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Institut für Zukunftsstudien und Technologiebewertung
Institute for Futures Studies and Technology Assessment

Project Report

for the

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Iterative expert survey on risks to keeping decarbonisation of EU power systems on track

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Summary

The decarbonisation process in the EU is and will be confronted with a broad spectrum of risks which might jeopardise its success. As one specific module of the ECF-project “From Roadmaps to Reality (R2R)” our researcher-team of the IZT was asked to conduct a Delphi survey in order to get assessments on the various risks from a broad variety of experts from EU-countries.

A Delphi study was conducted with two rounds of responses from experts. For that purpose a questionnaire in two versions was produced and a database was created with input from IZT and ECF. Based on the two rounds of our Delphi survey we were able to up-date the expert database considerably.

Despite all necessary preparations as well as additional efforts it was not possible to receive the targeted 100 – 150 responses from the expert community in the EU. There were 37 responses from experts in the first round and 50 in the second round. Altogether – considering the overlap of experts participating in round 1 as well as in round 2 there were 73 experts from 10 countries involved in the Delphi survey.

Nevertheless, despite the low return there are several tentative results and conclusions which can be drawn from the survey. Because we changed the questionnaire for round 2 and left out the category “Solutions” the expert estimations for those items can be only interpreted for round 1 (see 3.3).

Most risks can be expected to occur and jeopardise the decarbonisation process in the EU rather soon, that is until the year 2020. This leads to the conclusion, that measures, solutions and activities for reducing or eradicating those risks should be started or strengthened as soon as possible.

The highest estimated risks in the 1st and the 2nd Delphi are risk 4 “Increased electricity prices” and the network infrastructure related risks 5 “Inadequate network infrastructure” as well as risk 6 “Inadequate system balancing capacity”. The second highest rankings are political risks in a more general form in risk 1 “Policy uncertainty and instability” and risk 2 “Locking-in high carbon assets”. It might be the case that the high response in risk 1 may be connected to risk 2 as a politically counterproductive signal for the EU decarbonisation process. Participants rated risk 4 as urgent especially on the national level of EU-countries. In another tendency risk 5 seems to become important 2020 and risk 6 even after 2020. The network infrastructure risk 5 is – according to the experts estimations – more related to the EU-Level while inadequate system balancing capacity is more related to a national level.

The results in the 2nd Delphi in the assessment of the three countries Germany, Spain and Italy differ from to the overall estimations by the experts from other countries. This group of three countries voted as the highest risk for risk 9 “Planning and permitting delays” and risk 7 “Weak and insufficient governance”. This could be a signal for an already existing higher rate of investment activity supporting decarbonisation in these three countries than in other EU-countries. An interesting assessment tendency came from the group of energy companies which estimated the political risks slightly lower than the other experts with another institutional affiliation (academic/think tank).

Risk 3 “Dependency on one low-carbon technology” and risk 8 “Supply chain constraints” were the lowest estimated risks in the overall 2nd Delphi and the different analysed groups.

1. Context: Adapting to the "R2R" Project

The latest report from the IPCC about climate change has underlined the pressing need for faster and for structural changes in several policy fields in order to reduce the negative effects of climate change and additional problems related to our life style and mode of production. A central policy area in this regard is energy policy, because the production of energy and the dominant energy regimes in the EU are still a major source for emissions and negative effects for the climate and our societies.

The European Commission's „Energy Roadmap 2050" (2011) therefore was considered an important step forward in realizing a decarbonised energy system for Europe. It has the potential to give much-needed orientation to a sector for which long-term planning is crucial, especially because it sets out various scenarios for how a decarbonised, competitive and secure energy system for Europe can be achieved.

With this background, the ongoing transition process toward a low-carbon economy in Europe is an extremely complex development full of uncertainties, possibilities as well as risks. The key objective of the project "Iterative expert survey on risks to keeping decarbonisation of EU power systems on track" was to supplement the ongoing research and working process and specifically the project "From Roadmaps to Reality (R2R)" of the European Climate Foundation (Brussels) and its cooperation partners. It was meant to be an analysis of the extent to which the European Commission's planned / likely decarbonisation pathway is on track, an assessment of risks to staying on track and selected solution recommendations.

The IZT-team has prepared and conducted 2 round Delphi-study in close cooperation and deliberation with ECF and in accordance with the preliminary findings of the first phase of the "R2R"-project. Therefore, the content of the Delphi-study considered the following topics and aspects:

- Baseline assumptions
- The extent to which decarbonisation is on track
- The relative importance of different building blocks which underpin the decarbonisation process
- The key challenges
- The major risks, their likelihood and their implications/impact (exploration of risk interactions/dynamics depending on practicality of doing so within survey; advice welcome)

2. Preparation of the Delphi survey

Delphi is a proven method within the field of scientific future research with the function of obtaining a range of opinions of a group of experts by a series of questionnaires interspersed with controlled opinion feedback for long-term prospection. Delphi surveys are one of the classical methods for technology foresight. Developed by the RAND Corporation in the early 1960's, the method has since then been applied in many national foresight activities, as well as in numerous industrial, commercial and even policy studies.

Each participant completes a questionnaire and is then given feedback on the whole set of responses or of parts (responses in the form of percentage, or in addition written responses etc.). With this information, the experts fill out an additional questionnaire. The responses from

the other participants may change his/her opinion, based upon his/her evaluation of distribution of assessments and likely new information and arguments provided by other participants via comments. Whilst introducing some of the advantages of a discussion into the survey the anonymity of the process ensures that the opinions of influential individuals or representatives do not dominate the results. Instead the most likely or convincing developments are identified based on rational arguments.

While traditionally conducted via mail, other variations of Delphi can be conducted online or face-to-face. In the original Delphi process, the key characteristics of this method were (1) structuring of information flow, (2) feedback to the participants and (3) anonymity for the participants (King Baudouin Foundation 2005, pp. 109 – 120, Gnatzy 2011, Cuhls 1998).

It is suited to cope with a high degree of uncertainty and address issues which are very complex. Beyond the explorative predictions Delphi can stimulate discussions among an expert community, especially within a project consortium. It helps to establish common views – either in form of a consensus on the most likely developments or by identifying issues of dissent with clearly defined opinions.

Based on the project objectives within the “R2R” project and considering the complexity a two round Delphi survey was developed (see chapters 3 and 4).

For the two-round survey, the IZT team compiled a database with around 2,000 experts of which 400 contacts have been contributed from the ECF network. We expected that with this high number of invited experts and with the background of a professional network like that of ECF it would be possible and very likely to get a return of 100 – 150 feedbacks for the survey.

