II SELTE

SEMINÁRIO DE LINHAS DE TRANSMISSÃO DE ENERGIA

6 e 7 AGOSTO/2025

BRASÍLIA - DF
Hotel Royal Tulip

TECNOLOGIAS EMERGENTES NA TRANSMISSÃO E A TRANSIÇÃO ENERGÉTICA

Palestrante:
João B. G. Ferreira da Silva
Paranaíba Transmissora de Energia S/A
Diretor Técnico - CTO

REALIZAÇÃO:

ENG SMART LEAD

Instituto ABRATE

ABRATE

1 – CONTEXTUALIZAÇÃO

Impactos da transição energia na transmissão.

"No energy transition without transmission"

Mudança na logica do modelo

- Geração concentrada ⟶ Grandes sistemas transmissão

- Geração distribuída: Expansão na transmissão em todos os níveis de tensão

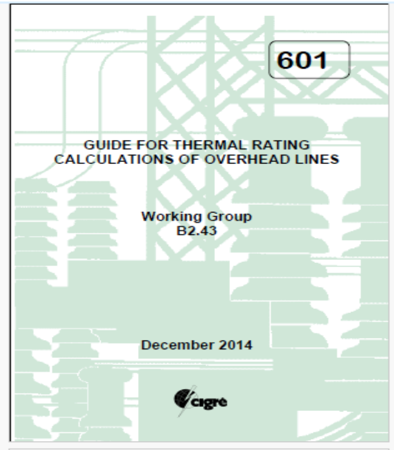
- Consequência: "Aumento global na capacidade de transmissão"
  - Sistemas de transmissão existentes
  - Novos sistemas a serem construídos (novas LT's/SE's)

2 – AUMENTO DA CAPACIDADE DE TRANSMISSÃO EM LINHAS EXISTENTES

2.1 – Dynamic Line Rating (DLR)

Monitoramento tempo real da temperatura/flecha

- Linhas Curtas: Limites térmico/Temperatura condutor
- Condutores ACSR (75ºC/90ºC)
- Monitoramento tempo real: Corrente + temperatura + vento
- Várias ferramentas/Modelos desenvolvidos
- Em ampla utilização no mundo: Aumentos de até 20-30% na capacidade de transmissão
- Engineering + forecasting
- Soluções ambientalmente amigáveis



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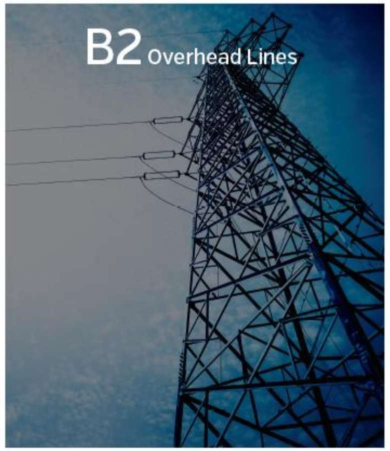

Forecasting Dynamic Thermal Line Ratings

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2.1 – Operação com monitoramento em tempo real (DLR)

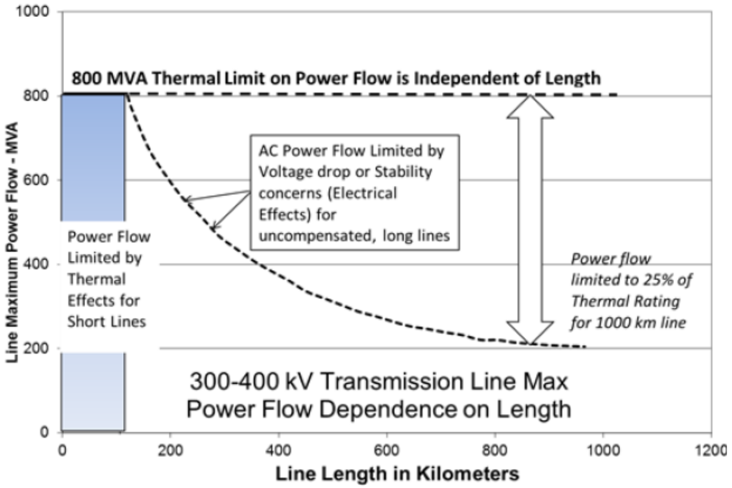

Figure 1-1 Maximum power flow for AC transmission lines versus line length

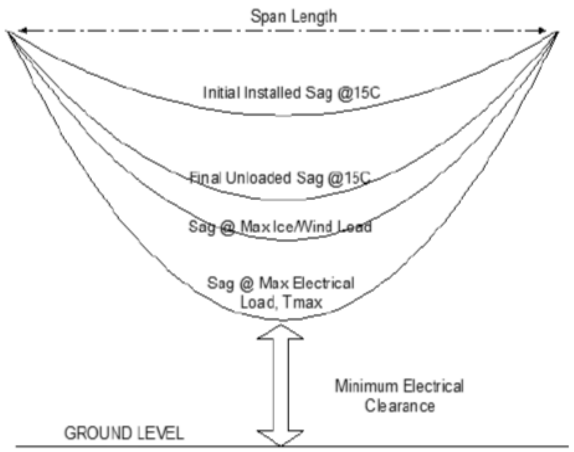

Figure 1-5 Typical sag-tension variation with time, mechanical load, and temperature

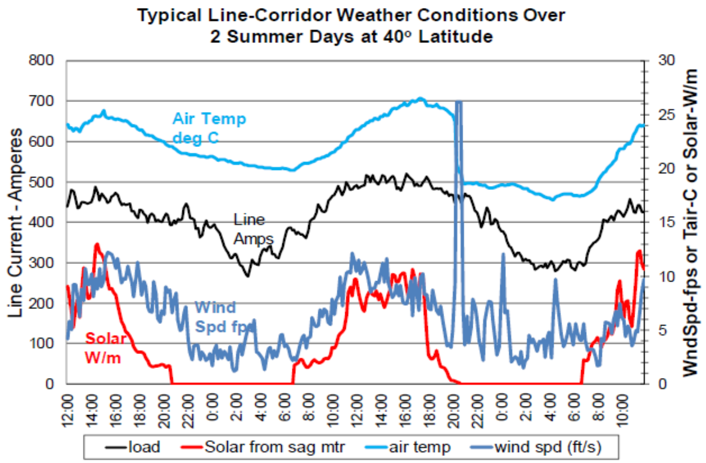

Figure 3-1 Typical daily variation in line corridor weather parameters

2.1 – Operação com monitoramento em tempo real (DLR)

