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New Landscape & Design Approachs in Europe

Agenda

1. Introduction Europoles Group
2. Design vs. Feasibility
   Actual Developments in Extra High Voltage Grids
3. The “Magic Triangle”
4. Actual Developments & Improvements

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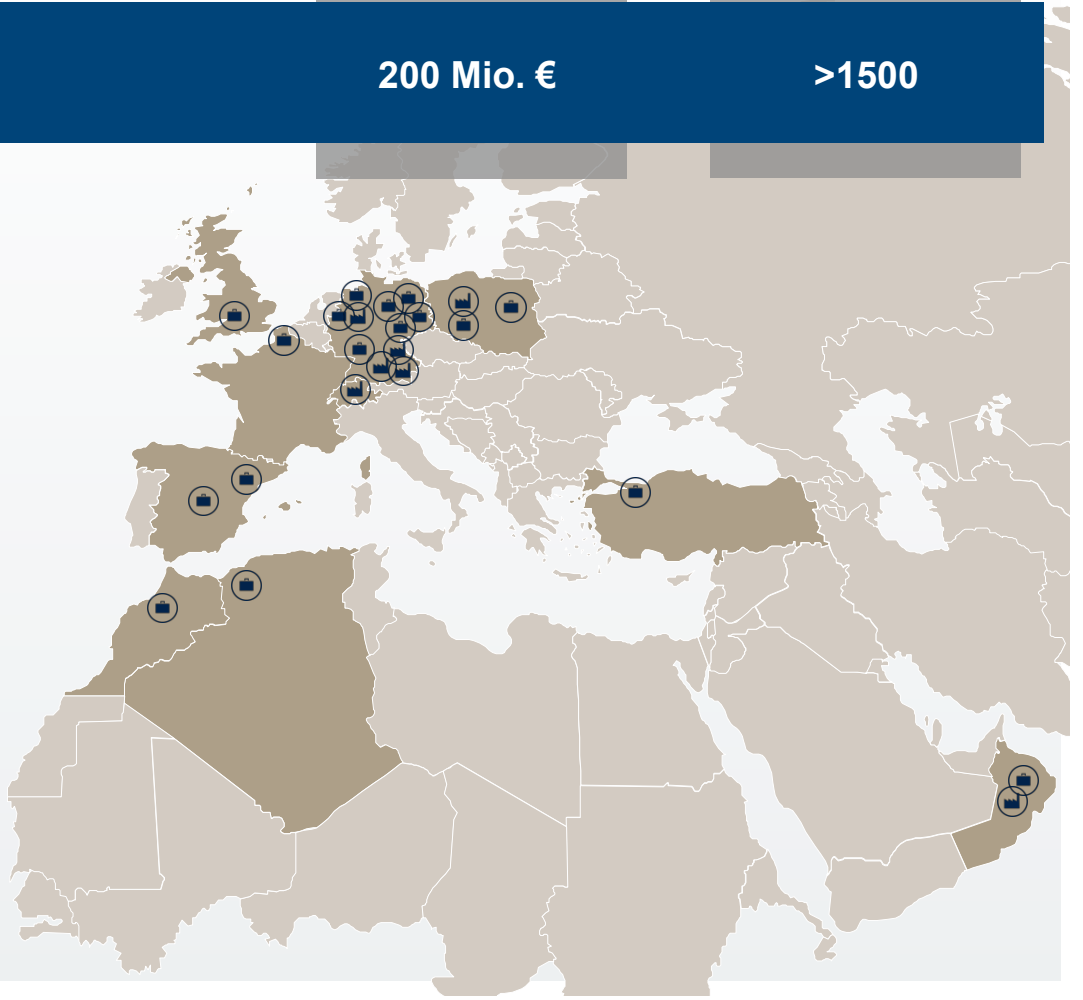
Fact & Figures

	Turnover 2014	Employees
Europoles GmbH & Co. KG	**200 Mio. €**	**>1500**

- Market Leader in Europe
- More than 125 years experience in the poles business
- 9 Factories in Germany, Poland, Switzerland, Oman & Marocco
- Production facilities for concrete, steel and fibreglass poles
- Technical Department & Production of steel, concrete, fiberglass & hybrid structures – 3m to 130m



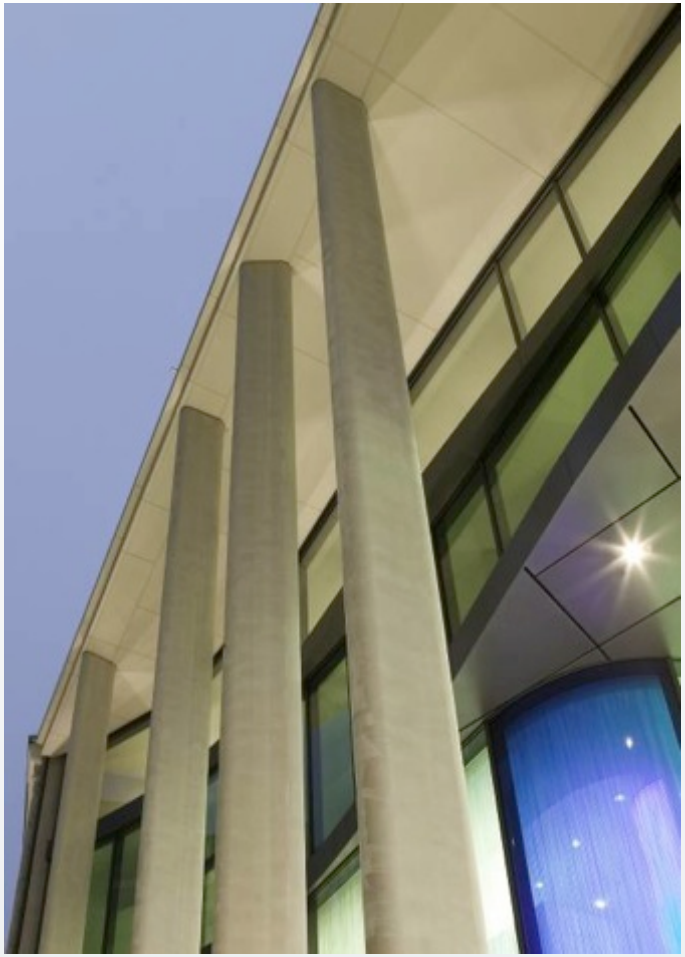
References – Customized Solutions

Special Catenary Poles - Rhombus Shape, Leipzig

Frangible Antenna Structures, Airport Hamburg

References – Customized Solutions

Floodlight Mirrow Pole, Yas Island Abu Dhabi



Special colored concrete columns, Leipzig

Innovations: Hybrid Design - Steel + FRP

Hybrid pole in action

Hybrid pole - details

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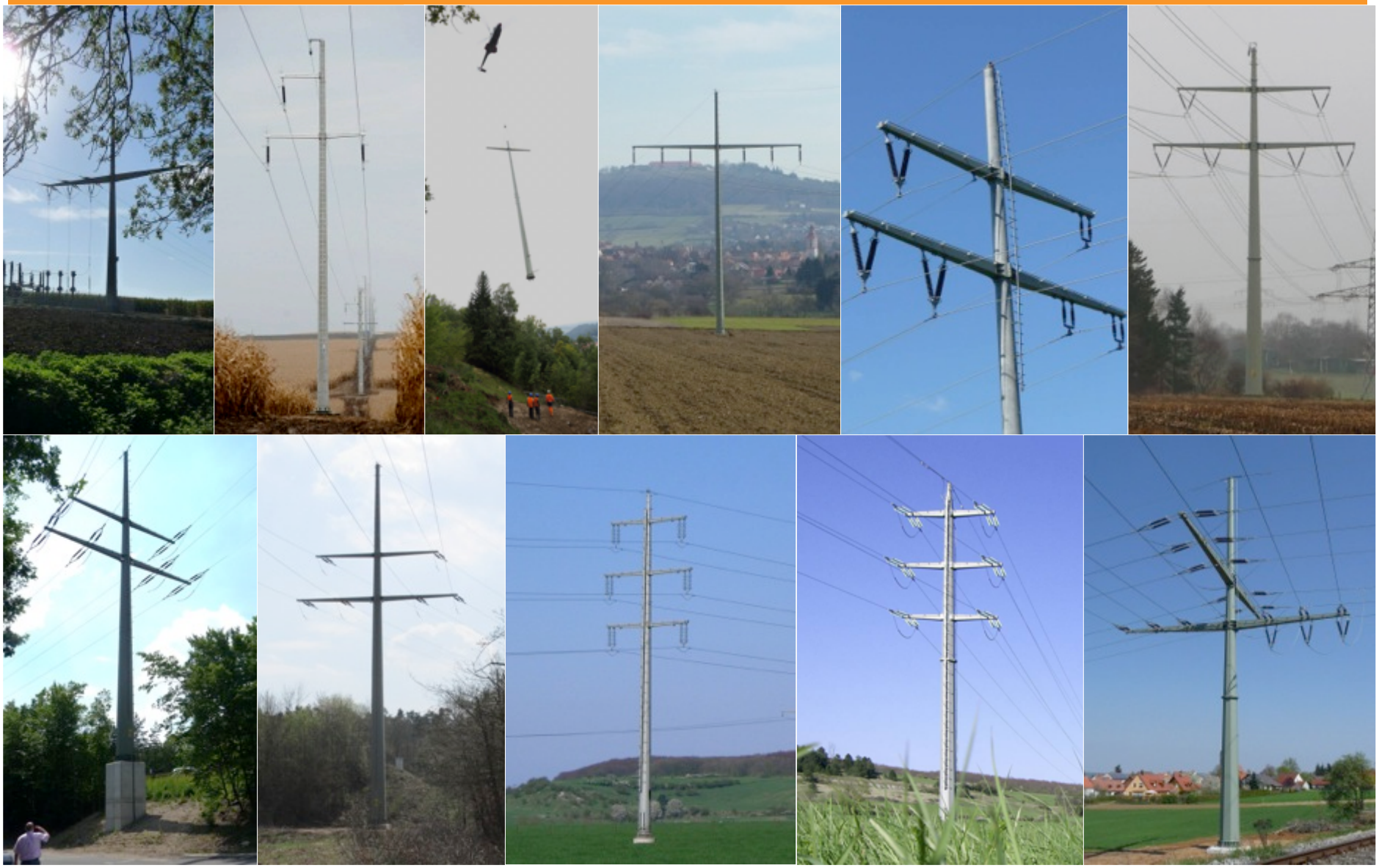