Despite various efforts to increase the number of respondents to the questionnaire, it was impossible to receive more than 73 filled questionnaires. This is way short of the target of 100 – 150 responses. Based on experience and reflections the main reasons for the low participation seem to be:

1. The subject area is extremely complex and therefore challenging for individual experts. The experts need to be at least an expert for one country and the EU. They need expertise in several fields of energy systems and energy policies. Several of our phone calls with invited experts proof the importance of this factor.
2. Some feedback and especially the phone calls to invited experts have shown us, that for all the experts the general and daily time pressure (stress) is immense and has the effect that those experts have many other priorities than answering a questionnaire.
3. Because of the delay of the preparations (especially the input from ECF for the questions which should be asked, and because of the addition of the topic “solution” into the questionnaire) Round 1 of the Delphi was confronted with extra time pressure on the side of the experts because of the pending holiday season.

3. Delphi survey – 1st round

In the first round of the Delphi survey, we sent invitations to 1,864 energy experts across the EU.

Based on the project objectives F a questionnaire with a focus on impact risk assessment and policy solutions assessment was developed. The survey has the electricity sector at its core, focusing on the question whether the current operating environment adequately delivers the transformation of the power system as described in the European Energy Roadmap 2050.

The questionnaire was divided into three main sections with two additional open boxes (for additional answers and comments) at the end of section one and two.

1. Baseline Information
2. Step 1: Impact Assessment of risks
3. Step 2: Policy Solutions

Within an internal discussion-process of the "R2R"-partner consortium the ECF selected in a first phase 6 risks which were considered most important vis-à-vis the EU-decarbonisation process. After some additional debate the ECF-project-team suggested to add the category "Solutions" into the survey. This took the form of 11 policy solutions in order to gain perspectives of a large, EU-wide constituency of experts and stakeholders on energy issues.
In a first part of the questionnaire, the participants were asked to assess the impact of risks against the current policy and market reality, assuming no new policy initiatives or measures are put in place going forward.
The list of selected risks:

- Risk 1: Risk of policy uncertainty and instability
- Risk 2: Risk of locking-in high carbon assets
- Risk 3: Risk of dependency on one low-carbon technology (CSS-Carbon Capture and Storage, biomass, nuclear, wind, etc.)
- Risk 4: Risk of increased electricity prices
- Risk 5: Risk of inadequate network infrastructure
- Risk 6: Risk of inadequate system balancing capability (demand response, storage, flexible generation)

Subsequently followed in a second part, a list of policy solutions were assessed in terms of the impact to the above listed risks, the level of what they should be applied to and at which point in time they are likely to be implemented.

Impact categories

Very low	rather low	rather high	very high	Don't know

Likelihood

Until 2015	Until 2020	Until 2030	After 2030	anytime	Don't know

Level

EU	National	Regional

The list of selected policy solutions:

- Solution 1: Full implementation of the agreed 3rd Energy Package
- Solution 2: New and additional measures to activate demand response
- Solution 3: Full implementation of Infrastructure regulations on guidelines and financing
- Solution 4: New and additional measures to drive cross-border infrastructure, like: interconnection target for 2030 (like the current 10% target by 2020)

- Solution 5: New and additional measures to drive cross-border infrastructure, like: interconnection target for 2030 (like the current 10% target by 2020)
- Solution 6: Innovation and R&D in low-carbon technologies: full implementation of existing SET-Plan & Horizon 2020 programmes
- Solution 7: New and additional measures on innovation in energy technologies, like: Increased R&D spending
- Solution 8: Reformed EU ETS
- Solution 9: A new binding EU RES (Renewable Energy Sources) target for 2030
- Solution 10: A new binding EU EE (Energy Efficiency) target for 2030
- Solution 11: An EU EPS for power sector for 2030

3.1 Evaluation 1st round Delphi

The total number of survey participants in the 1st Delphi was 37, of which 14 participants selected to have expertise in EU. The institutional affiliation is academic/think tank (14) of most experts, followed by Consultancy (7) and Energy Company (5).

3.2 Risk assessment in the 1st Delphi round

Fehler! Verweisquelle konnte nicht gefunden werden. shows the result of the risk assessment of all presented risks in the first round of the Delphi survey. For a better clarity of the evaluation the categories “rather high” and “very high” have been merged to the category high (the same applies for the categories “rather low” and “very low”). The result is that the majority of the selected six risks of the EU decarbonisation were considered high by the survey participants. The distribution of votes between the categories “very high” and “rather high” is relatively equal apart from the distribution of votes for the risk of policy uncertainty and instability (risk 1). In this case the majority of survey participants mainly voted the category “very high”. Furthermore the risk of dependency on one low carbon technology is preponderantly rated low. There is a significant weight on category “rather low”.

The order of the estimated risk impact by participants is shown in Table 1, it starts with the highest risk and ends with lowest estimated risk for the EU decarbonisation process. Risk 5 and 6 were judged similarly in this survey by attendees.

Risk	**Cumulate frequency in the categories “very high” and “rather high”**
Risk 1: Policy uncertainty and instability	34
Risk 2: Locking-in high carbon assets	29
Risk 4: Increased electricity prices	28
Risk 5: Inadequate network infrastructure	23
Risk 6: Inadequate system balancing capability	23
Risk 3: Dependency on one low-carbon technology	15

Table 1: Sorting of risks after their estimation of their relevance from high to low

3.3 Solution assessment in the 1st Delphi round

The second part of the 1st Delphi survey round comprised a package of eleven selected solutions to decrease the most relevant risks of the EU decarbonisation (see chapter 3.2).

In the following part some of the most interesting estimations in the survey of solutions for the six selected risks are described.

The most clearly positive effects by the survey experts was seen from

Solution 4: New and additional measures to drive cross-border infrastructure (Figure 1).