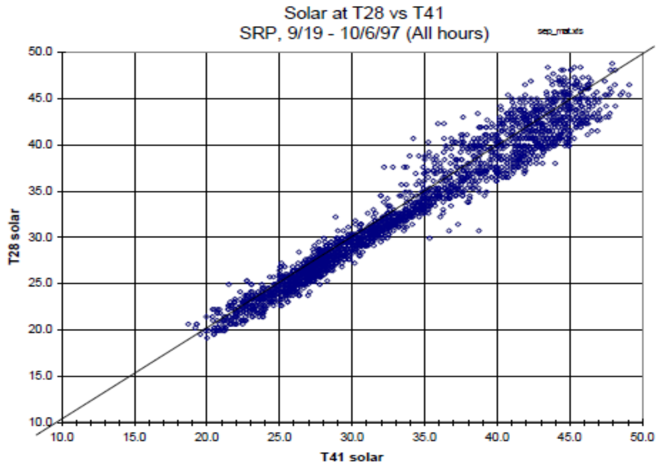

Figure 3-4 Conductor temperature (air + solar rise) at two different locations

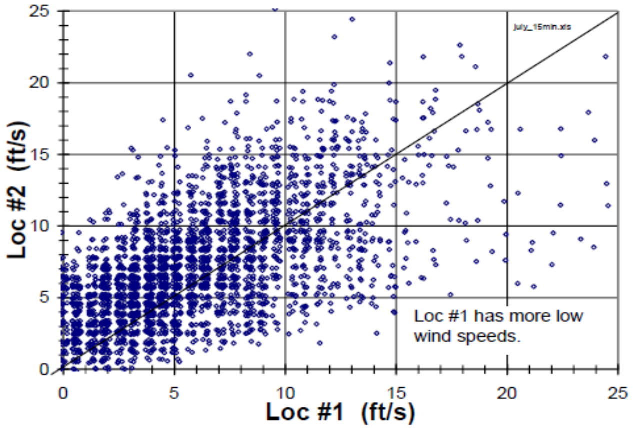

Figure 3-5 Wind speed difference at two different locations

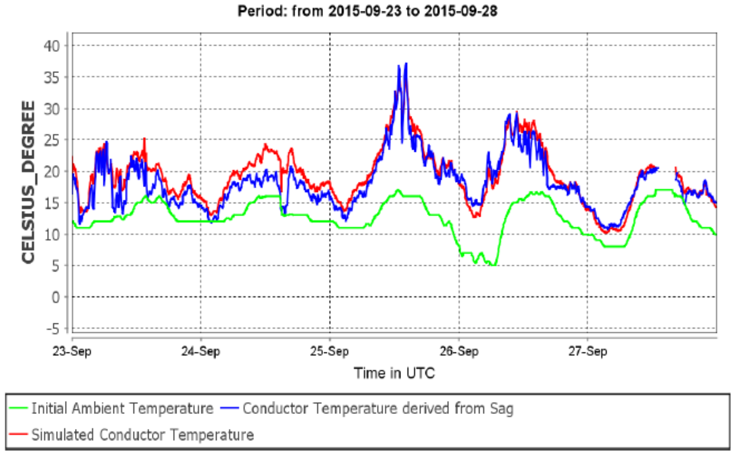

Figure 6-1 Calculated & sag-based conductor temperature vs measured air temperature

2.1 – Operação com monitoramento em tempo real (DLR)

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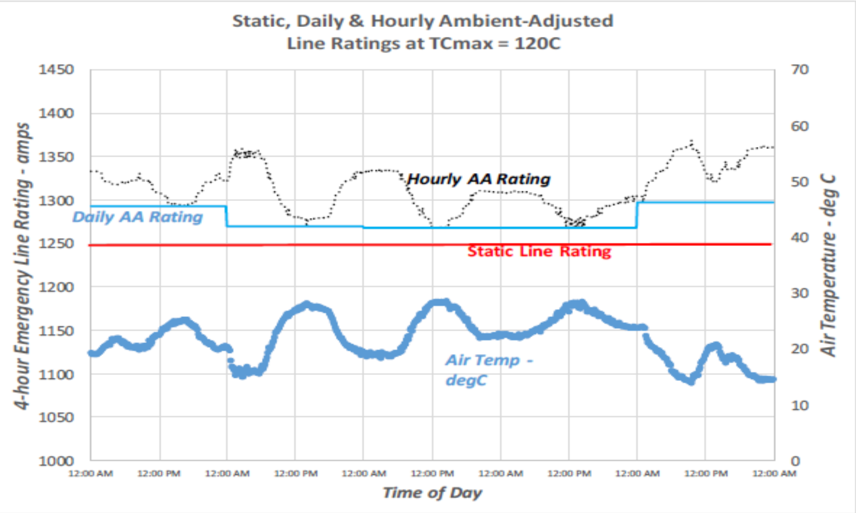


Figure 4-3 DLR-AA ratings varying hourly and daily

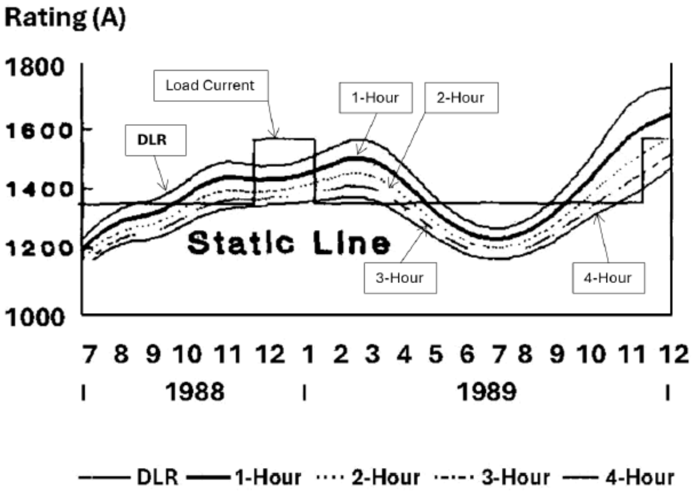
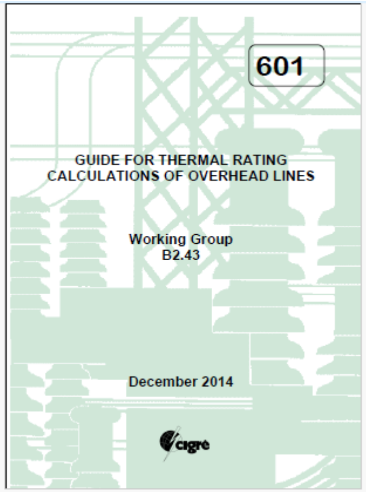


Figure 4-1 Example of predicted Dynamic Line Ratings [21]



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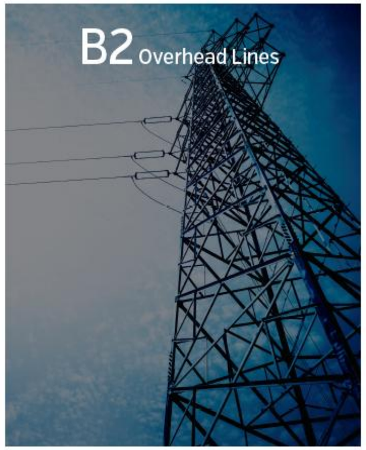

Forecasting Dynamic Thermal Line Ratings

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2.2 – Uso Condutores HTLS – Alta Temperatura e Baixa Flecha

- Operação com temperaturas mais elevadas
- Uso do mesmo ROW, mesmas estruturas, mesmas fundações
- Engenharia: cada caso é um caso diferente!

- O

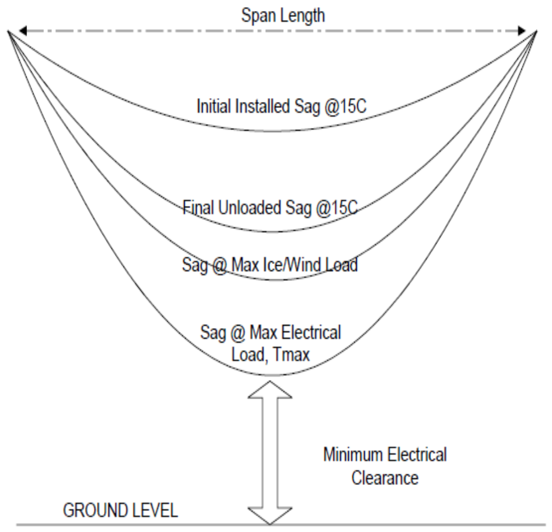
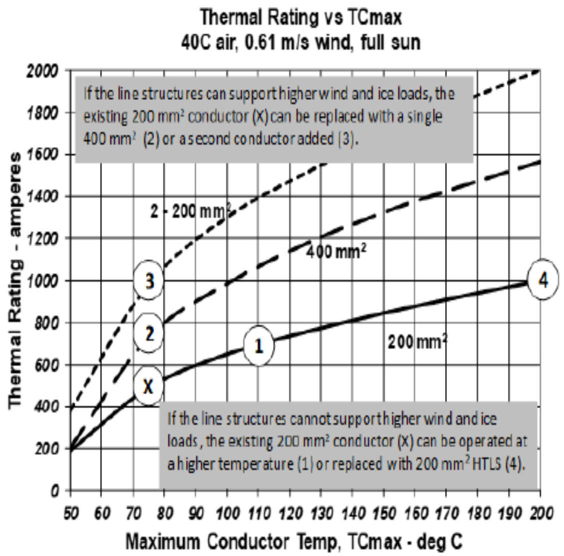


Figure 7 - Typical sag-tension variation with time, mechanical load, and temperature.



