The Electricity Supply of the Future and the CIGRE Roadmap

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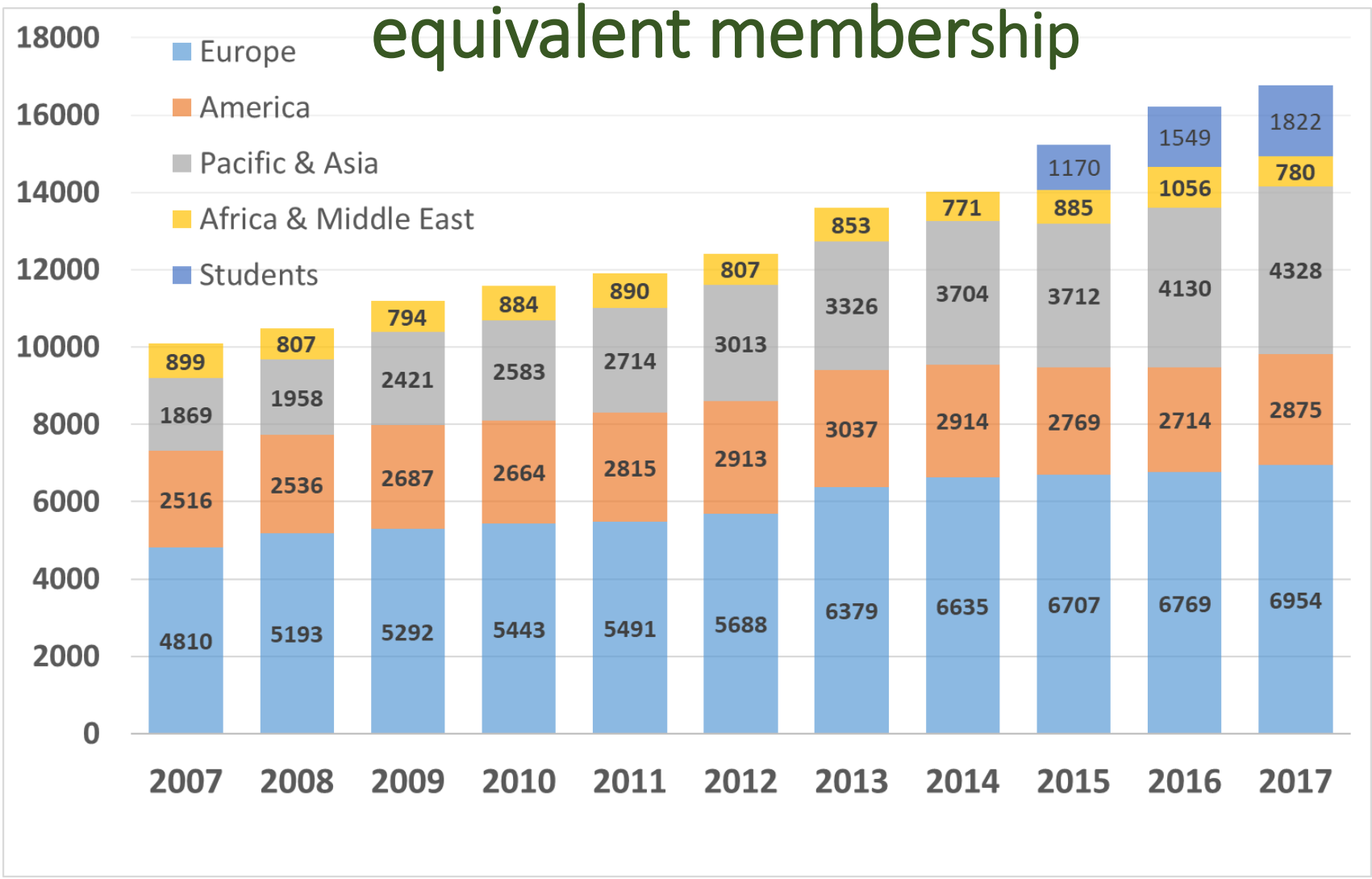
Some CIGRE statistics