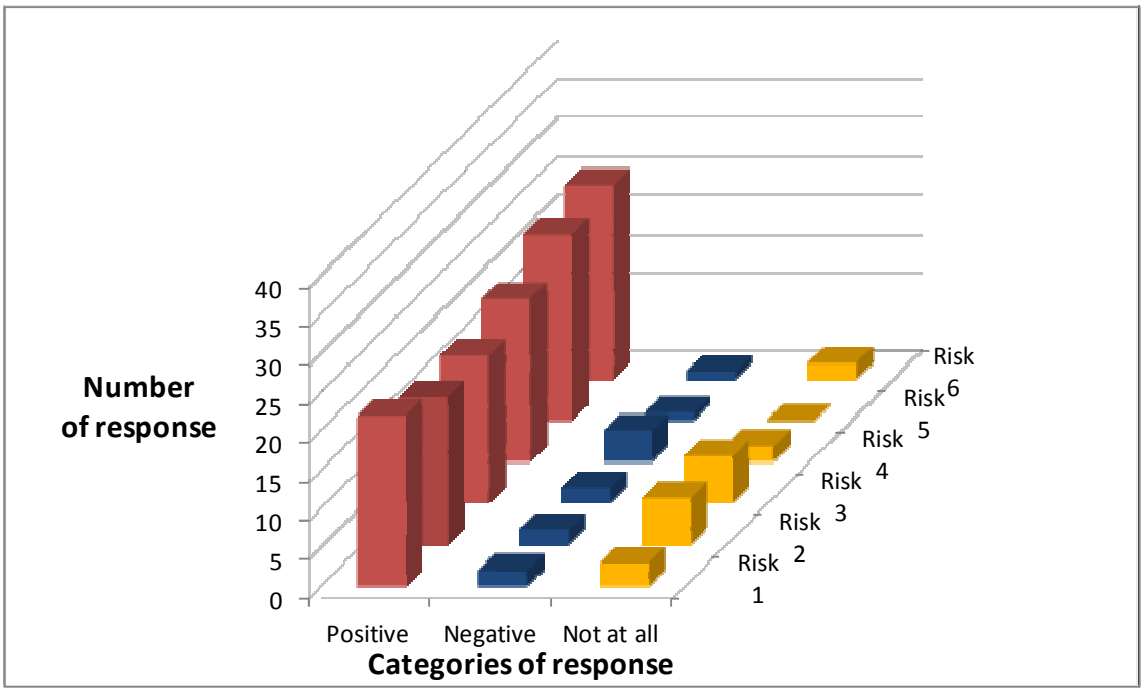

Figure 1: Survey result of the estimation of the impact of new and additional measures to drive cross-border infrastructure, like: interconnection target for 2030 (solution 4) on the selected six risks for the EU decarbonisation (source: IZT analysis).

This major issue is followed by lower but still positive estimations for:

Solution 3: "Full implementation of Infrastructure regulations on guidelines and financing" and

Solution 7: "New and additional measures on innovation in energy technologies"

Participants estimated the influence on most of the six risks the following solutions rather positive:

Solution 5: New and additional measures to drive cross-border infrastructure, like: installing ISO (Independent System Operator) model (shift away from national-for-profit TSO (Transmission System Operator) to regional or pan-EU neutral ISO)

Solution 10: A new binding EU Energy Efficiency target for 2030

Solution 2: New and additional measures to activate demand response"

Solution 6: Innovation and R&D in low-carbon technologies: full implementation of existing SET-Plan & Horizon 2020 programmes

Solution 9: A new binding EU RES (Renewable Energy Sources) target for 2030

In addition to the positive effects there are some appraisals in this survey which insinuate negative tendencies of the following solutions:

Solution 1: Full implementation of the agreed 3rd Energy Package
Solution 8: A reformed EU ETS
Solution 11: An EU EPS for power sector for 2030

A number of participants estimated those in regards to the risk of increasing electricity prices (risk 4) negative. Alongside solution 9 and 11 are rated negative for the network structure and the system balancing capacity (risk 5 and 6). Experts also evaluated solution 1 with a negative tendency on risks related to a slow or non- transformation of the electricity power sector (e.g. risk 2, 3 and combined with that risk 4).

4.4 Summary of the results according to the selected risks of the survey

Due to low return ratio in the first round, the interpretation of the answers need to be handled carefully and cannot be “respesentative”.
In this part the most influential solutions on each risk are summarized. Table 2 displays a clear tendency of participants for a bundle of possible solutions for reducing five of the six selected risks. The range of the bundle is from at least three up to five solutions to decrease risk 6. It is interesting to note that participants of the survey favour solution 4: “New and additional measure to drive cross-border infrastructure” for reducing risk 4 “increasing electricity prices”.

Risk	**Solutions per risk deemed most influential to the specific risk**
R1: Policy uncertainty and instability (1)	S1: Full implementation of the agreed 3rd energy package S3: Full implementation of infrastructure regulations on guidelines and financing S8: Reformed EU ETS S9: A new binding RES target for 2030 S10: A new binding EU Energy Efficiency target for 2030 S 11: An EU EPS for power sector for 2030
R2: Risk of locking-in high carbon assets (2)	S6: Innovation and R/D in low carbon technologies: full implementation of existing SET-Plan & Horizon 2020 programmes S7: New & additional measures on innovation in energy technologies, like: Increased R&D spending S8: Reformed EU ETS
R4: Risk of increased electricity prices (4)	S4: New and additional measure to drive cross-border infrastructure, like: interconnection target for 2030 (like the current 10 % target by 2020)
R5: Risk of inadequate network infrastructure	S3: Full implementation of infrastructure regulations on guidelines and financing S4: New and additional measure to drive cross-border infrastructure, like: interconnection target for 2030 (like the current 10 % target by 2020) S5: New & additional measures to drive cross-border infrastruc ture; like installing ISO model (shift away from the national for profit (TSO) to regional or pan-EU neutral ISO S6: Innovation and R/D in low carbon technologies: full implementation of existing SET-Plan & Horizon 2020 programmes
R6: Risk of inadequate system balancing capability	S1: Full implementation of the agreed 3rd energy package to Risks S2: New and additional measures to activate demand response

	S3:	Full implementation of infrastructure regulations on guidelines and financing
	S4:	New and additional measure to drive cross-border infrastructure, like: interconnection target for 2030 (like the current 10 % target by 2020)
	S5:	New & additional measures to drive cross-border infra structure; like installing ISO model (shift away from the national for profit (TSO) to regional or pan-EU neutral ISO
R3: Risk of dependency on one low-carbon technology (3)	S6:	Innovation and R/D in low carbon technologies: full implementation of existing SET-Plan & Horizon 2020 programmes
	S7:	New & additional measures on innovation in energy technologies, like: Increased R&D spending
	S9:	A new binding RES target for 2030

Table 2: Summary of solutions which tend to have a positive influence on the selected risks of EU decarbonisation by estimation of the survey participants (source: IZT analysis).

The majority of solutions should be introduced and applied on EU-Level with the exception of solution 2 which ought to be applied on both EU and national level. In particular, solutions 11, 10 and 2 suggest that a better coordination and cooperation between the EU- and national levels is necessary. Most solutions, request to take action during the next few years but at least until 2020 (see Figure 2). It is apparent that those issues need to be strengthened and mobilized soon.

Responses to the open Delphi sequence in round 1 where often related to this topic. Here are three comments from different experts: “EU level for the policy lead but almost all policies need national and often regional implementation.” – “Monitor the implementation of all measures on national level.” – “Three aspects are the key: legislative stability and legal security; renewable energy research and infrastructure; energy efficiency improvement.”

