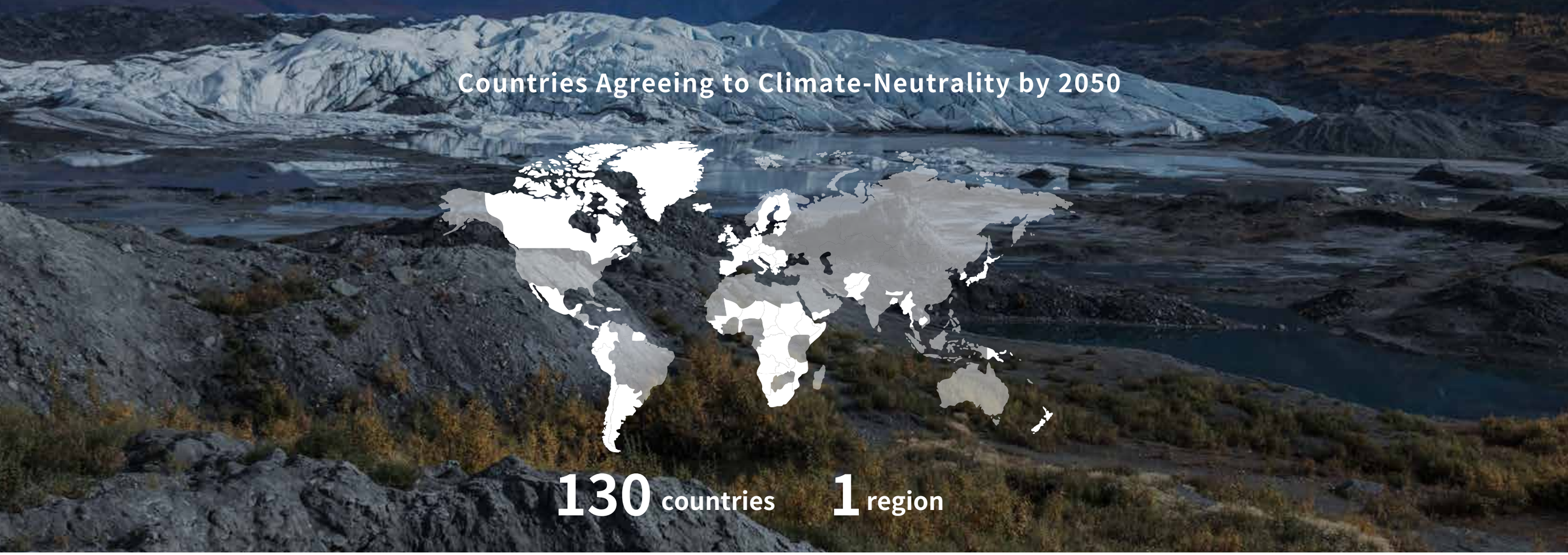
TOSHIBA

# *AEROXIA*™

**The Permanent $SF_6$-free Solution for Climate-Neutral Power Grids**




# An Ambitious Target toward Climate-Neutrality by 2050

The Paris Agreement is a legally binding international treaty on climate change, which was adopted by 196 Parties at COP 21 in Paris on 12 December 2015 and entered into force on 4 November 2016.

The goal is to limit global warming to well below 2, preferably to 1.5 deg.C, compared to pre-industrial levels.

The 130 countries, including Japan, and 1 region have committed to realizing a climate-neutral society by 2050. [1]

Reference:
[1] United Nations Environment Programme “Climate Ambition Alliance: Net Zero 2050” (2020)

