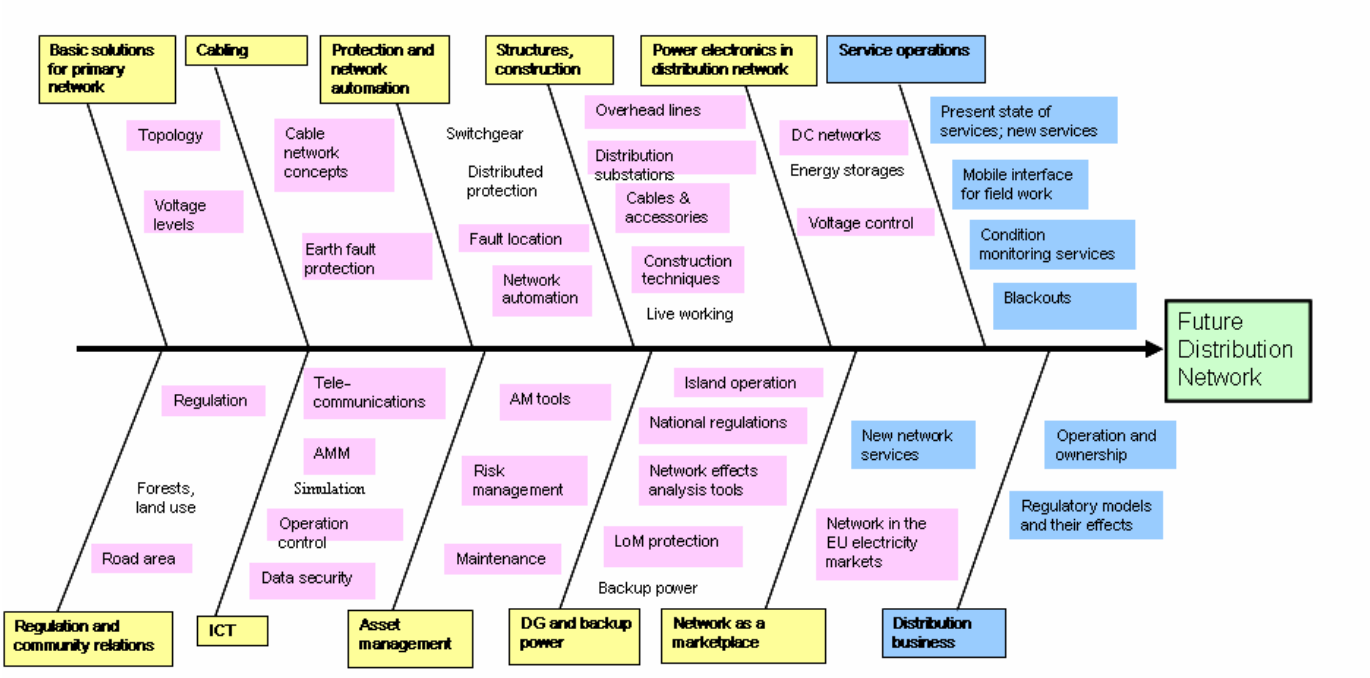
Road Map 2015

Electricity Networks,

Electricity Use &

Electricity Markets

Result Report



20 December 2007
Esa Pekkola

Foreword

Because the lifetimes of electricity networks are typically long (several decades), solutions concerning electricity networks will have far-reaching effects. Reaching the future target state by the optimal use of resources calls for long-term planning and description of both the actions and the total project.

Organising and compacting the project constellation into a consistent whole was a laborious task. As a result, a map of twelve research projects was put in priority order and scheduled for the eight-year implementation period by the participants of the road map process. The total costs of the research programme were estimated to be 18.4 M€; two thirds (12.4M€) of the Road Map project will focus on the creation of the export technology, while one third (6.1 M€) will be allocated to the improvement of the business efficiency and to the research of the service market, the operation environment and customer services. The necessary annual research investment for the implementation of the Road Map 2015 programme is 2.3 M€ during the next eight years. About 4.7 M€ (27.1 %) of the whole research input is directed to projects, in which AMM technology is utilised or developed. The five highest-scored research objectives were: Network automation and ICT technologies, Total concept of the rural networks, Operation and ownership of a network company, Integration of the distributed generation to the electric network, and Utilisation and development of the AMM technology.

The starting point for the Road Map 2015 project was the project "Distribution Network 2030, Vision of the Future Power System" completed in autumn 2006; the project was carried out in cooperation with the stakeholders in the electricity distribution sector and it was coordinated by the Technical Research Centre of Finland VTT /1/. To reach the objectives defined in the Distribution Network 2030, the preparation of the Road Map 2015 project was started in September 2006, and the actual project commenced at the beginning of 2007. By the support of the Finnish Electricity Research Pool and the Finnish Energy Industries, the research projects were determined in close collaboration with a large expert group representing electricity distribution companies and service providers in the field, and the representatives from various research institutions and universities. Also representatives from the technology and ICT industries participated in the determination of the project; further, comments from the industry were heard in the project evaluation phase. Hence, the entire electricity distribution sector was involved in drawing up the Road Map 2015 for research.

The objective of the Road Map 2015 project was to generate a controlled process for technology development and enhancement of innovations in order to move from the present to the target state as defined previously in the Distribution Network 2030 project.

The projects defined in Road Map 2015 are short- and long-term research projects, development and pilot projects. With the road map, the coordination and efficient utilisation of resources can be guaranteed.

Road Map 2015 is divided into two closely interrelated entities:

1) Thematically organised workshops on electricity distribution topics and
2) Development projects concerning the products and services of the manufacturing industry and service enterprises in the field.

The research topics defined in the Road Map 2015 project can be grouped into four thematic sections:

- *Electricity distribution business and operational efficiency of an electricity network company, 2.3 M€*
- *Electricity distribution business and operational efficiency of an electricity network company, 5.6 M€*
- *Network automation and new automation technology, 5.0 M€*
- *Service operations and distribution network maintenance, 5.4 M€*

For the above areas, the total research investment for the period of eight years is 18.4 M€.

Introduction

The implementation of substantial changes in electricity distribution networks takes several years, even decades. The achievement of the set objectives calls for a systematic, long-term action plan, which is updated according to changing environmental factors and to the financing and realisation of which the different stakeholders commit themselves. The action plan is not merely a renewal project based on the adoption of new technology. The situation becomes more complicated, when we have to take into account the new sources of energy, new business concepts and political decisions associated with energy production. Moving gradually away from oil-based fuels to other sources of energy in transport also has a further influence on the situation.

The planning of Road Map is influenced by international programmes and development projects; the Finnish development actions have to be appropriately integrated into the international research and development. Further, in our activities, we have to be able to focus on the right areas in the on-going change process. The electricity networks and energy systems are developed at the Nordic, European and global level. By correctly focusing and prioritising our development activities, we will be able to maintain our competitiveness and improve our position in the international markets of energy generation and distribution.

In Finland, the renewal of electricity networks has become a topical issue because of the condition of ageing wood poles but also because of the tightening requirements set by the information society to the quality of electricity. Something has to be done fairly soon about the lines built in the 1960s and 1970s; owing to environmental considerations, the preservation of wood poles cannot be continued by the methods applied so far.

Development needs for both rural and urban networks arise from the increasing reliability requirements, which result from an increase especially in the loads sensitive to supply interruptions and quality deviations. In addition to the capacity utilisation rate and the new control technology, reliability issues play a key role in the development of power transmission networks. Protection against blackouts is an important factor when planning the development of network structures and also when considering network improvement investments.

As to the factors associated with technologies and the operational environment, the rapid techno-economic development of power electronics and ICT together with changes in the community structure and pressures imposed by environmental factors on energy generation have the greatest impact on the current development actions. These factors play a key role in the development of power systems in the long term.

The need for a Finnish road map is also manifested by the fact that similar national road map projects have already been executed in a number of countries, for instance in the U.K., the U.S.A. and Canada. In Europe, there is the ERMInE project that will continue until the end of 2007. In Finland, large electricity network companies also have projects of their own, and the Finnish technology industry has shown interest in projects associated with the development of the future network solutions both for domestic and export markets.