- **58** National Committees
- **98** countries represented in 2017
- **10 000+** individual members
  - 670+ young members
  - 1800+ student members (no fees)
- **1250+** collective members
- **4000** experts in Working Groups (8 % ladies)

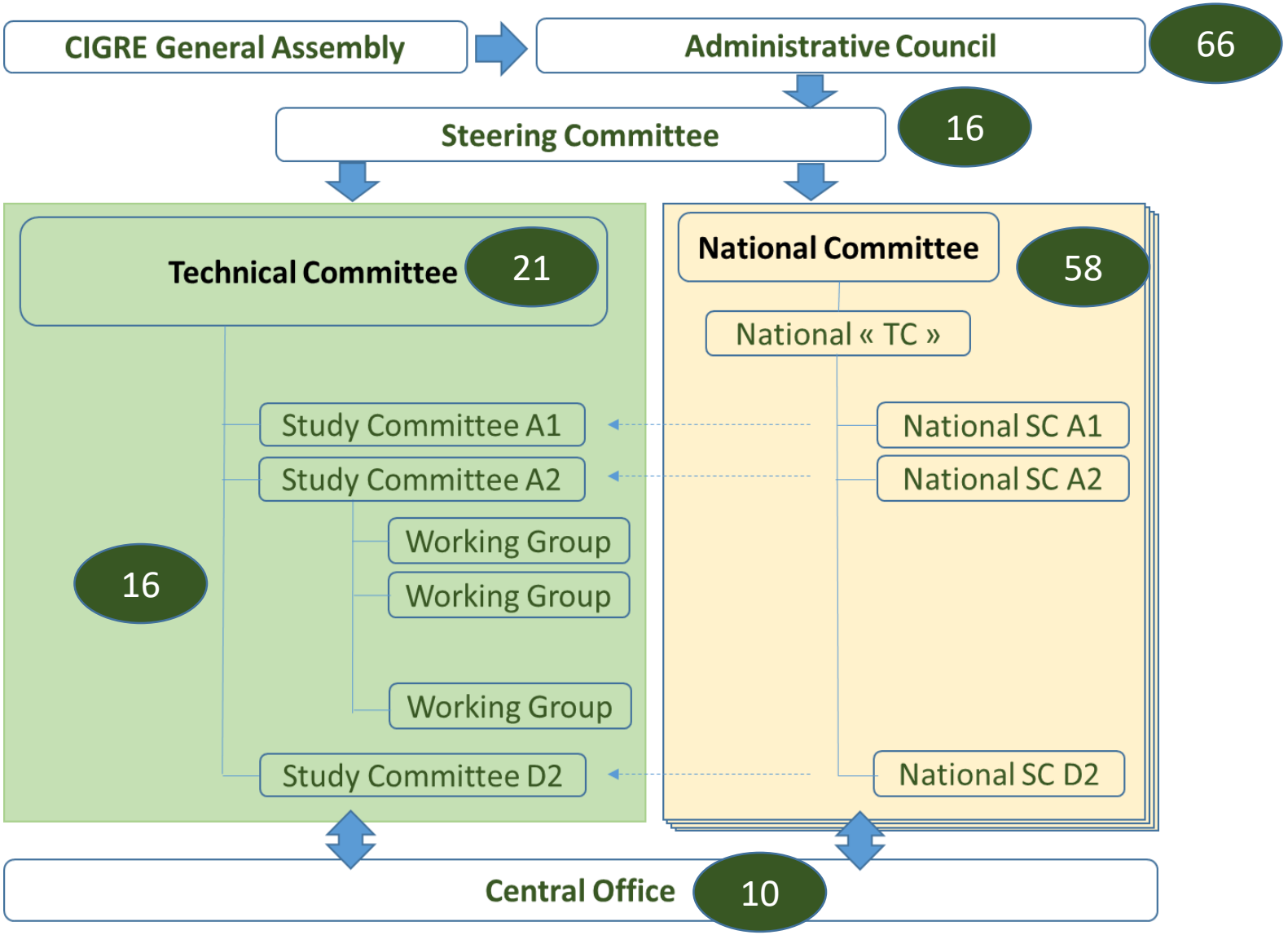
Evolution of CIGRE equivalent membership



