Key Take Away's C3

CIGRE Paris Session 2024

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Today

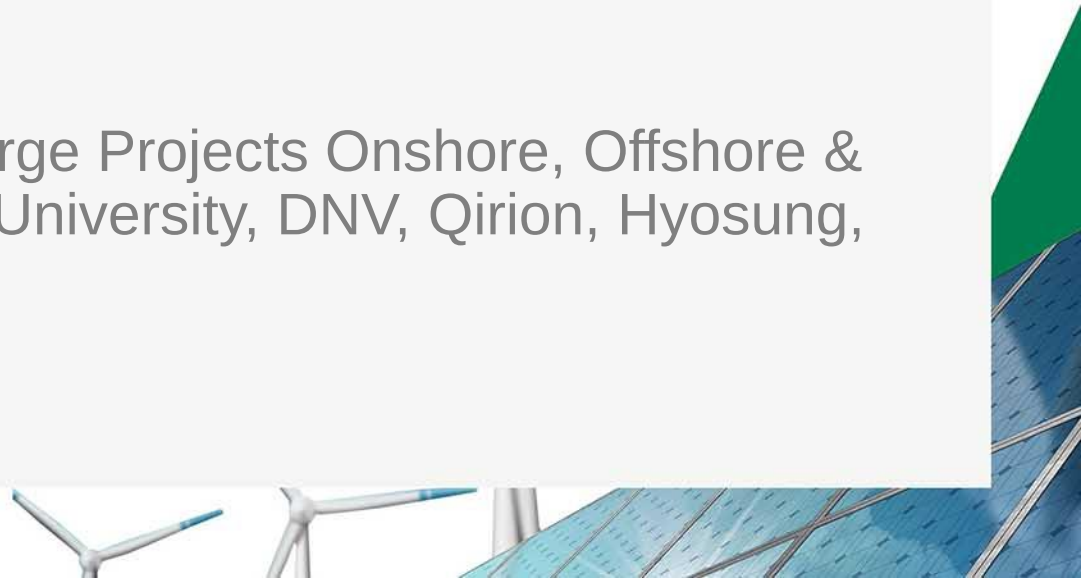
1. What is C3?
2. Papers
3. Working Groups (WGs)
4. Tutorial WG C3.09A
5. Study committee meeting C3
6. Preferential subjects 2026
7. What’s next?
8. WG C3.15

What is C3?

- Power System Sustainability and Environmental Performance

- Mission: facilitate and promote sustainable development of power grid
  - Environmental impact (life cycle approach)
  - Climate change and Sustainable Development Goals (SDGs)
  - Stakeholder engagement and communication
- Focus on interaction between human and natural environment

- Contributing organizations (C3 NL): TenneT (Large Projects Onshore, Offshore & Grid Field Operations), Antea, Movares, Avans University, DNV, Qirion, Hyosung, Enexis



Papers

- 36 in total, 2 from the Netherlands

ID: 10286
C3 POWER SYSTEM SUSTAINABILITY AND ENVIRONMENTAL PERFORMANCE - Full Papers
Topics: C3 PS3 - Sustainability Starting for the Supply Chain
Keywords: Ecodesign, Green Procurement, Grids supply chain, LCA, Sustainability

Ecodesign aspects to enhance circularity and boost sustainable

Marcela MANTILLA, Pascale PRIEUR, Samuel NGUEFEU
RTE, France

ID: 11303
C3 POWER SYSTEM SUSTAINABILITY AND ENVIRONMENTAL PERFORMANCE - Full Papers
Topics: C3 PS3 - Sustainability Starting for the Supply Chain

Tackling Scope 3 GHG Emissions of Grid Investments: Creation of Accounting Platform and CO2 Models for Tracking Emissions of Purchased Goods and Works

Vincent DU FOUR, Philipp VON NORMANN
Elia Group, Belgium

ID: 10450
C3 POWER SYSTEM SUSTAINABILITY AND ENVIRONMENTAL PERFORMANCE - Full Papers
Topics: C3 PS2 - Climate Change and Impact on Power System, a Holistic Approach
Keywords: Electrical Substation, Grid Resilience, Climate Change, Coastal Flooding, Substation Cost Estimation

From Risk to Resilience: Quantifying the Financial Impact of Proactive Physical Infrastructure Improvements in Substations

Charlie {Chun} LI[1], Brian P. HERRMANN[1], Matthew D. UBER[2]
[1]Burns & McDonnell, United States of America; [2]J-Power USA, United States of America

ID: 10974
C3 POWER SYSTEM SUSTAINABILITY AND ENVIRONMENTAL PERFORMANCE - Full Papers
Topics: C3 PS2 - Climate Change and Impact on Power System, a Holistic Approach
Keywords: area planning, carbon emission, land-use change, mitigation, peat

Highlighting forgotten emissions: Calculate and mitigate carbon loss from infrastructure construction on peatland

Ellen TORSÆTER[1], Magni O. KYRKJEEIDE[2], Marte FANDREM[3]
[1]Statnett SF Norway; [2]NINA Norway; [3]NTNU Norway

ID: 10451
C3 POWER SYSTEM SUSTAINABILITY AND ENVIRONMENTAL PERFORMANCE - Full Papers
Topics: C3 PS3 - Sustainability Starting for the Supply Chain
Keywords: Construction, Embodied Carbon, Power Infrastructure, Sustainability

A Framework for Sustainability-centric Decision Making in the Selection of Construction Materials for Power System Projects

Alexander D. PAGNOTTA, Lyndsey COVERT
Burns & McDonnell, United States of America

C3
Power system environmental performance

PS1: Public acceptance and stakeholder engagement in power system generation, transmission & distribution infrastructures

- Experiences in dealing with public acceptance of new & existing infrastructures.
- Strategies, tools, indicators and methods that allow an effective stakeholders engagement.
- Role of mitigation, compensation an offsetting measures- whole life of infrastructures.

