Beyond the simple matter of asset management…

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Context

Transmission Systems Operators (TSOs) have to face a wide range of constraints

- Amount of assets linked to huge investments to maintain and develop a grid
  - Whose the lifespan of equipment is greater than four of five decades
- Fast unceasing moving context
  - Technical, economical, environmental and social
- Increasing challenges
  - To adapt to new customer needs
  - To integrate renewable energy generation at a very large scale
  - While improving reliability and availability of the grid towards very high levels of quality

The company at a glance

RTE is the French TSO

- In charge of the operation, maintenance and development of a grid of more than 100 000 km of circuits
  - From 63 to 400 kV
- Biggest TSO in Europe
  - Widely involved in managing interconnection line with other European countries
- More than 4100 km of circuits are underground
- 81 % of new 63 and 90 kV lines were underground during the 2010-2012 period
  - Against 29 % ten years earlier
- While insulated cables were used only in dense populated areas on short distances, the underground solution is now installed for various purposes
  - In rural areas
  - For interconnections to secure the supply of large areas
    - A 64 km underground link will be in service in 2014 between France and Spain (320 kV DC, 2x1000 MVA).

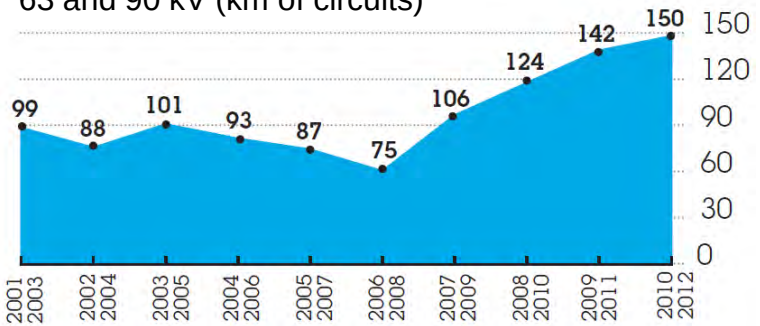
Trend of new underground circuits

THE RTE GRID (31/12/2012)
(km of circuits in service)

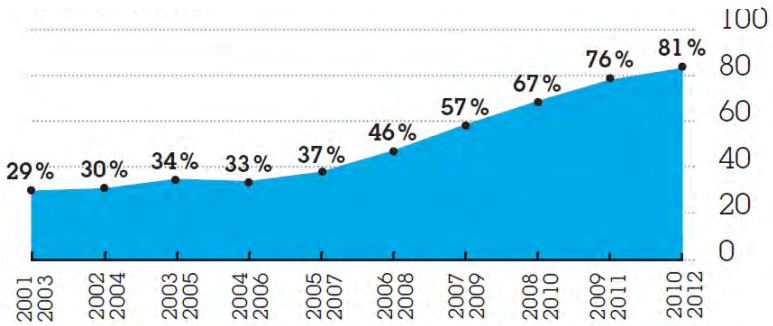
⇨ **New outlook of asset management**

	400 kV	225 kV	150 kV	90 kV	63 kV	≤ 45 kV	Total
Overhead	21410	25557	1061	16566	35555	345	100494
Underground	**3**	**1037**	**2**	**649**	**2412**	**87**	**4190**
UGL 2011		+19		+45	+106	+3	+173
UGL 2012		+13		+61	+160		+234

NEW UNDERGROUND LINES
63 and 90 kV (km of circuits)



RATIO OF UNDERGROUNDING OF NEW LINES
63 and 90 kV



RTE publishes the 2012 French Electricity Report

Scope of work

RTE was involved in many Papers of Jicable conference and WETS workshops

- The presentation shows the French experience and good practices shared with the manufacturers
- Several aspects of asset management are discussed, but also other topics from the design of a cable system up to maintenance and repair
  - Because the asset management is more efficient if the total life cycle of the cable system is taken into account at early stages

About the conference, the illustration by Jicable papers should give an idea of

- The wide range of topics discussed during the parallel sessions
- How valuable can be the information

- For each presented paper, a link is given to the first page which can be downloaded for free, with abstract and references of the authors

Contents

Presented actions to prepare or to improve asset management

- Rationalisation of conductor range and economical design of cable conductors
- Condition and life assessment of paper cables
- Health Index
- Upgrading of existing systems
- Retrofitting of pipe-type cables
- Transition joints
- Installed cables database
- Maintenance and repair
- Leak location of oil-paper cables