Study Committees & Working Groups

- **16** Study Committees (SC)
- **230** Working Groups (WG)
- **~ 40** new WG Terms of Reference / yr
- **~ 40** Technical Brochures / yr

Organisational structure



CIGRE events

- **Session** in Paris (France) in even years
- Two **symposia** elsewhere in odd years
- ~10 **colloquia** per year (SC + NC)
- ~20 **other events** per year (NC)
- **Joint events** with IEC or IEEE-PES

CIGRE publications

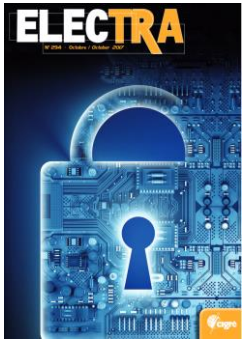
1-2/yr

~40/yr

3/yr

CIGRE services to its members

- **Electra** journal



6/yr

10 000 +

- Free access to all CIGRE publications via **e-cigre**

e-cigré on-line library and bookstore

- Reduced **registration fees** to CIGRE events
- **Preferential prices** for CIGRE hard copies and books
- Platform of **collaborative tools** (KMS) for Study Committees and Working Groups
- CIGRE **awards**

CIGRE services to National Committees

- On-line **membership database** for each NC
- On-line platform to manage the **renewal of NC** representatives on Study Committees
- On-line platform for the **submission of synopes** and papers for the Paris Session
- Participation to the **funding** of national events
- On-line platform to manage the nomination of national experts on **new Working Groups (coming soon)**
- Knowledge Management System (**KMS**) for NCs

CIGRE promotion actions

- **Free** membership for students
- **Free** registrations to Paris Session for 2 young members per NC
- **Free** access for non-members to all publications 3 years after publication
- **Free** membership for non-member delegates at Paris Sessions
- **Free** membership for new members after 1st October
- **CEO event** during the 2018 Paris Session

About CIGRE contribution to the Power Systems of the Future

The purpose of modern power systems is to supply electric energy satisfaying the following conflicting requirements:

- High reliability and security of supply
- Most economic solution
- Best environmental protection

Power systems in transition

- Policies for **lower carbon**, renewable energy sources (RES), efficient energy use
- **Integration** of RES and distributed generation (DG) into the grids
- Increased **customer participation** and new needs for distribution grids
- Progress in technology including ICT
- End-of-life **grid renewal** (ageing assets)
- Methods to **connect remote areas** with no electricity
- **Market design** and regulatory mechanisms for an equitable, cost-effective transformation
- **Environmental compliance** and sustainability

Grid models

1. Increasing importance of large networks for **bulk transmission**
   - capable of interconnecting load regions and large centralized renewable generation resources including offshore,
   - to provide more interconnections between countries and energy markets.

