לשכת המהנדסים האדריכלים והאקדמאים במקצועות הטכנולוגיים בישראל

AEAi

חידושים ועדכונים - במתקני חשמל מ"ג:
עדכונים רגולטוריים, השפעות סביבתיות ופתרונות טכנולוגיים ליישום בשטח

July - 2025

Dov Zimerman
Eaton

EATON
Powering Business Worldwide

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EATON

חברה גלובלית לניהול אנרגיה.

מעסיקה כ-**92,000** עובדים ברחבי העולם, ביותר מ-**175** מדינות עם מכירות שנתיות של מעל

24.9 מיליארד דולר (2024)

We make what matters work.*

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Eaton ישראל

- מוצרי איטון נמכרים בישראל מאז 1954
- הסניף הישראלי של החברה ממוקם ברעננה
- מערך לוגיסיטי ומחסן גדול עם זמני אספקה מהירים באזור תעשיה כנות

מחלקות:

1. לוחות וציוד מתח נמוך
   - א. לוחות וציוד מיתוג
   - ב. פסי צבירה
   - ג. תאורת חירום
   - ד. מערכות גילוי אש
2. לוחות וציוד מתח גבוה (נטולי גז SF6)
3. ארונות וציוד ל-Data Center ולחדרי IT
4. מערכות גיבוי UPS ואגירת אנרגיה

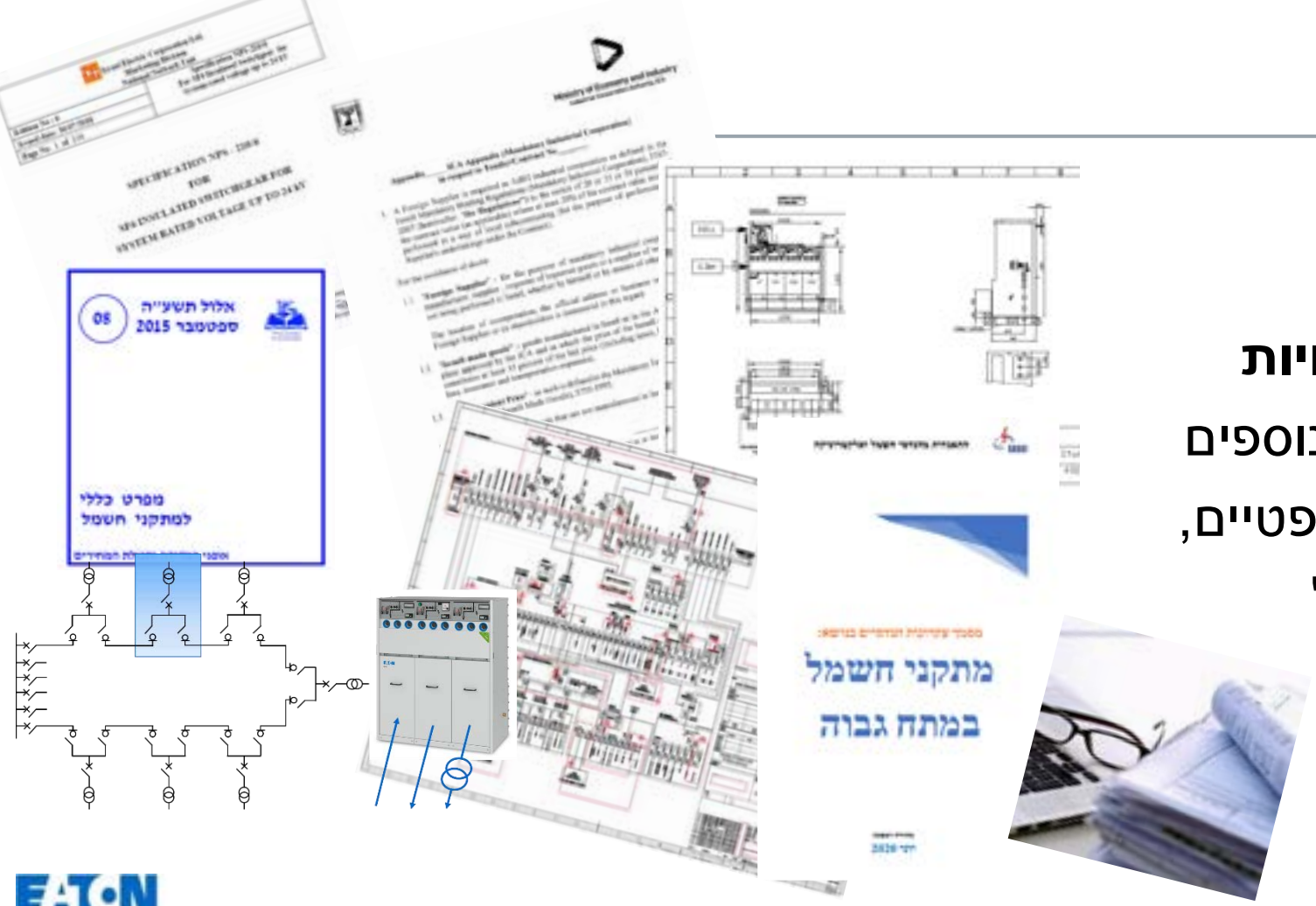
מסמכים

- **תוכניות**
- **מפרטים**
- **כתבי כמויות**
- מסמכים נוספים

מסמכים משפטיים,

מסחריים וכו'

- ועוד



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מסמכים

חובת התקנת לוח

2. כל מיתקן חשמלי יצוייד בלוח, אחד או יותר, בהתאם לתקנות אלה.

תכנון, התקנה ותחזוקה של לוח תק' תשס"ח-2008

3. (א) לוחות יתאימו לפחות לתקנים שיחולו עליהם במפורש בתקנות לפי החוק.

(ב) לוח יתוכנן בידי חשמלאי בלבד; לוח יותקן ויתוחזק בידי חשמלאי או בפיקוחו.

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המפרט הטכני – תקנים ובדיקות

2. תקנים ובדיקות

2.01 כל חלקי הלוחות ומרכיביהם השונים מנתקים/מפסקים וכו' ייוצרו, ייבדקו, יקוטלגו ויאושרו בתעודות Type-Tested רשמיות בהתאם לדרישות תקני IEC/ EN/ ISO הבאים (במהדורתם האחרונה):

IEC 62271-1	High-voltage switchgear and controlgear – Common specifications for high-voltage switchgear and control gear standards
IEC 62271-100	High-voltage switchgear and controlgear – High-voltage alternating-current circuit-breakers
IEC 62271-102	High-voltage switchgear and controlgear – Alternating current disconnectors and earthing switches
IEC62271-103	High-voltage switchgear and controlgear – High-voltage switches
IEC 62271-200	High-voltage switchgear and controlgear – AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

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Xiria

Rated Voltage: 24kV

Rated normal Current: 630A

Loss of service continuity: LSC2B

Partition class: PM

Internal Arc Classification (IAC): AFLR 20kA – 1s

Xiria complies with the following international standards

IEC 62271-1
IEC 62271-100
IEC 62271-102
IEC 62271-103
IEC 62271-200
IEC 62271-304
IEC 61869-1

IEC 61869-2
IEC 61869-3
IEC 60529
EN 50181

ISO 9001
ISO 14001
ISO 50001

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אישורים

חברת החשמל

עסקי - שמור

חטיבת שירותי רשת
אגף הנדסת רשת
מח' פיתוח טכנולוגיות רשת

כ"ב אייר תשפ"ד,
30/05/2024
מספר: 737-0000334-2024

הנדון: <u>מסדר מתח גבוה דגם Xiria תוצרת חברת EATON, הולנד</u>

<u>חידוש אישור</u>

סימוכין: מסמך מס' 737-000011-2020 מיום 18/06/2020

הצהרת יצרן בדבר עמידה בתקן

בהמשך לפנייתכם בבקשה להאריך את תוקף אישור לוחות מתח גבוה מדגם Xiria, שהונפק ביום 18/06/2020 (אישור התקנת ציוד מספר 737-000011-2020).

1. הציוד הוא מסדר מתח גבוה מבודד באוויר.
2. המסדר מצויד במפסקים/מנתקים העובדים בריק.
3. מתח העבודה של המסדר הינו 24 קייו.
4. זרם העבודה של המסדר הינו 630 אי.
5. משפחת המוצר מסופק יחד עם הלוח ע"י חברת EATON.

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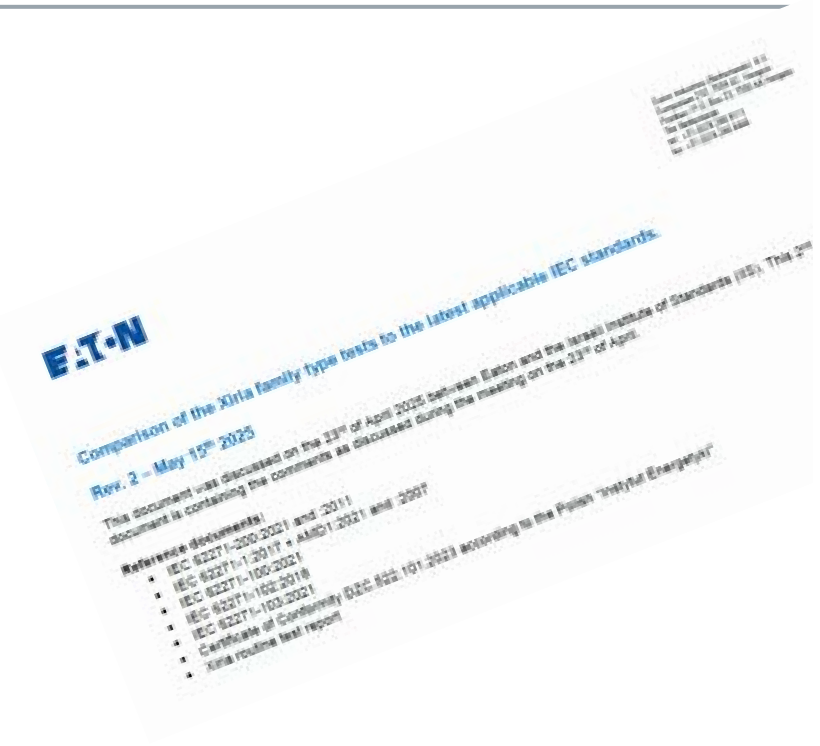
אישורים