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Design vs. Feasibility

Actual Developments in Extra High Voltage Grids

Design vs. Feasibility

Actual Developments in Extra High Voltage Grids

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Ultra Compact Lines - Samples

Most Compact Design, Statnett - 420kV with 5m Phase-Distance

Design vs. Feasibility

Actual Developments in Extra High Voltage Grids

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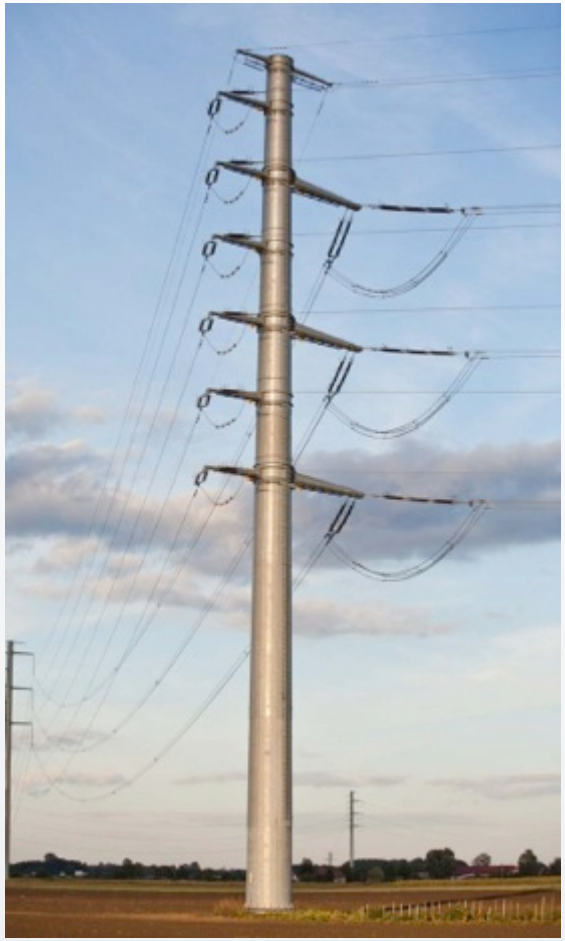
Entrainment 2x 110 kV with 1x 380 kV

Tension pylon 1x 380 kV + 2x 110 kV



Detailed view

400kV Compact Line – First line in Dubai

380 kV Compact Line Dubai

380 kV Compact Line Dubai - Details

2x380kV Compact system – Terna Italy

2x 380kV Line – Suspension and Tension Poles, Italy

Landmarks & Design Poles - Skandinavia

Landmark Samples

Design vs. Feasibility

Actual Developments in Extra High Voltage Grids

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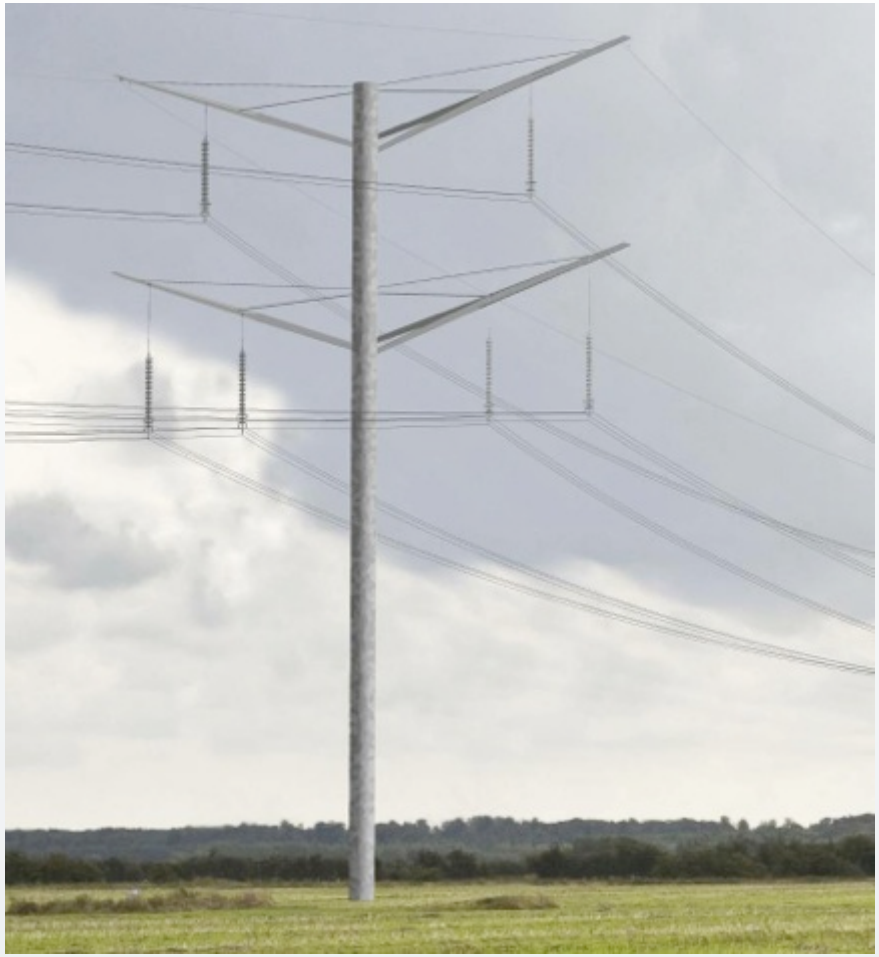
400kV Developments Denmark & Italy



Bystrup„Eagle Wings“ Kasso-Tjele, Denmark

Terna, HDA Architects

Design vs. Feasibility

Actual Developments in Extra High Voltage Grids

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Design comes true!

Bystrup„Eagle Wings“ Kasso-Tjele, Denmark

Terna, HDA Architects

400kV – Wintrack Lines, Netherlands

Wintrack Design – TenneT 2 x 400kV

Wintrack Design – TenneT 2 x 150kV + 2 x 400kV

Design vs. Feasibility

Actual Developments in Extra High Voltage Grids

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History TenneT – 10 years anniversary

2005	Prequalified for the first TenneT–Wintrack pylon in partnership with Lapp Insulators
2006	Alternative draft with compact cross arm and concrete poles (as well as hybrid construction)
2008	Presentation of the Wintrack pole II by TenneT Prequalification of Europoles
2009	Development and calculation of optimized structures (concrete, steel, hybrid and aligned foundations)
2011	Comparison of the Wintrack Design with the German normative situations
2013	Presentation of monopole structure at TenneT TSO in Bayreuth
2014	Prequalification „Wintrack II invitation of tender for compact towers“

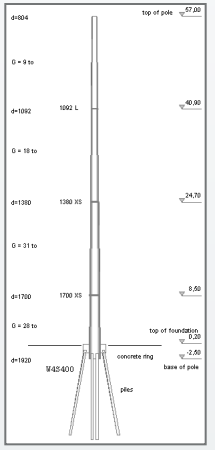
EUROPOLES has experience with the TenneT Wintrack-Construction since 2005

2005: first draft of Wintrack-Pole TenneT

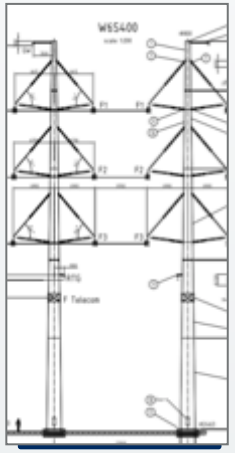
2006: EP-LAPP draft

Seit 2006: test setup in Neumarkt

2008: Prequali-fication for Wintrack I



2009: Pole with optimized foundation



2014: New pole type Wintrack II: 4x 400kV

Design vs. Feasibility

Actual Developments in Extra High Voltage Grids

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Design vs. Feasibility

Actual Developments in Extra High Voltage Grids

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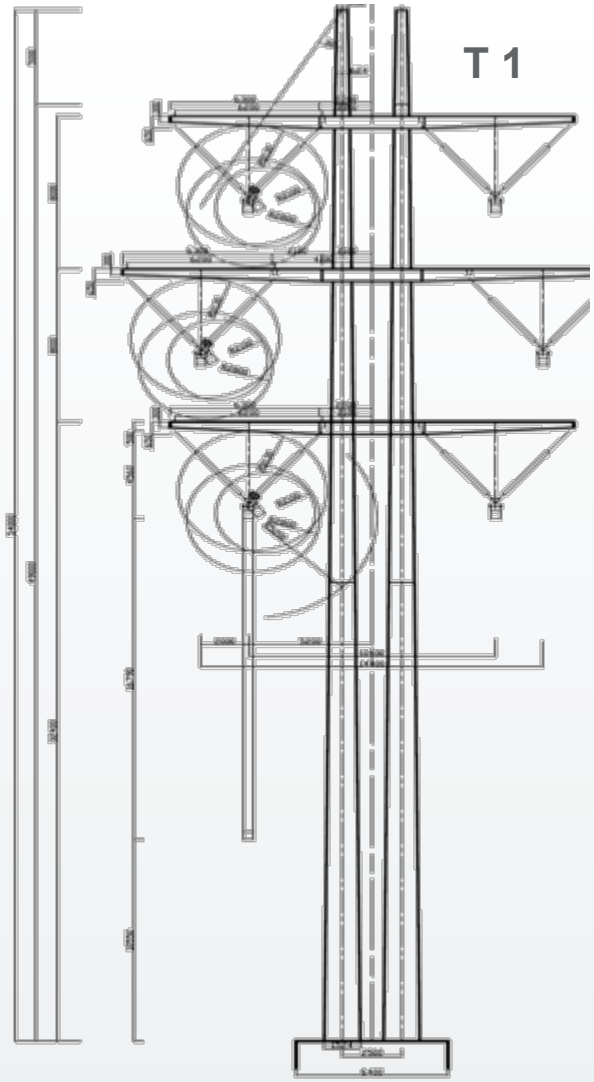

