

Expert Elicitation Protocol on Direct Current Tools and Technologies in (demo name)

Elicitation Protocol

Expert:.....

*Anonymized-author
information¹*

*Anonymized-author
information²*

*Anonymized-author
information³*

1. Introduction - Duration: 10 minutes

a. State of the Art of the study:

The widespread concern about using renewable energies for power generation brought attention to the dominance in deploying and using DC solutions. Despite the vital role these solutions play in supporting the race to decarbonize the energy sector, there is a deficiency in studies on user (expert) perceptions of them. These users as per this project are the experts in the DC, hence this survey.

b. Notes on Expert Elicitation:

Attached, you will find a series of questions intended to elicit your expert judgments on various topics regarding the DC solutions. The topics to be addressed come largely from the existing literature, where they are mainly mentioned briefly but not discussed in detail, given the infancy state of DC in general.

Participants are asked to draw upon their expertise and provide insightful perspectives when answering the questions as individual experts. In other words, we are not asking you to represent the organization you are affiliated with. Each participant will be assigned a number that will be used in place of names when we report results for each expert in this project.

c. Description of the Target for the Proposed DC Solutions

The DC solutions identified in this section are designed to facilitate the establishment of different activities related to DC in data centres, buildings, industry, and ports. The activities include: establishment of DC energy hubs, and grids. As well as to assist in the coordination, control, durability, autonomous recovery, and protection of DC grids. Additionally, they aid in enhancing the adaptability, modular design, and expandability of these DC solutions in data centres, buildings, industry, and ports.

List of the Proposed DC Solutions and their Descriptions - show one slide per category

| S/No | DC Solutions | Description |
|------|---|--|
| 1. | Smart and sustainable DC cables | Cables to provide the interface between DC sources and loads, conforms Current-OS specifications, consider aspects such as “elec-trothermal aging”, ergonomics, and environ - mental impact. |
| 2. | DC measurement device | Current measurements up to 1000 A DC Voltage measurement up to 1500 V DC |
| 3. | DC-connectors | DC connectors manage safe connection and disconnection in DC grids, using active or passive arc extinguishing methods to prevent damage and ensure user safety. |
| 4. | Static protection system | Provides ultra-fast protection for DC micro-grids, quickly isolating faults and ensuring system reliability using advanced detection and solid-state breakers. |
| 5. | Semiconductor-based circuit-breaker | A solid-state circuit breaker to quickly and reliably protect DC grids, overcoming the challenge of no natural zero-crossing in DC currents. |
| 6. | Protection DC system design tool | Enable the design of protection system for DC grids |
| 7. | DC-DC converter power distribution unit | Power-flow-control between DC appliances |
| 8. | LVAC-LVDC interlink converter | Active-front-end with droop-control capabilities on the DC side. |
| 9. | DC solutions design tool | Evaluate different DC architectures and compare with convention AC radial networks. |

2. Given the goal of achieving the target in 1(c).

- a. How feasible is the use of *DC* in the described target?
- b. How important is the use of DC in the described target?
- c. How important is each of these DC solutions?

| # | DC Solutions | Not feasible | Somewhat feasible | Feasible | Very feasible | Not able to respond |
|-----|-------------------------------------|--------------|-------------------|----------|---------------|---------------------|
| 1. | Smart and sustainable DC cables | | | | | |
| 8. | DC-connectors | | | | | |
| 6. | DC measurement device | | | | | |
| 4. | Static protection system | | | | | |
| 5. | Semiconductor-based circuit-breaker | | | | | |
| 10. | Protection DC system design tool | | | | | |

| | | | | | | |
|----|---|--|--|--|--|--|
| 7. | DC-DC converter power distribution unit | | | | | |
| 3. | LVAC-LVDC interlink converter | | | | | |
| 9. | DC solutions design tool | | | | | |

3. Barriers to adoption: includes all factors which have been highlighted to hinder widespread adoption of DC solutions highlighted in 1(c).