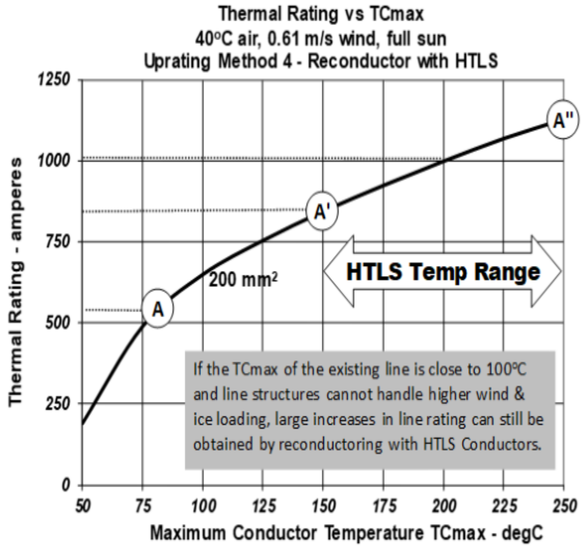
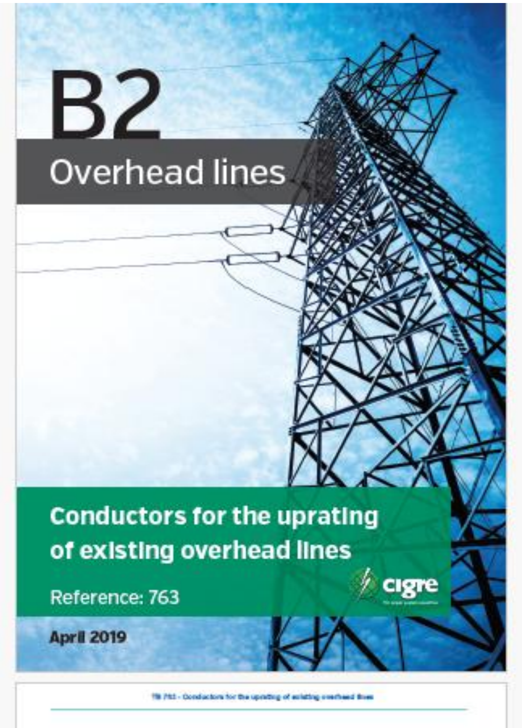


Figure 5 - Thermal rating Vs TC_{MAX}

2.2 – Uso Condutores HTLS – Alta Temperatura e Baixa Flecha

Table 7 - Acronyms & descriptions for HTLS conductors [10]

Type	Core	Envelope	Acronym or trademark	Description
0	Galvanized or aluminium clad steel	Hard drawn aluminium	ACSR	Conventional 1350-H19 Aluminum, steel reinforced
1	Galvanized, mischmetal or aluminium clad steel	Thermal aluminium AT1 (TAL or 60TAL)	TACSR	Thermal resistant aluminium alloy conductor, steel reinforced
1	Invar steel	Thermal aluminium AT1 (TAL or 60TAL)	TACIR	Thermal resistant aluminium alloy conductor, invar reinforced
1	Galvanized, mischmetal or aluminium clad steel	Thermal aluminium AT2 (KTAL)	KTACSR	High strength, thermal resistant aluminium alloy conductor, steel reinforced
1	Galvanized or mischmetal clad steel	Thermal aluminium AT3 (ZTAL or	GZTACSR	Gap type, ultra-thermal resistant aluminium alloy conductor, steel reinforced
1	Galvanized, mischmetal or alum-clad steel	Thermal aluminium AT3 (ZTAL or	ZTACSR	Ultra-thermal resistant aluminium alloy conductor, steel reinforced
1	Invar steel or aluminium clad invar steel	Thermal aluminium AT3 (ZTAL or	ZTACIR, ZTACIR/HACIN	Ultra-thermal resistant aluminium alloy conductor, invar reinforced
1	Invar steel or aluminium clad invar steel	Thermal aluminium AT4 (XTAL)	XTACIR, XTACIR/HACIN	Extra thermal resistant aluminium alloy conductor, invar reinforced
2	Galvanized, mischmetal or alum-clad steel	Annealed aluminium 1350-0	ACSS	Aluminium conductor, steel supported
3	Metal matrix composite	Thermal aluminium AT3 (ZTAL or	ACCR, ACMR	Thermal-resistant aluminium alloy conductor, metal matrix composite core reinforced
4	Polymer matrix composite	Thermal aluminium AT1 (TAL or 60TAL)	ACPR	Thermal-resistant aluminium alloy conductor, polymer matrix composite core reinforced
4	Polymer matrix composite	Thermal aluminium AT3 (ZTAL or	ACCFR, ACFR, ACPR	Thermal-resistant aluminium alloy conductor, polymer matrix composite core reinforced



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2.2 – Uso Condutores HTLS – Alta Temperatura e Baixa Flecha

- Várias soluções; múltiplos usos; Atenção com ferragens

Figure 25 - Compact (Formed Wire) conductors

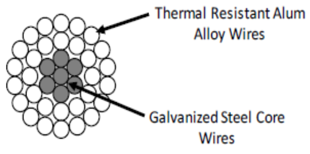


Figure 30 - Cross-section of TACSR conductor

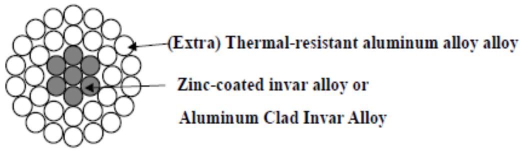


Figure 31 - Crossection of (Z)TACIR

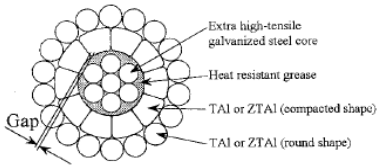


Figure 32 - Cross-section of GTACSR conductor

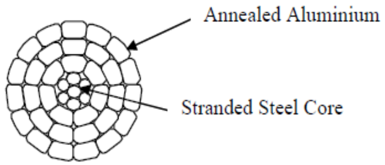
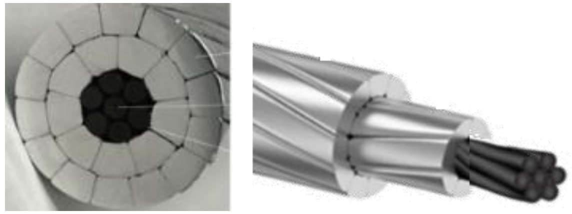
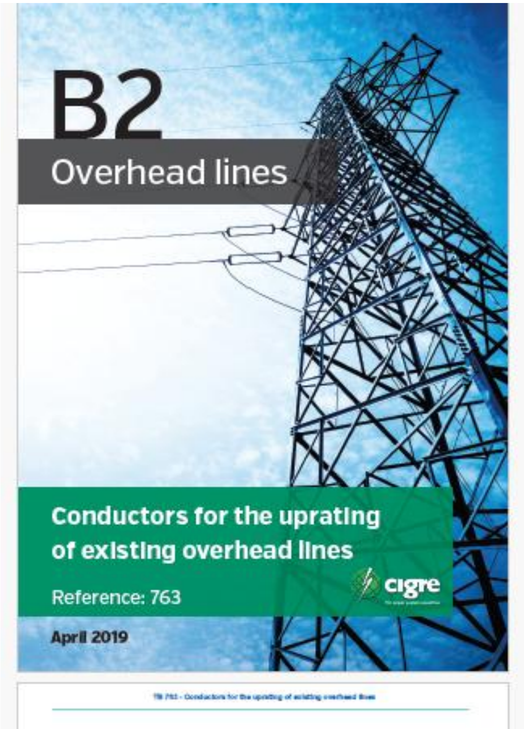


