







« *networking the networkers* »

# TERENA COMPENDIUM

of National Research  
and Education Networks  
in Europe

**2008 Edition**

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# CONTENTS

Introduction	4	3B.3 Traffic Load	51
Summary of Key Findings	6	3B.4 Congestion	56
		3B.5 IPv6	57
<b>1 Basic Information</b>	<b>11</b>	<b>3C Other services</b>	<b>60</b>
1.0 NRENs that have Responded to the Questionnaire	11	3C.1 Overview	60
1.1 Legal Form of NRENs	13	3C.2 Network Operating Centres	61
1.2 History	16	3C.3 Performance Monitoring	63
1.3 Major Changes in NRENs	18	3C.4 Optical Services	64
		3C.5 Quality of Service	65
<b>2 Users/Clients</b>	<b>23</b>	3C.6 Security	65
2.1 Overview	23	3C.7 Authorisation and Mobility Services	66
2.2 Connection Policies	25	3C.8 Housing Storage, Hosting, Content Delivery Services	67
2.3 Percentage of Total Access Capacity Available for Different Categories of Users	27	3C.9 Network communication Tools	69
2.4 Number of Connections to Universities and Bandwidth	28	3C.10 Network Computing Resources	73
2.5 Percentage of Schools Connected through the NREN	28	3C.11 e-Learning	73
		3C.12 User and Client Support	74
<b>3A Network and Connectivity Services</b>	<b>31</b>	3C.13 PR and Communications	77
3A.1 Overview	31	3C.14 Changes in Services	78
3A.2 Numbers of PoPs, Managed Links and Managed Sites on the Network	32	3C.15 Indexation of the Digital Divide	82
3A.3 Core Network Size	33	<b>4 Funding and Staffing</b>	<b>83</b>
3A.4 Core Capacity on the Network	36	4.1 Overview	83
3A.5 Expected Change in the Core Capacity in Two Years' Time	40	4.2 Staffing	84
3A.6 External Connectivity: Total External Links	41	4.3 Total Budgets, 2004 and 2008	87
3A.7 Dark Fibre	44	4.4 Income Sources	89
3A.8 Cross-border Dark Fibre	45	4.5 Expenditure by Category	93
3A.9 Networking Equipment	46	4.6 Expenditure by Network Level	93
		<b>APPENDICES</b>	<b>94</b>
<b>3B Traffic</b>	<b>47</b>	1 Alphabetical Lists of NRENs	94
3B.1 Overview	47	2 Glossary of Terms	95
3B.2 Traffic in 2007	50		

# INTRODUCTION

Since the publication of the first edition of the Compendium in 2001, it has grown into a sought-after and authoritative source of reference for all those who take an interest in the development of research and education networking. The information contained in the Compendium has continued to grow in variety and dependability, even though caution in interpreting the data remains essential.

This year's edition is the fourth that has been published as part of the GN2 (GÉANT2) project and it has benefited from the input from activity leaders in that project. This year, the editing process has been shared by John Dyer and Bert van Pinxteren. Like last year, an attempt was made to aggregate data for groups of NRENs and to look at and partially explain multi-year trends. Summarised and analytical information is provided in a number of 'overview' sections at the start of each chapter. Throughout the Compendium, analytical or explanatory text has been highlighted. Various sections in the Compendium have been re-organised, in order to align it with the taxonomy that was developed by the TERENA Task Force on Life Cycle and Portfolio Management (succeeded in 2008 by the Task Force on Management of Service Portfolios).

Some of the trends have again been summarised in the 'Summary of Key Findings.'

The production of the 2008 edition was overseen by a Review Panel composed of the following people: Claudio Allocchio (Italy), Tryfon Chiotis (Greece), Mike Norris (Ireland), Esther Robles (Spain) and Shirley Wood (UK). Input was also received from other members of the TERENA Technical Staff, the Secretary General and the Executive Committee. Anikó Nagy, who was recruited for this project as a Data Analyst, was responsible for reminding NRENs, handling requests for information and clarification and for preparing the tables and graphs.

Collecting data of this type typically requires the involvement of a number of people from each NREN, as well as careful checking by NREN staff. TERENA wishes to express its gratitude to all those in the NREN community who contributed to

the gathering, submitting, clarifying and checking of the data contained in this publication.

The Compendium consists of two parts: the basic information as submitted by the individual NRENs (available on the Web at <http://www.terena.org/activities/compendium>) and this publication.

