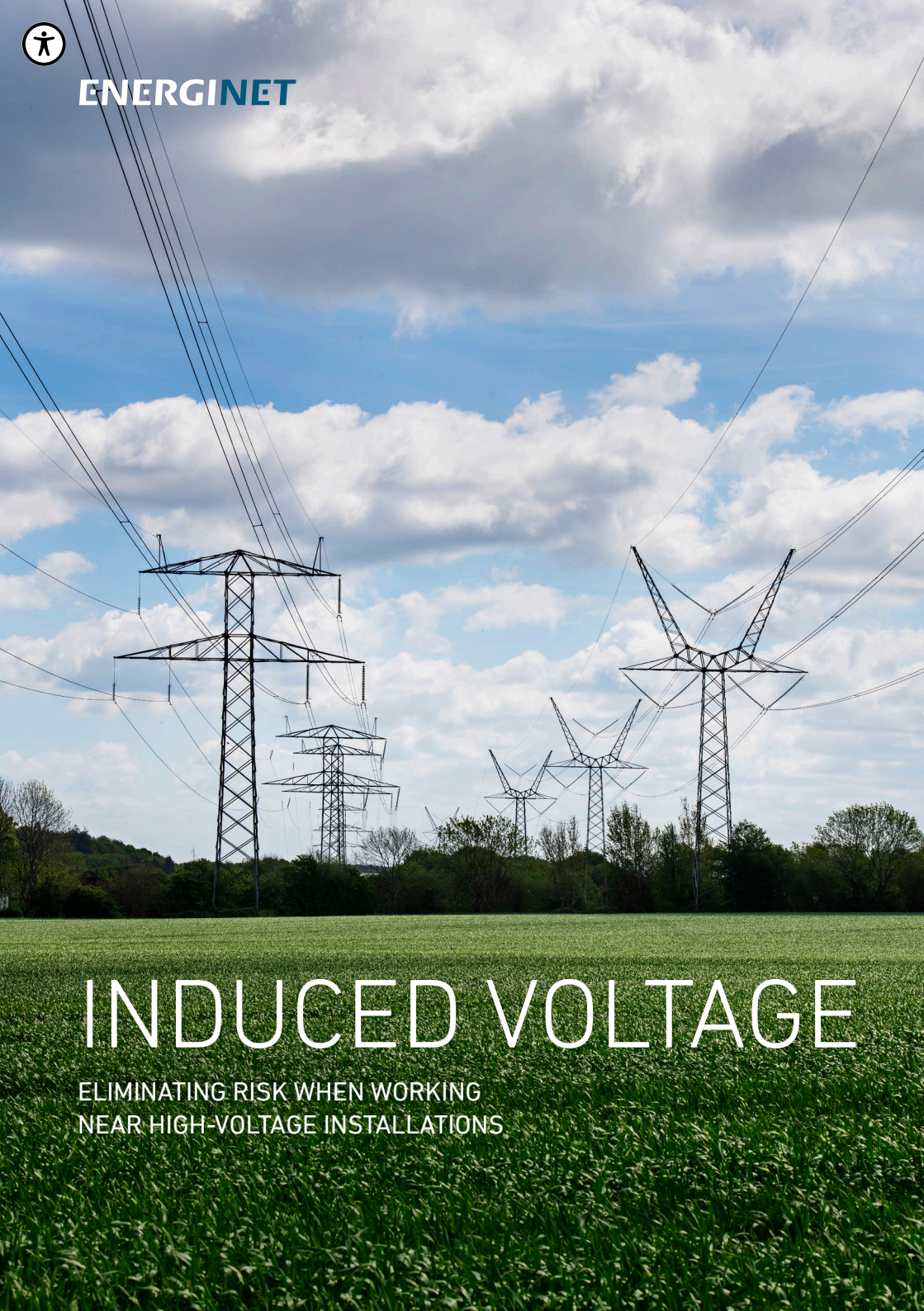


ENERGINET

INDUCED VOLTAGE

ELIMINATING RISK WHEN WORKING
NEAR HIGH-VOLTAGE INSTALLATIONS

CONTENTS

Photo: Johannes Stentoft Clausen, Senior Manager of Power Lines, and Jacob Devantier Larsen, Senior Manager of Asset Technology