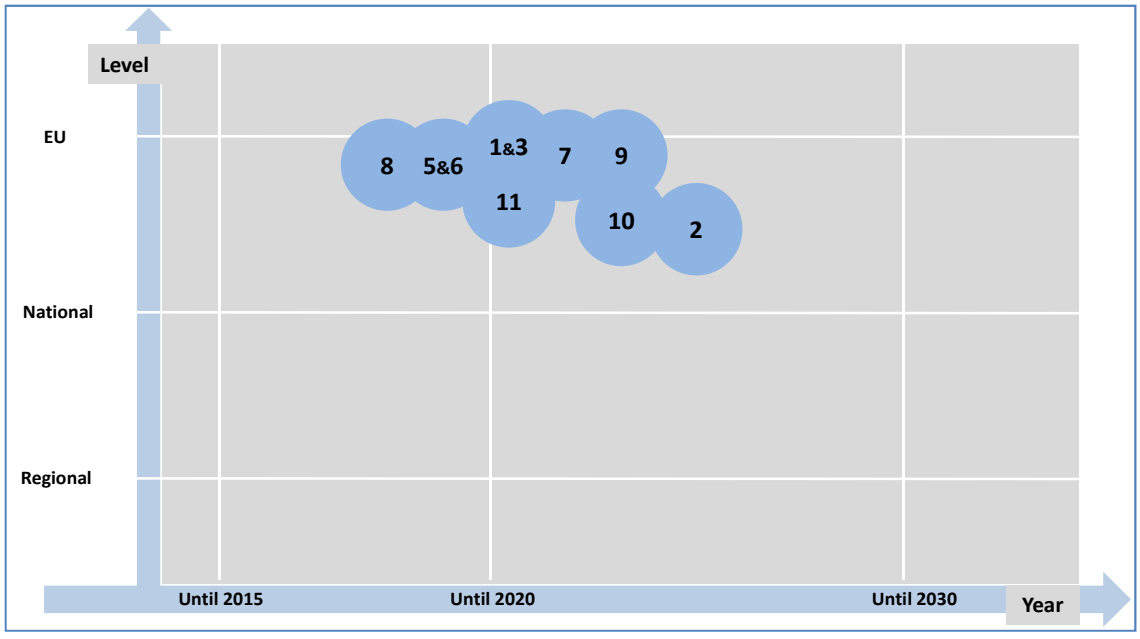

Figure 2:: Estimation of time and political level each of the 11 selected solutions should be implemented by 1st Delphi participants.

4. Delphi survey – 2nd round

For the second round of the survey, we updated the list of experts of the IZT and ECF network and sent out invitations to 1.845 experts across the EU.

We sent two versions of invitation letters, aiming for a high participation. One was formulated for those experts who had participated in the first round and another version for those experts who had not. As a consequence of the low participation in the first round, we reduced the length and complexity of the questionnaire and thus focused on the risk assessment. In addition to the six risks presented in the first round, the ECF-team selected three more risks for assessment:

1. Risk of weak or insufficient governance structures
2. Risk of supply chain constraints
3. Risk of planning and permitting delays

The questionnaire was divided in two main sections with an additional open box for further suggestions on the topic. The first section was to obtain general information from the participants – almost identical with round 1.

In the second part, the participants were asked to assess the impact, likelihood and solution level of the nine risks in regards to the decarbonisation of the power sector, assuming that no new policy initiative or measure will be implemented beyond of what is in place today.

The categories to assess the impact, likelihood and solution level were only slightly changed to the first round:

Impact categories

Very low	rather low	rather high	very high	Don't know

Likelihood

Until 2015	Until 2020	Until 2030	After 2030 anytime	Don't know

Level

EU	National	Regional

4.1 Evaluation 2nd round of the Delphi survey

The total number of participants in the 2nd Delphi survey was 50 of which 15 have their main energy expertise in Germany, 11 participants in Spain and 7 experts in Italy. The institutional affiliation of the participants is mainly academic/think tank (24 out of 50). Nearly one quarter of participants is affiliated to an energy company (12), less than one fifth of the experts has a consultancy (7) or NGO (6) background.

4.2 Risk assessment in the 2nd Delphi round

After summarizing the votes in the categories “very high” and “rather high” to one category “high” the risk of increased electricity prices (risk 4) and the risk of inadequate network infrastructure (risk 5) are estimated highest from all experts (see Figure 3). A likewise high importance has been given to the risk of policy uncertainty and instability (risk 1) and the risk of planning and permitting delays (risk 9). Although risk 1 was not rated highest according to the summary of categories, it received the highest votes within the category “very high”. The risk of dependency on one low-carbon technology (risk 3) is valued lowest. The risk of supply chain constraints (risk 8) is estimated almost equally low and high.

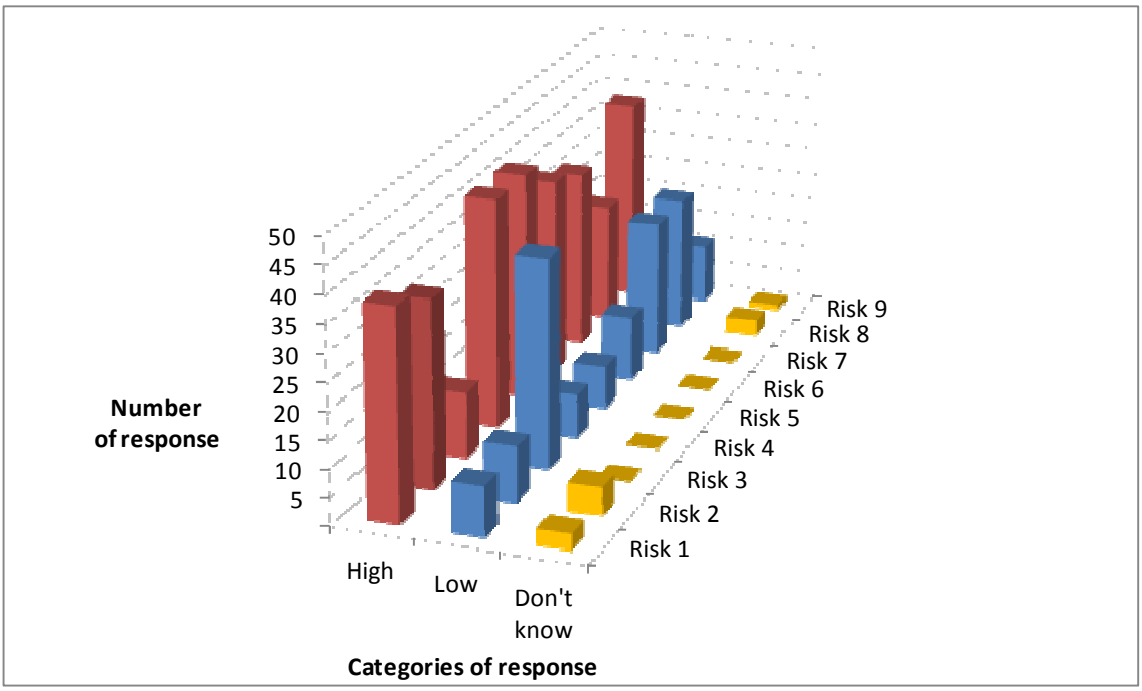

Figure 3: Assessment by participants of nine risks in the 2nd Delphi survey

The order of the estimated risks according to their absolute frequency, starting with the highest number, is given in Table 3. Risk 4 and 5 and risk 1 and 9 have a similar frequency in this survey.