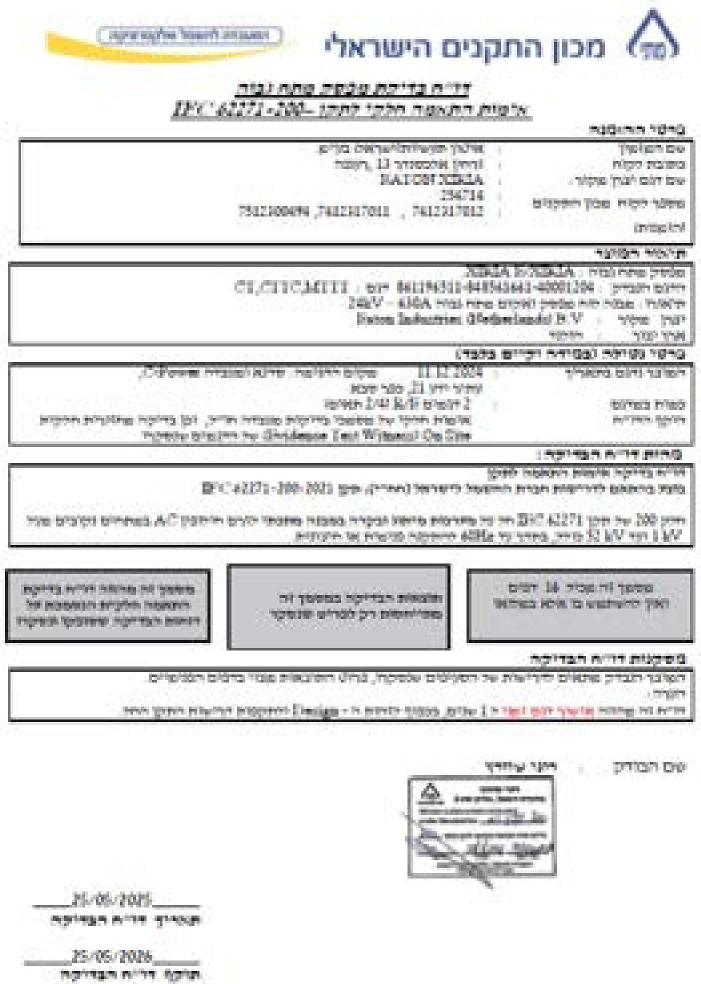

Comparison of the Xiria family type tests to the latest applicable IEC standards.

Rev. 2 – May 15th 2025

This document was discussed on the 23rd of April 2025 between Eaton and the Israeli Institute of Standards (IIS). This 2nd document is containing the comments as discussed during the meeting on the 23rd of April.

Reference documents:

- IEC 62271-200:2021 and :2011
- IEC 62271-1:2017 + AMD1:2021 and :2007
- IEC 62271-100:2021
- IEC 62271-102:2018
- IEC 62271-103:2021
- Certificate of Conformity DEC 822 101 2023 according to the Polish "Instytut Energetyki"
- Xiria routine test report


מכון התקנים הישראלי

דו"ח בדיקת מפסק מתח גבוה

אישור התאמה חלקי לתקן IEC 62271-200

Eaton Industries (Netherlands) B.V

IEC 62271-200-2021

25/05/2025

תאריך דו"ח הבדיקה

25/05/2026

תוקף דו"ח הבדיקה

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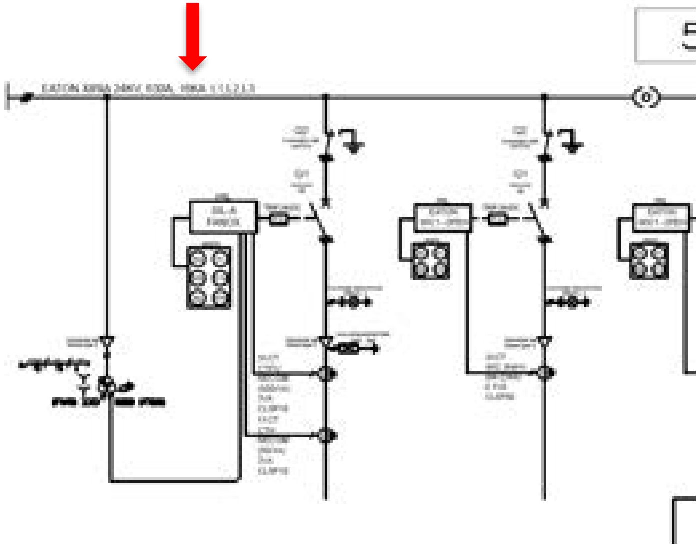
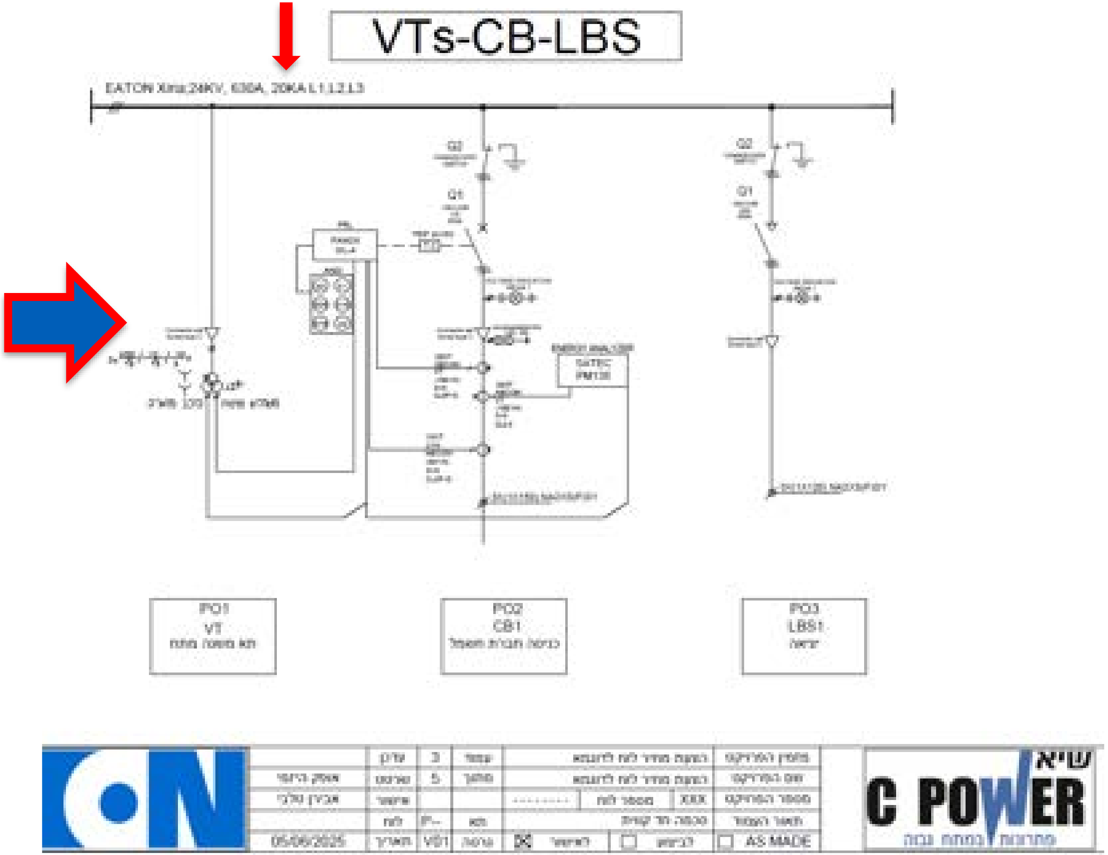
16kA – 20kA





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SF6 (fluorinated gas)

APPLICATIONS OF THE GAS

SF_6 is routinely used as an electrical and heat insulator in medium- and high-voltage T&D applications. These include:

- Circuit breakers
- Switchgears
- Power, voltage, and current transformers
- Gas-insulated lines
- Capacitors

https://dilo.com/sf6-gas/useful-information-sf6/properties

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What is SF_6?

- First reported in 1900 by French Chemist **Henri Moissan**
- **SF_6 or sulfur hexafluoride** is a human made, colourless, and odourless **gas.**
- Chemically stable, Non-toxic*, Non-flammable
- F-gases are a range of chemicals involving fluorine which have been used for a variety of things including the manufacture of shoes, tennis balls, and windows, and as a coolant in refrigerators.
- **Good properties as a dielectric insulating medium, prevents voltage electrical breakdown and explosion hazards.**

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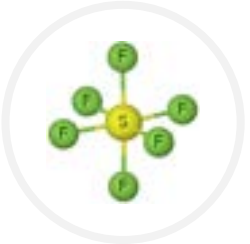
SF_6 (Fluorinated gas)

Colorless and odorless

Non-toxic

Chemically stable

Non-flammable



- **Excellent Dielectric strength**
  - 2.5 times higher than that of air
- **Outstanding Arc quenching**
  - SF_6 is 100x more effective at quenching an arc than air
  - Creates resistance across the arcing contacts and eventually extinguishing the arc.
  - Once the arc is extinguished, sulfur hexafluoride begins to regenerate almost immediately.
- **Great Thermal properties**
  - More effective at dissipating heat then air, nitrogen, or other dielectrics.
  - The volumetric specific heat of SF_6 is 3.7 times that of air, meaning it is more effective at removing heat from the electric equipment

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Challenges in distribution grids

How does the grid look like in 2030?

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Challenges in distribution grids

EU Green Deal

The Energy Transition is on full speed

Economic growth + **Ongoing sector coupling** = **Rise of electrification**

Grid connections, Switchgear and circuit breakers

Fossil-powered generation → Mixed green sources of power (including wind, solar and gas)

New legislation
11 March 2024!