PS2: Climate change and impact on power system, a holistic approach

- Expected variations in the climate variables according to different scenarios. Potential impacts on power infrastructure and on system operation.
- Risk assessment methodologies & experiences.
- Adaptation measures: lessons learned & criteria to be considered for the future and existing infrastructures.

PS3: Sustainability starting for the supply chain

- Inclusion of eco-design and circularity criteria: solutions to reduce impact along the whole life of the assets.
- Green procurement: experiences and methodologies to incorporate sustainability aspects in tendering decisions.
- Decarbonisation: accounting scope 3 emission and reduction strategies.

Papers

ID: 10515
C3 POWER SYSTEM SUSTAINABILITY AND ENVIRONMENTAL PERFORMANCE - Full Papers
Topics: C3 PS1 - Public Acceptance and Stakeholder Engagement in Power System Generation, Transmission & Distribution Infrastructures
Keywords: stakeholder engagement, public acceptance, biodiversity, sustainability, nature, nature-inclusive desgin

Harmonizing Nature's Symphony: biodiversity as a powerful tool for public acceptance

Paul HARTMAN[1], Claire DEURVORST[2], Henk SANDERS[2]
[1]Antea Group; [2]TenneT

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Harmonizing Nature's Symphony: biodiversity as a powerful tool for public acceptance

Paul Hartman (Antea Group), Claire Deurvorst (TenneT), Henk Sanders (TenneT)

Motivation

- The planetary boundaries that regulate that stability and resilience of our planetary system are increasingly in danger. In this paper the biosphere boundary is addressed.
- The energy transition has a significant spatial impact and a TSO's grid and its surroundings present a lot of opportunities to incorporate biodiversity measures.
- Incorporating biodiversity measures not only helps addressing the planetary boundary, but it's also a powerful tool for public acceptance (especially in a densely populated country like the Netherlands).
- Various legislations such as the national Environment Act (Omgevingswet) and the recently adopted EU Nature Restoration Act give added urgency to take the issue of biodiversity further.
- Thanks to intrinsic motivation from colleagues, biodiversity measures can be taken to the next level.

Objects of investigation

- Maasbracht substation expansion
- Biodiversity opportunities below high voltage lines
- Step Stone Pylons
- Eco-Friendly Offshore connections
- Green Nets coalition (Ecological Infrastructure)

Method/Approach

- Qualitative case study

Discussion

- Biodiversity measures can create a win-win scenario for both a TSO and stakeholders. In our cases the maintenance costs have been lowered and stakeholders generally become more cooperative in the development process.
- Difficult to quantify the gain of implementing biodiversity measures for public stakeholders. It is difficult to say how developments would have turned out if biodiversity measures were not implemented.

Conclusion

- TenneT actively contributes to preserving or improve biodiversity by incorporating measures into the development and maintenance of the electrical grid.
- The incorporation of biodiversity initiatives not only contributes to environmental sustainability but also serves as a strategic tool for public acceptance.
- A common factor in all the projects that the paper showcased is that biodiversity measures have heavily contributed to collaborative trust between all parties involved within the development process.
- Through ecological research, collaboration with influential nature organizations, and the implementation of biodiversity measures, TenneT builds trust and positive relationships with stakeholders, ensuring a harmonious integration of grid development with the natural environment.
- Biodiversity often gives positive energy, both to internal and external stakeholders.

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Biodiversity as a powerful tool for public acceptance CASES

Biodiversity for smooth process

- Maasbracht is a large substation with an important function as a link between the Netherlands, Belgium and Germany. The substation must be expanded and reinforced, which has a significant impact on the surrounding area.
- Taking the natural environment seriously and including stakeholders early helps to facilitate a smooth permit process with governmental agencies.
- If TenneT does not account for biodiversity enough, it is at risk to delay the development for up to at least a year.

Biodiversity opportunities below high voltage lines

- In both cases (lizard lane and the grazing donkeys and/or sheep) win-win situations were sought for:
  - Nature: enhancing biodiversity
  - Safety: far less risk of flashovers
  - Cost reduction: lower maintenance costs
  - Time savings: fewer inspections
  - Contented stakeholders: 'feel-good' by stakeholders, space for (homeless) donkeys and work for sheep herds.

Step stone pilons

- From problem to opportunity: using mast feet to improve biodiversity (internal and external stakeholders) while increasing safety (internal stakeholders) and reducing maintenance (external stakeholders).