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1 Content of the research

1.1 Project objectives

A key objective of the project is to define a broader research context; the Road Map 2015 project is an extensive co-ordination action networking a number of research units and industry. The role of the Road Map project in the technological development of the electricity distribution sector is illustrated in Figures 1.1 and 1.2.

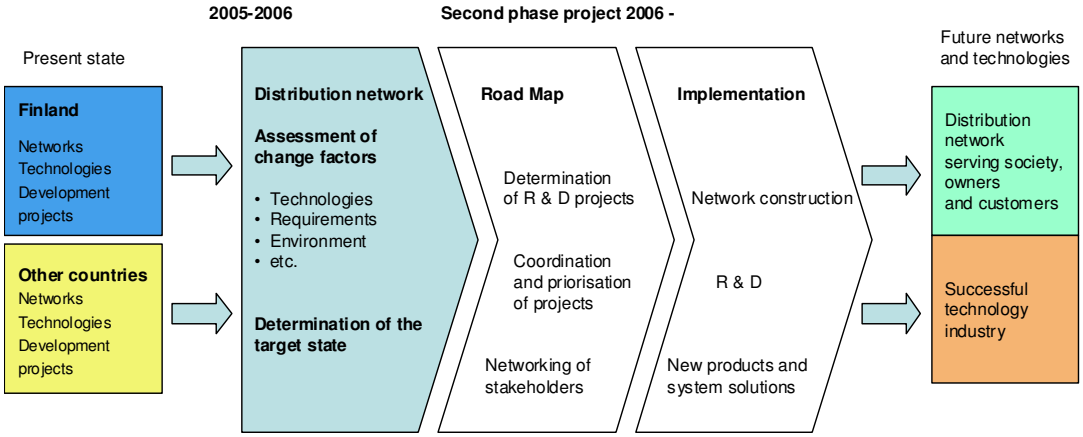

Figure 1.1. Role of the Road Map 2015 project in the technology development in the electricity distribution sector /1/.

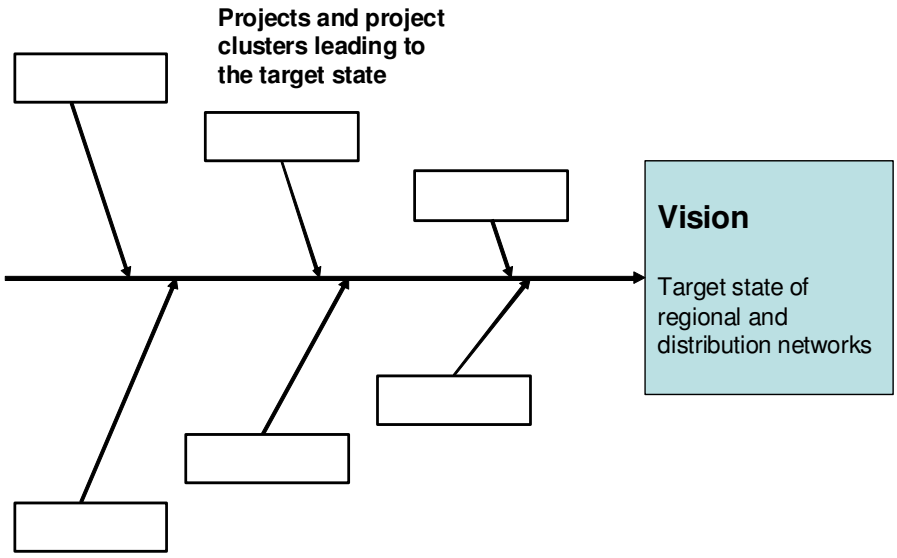

Figure 1.2. Role of the vision in the determination of the objectives of the Road Map 2015 project /1/.

The key objectives for the electricity distribution networks of the future are improved reliability, a significant decrease in the blackout probability, cost efficiency, taking the future regulation rules into consideration, environmental issues, an increase in distributed generation, adaptability of the networks, and "the focal points of the visions" (see /1/, Chapter 7). In addition to the objects defined in the Distribution Network 2030 Report /1/, the Road Map 2015 programme also includes the use of electricity and AMM technology.

1.2 Alignment of the research projects

The Road Map project was divided into two closely related entities:

1) **Thematically organised workshops on electricity distribution topics** and
2) **Development projects concerning the products and services of the manufacturing industry and service enterprises in the field**.

The project aimed at the following results:

- Determination of the anticipated challenges and recognition of the development needs both in technology and operations. The areas of emphasis in the research were the primary network, power quality and reliability issues, services based on ICT, and the new business concepts.
- A research map was drawn up of the national actions and projects to be implemented in Finland, taking into account the research activities in other countries. The research map includes various proposals for research projects in the field. With the research map, it is possible to divide the topic area into sections, to see how different projects are linked together, to identify possible gaps and overlaps in the research field, to perceive the temporal location of research activities, the need for resources and the anticipated deliverables from the project.
- Among the objectives of the project is also to raise discussion on the adaptability of the solutions found from other countries to the Finnish and Nordic conditions, and thereby to foster international cooperation.

The project answered the following questions:

- What are the most essential anticipated development needs in the Finnish regional and distribution networks?
- What research projects should be started in the field? How are these projects linked to each other? What are the larger units to be formed of these research projects?
- How are the construction and maintenance actions allocated in the near future to ensure that, taking into account the long life spans of networks, the future standards are met in an economically acceptable way? How are the projects funded and what are their opportunities?
- What are the most essential development needs concerning the products and services of the manufacturing industry and service enterprises in the field?

The objective of the item 2 is to describe and plan, together with the manufacturing and service industry, the projects by which the products, systems and services in the market are kept competitive both in the domestic and export markets.

The thematic areas of the item 2 are: development projects associated with component technology, service products, installation technology, accessories and materials, business concepts and end-customer services. Besides the development projects related to the actual technology and products, also the demonstration, piloting and promotion of the adoption of new solutions are within the scope of the survey.

2 Financing and implementation of the research

2.1 Participants and sponsors

The electricity distribution sector was extensively represented in the Road Map 2015 project: research institutions and universities, electricity network companies, sales companies, service providers and technology industry all participated in the project implementation. The project stakeholders are illustrated in Figure 2.1.

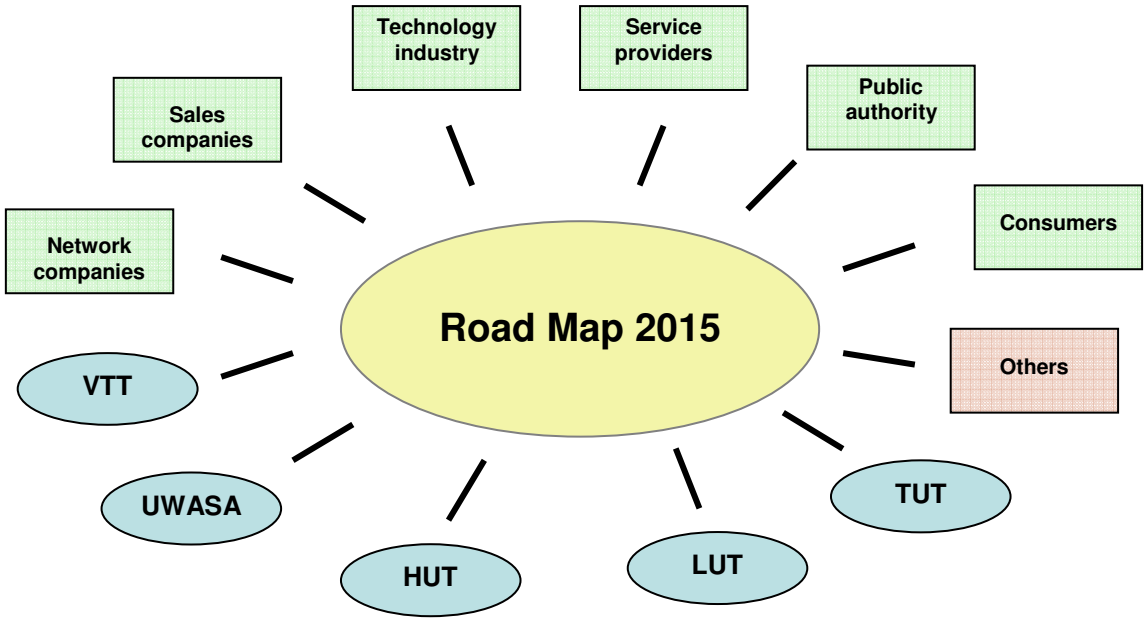

Figure 2.1. Stakeholders in the Road Map 2015 project.
(VTT=Technical Research Centre of Finland, UWASA=University of Vaasa, HUT=Helsinki University of Technology, LUT=Lappeenranta University of Technology, TUT=Tampere University of Technology)

The Road map 2015 project was financed by the same stakeholders that were already participating in the Distribution Network 2030 project; new stakeholders to finance the project were ABB Pienjännitekojeet (Low Voltage Products) and Prysmian Cables and Systems.

