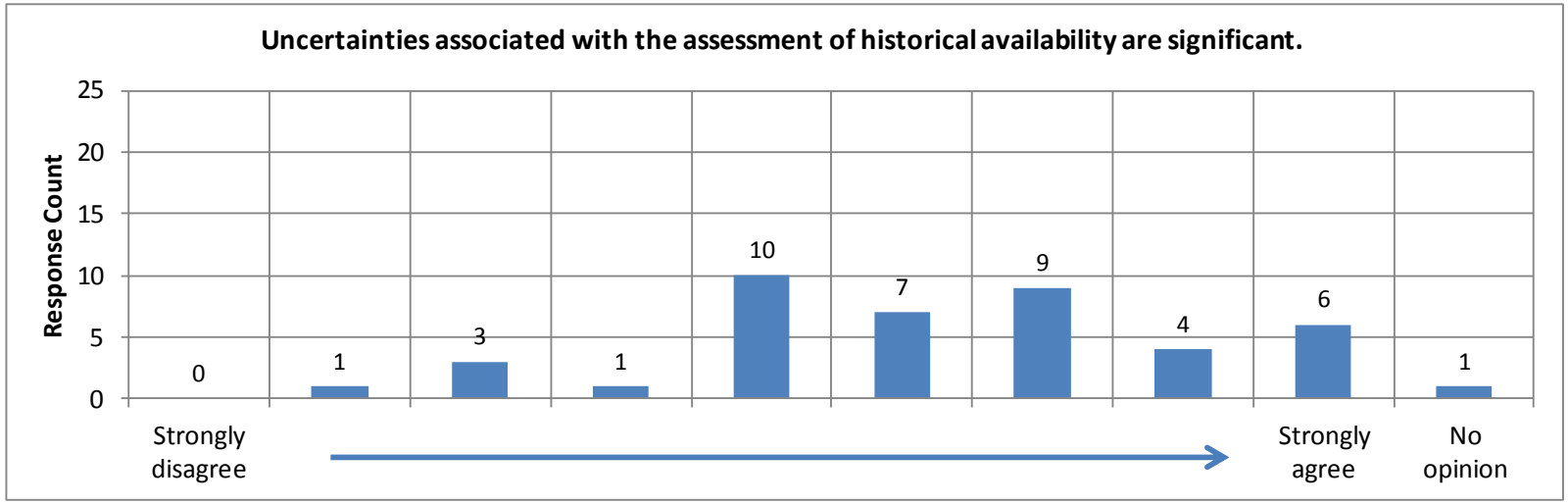
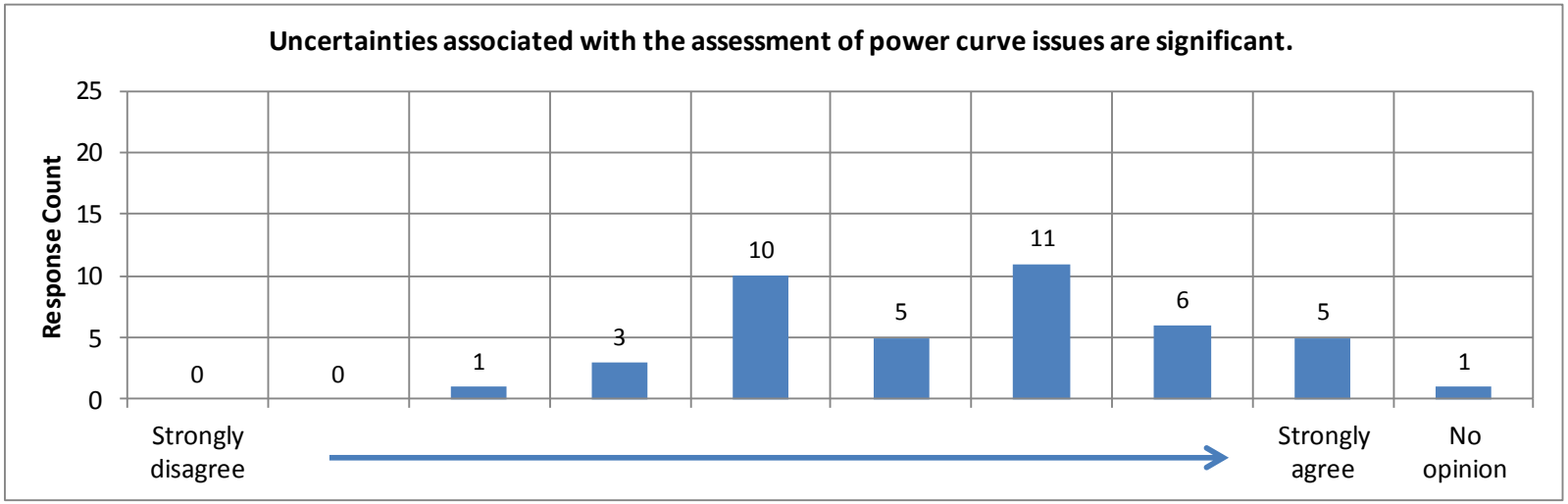
Section 9 – Uncertainty analysis





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