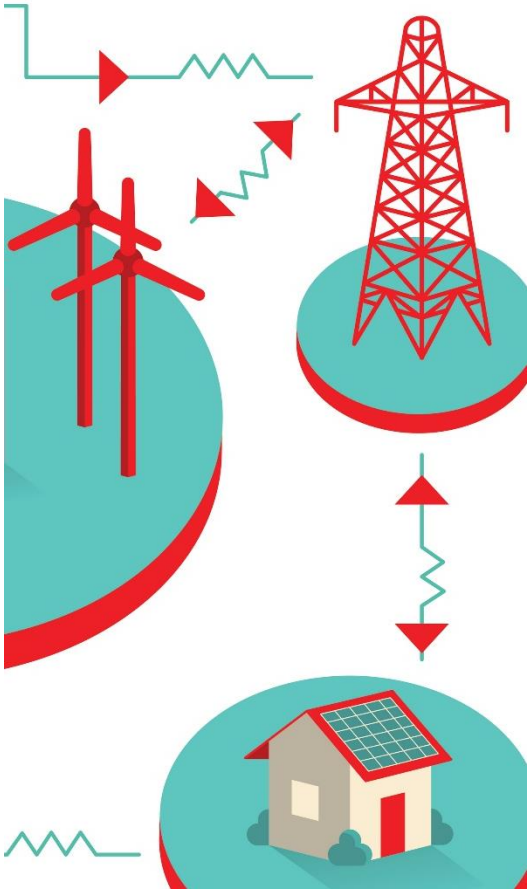
2. The emergence of clusters of small, **largely self-contained distribution networks**
   - which include decentralized local generation, energy storage and active customer participation
   - intelligently managed so that they are operated as active networks providing local active and reactive support.

The best future will likely have a mix of the two models. 10 issues drive the transformation, and CIGRE contributes strongly to them.

Electricity supply systems of the future : the 10 issues

1. ACTIVE DISTRIBUTION NETWORKS
2. DIGITALISATION OF THE WHOLE ELECTRICITY SUPPLY CHAIN
3. INTEGRATION OF HVDC/POWER ELECTRONICS
4. SIGNIFICANT INSTALLATION OF STORAGE
5. NEW SYSTEMS OPERATIONS /CONTROLS
6. NEW CONCEPTS FOR PROTECTION
7. NEW CONCEPTS IN PLANNING
8. NEW TOOLS FOR TECHNICAL PERFORMANCE
9. INCREASED USE OF EXISTING INFRASTRUCTURE AND NEW T&D DEVELOPMENTS
10. STAKEHOLDER AWARENESS

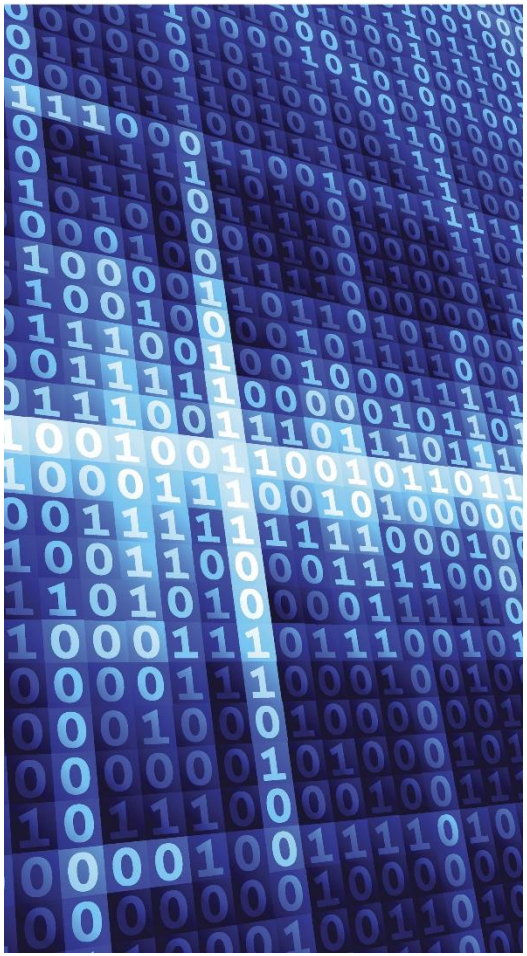
1 Active distribution networks



Key Challenges

- Distribution level needs more “smartness”
- Massive penetration of distributed generation units imposes the need for their control and coordination
- Smart metering implementation and active demand participation
- Evolution of markets and regulation;
- New market-oriented control of distributed generators, such as virtual power plants, interacting with transmission and distribution grid operation
- Novel distribution network architectures, that support local balancing, such as Microgrids