Assets of many decades

CE – B1 CABOS ISOLADOS

Rationalisation of conductor range

☹ Previous situation: High number of cable sizes with their made-to-measure accessories

- Heterogeneity of the grid
- Specific or lower volumes of cables and accessories manufacturing for a given size
- Lost launching lengths and useless handling and operations between different cables production, complexity of the planning for the manufacturers
- Larger stocks of spare items to fulfil many different sizes, otherwise risk of stock shortage and power link unavailability
- Multiplicity of engineering studies
- Duplication of assembly instructions, multiplicity of tools, specific skills

⇨ Harmonisation of an optimised range of components

- Made possible by transition joints connecting new cables to existing systems, and cables of different sizes
- Larger volumes of purchasing, easier stock control

Economical design of cable conductors

Present way of conductor selection → minimal investment cost for a given current rating

Evolution to turn to a wider discussion → in order to take into account the future cost of losses and lower environmental impact

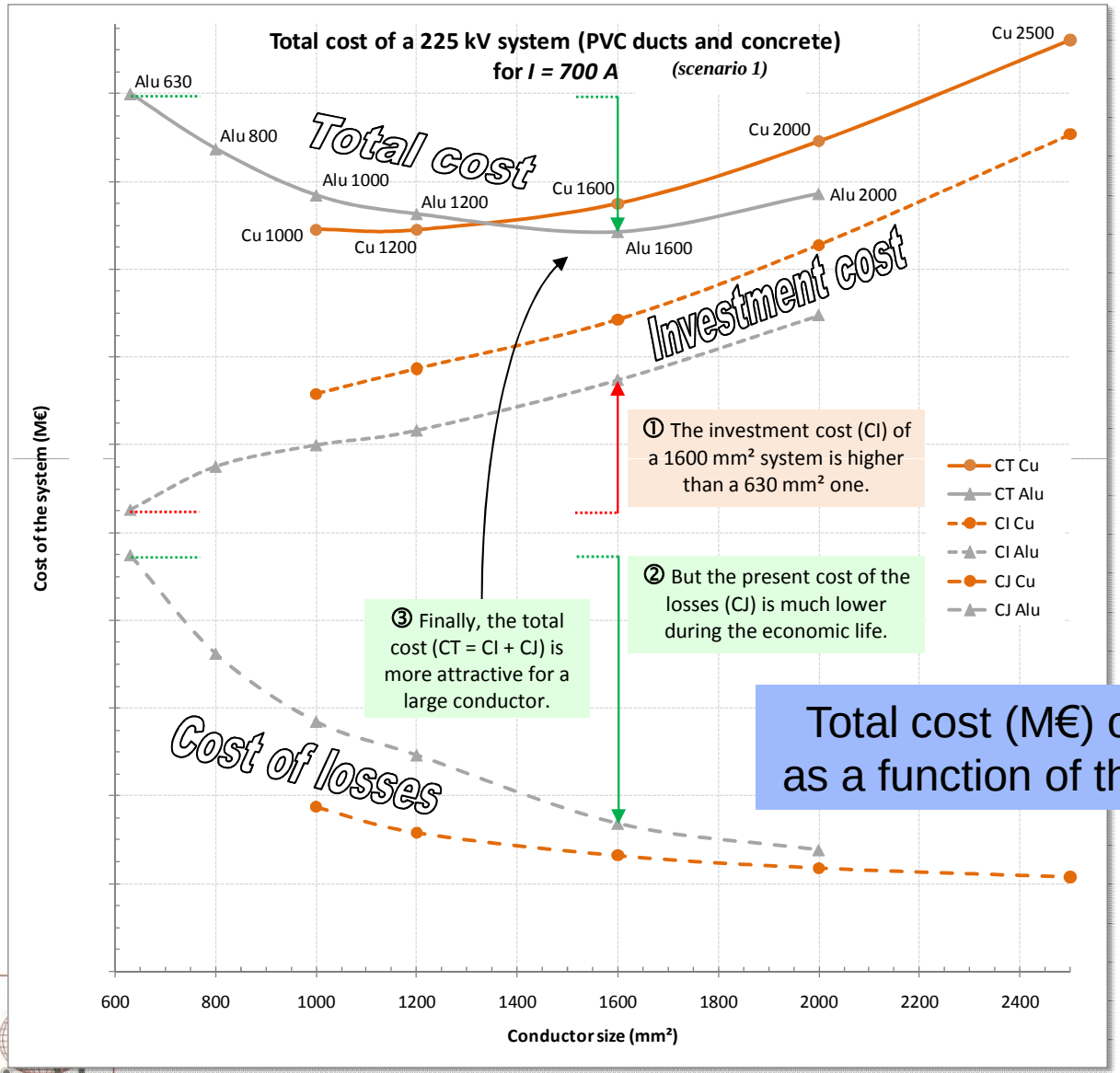
Criterion of thermal behaviour

- To withstand the maximum temperature of the insulating layer in any operation modes
  - Calculation data described by IEC standards (60287, 60853, 60949)
- Selection of the closest conductor size allowing the required operating temperature