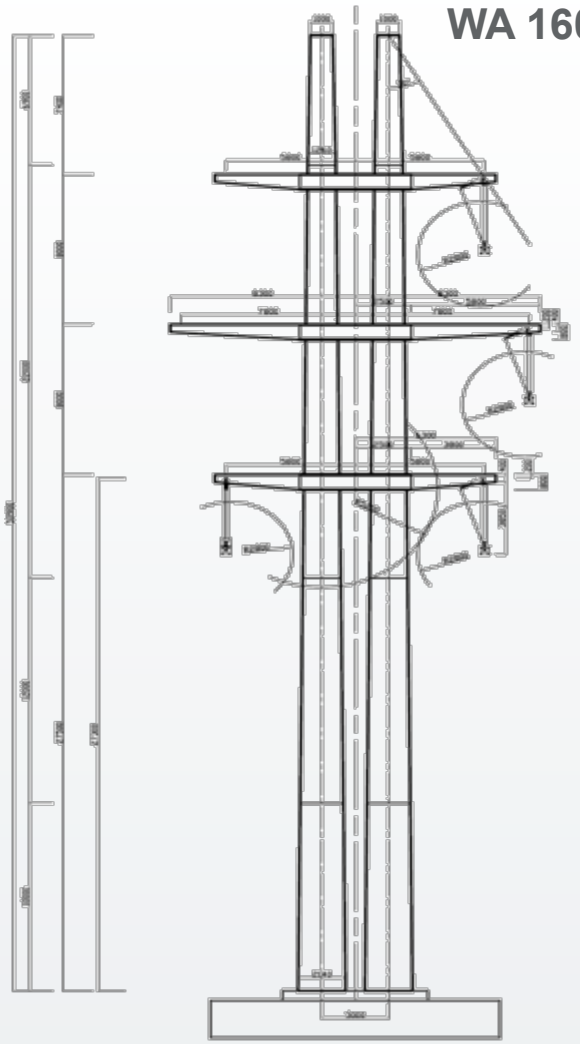

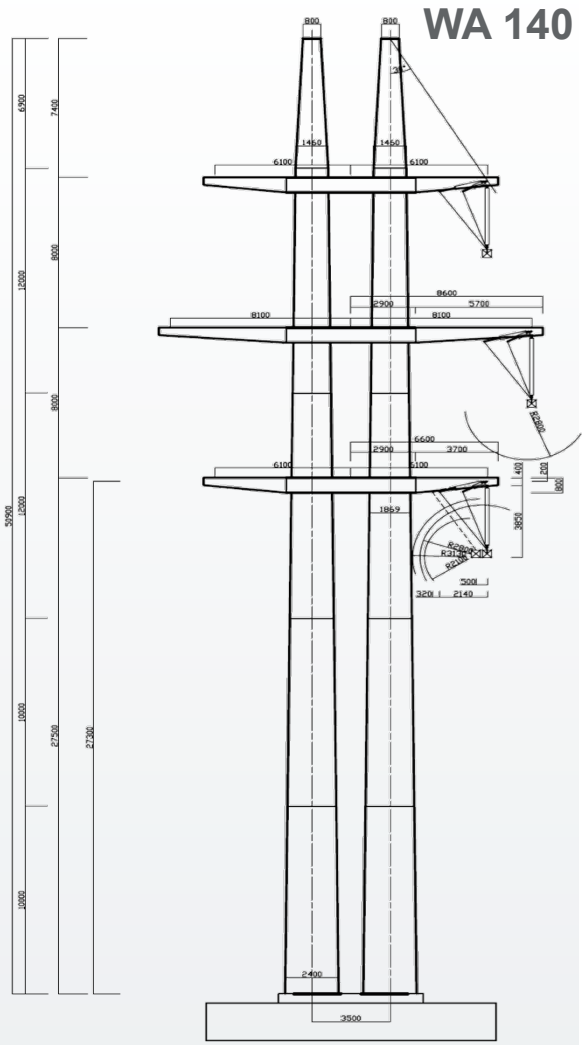

Development for 380kV: 6 x 4 x 565-AL1/72-ST1A (ACSR 565/72) WZ 4, EZ 2, Windspan 400m

Design vs. Feasibility

Actual Developments in Extra High Voltage Grids

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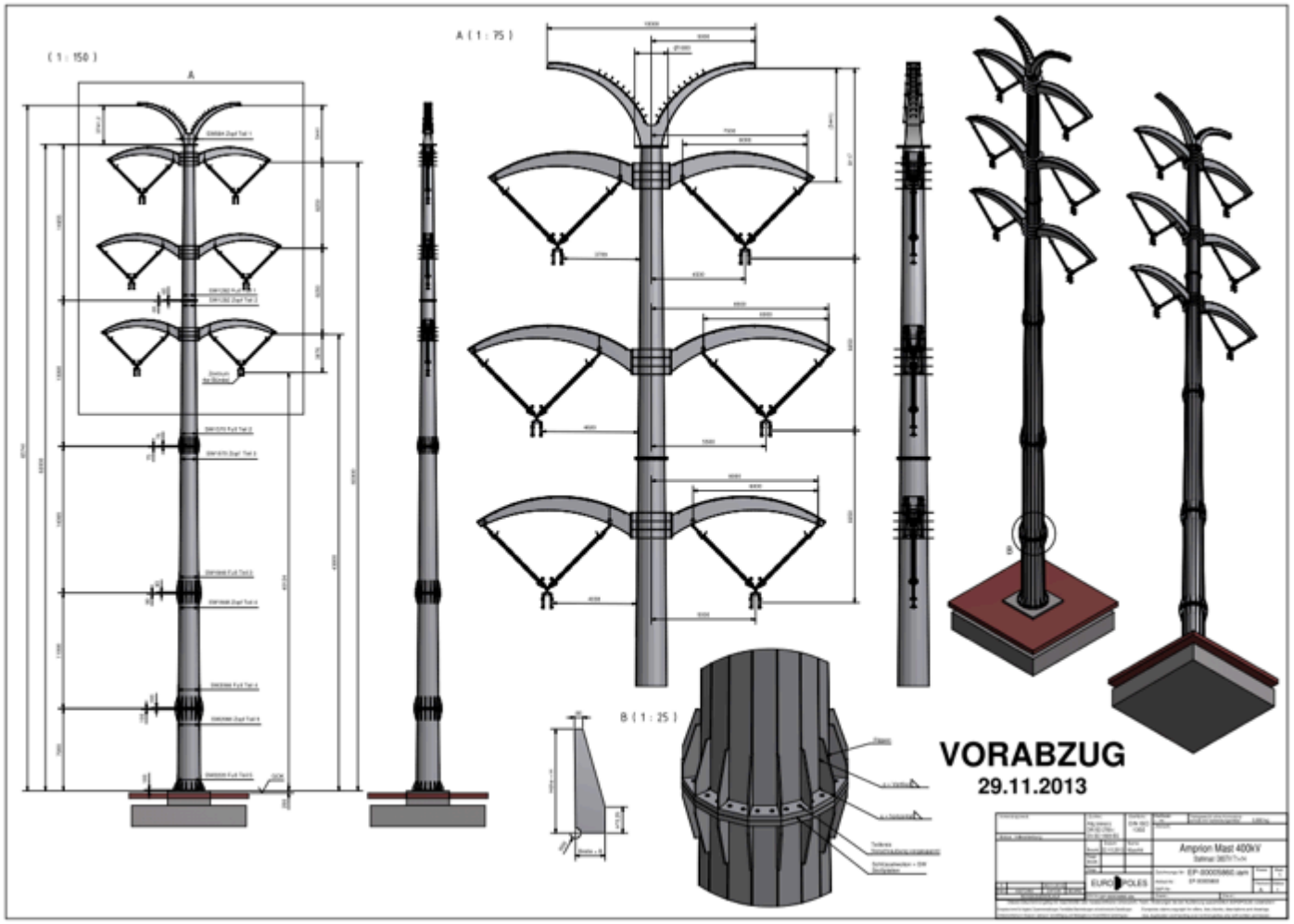
Details T+14 in Steel



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Summary:

- The TSO have a huge number of standard lattice tower designs
- A lot of TSO are worried to develop new Pylon Designs
- The development can take decades
- But: The state-of-the-art engineering and technology knowledge allows new structures with competitive prices

Result:

There must be „a good reason“ to use new structures:

- Motivation to try new things
- Trust in new solutions & designs
- Good engineers/ consultants with experience
- **Higher public acceptance**