Figure 33 - Cross-section of ACSS/TW conductor





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- Engenharia ajustada: aproveitamento torres e fundações

2.2 – Uso Condutores HTLS – Alta Temperatura e Baixa Flecha

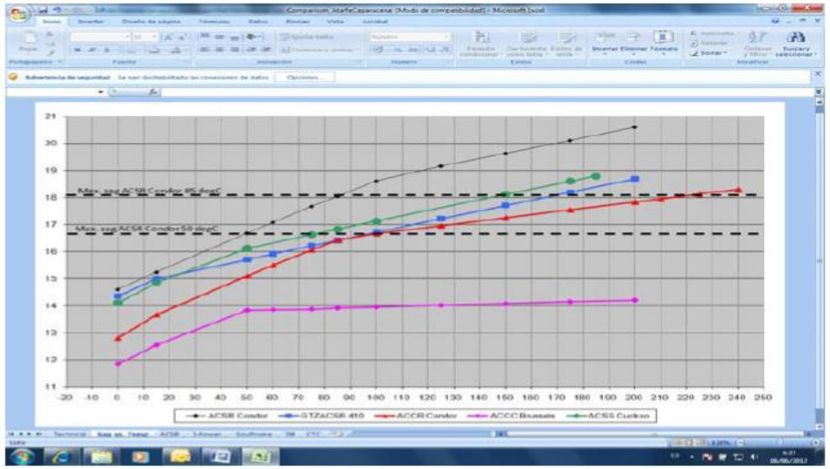
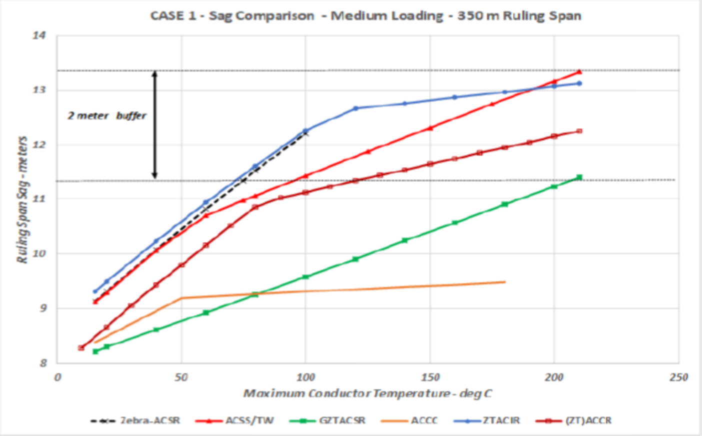
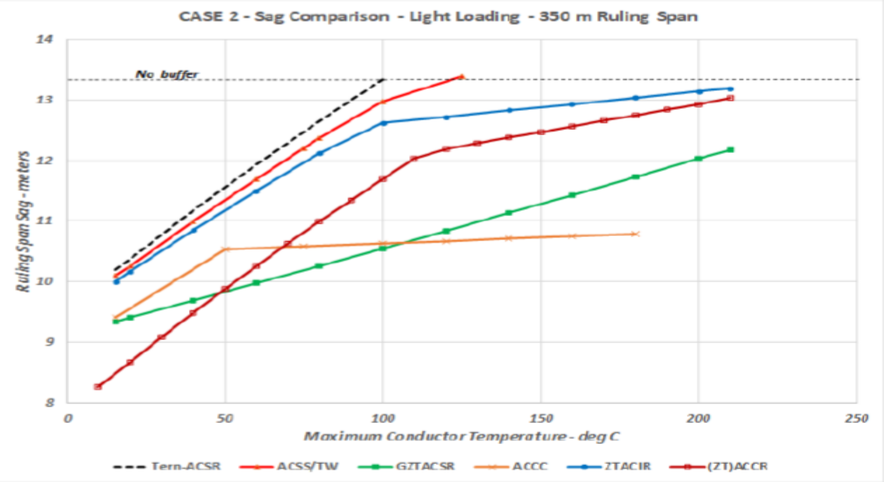
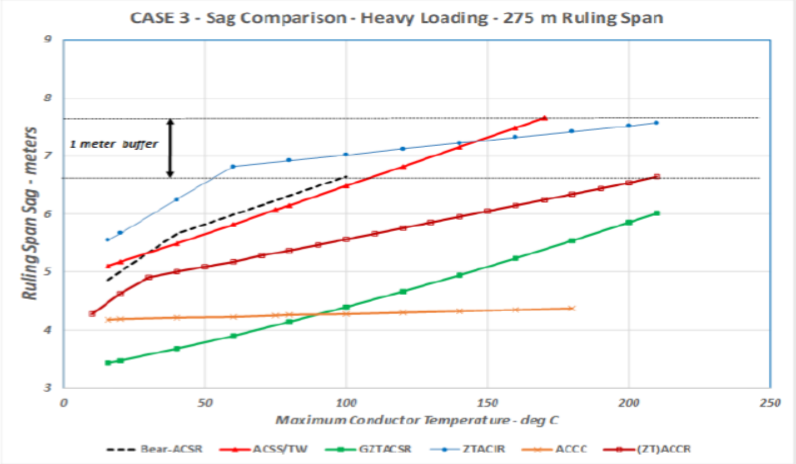


Figure 37 - Comparison of sag versus conductor temperature







2.3 – Reforçando Torres e Fundações

- Quando "uprantings" exigem "upgranding"
- As torres existentes não suportam novas (mais) cargas

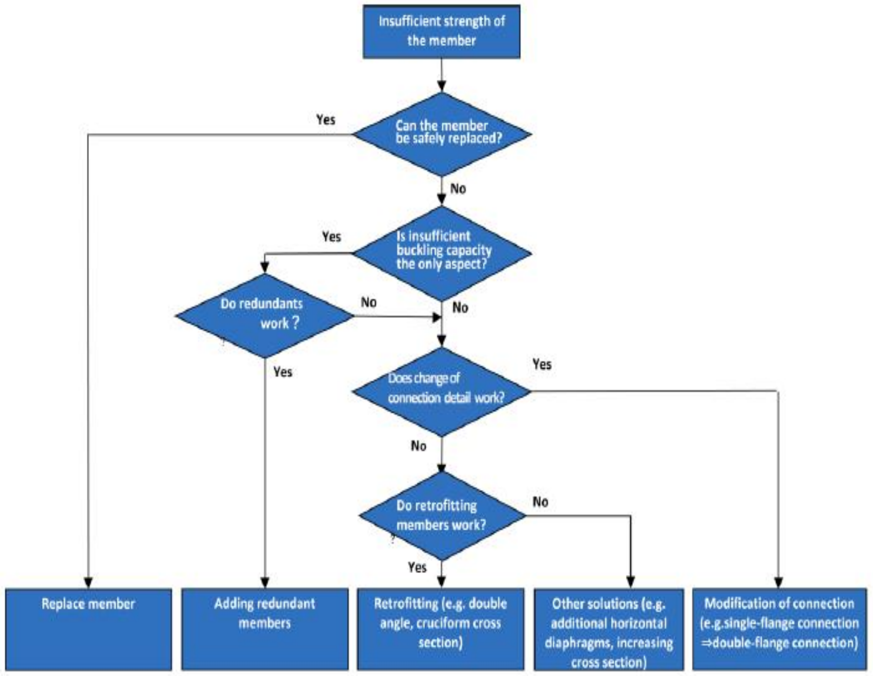
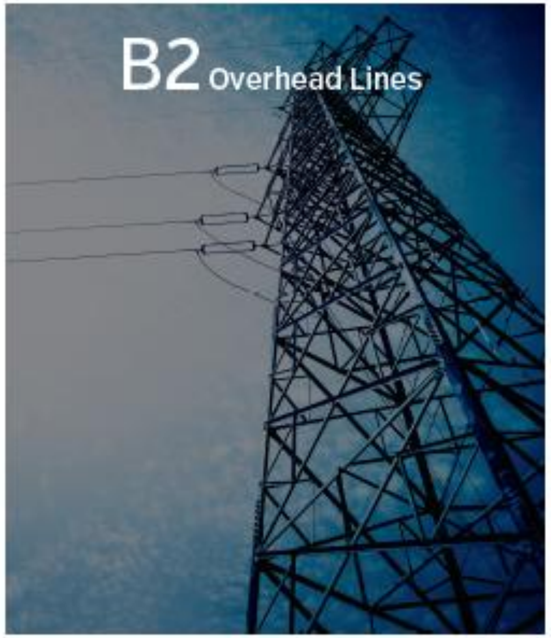