Risk	Cumulate frequency in the categories “very high” and “rather high”
Risk 4: Risk of increased electricity prices	42
Risk 5: Risk of inadequate network infrastructure	42
Risk 1: Risk of policy uncertainty and instability	38
Risk 9: Risk of planning and permitting delays	38
Risk 6: Risk of inadequate system balancing capability (demand response, storage, flexible generation)	36
Risk 2: Risk of locking-in high carbon assets	34
Risk 7: Risk of weak or insufficient governance structures	33

Risk 8: Risk of supply chain constraints	22
Risk 3: Risk of dependency on one low-carbon technology	12

Table 3: Sorting of risks after their estimation of their relevance from high to low

One of the comments to the open question in round 2 was the following comment, underlining the overall assessment of the experts: “The process of decarbonisation requires a high involvement of Citizen involvement, given that part of the final solution can be done technically but the rest needs acceptance and investments by Citizen. Furthermore the need for stable political environments to further the very long-term process, requires pressure from the Citizen. Therefore it is necessary to ensure involvement with other instruments than legislation.”

Figure 4 illustrates the overall assessment of occurrence in level and time of the nine risks. It can be seen that risk 1, 4, 9, 5 and 4 are estimated to occur on the national level. Risk 2 and 8 are lying between national and EU-level, whereas risk 7 and 3 clearly tend to EU-level. Risk 4 stands out as the earliest of all, followed by risk 7, 9, 2, 8 and 5. After 2020 risk 3, 6 and 1 are assessed to be important.

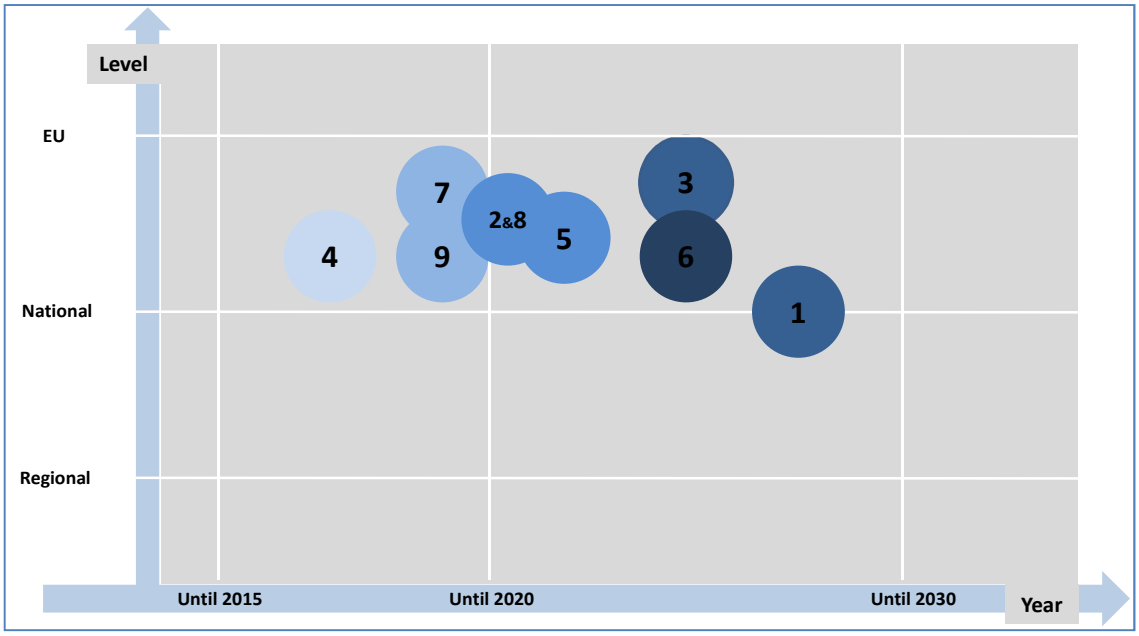

Figure 4: Assessment of risks in level of politics and time of their expected occurrence

Due to the emphasis of given country expertise in Germany, Spain and Italy a separated analysis of risks was made. Looking at the absolute frequency of these three countries in their risk assessment a clear tendency to the risk planning and permitting delays (risk 9) and the risk weak or insufficient governance structures (risk 7) appears which were highest followed by the risk increased electricity prices (risk 4) and the risk inadequate network infrastructure (risk 5). In comparison with the other countries they have a higher tendency to the risks 5 and 4 but furthermore to the risk inadequate system balancing capability (risk 6) and the risk policy uncertainty and instability (risk 1) (see Figure 5).

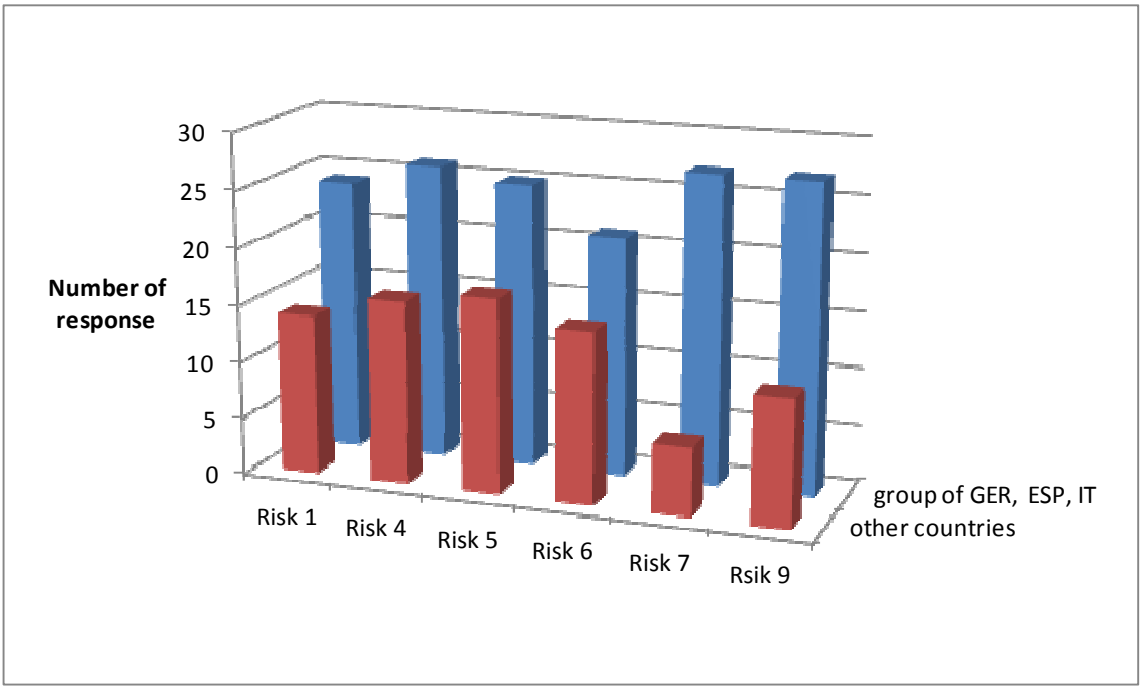

Figure 5: Comparison of the assessment for the highest estimated risks due to countries