The „Magic – Triangle“

The “Magic Triangle“

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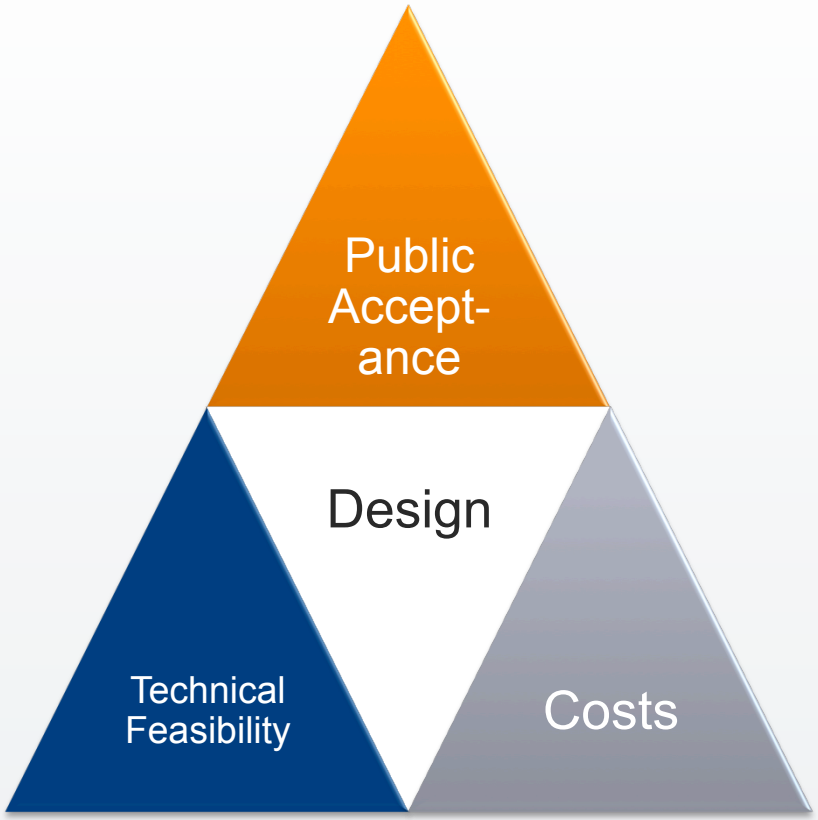

The “Magic Triangle“

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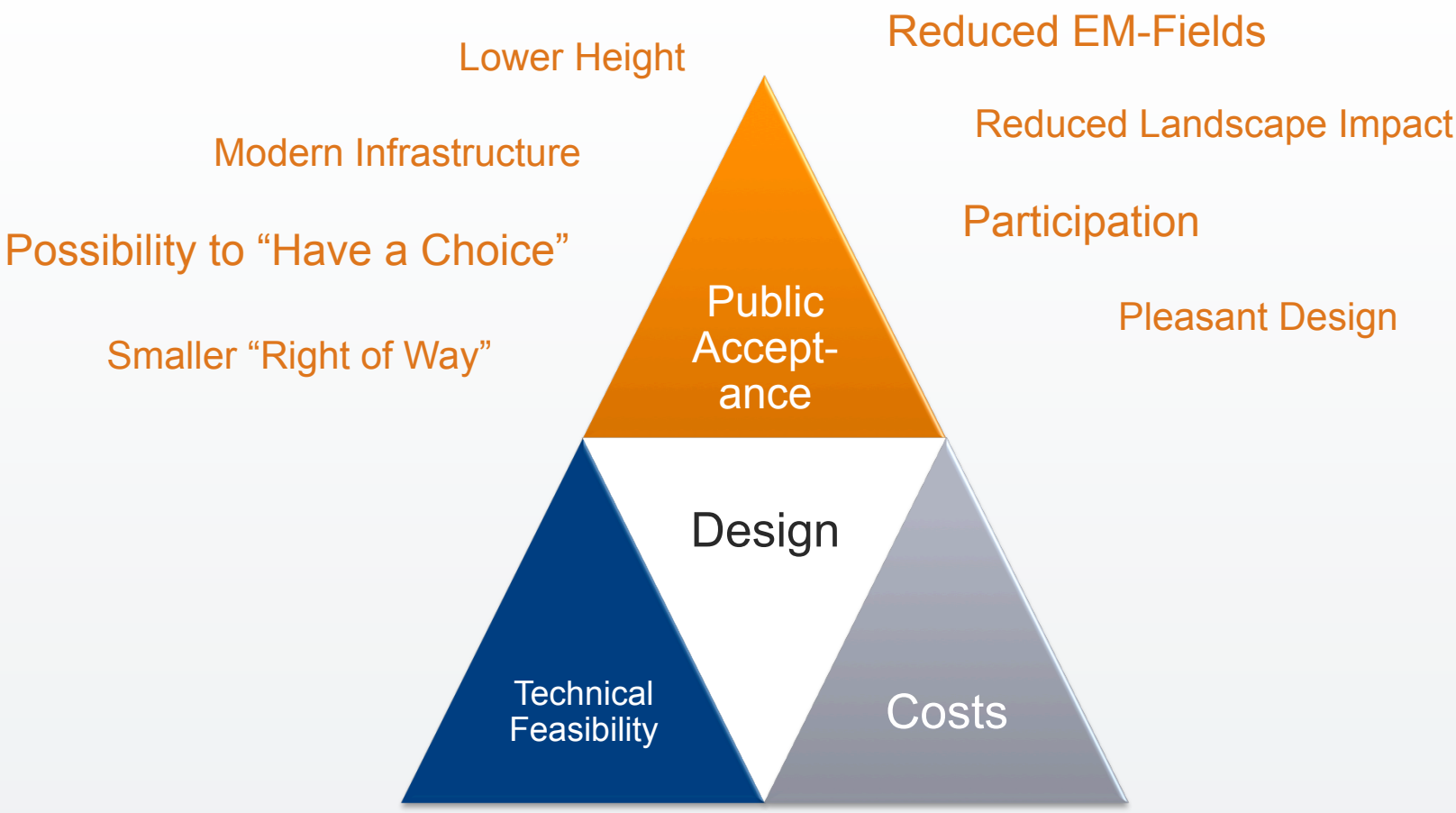

The “Magic Triangle“

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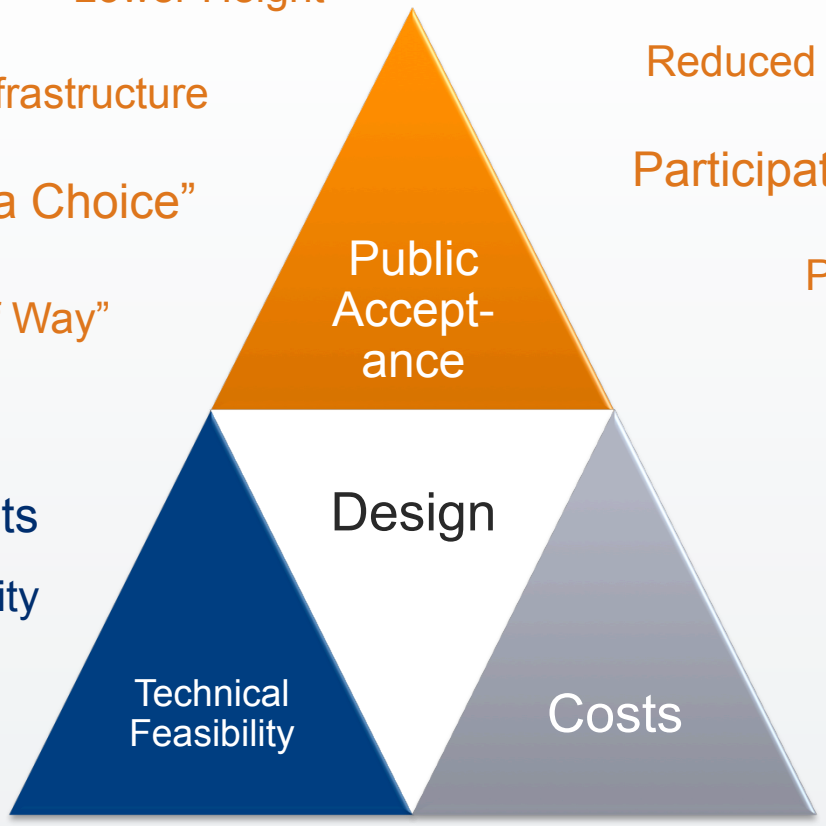

Lower Height

Modern Infrastructure

Possibility to “Have a Choice”

Smaller “Right of Way”

Reduced EM-Fields

Reduced Landscape Impact

Participation

Pleasant Design

National Standards

Statical Requirements

Ageing & Fatigue

Durability

Corrosion Protection

Lifetime >80 years

Earthing & Flash Protection

Electrical Requirements

Induced currents

Electrical clearance

EM-Fields

The “Magic Triangle“

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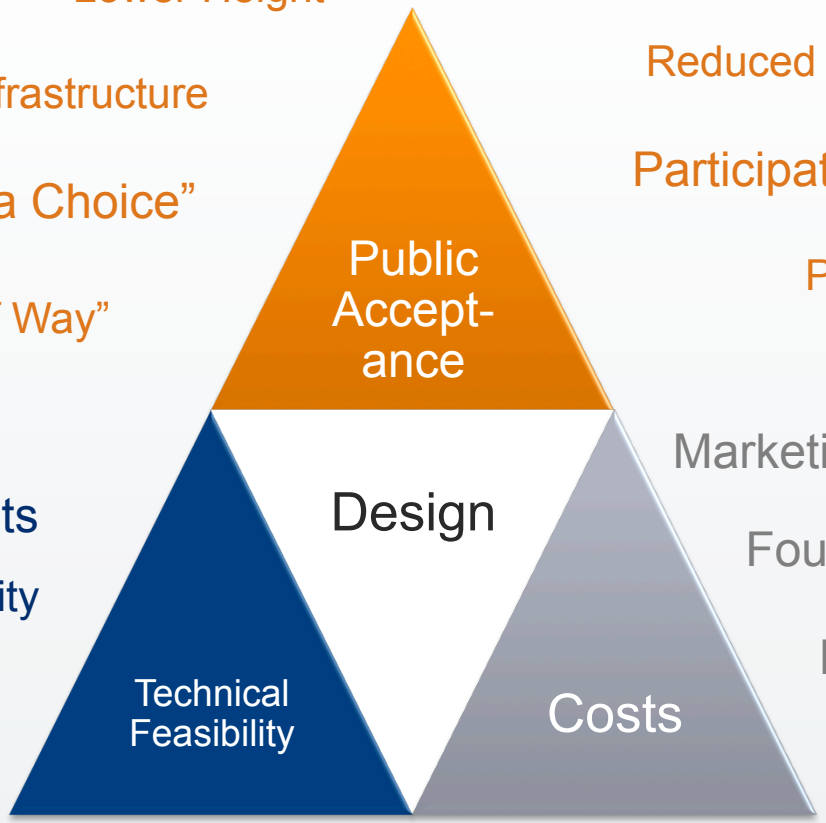