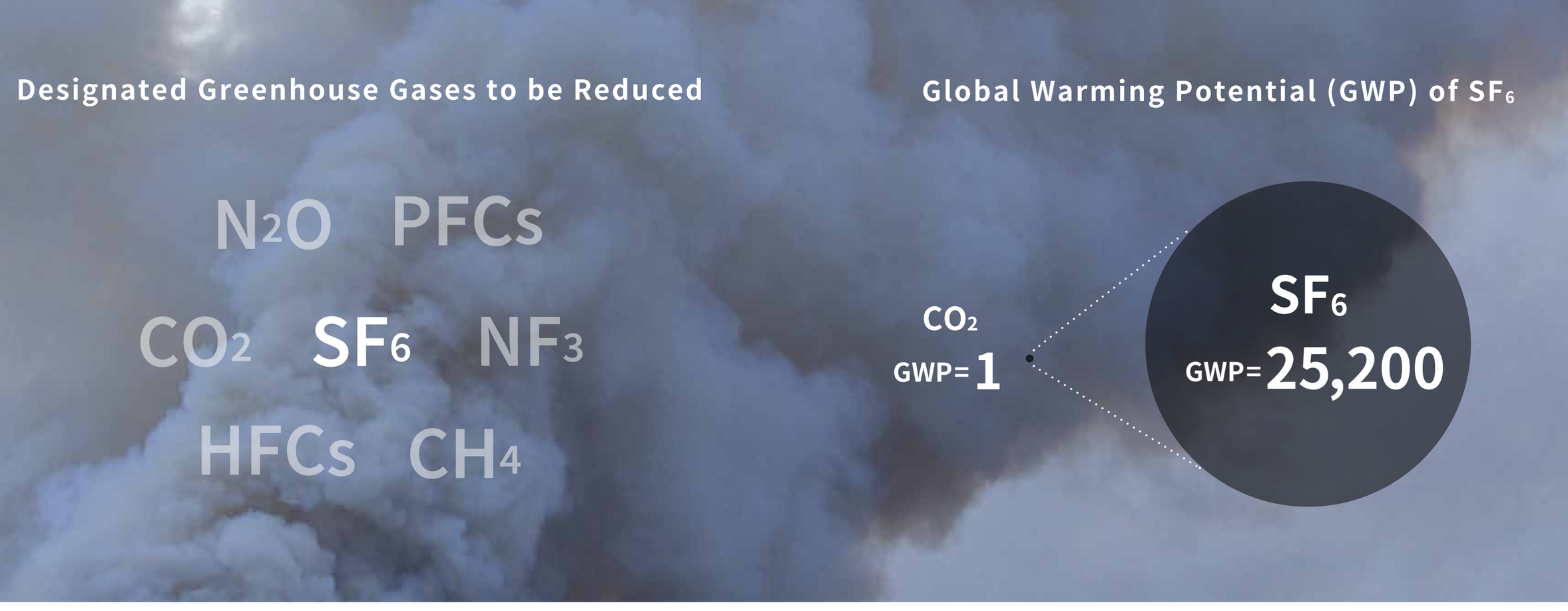

# Net Zero Emissions Goal

“Net Zero” means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance.

More than 70 countries have set a net-zero target, covering about 76% of global emissions.
On October 26, 2020, Prime Minister Yoshihide Suga unveiled Japan's ambitious milestone of net zero emissions by 2050. This bold pledge sets Japan on a course to become climate-neutral in 30 years.

The energy sector, which emits about 85% of all greenhouse gases[2], needs to be more proactive in contributing to the goal.

Reference:
[2] National Institute for Environmental Studies “GHG Emissions Data” (2020)




# $SF_6$ Gas Designated as a Greenhouse Gas to be Reduced

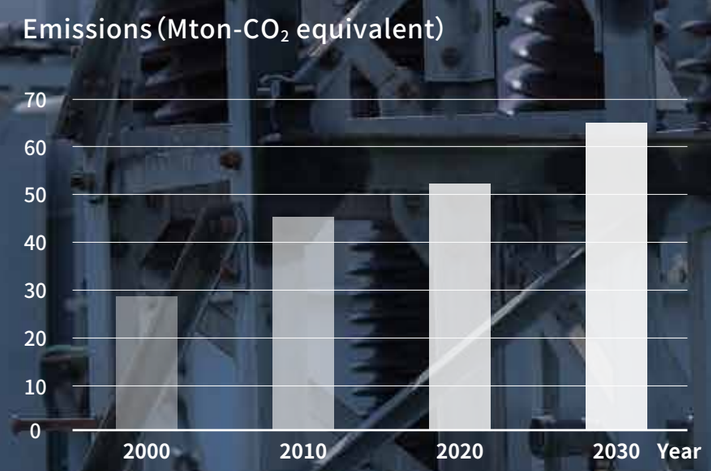
$SF_6$ was designated as one of the greenhouse gases to be reduced at the Third Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3) held in Kyoto, Japan in 1997.