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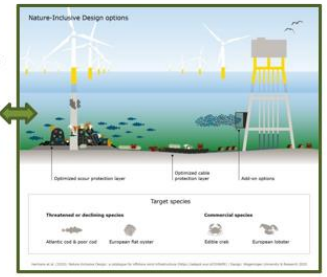
Biodiversity as a powerful tool for public acceptance CASES

Ecofriendly Offshore and Green Bonds

- Marine biodiversity suffers from (over)fishing and now offshore wind farm construction. The construction of these wind farms also offer opportunities, also because there is no fishing allowed in these areas. By involving local stakeholders, it is possible to identify opportunities for enhancing marine biodiversity.
- Green financing is one way of sustainable financing which promotes low-carbon and sustainable pathways. TenneT has drawn up a so-called 'Green Financing Framework' that serves as a framework for monitoring the sustainability quality of the projects financed by issuing green financing instruments. The proceeds of the green bonds are used to finance, refinance and/or invest in projects relating to the decarbonisation of the grid.



Green Nets coalition (Ecological Infrastructure)

- The larger infrastructure parties together manage a large area (about 1,000 km2). In a partnership with these infra stakeholders and nature organisations, biodiversity is improved by aligning it with opportunities in the managed areas. This is supported by the biodiversity Opportunity Map.
- The stakeholders involved ensure a healthier environment and create a positive image.

Conclusion

- TSO's can actively contribute to preserving biodiversity by incorporating measures in the development and maintenance of the electrical grid.
- Through ecological research, collaboration with influential nature organizations, and the implementation of biodiversity measures, a TSO builds trust and positive relationships with stakeholders, ensuring a harmonious integration of grid development with the natural environment.
- The incorporation of biodiversity initiatives not only contributes to environmental sustainability but also serves as a strategic tool for public acceptance.
- This paper extends a call to other system operators to take an active role in embracing sustainable practices, collaborating with stakeholders, and incorporating biodiversity measures into infrastructure projects. This ensures a positive societal impact and the continued health and resilience of our planet's interconnected web of life.

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Papers

ID: 11879
C3 POWER SYSTEM SUSTAINABILITY AND ENVIRONMENTAL PERFORMANCE - Full Papers
Topics: C3 PS2 - Climate Change and Impact on Power System, a Holistic Approach
Keywords: Climate change, transmission grid, adaptation, risk, downburst, flood, scenario, TSO, the Netherlands

The impact of climate change on the Dutch transmission grid: Leading risks and adaptation strategies

Joris DEN BREEJEN[1], Astrid SCHELLINGS-KOEKOEK[2]
[1]TenneT TSO; [2]Movares

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POWER SYSTEM SUSTAINABILITY AND ENVIRONMENTAL PERFORMANCE

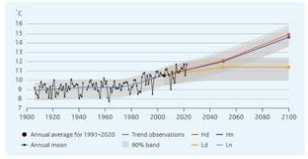
Paper ID 11879

The impact of CLIMATE CHANGE on the Dutch transmission grid: Leading RISKS AND ADAPTATION strategies

Astrid Schellings – Koekoek (Movares) & Joris den Breejen (TenneT TSO)

Motivation

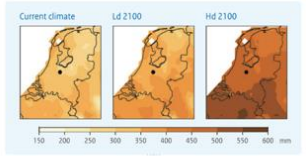
- Global and local climate change impact increasingly significant
- Worldwide grid expansion projects → new infrastructure, built to last
- Research on impact of climate change on high voltage grid limited
- GOAL: identify key climate change risks for onshore Dutch high voltage grid, assess previous studies and provide a starting point for future research



Annual mean temperature (Dutch average): observations (black) and the four KNMI'23 climate scenarios (2050 and 2100, in three colours; Ln and Ld coincide).

Method/Approach

- Qualitative assessment of climate change impact
- Based on IPCC and KNMI (Dutch meteorological institute) data, among others
- Interview with experts and engineers
- Case studies and expert judgement



Maximum precipitation deficit in the 5% driest years in the current climate and in the two dry KNMI'23 climate scenarios for around 2300. Black dot: De Bilt

2023 – record weather

- A year of records, globally & in the Netherlands
- In the Netherlands: record warm, record wet, record dry & record storms (!)

Impact on Dutch high voltage grid

- Limited in 2023, but in the past severe (Vethuizen & Oosterwolde)
- More records and extremes are expected in the future
- Costs, downtime & safety risk

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The KNMI'23 climate scenarios for the Netherlands in summary

- Accelerated sea-level rise
- Increase in average and extreme temperatures
- More sunshine
- More droughts
- Wetter winters
- More extreme summer showers
- Potentially stronger wind gusts and downbursts during heavy showers
- Little change in wind speed and direction

What may the future hold?

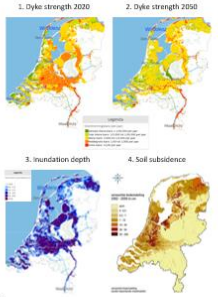
- Four KNMI climate scenario's based on IPCC data and models (see top-left)
- Impact on the Netherlands (see top-right)

What does this mean for Dutch onshore HV grid?