Due to the category institutional affiliation in “academic/thing tank” and “company energy” a separated analysis of their specific risk assessment was made as well. Independent from the country background the risks 4, 5 and 1 were estimated high. A different tendency is presented in the appraisal of risk 6 and 9 (see Figure 5). Academic institutions tended to risk 9 while energy companies tended more towards risk 6 (see Figure 6).

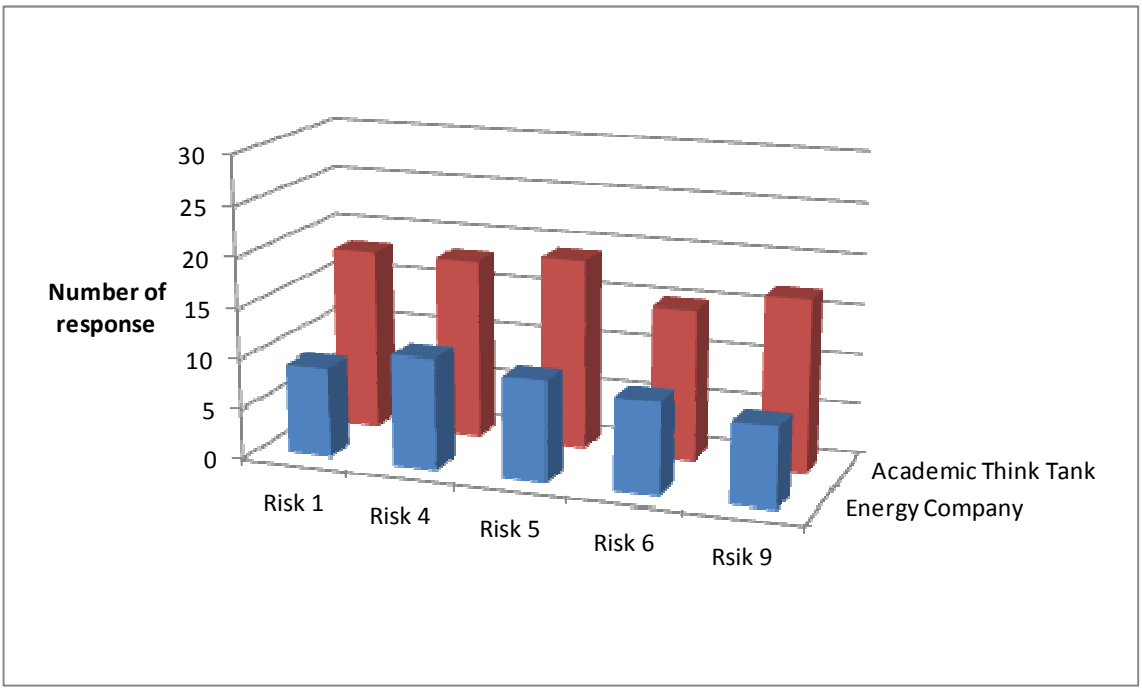

Figure 6: Comparison of the assessment the highest estimated risks due to institutional affiliation

4.3 Comparison between the 1st and 2nd Delphi round

The overall number of experts who participated in both Delphi surveys is 14. The following Figure 7 and Figure 8 present the results of the risk assessment of the six identical risks in both rounds. This comparison shows that their estimation in both rounds was relatively similar. The only exception is the risk of inadequate network infrastructure (risk 5) which was rated higher in 2nd Delphi which explains that the visibility of responses from the 1st round, has an influence to forming opinions in the second round.This result corresponds to those of the 2nd Delphi by all participants who estimated risk 5 quite high. There is no indication that adding three additional risks to the assessment had an influence on the participant's responses.

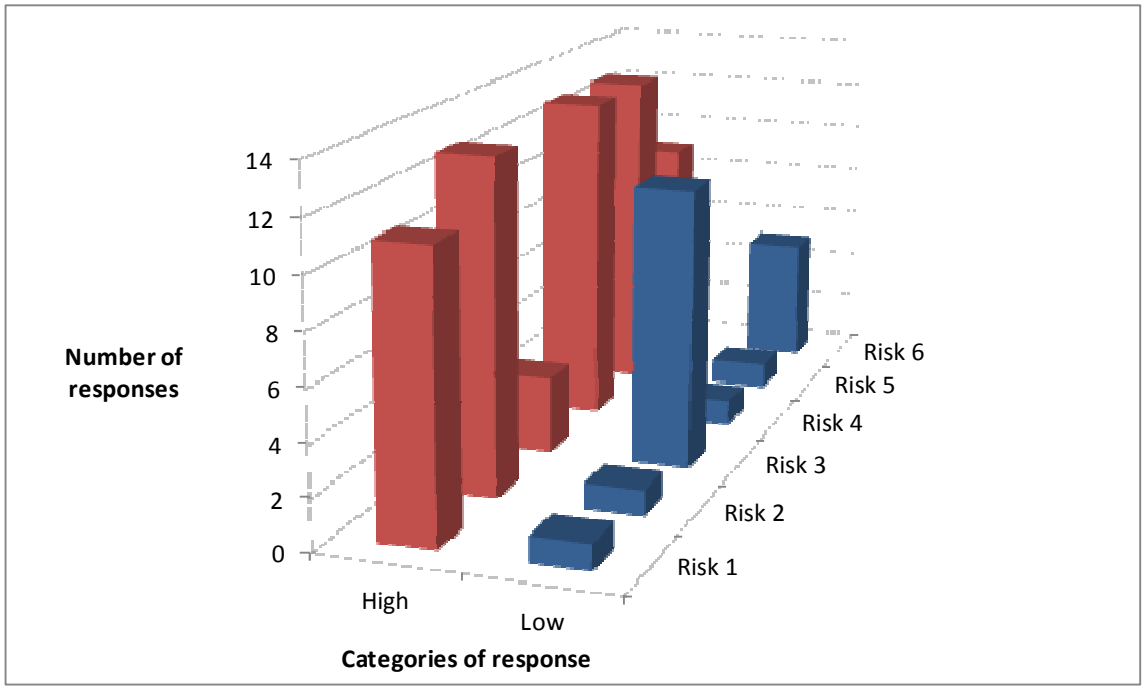

Figure 7: Results of the risk assessment of 1st Delphi who took also part in the 2nd Delphi