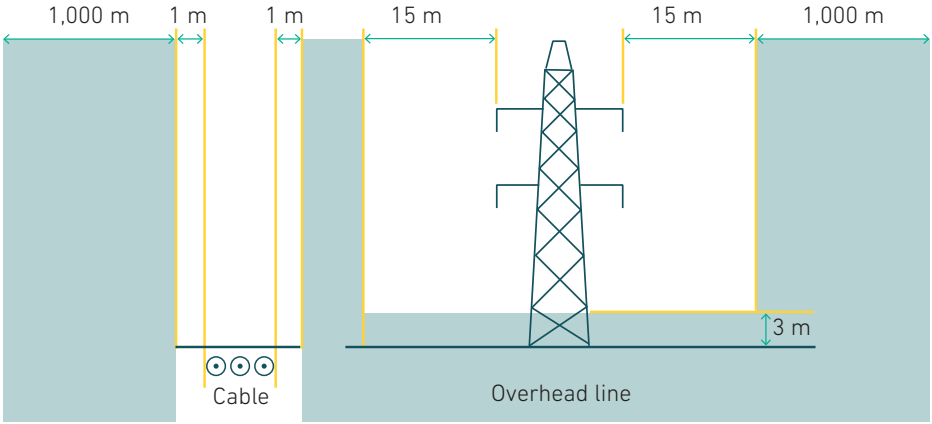
INTRODUCTION

This leaflet explains what you and your project need to do in relation to the risk of induced voltage. It is aimed at project managers or subproject managers working on Energinet's construction projects. This leaflet may also be used as inspiration for everyone else involved in Energinet's projects.

The contents of this leaflet should be taken as a guide to identifying the risks from induced voltage from our own transmission grid, and also from distribution grids and electrified railways, for example.

This leaflet includes information about work performed on electrically conductive installations located within 1,000 metres of a high-voltage installation, but outside the safe distance area marked in green in the figure below.

Written consent from the facility owner is required for entry beyond that safe distance. The safe distances are stipulated by the Danish Safety Technology Authority to prevent electrical accidents. Read more in "Beware of the power lines and your line" – a leaflet published by the Danish Safety Technology Authority.



WHAT IS INDUCED VOLTAGE?

When electrically conductive installations, such as construction fences, storage facilities, pipelines, interrupted overhead lines or cables, are close to live high-voltage installations, it may cause induced voltage in the electrically conductive installations.

At the point of contact, induced voltage can cause a strong electric shock, which can, at worst, be fatal.

It is therefore important to be aware of the risk of induced voltage when working on electrically conductive installations near a live high-voltage installation.

A high-voltage installation consists of components with an electrical voltage of more than 1,000 V alternating current or more than 1,500 V direct current.

Among other things, a high-voltage installation can be a substation, an overhead line connection or a cable connection.

WHERE IS THERE A RISK OF INDUCED VOLTAGE?

There is a risk of induced voltage when an electrically conductive installation is located within a 1,000 metre radius of a live high-voltage installation. Examples of electrically conductive installations where induced voltage may occur could be:

- Overhead lines or cables out of operation
- Fences isolated from electrical earthing
- Pipelines
- Overhead line towers being assembled or dismantled

In general, the risk of harmful induced voltage in fences and machines is considered negligible. However, it may cause a micro shock (spark). Read more in Energinet's "Guidelines on work in electric and magnetic fields".

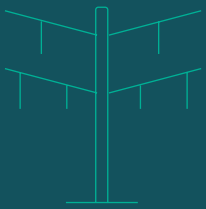
MAGNITUDE OF INDUCED VOLTAGE

The magnitude of induced voltage in an electrically conductive installation depends on several factors:

- The size of the current in live high-voltage installations
- The distance between live high-voltage installations and the electrically conductive installation
- The length of partly or completely parallel electrically conductive installations with live high-voltage installations
- The design of the electrically conductive installation
- Electrical earthing of the electrically conductive installation

The risk of induced voltage may be present in the entire length of the electrically conductive installation – even where there is a significant distance to the live high-voltage installation.