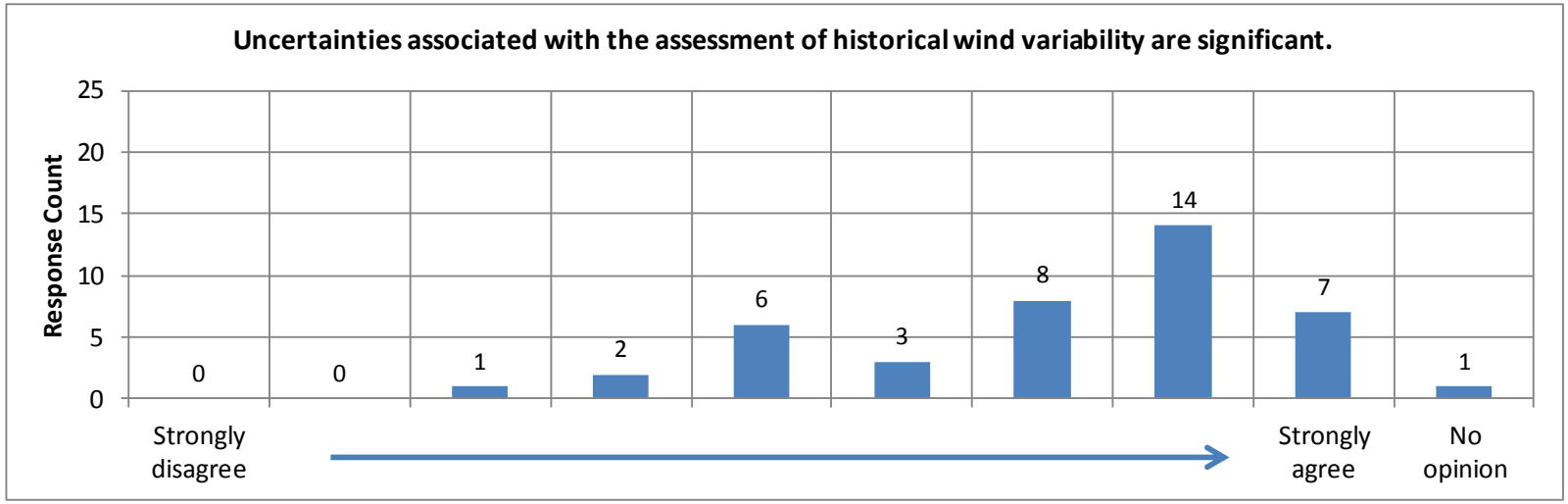

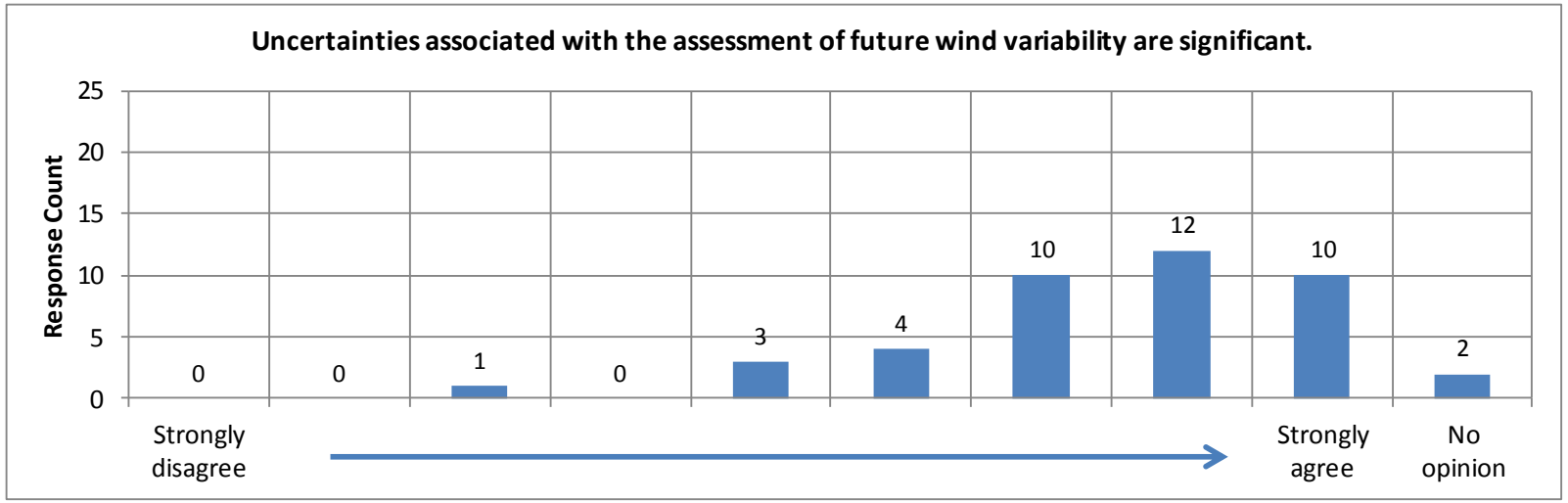

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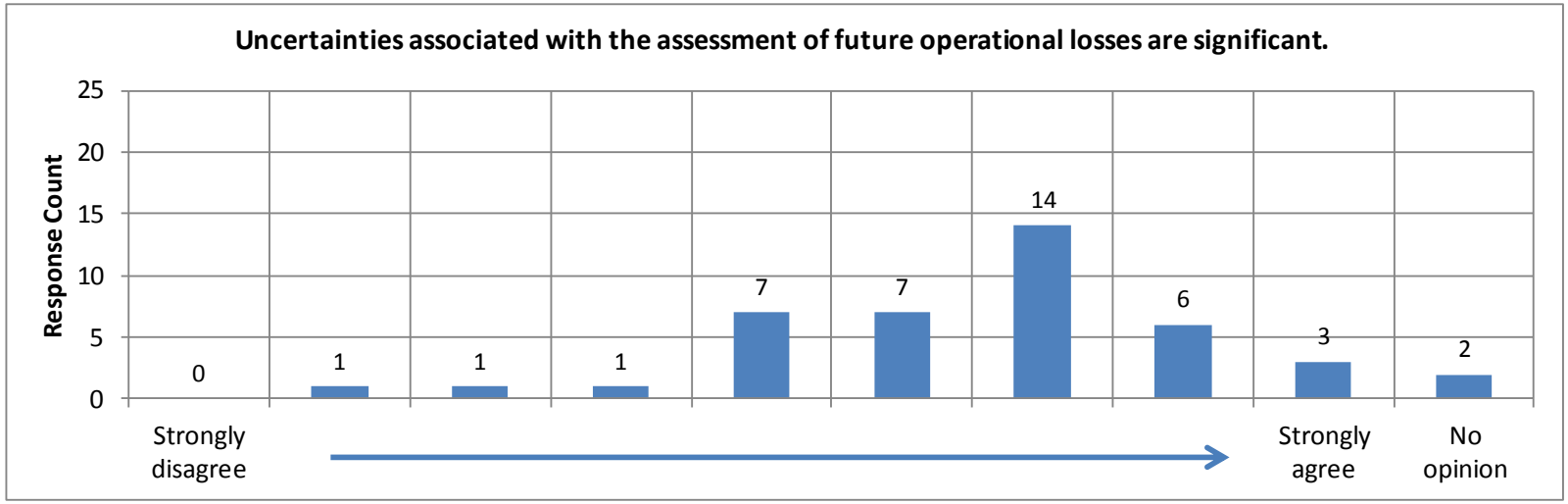