- Wetter winters and sea level rise
  - Flooding, soil instability, changing soil resistance (cables)
- Extreme summer showers
  - Local flooding
- Stronger wind gusts and downburst events
  - Changing wind loads on buildings, trees and towers
- Increase in average and extreme temperatures
  - Line sag and rating, overheating, metal expansion, thermal dissipation of cable
- Droughts
  - Wildfires, soil instability, salinization, earthing systems

Flood risk study

- Cross-sectoral working group (TSO, DSO, gas utilities)
- Dyke strength, inundation depth & soil subsidence key inputs
- Occurrence rate > 1/10.000 year (<10.000 'acceptable risk')
- Horizon 2050, sea level rise not considered (!)



Results:

- Inundation to 1 meter: 94 substations (2020), 64 (2050)
- Inundation to 2 meters: 42 substations (2020), 33 (2050)
- Common cause event (1 meter): 13 substations (2020 & 2050) (Borgsweer, Groningen)
- Common cause event (2 meter): 7 (2020) or 8 (2050) substations (increase due to soil subsidence) (Oudeschip, Groningen)

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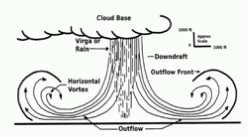
Downburst study

- Next 10 years in the Netherlands: 350 km overhead lines, 1000 towers
- Collaborative study: Belgium, Germany and the Netherlands (TSO's)
- Apart from working group



Schematic representation of downburst

- Three wind zones: 29.5, 27, 24.5 m/s
- TenneT standard tower design: 45 m/s
- Oosterwolde & Vethuizen: 40/50 m/s (estimate)
- Downbursts: more common inland, SW-NE orientation
- Climate change: 60 m/s (expectation in H scenarios, uncertain, limited data)

Wind zones in the Netherlands

Design criteria & standards

- New design criteria for new-built substation (efficiency t.b.d.):
  1. Non-floodable location
  2. Maximum flood levels of 2 meter above ground level
  3. Occurrence rate of less than 1/10.000 year ('acceptable risk')
- No new design criteria for towers (yet?)
- Future of working group: work on common methodology and impact droughts on various asset groups

Gaps in knowledge (not exhaustive)

- Impact of sea level rise on flood risk?
- Effect of extreme showers on substation?
- Effect of wetter winters, sea level rise en extreme showers on soil (in)stability?
- Impact of increased average & extreme temperatures on line sag and rating, overheating, metal expansion, thermal dissipation of cable?
- Impact of droughts on soil (in)stability, salinization, earthing systems unknown?

Conclusion

- Critical nature of the high voltage grid means potential climate change impacts need to be taken seriously
- Exact effect of climate change unclear but will certainly have an impact: only starting to scratch the surface
- Research into flood risk and downburst events important, but incomplete considering climate change
- TSO assets life expectancy > 50 + years, plan for the distant future
- Change design standards if necessary
- Collaborate, work together and learn from each other: cross border and with other grid operators and utilities

Only together can we guarantee a resilient future for the grid

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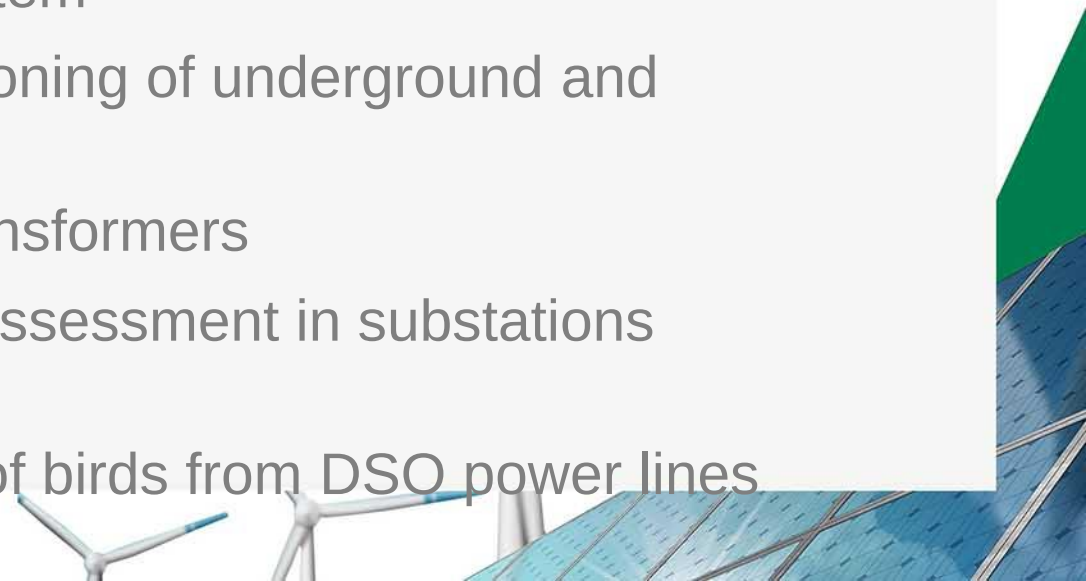
Working Groups