The project stakeholders and their financial contributions are presented in Appendix 1.

The project was managed and coordinated by Oy Merinova Ab. The project partners were VTT Technical Research Centre of Finland, University of Lappeenranta, Tampere University of Technology, Helsinki University of Technology, University of Vaasa, the Finnish Energy Industries, and the Finnish manufacturing industry. The chairs of workshops came from energy industry, while Workshop 5 was chaired by Merinova. The project was financed by electricity network companies, ABB, Prysmian Cables and Systems and Ensto Sekko, and their representatives participated in the workshops as responsible experts and utilisers of the research results. In addition, Finnish Electricity Research Pool took part in the project by providing funding and expertise and by publishing information material on the project results.

2.2 Research implementation

The research was carried out in cooperation with the parties concerned in five workshops structured around the themes of the project plan. The first four workshops were planned and organised in cooperation with the chairs representing energy industry and

the secretariat representing four universities of technology operating in the field. The fifth workshop was organised by Oy Merinova Ab, the responsible organisation, at the premises of the University of Vaasa.

2.2.1 Starting phase of the research

In the first phase of the research, based on the Workshops 1–4, twenty research and development themes that were considered the paramount ones were determined. Short project descriptions were compiled on these themes, and they were sent for the participants of the workshops for scoring during the summer of 2007. As a result, a project list set in priority order by the workshop participants was obtained.

2.2.1.1 Starting phase project descriptions: financing needs

The estimated financing need of the twenty project descriptions of the initial phase amounted to about 18.4 M€.

2.2.2 Continuation of the research

The project list was processed further in the fifth workshop held at the beginning of September 2007. In the workshop, the projects were grouped according to themes into larger project units:

- Service products for electricity network companies
- Products of electricity distribution technology
    - Systems and components
    - Information and communications technology
- Products associated with the development of network company business activities

The workshop discussed the financing of the 20 project proposals, their scheduling and dependence on each other. It was suggested that some project proposals should be combined to get a better general view of the project plans.

3. Twenty projects set in priority score order in the workshops 1 – 4

Table 3.1 lists the projects in the priority score order. Here it is worth noticing that all projects have received the full twelve points from some scorer, and therefore the distribution of scores in the graph of Figure 3.1 is quite even. Hence, the scoring does not give a clear signal how to cut down the number of projects.

Table 3.1. Projects in priority score order

Project title	Total	Share of max. score
Network automation and ICT technologies	256	39.5 %
New electricity distribution system	229	35.3 %
Total concept for rural underground cable network	227	35.0 %
Regulation models and control effects	203	31.3 %
Integration of distributed generation into the electricity network	193	29.8 %
Development of energy efficiency	186	28.7 %
New customer services and marketplace development in a network company	169	26.1 %
Development of new protection solutions	164	25.3 %
Development of technical solutions in AMM systems	158	24.4 %
Development of service market	141	21.8 %
Development of technical solutions in regional networks	140	21.6 %
Development of urban distribution networks	138	21.3 %
Management of blackouts	131	20.2 %
Improving the process efficiency in a network company by AMM	125	19.3 %
Effects of blackouts from the electricity user and society viewpoint	124	19.1 %
Power electronics and DC distribution in electricity distribution	116	17.9 %
Operation and ownership of a network company	108	16.7 %
Development of customer information and self-services	87	13.4 %
New-generation information application system for asset management	84	13.0 %
Development of regional network management	67	10.3 %

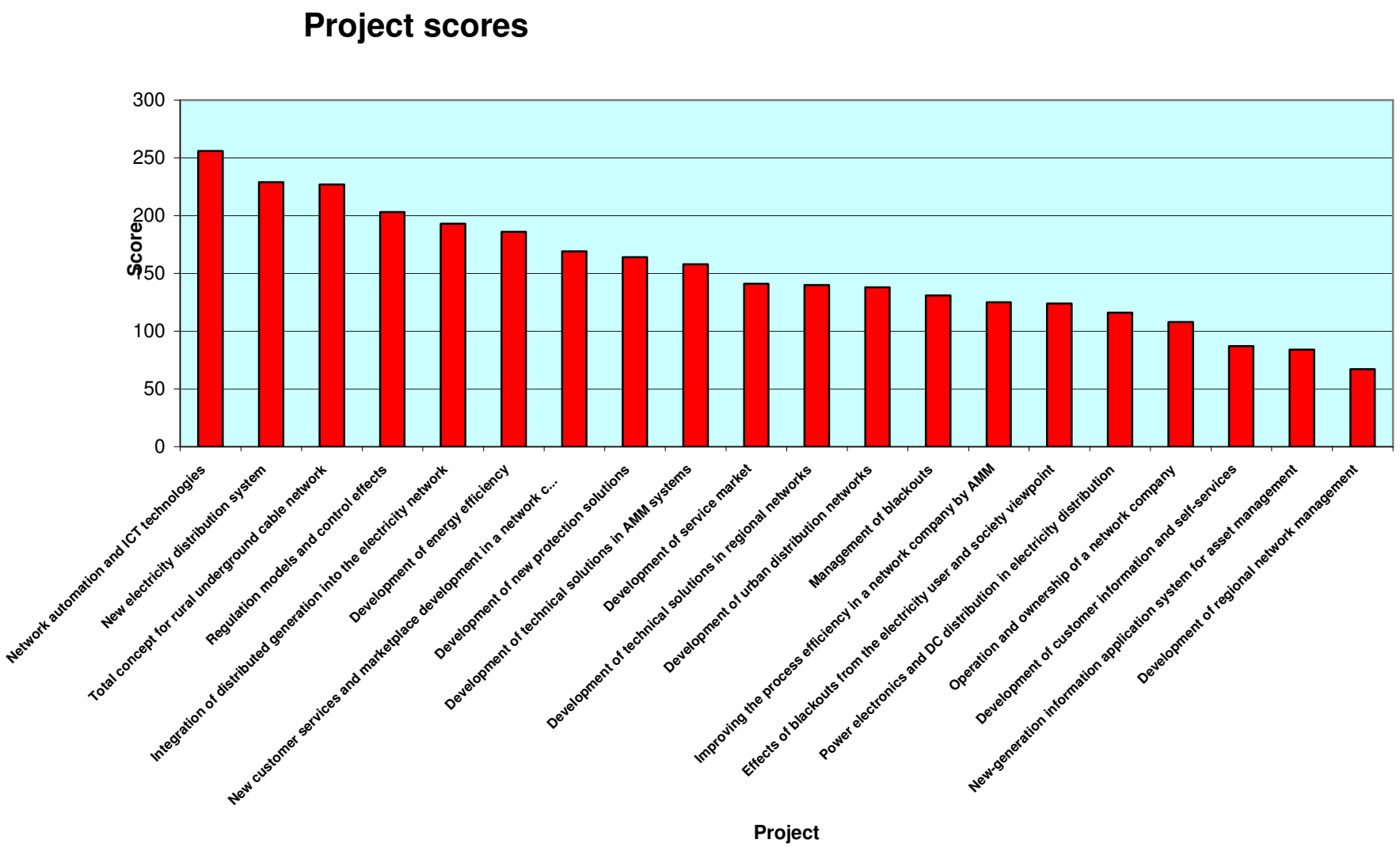

Figure 3.1. Project scores

4. Combination of projects and removal of overlaps

4.1 General

To condense the project proposals, to remove overlaps and to identify the most promising projects from the perspective of export and job opportunities, Workshop 5 was held in September 2007. The twenty spearhead projects identified in the first phase were divided into three themes:

- **Products associated with the development of network company business activities**
- **Products of electricity distribution technology**
  - *Systems and components*
  - *Information and communications technology*
- **Service products**

Of the above themes, the products of electricity distribution technology have further been divided into subcategories so that the projects focusing on the primary-side technology and the ICT-related projects constitute groups of their own.

