

International Energy Agency

Implementing Agreement

on

**ELECTRICITY NETWORKS ANALYSIS, RESEARCH
AND DEVELOPMENT
(ENARD)**

**Annex IV
"Transmission systems"**

Prepared
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1. Introduction

1.1. *Background and Motivation*

ENARD, the IEA Implementing Agreement on Electricity Networks Analysis, Research and Development, was established as a new Implementing Agreement in July 2006 with a view to facilitating the uptake of new operating procedures, architectures, methodologies and technologies in electricity T&D networks, such as to enhance their overall performance in relation to the developing challenges of electricity markets, renewables integration, network renewal and network resilience.

ENARD's Annex I (Information Collation and Dissemination) work programme is responsible for the systematic collation and dissemination of T&D network related information and data and also for the organisation and delivery of a series of topical experts' meetings and workshops. The latter are regarded as a key enabling mechanism in the identification of priority areas, to be addressed in detail, in potential new Annexes.

One of the priority areas is power transmission. Transmission systems will continue to play a key role in the power systems of the future and are expected to become increasingly important for a number of reasons:

- The present emphasis on climate change and CO₂ mitigation is likely to result in an increased share of electricity as a primary energy carrier, with consequentially increased pressures to maintain high quality and secure electricity supplies.
- Present targets for development and deployment of renewable energy sources in general, and wind energy in particular, are a main driver for transmission system developments. Offshore wind, representing a vast and largely untapped potential, is a special challenge in this respect.
- A key challenge to be addressed in the context of any such massive development of variable generation such as wind relates to its regulation and balancing. This will require flexible transmission solutions, improved operational tools and enlarged balancing markets.
- The development of a fully integrated, liberalised market is a key element for the future and sets new challenges for the grids of the future. The user will become a key

player in the electricity system.

- Transmission grids can be made more flexible and controllable as new technologies based on advanced power electronics become available.
- Permits for new installations of overhead transmission lines are difficult to obtain due to pressure of the general public. New challenges, both technical and economical, arise from the increasing trend to force the use of cables in transmission networks to avoid overhead lines.

ENARD's contribution to this process is to act as an authoritative, comprehensive and unbiased source of information, data and advice to Governments, policymakers and key industry stakeholders, whilst also supporting the IEA's G8 Gleneagles Programme-of-Work.

1.2. *The ENARD Annex I Transmission Systems Workshop, September 2007*

The ENARD Annex I transmission systems workshop¹ was convened to help develop the structure and content of a dedicated new ENARD work programme activity (Annex) in this area. The workshop drew the support of 24 participants from 12 countries and comprised a series of expert presentations, dedicated working groups and open discussion and dialogue.

Consensus was reached in relation to the development of a dedicated ENARD transmission systems Annex (Annex IV), with the objective of addressing various technological, operational and planning issues, such as to provide authoritative guidance to the IEA, G8 and CEC, 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, with a view to its formal presentation to the April 2008 ENARD Executive Committee meeting.

1.3. *Scope of Annex IV*

The aim of the new Annex IV is to establish a long term vision for developments in transmission systems beyond 2020. The scope of the work includes addressing the main

¹ Proceedings of the ENARD Annex I Transmission Systems Workshop, held in Trondheim, Norway, September 2007. EA Technology report no.6179, October 2007

barriers towards a necessary development of transmission capacity and to identify the most promising solutions and challenges in terms of expansion planning and market analysis, secure operation of the transmission networks and the need for new transmission technology.

The Annex should be of real relevance to TSOs and other key stakeholders by addressing the most relevant issues, such as risk management, risk based planning, technology to enhance capacity and utilisation, lower maintenance and increased reliability by introducing new technologies.

Other key considerations in the development of the new Annex are:

- It should provide an added value extra-European dimension by helping facilitate high level political objectives and providing guidance to the IEA, G8 and CEC.
- It should address incentives to enhance transmission capacity (both via better use of existing systems and via planning and implementation of system expansions).
- It should similarly address the provision of adequate levels of system security.
- It should provide a valuable information exchange forum.
- It should provide insight on how market integration can be enhanced.
- It should give indication on how the integration of variable energy sources is enhanced by more flexible grids.
- It should identify and highlight examples of “best practice”.

