



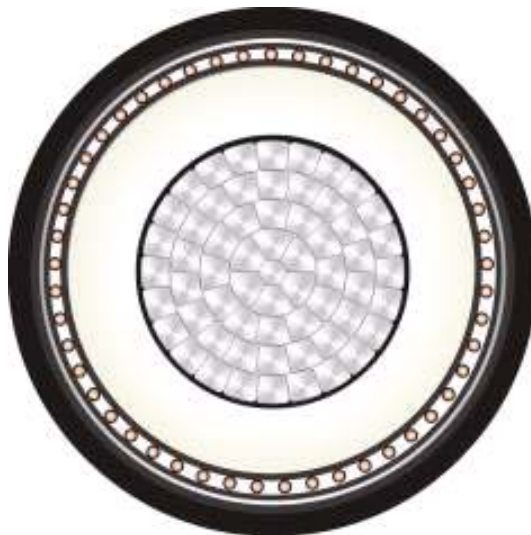
**IEA Implementing Agreement on  
Electricity Networks Analysis, Research and Development (ENARD)**

*Annex I Workshop Profile*

*“Transmission Systems”*

**Annex I: Information Collation and Dissemination**

**Annex I Workshop held Rosenberg Arena, Trondheim, Norway,  
24<sup>th</sup> - 25<sup>th</sup> September 2007**



*[“HVDC Light Cable” - from the presentation given by Hans Gners, ABB]*

*Summary:*

*The workshop drew the support of 24 participants from 12 countries and comprised a series of expert presentations, working groups and open discussion.*

*Consensus was reached in relation to the development of a dedicated ENARD transmission systems Annex, with the objective of addressing various technological, operational and planning issues, such as to provide authoritative guidance to key policy and decision makers, whilst also being of real value and use to its essential TSO stakeholders. The workshop concluded by reaching agreement on the anticipated scope of the new Annex and for its forward development.*

This workshop forms one of a series of ENARD Annex I workshops organised and delivered by EA Technology in its capacity as ENARD Annex I Operating Agent



# Workshop profile

## 1 Introduction

The workshop was convened as the fifth in the series of topical experts' meetings and workshops of the International Energy Agency (IEA) Implementing Agreement on Electricity Networks Analysis, Research and Development (ENARD). ENARD covers a wide range of issues associated with electricity transmission and distribution (T&D) systems. Annex I is the central information collation and dissemination Annex and also contributes to the definition of future priorities for the Implementing Agreement as a whole.

Annex I is essentially led by a series of topical experts' meetings and workshops, each addressing particular areas of interest that act as the foundation for the development of future collaborative research and development (R&D) Annexes. Further details may be found on the ENARD web-site at [www.iea-enard.org](http://www.iea-enard.org) or e:mail [enquiries@iea-enard.org](mailto:enquiries@iea-enard.org).

## 2 Workshop Aim and Objectives

The workshop was convened with a view to helping define the work programme priorities in a potential Annex on "Transmission Systems" and sought to address:

- Current state-of-the-art;
- Different approaches and solutions adopted;
- Key challenges ahead
- Technologies available and Market implications;
- Information requirements;
- Requirements and opportunities for future international collaborative R&D;
- The associated opportunity to develop a structured follow-on (R&D) Annex.

## 3 Workshop Structure and Programme

The workshop was structured to comprise a series of expert presentations, followed by break-out into a series of working groups. The workshop re-convened for working groups to report, and for open discussion and agreement on the principal workshop outcomes and conclusions.

The workshop was opened by Sverre Aam, Managing Director of SINTEF Energy Research, Norway, who were hosting the workshop, with Lars Audun Fodstad (Norwegian delegate to the ENARD ExCo) responding by welcoming participants and highlighting the challenges of the European Commission's binding targets for biofuels and renewables. Stig Goethe (Chair,

ENARD Implementing Agreement) noted that the emphasis on climate change and CO<sub>2</sub> mitigation is likely to result in an increased share of electricity as a primary fuel, and John Baker, ENARD Annex I Operating Agent (EA Technology, UK), described the essential role of Annex I.

## 4 Expert Presentations

### Wide Area Measurement Systems – monitoring and control

(Philip Overholt, Dept of Energy, USA)

Mr Overholt described the Office of Electricity Delivery and Energy Reliability in terms of leading the US effort to modernise the grid, enhance security and reliability and facilitate recovery from disruptions. He described Wide Area Measurement Systems (WAMS) which addressed the lack of wide area visibility and time-synchronised data recorders noted in the review of the US/Canadian 2003 blackouts. WAMS led to the North American SynchroPhasor Initiative (NASPI: [www.naspi.org](http://www.naspi.org)) which aims to create secure synchronised power system data measurement. Moving on to the present day, Mr. Overholt described the Phasor Technology Research Roadmap, which ultimately intends to deliver enhanced utilisation of the existing power transmission infrastructure.