It requires complex calculations to determine the magnitude of induced voltage. It is therefore not possible to give a standard answer as to how large the distance must be from a live installation to eliminate the risk of induced voltage.



When assessing the risk of induced voltage, it is important to assess all likely scenarios.

This also applies to fault situations at the high-voltage installation.

HOW CAN YOU REDUCE THE RISK OF INDUCED VOLTAGE?

Incorporate the risk of induced voltage as early as the planning phase. Try to take the following into account when planning the physical location of the electrically conductive installation on which you are to build or work:

- Maximise the distance to live high-voltage installations.
- Avoid having long pipeline sections running parallel with live high-voltage installations.
- A crossing between the electrically conductive installation and a live high-voltage installation (typically cable or overhead line) must be perpendicular – as far as possible.

WHAT DO I NEED TO DO IN RELATION TO THE RISK OF INDUCED VOLTAGE?

Familiarise yourself with your work area
Check Web GIS El and www.ler.dk
You should always check in a radius of 1,000 metres from your planned work area if any of the following is present:

- High-voltage installations owned by utility companies (10–60 kV)
- Energinet's electricity transmission grid (132–400 kV)
- Third parties, for instance electrified railways, etc.

If you are a project manager or subproject manager on an Energinet project, there are some issues for you to check out in relation to your either maturation or establishment project. The following issues are important when it comes to identifying risks of induced voltage and ultimately avoiding electrical accidents during the construction work.

REMEMBER:

All identified risks, agreements with utility companies and Transmission Lines' technical standards on work carried out under induced voltage must be issued together with relevant calls for tenders, for instance construction contracts.

High-voltage installations owned by utility companies (10–60 kV)
You must inform the utility company of your project and its scope. Together with the utility company, you must carry out a risk assessment to form the basis of the agreements on the individual work procedures for your project. Remember to prepare written agreements and procedures.

Energinet's electricity transmission grid (132–400 kV)
You should contact the Transmission Lines internal group dealing with close-proximity routing. They will help you with a calculation based on which they will assess whether measures should be taken in relation to work in the project carried out under induced voltage.

Third parties, for instance electrified railways, etc.
You should contact the Transmission Lines internal group dealing with close-proximity routing. They will help you with a calculation based on which they will assess whether measures should be taken in relation to work in the project carried out under induced voltage.

CONSEQUENCES

If the risk of induced voltage is not verified in the maturation and engineering (design) phases, it may cause challenges in the establishment phase. For instance, it may be necessary to make a forced outage of parallel and intersecting grids, disrupting operations.

If forced outage is not possible, it may be that work cannot be carried out or that there is a risk of induced voltage, which may lead to electrical accidents.

HOW SHOULD INDUCED VOLTAGE BE MANAGED, WHEN IT IS A REALITY?

Optimally placed earthing is installed at the electrically conductive installation on which work is carried out.
Earthing is referred to as:

- End-point earthing if the earthing switch in the substation is closed.
- Temporary earthing is a movable flexible electrical earthing mounted on the electrically conductive installation on which work is carried out or on the equipment used.

On the next page is a figure with three steps showing the result of earthing location as work takes place. Earthing makes work on the electrically conductive installation safe (green). The colours from orange to yellow illustrate a change in the magnitude of induced voltage.

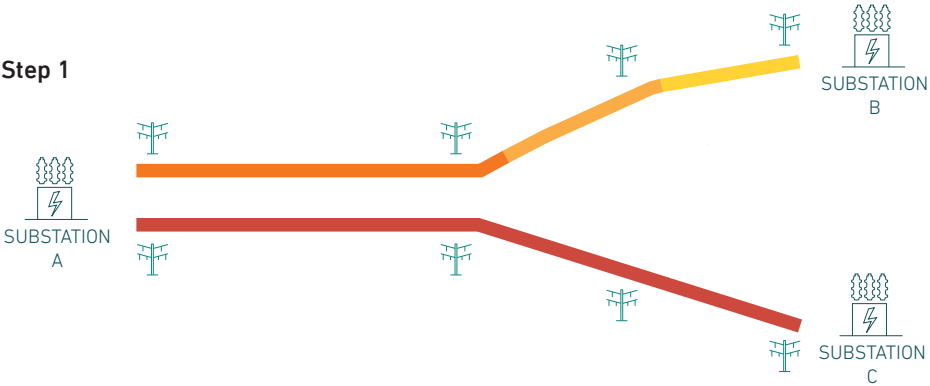
Step 1:
Lines A–C are in operation
Lines A–B are out of operation, and no end-point earthing or temporary earth has been established.