4.2 Results of condensing the projects

By combining projects that were closely interrelated, the list of twenty projects could be cut to twelve. The scheduling of the projects was extended over the entire duration of the Road Map 2015 project so that there would be some activities also for the final years of the project. In the discussions concerning the financing opportunities for the projects, it was found that the total sum of 18.3 M€ of the budget estimates is outside the scope of the research budgets in the field. Therefore, in the financing phase, there is still need for cutting down the projects.

It was decided to combine the two projects under blackout research as a single project, and the order and schedule of the subprojects were rearranged. It was found that it is necessary to draw up and complete a code of practice and reliability criteria for blackout situations before the state imposes any requirements or sanctions on the subject.

4.3 Concise list of the projects

The Road map 2015 research projects are listed in Table 4.1 in the priority score order.

Table 4.1. List of the projects included in the Road Map 2015

Project No.	Project title	Costs k€	Years
1	Network automation and ICT technologies	3190	2008 - 2015
2	Total concept for rural distribution network	1400	2007 - 2010
3	Operation and ownership of a network company	1345	2007 - 2014
4	Integration of distributed generation into the electricity network	1000	2008 - 2013
5	Utilisation and development of AMM technology	4744	2008 - 2013
6	Development of service market	591	2008 - 2009
7	Development of new protection solutions	500	2007 - 2009
8	Development of regional networks	1550	2008 - 2015
9	Development of urban distribution networks	830	2008 - 2012
10	Effects of blackouts from the electricity user and society viewpoint, management of blackouts	850	2008 - 2012
11	Power electronics and DC distribution in electricity distribution	1490	2007 - 2011
12	New-generation information application system for asset management	860	2008 - 2010
	Total k€	**18346**	

Those interested in cooperation or joining the projects are kindly asked to contact

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4.4 Road Map 2015 project map

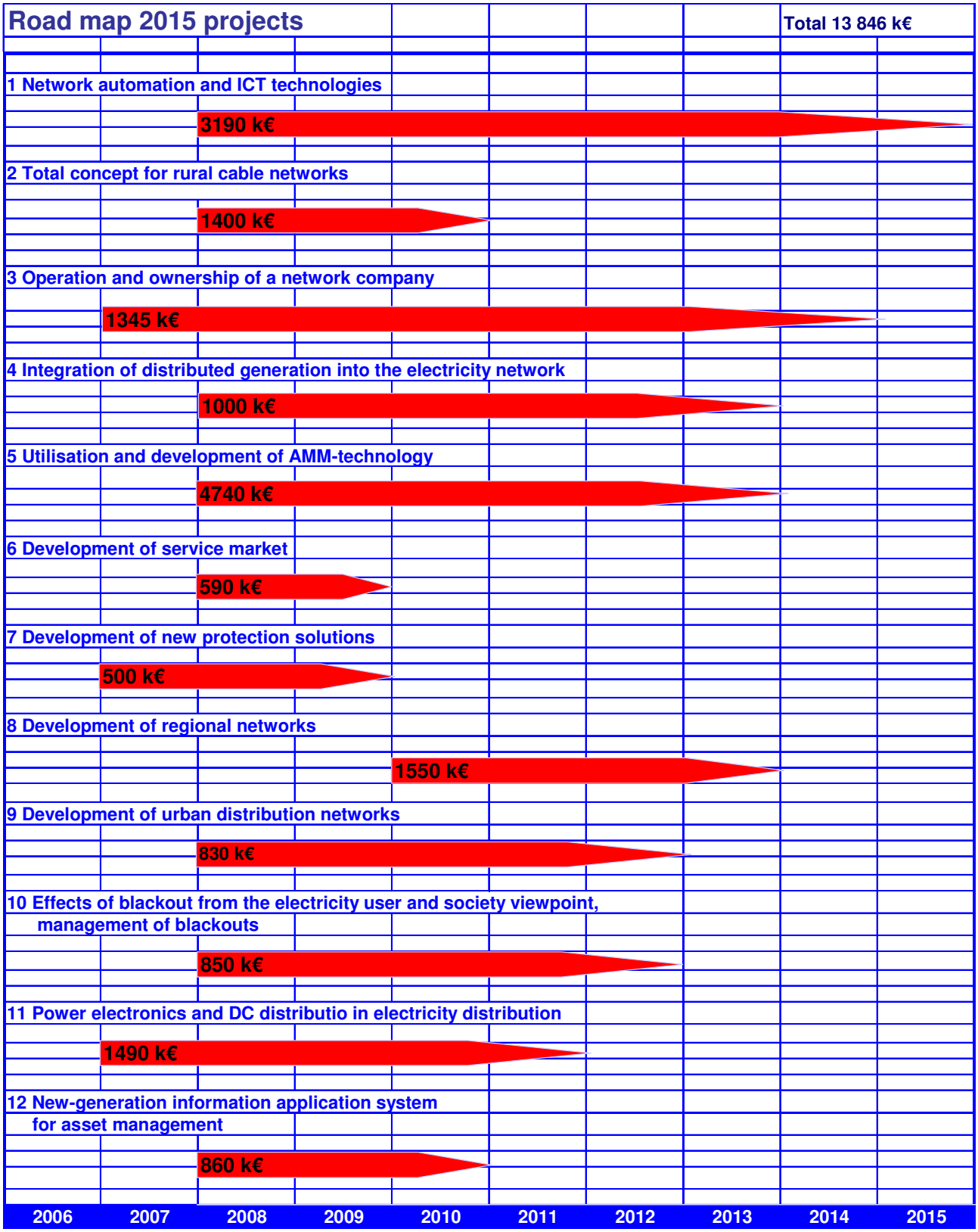

Figure 4.1 Road Map 2015 projects and their estimated costs

4.5 Road Map 2015 technology projects

Figure 4.2 lists those Road Map 2015 projects that are anticipated to have the highest potential for generating new, exportable technology.