Figure 5-1 Flowchart for reinforcing an existing lattice tower



Increasing the Strength Capacity of Existing Overhead Transmission Line Structures

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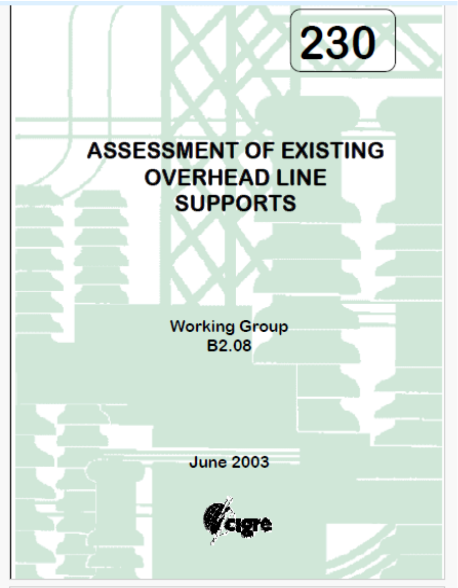
2.3.1 – Aumentando a Altura de Torres



TB 230 - 2003

Figure 19 - Tower Lifting by Crane

Figure 20 - Tower with bottom extension installed

2.3.2 – Alguns Reforços em Torre

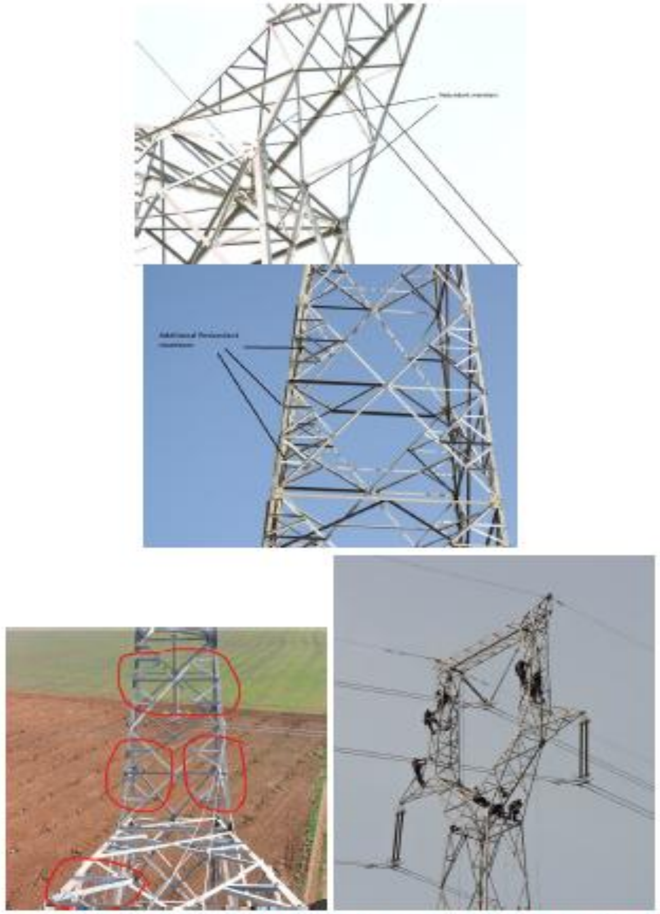
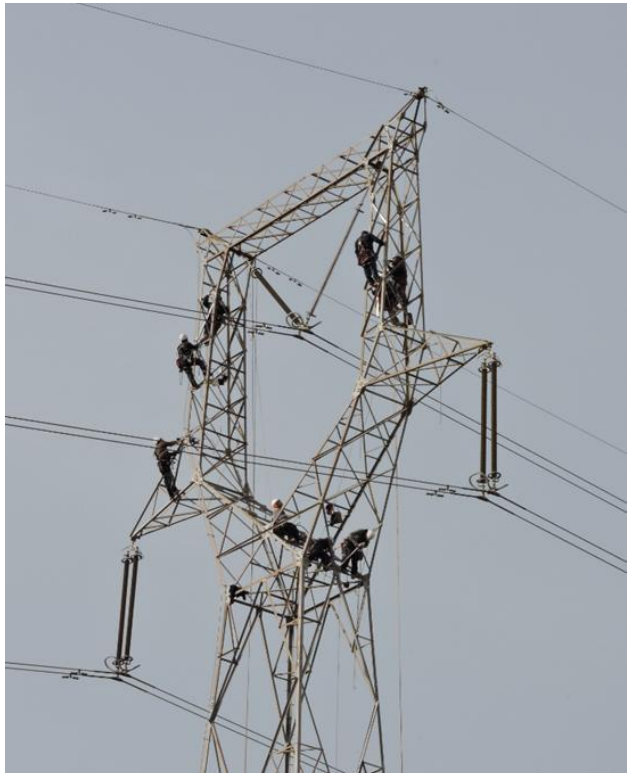
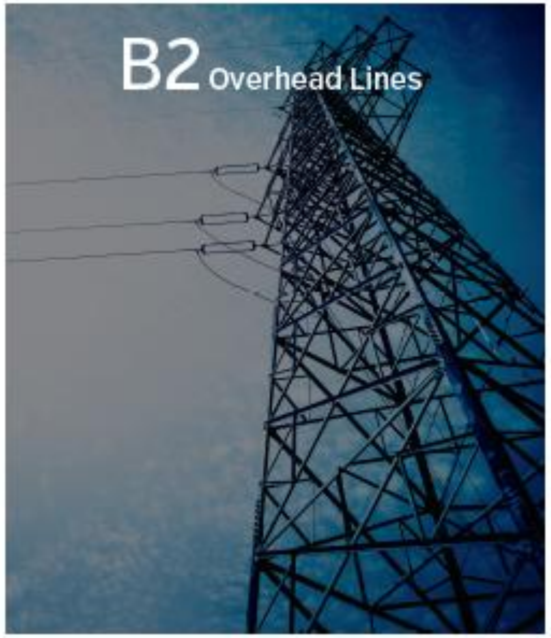


Figure C-6 Example 6: adding redundant members to reduce buckling length of leg and diagonal members (courtesy of Red Eléctrica, Spain)





Increasing the Strength Capacity of Existing Overhead Transmission Line Structures

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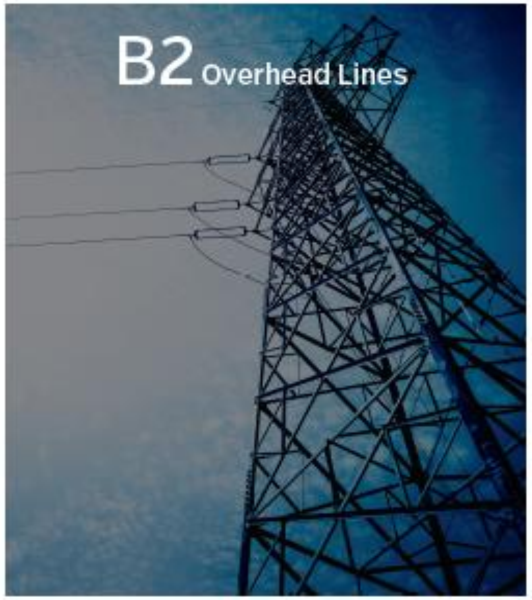
2.3.3 – Alguns Reforços em Torres e Fundações