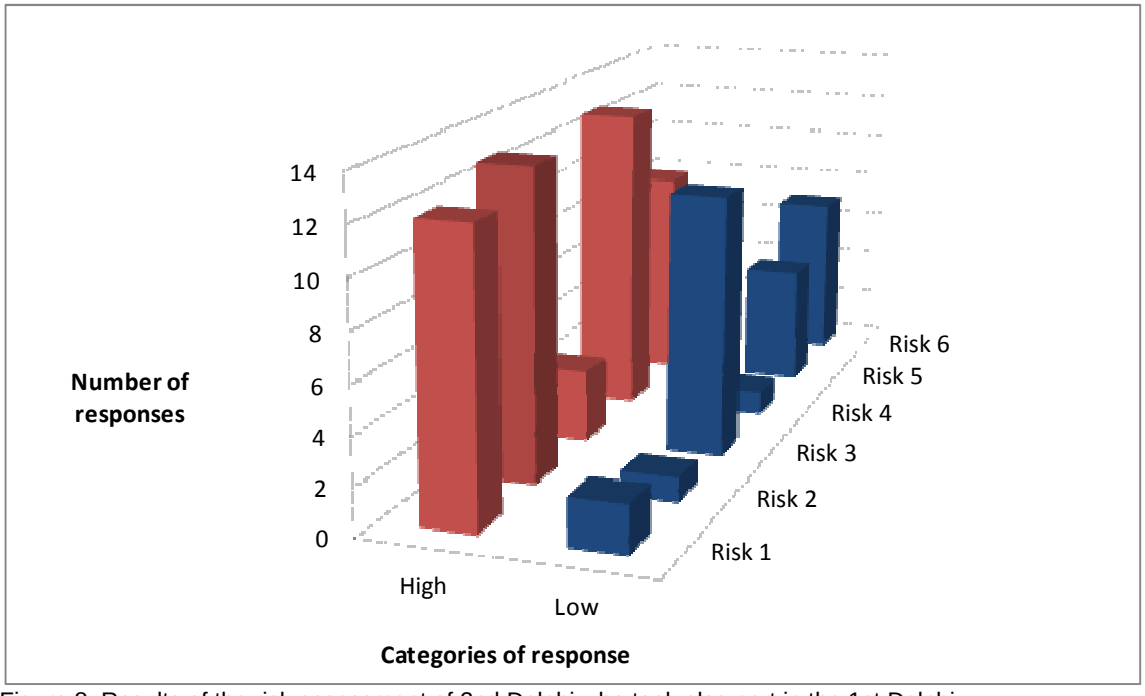

Figure 8: Results of the risk assessment of 2nd Delphi who took also part in the 1st Delphi

5. Interpretation and Conclusion of the Delphi Survey

The current aims of EU energy policy require the implementation of broad spectrum of measures in all member states and put into practice to keep the process of EU decarbonisation on track. That includes a functioning open and competitive internal energy market, the security of energy supply, energy efficiency and saving, further development of renewable energy technology and the interconnection of energy networks.

The implementation of the regulation, the market rules, guidelines, capacity mechanisms as well as the large investment are major challenges in the coming years. The perception that the policy and regulatory framework will change may prevent investors from financial commitments. When it is not possible to persuade the necessary investment approval bodies that the potential return warrants the level of risk involved. This is particularly relevant when investors lose money as a result of frequent or abrupt changes in Government policies. In both Delphi surveys the risk of policy uncertainty and instability was rated as the highest in the process of the EU-decarbonisation. Government decisions e.g. the extension of economic durability of using fossil assets in the power sector would impede decarbonisation dramatically. The impact of such a trajectory for decarbonisation is supported by participating experts by a high ranking for the risk locking-in high carbon assets (risk 2) in both Delphi rounds.

The high valuation of the risk increasing electricity prices (risk 4) suggests to focus on costs and competiveness ensuring the affordability for the power sector transition. The future coordination of network planning by system operators and the identification and financial support for key interconnections between national systems will improve and stabilize the EU wide network. A significant change in the requirement for network infrastructure may lead to a one-off step change in the network costs. However, the constraints on rates of deployment have a more influence in security of supply issues than in affordability issues. Without securing the future market opportunities, it will be difficult to achieve the investments with long timescales. There is a risk of regulators to fail in authorizing a basis for network enhancements ahead of a defined need. This is shown in a high rating of the risk inadequate network infrastructure (risk 5) and the risk inadequate system balancing capability (risk 6) in both surveys. The transition of the power sector requires a replacement of assets assuming successful policies to keep different technology options open to reduce investors´ uncertainties through risks of new features. In both survey, the risk dependency on one low carbon technology (risk 3) was rated the lowest of all risks. .

In the second round the risk supply chain constraints (risk 8) was rated the second lowest which may restrict the deployment of low carbon assets if the relevant investment decisions need to be taken in well advance of any specific orders being secured (e.g. it may take several years to develop the port and barge capacity to deploy offshore wind or facilitate training for skilled workforce). Figure 9 presents an overview of the overall risk assessment in both Delphi rounds. Two risks in one of the blue circles represent a similar assessment by the experts.

In the 1st Delphi the risk policy uncertainty and instability (risk1), the risk locking-in high carbon assets (risk 2) and the risk increasing electricity prices (risk 4) were rated high, followed by the risk inadequate network infrastructure" (risk 5) and the risk inadequate system balancing capacity (risk 6).