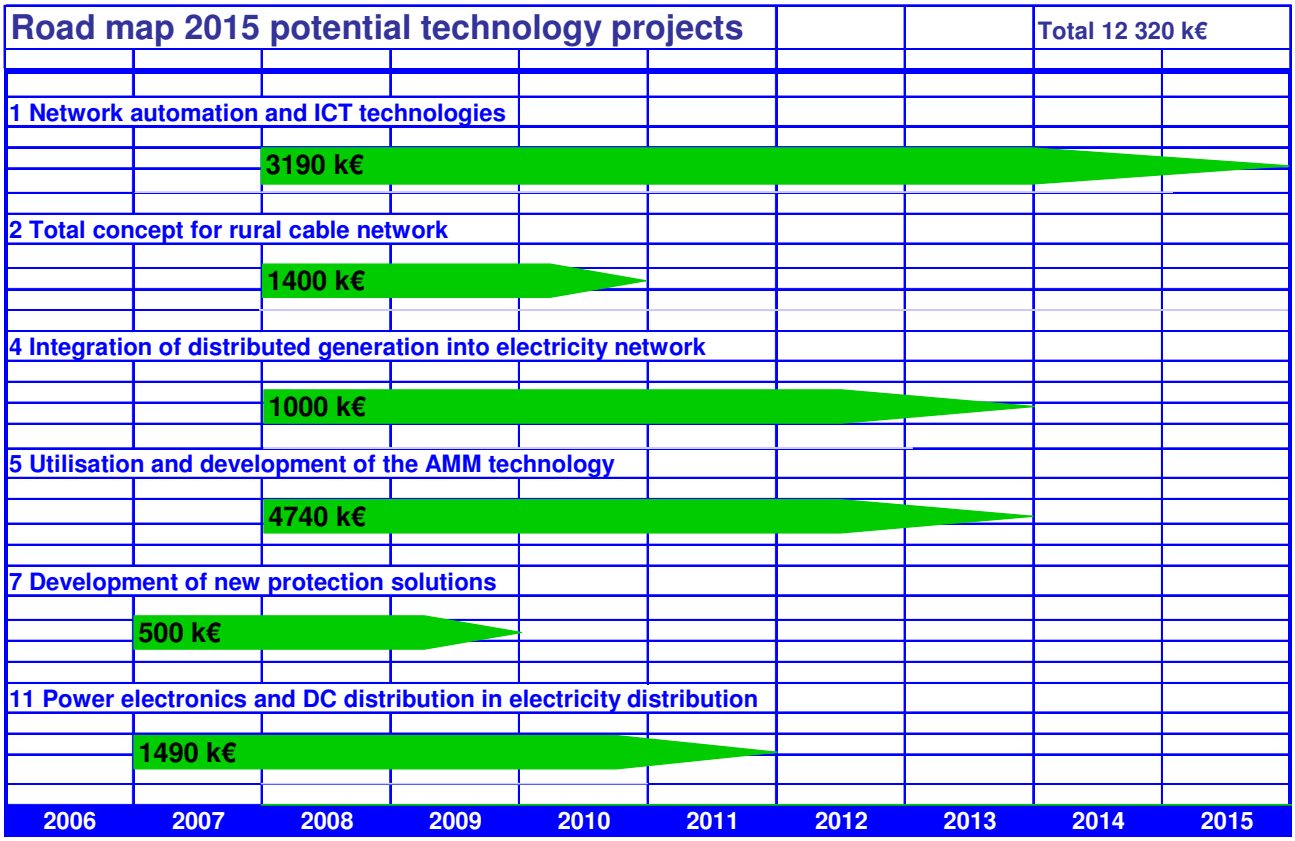

Figure 4.2. Road Map 2015 technology projects and their estimated costs

4.6 Comparison with the targets of the Distribution Network 2030 project

Figure 4.3 illustrates the research areas of the Distribution Network 2030 project. The violet background indicates the research targets introduced in the Road Map 2015 project descriptions, while the new research topics are coloured with blue. As we can see, the research topics identified in the Road Map 2015 project cover quite well the research topics of the Distribution Network 2030 project.

The Road Map 2015 project does not have a direct connection to the target areas of *forests and land use*, *simulation*, *switchgear*, *distributed protection*, *live working*, *backup power* and *energy storages*.

Important issues in this list are the switchgear adapted to the Finnish weather conditions, required to improve the power quality and reliability of old overhead networks, and the associated distributed protection, that is, equipment required for sectionalisation, and the energy storages for microgrid solutions and for protection against short-term power failures. These technologies do not necessarily have to be produced in Finland, but it should be ascertained by demonstrations and piloting that we have access to the reliable technology.

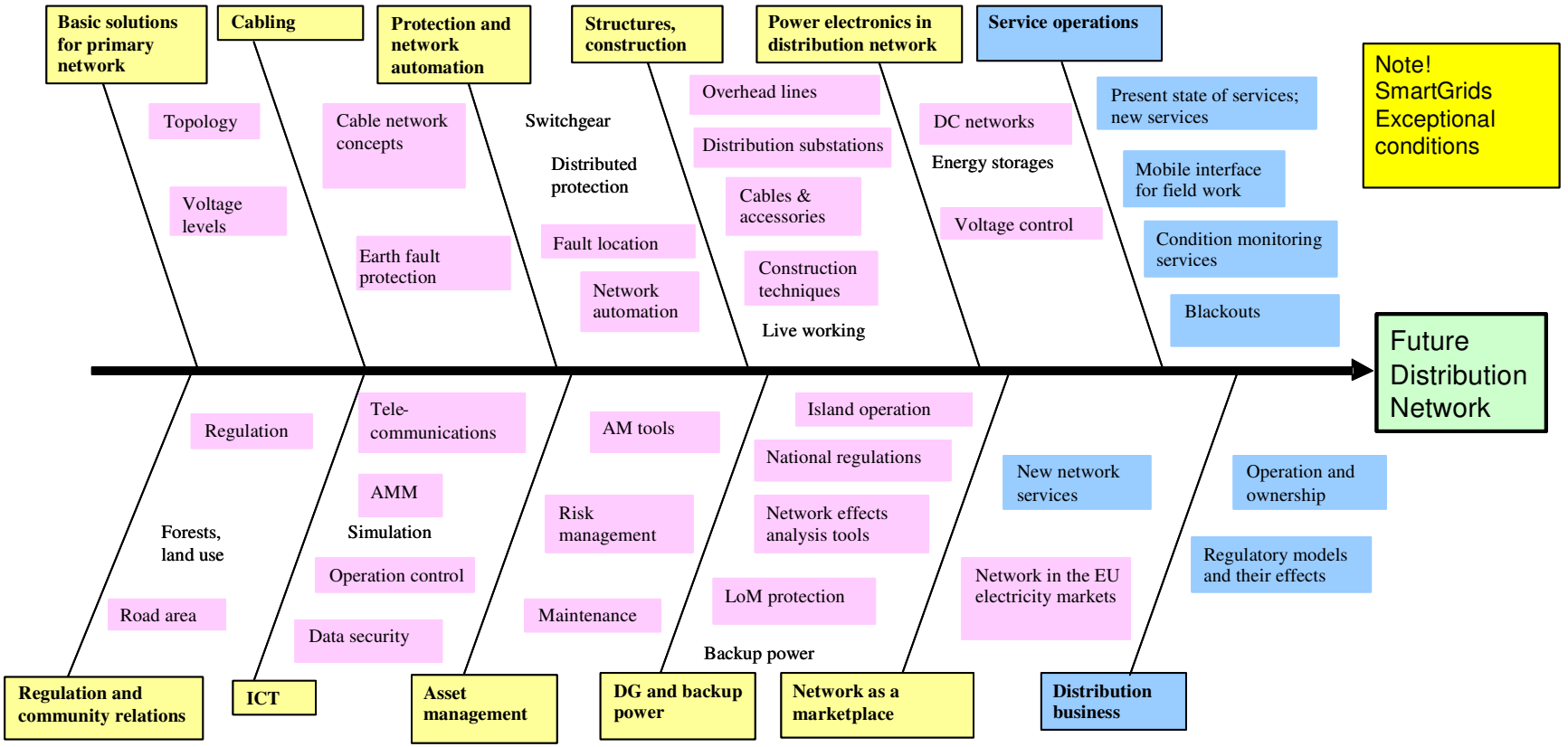

Figure 4.3. Comparison of the project areas of the Road map 2015 with the objectives of the Distribution Network 2030 project; new research topics included in the Road Map 2015 /1/.

5 Technology development opportunities in Finland

When drawing up the final project descriptions, it has to be considered whether the primary-side technology (lines, nodes) and the related automation could be separated from each other in the new electricity distribution technology. As for network automation, there will probably be two main lines for quite a while: 1) the new technology, in which all the automation is already integrated into the primary equipment and 2) "gluing" the automation to the old system by various separate automation components. For example, in manufacturing or original installation, automation can be enclosed inside a light kiosk substation that provides protection against weather. Intelligence integrated into primary-side products brings competitive advantage.

A major challenge for the communication and information systems is the automation of distribution substations and the low-voltage network, not to mention the inclusion of hourly AMR in the automation. The information systems are undergoing a substantial change. Will the future solution be that monitoring of the distribution network and distribution substations is included in the SCADA, and AMR in a system of its own?