In response, industries using $SF_6$, such as electric power equipment, particle accelerators, metal refining, semiconductor manufacturing, and so forth, have strictly controlled and curbed the amount of $SF_6$ released into the atmosphere, thereby limiting the actual impact of $SF_6$ on global warming to 0.2% of the total.

However, since the atmospheric lifetime of $SF_6$ is as extremely long as 3,200 years and the global warming potential (GWP) of $SF_6$ is 25,200 times greater than that of $CO_2$[3], potential environmental risk from $SF_6$ usage remains high.

Reference:

[3] The IPCC finalized the first part of the 6th Assessment Report (2021)




Global $SF_6$ emissions
in electric power industries[4]

Increasing
environmental risks

Increasing
asset management costs

# $SF_6$ Gas
# in Electric Power Industries

$SF_6$ has excellent high-voltage insulation performance and large current switching capability as well as outstanding chemical stability. It is therefore widely used in electric power equipment along with precautions against potential environmental risks caused by accidental leakage.

The amount of $SF_6$ gas used for electric power equipment is increasing worldwide, and consequently the costs associated with strict $SF_6$ gas control, such as gas recovery, recycling, monitoring, reporting, education and so forth, are also increasing.

It's time for a “new approach” that reduces environmental and business continuance risks, enhances user’s convenience, and reduces operational costs.

Reference:
[4] US EPA “Global Mitigation of Non-$CO_2$ Greenhouse Gases” (2018)

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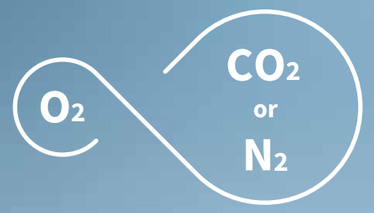
## Neo Ecology Solutions Realized with Natural Origin Gases

**A E R O** (Natural origin gases) + **A X I A** (Value (in Greek)) = **A E R O X I A**




### Natural Origin Gas Mixtures that are Friendly to Humans and the Environment

*AEROXIA*™ uses gas mixtures consisting of $N_2$, $CO_2$ [5] and $O_2$. Since these are common gases used in various industries including foodstuffs and completely free of artificial fluorinated and PFAS[6] gases, there is no potential risk for the environment, regulations and supply.

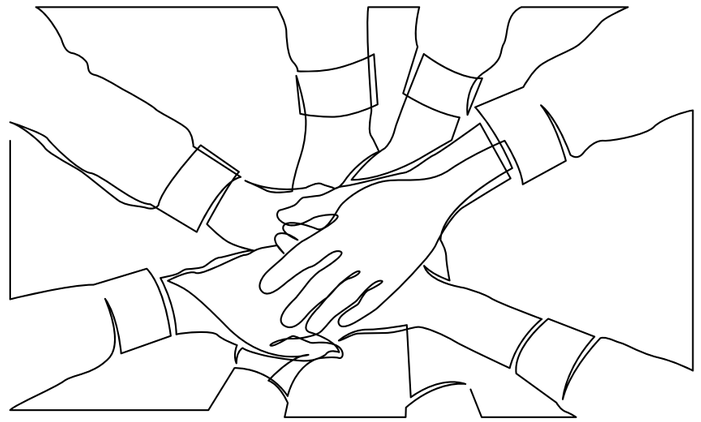
### Harmony with the Installation Site

*AEROXIA*™ provides electric power equipment suitable for the new era, which is environmentally-conscious and user-friendly without strict gas controls.

Notes:
[5] Industrial $CO_2$ gas is produced as a CCUS (Carbon dioxide Capture, Utilization and Storage) application and considered carbon neutral.
[6] Poly- and perfluoroalkyl chemicals. Banning is under discussion in EU, etc.

# “Seven Requirements” for $SF_6$ Alternative Solutions for Power Grids

Once installed, electric power equipment is operated for more than 30 years as critical infrastructure for the benefit of society.
Any alternative solutions must be fully compliant with the “7 requirements” evaluation criteria to evaluate $SF_6$ alternatives proposed by the $SF_6$ Alternative Gas Study Group.[7]



Reference:
[7] K. Taketa, S. Tsukao, K. Kawakita “Domestic situation and response based on trends in international $SF_6$ gas alternative technology” IEE of Japan (2021)

## EHS
(Environmental, Health and Safety)

Practically negligible EHS risks should be ensured.