It is emphasised that the new Annex must take an overall system view, considering transmission in the overall system context and as a key enabler in allowing operation of generation in a well functioning power market. Furthermore, it should demonstrate an appreciation and understanding of different TSO and political objectives (eg, via the “building of bridges” between political objectives and the tasks and responsibilities of the TSOs).

2. Objectives

The main objective of the Annex is to establish a long term vision for developments in transmission systems with the aim to serve as an essential information exchange forum and service ENARD's 3Rs of power systems development, namely network Renewal, Renewables integration and network Resilience.

The work will address the main barriers towards a necessary development of transmission capacity and identify the most important challenges in terms of expansion planning and market analysis, secure operation of the transmission networks and the need for new transmission technology. In addition to the integration of renewables the focus has to include all new low carbon generation, including clean fossil fuels and new nuclear energy, as these are all essential in terms of long term network developments.

The long term vision will identify and describe the most promising solutions related to the various technological, operational and planning aspects, including the need for development and application of new methods and tools. Finally the Annex should address the specific R&D activities needed as a result of the vision.

The Annex will be organised in two main activities focusing on the different areas of responsibility for transmission system operators:

- Expansion Planning and Market analysis
- System Operation Management and Security

A close coordination is necessary between the work carried out in the two activities in order to avoid overlaps and realising that for example the tools developed for operational purposes could also be of interest for planning studies. There is also a significant potential in integration of the various tools that are used for more efficient data management.

3. Activities

Task 1: Expansion Planning and Market Analysis

Context: Unbundling of the electric power industry creates new challenges for transmission expansion planning, in terms of environmental concerns (difficulties in getting construction permits especially for overhead lines), cost of transmission projects and the uncertainties concerning the benefit and profitability of transmission projects in a changing environment. The time horizon from planning and consenting processes to actual construction and commissioning of transmission projects are often longer than the corresponding process to construct new power plants. This represents a huge challenge towards the development of cost optimised and efficient transmission networks.

Objective: The aim of this activity is therefore to assess available methods and tools for transmission expansion planning, and to identify the need for new tools that integrate market modelling, network analysis and security assessment, also including the possible contribution of promising transmission technologies.

Scope: Support tools are expected to be of increasing importance and value for various tasks related to transmission planning. The main challenges and possible activities of interest to this task include:

- Transmission system planning in context of market rules.
- Analyses related to societal levels of risk and cost.
- Policy towards undergrounding.
- Risk based planning.
- Regulatory issues and consenting processes:
 - Investment incentives for cross border capacity.
 - Financing of transmission system infrastructure.
- Analyses related to grid solutions and integration of large scale wind power (onshore and offshore grids) and of other variable energy sources (photovoltaics, tidal).
- Analyses of congestion management and efficiency of the power markets.
- Selective introduction of competition for system expansions.
- Most promising (existing and emerging) technologies.

Deliverables: D1 - Report on availability and application of planning tools, market and network models and on the identification of need for new tools

Target audience: Transmission system operators, regulating authorities, political decision makers, researchers

Activity 1.1: Assessment of available methods and tools for transmission expansion planning

Activity 1.2: Potential of transmission technologies in enhancing power system exploitation

Activity 1.3: Identification of requirements for tools addressing new transmission planning needs

Task 2: System Operation Management and Security

Context: The development of electric power systems with a larger mix of generation technologies and an increased penetration of renewable energy sources is expected to lead to larger and more frequent changes in generation and load behaviour in the future. Generation will also be located further away from demand. This emphasises the need for new methods and tools for monitoring and control of power systems, including the activation of the loads (demand side participation).

Objective: The aim of this activity is therefore to assess available methods and tools for operational monitoring and control, and in particular to identify the need for new tools and methods to manage future challenges in balancing control also accounting for the potential of transmission technologies. This also includes market design and management of balancing services, as well as methods for adequate provision and distribution of operational reserves and other ancillary services. The development of real time markets is an essential element.