As a whole, the AMM technology and the related ICT, including the development opportunities for services, offer a huge business potential, if the development of 2nd- and 3rd-generation solutions is carried out fast and efficiently. This technology also has export potential. Therefore, all the projects utilising AMM or developing AMM technology were gathered under an umbrella project, which now consists of 17 subprojects; this way, it is easier to perceive the role of AMM technology. The total budget of the umbrella project, obtained by summing up the budgets of the subprojects is 4.7 M€.

The lack of commercially available switchgear adapted to the Finnish conditions may prove a bottleneck for the new network solutions. The development opportunities for medium-voltage switchgear, e.g. with respect to testing capacity and insulation technology, have already been used up. Furthermore, the volumes in the domestic markets are too small compared with the required development efforts.

6 Financing opportunities and distribution of financing

Potential sources for financing mentioned in the project descriptions are:

Finnish Electricity Research Pool

Companies in the field:

- electricity network companies
- electricity vendors
- service companies
- technology industry
- research funds

Public authority:

- TEKES
- EU
- Nordic research funding
- various ministries
- Electricity Market Authority
- legislative organs
- consumer associations
- universities

The figure below illustrates a model for the distribution of the financial contributions from the stakeholders of the Road Map 2015 project.

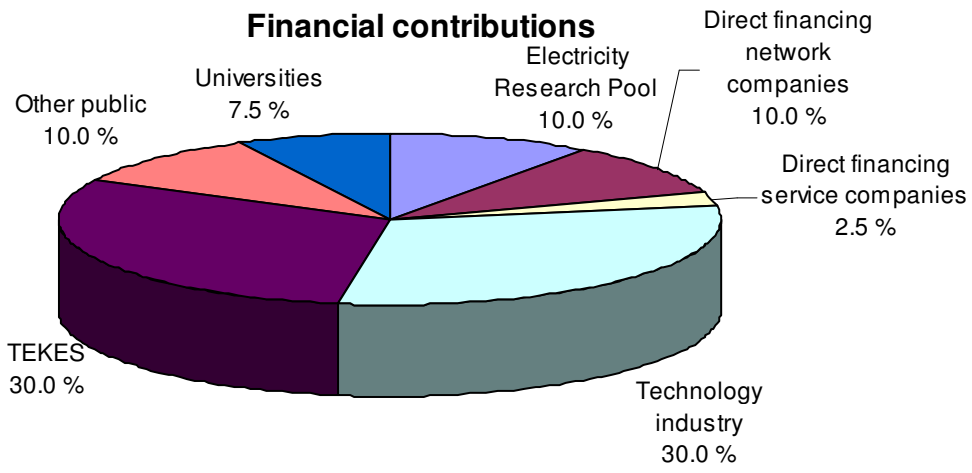

Figure 6.1 Outline of the distribution of the financial contributions between the parties of the Road Map 2015 project.

Starting from the total financing need of 18.4 M€ for eight years as presented in Table 4.1, we obtain the annual financial contributions from the project stakeholders as shown in Figure 6.2.

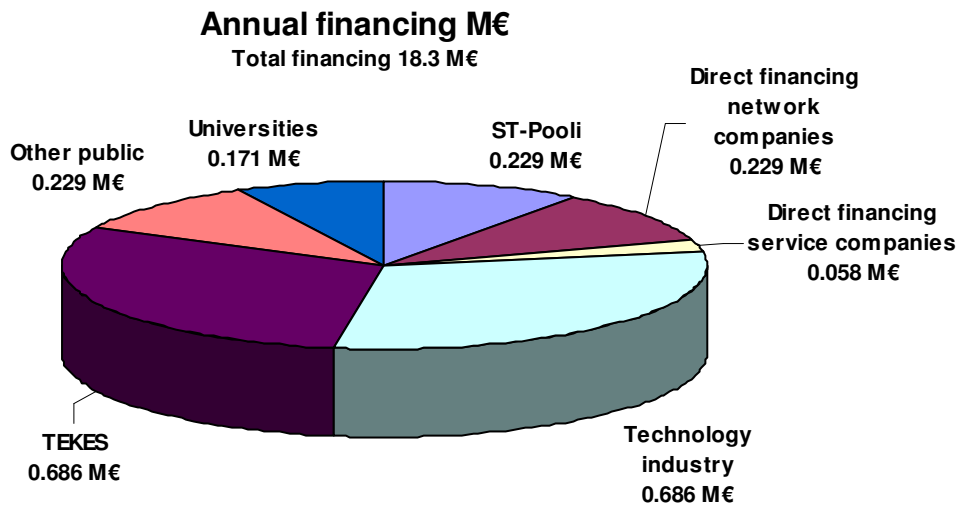

Figure 6.2. Annual financial contributions with a total budget of 18.4 M€ for the Road Map 2015 project.

If the number of subprojects in the Road Map 2015 project is decreased so that the project financing is cut down by a third, that is, the total financing need is 12.2 M€, we obtain an annual need for financing as shown in Figure 5.5.

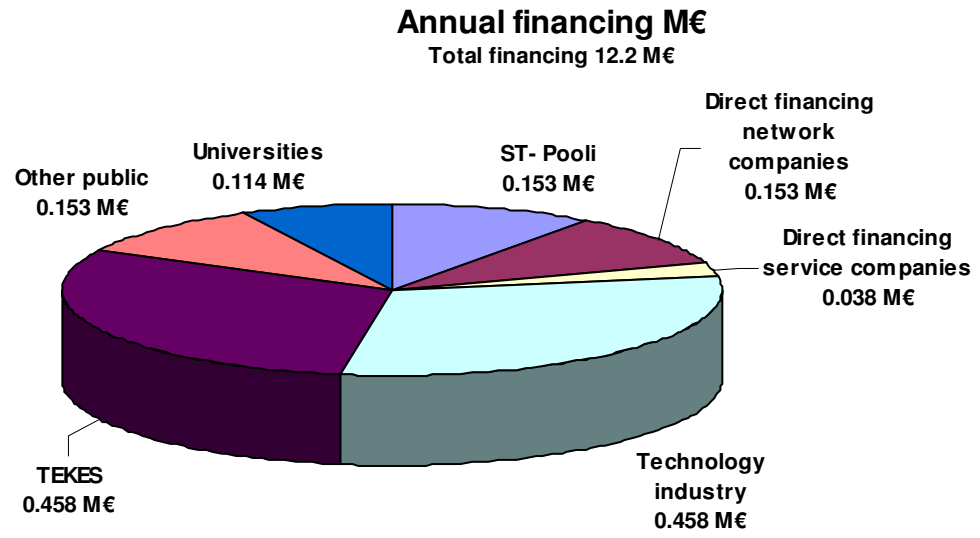

Figure 6.3. Annual financial contributions with a total budget of 12.2 M€ for the Road Map 2015 project.

7 Ongoing international research activities

7.1 SmartGrids Technology Platform

A Technology Platform closely related to the Road Map 2015 project is the "European SmartGrids Technology Platform, Vision and Strategy for Europe's Electricity Networks of the Future" under the 7th Framework Programme (FP7) of the EU. The preparation of the SmartGrids Platform was started in 2005 with the aim to generate a development vision and strategy for the European electricity transmission and distribution systems up to 2020.

The scope of the SmartGrids Platform is larger than that of the Road Map 2015 project, including for instance power transmission systems, energy generation and storage. Figure 8.1 depicts the operations of the SmartGrid Technology Platform /2/.

Figure 7.1. SmartGrids Platform Operations /2/ p. 33

Areas of operation common with the Road Map 2015 project are for instance network asset management, network technology and operation, consumer services and energy metering.