## Service Condition

-25°C

Applicable to outdoor use down to -25 deg.C or lower.

## Stable Supply

Gas supply should be ensured by multiple suppliers.

## Footprint

Replaceable equipment size is expected even for restricted applications e.g. underground substations.

## Life Cycle Cost

Reasonable total cost is expected, considering operation cost as well as initial cost.

## Gas Handling

Gas handling process should be easy and practical.

## Voltage Coverage

550kv

Scalable to higher ratings up to 550 kV preferably with a single solution.

# Realizing a Human and Environmentally-Friendly Solution

### GWP <1[8] and ODP=0[9]

*AEROXIA*™ uses carbon-neutral natural origin gas mixtures.
Negligible impact on climate change and ozone layer depletion
will be caused even if the gas is accidentally emitted to the atmosphere.

### No Concern about Human Health

*AEROXIA*™ uses only $N_2$, $CO_2$ and $O_2$, which are existing gases commonly used for foodstuffs etc. and completely free of artificial fluorinated and PFAS gases.

Notes:
[8] Global Warming Potential. The GWP of $CO_2$ is defined as 1.
[9] Ozone Depletion Potential. The ODP of CFC-11 ($CCl_3F$) is defined as 1.


# Enabling Sensible Operations

### Applicable for Outdoor Use

Since *AEROXIA*™ gases do not condense down to -50 deg.C even under high gas pressure, they are a perfect fit for low-temperature outdoor applications.

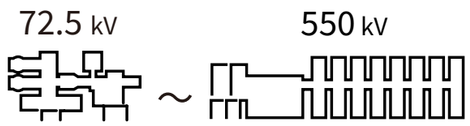
### Easy Gas Handling

The *AEROXIA*™ natural origin gas solution enables simplified gas handling processes where special gas handling gear is not necessary and even gas recovery may not be required.

### No Regulatory Risks, Stable Gas Supply Guaranteed

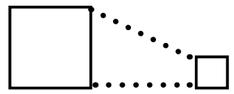
The *AEROXIA*™ natural origin gas solution uses neither artificial fluorinated gas nor gases containing PFAS substances; it only uses common, inexpensive natural origin gases ($N_2$, $CO_2$ and $O_2$) in common with various consumer applications. No potential risk of future regulation exists. Stable gas supply is guaranteed.


# Realizing Versatile Solutions




## Potentially Scalable to Cover the Existing Ratings

The *AEROXIA*™ natural origin gas solution is based on mature $SF_6$ design technologies.  It is therefore potentially scalable to cover the existing high voltage and large capacity ratings.



## Enabling Compact Equipment by Continuous Technical Innovations

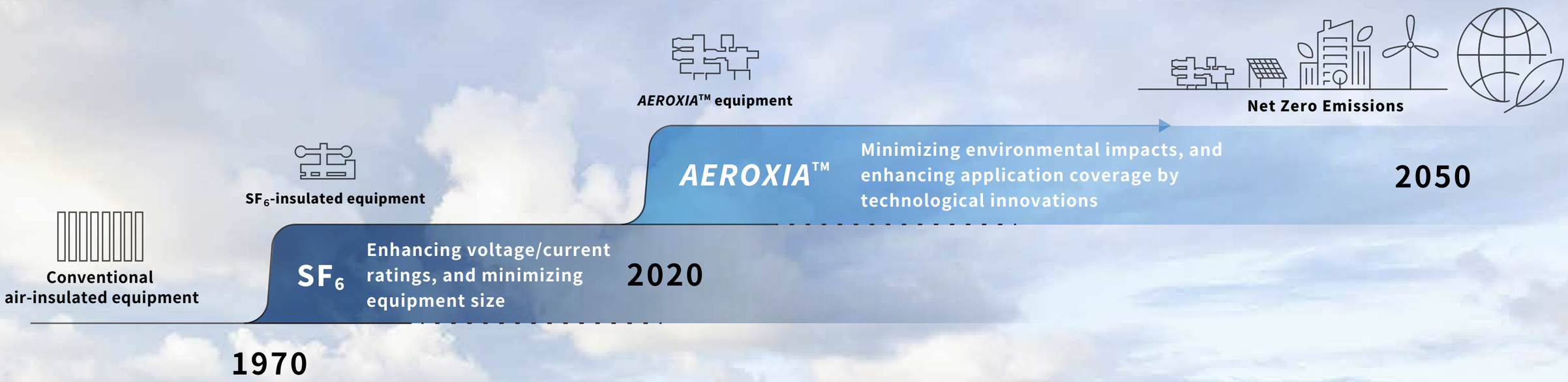
In fact, $SF_6$ equipment has been drastically downsized over decades by design improvements and technological innovations. The *AEROXIA*™ solution has already achieved replaceable equipment size of the 72/84 kV GIS, and will realize compatible equipment size to those of existing $SF_6$ products by continuous technical innovations.