Criterion of economic optimization of power cable size

- To take into account the discounting cost of losses (present value of the losses during the economic life)

  Total cost = investment cost + present cost of losses



Total cost (M€) of the power link as a function of the conductor size

Condition and life assessment of paper cables

Diagnostics and maintenance of high-pressure fluid-filled paper cable

- Dissolved Gas Analysis (DGA)
- Location and pumping contaminated oil
- Degassing oil and reinjection in station tank

Hydrogen elimination from HPOF pipe-type cables

- Consolidation of DGA experience
- Secure process for local gas-bleeding
- Oil reprocessing

- Local processes to avoid whole refilling
- Reduction of unavailability and cost
- Regular cable maintenance teams

DGA Data sharing

- Huge amount of data (US and France) was analysed
- Identification of gas pattern, linked to specific troubles (especially terminations)

Health Index

Tool dedicated do risk and asset management

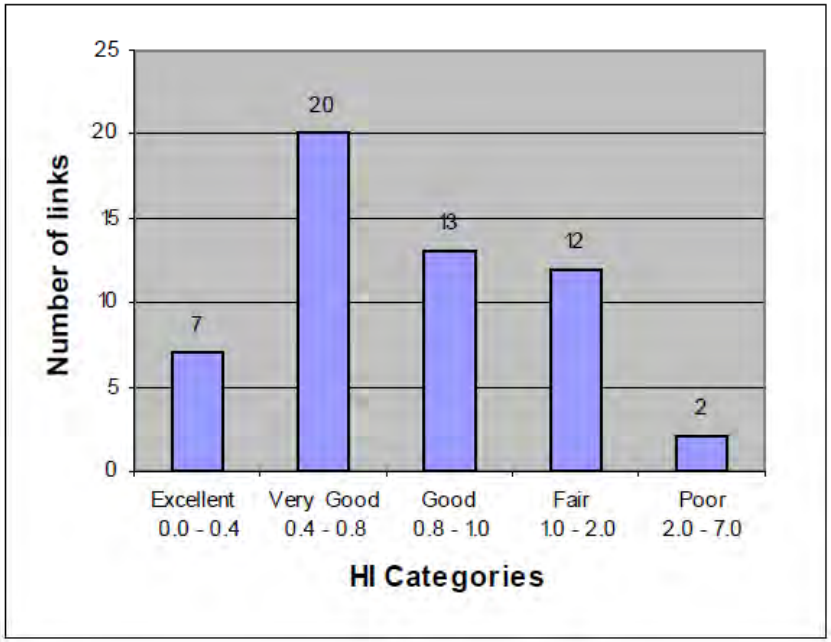
- To reflect the condition of the system
- Identification of influencing factors which affect the global performance
  - Examples: electrical stress, temperature, time
  - Grading I_{fi} = translation of the characteristic into a mark (high value means poor condition)
  - Weighting W_{fi} = estimated relative importance of the influent factor compared to others