Global installed base of SF_6 **growth by 75% by 2030** ***if no legislation**

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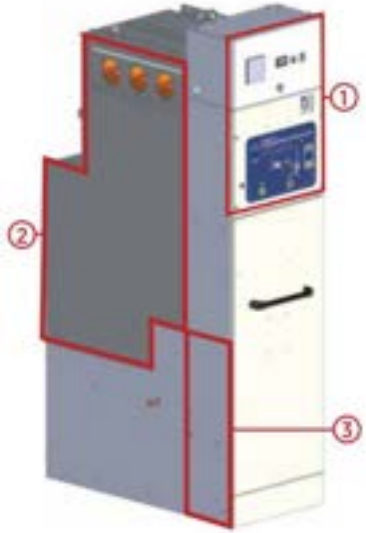
SF_6 switchgears & GIS/AIS Switchgears

HMH Series
Air insulated Switchgear

URING Series
SF gas insulated switchgear



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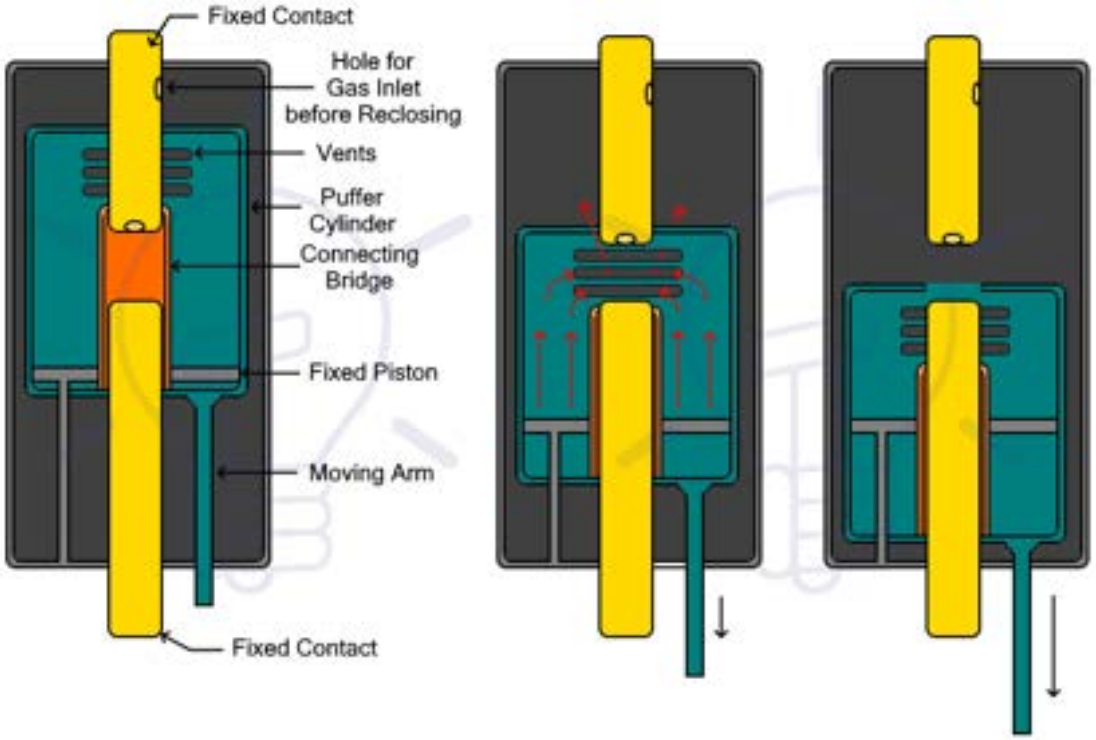
SF_6 in High-voltage equipment



Puffer type SF6 Circuit Breaker

https://www.electricaltechnology.org/2021/08/sf6-sulphur-hexaflouride-circuit-breaker.html

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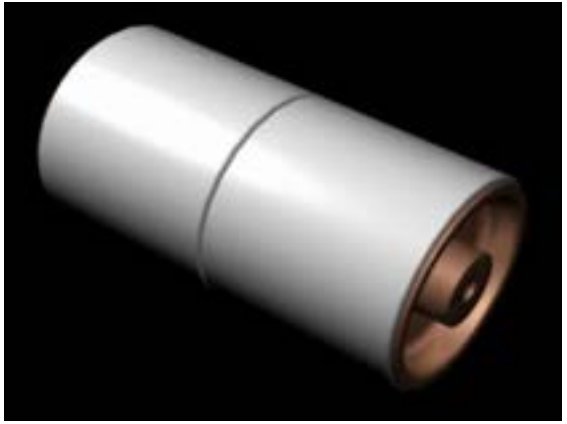
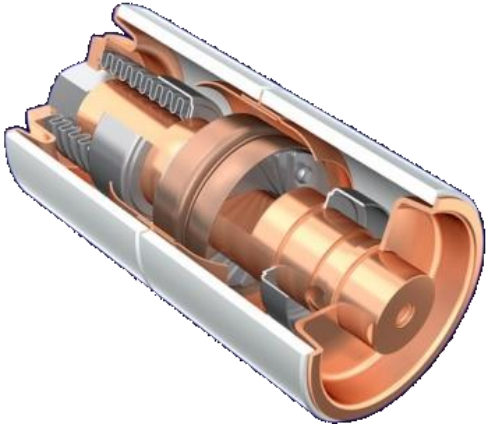
Network design

Arcs

- Switching in vacuum



- 24kV VB18 interrupter



- Switching in oil

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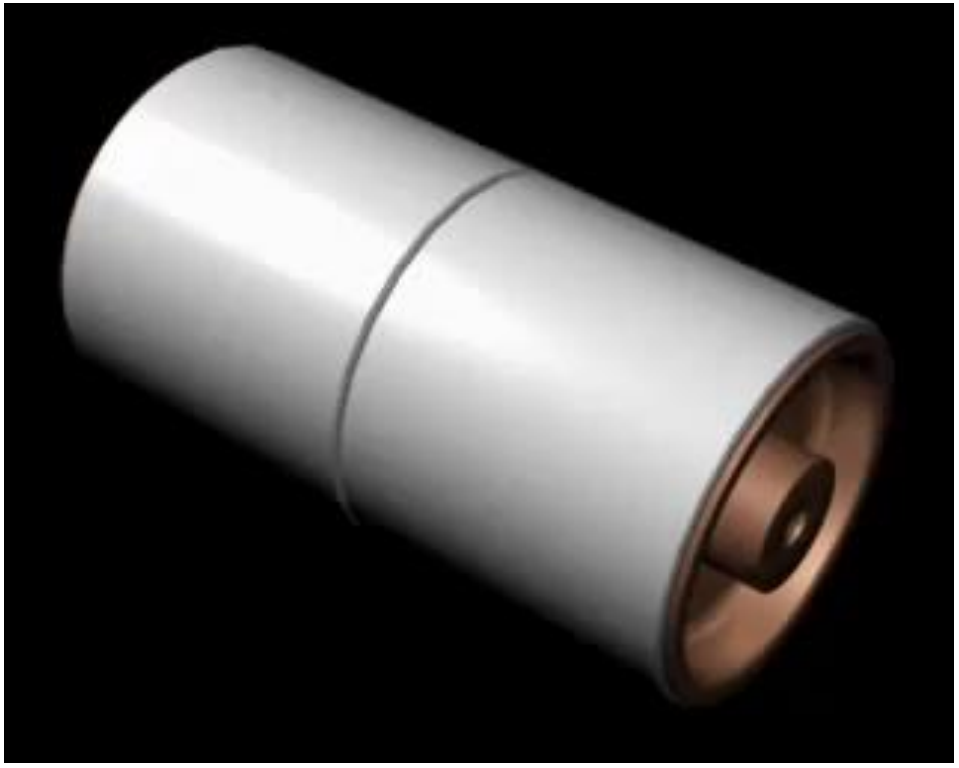
Eaton Vacuum Interrupters



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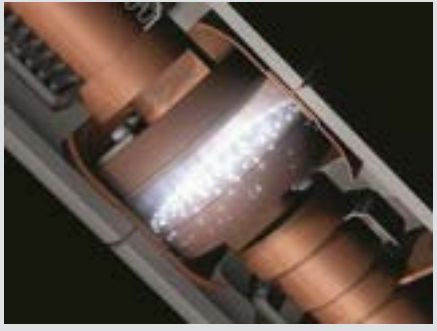
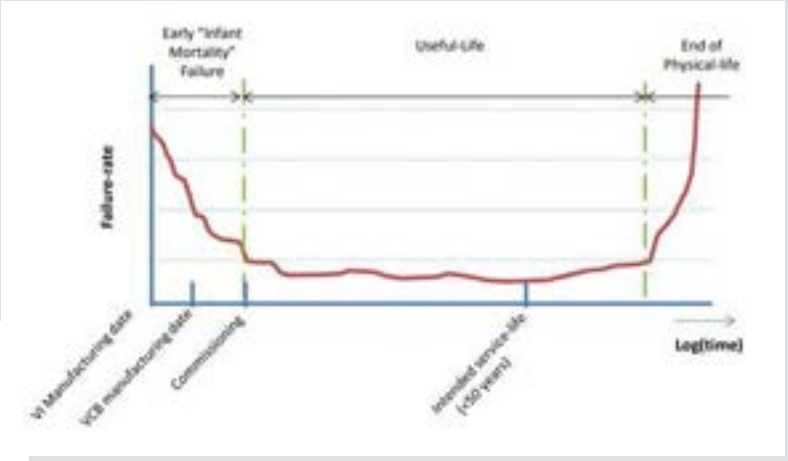
Using Eaton Core Technologies

Vacuum technology

- Safe, compact & reliable construction None
- affected contacts Environmentally friendly
- switching medium 30.000 operations





MTBF Eaton VI > 100.000 year

Design life >= 100 year

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Why SF_6 is used in switchgear?

- SF_6 has been widely used in the electrical industry to prevent short circuits and accidents
- When used as an interrupting medium, SF_6 is able to quench the arc
- It is non-flammable, non-explosive, colourless, odourless, and non-toxic*
- It is effective as an insulating material for medium and high-voltage electrical installations
- SF_6 switchgear falls under three categories:
  - Closed pressure systems
  - Controlled pressure systems
  - Hermetically sealed systems

*Whilst SF_6 is non-toxic, it does not support life and can cause suffocation. Heavy duty switching operations can generate harmful by-products from decomposition.

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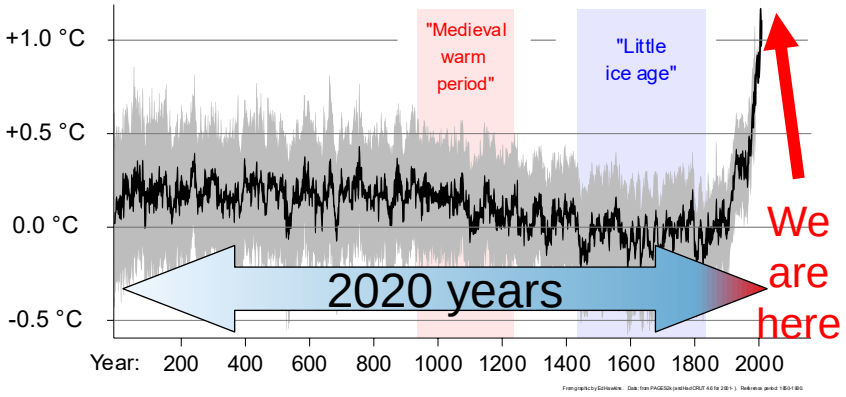
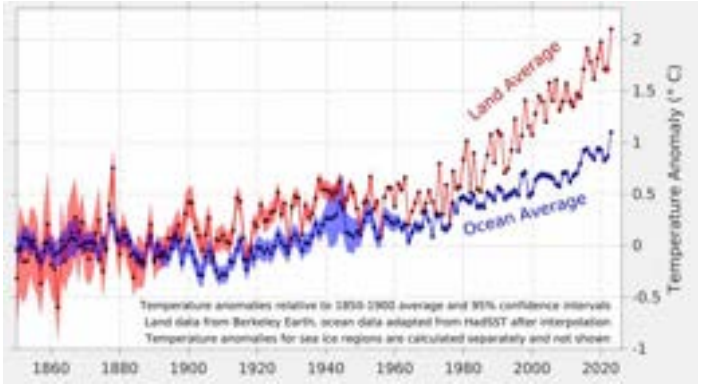
Global view on climate and energy
Motivation: global temperature rise