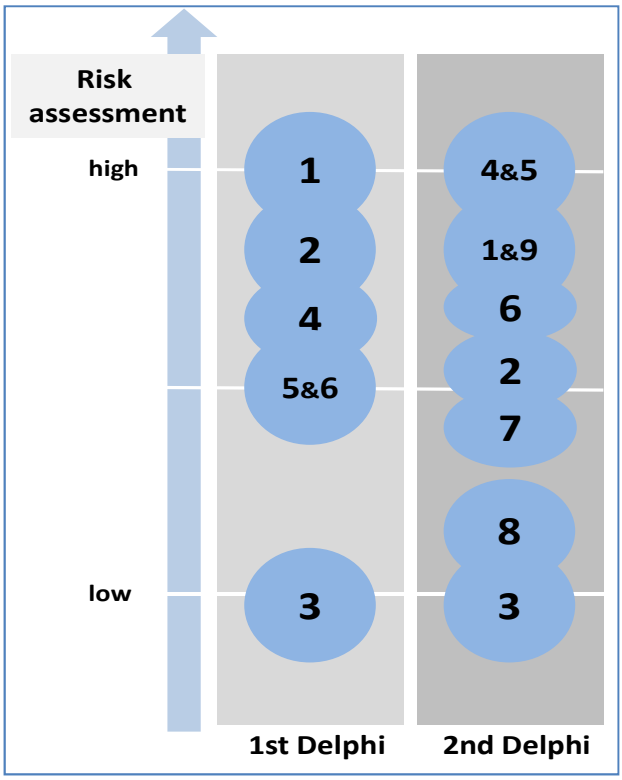

Figure 9: Comparison of the overall risk assessment of all participants in the 1st and 2nd Delphi

Notably, this results changed after evaluating the second round. Participants tend to rate the risk increasing electricity prices (risk 4) and inadequate network structure (risk 1) highest, which can be related to each other. Due to further network expansion this may probably lead to higher prices for consumers. The risk locking-in high carbon assets (risk 2) tends to be less important in the 2nd survey. This risk tends to depend on specific EU country politics, which survey findings support after a closer look and the major country groups. Risk 6 “Inadequate system balancing capacity” is estimated as a high risk however enhanced after 2020. This interpretation is further supported by considering the estimation of time for implementation for solution 2 “New and additional measures to activate demand response”.

The following Figure 10 gives an overview of the estimations in both surveys including the results for the separate analysis in the group’s country and institutional affiliation. The most prominent tendency in both surveys and in the specific groups is the relatively low assessment of the risk dependency on one low-carbon technology (risk 3). This may be a signal from experts that there exists today already a broad range of renewable technologies, as well as non-renewable technologies (e.g. nuclear power or fossil gas) with a low-carbon effect. However this statement is very vague due to the small number of participants from countries such as France or Poland. Furthermore the risk supply chain constraints (risk 8) was rated low, even in the group energy companies, this result is not surprising. Due to the high participation of energy experts from the countries Germany, Spain and Italy and of two groups of institutions, which were considered closer in the survey analysis. An interesting difference within these groups is the assessment of the risk planning and permitting delays (risk 9) and the risk weak or insufficient governance structures (risk 7). In comparison of this group to all other countries there is also a difference between the assessment of the risk inadequate system balancing capacity (risk 6) and the risk locking-in high carbon assets (risk 2). What can be explained that those three countries have already a higher investment activity in the decarbonisation process.

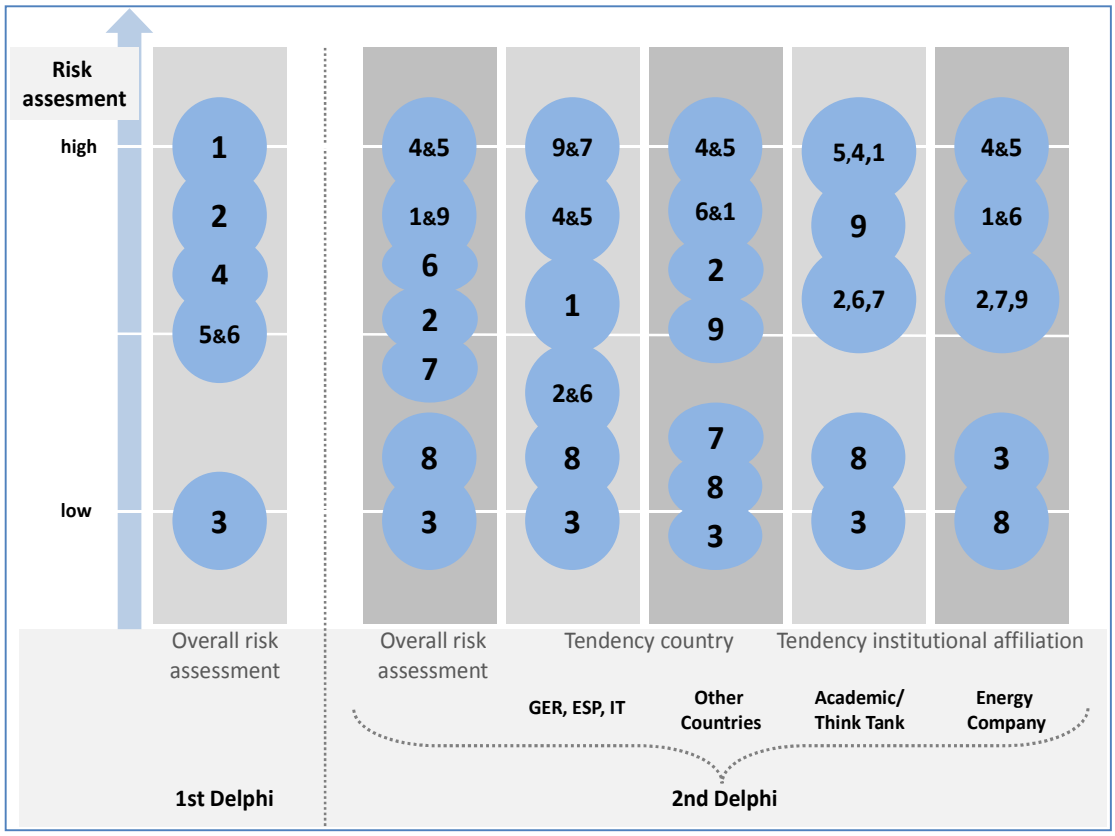

Figure 10: Comparison of risk assessment in the 1st and 2nd Delphi including specific assessment according to countries and institutional affiliation

While risk 7 could be a sign that investments abroad are possible but have to be secured. In the case of the assessment of risk 2 and 6 from those three countries one interpretation could be that especially in the group of other countries some important technological decisions have to be made e.g. new build-up of energy production capacity. That is, strongly related to an adequate system balancing capacity especially if it concerns the expansion of renewable energies.

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List of acronyms

CCS	Carbon Capture and Storage
ECF	European Climate Foundation, Brussels
EE	Energy Efficiency
EPS	CO_2 Emissions Performance Standard
ETS	Energy Transformation System
IASS	Institute for Advanced Sustainability Studies, Potsdam
IEA	International Energy Agency, Paris
ISO	Independent System Operator
IZT	Institute for Future Studies and Technology Assessment, Berlin
R&D	Research and Development
RES	Renewable Energy Sources
SET-Plan	(The European) Strategic Energy Technology Plan
TSO	Transmission System Operator
UNEP	United Nations Environment Program, Nairobi
WBCSD	World Business Council for Sustainable Development, Geneva