Step 2:
Lines A–C are in operation
Lines A–B are out of operation, and the end-point earthing is connected at both ends of the line at substation A and substation B, respectively.

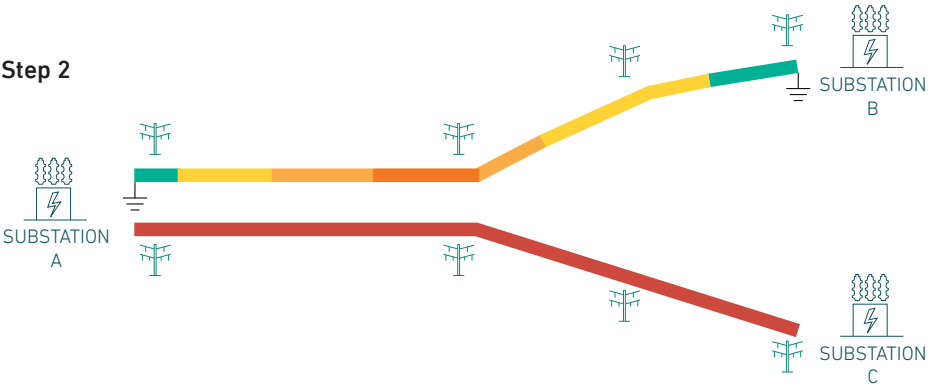
Step 3:
Lines A–C are in operation
Lines A–B are out of operation, end-point earthing is earthed and temporary earth has been established for the entire section. The line is now secured against induced voltages.

- Cable or overhead line in operation. Lines A–C
- Higher level of induced voltage on cable or overhead line. Lines A–B
- Medium level of induced voltage on cable or overhead line. Lines A–B
- Lower level of induced voltage on cable or overhead line. Lines A–B
- Cable or overhead line without risk of induced voltage
- End-point earthing and/or temporary earth

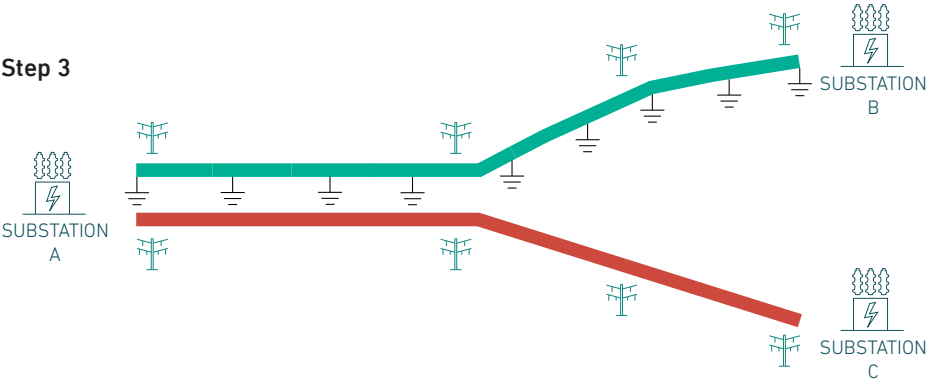
Step 1



Step 2



Step 3



LEGISLATION

THE CLIENT, PROJECT SUPERVISORS, CONSULTANTS AND CONTRACTORS ARE ALL RESPONSIBLE FOR SAFETY AND WORKING ENVIRONMENT.

When induced voltage is present in equipment or materials, there is an strong need for employees to be aware of the risks involved and how to eliminate these. In non-electrical works, contractors often lack this knowledge.