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Induced currents

Electrical clearance

EM-Fields

Marketing Costs

Foundation Costs

Pole Costs

Cost for extra Design

Learning Costs

Development Costs

External Consultants

Test program

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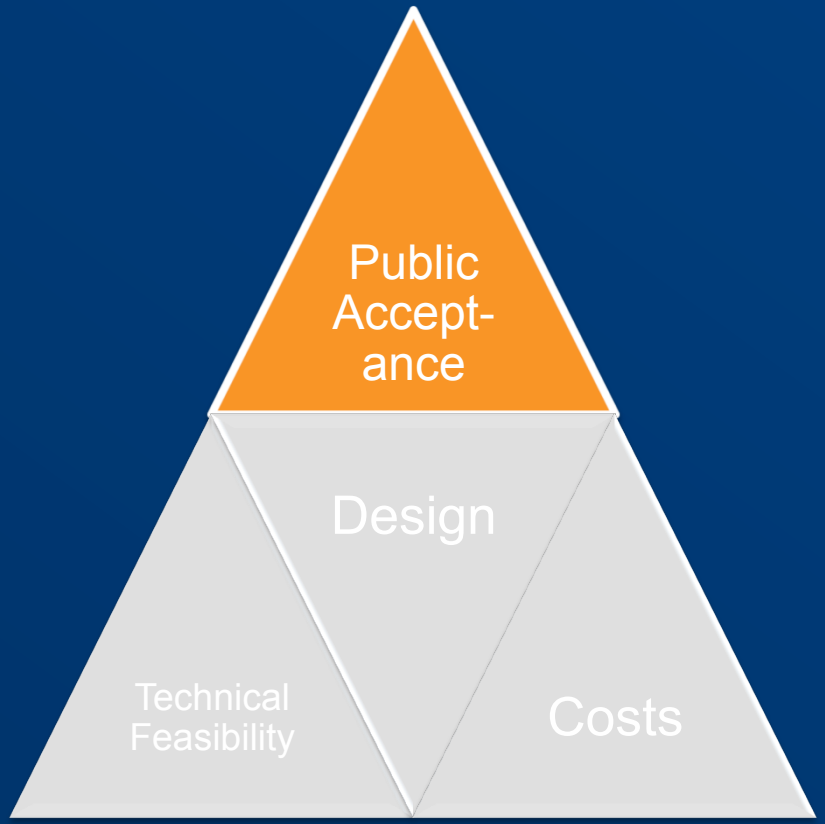


Actual Developments & Improvements

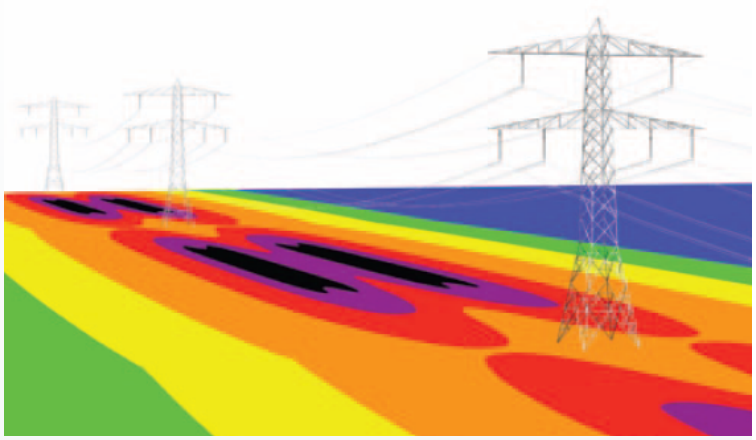
Reduction of electromagnetic fields and space requirements

Background:

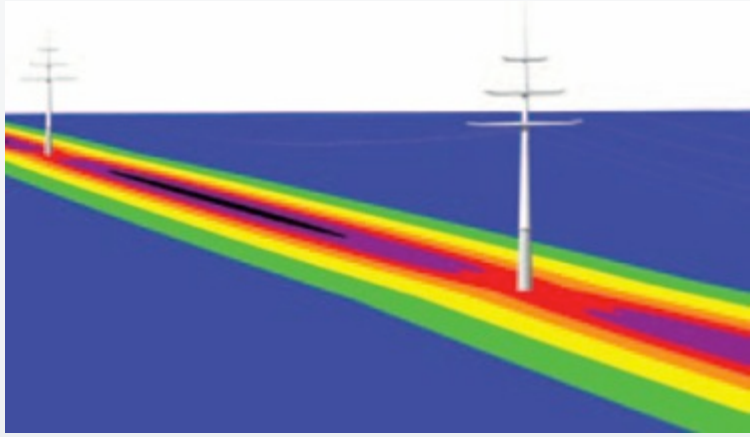
- Magnetic field standard of the International Commission for Non Ionising Radiation Protection (ICNIRP) = 100 microTesla
- E.g. TenneT magnetic field standard in the Netherlands = 20 microTesla
- E.g. Dutch Ministry of Housing, Planning and the Environment = 0,4 microTesla for people living close to the OHL

Conclusions:

- Compacting the pole by using monopoles
- Using compact insulators
- Specially designed poles with less space requirements

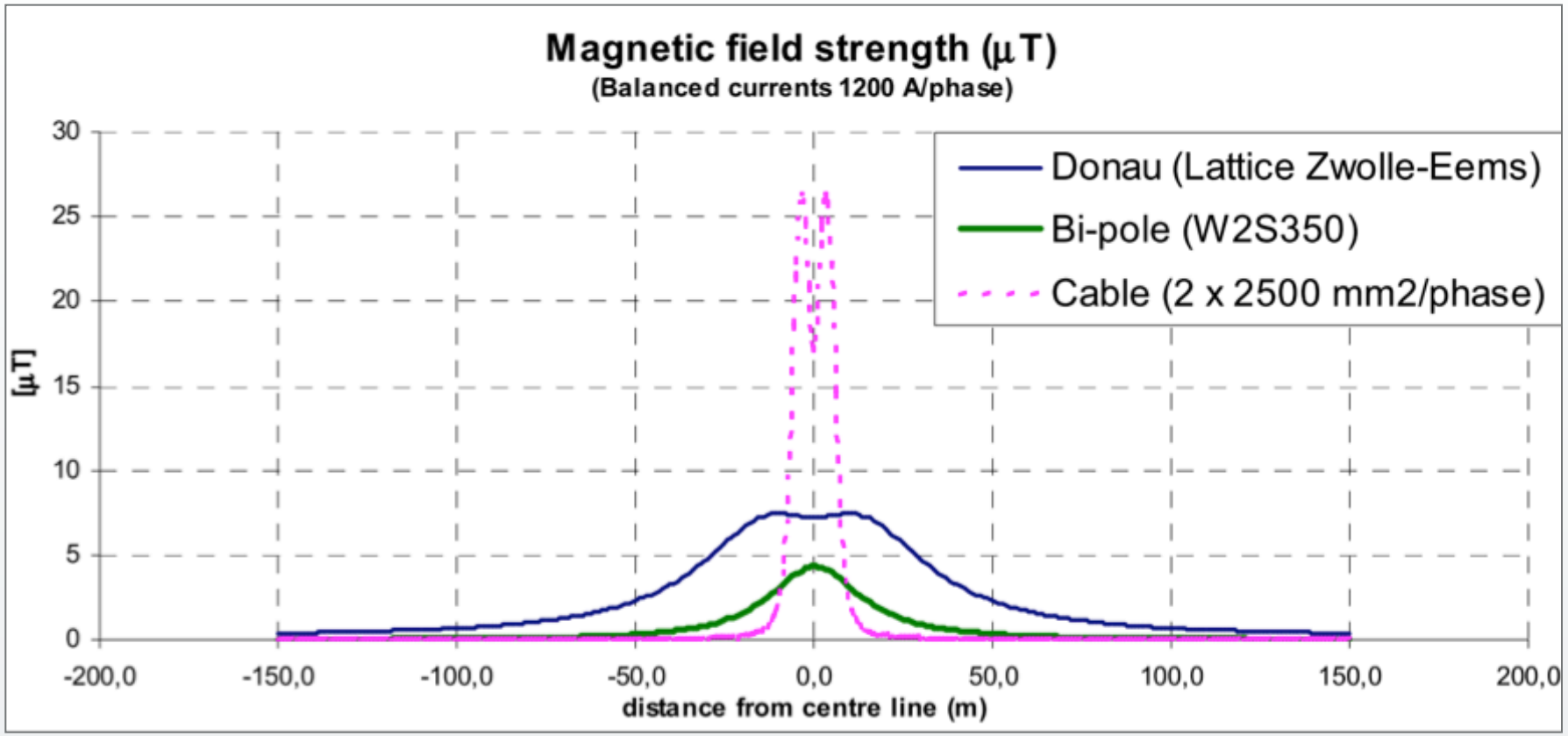


EMV-fields of traditional lattice towers



EMV-fields of innovative pole designs – Wintrack I simulation

Reduction of electromagnetic fields and space requirements



Different conductor arrangements leading into different magnetic field strengths (KEMA Study: Bi-pole Tower design resulting in low magnetic fields)

