

Q 13: A variety of C4-FN based mixtures (with and without oxygen) and composition ratios (some even undisclosed) is reported. With every manufacturer having its “proprietary gas” could “inter-operability” be realized? Can specialist predict whether a “one-gas-fits-all” solution is waiting at the horizon or at what time horizon convergence of various technologies can be expected?

Answer: Promoting industry-level discussions including relevant stakeholders (manufacturers, users, government and so forth) can be a good attempt to prevent a confusing situation with a variety of gases/mixtures. In Japan, industry-level organizations were established, where Japanese major seven switchgear manufactures have reached a common base of requirements for SF6 alternative solutions and created a joint roadmap to develop and release non-SF6 switchgears to the market. This helps users and government to consider most effective and reasonable plan of how and when to introduce the emerging technologies and products.

#### The JEMA roadmap of non-SF6 switchgear development and industry-level discussions in Japan

JEMA (Japan Electrical Manufacturers’ Association) is an industrial association that covers power transmission & distribution fields. The task force on SF6 alternative technologies (hereafter called “TF”) was established in August, 2021 in JEMA, composed of the Japanese major seven switchgear manufacturers.

The main missions of the TF are as below :

1. Development of a roadmap of non-SF6 switchgear development
2. Opinion coordination with stakeholders, such as TDGC (Japan T&D Grid Council), etc.
3. Opinion coordination with policy makers to incubate and introduce non-SF6 technologies properly in Japan
4. Enlightenment/education to promote environmental activities of T&D industries.

While the world aims toward “Carbon Neutrality by 2050”, the Japanese major seven switchgear manufacturers of the TF did share the increasing need to take appropriate actions and preparations to reduce SF6 gas used in the power grids as a social responsibility to maintain this important infrastructure.

The manufacturers of the TF agreed to develop a joint roadmap of non-SF6 switchgear development in order to show when non-SF6 switchgears would be available in the market, which activates industry-level discussions for relevant stakeholders (manufacturers, users, government and so forth) to build most effective and reasonable plan of how and when to introduce the emerging technologies and products. Particularly in some countries including Japan, as huge existing SF6 switchgears will reach their end-of-life within 5 to 10 years from now, it should be essential to get SF6 alternative products ready by then, otherwise asset owners will have to continuously possess huge SF6 gas during next 40 years again as a typical lifetime of a switchgear.

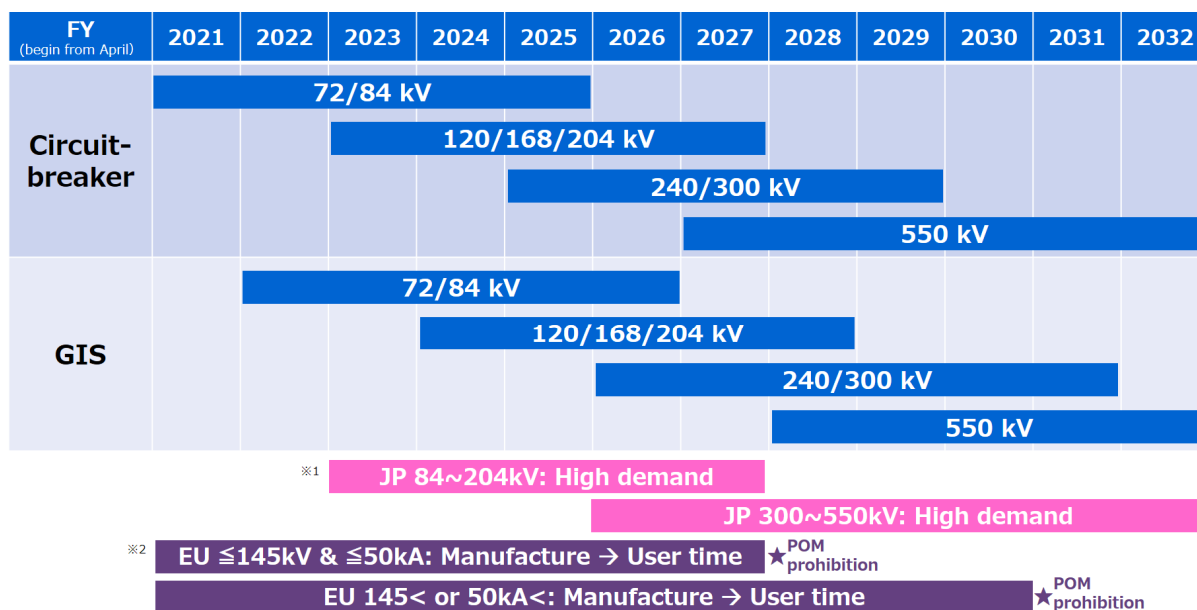
The roadmap was developed on the anonymous questionnaire basis by the different manufacturers of the TF, which, as a result, summarized when the manufacturers would release non-SF6 switchgears to the market for the voltage ranges from 72 kV up to 550 kV. This activity was possible because there was a consensus on the basic requirements to the SF6 alternative technologies as called “7 requirements” (shown in Table 1) that had been

developed by “SF6 Alternative Gas Study Group” composed of Japanese 11 utilities, 7 manufacturers and 6 academia and CRIEPI, together with TDGC and JEMA as observers [1]. Actually in creating the joint roadmap, participating manufacturers did consider the “7 requirements” as a common condition.

The roadmap (shown in Figure 1) was published on the JEMA’s website [2] on 30 May 2022, and discussions have already begun between TDGC (users’ side) and JEMA (manufacturers’ side) based on this joint roadmap, regarding most effective and reasonable plan of how and when to introduce the emerging technologies and products.

Table 1 7 requirements to the SF6 alternative technologies [1]

No.	Category	Requirement
1	EHS	Especially, toxicity of decomposition gas and decomposition
2	Service Condition	Normal use conditions specified in the standard
3	Stable Supply	Stable supply of alternative gases is possible in the future. It is desirable that gas can be supplied by multiple suppliers
4	Gas Handling	Simple handling of SF <sub>6</sub> alternative gas
5	Life Cycle Cost	Life cycle cost is equivalent or reasonable to SF <sub>6</sub> gas equipment
6	Footprint	Replacement in locations where installation space is limited
7	Voltage Coverage	Support up to the maximum operating voltage of 500 kV-63 kA



※1: High demand of replacing aged equipment in Japan, investigated by JEMA (Ref: 櫻尾, 「SF6ガス代替技術の動向と要件」, 電気評論 (2020年); 武田, 「国際的なSF6ガス代替技術の動向を踏まえた国内の状況と対応について」, 電気学会全国大会シンポジウム (2021年))  
 ※2: Ref: European Commission, Proposal for amending Directive EU 2019/1937 (5 April 2022); ENT50-E and T&D Europe, Position Paper “Transition Times from SF6 to alternative technologies for HV and EHV applications” (2021)

Figure 1 The JEMA roadmap of non-SF6 switchgear development [2]

## Bibliography

- [1] K. Nakamura, S. Tsukao, T. Nishioka, K. Taketa, T. Uchii, H. Hama, “Management of SF<sub>6</sub> gas leakage from substation equipment and technical guidelines on application of substation equipment using SF<sub>6</sub> alternative gases in Japan”, CIGRE 2022, Paper B3-10736
- [2] The Japan Electrical Manufacturers’ Association, “Roadmap of Transition toward SF<sub>6</sub> Alternative Technologies”,  
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