$$HI = \Sigma [W_{fi} \times I_{fi}]$$

  - Marks may have various backgrounds: statistics, scientific, observation

Help in comparing technical and financial efficiency of new investment

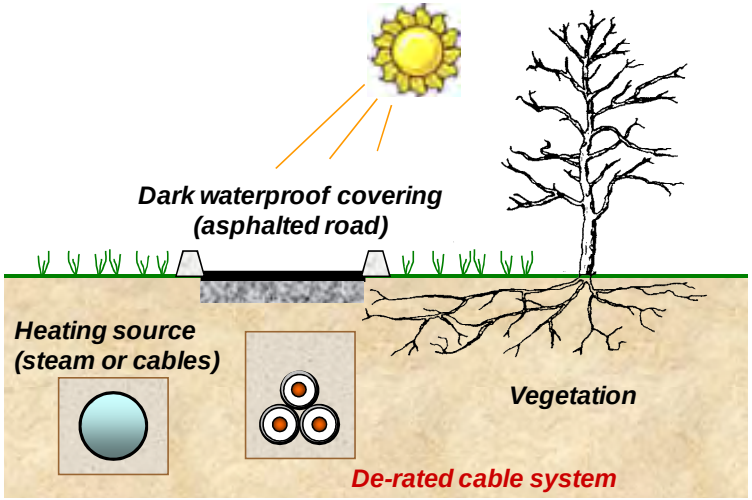
- Decision to postpone / upgrade / refurbish
- Plan, hierarchy, schedule



Upgrading of existing systems

Stronger and longer…

- Economical constraints, administrative authorizations, increasing societal concerns, congested areas
- Utilities tend to expect longer life expectancy of their equipment and require more power from existing systems



(Results of Cigré WG B1.11)

Improvement of existing system performance

- Increased transmitted power
- Lower environmental impact
- Enhanced safety

Methodology

- Assessment of current performances
- Upgrading techniques
- Assessment of the impact of the upgrading process of one parameter on all other parameters
- Case studies

Retrofitting of pipe-type cables

Operation by RTE of 48 circuits of pipe-type cables

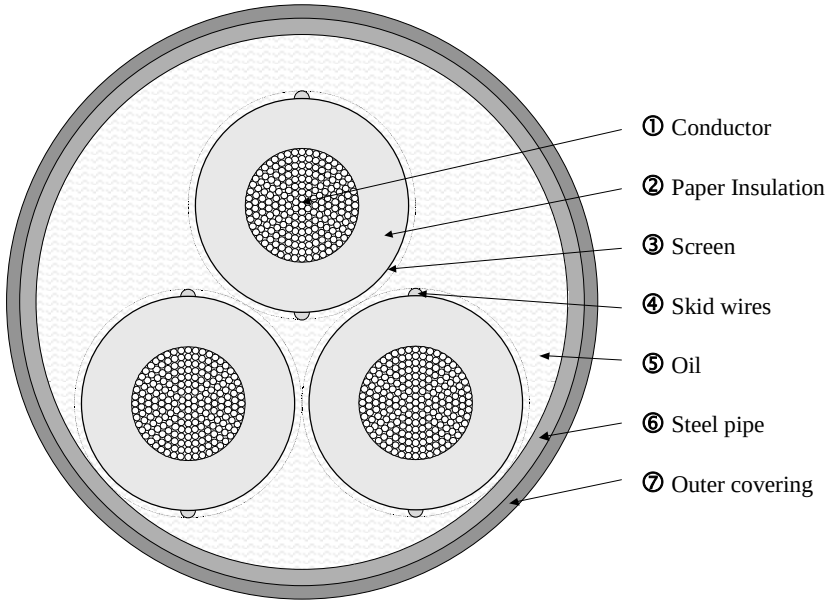
- Installation between 1957 and 1988
- 250 km
- Mainly involved in the backbone of the 225 kV in French big cities

Reliability of the technology considered as satisfactory, but several concerns

- Preservation of skills
- Supply of spare parts

Decision of a programme of renewal

- Diagnostic from the analysis of dissolved gases
- Qualification of a retrofitted solution
- Deployment scheduled from 2015 to 2040



Main advantages

- Simplification of cable route studies and administrative procedure
- Neither civil works nor disturbances for residents
- Cost

Transition joints

Start from specific components

- Every manufacturer qualifies and installs the whole system (cable and accessories)

Maintenance et development of the grid

- Lifespan of underground links > 40 years
  - Lack of spare parts
- Extensions to connect to existing sections

Identification of all criteria to improve compatibility

- Geometry and dimensions
- Materials
- Assembly

Compatibility matrix and recommendations

Dedicated mechanical testing area

- To adapt the scope of tests
- To reduce the qualification duration

Installed cables database

Knowledge of installed cables essential to

- Routine management
  - History, maintenance, repair
- Life cycle management
- Safety of workers and facilities