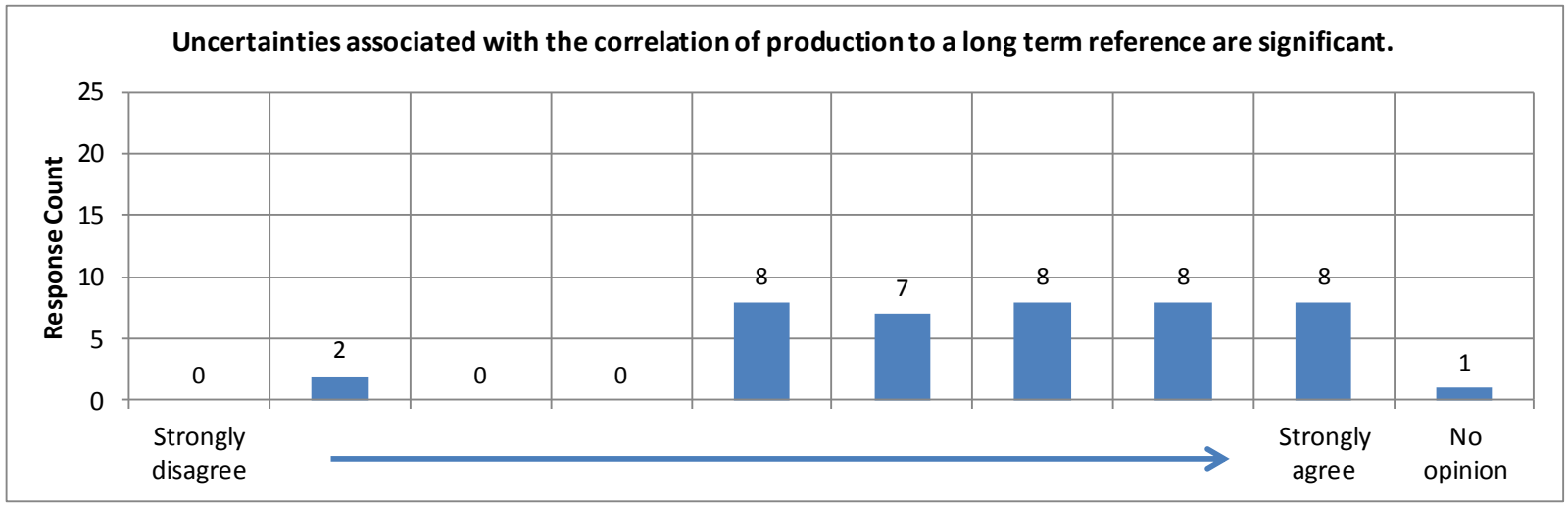

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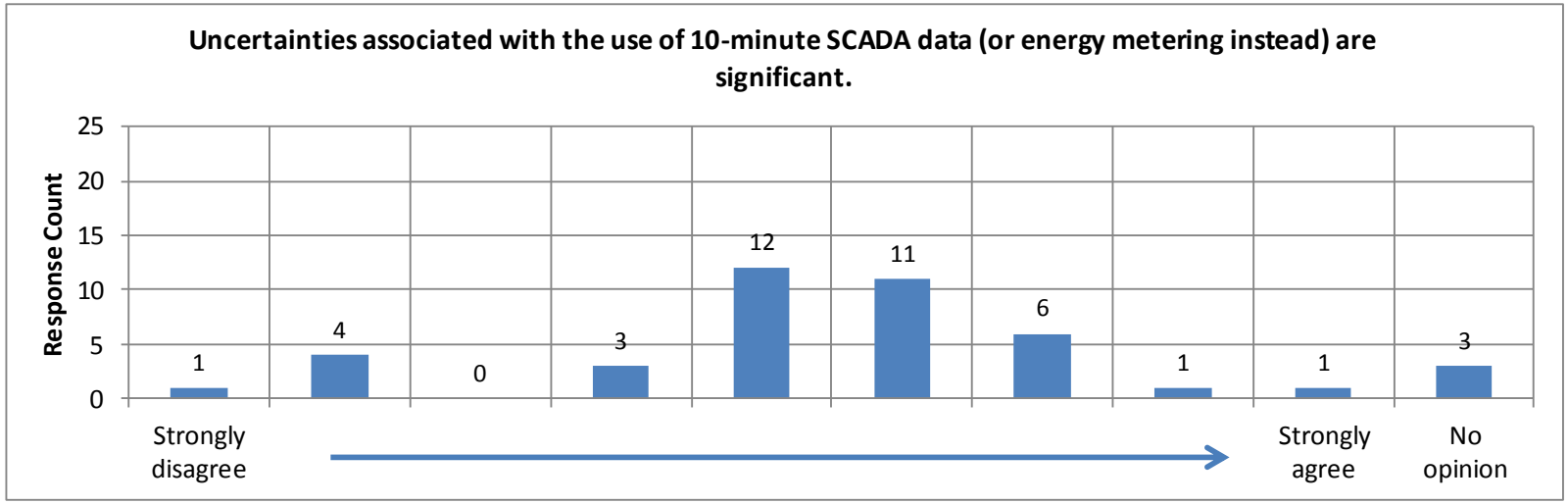

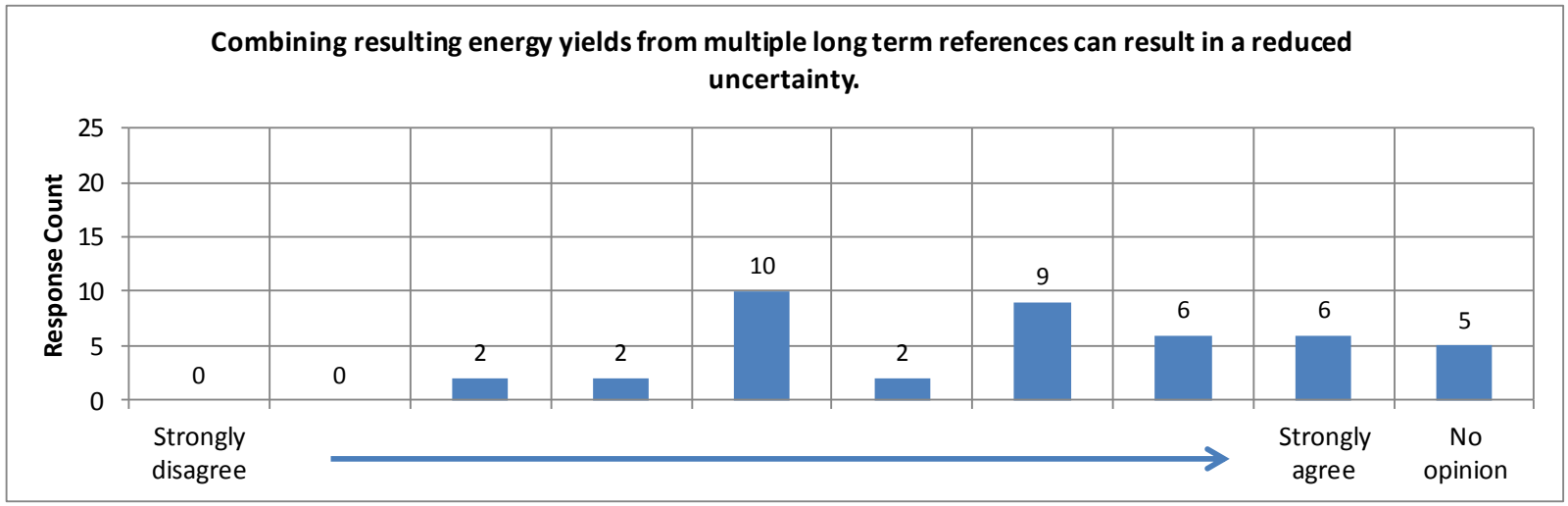