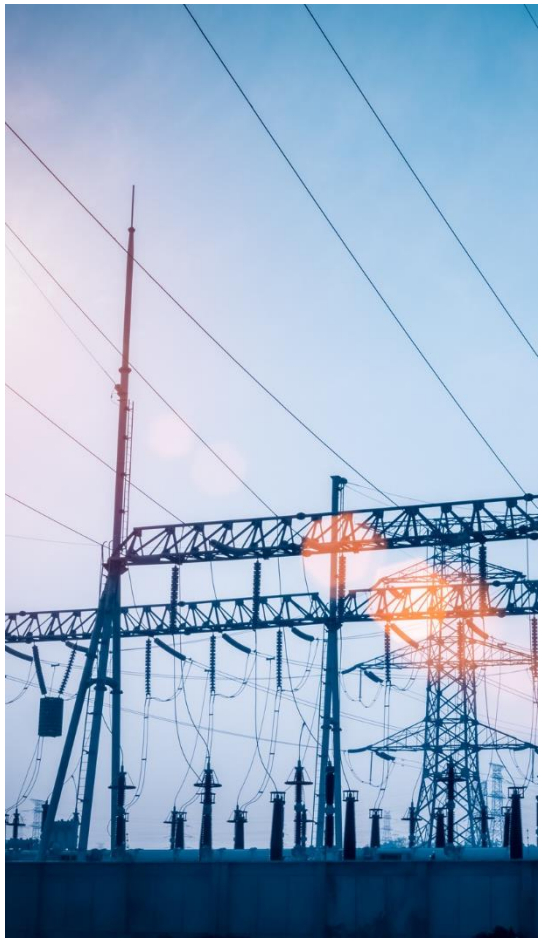
2 Digitalisation of the whole power supply chain



Key Challenges

- Cyber security and access control
- Real-time data acquisition to operate the system but also to send the right signals to the market operators
- Need for a secure and effective telecommunication network in order to transfer information at all times with the required level of services
- New architectures of information, communication technologies and algorithms for system operation, protection, maintenance, etc.
- Disaster recovery and restoration plans

3 Integration of HVDC/Power electronics



Key Challenges

- Integration of multi-infeed HVDC networks in the AC network
- Effects of PE penetration at all voltage levels
- Need for appropriate models for HVDC and PE systems for network performance studies
- Fault recovery of HVDC networks
- Standards and Grid Codes for HVDC grids to enable gradual system development ensuring compatibility among different converter manufacturers

4 Significant installation of storage

Key Challenges

Construction issues:

- Advanced material for construction
- Reduction of installation and construction costs
- Reduction of environmental impact, recycling
- Reduction of energy losses, improve efficiency of charge/discharge cycles
- Decrease weight and increase size density
- Life-time estimation models, ageing mechanism

Operation and network issues:

- Modeling for steady state and dynamic simulations
- Management of storage for peak shaving, ancillary services, RES balancing and energy arbitrage
- Sizing and siting of storage devices
- Co-operation with RES in hybrid systems
- Management in autonomous power systems

5 New systems operations / controls

Key Challenges

Operational challenges :

- Power balancing
- Congestion management
- Active and reactive reserve
- Risk management and probabilistic approaches

Evolution of power system control:

- Improve the awareness of the overall system status
- Integrate power electronics based technologies
- Define boundaries between TSO and DSO systems
- Information exchange and operational interfaces between TSO, DSOs and other stakeholders