Global Average Temperature Change



Source:Global temp. Change: By RCraig09 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=87832845

Land and Ocean Temperatures 1850-2023



Source: https://berkeleyearth.org/global-temperature-report-for-2023/

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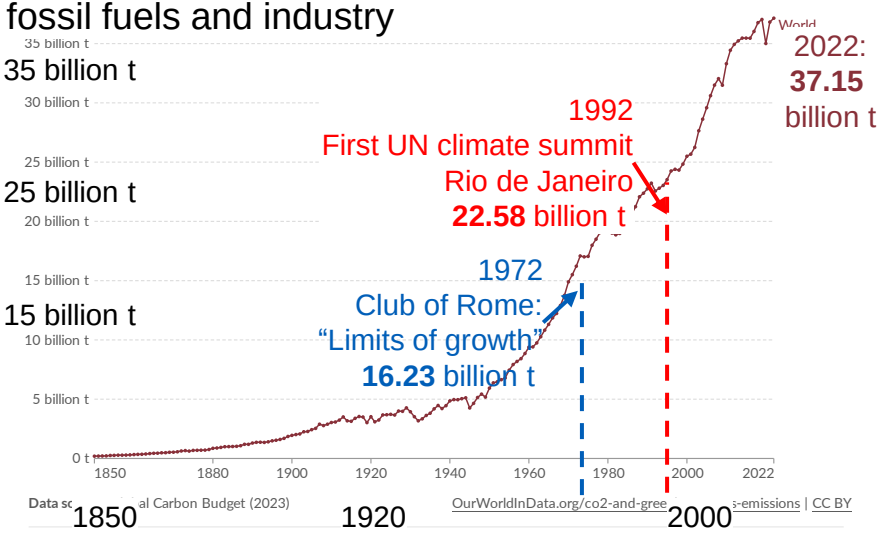
Global view on climate and energy

Motivation: CO_2 emissions

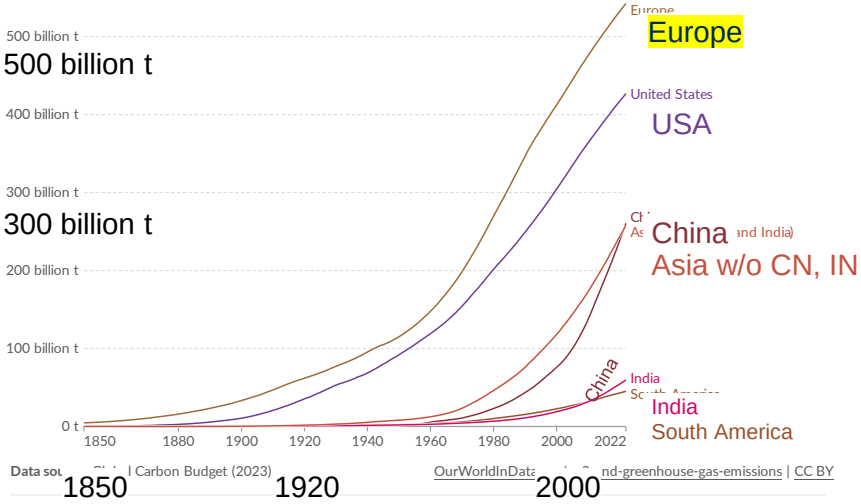
Worldwide annual CO_2 emissions from fossil fuels and industry



1. **Fossil emissions**: Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

https://ourworldindata.org/grapher/annual-co2-emissions-per-country

Cumulative CO_2 emissions from fossil fuels and industry since 1750



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https://ourworldindata.org/grapher/cumulative-co-emissions

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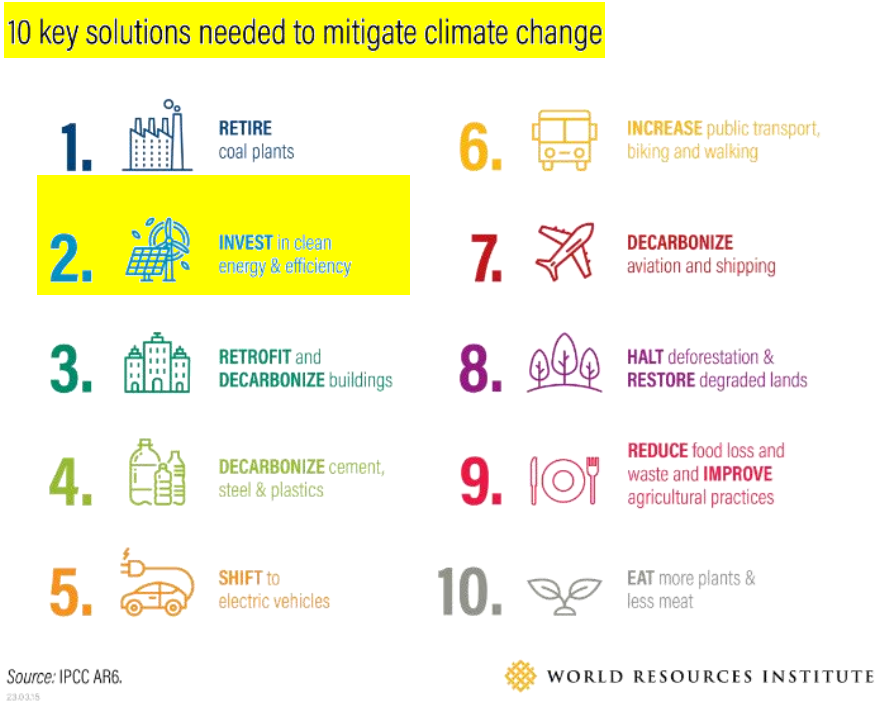
Motivation: Energy efficiency
Invest in clean energy and efficiency

- IPCC report 2023
  - Power generation, buildings, industry, and transport are responsible for close to 80% of global emissions
  - One necessary measure is **investment in clean energy & efficiency (2.)**



Source: https://www.wri.org/insights/2023-ipcc-ar6-synthesis-report-climate-change-findings and https://www.ipcc.ch/report/ar6/syr/

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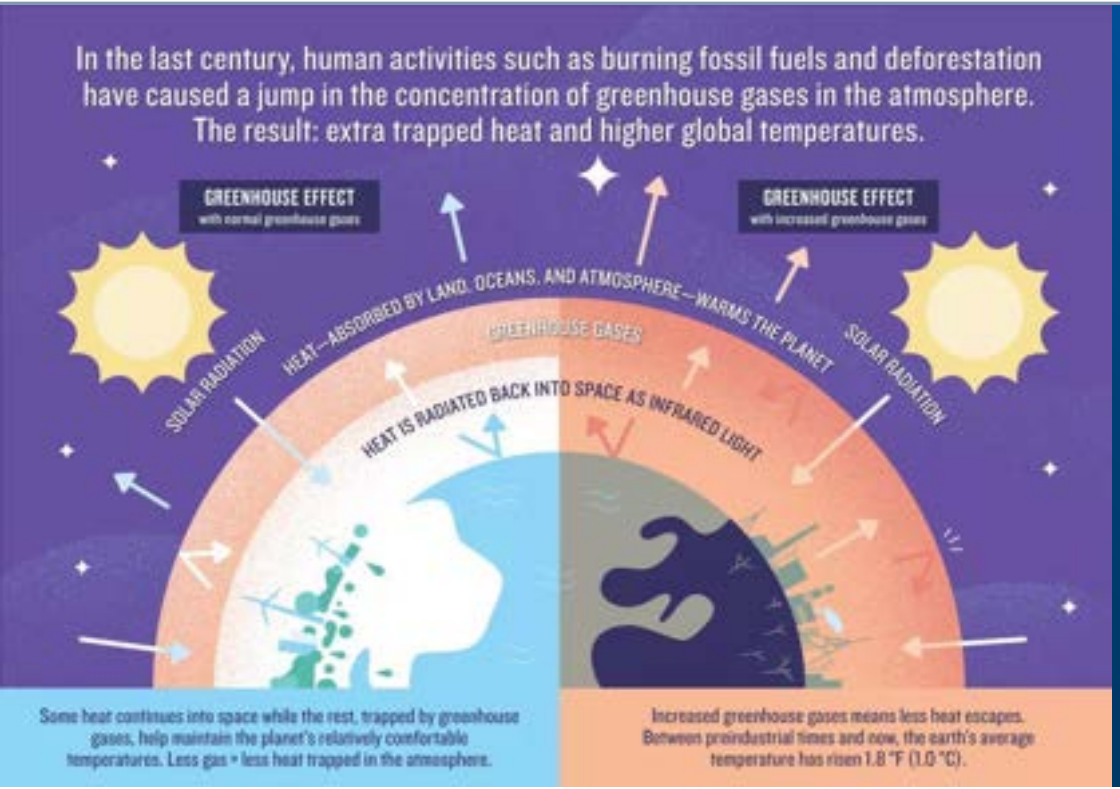
What is a greenhouse gas?



Daytime: the sun shines through the atmosphere, warming the earth's surface.

Nighttime: the earth's surface cools, releasing heat back into the air. But some of the heat is trapped by the greenhouse gases in the atmosphere.

Greenhouse gases act like the glass walls of a greenhouse trapping in the heat.

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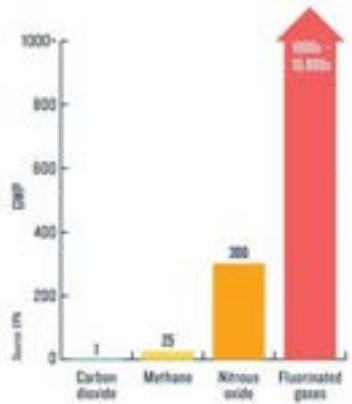
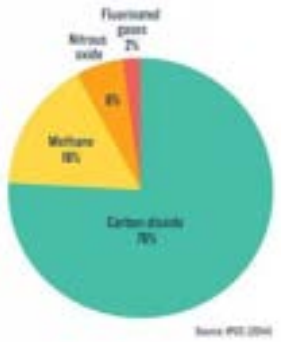
SF_6 aka fluorinated gas

- Over a 100-year period, SF_6 is **23,500** times more effective at trapping infrared radiation than an equivalent amount of carbon dioxide (CO_2).
- SF_6 is also a very stable chemical, with an atmospheric lifetime of **3,200 years**.

HOW GREENHOUSE GASES WARM OUR PLANET



The global warming potential (GWP) of human-generated greenhouse gases is a measure of how much heat each gas traps in the atmosphere, relative to carbon dioxide.



How much each human-caused greenhouse gas contributes to total emissions around the globe.