Figure C-20 Example 19: reinforcing main legs and foundations (courtesy of DNV, Netherlands)

Figure 22 - Foundation trial pit and upgrading examples



Increasing the Strength Capacity of Existing Overhead Transmission Line Structures

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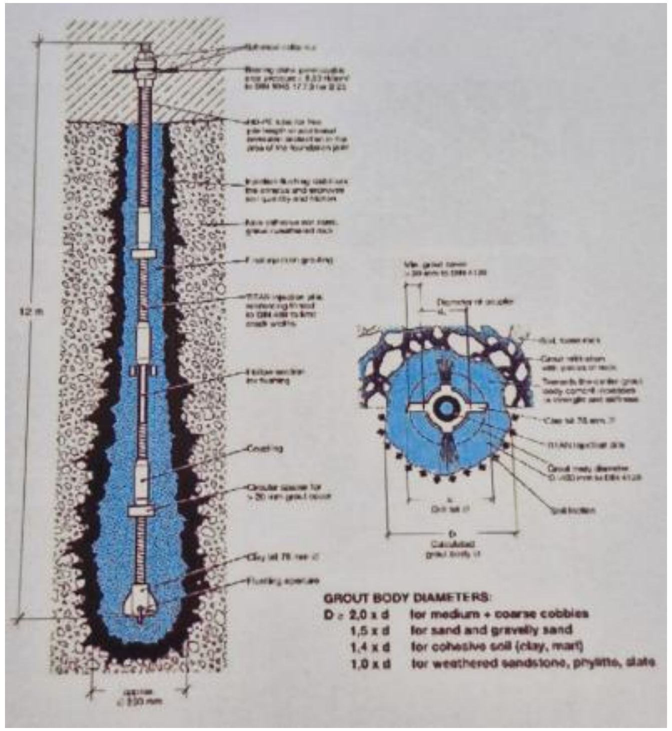
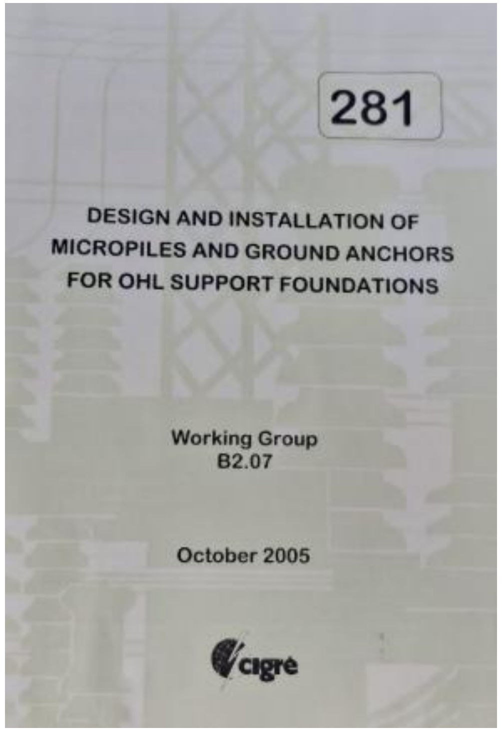
2.3.4 – Alguns Reforços em Fundações

- Reforços com micro-estaca injetada




281

DESIGN AND INSTALLATION OF
MICROPILES AND GROUND ANCHORS
FOR OHL SUPPORT FOUNDATIONS

Working Group
B2.07

October 2005

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3 - TECNOLOGIAS PARA NOVOS SISTEMAS TRANSMISSÃO

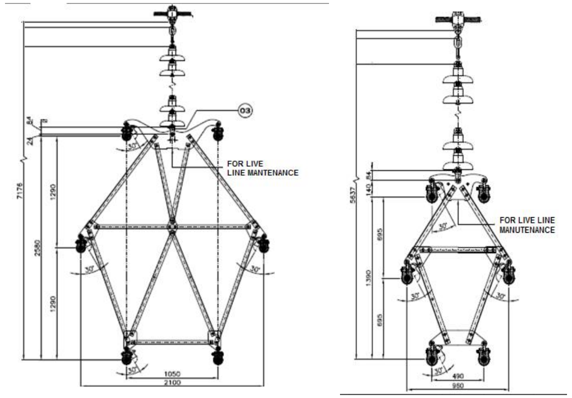
II SELTE SEMINÁRIO DE LINHAS DE TRANSMISSÃO DE ENERGIA

3.1 – Compactação

Um natural aumento na capacidade de transmissão

LT 230 kV – Eletronorte

Sistemas “FEXCOM”



LT 500 kV – Paranaíba Transmissora

Expansão feixes (linhas HSIL)