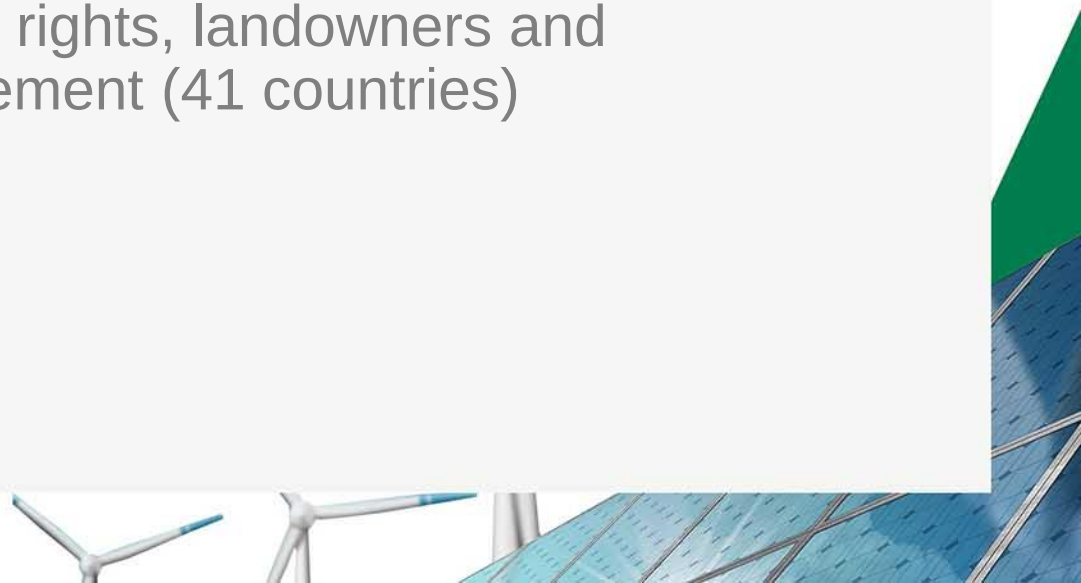
- AG C3.01 – EMF and human health (permanent advisory group)
- **C3.09A** – sustainable corridor management (finished)
- **C3.15** – Best environmental and socio-economic practices for improving public acceptance of high voltage substations
- C3.20 – Sustainability goals in the power sector
- *C3.22* – Vegetation management in substations
- C3.25 – Eco-design methods for the power system
- *B1/C85* – Environmental impact of decommissioning of underground and submarine cables
- A2/C3.70 – Life Cycle Assessment (LCA) of transformers
- B3/A2/A3/C3/D1.66 – Guidelines for life cycle assessment in substations considering carbon footprint evaluation
- C3/B2.24 – Methods of reducing electrocution of birds from DSO power lines



Tutorial WG C3.09A - sustainable corridor management

- Prepared by Aleš Kregar (SI), Nadia Kucher (DE), Luiza Martins (BR), Vlatko Ećimović (HR), Olivia Geels (BE)

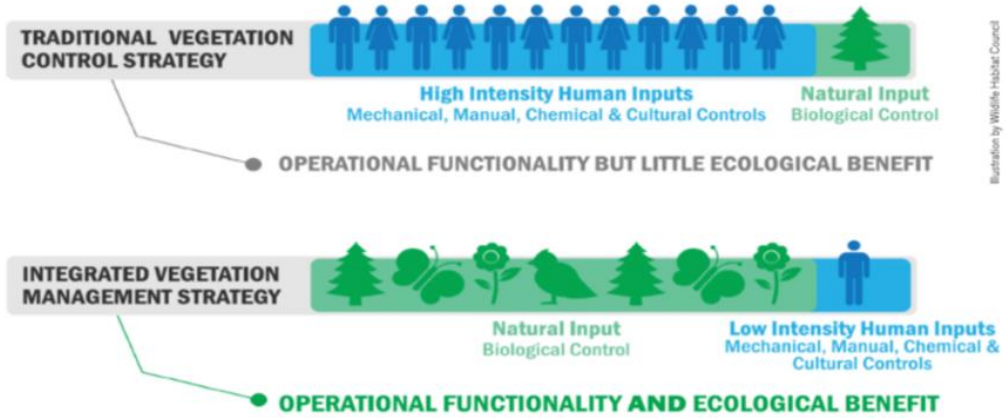
- Corridors beneath overhead power lines are critical to the electricity network
- Power grid regulators, system owners (SO) and operators are challenged to improve the sustainability of the power network, stakeholder engagement often critical. Biodiversity as a tool to increase public acceptance?
- Worldwide survey of corridor definition and land rights, landowners and stakeholders, and protective vegetation management (41 countries)

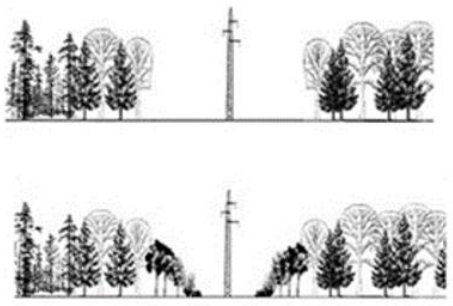


Tutorial WG C3.09A - sustainable corridor management

Definition

"a practice to **proactively** manage power line corridors to improve asset reliability and public safety while enhancing the land's **ecological value** and overall sustainability"