Scope: A key issue to be addressed is the operational challenges related to massive development of offshore wind power. One example to illustrate this problem area is the visions of a North Sea “supergrid” to harness the potential of deep water offshore wind and tidal energy. Development of the necessary transmission capacity to tap into this potential and its control is a huge task. This requires new thinking about the management and exchange of balancing services, and the possibilities and impacts of enlarged control areas (across borders and interconnections) need to be thoroughly analysed.

Another area of interest is Wide Area Monitoring Systems (WAMS) based on synchronised phasor measurements. Together with developments in ICT this technology provides for a number of new applications and functions within control centres related to state estimation and situational awareness. The contribution of this Annex would be to identify and describe the most promising applications from a system operation point of view.

Important challenges and possible activities of interest to this task include:

- Development of balancing and real time markets.
- Probabilistic (risk) based operation planning methodologies.
- Development of flexibility (e.g. frequency response capability) of low carbon generation plant including renewables to ensure adequate balancing cover under rapidly varying generation mix.
- Load (demand) as a resource with reference to the IEA’s Implementing Agreement on

Demand Side Participation (DSP).

- Application of WAMS for improved situational awareness.
- Application of power flow control in the grid (phase shifting transformers, FACTS and HVDC).
- Crisis management/security of supply.

Deliverables: D2 - Report on availability and application of advanced operational tools and on needs for new operational monitoring and control tools

Target audience: Transmission system operators, regulating authorities, political decision makers, researchers

Activity 2.1: Assessment of available methods and tools for operational monitoring and control

Activity 2.2: Role of transmission technologies to enhance power system control

Activity 2.3: Identification of needs for new methods and tools to manage balancing control

4. Deliverables

The main deliverables will be workshops and reports, including an executive summary report

- Workshops, tentatively in collaboration with other relevant organisations, such as CIGRE.
- Reports:
 - D1 - Report on availability and application of planning tools, market and network models and on the identification of need for new tools
 - D2 - Report on availability and application of advanced operational tools and on needs for new operational monitoring and control tools
- Executive summary describing a long term vision for developments in transmission systems, the need for further R&D and recommendations regarding policy developments.

6. Rights and Obligations

6.1. Rights

The principal results and outputs from the Annex IV programme-of-work will remain confidential to the Annex IV Participants for a period of not less than two years after the completion of the Annex, unless all the Participants agree to an earlier release of information.

The Annex will also be required to produce an executive overview report of its activities, not containing any sensitive information or data, and which is suitable for publication in the public domain.

Although the programme-of-work, as described herein, is not anticipated to lead to the development of any new Intellectual Property (IP), the ownership and commercial exploitation of any IP which may be produced shall be established by the unanimous vote of the ENARD Executive Committee, consistent with Article 8 of the ENARD Implementing Agreement.

6.2. Obligations of the Operating Agent

The Operating Agent (OA) is responsible for the overall technical and administrative management of work performed within Annex IV and for implementing the decisions of the IEA ENARD Executive Committee. The work is structured on two levels: Annex and Activities. The OA and the Activity leaders are responsible for the work undertaken at these levels as follows:

Operating Agent:

- Coordination, scheduling and communication between Activities.
- Assisting Activity leaders.
- Preparing, leading and summarizing Annex meetings (twice annually).
- Reporting to IEA ENARD Executive Committee (status & annual reports).
- Coordinate/ensure publications of technical reports and other materials.

The responsibility as Operating Agent will be shared equally between CESI RICERCA and SINTEF energy Research.