Two extensive documents have been published on the SmartGrids Platform:

/2/ EUR 22040: European Technology Platform Networks of the Future for Europe's Electricity Vision and Strategy SmartGrids
European Commission, 2006, 44 pp, ISBN 92-79-01414-5

/3/ EU 22580: Strategic research agenda for Europe's electricity networks of the future
Directorate-General for Research Cooperation Energy, 2007, 92 pp,
ISBN 92-79-03727-7, ISSN 1018-5593

Information on the calls for proposals for 2007 under the SmartGrids Platform can be found in the document

/4/ Work programme 2007, Cooperation theme 5, Energy
European Commission C (2007) XXXXX

Information on the call dates for SmartGrids projects for 2008 can be found in the FP7 Energy Research website and on the Smartgrids homepage **www.smartgrids.eu**. The Second General Assembly SmartGrids will be held in Bad Staffelstein, Germany in the monastery of Kloster Banz on 8–9 November 2007. A document under preparation that is of importance for the Road Map 2015 project is the Strategic Deployment Document (SDD) of the Smartgrid TP, the draft of which will be discussed in the General Assembly in Bad Staffelstein.

Information on the SmartGrids TP is available also at the TEKES website. There are no Finnish members in the Advisory Council of the Smartgrids Technology Platform, but in the Mirror Group there is a Finnish member Jari Eklund from TEKES.

7.2 ERMInE project

The Electricity Research Road Map in Europe (ERMInE) project is an European cooperation action for the years 2006–2007, supported by the European Commission under the 6th R & D Framework Programme. The project partners are Norway, Poland, Italy and the Netherlands, and EURELECTRIC from Belgium. The project homepage: **http//:www.ermine.cesiricerca.it**.

The boundaries of the project are electricity generation, transmission, distribution and end-use (customer interface). Four Area Workshops covering the entire Europe have been organised within the project. Workshop 1 – Western Europe was held in Brussels, Workshop 2 – Northern Europe in Oslo, Workshop 3 – Eastern Europe in Warsaw and Workshop 4 – Southern Europe in Rome. A focused meeting was held on 2 October 2007 in Milan for the discussion and validation of the ERMInE Road Map, and the results of the ERMInE project will be presented in the Final Conference in Brussels in February 2008. The conference programme was not available at the time of writing this report.

7.3 CIRED 2007

CIRED *(Congrès International des Réseaux Electriques de Distribution)* is an international conference on electricity distribution. The first CIRED Conference was held in 1971. The conference was first held every two years alternately in Belgium and the United Kingdom. The latest CIRED Conference took place from 21 to 24 May, 2007 in Vienna, Austria. A number of 1101 participants attended the conference, and there were about 30 research reports from Finland. Finland is represented in the CIRED Directing Committee by Pertti Lindberg from the Finnish Energy Industries, whereas in the Technical Committee there is no Finnish representative at the moment. CIRED homepage: **www.cired.be**. Information on the CIRED Finnish National Committee is available at **www.energia.fi/fi/kvasiasiat/cired**.

CIRED focuses on the design, construction and operation of public distribution systems and of large installations using electrical energy in industry, services and transport. Some idea of the scope of the activities may be gained from the list of reports of the Vienna Conference.

List of reports

Session 1 NETWORK COMPONENTS
- Design
- Life cycle of components
- Environmental issues
- Dialogue session

Session 2 POWER QUALITY AND EMC
- LF Distributing Phenomena
- Power Quality
- Electromagnetic compatibility (EMC) and safety problems
- Improving Power Quality and Managing Electromagnetic Fields
- Dialogue session

Session 3 OPERATION, NETWORK PROTECTION & CONTROL
- Operation
- Network control (monitoring, protection, control)
- Dialogue session

Session 4 DISPERSED GENERATION - MANAGEMENT & UTILISATION OF ELECTRICITY
Dispersed Generation
Energy Efficiency
Demand Side Management (DSM)
Dialogue session

Session 5 POWER DISTRIBUTION SYSTEM DEVELOPMENT
Impacts and influences on planning
Criteria, methods and systems for achieving the goals
Real and practical experiences
Dialogue session

Session 6 MANAGEMENT-ORGANISATION SKILLS
Business goals and strategies in electricity distribution
Organisation and business structures in electricity distribution
Human resource management and professional skills in electricity distribution
Competitiveness including reduction in costs in electricity distribution
Dialogue session

SPECIAL REPORTS
Network components
Power Quality and EMC
Operation of Networks
Distributed Generation
Networks Development
Deregulation-Management-Skills

Also a Technical Exhibition presenting the latest innovations, products and services is organised in association with the CIRED Conference. As a whole, CIRED is a central technology forum from the perspective of the Road map 2015 project. Active participation in the Conference provides an excellent opportunity to promote awareness of the Finnish technology know-how among the experts in the field.

7.4 IEA Implementing Agreement ENARD

The International Energy Agency (IEA) has launched a global implementing agreement Electricity Networks Analysis, Research & Development (ENARD). ENARD homepage: **http://www.iea-enard.org**

The first-year cooperation objectives are:

- the collation, exchange and promulgation of information and data in relation to current and anticipated electricity T&D developments within the participating countries and associated programme activities
- the in-depth review and analysis of the associated key R&D, design, operational and management issues in relation to electricity transmission networks
- the complementary in-depth review and analysis of a range of key issues relating to the R&D, design, operation and management of electricity distribution networks
- the in-depth review and analysis of prevalent and anticipated regulatory frameworks and their associated impact on the economic evaluation and optimisation of network asset portfolios

At present, there are eleven European countries participating in ENARD: the Netherlands, the United Kingdom, Belgium, Spain, Italy, Austria, Norway, Sweden, Finland, Switzerland and Denmark. As the IEA is a global organisation, also participants outside Europe are welcomed.

Two Annexes will commence work at the beginning of 2008:

Annex II: DG System Integration

Annex III: Infrastructure Asset Management

A fourth Annex dealing with electricity transmission issues is to be developed.

7.5 Road Map 2015 projects and international research activities

The international programmes and activities have a number of common research areas with the Road Map 2015 projects. Active participation in international projects provides an opportunity to influence international development trends and simultaneously to market in advance the technology generated in our projects. Naturally, to be successful, we have to make correct project decisions in time and be agile in our product development.

8 Interface with the strategic centre "Energy and the Environment" for science, technology and innovation

8.1 High-technology potential of the Road Map 2015 project

Of all the Road Map 2015 projects, when successful, the most promising development target is the low-voltage distribution network automation system based on AMM technology. A risk of such a system product is its marketability in export markets. The adaptation of the automation system to a local electricity distribution culture with different system and customer interfaces calls for an efficient local sales network. A small, new export company may fail to enter the markets. On the other hand, if only individual system components are marketed, the benefits of integration are not utilised.

The protection relays and power electronic devices associated with electricity use represent typical Finnish export technology, and therefore it is easier even for a small export company to find export channels for these products.

Also the traditional cable technology may have export potential, especially when combined with condition monitoring, fault location automation and modern installation techniques.

The development of energy efficiency provides a significant business opportunity for the Finnish industry, because in addition to the existing technology with development potential, it is essentially based on expertise and consultation. However, we have yet not considered energy efficiency from the international business point of view, nor have we anticipated the possible pressures imposed by the state and the EU on the energy efficiency. Certain requirements will definitely be set also for electricity network companies, and they have to be ready to somehow answer them.

Information and communications technology, automation and information systems are included in a number of Road Map 2015 project proposals, yet they do not constitute a compact unity with clear objectives, and as separate proposals, the projects are still too fragmented to reach effective overall results. If the targets are too general, productisation of technology or concepts is difficult. Further, it is not advisable to develop information technology only within the strategy centre of "Energy and the environment", but also active cooperation with the strategic centre "Information and communication industry and services" is required. A precise focus together with correct timing and appropriate techniques will bring success in international business.

In the Road Map 2015 projects, the strategic centre "Energy and the environment" has a significant international business potential available. As there already is large-scale production of electricity distribution technology for international markets, and Finland is internationally known for its expertise in certain technologies, the utilisation of this potential should not be forgotten in the future strategic centre for science, technology and innovation (SHOK).

8.2 Finland's opportunities to develop international high-tech solutions for electricity networks

In the international assessments, network automation together with communications and protection technology have been identified as the key strategic areas of excellence

of the Finnish export industry. For instance in the international assessment /5/ carried out in connection with the SmartGrids Platform, Finland was ranked among the four European top countries. In addition to the significant export industry in the field, also the systematic and internationally documented research made from the early 1990s onwards in the EDISON, TESLA and DENSY technology programmes of TEKES has contributed to this top ranking.