Reduction of the visual impact

Background:

- Resistance of residents and nature conservation organisations
- Lobby against extensive and high lattice towers

Conclusions:

- Reduction of the height and width of the poles
- Replacement of lattice with monopole designs
- Especially designed poles adopting the surrounding landscape

400kV „Camouflage Pole“ – Design Competition UK

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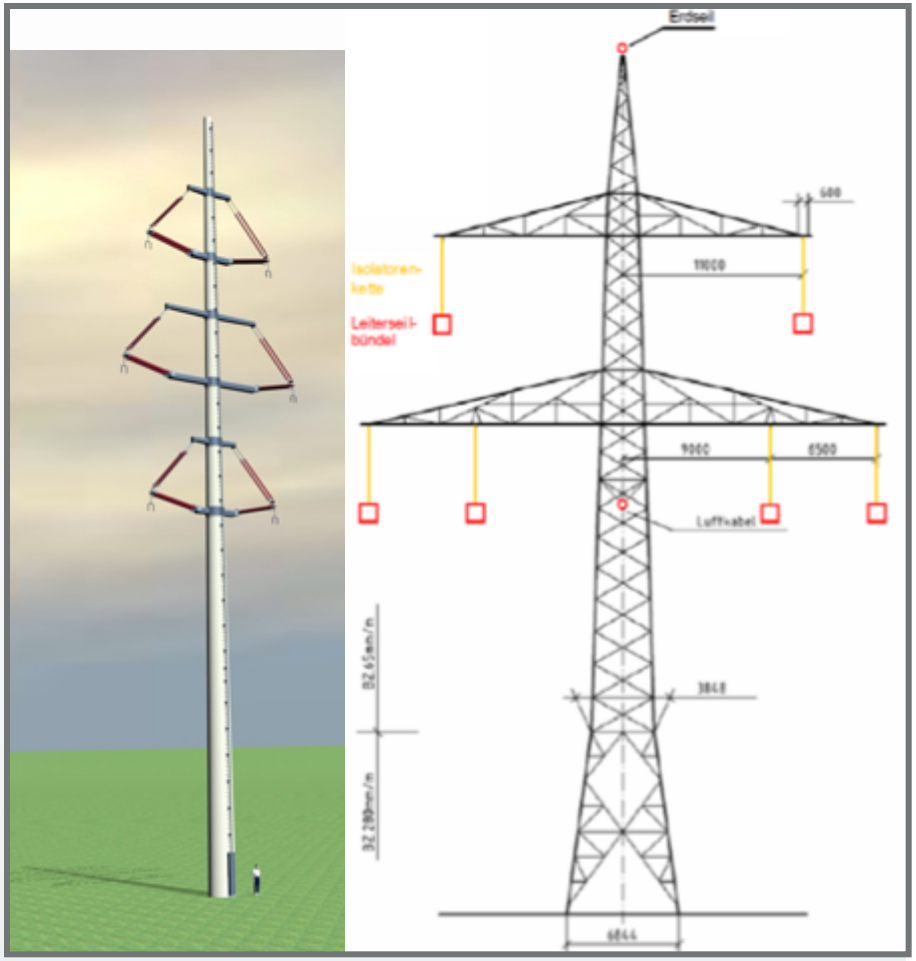
Reduction of the footprint of the line

Background:

- High costs for occupied land – especially in populated areas
- Problems with land owners and “right of ways”
- Limitation of the landscape for big foundations and cross-section dimensions

Conclusions:

- Changing to monopole designs – enables the reduction of the footprint of the pole and under the line
- Usage of new foundation methods
- Very expensive alternative: Usage of underground cables



Comparison „Compact Pole“ to Lattice Structure

Actual Developments & Improvements

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Integrated Foundation

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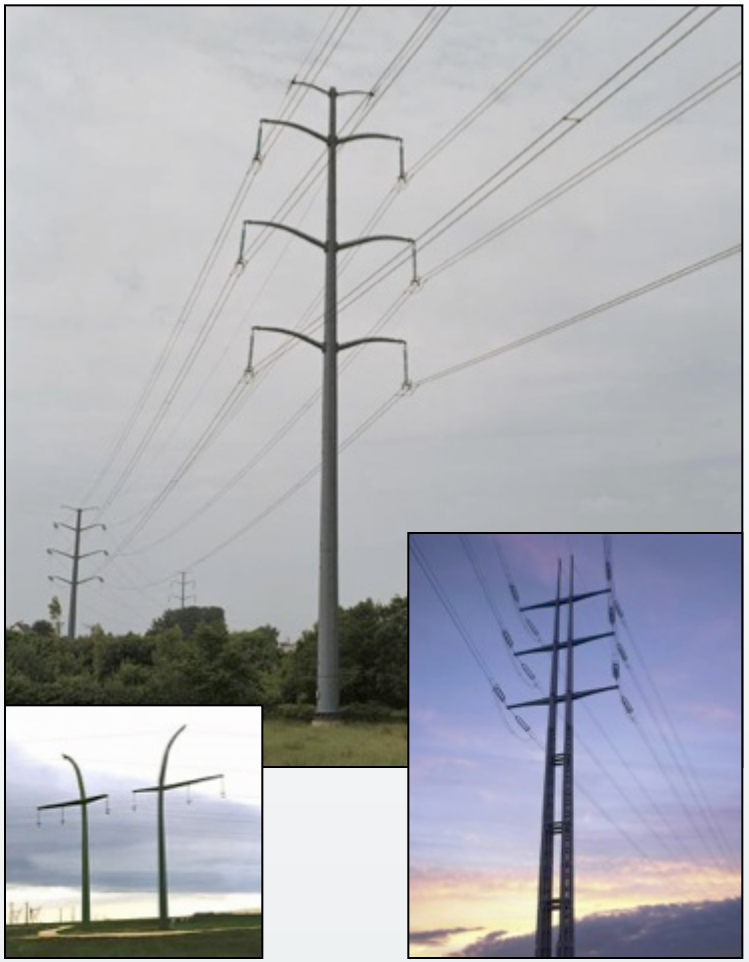
Extra High Voltage - actual situation Compact & Designer Poles:

- Reduction of visual impact
- Reduction of electric magnetic fields
- Reduction of “right of way”
- Reduction of pole footprint
- Fast erection due to preassembled delivery

↗ Higher acceptance by the people, smaller trenches, lower impact on landscape

↘ Much higher costs (3x – 10x) compared to steel lattice



Actual Developments & Improvements

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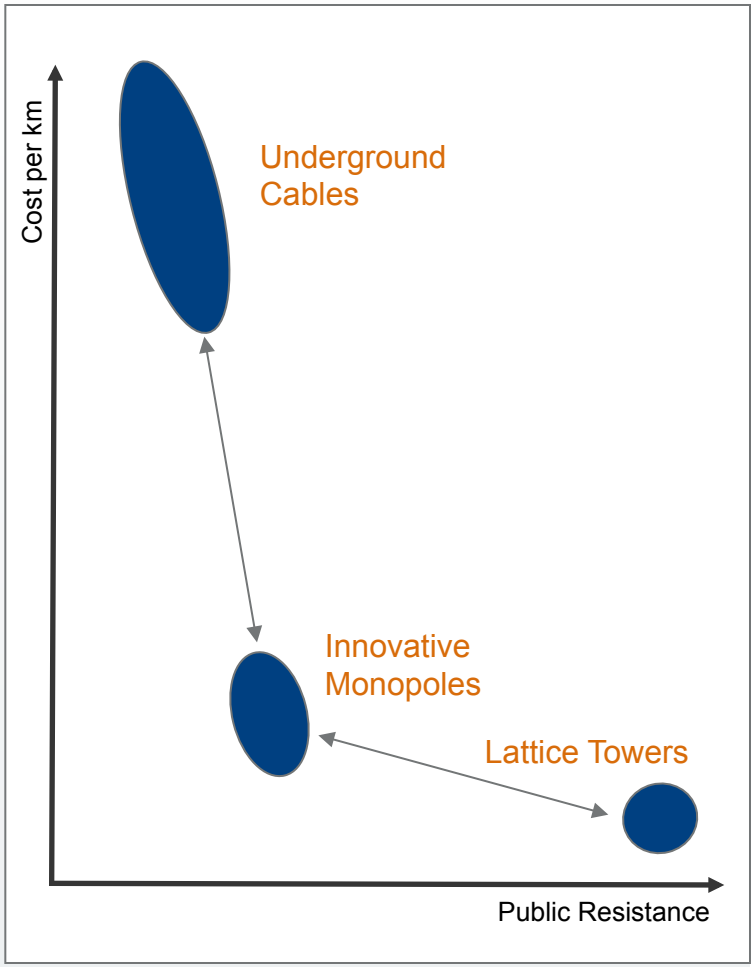
Summary:

Solution 1: Underground Cable

1. Extreme expensive
2. High losses due to compensation
3. Difficulties to reach and upgrade

Solution 2: Monopoles & Compact Lines:

1. Suitable for medium & high voltage requirements
2. Reduction of the protective strip, smaller footprint
3. Better integration in the landscape
4. Cost effective solution – competitive to steel lattice