6.3. Obligations of the Participating countries

Each participating country within Annex IV shall be required to nominate a National Co-ordinator (otherwise known as a “National Expert” or “Expert”). The National Experts will be expected to have a good working knowledge of transmission system operation and planning terminology and methodologies. Each National Expert will be required to:

- Provide the Operating Agent with a National Participation Letter, indicating their commitment to the Annex. The collective set of National Participation Letters represent the National Participation Plan;
- Attend and participate in the programme of two Experts’ meetings per year, to be organised by the Operating Agent in the discharge of its obligations;
- Support the Operating Agent in the discharge of its obligations via the timely and appropriate provision of information, data and other material, as may reasonably be required to service the requirements of the programme-of-work, as described in section 3 above;
- Take the lead responsibility on an individual national basis in relation to the sourcing and collation of any information inputs that may reasonably be required to service the requirements of the Annex;
- Take the lead responsibility on an individual national basis for the dissemination of the outputs from the Annex.

The work is further structured on two levels: Tasks and Activities. The Task Leaders and the Activity Leaders are responsible for the work undertaken at these levels as follows:

Task Leader:

- Prepare task plan and scheduling.
- Coordination, scheduling and communication between activities
- Produce and submit deliverables at Task level to OA

Activity Leader:

- Prepare activity plan and scheduling.
- Coordinate activity work and communicate with other participants.
- Reporting on activity work to Task Leader.

7. Budgets

The performance of Annex IV will require a combination of financial and in-kind contributions, as described below.

7.1 Operating Agent

The Operating Agent role will be funded on a cost-share basis, between the participating countries. A financial contribution of EUR 23,000 per participating country is required (payable over the 24 months of Annex IV) for the discharge of the Operating Agent's duties, subject to a minimum of five countries participating in the Annex.

7.2 Annex Participants

The Annex Participants will be expected to support National Expert participation at a minimum level of 4 person-months per participating country, over the 24 months of Annex IV. Multiple Experts may be assigned, as appropriate, e.g. from the power transmission sector (especially TSOs), industry R&D centres etc.

All participating countries will be required to provide National Expert representation and contribution to the four Experts' meetings, to be held throughout the discharge of Annex IV. Travel and accommodation costs for these meetings shall be the responsibility of the Annex Participants.

Active participation is expected outside of the programme of Experts' Meetings, including, but not limited to, ongoing dialogue and information exchange via email, the Annex IV portion of the ENARD web-site, occasional conference calls and related.

7.3 Budgetary Overview

Table 7.1 below provides a budgetary overview of the contributions required from the Annex Participants, for the delivery of Annex IV, based upon the assumption of a 1st January 2009 commencement.

Table 7.1:- Contributions required from Annex Participants for Annex III

Role/Activity	Financial/manpower provision	
	2009	2010
Annex IV Operating Agency	EUR 12.000,-	EUR 11.000,-
Annex IV National Coordination/ National Expert role	2 Person Months	2 Person Months

8 Related working groups and activities

Task 1

IEA Wind Energy Systems – Annex 25: Design and Operation of Power Systems with Large Amounts of Wind Power

IEA Demand-Side Management – Annex 17: Integration of Demand Side Management, Energy Efficiency, Distributed Generation and Renewable Energy Sources

CIGRE Study Committees

C1: System Development and Economics

C5: Electricity Markets and Regulation

IEEE Power & Energy Society: Technical Committee Power System Planning and Implementation

Task 2

IEA Wind Energy Systems – Annex 21. Dynamic models of Wind Farms Power System studies

IEA Demand-Side Management - Annex 18 Demand Side Management and Climate Change

VLPGO: Very Large Power Grid Operators

CIGRE Study Committee

C2: System Operation and Control

C4: System Technical Performance

IEEE Power & Energy Society Technical Committee Power System Operations

IEEE Power & Energy Society Technical Committee Power System Analysis, Computing and Economics

9 Further Work

It is recognised at the outset that Annex IV may well generate new ideas for the application of practical transmission system techniques and/or identify the requirement for further targeted R&D. The Annex Participants shall therefore review the basis for any such further work, towards the completion of the Annex, or as may be requested by the ExCo. Subject to the conclusions of such review, the basis for the extension of the Annex, via future follow-on Annexes shall be determined, for submission to the ExCo. There shall however be no obligation on any Participant in Annex IV to participate in any future Annexes, as may be decided.