LT 500kV – Chesf

3 - TECNOLOGIAS PARA NOVOS SISTEMAS TRANSMISSÃO

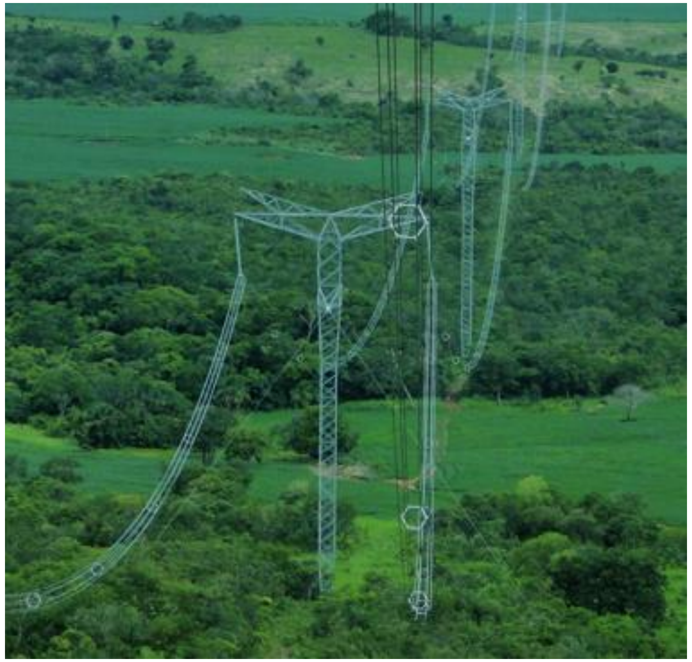
II SELTE
SEMINÁRIO DE LINHAS DE TRANSMISSÃO DE ENERGIA

3.2 – Novos sistemas HVDC

Tecnologia SVC para conversoras

3.3 – Super Grids

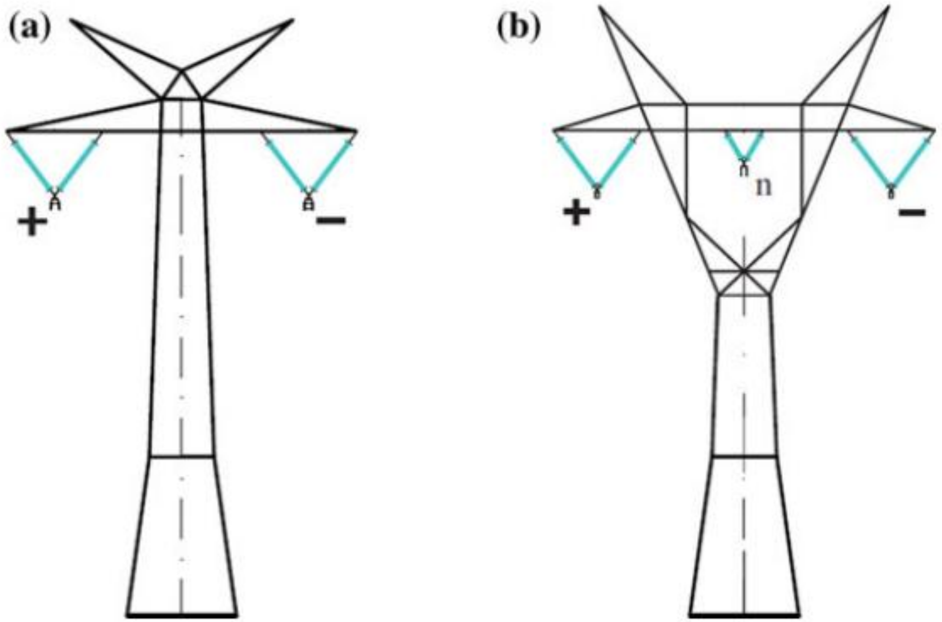
Sistemas mais possantes ±800kV, ±1000kV

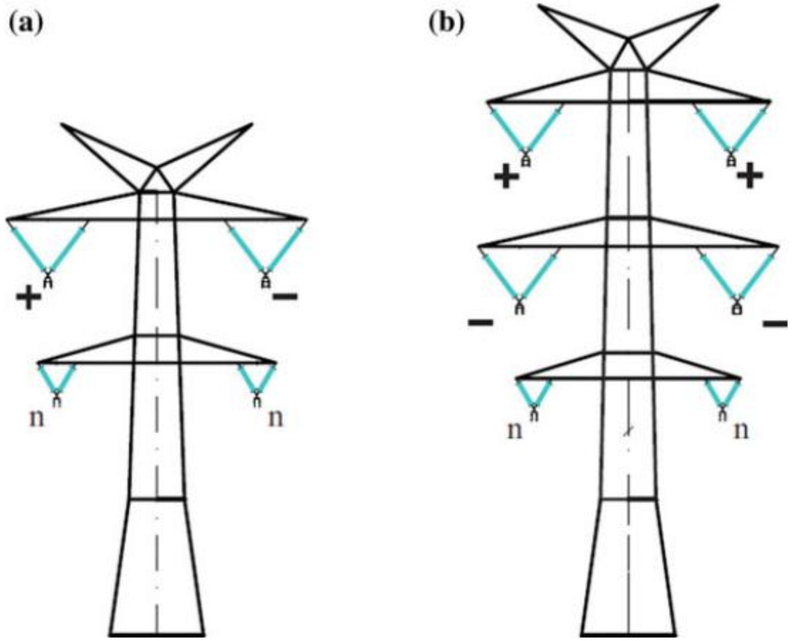


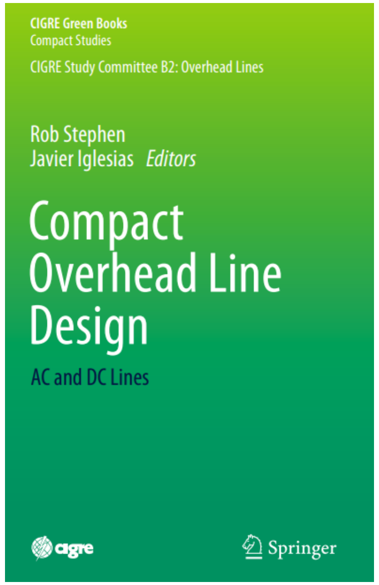
LT +/- 800 kV – Belo Monte Transmissora

II SELTE SEMINÁRIO DE LINHAS DE TRANSMISSÃO DE ENERGIA

3.4 – Upratings: Conversão AC + DC







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3.4 – Upratings: Conversão AC + DC

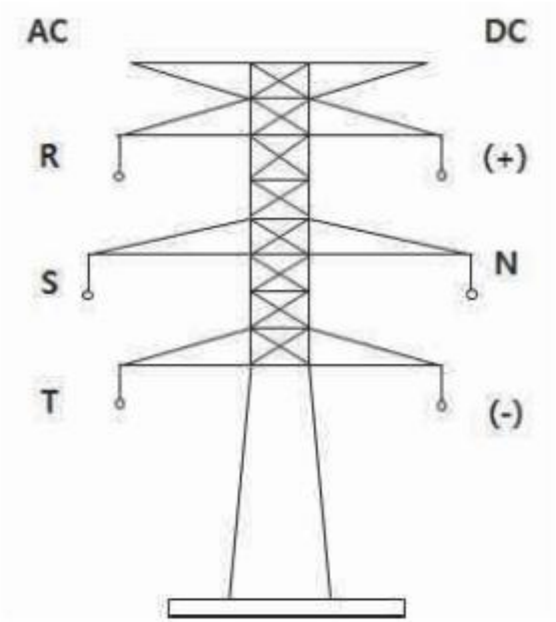

Figure 9. AC/DC hybrid line configuration

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B2 OVERHEAD LINES
PS1 - Challenges & New Solutions in Design and Construction of New OHL

Electrical environment evaluation of HVAC/HVDC hybrid overhead transmission line using a reduced-scale model

Koo Yong SHIN[1], Joon Arm OH[1], Seung Woo Lee[1], Kwang Man Ko[1], Mun No JU[2], Jeong Min WOO[2,*]

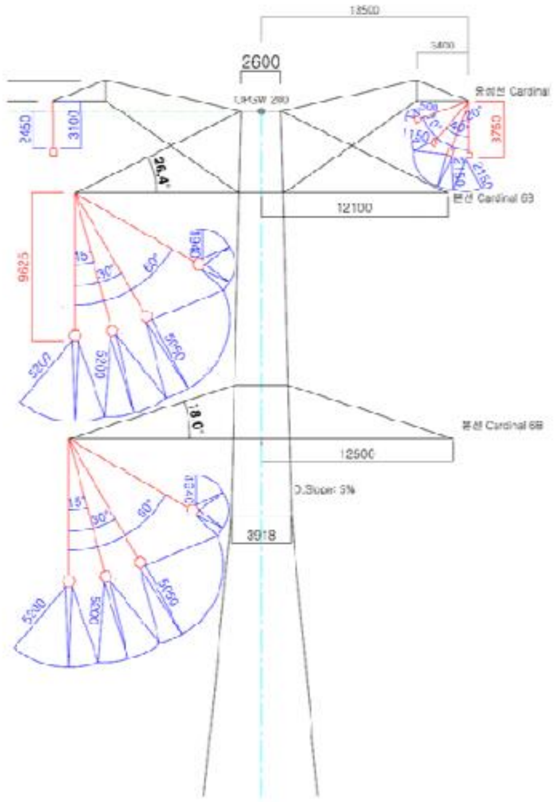
[1]Korea Electric Power Research Institute (KEPRI), Korea Electric Power Corporation (KEPCO), Daejeon 34056, Korea

[2]Electrical Environment Research Center, Korea Electrotechnology Research Institute, Changwon 51543, Korea

Republic of Korea

*woojm@keri.re.kr

3.5 – Duplo bipolo com Retorno Metálico



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B2-310

CIGRE 2018

Full Scale Test for ±500kV HVDC Double Bi-Pole with Return Conductor Overhead Transmission Line

K.Y. Shin*[1], G.M.KWON[1], J.H.LEE[1], W.J.CHOI[1], C.K.PARK[1], J.M.Woo[2], M.N.Ju[2]
[1]Korea Electric Power Corporation, [2]Korea Electrotechnology Research Institute
Republic of KOREA

3 - TECNOLOGIAS PARA NOVOS SISTEMAS TRANSMISSÃO

3.6 - Estruturas hibridas com membros isolantes

Compact plus tower – Vattenfall

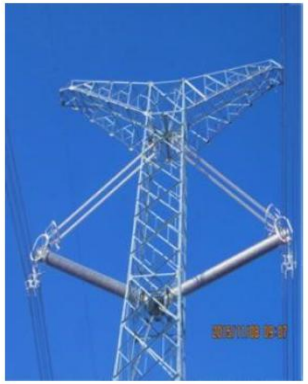

Figure 9-9 800kV DC hybrid tower, steel and FRP composite

Figure 9-10 Hybrid tower, steel and FRP composite

Figure 9-12 1100kV hybrid tower, steel and FRP composite.