[from the presentation given by P Overholt, Dept of Energy, USA]

### Management of a transmission system at the heart of Europe

(Thilo Krause, Federal Office of Energy (FOE), Switzerland)

Switzerland's geographical position at the heart of Europe results in some 20% of the total UCTE cross-border transmission capacity, but only circa 3% of total UCTE consumption. Electricity market liberalisation is to be introduced from January 2008, with significant structural changes. Electricity market mechanisms are the principal determinants in the large cross border power flows, with the potential for large deviations between the actual day and day-ahead forecasts, and consequential effects on system security and stability. Dr Krause indicated that SFOE is keen to investigate potential solutions, e.g.

development of enhanced congestion management schemes and a working group is addressing such issues on a year 2015 perspective.

### Challenges and solutions for offshore transmission

(Jens Bömer, Ecofys, Germany)

Dr Bömer described the challenges of connecting UK East Coast offshore wind farms, each rated circa 100 MVA. Connection via traditional 3 core cables is likely to be expensive and connection via bipolar DC cables is thought to be a step change in technology and risk. A new bipolar AC transmission concept was described, using 3 bipolar pairs of single core cables which could provide an offshore transmission capacity of circa 1,300 MVA. Remaining issues include the laying technology and long term cable behaviour, but the concept has potential to provide high offshore transmission capacity at reduced capital and operational cost.

### Power system research activities in Helsinki University of Technology

(Liisa Haarla, Helsinki University of Technology (TKK), Finland)

Professor Haarla covered two TKK research projects being conducted in collaboration with the Finnish TSO, Fingrid Oyj:

- The power system security project is aimed at quantifying the security level of a transmission grid under a range of operating conditions, with the objective of operating at a constant level of security.
- The power system damping project aims to measure the damping on the Nordic power system under real time operational conditions. The work may progress towards automated system control and/or protection.

Professor Haarla concluded by briefly describing her thoughts in terms of future research projects.

### Transmission technologies for Europe

(Hans Gners, ABB)

Mr Gners noted the projected increases in transmission capacity over the next 25 years and the essential role of transmission infrastructures in terms of security of supply, market development, renewables integration and overall system enlargement. He also noted experiences of prioritised interconnections in Europe and the US, with perhaps 10 to 15 years required to build new transmission lines. These factors present challenges to which ABB aims to provide technological solutions, with the key technologies being cables, HVDC converters and FACTS. He noted that HVDC Light could become cost competitive, relative to the current generation of 380 kV overhead lines, over distances of several hundred kilometres.

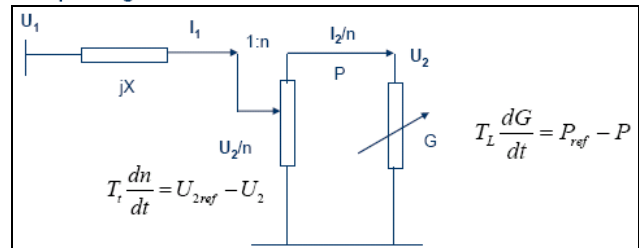
### Operating transmission systems close to the edge

(Arne Holen, NTNU + Leif Warland, SINTEF, Norway)

Professor Holen summarised two strategies to mitigate system collapse: preventative strategies (including 'n-1',

other deterministic approaches and risk based techniques); and dynamic techniques (providing real time monitoring and control of system state). He described the Voltage Instability Predictor (VIP) via the application of phasor measurement techniques as a key determinant in assessing voltage instabilities. The approach was illustrated by a simple example based upon a tap changer and thermostatically controlled load, with a sudden change of the infeed voltage as the initiating disturbance.

#### Dynamic approach to voltage instability by a simple example: Tap changer and thermostat controlled load



(from the presentation given by A Holen, NTNU, Norway)

Professor Holen asked if both increasing system utilisation and enhancing system security was "mission impossible".

### Risk based analysis in transmission system operation planning

(Lars Vormedal, Statnett, Norway)

Mr Vormedal provided some background on Statnett and its vision to be Europe's leading and most efficient TSO. He described the Nordic electricity market within NordPool and Nordel, and the principal market mechanisms. Statnett's operational planning process was described in terms of seasonal, weekly and day ahead aspects and the interconnections and trading arrangements with Russia, Finland, Sweden and Denmark. The case for moving towards a probabilistic planning process, allowing trade-off between costs and risks, was described. The approach has been extensively used during system maintenance and extending its use is planned, with the objective of increasing system capacity and reducing bottleneck costs.