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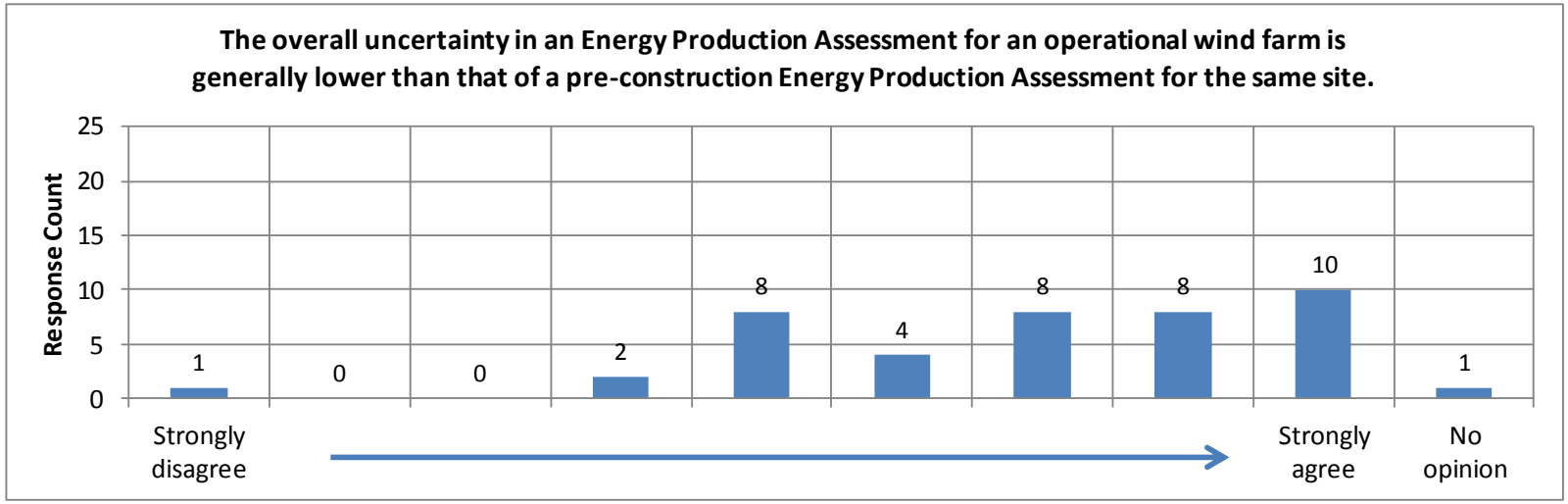

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- AXYS Technologies, Canada
- Barlovento Recursos Naturales, Spain
- BBB Umwelttechnik GmbH, Germany
- DCNS, France
- DNV KEMA, Netherlands
- Dong Energy, Denmark
- DTU Wind Energy, Denmark
- ECN, The Netherlands
- Entegra Ltd, India
- Eole Generation, France
- EOLE-RES, France
- E.ON New Build and Technology, UK
- ERELIA / GDF SUEZ, France
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