Most tables and graphs first show the EU<sup>1</sup> and EFTA<sup>2</sup> countries and then other countries in Europe and North Africa. A list of all those countries is given in section 1.0. Data are usually presented in alphabetical order by the English-language name of each country. An alphabetical list of NRENs included in the Compendium is in Appendix 1. For the second time, countries from outside of Europe were asked to provide some basic data, in the form of responses to a mini-questionnaire. In a few cases, information from these questionnaires has been included for illustrative purposes. The full data can be found on the Web.

Note that unless otherwise specified, the data describe the situation at or close to the 31<sup>st</sup> of January, 2008.

It is hoped that this eighth edition of the Compendium will prove to be at least as valuable as the previous ones. Feedback is again invited and is key to the future development of the Compendium!

John Dyer/Bert van Pinxteren  
TERENA

<sup>1</sup> On 1 January 2007, Bulgaria and Romania joined the EU. Where information on EU/EFTA countries is presented from 2006 and earlier years, that information does **not** include Bulgaria and Romania. Information from EU/EFTA countries from 2007 **does** include Bulgaria and Romania.

<sup>2</sup> The EFTA countries are Iceland, Norway, Switzerland and Liechtenstein. Liechtenstein is serviced by SWITCH (Switzerland) and not counted separately in this Compendium.

In a number of places in this document, reference is made to the EARNEST studies. These are foresight studies into research and education networking that were carried out within the framework of the GN2 project and supported as such by the European Union. The studies ran from March 2006 to October 2007 (see <http://www.terena.org/activities/earnest>). The summary report, 'Innovation, Integration and Deployment - Challenges for European research and education networking Innovation', ISBN 978-90-77559-18-5 is available from the TERENA Secretariat and on the Web, at <http://www.terena.org/publications/files/EARNEST-Summary-Report.pdf>

As part of the EARNEST work, a new index is being developed to measure the performance of NRENs in different countries. It makes use of some of the data collected for the Compendium. The results of this study (the Geographic Issues Study) will be published by TERENA later this year.

## SUMMARY OF KEY FINDINGS

Unless otherwise specified, all NRENs have been asked to provide data that describe the situation at or close to the 31<sup>st</sup> of January, 2008.

### Legal Form

In many countries in Western Europe, research networking started a few years before or after 1980. Countries in Eastern and Southern Europe followed ten or more years later, after 1990.

The most common model in the EU and EFTA countries is an NREN which is a separate legal entity. This separate legal entity is controlled by the research and education community which itself is (largely) government funded. It is important to note, however, that several other models exist. In the other countries, there is a greater variety.

NREN development requires the commitment of all major stakeholders, such as funders and users. A governing model that allows the participation of these stakeholders would seem to be the most appropriate; such a situation can be achieved a number of different ways.

NRENs that can operate with a certain amount of independence from their respective governments may have certain advantages, such as easier decision-making procedures and the ability to recruit and retain suitably qualified staff. This may help to explain why this model is more common in countries where research networking has developed over many years and is now well established.

### Users/Clients

All NRENs can and do connect universities, research institutes and, with four exceptions, institutes of higher education. For other institutions, there are great differences in policy between NRENs. For the EU/EFTA countries, on average more than 80% of the access capacity is used for the tertiary education sector.

Looking back five years, there is a clear trend in the bandwidth of Universities. In 2003, the 'average' university was connected at Megabit capacity. In 2008, that

has changed to Gigabit capacity. The trend is similar, though less pronounced, in the other countries.

For institutions other than Universities, it is reasonable to expect that capacities will have increased as well. Yet, most secondary and primary schools are not (yet) connected at Gigabit capacities.

For a while, the expectation has been that the connections by NRENs to Primary and Secondary schools would rise from year to year. This seems not to have happened – instead, the situation seems to be more or less stable overall. This is due not so much to the fact that connections to primary and secondary schools are not considered important, but rather to differences in national policies. In some countries, it has been decided that these connections should be a task of the NREN – and this is shown in the Compendium. In other countries, however, this is a task that is performed by separate organisations.

### Network Connectivity Services

Over the past five years, there have been increases both in average core network size and in core backbone capacity. Average core network size has quadrupled in that period, whilst the average core backbone capacity has more than doubled. For non-EU/EFTA countries, the effect of the introduction of affordable Gigabit Ethernet technology is clearly visible.

For the coming period, the trend is clearly that in most countries, the core capacity will evolve to multiples of 10 Gb/s. It is interesting to note that many EU/EFTA countries foresee further upgrades in the next two years. Many other countries have also upgraded to Gigabit capacities.

It should be noted that this considerable growth has taken place in spite of the fact that on average, NREN budgets have remained fairly stable over the past period.