Instead, development efforts associated with primary-side equipment, especially medium-voltage circuit breaker technology, have been practically non-existent both in Finland and in Scandinavia. We have also lost medium-voltage instrument transformers and cast-resin insulation technology in the international division of tasks.

In the field of renewable energy generation, our strength lies especially in wind power components: generators and the related power electronics. The slow progress of the domestic wind power construction compared with the leading European countries has limited the domestic delivery of equipment to individual demonstrations and pilot projects. Also in diesel technology, the use of palm oil and other biofuels will increase. If the international markets for wind power installations open up to the Finnish industry, we already have the readiness to include protection and grid connection technology to these installations. In diesel power plants, electrification and automation have traditionally been included in the delivery.

Finland has a long tradition in electricity meter and automation manufacturing. The new AMM technology has also brought new enterprises to the field. As we already have expertise in ICT, the area of low-voltage network automation may offer an interesting target for business development, if we are ready to react rapidly and are successful in product development.

Considering the international division of work and export in the field of electric power systems, the protection of medium-voltage networks is among the strengths of Finland. As we have also new and expanding export-oriented industry in protection technology, and the connection of distributed generation to the grid is creating development needs for protection, the network protection will constitute a key area of expertise in Finland also in the future.

Our expertise in power electronics is one of the cornerstones of the Finnish electrotechnical export. If the application and use of power electronics increase in the distribution networks or the DC distribution gains ground, these new technology products will fit well in our export assortment. A power electronics unit to connect distributed generation to the grid in the MicroGrid power range would be such a potential product.

8.3 EU Energy Policy

The European Commission has unveiled its Action Plan on Energy Efficiency to reduce energy consumption by 20 % by 2020. At the same time in Finland, the target is to increase the share of renewable energy to over 30 % of the gross energy onsumption in 2010. As electric energy constitutes a significant part of the total energy consumption, the electricity distribution technology, which is in the focus of the Road Map 2015 project, is required to support achieving these objectives.

Efficient use of electric energy calls for reduction of losses and efficiency improvement in various processes. Examples of advances are the rotation control implemented with frequency converters in various processes in industry, building automation and civil engineering, and the application of LED technology in lighting.

8.4 Development needs in electricity distribution networks

As it was stated previously, the Finnish rural power systems built in the 1960s and 1970s are reaching the end of their technical lifetime; simultaneously, requirements related to power quality and reliability are increasing in significance. Power quality and reliability of supply can be improved by increasing the cabling rate, by network topology, and by transferring power lines from forests to roadsides. A rapid way to limit the effects of disturbances is to increase network automation.

On the other hand, the development of information and communications technology provides new opportunitites for protection, automation and energy metering in electricity networks. In the future, it will be possible to monitor energy consumption and the state of the whole network in real time. Hourly metering of electric energy enables the generation of real, consumer-specific consumption profiles, thus making it possible to abandon load models. Consequently, the network planning principles can be further specified.

While nowadays automation and sensoring typically extend from the control room to 110/20 kV primary substations (disconnector substation automation as an exception), in the future, the entire distribution network will be within the scope of automation. Also distribution substations and low-voltage networks will be within control and sensoring.

In the future, the "3rd-generation" remotely read energy meter will play a central role in the automatisation of low-voltage networks. The meter acts as an intelligent terminal at the consumer, and in addition to properties associated with energy metering and bidirectional data transfer, it should be able to transmit energy consumption controls to the customer's devices. The latter characteristic is essential for the temporal control of the energy-saving automation and energy consumption.

The above-described vision for the automation of the entire electricity network presents great challenges for the data transfer capacity of the automation systems and for the systems themselves. Instead of 10 to 30 primary substations, automation will cover hundreds of distribution substations, and thousands or even tens of thousands of customers. This implies that an automation system of its own probably has to be developed at least for the AMM of low-voltage networks. By renewing and developing the DMS further, it may be possible to include the distribution substation automation in the SCADA system. Thus, based on the above, we can see that there is a massive development wave coming, on which we can ride if we are able to react fast.

Distributed energy generation and new network solutions build pressure on the development of network protection. Development targets are for instance: loss of mains protection, adaptive protection, multi-criteria algorithms, increasing intellligence in protection, and more extensive utilisation of communications technology.

The technical development and rapidly decreasing costs of power electronics create opportunities to apply power electronics and DC distribution solutions also in electricity distribution. Possible applications are for instance the connection of microgrids and distributed generation to the grid and the power electronic units, "power quality stations" to improve the customer power quality.

Conclusion

General

In the Road Map 2015 project, the electricity distribution sector identified a large group of research themes. The projects can be divided into two thematic units:

1. Projects associated with the electricity sales business, development projects concerning the business operations of a network company, and development projects related to the operations and services of service companies, and

2. Development projects associated with the manufacturing technology industry and information and communications industry.

The power quality experienced by the end-customers and the reliability of supply are emphasised in the operation of network companies. An electricity vendor wants the tariffs to be dynamic and reflect the market price of energy, while an electricity user is looking for low prices and stability in pricing. Service companies are trying to move from direct hourly rate billing to long-term performance-based contracts. Technology companies, ICT companies included, aim at standardised, exportable technology and product range that are suitable for all their customers.

The network companies are facing various requirements: they have to renew the rapidly ageing networks by applying the new technology, and simultaneously, they should also be able to take advantage of the automatic metering technology and the potential it provides for customer services and control of energy saving; hence, we can see that there are definitely enough challenges for the network companies when they try to find the right path for planning the future investments.

What are the further actions to be taken?

The pilot and demonstrative projects associated with the new technology promote and speed up the technology development. Therefore, it is of central importance that network companies are actively participating in these pilot projects, in which the new technology is tested. This will accelerate and promote the penetration of the new technology into the markets and facilitate the acquisition of references required in the international marketing.

Participation in international actitivities, such as CIRED, and projects like SmartGrids and IEA-ENARD is necessary in order to maintain our expertise and to market the new technology in advance. This way, we will promote our reputation as an expert in the field and prepare the ground for the export of our technology.

Because of the constant change and development in the business environment, the Road Map 2015 plan has to be reviewed in five years' time.

How will the results be utilised?

The results will be used as background information for financing considerations and preparation of research projects in the technology industry. The results may also be used for the preparation of technology development plans for distribution, electricity trading and service companies operating in the field.

Summary

For any technology product to be successful, it is necessary to follow the principle "Do right things at the right time".

Particularly in a country like Finland, where the domestic markets are small, being early on the scene with the development projects that are relevant for the future markets leads to success also in the global markets, as the new technology may benefit from the market boom and does not have to fight for a share in mature markets.

The new Finnish Electricity Research Pool will play a key role in starting and seed financing of the Road Mat 2015 projects. Successful financing decisions to promote the technology in the field will have a positive impact on the competitive position of our technology in the international markets.

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www.iea-enard.org	IEA Implementing Agreement ENARD homepage

Appendix 1

Road Map 2015 project stakeholders and their financial contributions

Project stakeholder	Share %	Financing/ €
Tekes	49.7 %	68 000
Finnish Electricity Research Pool	22.2 %	30 400
Merinova	3.1 %	4 200
Fortum Sähkönsiirto[1]	2.8 %	3 800
Vattenfall Verkko	2.8 %	3 800
Suur-Savon Sähkö	2.8 %	3 800
Vaasan Sähköverkko	2.8 %	3 800
Helen sähköverkko[2]	2.8 %	3 800
ABB, Pienjännitekojeet[3]	2.8 %	3 800
ABB, Sähkönjakeluautomaatio[4]	2.8 %	3 800
Ensto Sekko	2.8 %	3 800
Prysmian Cables and Systems	2.8 %	3 800
Total financing	**100.0 %**	**136 800**

[1] Fortum Distribution
[2] Helsinki Energy, Electrical network
[3] ABB Low Voltage Products
[4] ABB Substation Automation Products