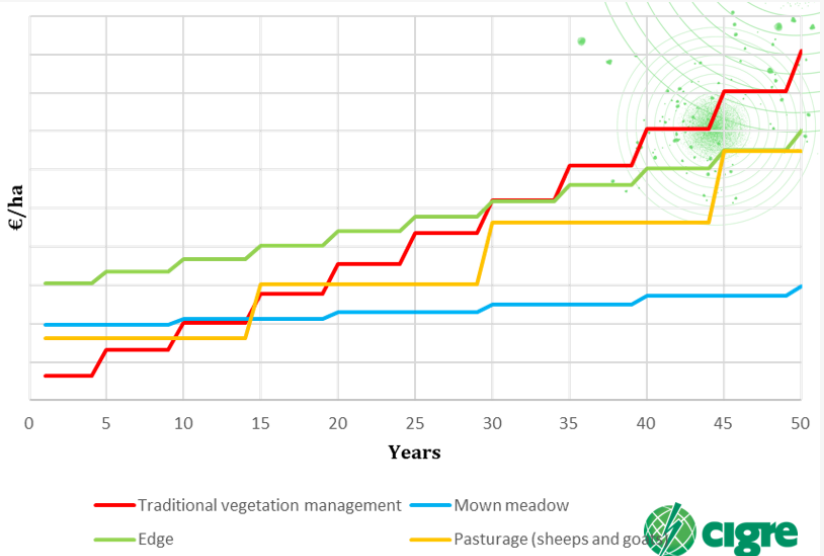


Cost-benefits analysis

(The Belgian case)

Return on Investment:

- 35 years for forest edges
- 20 years for grazing
- 15 years for mown meadow



Tutorial WG C3.09A - sustainable corridor management

Examples of best practices from across the globe

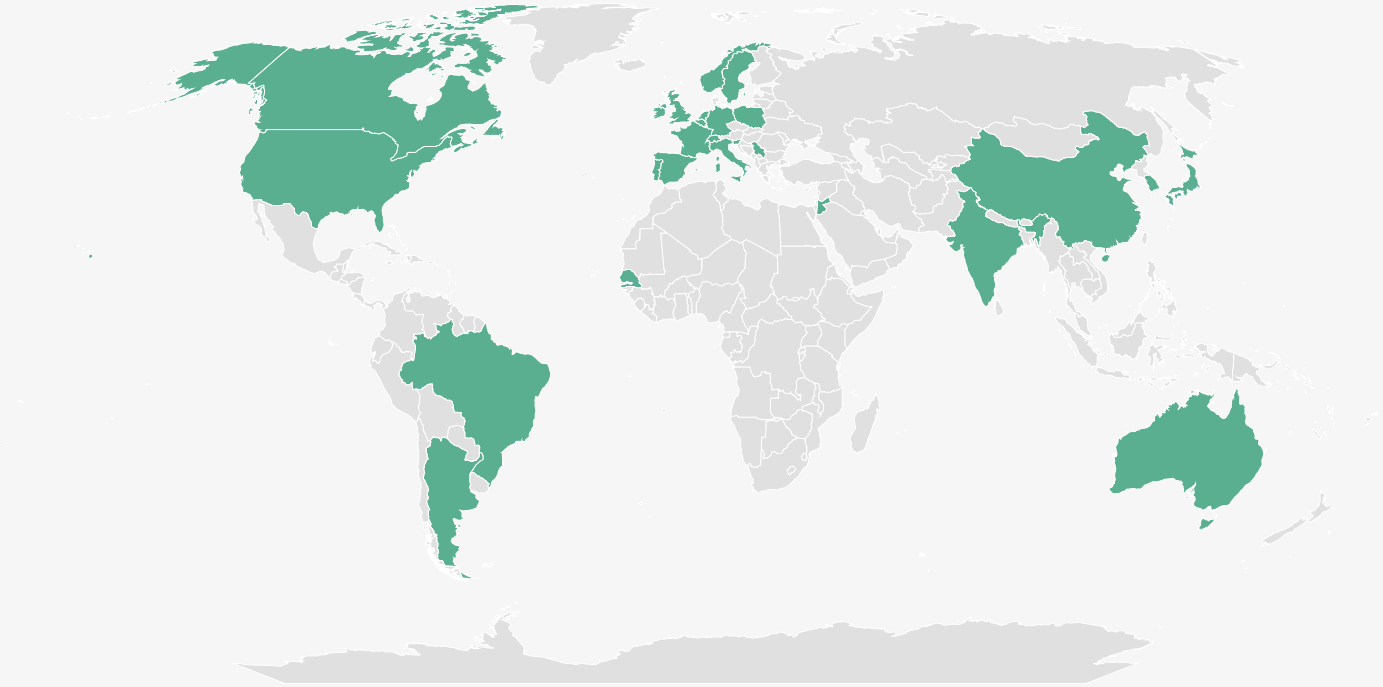
- Biodiversity and vegetation management
- Integrated Vegetation Management
- Selective cutting of trees
- Establishment of new ecologically valuable habitats
- Habitat management plan
- Protecting rare plants
- Expansion of agricultural land
- Establishment of new habitat
- Protected Area vegetation management
- Garrano Horses for Vegetation management
- RoW Reconversion

Benefits of sustainable corridor management :

- ✓ Cheaper than the classical maintenance
- ✓ Improved biodiversity and habitats
- ✓ Improved reputation for the power line operator
- ✓ Improved stakeholders' relations (municipalities, forest/nature agencies, landowners, nature protection NGO's, local stakeholders, ...)