Sistema Shemar

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CIGRE Study committe B2

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG B2.96

NAME OF THE CONVENOR
Ahmed Usama (CANADA)

TITLE
Composite Insulated Cross-arms for New-build and Retrofitted Transmission Line Supports

THE WG APPLIES TO DISTRIBUTION NETWORKS: NO

ENERGY TRANSITION
4 / Sustainability and Climate Change

POTENTIAL BENEFIT OF WG WORK
3 / likely to contribute to new or revised industry standards
4 / state-of-the-art or innovative solutions or directions
5 / Guide or survey on techniques, or updates on past work or brochures

STRATEGIC DIRECTION
1 / The electrical power system of the future reinforcing the End-to-End nature of CIGRE: respond to speed of changes in the industry by preparing and disseminating state-ofthe-art technological advances
3 / Focus of the environment and sustainability (in case the WG shows a direct contribution to at least one SDG)

SUSTAINABLE DEVELOPMENT GOAL
9 / Industry, innovation and infrastructure

Novo WG SC B2.96 – Cigré

3 - TECNOLOGIAS PARA NOVOS SISTEMAS TRANSMISSÃO

3.7 - Estruturas em FRP

Figure 9-2 The 230 kV FRP lattice structures with composite insulators

230 kV FRP Lattice Tower

Figure 10-8 FRP cross-braced H-frame

FRP Portal Tower

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3 - TECNOLOGIAS PARA NOVOS SISTEMAS TRANSMISSÃO

3.7 - Estruturas em FRP


Figure 10-18 Placing a H-f


Figure 18-7 Angle tension structure


Figure 18-6 H-frame tension structure

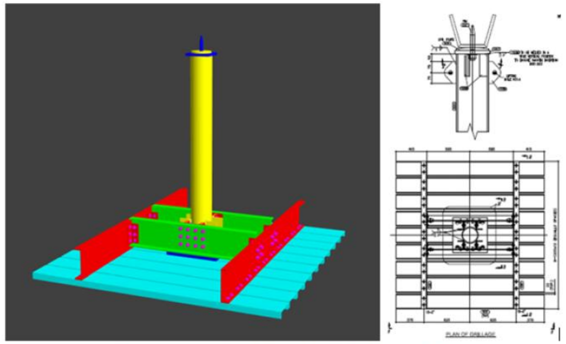
Figure 8-1 FRP pad and chimney foundation for guyed pole

FRP Grillage Foundation

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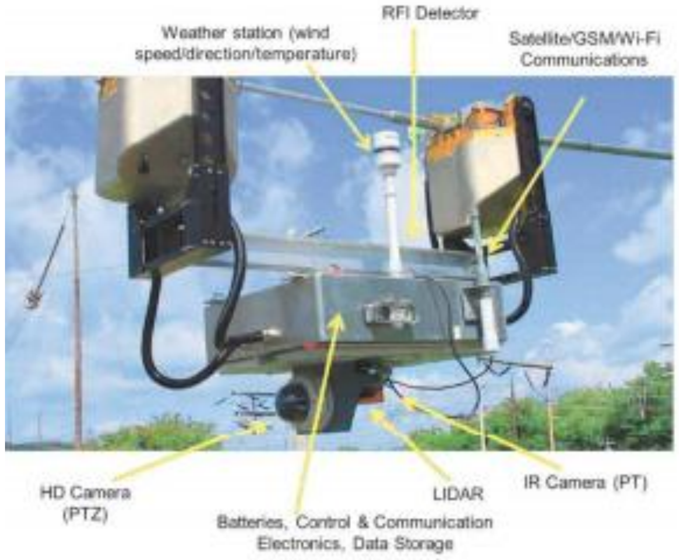
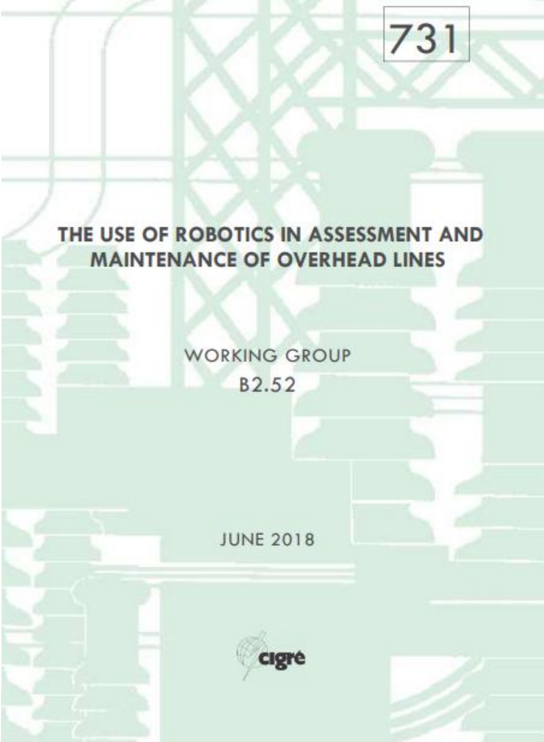
4 – TECNOLOGIAS CONSTRUTIVAS E DE MANUTENÇÃO

- Uso de robôs

Figure 3.1-1 LineScout Robot from Hydro-Québec

Figure 3.1-4 Expliner Robot from HiBot
(Debenest et al. 2010, © 2010 IEEE)





4 – TECNOLOGIAS CONSTRUTIVAS E DE MANUTENÇÃO

II SELTE SEMINÁRIO DE LINHAS DE TRANSMISSÃO DE ENERGIA

- Uso de robôs / drones

Figure 3.1-11 LineROVer Robot from Hydro-Québec
(Photo courtesy of IREQ, © Hydro-Québec)

igure 3.1-7 Power Line Inspection Robot (PLIR) from the University of KwaZulu-Natal

Figure 3.2-2 AAI Aerosonde
(Cruise Speed 27 m/s, Payload 8 kg)

Figure 3.2-4 UAR 45 Red Eléctrica de España

Figure 3.2-9 Exemple of Hexacopter with Propeller Side Protection and Camera for Visual Inspections (Diameter about 1 meter)

4 – TECNOLOGIAS CONSTRUTIVAS

- Novo WG SC B2.92 – Cigré

Estacas helicoidais

Bloco pré moldado

Lançamento simultâneo de 6 condutores

CIGRE Study Committee B2

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG[1] B2.92	Name of Convenor: Hugo VALENTE (PORTUGAL) E-mail address: hugo.valente@ren.pt
Strategic Directions #[2]: 1, 2, 3	Sustainable Development Goal #[3]: 9, 11

This Working Group addresses these Energy Transition topics:

- [ ] Storage
- [ ] Hydrogen
- [ ] Digitalization
- [x] Sustainability and Climate Change
- [x] Grids and Flexibility
- [ ] Solar PV and Wind
- [ ] Consumers, Prosumers and Electrical Vehicles
- [ ] Sector Integration
- [ ] None of them

Potential Benefit of WG work #[4]: 3, 4, 5, 6

Title of the Group: Update on Overhead Transmission Lines Construction Methodologies

Scope, deliverables and proposed time schedule of the WG:

Background:

The construction of OHL involves different fields of expertise, starting from access planning, then foundation works, assembly and erection of towers and finally stringing of conductors.

There are different methods to accomplish each of these tasks. It is therefore very important to ensure, from the design phase, that the chosen methodology is adequate, taking into account:

- Local environmental, climatic and terrain conditions;
- Local particularities and restrictions;
- Available equipment and labour;
- Logistics and project planning.

Only planning that takes these aspects into account will allow an overhead line to be built efficiently while guaranteeing the safety of workers.

Purpose/Objective/Benefit of this work:

This WG will provide a state of the art of the main methodologies currently used in the world, for the following three stages of OHL construction:

- Installation of foundation;
- Assembly and erection of towers;
- Conductor stringing.

This information will then be analysed and the main findings will be used to elaborate recommendations on best practices and methodologies.

The state of the art will also include a review of the latest innovations for the construction of OHLs.

TOR WG B2.92 _Signed TC Chair.docx
Template 2024-01-08