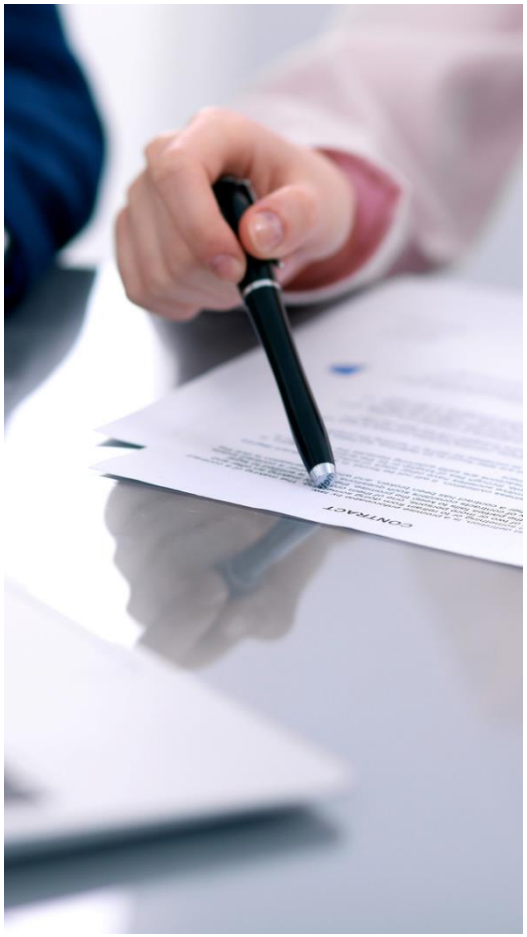
6 New concepts for protection

Key Challenges

- Limitations of special protection schemes in terms of reliability, flexibility and maintenance cost
- Impact of power electronics interfaced generation technologies with decreased short circuit currents
- Coordination between protection and new generators capabilities – capabilities for fault ride through
- Inadvertent islanding detection and intentional islanded operation
- New protection and automation functions for distribution networks based on communication networks

7 New concepts for planning

Key Challenges



- Very high uncertainties including higher community awareness: impacts ability to plan to minimize asset stranding, while maintaining reliability and quality
- Changes in technology: need to understand cost, capabilities and lead times of each solution to enable comparison between options
- Changing economic drivers: impacts on availability of funding and investment, risk, etc.: increasing uncertainty of long
- Changing market and regulatory environment: impacts on level of central planning vs. market solutions
- Changing nature of supply and demand including demand response, transport electrification, etc: increases uncertainty of long term solutions, potential for asset stranding

8 New tools for technical performance

Key Challenges

- Advanced numerical methods for the solution of dynamic problems in integrated timeframes and for multiphase power-flow problems
- Advanced tools and techniques for power balancing and reserve requirement evaluation
- Operational tools allowing a probabilistic and risk-based planning
- Model active control strategies (centralized control systems, grid-friendly appliances, demand side management, etc.)
- Models for new and advancing technologies
- Advanced load modeling techniques
- Techniques to model decentralized control applications, such as multi agent techniques
- Co-simulation platforms for simulation of both transmission systems and distribution systems and other energy carriers

9 Increased use of existing infrastructures and new T&D developments

Key Challenges

- Uprating of existing lines, such as replacing old conductors by high temperature conductors, re-tension of existing conductors, upgrading voltage level, use real time thermal monitoring, etc.
- Conversion of AC to DC lines, considering hybrid lines (DC & AC), compact lines and aesthetic supports
- New insulated AC or DC submarine and underground cables for HV applications, e.g. offshore wind farms
- Compact design of converter stations for off-shore and urban applications
- Requirements for T&D equipment to withstand transients and over voltages

10 Stakeholder awareness

Key Challenges

In the planning phase:

- Demonstrate the usefulness and the benefits that will result from the project
- Guarantee that sustainable development principles and issues are being incorporated at this stage
- Take into account public views and needs already in the design steps, e.g. choice of alternatives

In the construction and operation phases:

- Demonstrate the compliance with environmental standards, obtain support for the necessary actions, e.g. maintenance

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