Study committee meeting C3

Worldwide attendance study committee meeting C3



Preferential subjects Paris Session 2026

PS1: Biodiversity conservation & enhancement: towards positive contribution

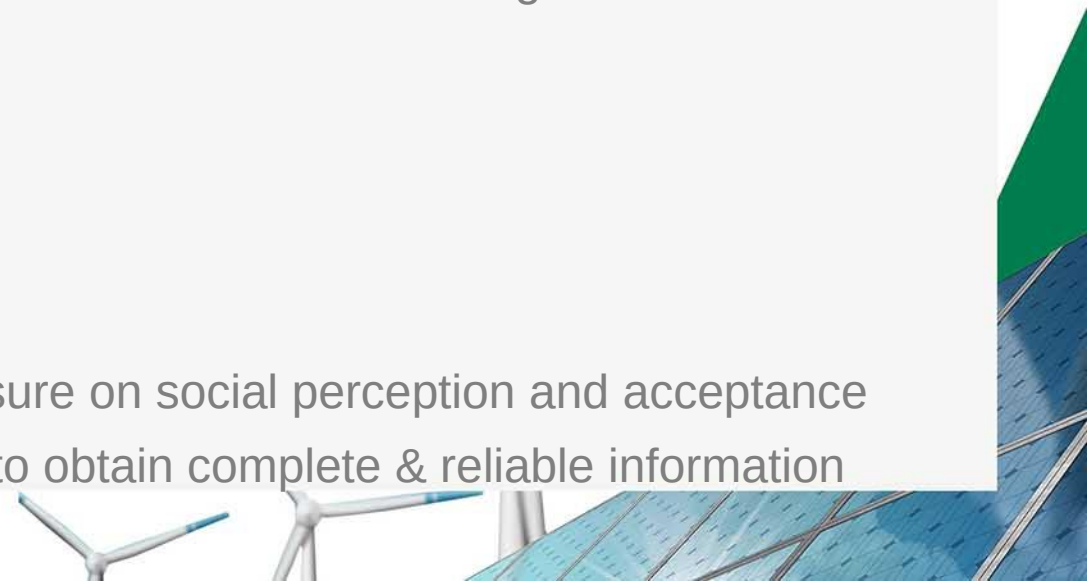
- Mitigating the impact from power system infrastructure: new generation facilities, transmission and distribution. Preventive and corrective measures: nature inclusive design, commissioning, asset management and end of life
- Offsetting measures & ecosystems restoration. Net Zero impact and positive impact. How to measure?
- New standards regarding biodiversity. i.e. IPBES; TCNFD

PS2: Building a more sustainable power system for the future

- Identification, quantification and assessment of impacts. Tools and methodologies. LCA approach, considering climate change and beyond
- Eco-design to reduce impacts
- Innovative solutions to enhance circularity

PS3: Disclosing sustainability

- Reporting standards and regulation, indicators
- Stakeholder reporting requirements, impact of disclosure on social perception and acceptance
- Value chain information, strategies & methodologies to obtain complete & reliable information



What's next?

- Themeday 2025 (t.b.a.)
- Trondheim 2025
  - C3.15 tutorial
- Papers for Trondheim
- Papers for Paris
- Working Groups

SYMPOSIUM THEME

The CIGRE NRCC 2025 symposium in Trondheim will be on the theme: Changes Needed in The Power System – for the Energy Transition. This will be divided into two topic streams:

PS1: Integration of renewable energy resources to the grid

- Environmentally friendly power grid and its equipment
- New applications and technologies applied to AC and DC onshore and offshore grid
- AC and DC onshore and offshore grid
- AC grid development, protection of the future meshed AC and DC system
- Sector integration including hydrogen, EV, energy hubs, DER
- Services/operation applied to AC and DC onshore and offshore grid
- Monitoring the system applied to AC and DC onshore and offshore grid
- Maintenance and Services applied to AC and DC onshore and offshore grid

PS2: Technologies supporting the power grid for energy transition to carbon neutral energy production

- Requirements for power grid and its equipment
- Inverter based control interacting with existing system and Converter stability issues (resonance stability, converter driven stability)
- Coordination between AC and DC networks
- Grid forming
- Multivendor interoperability
- New modelling tools
- Planning and operation of lower inertia system
- System analysis (technical)
- Black start and resilience aspects including DER integration
- Optimize and increase the capacity of the energy transmission network
- Reliability and security – critical infrastructure

WG C3.15

Goal

- *“The working group aims to make an inventory of the best practices, options, and boundary conditions for the integration of substations in their environment.” (ToR)*
- The TB describes the results of the WG in exploring the best spatial, environmental and socio-economic practices for improving social acceptance of new and existing substations on land from 2016-2024.