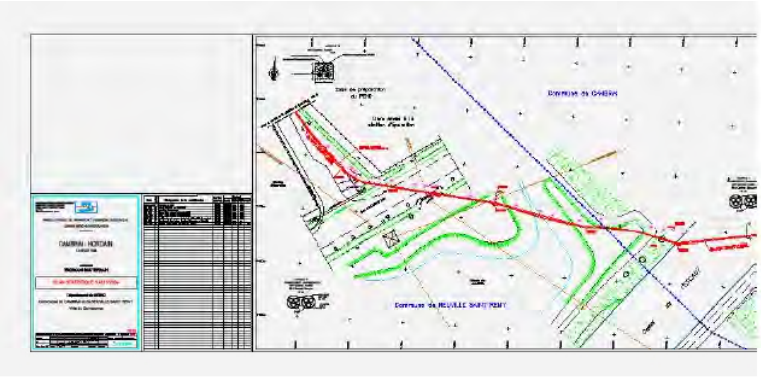
RTE's database

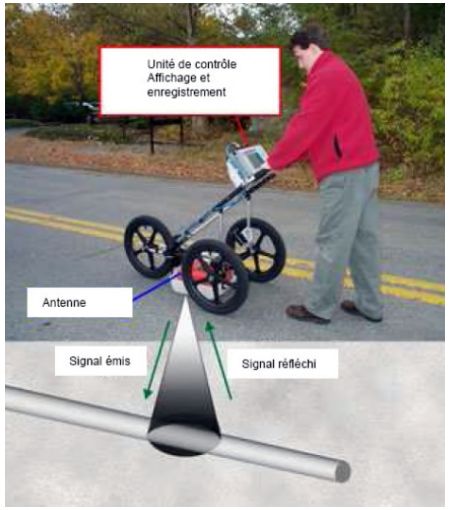
- Evolution of the grid
- Replacement of equipment after maintenance
- Diagrams and worksheets

Documentation and log book

User-friendly Information Tools

- To describe assets and their environment





Preventive maintenance

Re-examination of all preventive maintenance operations

Operations performed by RTE teams

- Need of training courses for maintenance teams
- Several sessions with different skills (cables with or without oil) and levels)
  - Fundament of techniques, workmanship skills and safe work
- Other sessions to review the rules and policy (why, how, when)

Capitalization of know-how and sharing through specific forms

RTE

VP3 **Visite des ouvrages d'art et de galeries**

Cette visite permet de contrôler l'absence d'anomalie (rongée, suspente cassée,...) qui pourrait engendrer à moyens termes des dégâts ou avaries sur les liaisons ou infrastructures. De plus, elle permet de contrôler les accès, les infrastructures, pour faciliter les interventions.

Acteurs : Groupement de postes ou équipes câbles

Etat de liaison : En service

Investigations :

Recherche d'éventuelles modifications des caractéristiques de nos liaisons	- Rupture de suspentes (plastiques, tiges, colliers,...) - Dégradation de la gaine, du tablebier, - Dégradation de l'état général de la galerie (accès, lumière, téléphone, ...), - Contrôle du bon fonctionnement des pompes (si présence), - Contrôle des étiquettes d'identification des liaisons, - Contrôle aération (si présence).
Recherche d'éventuelles modifications des caractéristiques de l'environnement	- Contrôle des ouvrages mobiles (ex : porte d'une trappe de visite d'1 m²,...), - Modification des accès (ex : tampons soudés,...), - Effondrement, inondation,...
Constat des anomalies pour une éventuelle saisie d'un avis dans Maximo	- Modifications des caractéristiques de nos ouvrages (ex : passage sous fourreau dans une partie de la galerie, ...), - Modification de l'environnement (ex : proximité de câble 20 kV, ...), - Prévision de travaux (ex : changement des suspentes,...)
Nouvelle « document opérationnel »	- Travaux sur les câbles HTB en galerie (document opérationnel n° x°), - Documentation sur les préconisations d'intervention en galerie

Etiquette d'identification de la liaison

Suspentes

Policy of maintenance

Based on visits to the installations

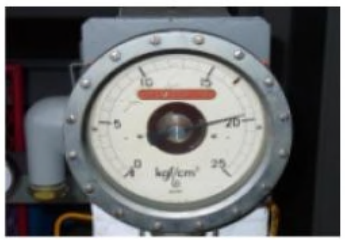
- Inspection of specific equipment, checking points, performance of regulatory inspections
  - Visits: observation of cable routes (infrastructure and environment of the cable). Any modifications?
  - Checks: validation of correct operation of various devices (pressure gauge, pump, earthing system)
  - Inspections: Measurement of vessels pressure