# The Neo Ecology Solution realized with *AEROXIA*™


***AEROXIA*™ - GIS　72.5 kV***

*Collaboratively developed with MEIDENSHA CORPORATION.

| EHS (Environment, Health and Safety) | -25℃ Service Condition | Stable Supply | Gas Handling | LifeCycle Cost | FootPrint | 550kv Voltage Coverage |
|---|---|---|---|---|---|---|
| ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |




# Shifting to the Neo Ecology Solution

Toshiba will contribute to Net Zero Emissions by 2050 with the *AEROXIA*™ $SF_6$-free natural origin gas solution.

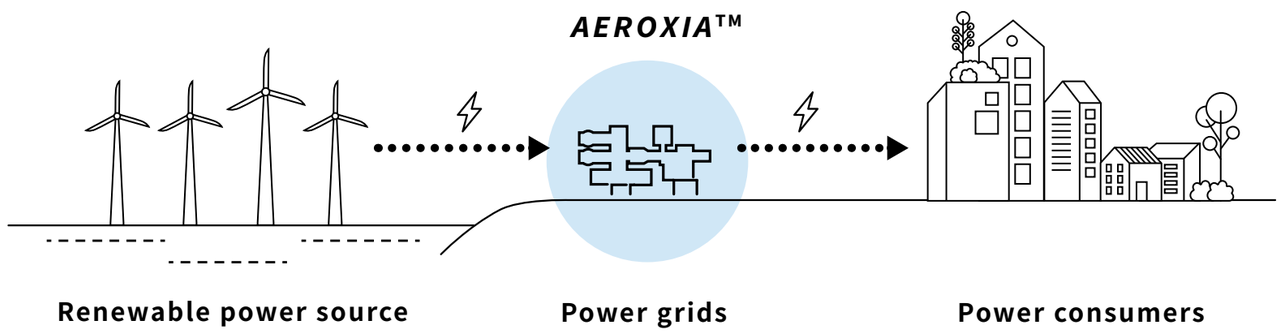
For the past 50 years, sophisticated $SF_6$ technologies have greatly contributed to the reliability, economy and robustness of power grids and have achieved compact equipment up to UHV-class applications over 1,000 kV.

However, the next 50 years will require a gradual shift to Neo Ecology solutions to realize Net Zero Emissions Goals by 2050.

Toshiba will contribute to this global challenge with the *AEROXIA*™ $SF_6$-free solution that is free of any fluorinated gases.

# Generating, Delivering, and Using Clean Power.

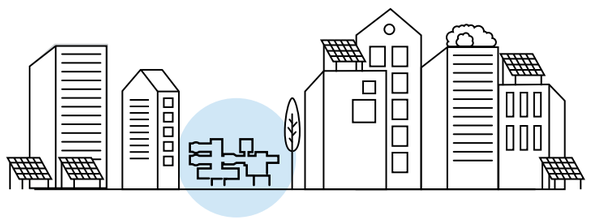
Clean power generated with renewable sources may be delivered to consumers in an environmentally-friendly way, using low-carbon electric power equipment in the power grids.



*The image is for illustration purposes.

# Expansion of distributed power systems will make electric power equipment more familiar to people and societies.

Distributed power systems using renewable energy sources are
expanding and locally produced energy is becoming more common in cities and towns.
Clean and smart power equipment will blend into local
surroundings while supporting the quality of life for our societies.




*The image is for illustration purposes.

# AEROXIA™

**The Permanent $SF_6$-free Solution for Climate-Neutral Power Grids**

**Toshiba will contribute to climate-neutrality by 2050 with innovative natural origin gas solutions for power grids.**
**Committed to People, Committed to the Future.**

TOSHIBA

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