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Greenhouse gas equivalents

Preventing emission of 1kg (2.2lbs) of SF_6 has the equivalent environmental impact as

5

Removing 5 vehicles from the road for an entire year

11

Preventing the burning of 11 metric tons of coal

54

Eliminating the combustion of 54 barrels of oil

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Greenhouse Gases Global Warming Potential (GWP)

Gas	Common Source or Application	Global Warming Potential (GWP)
Carbon Dioxide (CO2)	Fire suppression, carbonated beverages, by-product of fossil fuel consumption	1
Methane (CH4)	Consumed as fuel (also known as Natural Gas)	21
HFC6-152a	Refrigerant, aerosol spray propellant	140
Nitrous Oxide (N2O)	Known as 'Laughing Gases, pain relief in dental procedures, car performance, and preservative.	310
HFC-32	Refrigerant	650
HFC-4310mee	Solvent for cleaning process	1,300
HFC-125	Used as a fire suppression agent	2,800
HFC-143a	Refrigerant, aerosol spray propellant	3,800
HFC-236fa	Used as a fire suppression agent, refrigerant	6,300
CF4	Refrigerant, electronics fabrication	6,500
C2F6	Semiconductor fabrication	9,200
Fluoroform (HFC-23)	Semiconductor fabrication, fire suppressant	11,700
SF_6	**Electrical Switchgear**	**25,200**

Source: WPD, A Literature Review on SF6 Gas Alternatives for use on the Distribution Network, 2018 [2]

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SF_6 Toxic By-products

- Reactive decomposition by-products form when SF_6 is exposed to:
  - **spark discharges**
  - **partial discharges**
  - **switching arcs**
  - **failure arcing**
- Decomposition **by-products** can take the **form of gas** or **powders**
- If by-products are ingested or inhaled this can cause: eye, nose and throat irritation, **pulmonary oedema**, and other **lung damage**, skin and eye burns, nasal congestion, Bronchitis, rashes

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Kyoto protocol sets path for F-Gas regulation

The Kyoto protocol stimulated the European Union to enforce the 2007 F-gas regulation.

Today SF_6 is banned for most industries. Exception is the switchgear industry because in 2014 SF_6 was deemed to have no reliable alternative.

The switchgear industry and its users are responsible for 80% of total annual SF6 gas emissions.

European Union:

"No later than 1 July 2023, the Commission shall publish a report assessing whether ***cost-effective, technically feasible, energy-efficient and reliable alternatives*** *exist, which make the replacement of fluorinated greenhouse gases possible in new medium-voltage secondary switchgear and new small single split air-conditioning systems and shall submit, if appropriate, a legislative proposal to the European Parliament and to the Council to amend the list set out in Annex III."*
– **Current F-gas regulation**

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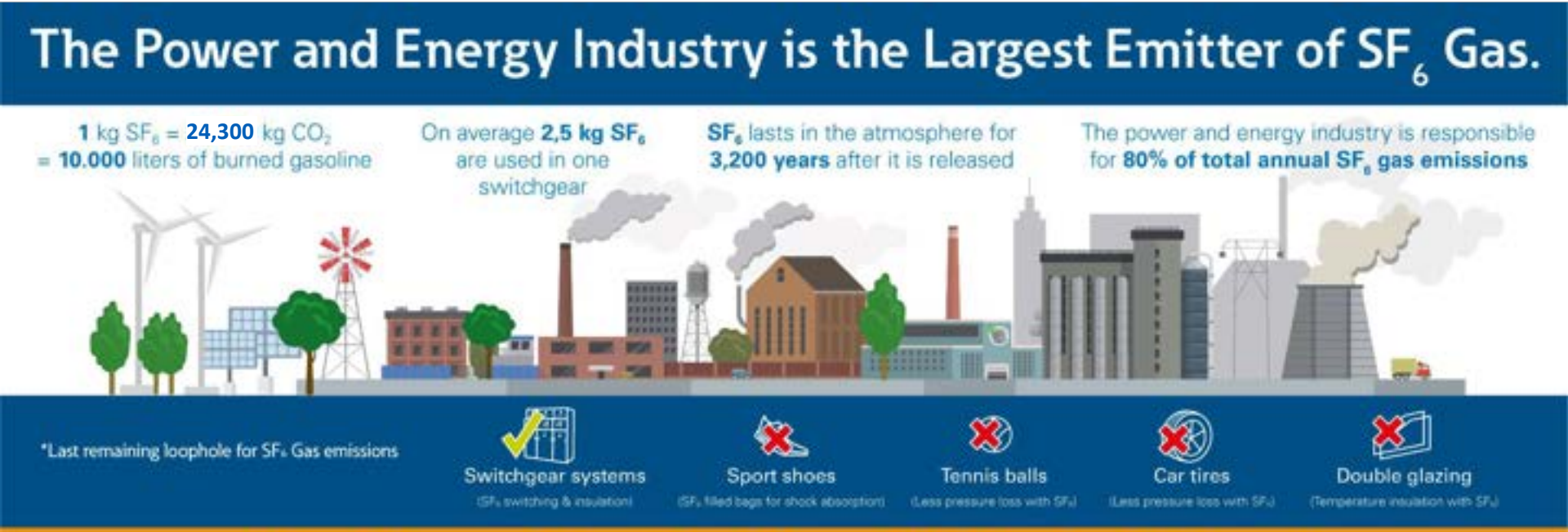
How damaging is SF_6 to the environment?



- IPCC AR6 Report
- ELI: http://data.europa.eu/eli/reg/2024/573/oj

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How damaging is SF_6 to the environment?

A rubber balloon filled with SF6 will expand and ultimately burst, as the smaller and faster-moving O2 and N2 molecules diffuse through the rubber skin into the balloon very much faster than SF6 can diffuse out. SF6 has been used to inflate car tyres, and Nike employed SF6 for air cushioning its Air Max shoes from 1978 onwards, as the use of this large molecule minimised leaks from the air cushions in the heel. Though the greenhouse potential of SF6 was recognised in 1992, it took them nearly 14 years to solve the problem; in the end, Nike used 65 layers of plastic to reduce nitrogen loss, and employed blow moulding to produce the desired product, the SF6-free AirMax 360 (photo, left).

https://www.chm.bris.ac.uk/motm/SF6/SF6h.htm

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עדכון 3-2024

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20.2.2024

REGULATION (EU) 2024/573 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 7 February 2024

on fluorinated greenhouse gases, amending Directive (EU) 2019/1937 and repealing Regulation (EU) No 517/2014

(Text with EEA relevance)

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עדכון 3-2024

מתי יחלו ההגבלות?

תקנות הגז נכנסו לתוקף **באירופה** 20 יום מהפרסום הרשמי – כלומר הם נכנסו כבר לתוקף **ב-11/3/2024.**

	מתח	החל מ-
איסור על התקנת ציוד או לוחות מתח גבוה המכילים גז SF6 / F-gases	**עד 24kV (וכולל)**	**1/1/2026**
איסור על התקנת ציוד או לוחות מתח גבוה המכילים SF6 / F-gases	מ- 24kV עד 52kV	1/1/2030
איסור על התקנת ציוד או לוחות מתח עליון עם F-gases בהם GWP ≥ 1*	מ 52kV ועד 145kV	1/1/2028
איסור על התקנת ציוד או לוחות מתח עליון עם F-gases בהם GWP ≥ 1*	מ 145kV	1/1/2032

*GWP - global warming potential

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EU Fgas Regulation

2024

Regulation (EU) 2024/573 of the European Parliament and of the council of 7 February 2024

- Leak checks § 5
- Leakage detection systems § 6
- Record-keeping § 7
- Recovery and destruction § 8
- Certification and training § 10
- Control of use § 13

01

2026

F-gas prohibition in MV switchgear

≤ 24 kV

(1-1-2026)

2028

F-gas phase out of HV switchgear between 52 kV and 145 kV

2030

F-gas phase out of MV switchgear between 25 kV and ≤ 52 kV

GWP values deleted for MV = Full F-gas ban on probation dates (exemptions apply)

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REGULATION (EU) 2024/573 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

Leak checks (*Article 5)*

Electrical switchgear shall not be checked for leaks provided that it complies with one of the following conditions:

(a) it has a tested leakage rate of less than 0,1 % per year as set out in the technical specification of the manufacturer and is labelled accordingly;

(b) it is equipped with a pressure or density monitoring device with an automatic alert system while in operation;

(c) it contains less than 6 kilograms of fluorinated greenhouse gases listed in Annex I.

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High-voltage switchgear and controlgear - Part 4: Handling procedures for gases for insulation and/or switching (IEC 62271-4:2022)

3.1.21
sealed pressure system
volume for which no further liquid, gas or vacuum processing is required during its expected operating duration

Note 1 to entry: Examples of sealed pressure systems are vacuum circuit-breakers or some MV circuit-breakers or MV switchgear with leakage rates < 0,1 %/a.

Note 2 to entry: Sealed pressure systems are typically assembled and tested in the factory.

Note 3 to entry: Expected operating duration starts when the device is sealed.

[SOURCE: IEC 62271-1:2017, 3.6.6.3, modified – Note 1 to entry and Note 2 to entry modified.]

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IEC 62271-4:2022

5 Gas handling during normal service life

5.1 Topping-up of gas to the filling pressure/density for insulation and/or switching

This subclause applies to gas compartments of closed pressure systems to assure continuity of service. Usually, the pressure/density monitor generates an alarm/indication due to too low pressure/density. The alarm value shall be proposed by the electric power equipment manufacturer.

A.6.14 Gas concentration alarm systems

Gas concentration alarm systems might be installed to monitor the SF_6 concentration in a room. Such alarm systems require detectors with very high long-term stability. The infrared absorption characteristic of SF_6 is used as the basis for most detectors of this type. An infrared source is used to heat a gas sample in a differential pressure-measuring device using a sensitive capacitance transducer. The pressure rise is measured.

Sensitivities down to 10 µl/l (ppmv) can be achieved. Automatic functional check facilities can

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IEC 62271-4:2022

Table A.1 – Measures when working with SF_6 electric power equipment

A notice stating that open fire, naked flames (for example matches), smoking, use of heat engines, heating to more than 180 °C and welding without special precautions are prohibited because SF_6 decomposes in the presence of certain metals above the temperature of 200 °C, and will decompose on its own at temperatures above 500 °C, should be displayed. Electric arcing (through normal operations or interruption of fault currents) causes decomposition. Naked flames can also cause decomposition. Instructions for giving first-aid (see A.2.8) should be displayed while SF_6 is being handled in any location.