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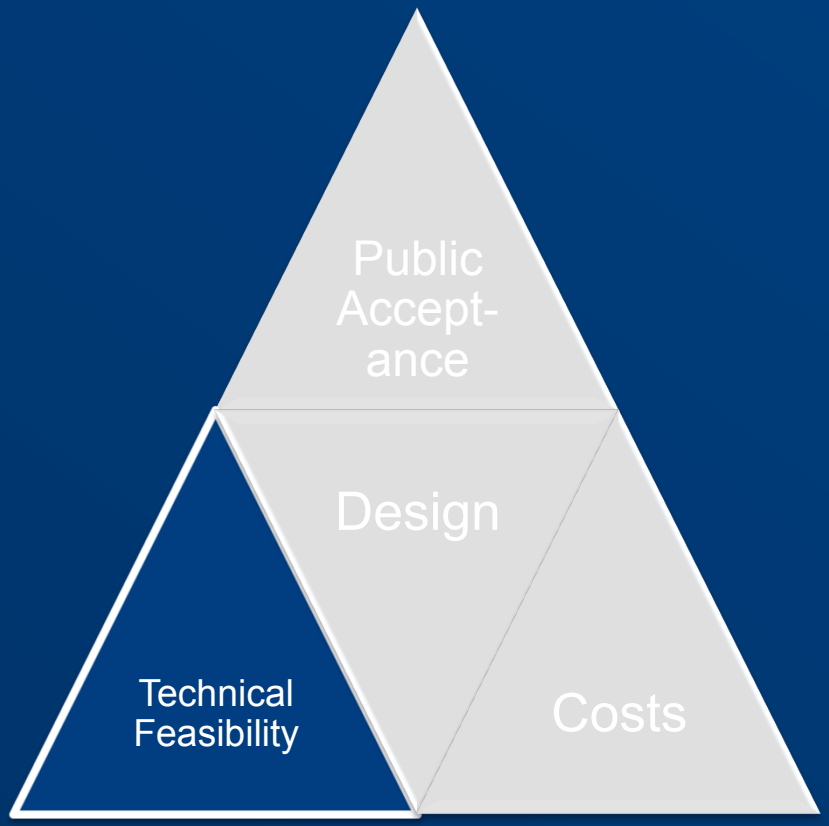

Actual Developments & Improvements

Actual Developments & Improvements

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Research project : Compact Extra High Voltage Pylons and Cross Arms

Objective:

Environmentally and resource friendly construction, that contributes with a **compact arrangement** of the conductors to a significant **reduction in line width** and required area – maintaining the **economic requirements** and **technical safety.**

Facts and Figuers:

Period:	24 months
Budget:	2,7 Mio. EUR, sponsorship approx. 1,8 Mio. EUR
Universities:	TU Braunschweig, TU Dresden, KIT (Karlsruhe)
Partners:	Fichtner, Lapp

Gefördert durch: Bundesministerium für Wirtschaft und Energie aufgrund eines Beschlusses des Deutschen Bundestages

EURO POLES LAPP INSULATORS Technische Universität Braunschweig FICHTNER TECHNISCHE UNIVERSITÄT DRESDEN KIT

Focus of development:

- Basic materials:

High-performance concrete (UHPC), FRP for cross arms&composite isolators, material & EMF-test

- Constructions:

Hybrid constructions concrete/steel / optimization through the use of multi edged cross section steel poles/ optimization of foundations (e.g. compact piles, drop over) / optimization of pole joints

Validated and accompanied by:

- Acceptance studies and surveys
- PR work
- Environmental assessment

Pole Bending Test with the equivalent of 80t tractive force

Actual Developments & Improvements

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Project partners - Compact Extra High Voltage Pylons and Cross Arms :

EUROPOLES	Europoles GmbH & Co. KG
FICHTNER	Fichtner GmbH & Co. KG
LAPP INSULATORS	Lapp Insulators GmbH
Technische Universität Braunschweig	Technical University of Braunschweig
TECHNISCHE UNIVERSITÄT DRESDEN	Technical University of Dresden
KIT Karlsruher Institut für Technologie	Karlsruher Institute for Technology

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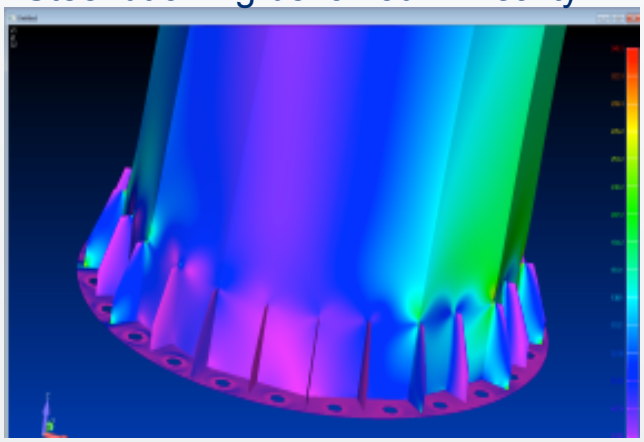
Full Scale Testing: Steel Transmission Poles

Full Scale Testing: Steel Transmission Poles

Steel buckling behaviour in reality



Simulated steel buckling behaviour

Full scale testing of steel poles

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Full Scale Testing: Ultra-High-Strength-Concrete (UHPC):

Pole Bending Test – UHPC, Load 80 tons

More than 10 full scale tests already done

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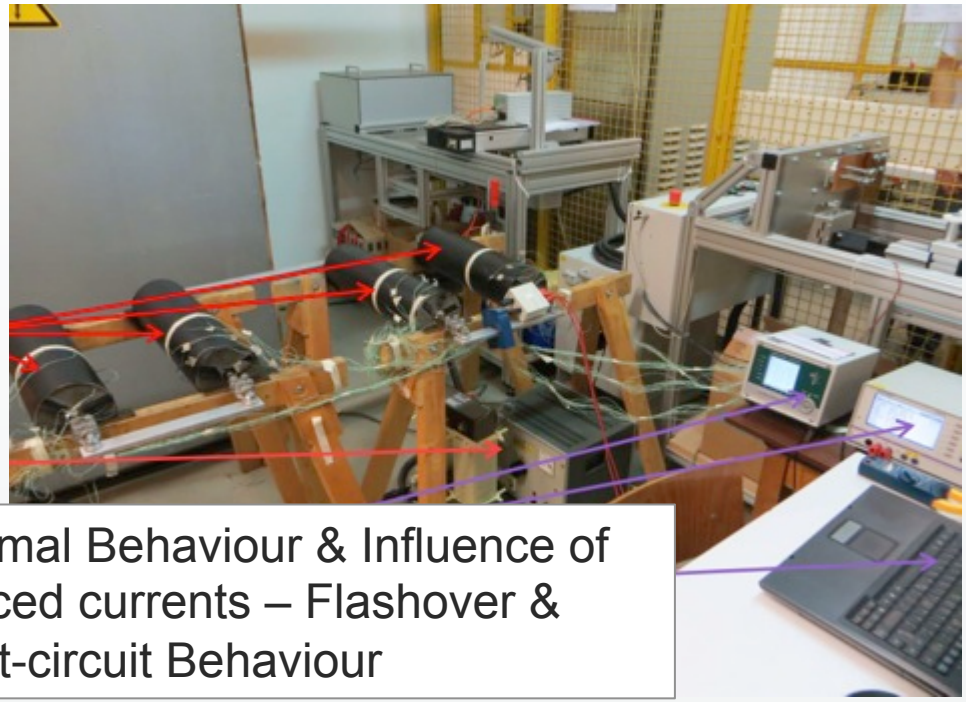
Mechanical Strength – Isolator Testing

Full Scale Testing of Fibreglass Isolators

Electrical Testing

Flashover Testing



Thermal Behaviour & Influence of induced currents – Flashover & Short-circuit Behaviour

Actual Developments & Improvements

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Summary:

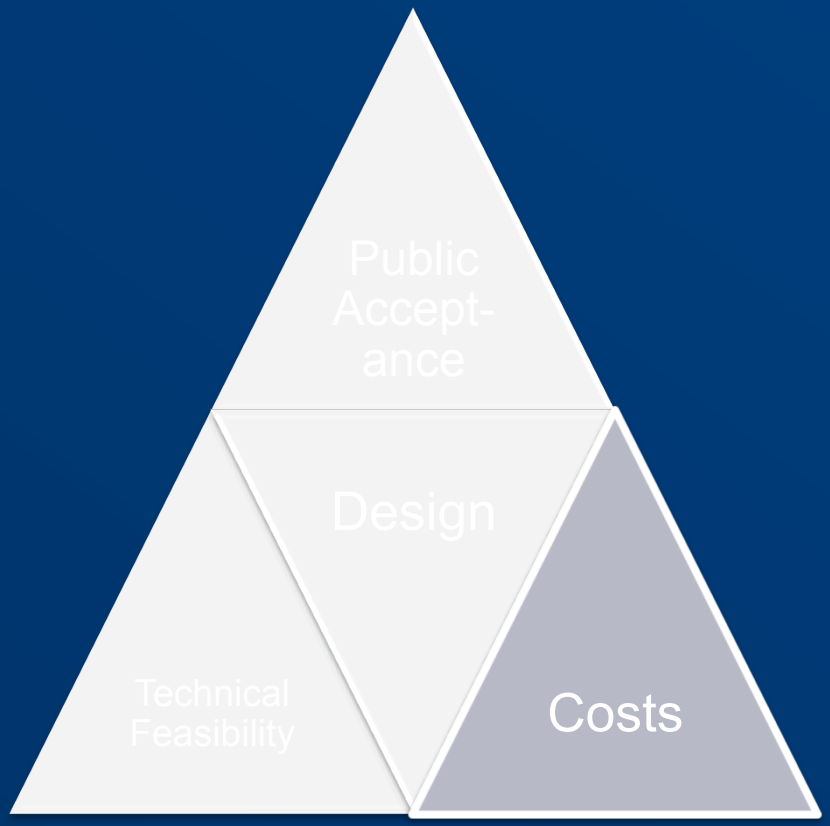
A lot of tests and calculations were already done