Which of the following do you think are **possible barriers to adoption** of DC solutions?, *select top 5.*

| A) | Barrier | Select |
|----|--|--------|
| | Power losses, quality, and safety issues | |
| | Reduced reliability in DC devices | |
| | Lack of use-cases in which DC is advantageous | |
| | Uncertain utility interaction: net metering, utility ownership, and agreed standards | |
| | Lack of pilot projects | |
| | Public perception of DC and readiness to ‘champion’ installations from DC projects | |
| | Incompatibility of DC systems components | |
| | Misconception and lack of knowledge leads to lengthy/expensive design and permit process | |
| | Lack of enough trained personnel in DC systems | |
| | Uncertain in regulatory roadmap | |
| | High costs of DC solutions | |

B) Any other vital barrier(s) not listed:

- i)
- ii)
- iii)

4. Expected time for widespread adoption of each of the DC solutions.

| # | DC Solutions | <2030 | 2030 | 2040 | 2050 | > 2050 | Not able to respond/ never gonna happen |
|-----|---|-------|------|------|------|--------|---|
| 1. | Smart and sustainable DC cables | | | | | | |
| 8. | DC-connectors | | | | | | |
| 6. | DC measurement device | | | | | | |
| 4. | Static protection system | | | | | | |
| 5. | Semiconductor-based circuit-breaker | | | | | | |
| 10. | Protection DC system design tool | | | | | | |
| 7. | DC-DC converter power distribution unit | | | | | | |
| 3. | LVAC-LVDC interlink converter | | | | | | |
| 9. | DC solutions design tool | | | | | | |

5. Perceptions of risk of non-availability or delay in adoption.

| # | DC Solutions | Insignificant | Moderate | Critical | Very critical | Not able to respond |
|-----|---|---------------|----------|----------|---------------|---------------------|
| 1. | Smart and sustainable DC cables | | | | | |
| 8. | DC-connectors | | | | | |
| 6. | DC measurement device | | | | | |
| 4. | Static protection system | | | | | |
| 5. | Semiconductor-based circuit-breaker | | | | | |
| 10. | Protection DC system design tool | | | | | |
| 7. | DC-DC converter power distribution unit | | | | | |
| 3. | LVAC-LVDC interlink converter | | | | | |
| 9. | DC solutions design tool | | | | | |

6. Discussion questions: Here open ended questions have been included to capture more insights from experts.
- Which technical breakthroughs will be needed for the DC solutions listed in 1(c) to become commercial contenders in data centres, buildings, industry, and ports? *minimum of three.*
 - Based on your expertise in DC, provide any other relevant DC solutions suitable for the data centres, buildings, industry, and ports not included in 1(c). *Minimum of three*
 - Why is the DC important in data centres, buildings, industry, and ports?
 - Kindly provide whatever you want to share with the elicitation team concerning DC solutions in data centres, buildings, industry, and ports.

7. Expertise level: experts self-ranking of their expertise for each of the DC solutions in 1(c).

How do you rank your expertise in each of the following DC solutions?

| # | DC Solutions | Low | Moderate | High | Very High | Not able to respond |
|-----|---|-----|----------|------|-----------|---------------------|
| 1. | Smart and sustainable DC cables | | | | | |
| 8. | DC-connectors | | | | | |
| 6. | DC measurement device | | | | | |
| 4. | Static protection system | | | | | |
| 5. | Semiconductor-based circuit-breaker | | | | | |
| 10. | Protection DC system design tool | | | | | |
| 7. | DC-DC converter power distribution unit | | | | | |
| 3. | LVAC-LVDC interlink converter | | | | | |
| 9. | DC solutions design tool | | | | | |

References

- Glasgo, B., Azevedo, I. L., & Hendrickson, C. (2018). Expert assessments on the future of direct current in buildings. *Environmental research letters*, 13(7), 074004.
- Knol, A. B., Slottje, P., van der Sluijs, J. P., & Lebret, E. (2010). The use of expert elicitation in environmental health impact assessment: a seven step procedure. *Environmental Health*, 9, 1-16.
- O'Hagan, A., Buck, C. E., Daneshkhah, A., Eiser, J. R., Garthwaite, P. H., Jenkinson, D. J., ... & Rakow, T. (2006). Uncertain judgements: eliciting experts' probabilities.
- Schmidt, O., Gambhir, A., Staffell, I., Hawkes, A., Nelson, J., & Few, S. (2017). Future cost and performance of water electrolysis: An expert elicitation study. *International journal of hydrogen energy*, 42(52), 30470-30492.
- Shayegh, S., Bosetti, V., & Tavoni, M. (2021). Future prospects of direct air capture technologies: insights from an expert elicitation survey. *Frontiers in Climate*, 3, 630893.
- Vossos, V., Gerber, D. L., Gaillet-Tournier, M., Nordman, B., Brown, R., Bernal Heredia, W., ... & Frank, S. M. (2022). Adoption pathways for DC power distribution in buildings. *Energies*, 15(3), 786.