The following pages outline the responsibilities, in line with applicable legislation, which apply to any building and civil engineering project, as well as the consequences of not considering the risk of induced voltage.

- Danish Working Environment Authority's Executive Order No. 110 of 5 February 2013, Executive Order on Duties of Project Supervisors and Consultants according to the Danish Working Environment Act
- Danish Working Environment Authority's Executive Order No. 117 of 5 February 2013, Executive Order on Duties of the Client
- Executive Order No. 1114 of 18 August 2016 "Executive Order on safety for execution of electrical installations" (in Danish only)

ROLES AND RESPONSIBILITIES

Energinet's responsibilities as client

- Responsibility lies with the client, even if the work is carried out by another party.
- The client coordinates the work, in the event of several project supervisors or executing parties
- The client shall ensure that special risks on the construction site, also in the ground, are identified, investigated, assessed and, to the extent necessary, dealt with prior to commencement of the work.

Project supervisors' and consultants' responsibilities

The legislation applies to both internal and external engineering (design) and consultancy. It is clear from the legislation that:

- In the engineering (design) phase, it must be ensured that construction and future maintenance work is compliant with working environment legislation
- Existing hazards and conditions which may affect health and safety must be detailed in the project material

Project manager's responsibilities

Early in the maturation and engineering (design) phases, it must be assessed whether there is a risk of induced voltage in the establishment phase. Induced voltage may derive from both Energinet's transmission grid and from external grids, such as distribution grids and other parties, for instance electrified railways.

If it is assessed that there is a risk of induced voltage in a project, the tender documents must describe how to ensure the project can be carried out without risk to personnel or equipment. Consequently, the risk of induced voltage must also be dealt with in the risk assessment.

There may be a risk of induced voltage in all projects – including non-electrical projects/parts of a project. Therefore, the risk of induced voltage must also be assessed for all subprojects.

The above passages are extracts from Executive Order No. 110 on Duties of Project Supervisors and Consultants and Executive Order No. 117 on Duties of the Client.

CLOSE-PROXIMITY ROUTING WITH METALLIC PIPELINE SYSTEMS

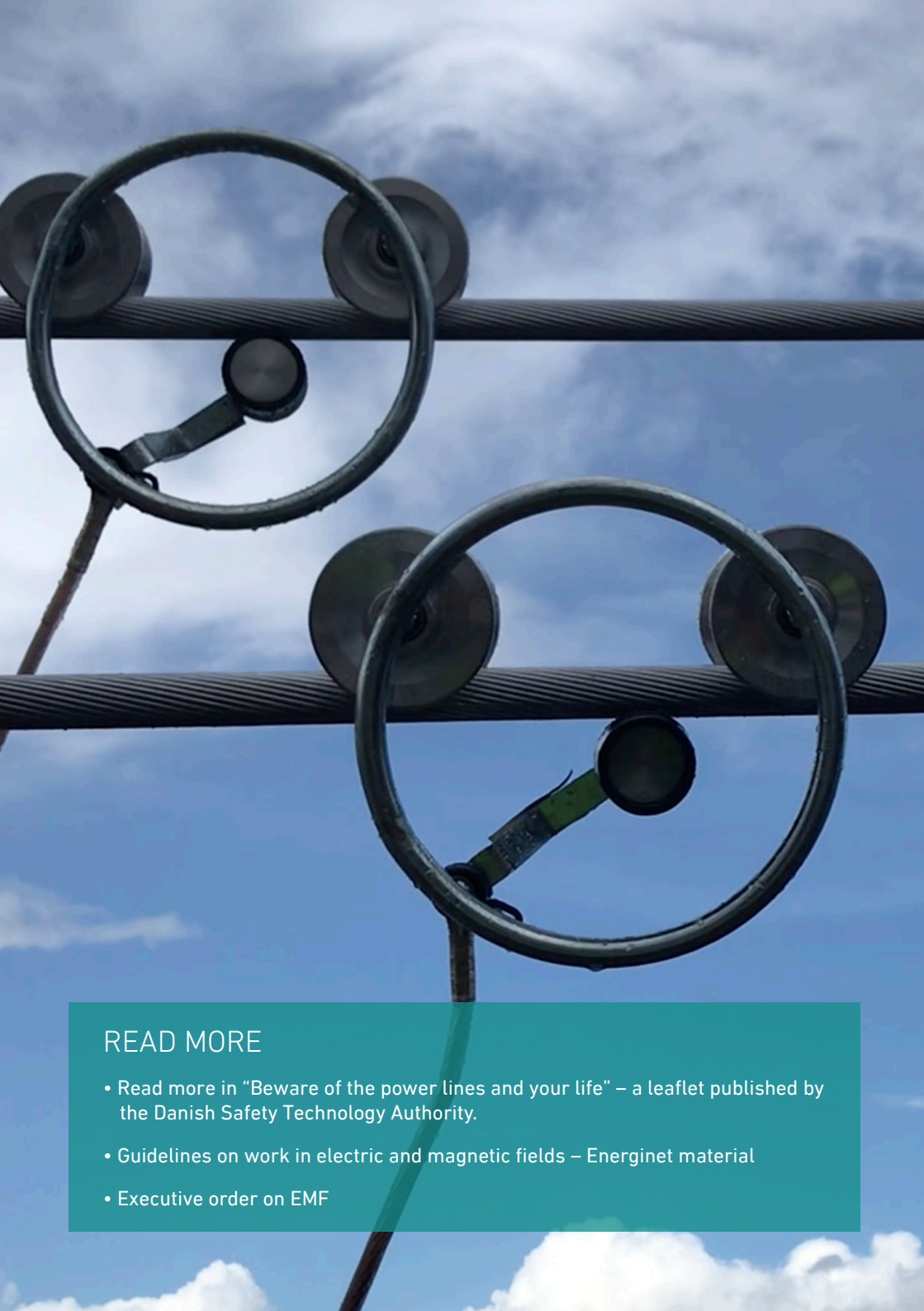
When Energinet establishes electrical transmission lines, we are obliged to investigate whether metallic pipeline systems may be affected, including working out the implications of and paying for any measures to be taken.