Frequency of maintenance operations

- According to cable technology, priority of the system operator

Plan with SAM maintenance module

- Extensive use of asset database and analysis



Corrective maintenance: Repair

Since 2010, repair work is operated by RTE maintenance team

- 63 to 225 kV
- For all technologies
  - oil-filled, fluid-filled pipe-type, synthetic, paper, gas-filled cable system

Special care to the necessary factors

- Skills, workers and equipment available for this work
- Adequate national stock of spare parts (cables and accessories)

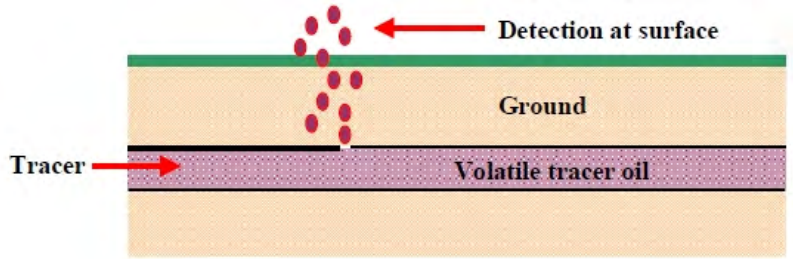
Specific training

- Special training for fluid-filled pipe-type technology
- Training integrated into cable purchasing contracts for extruded cable technology

Leak location of oil-paper cables

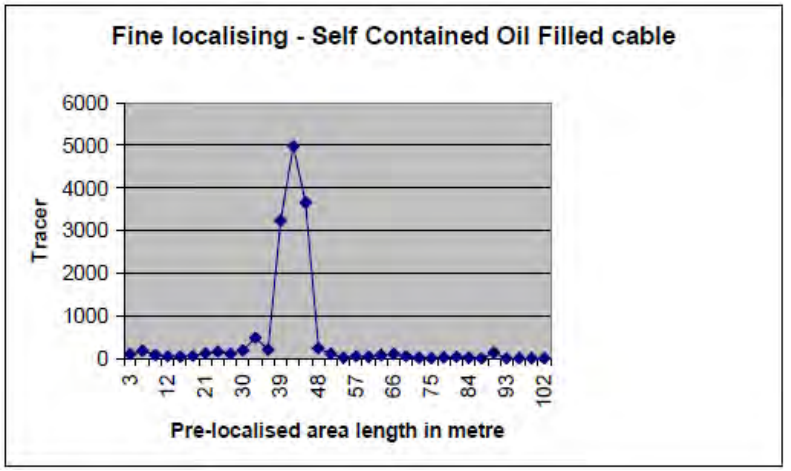
Evaluation of oil-leak location methods

- Hydraulic, acoustic, geophysical method
- Method with insulation decomposition gas detection
- Method with marker



Method with PFT Marker

- Injection of a volatile marker into the insulating oil
  - Highly compatible with oil and thermally stable
  - Very distinctive and easy to detect at low rate (10^{-15}!)
- Pre-location with air samples along the cable route and analysing
- Fine location with mobile mass spectrometer



Conclusions

TSOs are operating in a fast unceasing moving context

- High requirements of customers, new challenges
- Lifespan of equipment > 40 years
- Huge investments to develop and maintain the grid with a high level of quality, reliability and safety

Methods to improve asset management are essential

- Compatibility with components of different suppliers and generations
- Significant efforts to rationalise ranges of devices
- Extension of the performance of existing systems
- Diagnostic, monitoring and predictive maintenance
- Capitalisation of knowledge, durability of skills and teams
- Discounting cost of losses taken into account

All these items have been discussed during past sessions of Jicable and Wets workshop

- The next conference in June 2015 will be the best place to share innovative progress and experience

See you in Versailles in 2015!

www.jicable.org

Thank you for your attention

Questions?

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Author's biography

Frédéric Lesur graduated in power electronics in 1992 (Supélec, Paris).

He has been employed by Silec as a research engineer, involved in the development of 400 kV underground lines, in modeling and engineering tools design.

He moved to EDF utility in 1999, and was responsible for the cable system testing facility of Les Renardières.

He has been working for the engineering branch of RTE, the French Transmission System Operator, since 2007, on various topics as cable system design, current ratings, or EMF. His background led him to innovative technologies such as superconducting cables. He is in charge of numerical simulation and R&D activities for land and offshore large projects.

Frédéric Lesur is involved in various Cigré, IEEE/ICC, IEC and Jicable activities.