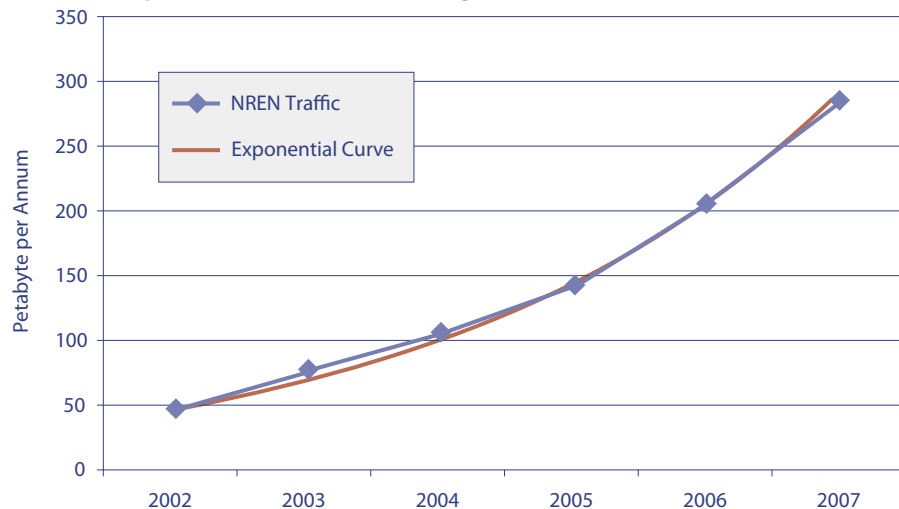
A number of NRENs have their own links to research bodies. Typically, these are dark fibre links. Some of these links are part of the emerging Global Lambda Integrated Facility, a world-scale wavelength-based laboratory for application and middleware development on emerging LambdaGrids.

There have been rapid developments in the area of dark fibre in recent years. Many (although not all) NRENs predict a further increase in the percentage of their network that is dark fibre by 2010.

A continuing development is the implementation of cross-border dark fibre links between NRENs.

The year-on-year growth rate for total IP traffic on a sample of 13 NRENs shows continued exponential traffic growth with a doubling time of around two years. This doubling period represents a year-on-year growth rate of approximately 46% per annum.

**Graph 3B.1.1 Traffic Growth per year, 2002 – 2007, sample of 13 NRENs in the EU/ETFA region**



These trends are matched by GÉANT traffic growth. The growth of IP traffic on the GÉANT network closely approximates exponential growth with a doubling time of 22 months.

IPv6 traffic is growing in real terms, but it does not grow as quickly as IPv4 and therefore the total percentage of traffic that is IPv6 is actually dropping.

For the majority of NRENs more than 75% of all of their IP traffic is between their customer sites and destinations on the commercial Internet.

It should be noted that in general, the traffic traversing point-to-point (P2P) lightpaths is not inspected or measured at present.

Eleven NRENs currently have operational P2P links in use either to carry production traffic or to support specific projects. The capacity of these links ranges from 1Gb/s to 10Gb/s. These links are in addition to any cross border fibre links used for production traffic.

There are a few typical patterns that emerge when examining the evolution of traffic and capacity over the years, as described in section 3B.3.

If NRENs are to fulfil their role as enablers of innovation it is vital that students, teachers and researchers are not discouraged from experimenting with novel and innovative uses of the network. A good way of encouraging innovation is to keep traffic loads consistently low. This needs constant monitoring of traffic and good capacity planning and funding, well in advance of need.

For the EU and EFTA countries, the average estimated congestion at the campus level has gone down for the second year in a row, but it has gone up a little at the External Connections level. In a way, this is a logical phenomenon: many NRENs have recently invested in backbone upgrades thus reducing congestion, but traffic increases will probably lead to increased congestion levels ahead of the next round of investments.

## Other Services

NRENs are now offering more Services to their customers. There are a few trends that can be noted from the data:

- In the EU and EFTA countries, 23% of the Network Operating Centres (NOCs) are outsourced; in the other countries, 18% of the NOCs are outsourced. Ninety percent of the NOCs in the EU and EFTA countries serve all of the NREN customers.
- At the moment, 16 out of the 30 EU/EFTA countries have Performance Enhancement and Response Teams (PERTs). Four are planning to establish one within the next year and a further six plan to do this within the next three years. Many NRENs from other countries also either have a PERT or are planning to establish one.
- Most NRENs that report offering point-to-point links in addition to their general IP production services say that these links are also used to carry IP traffic. Some such links, however, are used to carry framing protocols such as Ethernet.
- Most NRENs from the EU/EFTA countries use over-provisioning of bandwidth to provide an acceptable quality of service to their end users.
- In the area of security, there is still a large difference between EU/EFTA NRENs and NRENs in other countries. This has not changed since last year.
- The importance attached to authorisation and authentication is shown by the growth in the number of NRENs putting a federation in. Similarly, the number of NRENs operating a certification authority is now over 60% of all the NRENs in the EU/EFTA region.
- Eight out of the 30 EU/EFTA NRENs (27%) reported offering an IP telephony service service to (some of) its customers. Only four EU/EFTA NRENs have peerings with other institutions for the interconnection of IP Telephony deployments. Such peerings depend to a large extent on national legislations and policies.
- 21 out of the 30 EU/EFTA NRENs offer a videoconferencing service, either directly or via a third party. Many NRENs also offer additional services, such as archiving of video conferences and user support for the service.
- In the past year, there have been few changes in the area of Grid services.
- Most NRENs in the EU/EFTA area have at least one part-time person working on PR and communications. In other countries only a minority of NRENs provide effort for PR and communications.

The services portfolios of NRENs are evolving constantly. It is clear that more services are being added than are being phased out. Commercial paid or 'free' alternatives are clearly not yet an alternative for the full spectrum of NREN services, even though in a few countries Universities have started to make use of free e-mail services for their students.

## Funding and Staffing

It is almost impossible to compare NRENs by staff or budget size. This is because NREN budgets are structured differently; they have different tasks, which are also funded in different ways.

When comparing current budget data with data from past editions of the Compendium, it becomes clear that NREN budgets tend to be stable over time. There are fluctuations from year to year, depending on whether or not an important investment takes place during that year. But on the whole, the trend

is that budgets stay relatively stable and that NRENs are able to deliver more bandwidth and more services for roughly the same amount of money.

The situation is not as clear in the less developed NRENs. There, new possibilities for significantly upgrading international bandwidth (for example, under the GN2, EUMEDCONNECT or SEEREN projects) could act as a catalyst for increased national NREN budgets.

The data suggests that in these countries a modest increase in budget leads, in many cases, to a significant increase in traffic. However, as is clear from Chapter 3, there is not always a commensurate increase in services.

It is impossible to provide general recommendations for NREN funding mechanisms. However, it would seem that a model that involves the various stakeholders of NRENs in some way provides the best guarantees for an NREN's continued success. It should be noted that many NRENs are involved in innovative developments in their fields. Such innovations are often steered by separate funding mechanisms. It would seem important for NRENs to try to make use of such funds wherever they exist.



# 1 BASIC INFORMATION

## 1.0 NRENs that have Responded to the Questionnaire

There are 54 countries in the area that has been considered for this edition of the Compendium (basically, Europe and the surrounding countries in the Middle East and North Africa). In three countries, there are no NRENs or we do not have knowledge of NREN work in those countries. 42 NRENs responded to the survey, from as many countries. Not all NRENs were able to answer all of the questions, but many were. The following map and table give an overview of the NRENs that sent their replies and an impression of the completeness of those replies.

In most of the tables and graphs, the English-language abbreviation of the NREN's name has been used in order to denote the NREN. Table 1.0.1 provides a list of countries and the abbreviations of the NREN(s) from those countries that submitted information. Table 1.0.2 provides a list of some countries where we know that research networking exists, but from which no replies were received. Table 1.0.3 provides a list of other NRENs that provided information for the Compendium, as found on the Compendium website.

NRENs were asked to double-check and update their replies.

Two projects are relevant in this context: the EUMEDCONNECT project focusing on the Mediterranean region (see <http://www.eumedconnect.net>) and the Silk Highway and Occasion projects, focusing on the Central Asian countries (see <http://www.ist-occasion.org>). In addition, CEENet (<http://www.ceenet.org>) maintains contacts and provides support to many NRENs in Central and Eastern Europe and the former Soviet Union.

In a number of countries outside of the EU/EFTA area, two or more NRENs exist. This is the case for example in the Ukraine. In 2007, data were provided by URAN. In 2008, data were provided by UARNet.

More information about NRENs from the Asia/Pacific region can be obtained from APAN, <http://www.apan.net>; for Latin America, see CLARA, <http://www.redclara.net>; for Eastern and Southern Africa, see the UbuntuNet Alliance, <http://www.ubuntunet.net>. Worldwide co-ordination is performed through the CCIRN, <http://www.ccirn.org>. For North America, see <http://www.canarie.ca> for Canada and <http://www.internet2.edu> and <http://www.thequilt.net> for the U.S.