When a gas compartment is opened after the electric power equipment has been in service, personnel should wear suitable protective clothing in order to avoid contact with the fine solid by-products, which can be present. Particular attention should be given to protecting the eyes and the respiratory tract. Personnel working in or near to opened gas compartments, which have contained normally arced or heavily arced SF_6 should:

- use suitable tools and handling equipment;
- wear suitable protective clothing (see A.2.5);
- observe high standards of personal hygiene;
- clean themselves and their handling equipment using disposable materials, before leaving the work area;
- remove protective clothing and wash them thoroughly as soon as possible after having left the work area;
- ensure that clothing, tools and components which have been in contact with by-products are securely packed in sealed bags or other sealed containers and are subsequently treated to neutralise any residues.

עדכון 3-2024 ?

IEC 61936-1

Edition 2.1 2014-02

Power installations exceeding 1 kV a.c.
Part 1: Common rules

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IEC 61936-1 2014

8.8.2 SF_6 leakage

Recommendations for use and handling of SF_6 gas are given in IEC/TR 62271-303.

To cover the unlikely event of an abnormal leakage, ventilation shall be provided in the switchgear room and in other accessible locations where the accumulation of gas may present a hazard. In case of outdoor installation, no special precautions are needed.

In rooms with SF_6 installations, which are above ground, natural venting is sufficient, if the gas volume of the largest compartment at atmospheric pressure does not exceed 10 % of the volume of the accessible switchgear room. If this demand cannot be fulfilled, mechanical ventilation shall be installed.

In rooms with SF_6 installations which are below ground on all sides, mechanical ventilation shall be provided if gas quantities which pose an intolerable risk to the health and safety of personnel (see note below) are capable of collecting in terms of gas quantity versus size of the room.

Chambers, ducts, pits, shafts, etc., situated below SF_6 installation rooms and connected to them, shall have the possibility of being ventilated.

To guarantee that no thermal decomposition of SF_6 present in the atmosphere can occur the

The Energy Transition is on full speed

- Rise of electrification due to economic growth and ongoing sector coupling
- Move from coal-powered generators to mixed green sources of power including wind, solar and gas
- Increased grid connections and rise in switchgear and circuit breakers
- Global installed base of SF_6 was expected to grow by 75% by 2030

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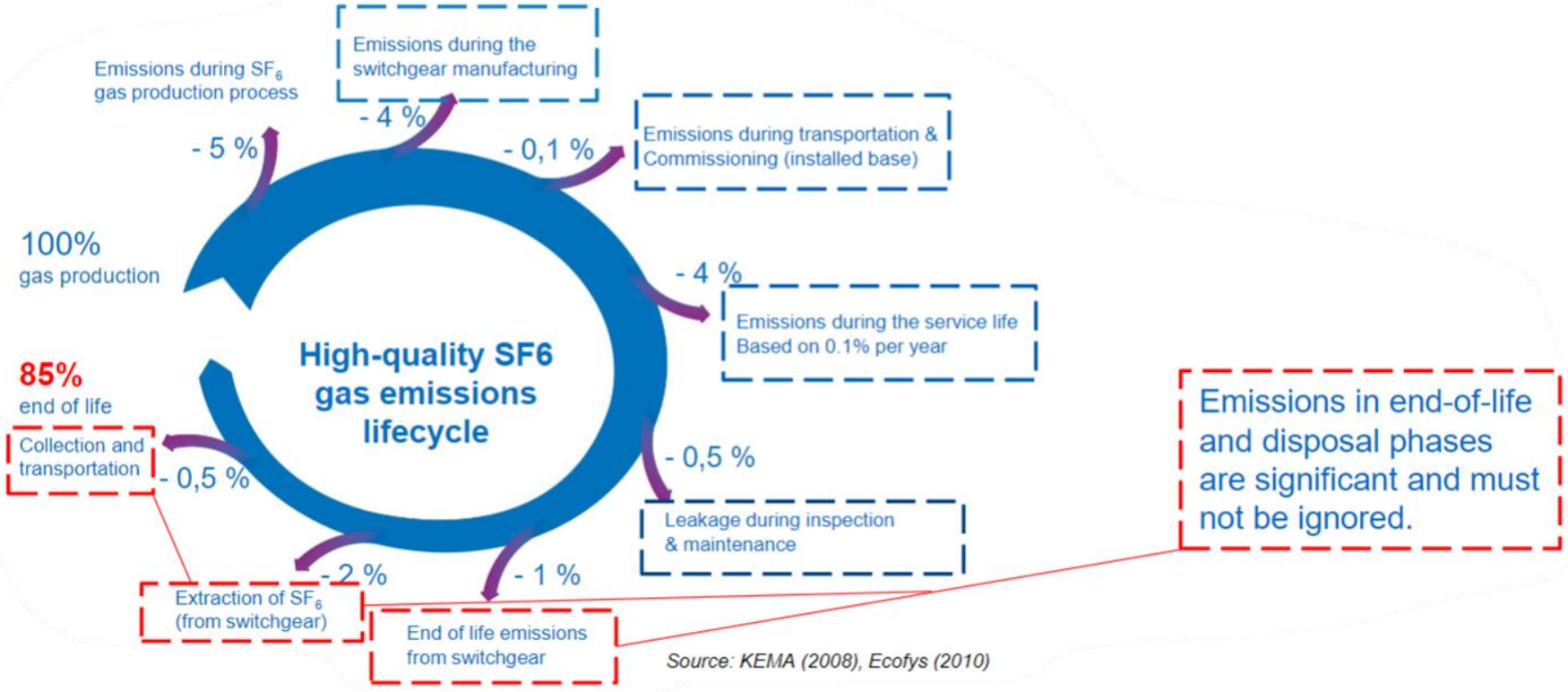
Leakage during Life Cycle



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- תאריך החלת האיסור -ינואר 2026, נוגע לתאריך **<u>הפעלת הציוד</u>** (ולא לתאריך הזמנת הציוד או להעמדת הציוד באתר) – ראו Article 13 - סעיף 9 ע"מ 29 בפרסום הרשמי המצורף, ולכן האיסור יחול גם על שימוש בלוחות שהוזמנו או אף הועמדו באתר (ולא הופעלו) לפני ה 1/1/2026.
- האיסור אינו נוגע לציוד מותקן ומופעל.
- תתאפשר מכירה של ציוד לצורך הרחבת לוחות קיימים או לצורכי תחזוקה, עם זאת סביר שמאחר והרגולציה תשפיע באופן ניכר על יצרני הציוד בחו"ל - זמינות הציוד והמחיר יהיו בהתאם.
- התקנות החדשות מכילות הגבלות ופיקוח הדוק גם על ייצור גזי ה "F", לרבות אופן השימוש בגזים, ההובלה, האחסון, ועד להנחיות ורגולציה בנושא הגריטה בשלב ה"end of live", כך שסביר שיהיו לכך השלכות משמעותיות על זמינותו ומחירו של גז ה- SF_6.

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(44) The import from and export to a State that is not party to the Protocol of HFCs as well as of products and equipment containing HFCs or whose functioning relies upon those gases should be prohibited as from 2028. The Protocol envisages that prohibition from 2033, and the purpose of its earlier application under this Regulation is to ensure that the global HFC reduction measures of the Kigali Amendment provide the envisaged benefit to the climate as soon as possible.

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SF_6

הפחתת פליטות גזי חממה בישראל

כדי לצמצם את ההשלכות של שינויי האקלים ולהתייעל בשימוש במשאבים, נוקטים בעולם פעולות ותוכניות להפחתת פליטות גזי חממה, בעיקר על ידי צמצום שרפת דלקים פוסיליים, סוגי דלק שמקורם במחצבים (נפט ותזקיקיו, גז) והטמעת תהליכי התייעלות בכל מגזרי הפעילות האנושית. ממשלת ישראל התחייבה ב-2021 להפחית פליטות גזי חממה עד 2030 בשיעור 27% בהשוואה ל-2015 ולעמוד באפס פליטות עד 2050 בהשוואה ל-2015. המאמצים הבין-לאומיים להפחתת גזי החממה מתקיימים במסגרת אמנת המסגרת של האו"ם להתמודדות עם שינויי האקלים

נושאי: אקלים, יחסים בין-לאומיים • נושא משני: הפחתת פליטות (מיטיגציה) • תאריך פרסום: 27.10.2019 • תאריך עדכון: 09.05.2024

דין וחשבון סביבתי לשנת 2022

טבלה 17: פירוט מקדמי ההתחממות הגלובלית של גזי החממה השונים כפי שנקבעו במסגרת מתודולוגיית החישוב של המנגנון הוולונטרי:

מקדם ההתחממות הגלובלית GWP			
עד שנת 2013	החל משנת 2014	החל משנת 2020	
1	1	1	CO_2 פחמן דו חמצני
310	298	265	N_2O תחנן תת חמצני
21	25	28	CH_4 מתאן
23900	22800	23500	SF_6 גופרית שש פלואורית

טבלה 15: סיכום דיווחי חברת החשמל למנגנון המקומי הוולונטרי של המשרד להגנת הסביבה הישראלי לשנים 2010 - 2014: פילוח הפליטות הישירות לפי סוג גזי חממה

פליטות גזי חממה (טון שווה ערך פחמן דו-חמצני)					
סה"כ פליטות	SF_6	CH_4	N_2O	CO_2	
34,312,517	49,998	10,684	128,097	34,123,738	2014
38,762,789	51,922	10,904	145,145	38,554,817	2013
46,363,988	50,519	16,770	188,309	46,108,389	2012
40,661,709	50,283	12,178	158,381	40,440,866	2011
39,467,669	33,149	10,930	150,993	39,272,597	2010

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What between now and 1-1-2026?