Therefore, you must check if there are, for example, gas pipelines, oil pipelines or district heating pipes within a radius of 1,000 metres. If this is the case, you must contact the Transmission Lines internal group dealing with close-proximity routing.

Section 32

An electrical installation must be designed taking into account the risk of dangerous induced touch voltage in other non-electrical installations located close to the electrical installation; if necessary, measures must be taken to minimise induced touch voltage to a harmless level for people and livestock.

Extract from Executive Order No. 1114 on safety for execution of electrical installations (in Danish only)



READ MORE

- Read more in “Beware of the power lines and your life” – a leaflet published by the Danish Safety Technology Authority.
- Guidelines on work in electric and magnetic fields – Energinet material
- Executive order on EMF

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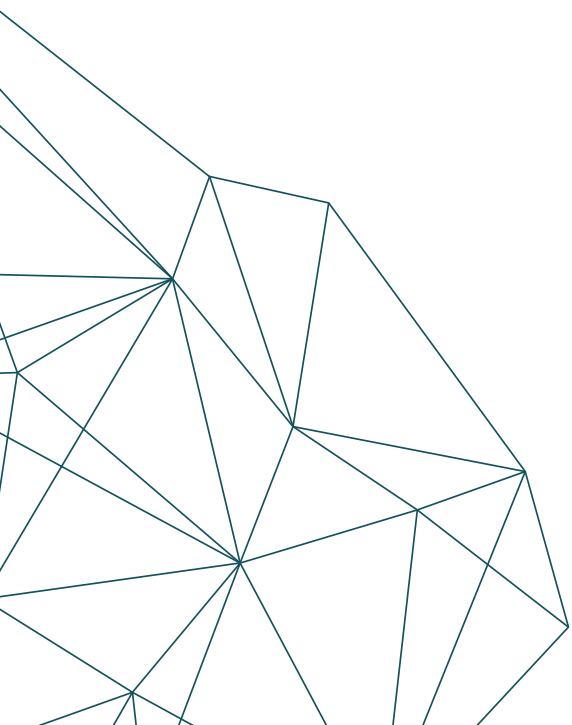

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