Status

I. Outlining an inventory and review of relevant publications, such as Cigre technical brochures; ☑

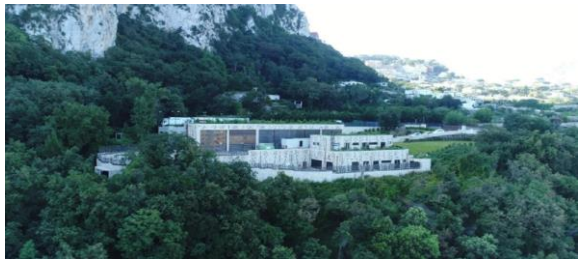
II. Learning from and using the results of the work of JWG B1/B2/C3; ☑

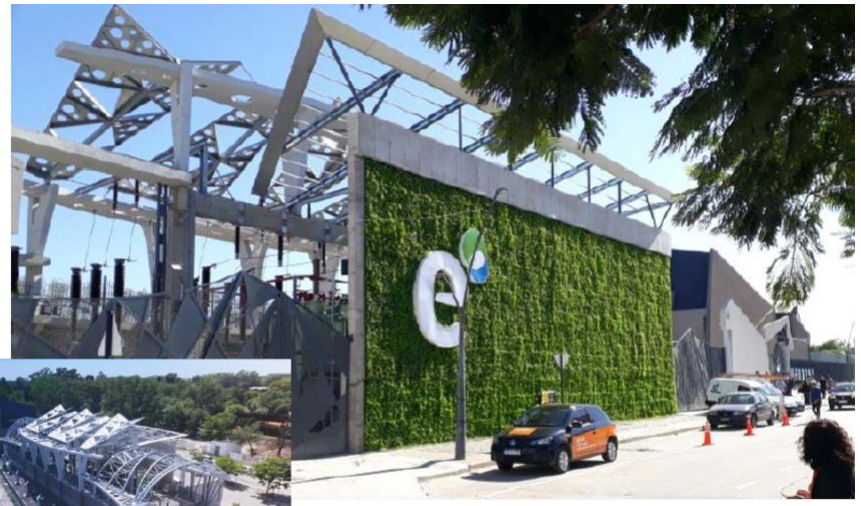
III. Collecting and analyzing approaches used in different countries using case studies; ☑

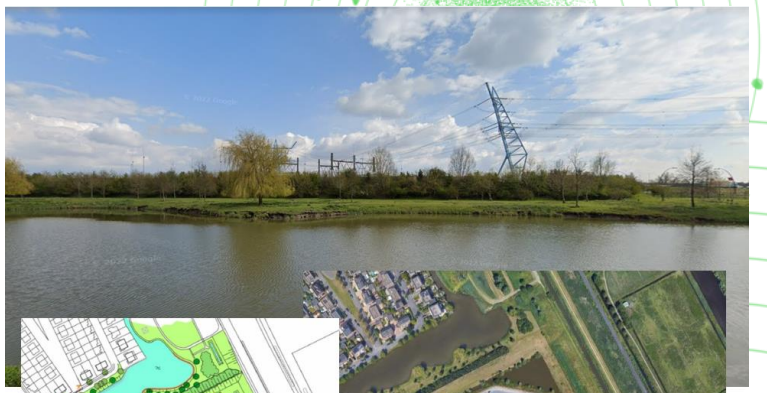
IV. Listing the information obtained in the previous steps in a database, accessible for TSO's and other Cigre members; ☑

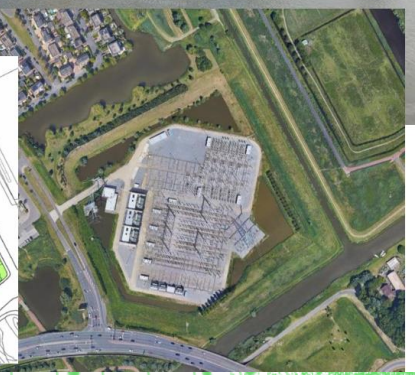
V. Gathering motivations for successful approaches and classifying them; ☑

VI. Summarising the information in a technical document and presenting it in a CIGRE Brochure ☑

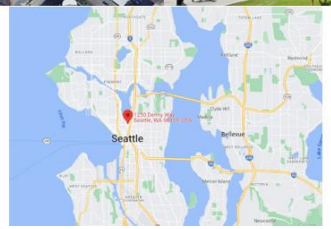


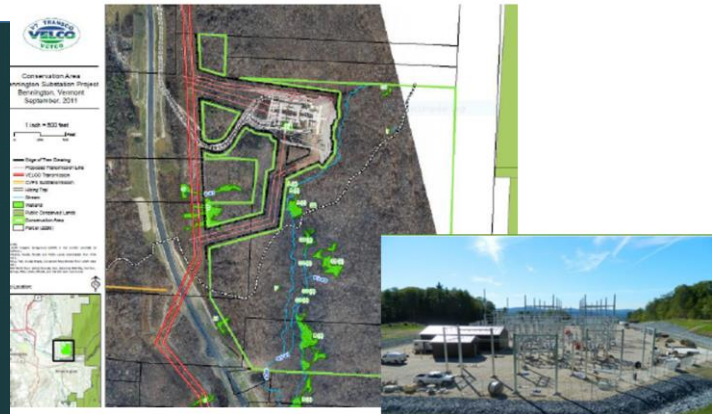






Blue: Substation, Red: Redevelopment area





Thank you!