To consider

- SF_6 insulation is seen as environmental unfriendly. The banked amount adds to CO_2 footprint
- The dismantling cost for SF_6 insulated gear will raise and negatively influence TCO
- Green public procurement in public tenders

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Switching to SF_6-free - answering challenges

Challenges

- Product selection
- Migration process

Roadmap for a smooth transition

- Education and awareness: understand available options considering performance, safety, and cost
- Access to resources: whitepapers, case studies, and expert insights
- Collaboration: engage with SF_6-free manufacturers and learn from their expertise
- Early adoption: act now

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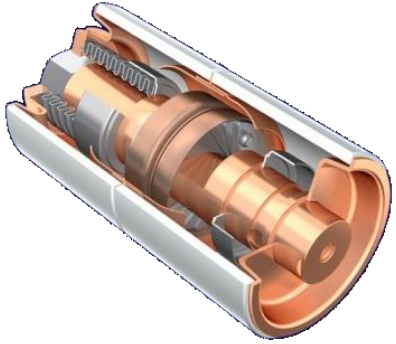
Alternatives to SF6 GIS

- Conventional AIS (primary switchgear)
- Fluorketones / Fluornitrilles (GIS) Prohibited PFAS, GWP
- Air (or natural air components) under high pressure (GIS)
- Solid Insulation (SIS)
- Air under Atmospheric pressure (AIR GIS) > Xiria

  - Switching in Vacuum



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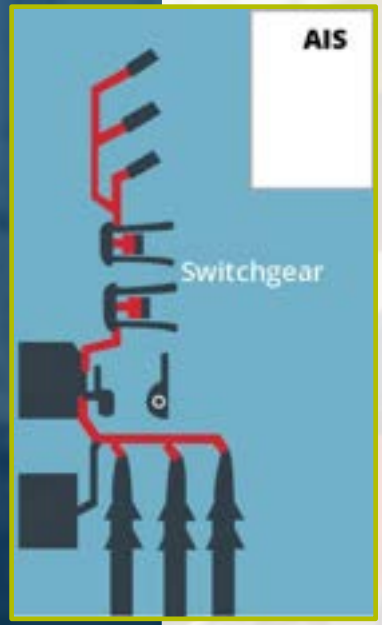
AIS - Conventional air-insulated switchgear



- Mainly for primary switchgear
- Primary insulation medium is Air (surrounding Air)
- No tank / hermetic concept
- More affordable than GIS
- Simpler structures than with GIS
- Withdrawable CBs / other modules
- Less down-time due to fast change of CB possible
- Larger dimensions compared to GIS/SIS (For high currents this difference is small)

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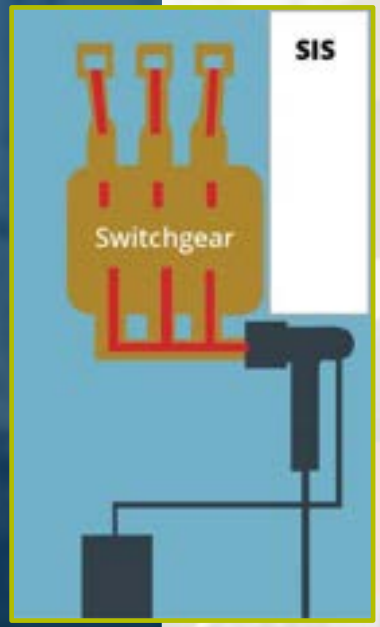
SIS - Solid insulated switchgear



- Primary & secondary switchgear
- Open enclosure / compartmentalized (PM)
- Primary parts are insulated with solid material
- Decreased air gap between phases
- Conductors enclosed in solid materials
- Compact and safe design – requires less space
- More expensive than AIS
- Keeps electrical properties as cast resin is not aging

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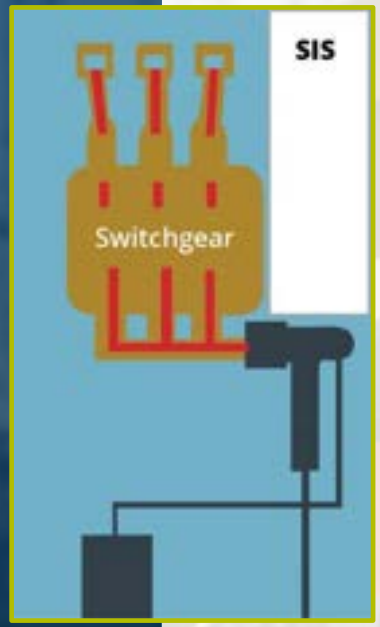
SSIS – Shielded or Screened SIS



- Conductive layer outside of the insulating layer)
- Ground shield around each phase of the switchgear
- No exposure to live parts
- The ground layer;
  - minimizes phase-to-phase interaction
  - reduces the likelihood of arc flash
  - helps to protect the insulating material itself
- More expensive than SIS
- The ground shield behaves like a «Faraday cage»

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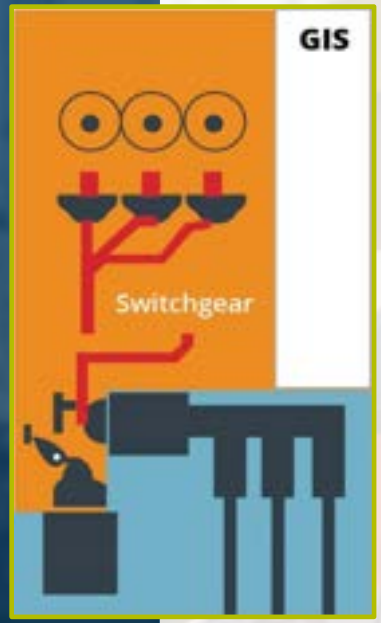
New GIS – Pressurized air or components of air (Industrial air)



- Secondary and primary switchgear
- Pressurized industrial air (mainly N2) or pressurized air
- Hermetically sealed-for-life tank
  (Active/primary parts in the tank require no maintenance)
- Compact design but pressure checks needed
- Operational personnel needs to be certified
- Pressure up to 2.5 bars abs - higher than with SF_6
  Dielectric properties can get lost when pressure is lost
- Relatively new technology
- If leaking than the dielectrical behavior is on stake

  (Design needs to be verified in the field for long-term behavior)

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Non-pressurized air-GIS

- Hermetically sealed-for-life tank; GIS
- For active/primary parts - no maintenance required
- Compact, safe design and less TCO
- Switching using vacuum interrupters
- Lifetime of more than 40 years
- Proven technology
- No pressure in the tank = no certified operational personnel needed
- Very stable dielectrical behavior, even if the tank would be leaking
- Xiria uses this proven technology
- On the market since 2002

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Ahead of our time

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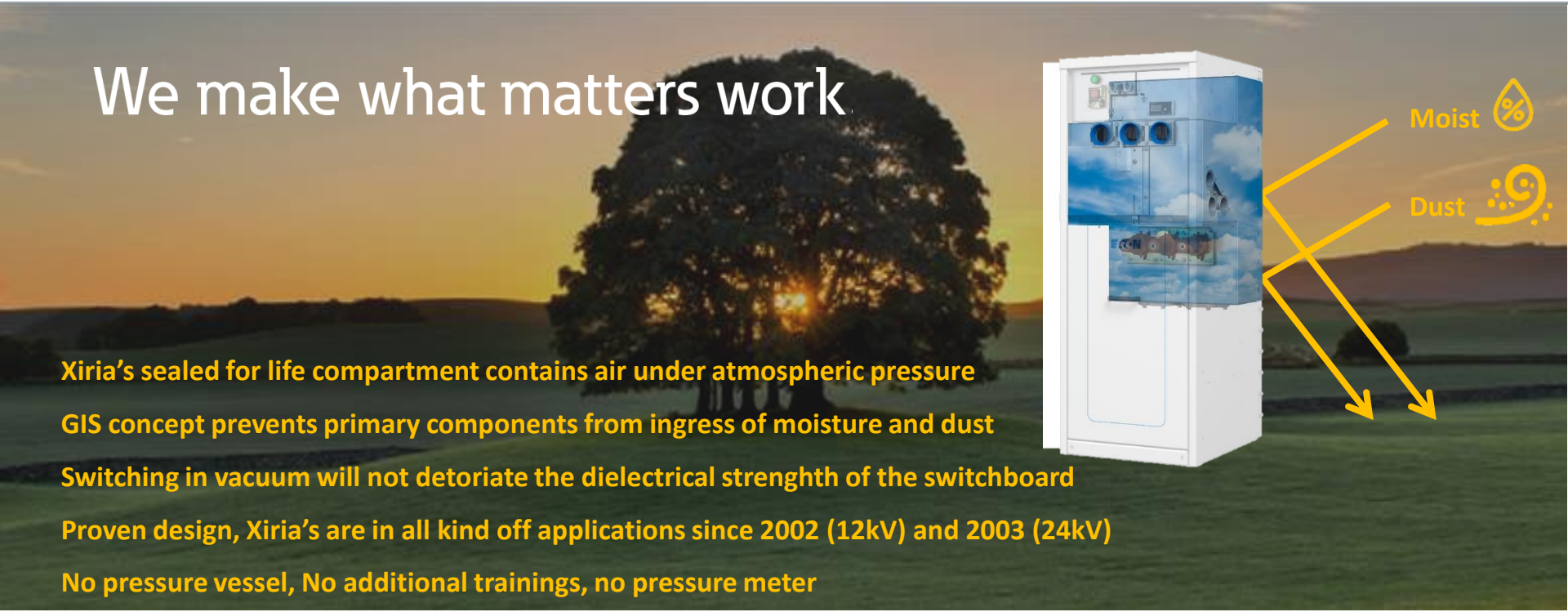
F-gas free Solution Natural Air GIS



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Sealed-for-Life Enclosure -GIS-

- The sealed compartment is filled with **dry air** and by sealing this compartment the primary parts and tripping mechanism are protected from environmental influences such as moist, dust and any kind of animals or insects
- By means of the sealed compartment the primary parts, switches and circuit breakers are maintenance free
- Where SF_6 insulated switchgear relies on a man-made gas to prevent from an internal arc, this solution is 100% F-gas free. With the benefit of maximised safety for people and the planet, personnel and our environment
- See also our Cired paper 0088 from the conference in 2021

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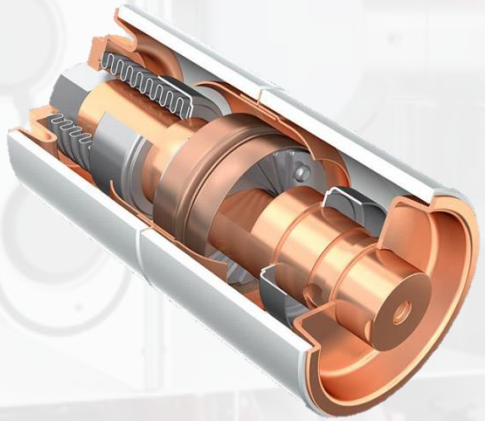
Core competences