1. Calculation models are available
2. Models are tested by full scale test
3. Poles are following statical basic rules

The market dynamic creates (cost) efficient solutions

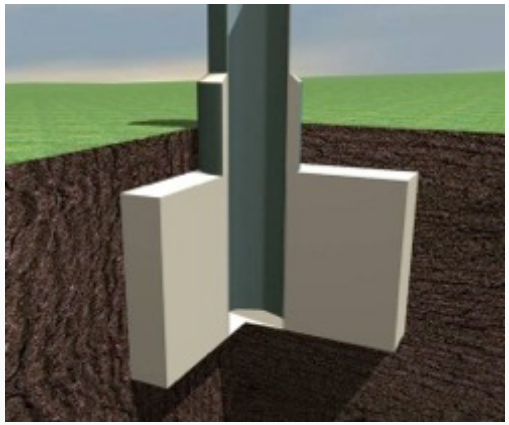
1. Learning curve > 30 years
2. A lot of structures are already decades in service
3. Electrical behaviour can be controlled

➢ **Solutions are feasible**

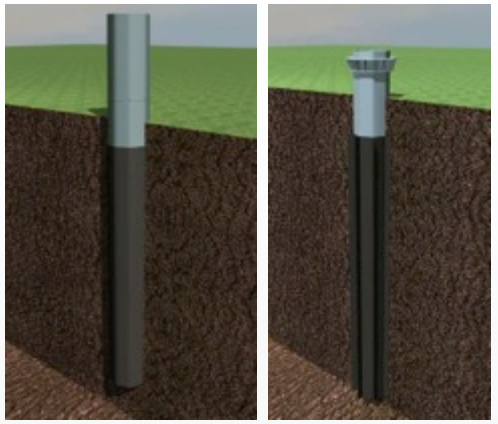


Actual Developments & Improvements

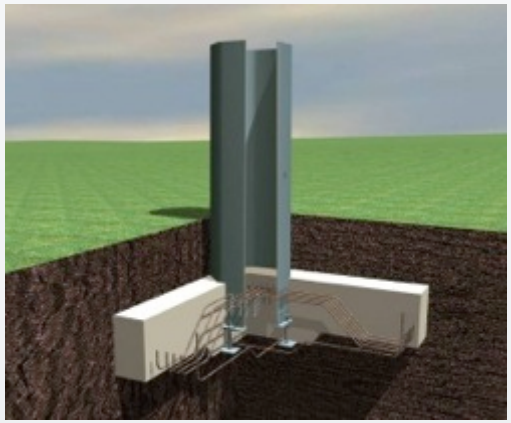
Reduction of Costs - Different Foundation Methods



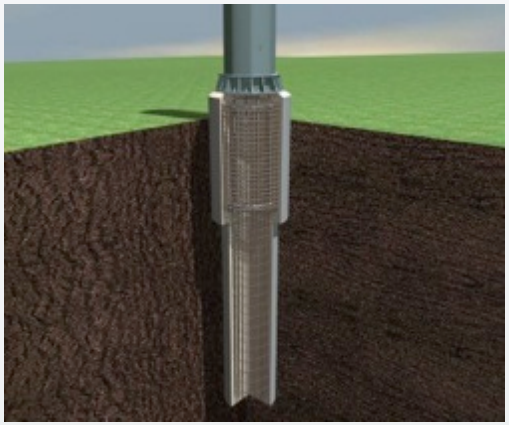
Block Foundation



Rammed Pipe Foundation



Section Foundation – embedded pole base part



Drilled Pipe Foundation

Alternative Solutions – based on ground conditions

Rammed pipe foundation for suspension poles

Star shape foundation on rammed pipes

Flat foundation with anchor bolts

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Star-Shape Foundation

Dimensions:

- 70m height
- Advertisements 3 x 25m x 5m

Actual Developments & Improvements

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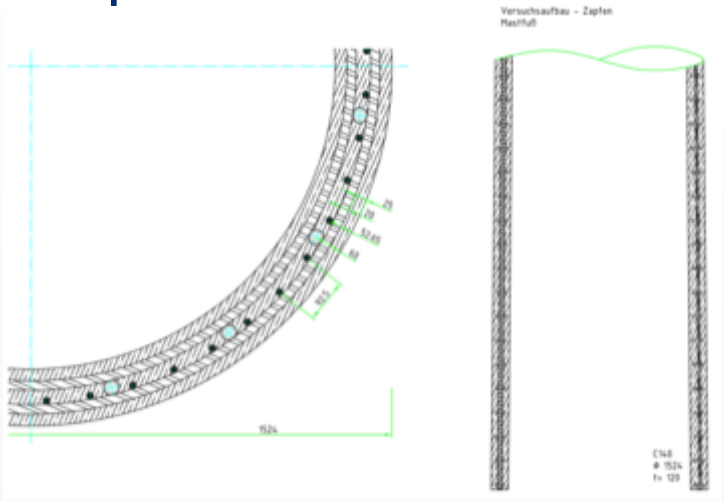
Drop over Foundation



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Latest Development – Section Foundation

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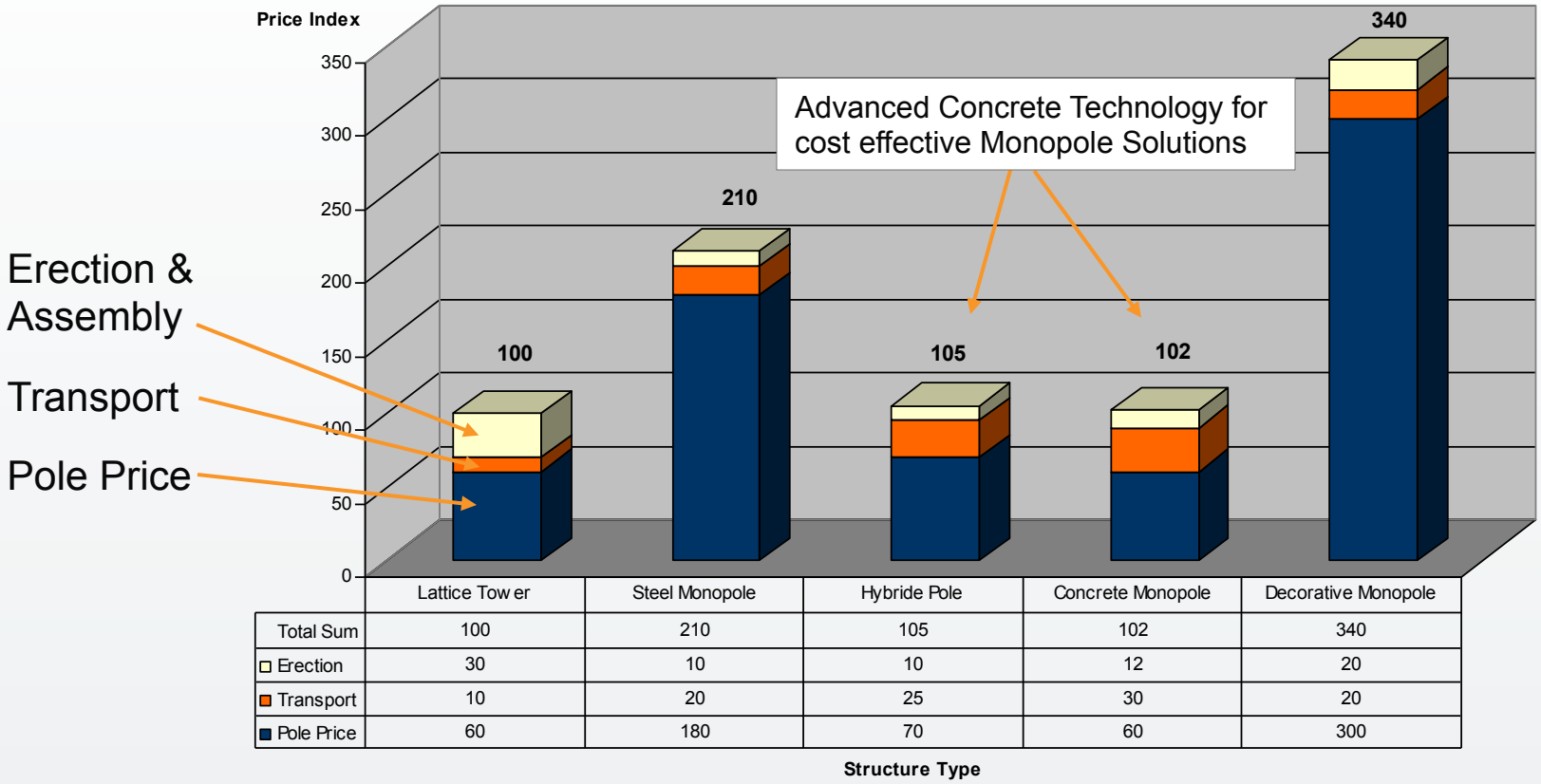
Price comparison – Lattice vs. Monopole Structures



	Lattice Tower	Steel Monopole	Hybride Pole	Concrete Monopole	Decorative Monopole
Total Sum	100	210	105	102	340
Erection	30	10	10	12	20
Transport	10	20	25	30	20
Pole Price	60	180	70	60	300