### A benefit framework for transmission system expansion planning in competitive electricity markets

(Paola Bresesti, CESI Research, Italy)

Dr Bresesti described a new framework to evaluate the technical and economic benefits of transmission system expansion. The need for a framework was triggered by the discrepancy between demand growth and increases in transmission capacity. Benefits include increased reliability and security of supply and improved market efficiencies and environments. A case study concerning the 380kV reinforcement between the mainland and Sicily was described. Enhancements could cover large scale renewables developments, trade-offs between transmission and generation investments and facilitation of the public planning process. The technique could also be applied on a pan-European basis.

## 5 Working Groups

Three working groups - Expansion Planning and Market Analysis (Chair: Arne Holen), Operational Management & Security (Chair: Liisa Haarla) and Technology (Chair: Kjetil Uhlen) - defined the priorities and themes for a new Annex. The individual reports are captured in table 5.1.

**Table 5.1:** Summary of Feedback from Working Groups

Expansion Planning and Market Analysis	Operational Management and Security	Technology
<ul style="list-style-type: none"> <li>• Network access (tariffs and pricing; grid codes; regulatory and institutional issues);</li> <li>• Risk based planning;</li> <li>• Cross border issues (e.g. large scale renewables integrations, systems with different market rules);</li> <li>• DG and DSM in transmission planning;</li> <li>• Transmission system lead times;</li> <li>• T&amp;D interfaces in the context of reliability and security of supply;</li> <li>• Co-ordination between operational and structural measures;</li> <li>• New analysis tools, e.g. market based.</li> </ul>	<ul style="list-style-type: none"> <li>• Whole system overviews;</li> <li>• Markets for renewables generation;</li> <li>• Reconciliation of difference between market structures and historical transmission system developments;</li> <li>• Integration of information and comms support;</li> <li>• System visualisation tools and techniques;</li> <li>• Operational risk management techniques;</li> <li>• Maintenance techniques for higher utilisation systems;</li> <li>• Regulation and balancing;</li> <li>• Dynamic operating techniques;</li> <li>• Analysis tools/ methodologies</li> </ul>	<ul style="list-style-type: none"> <li>• Enhancing transmission capacity and renewables integration, security-of-supply and electricity markets;</li> <li>• Application, costs/benefits, externalities;</li> <li>• Core technologies;</li> <li>• WAMS (applications, reliability, etc);</li> <li>• FACTS/Power Electronics (uptake, benefit/cost analyses);</li> <li>• Energy storage;</li> <li>• Communication and control;</li> <li>• System protection and control technologies;</li> <li>• Maintenance and life extension technologies;</li> <li>• Software developments.</li> </ul>

## 6 Workshop Outputs

A firm basis was agreed for developing a future work programme within a follow-on ENARD Annex, addressing “Transmission Systems Issues” as outlined here:

### Technology

- what is out there?
- how was it applied in practice?
- implementation experience and cost?
- delivered performance?
- lessons learnt?

### Operational Aspects

- situational awareness
- communications & supporting technologies
- crisis management/security of supply
- probabilistic based planning methodologies
- load (demand) as a resource
- dynamic ratings/operation
- “sweating the assets”/“close to the edge”
- trading

### Strategic/Planning Issues

- system planning in context of market rules
- societal levels of risk and cost
- risk based planning
- planning/consenting processes/horizons
- “big wind” integration
- selective competition for system expansions

## Annex IV “Transmission System Issues”

Key considerations in developing Annex IV include:

- providing guidance to the high level policy and decision makers;
- avoidance of over bias on power systems;
- satisfying key stakeholders, e.g. TSOs (addressing risk management, risk based planning, technology to enhance capacity, reliability and utilisation, lower maintenance; reliability of new technologies);
- help to facilitate high level political objectives;
- incentives to enhance transmission capacity;
- provide adequate levels of system security;
- provide a valued information exchange forum;
- highlight examples of “best practice”;
- consider transmission in the overall system context and as a key enabler of generation;
- provide added-value extra-Europe dimension;
- demonstrate understanding of different TSO and political objectives (e.g. build bridges);
- a vision for transmission systems beyond 2020 (e.g. address barriers, status)

ENARD, the IEA Implementing Agreement on Electricity Networks Analysis, Research and Development, functions within a framework created by the International Energy Agency (IEA). The views, findings and publications of ENARD do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.

### ENARD Participating Countries:

Austria Belgium Denmark Finland Italy Netherlands Norway Spain Sweden Switzerland UK