Safety, Sustainability and Availability

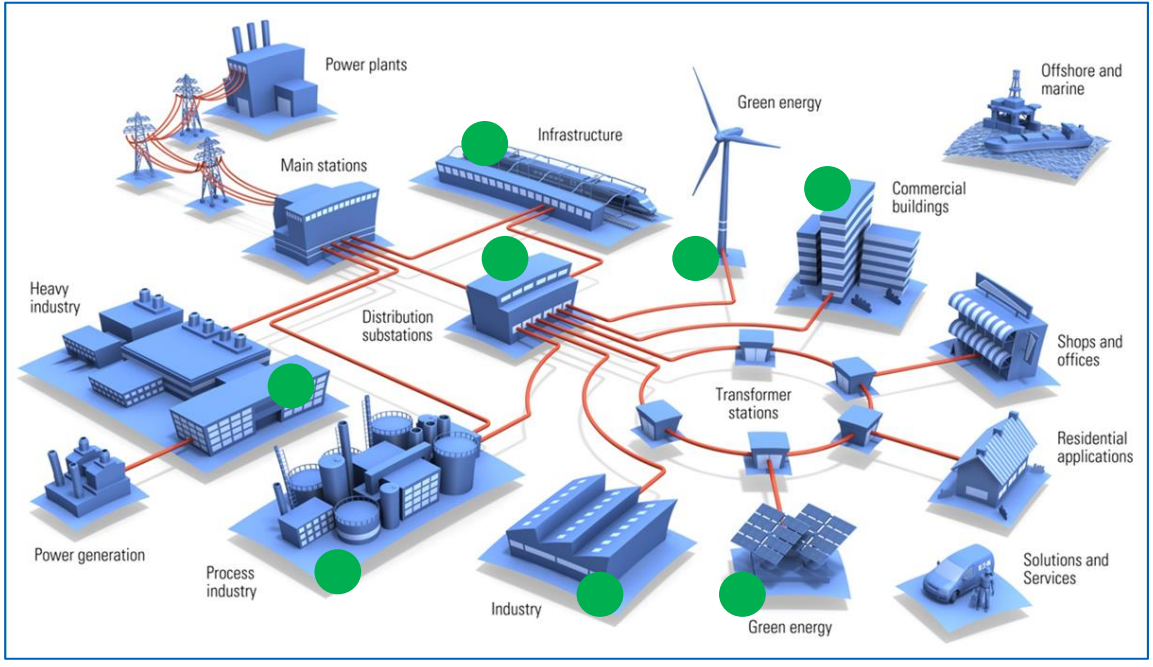
- Arc free design
- Arc proof design
- SF_6 free
- System integration

Vacuum Interrupters



Solid Insulation & Electrical Field Control

Xiria for high-end secondary applications



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Xiria NGX

- Single compact **500 mm** wide **extendable** panels
- Rated voltage 24 kV
- Busbar current 1250 A
- Circuit-breaker rating 630 or **1250 A**
- Short circuit rating up to 25 kA - 3s
- Internal arc classification **AFL(R) 25 kA - 1s**
- Loss of Service Continuity LSC2
- Partition class PM
- Robust **auto-reclose** switching mechanism (OCO)
- IEC type tested by STL laboratory **KEMA**, Netherlands

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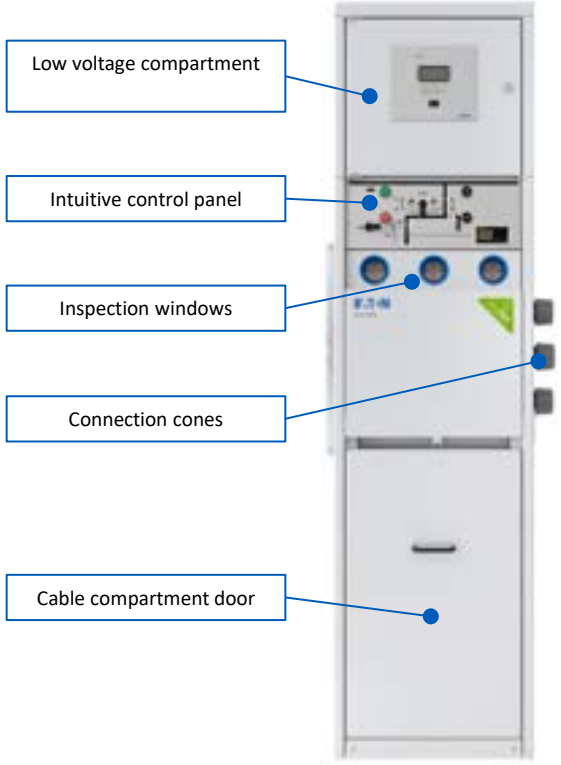
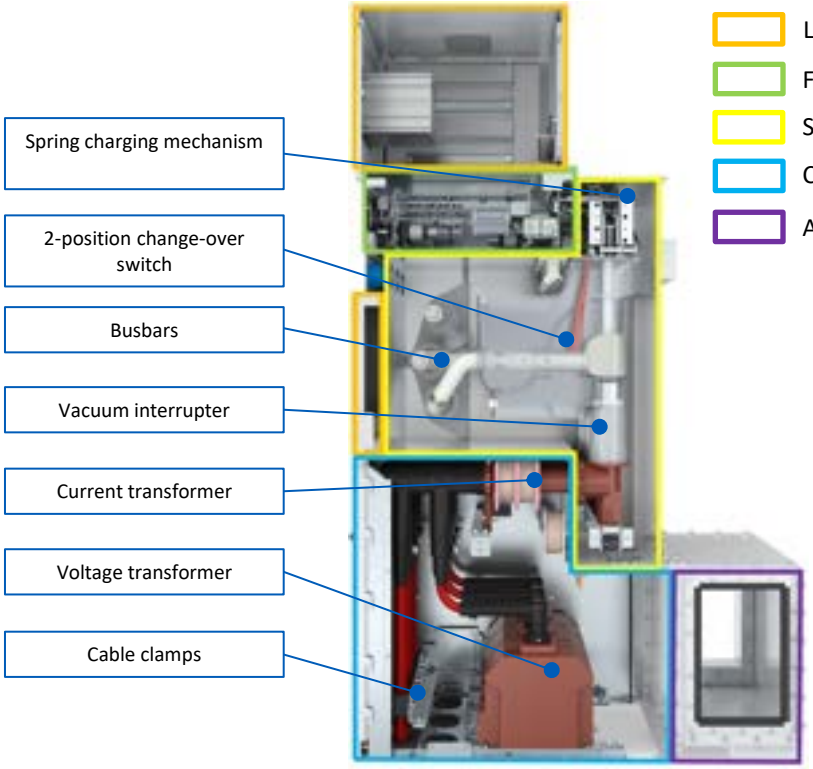
Xiria NGX basic design





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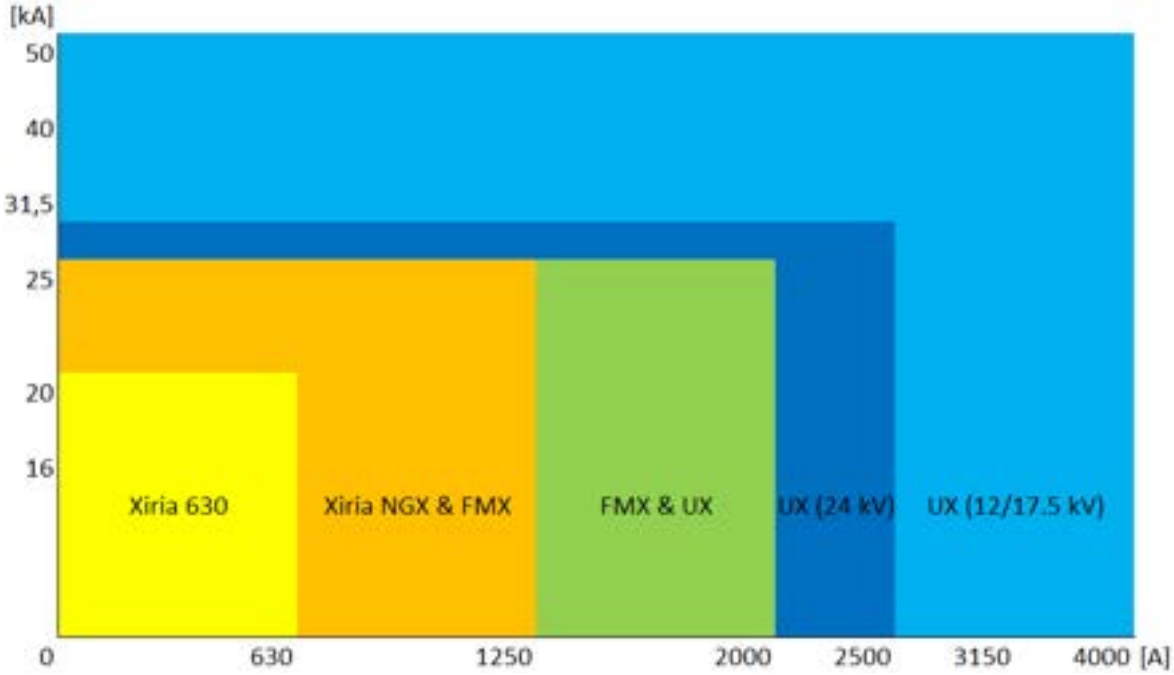
Product portfolio overview up to 24 kV

Xiria NGX

Xiria 630



Power Xpert UX

Power Xpert FMX

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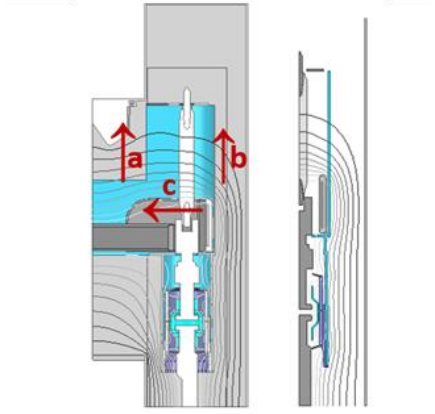
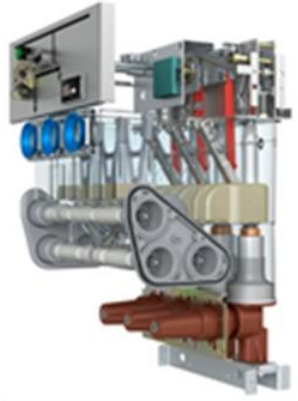
The Product Development moves on

- Technologies for higher voltages (38kV)
- Digitalization – Protection – Control
- 24kV -1250A compact SF6 free introduced
- …..





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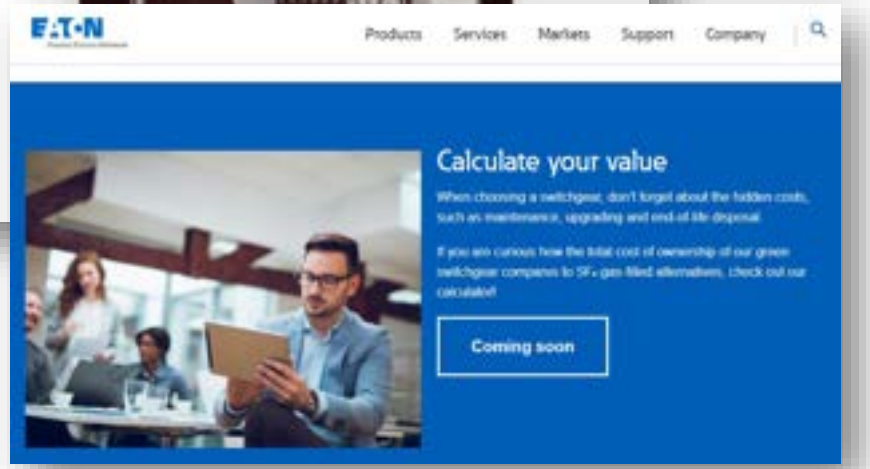
Further Reading



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דב צימרמן

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