**Table 1.0.1 NRENs and urls.** NRENs in **bold** are TERENA members.

Country	NREN	URL
<b>EU/EFTA Countries</b>		
Austria	<b>ACOnet</b>	<a href="http://www.aco.net">http://www.aco.net</a>
Belgium	<b>BELNET</b>	<a href="http://www.belnet.be">http://www.belnet.be</a>
Bulgaria	<b>BREN</b>	<a href="http://www.bren.acad.bg">http://www.bren.acad.bg</a>
Cyprus	<b>CYNET</b>	<a href="http://www.cynet.ac.cy">http://www.cynet.ac.cy</a>
Czech Republic	<b>CESNET</b>	<a href="http://www.cesnet.cz">http://www.cesnet.cz</a> , <a href="http://www.ces.net">http://www.ces.net</a>
Denmark	<b>UNI-C</b>	<a href="http://www.forskningsnettet.dk/eng">http://www.forskningsnettet.dk/eng</a>
Estonia	<b>EENet</b>	<a href="http://www.eenet.ee">http://www.eenet.ee</a>
Finland	<b>Funet</b>	<a href="http://www.funet.fi">http://www.funet.fi</a> , <a href="http://www.csc.fi">http://www.csc.fi</a>
France	<b>RENATER</b>	<a href="http://www.renater.fr">http://www.renater.fr</a>
Germany	<b>DFN</b>	<a href="http://www.dfn.de">http://www.dfn.de</a>
Greece	<b>GRNET</b>	<a href="http://www.grnet.gr/default.asp?pid=1&amp;la=2">http://www.grnet.gr/default.asp?pid=1&amp;la=2</a>
Hungary	<b>NIIF/HUNGARNET</b>	<a href="http://www.niif.hu">http://www.niif.hu</a>
Iceland	<b>RHnet</b>	<a href="http://www.rhnet.is">http://www.rhnet.is</a>
Ireland	<b>HEAnet</b>	<a href="http://www.heanet.ie">http://www.heanet.ie</a>
Italy	<b>GARR</b>	<a href="http://www.garr.it">http://www.garr.it</a>
Latvia	<b>SigmaNet<sup>3</sup></b>	<a href="http://www.sigmanet.lv/">http://www.sigmanet.lv/</a>
Lithuania	<b>LITNET</b>	<a href="http://www.litnet.lt">http://www.litnet.lt</a>
Luxembourg	<b>RESTENA</b>	<a href="http://www.restena.lu">http://www.restena.lu</a>
Malta	<b>UoM/RicerkaNet</b>	<a href="http://www.um.edu.mt/itservices/about">http://www.um.edu.mt/itservices/about</a>
Netherlands	<b>SURFnet</b>	<a href="http://www.surfnet.nl">http://www.surfnet.nl</a>
Norway	<b>UNINETT</b>	<a href="http://www.uninett.no">http://www.uninett.no</a>

<sup>3</sup> In 2007, the Latvian NREN changed its name to SigmaNet to distinguish itself from the commercial ISP "LATNET Serviss", which owns the LATNET trademark.

**Table 1.0.1** - continued

Country	NREN	URL
<b>EU/EFTA Countries</b>		
Poland	<b>PIONIER</b>	<a href="http://www.pionier.gov.pl">http://www.pionier.gov.pl</a>
Portugal	<b>FCCN</b>	<a href="http://www.fccn.pt">http://www.fccn.pt</a>
Romania	<b>RoEduNet</b>	<a href="http://www.roedu.net">http://www.roedu.net</a>
Slovakia	<b>SANET</b>	<a href="http://www.sanet.sk">http://www.sanet.sk</a>
Slovenia	<b>ARNES</b>	<a href="http://www.arnes.si">http://www.arnes.si</a>
Spain	<b>RedIRIS</b>	<a href="http://www.rediris.es">http://www.rediris.es</a> , <a href="http://www.red.es">http://www.red.es</a>
Sweden	<b>SUNET</b>	<a href="http://www.sunet.se">http://www.sunet.se</a>
Switzerland	<b>SWITCH</b>	<a href="http://www.switch.ch">http://www.switch.ch</a>
United Kingdom	<b>JANET(UK)</b>	<a href="http://www.ja.net">http://www.ja.net</a>
<b>Other European and Mediterranean Countries</b>		
Algeria	CERIST	<a href="http://www.arn.dz">http://www.arn.dz</a>
Azerbaijan	AzNET	<a href="http://www.aznet.org">http://www.aznet.org</a>
Belarus	<b>BASNET</b>	<a href="http://www.basnet.by/about/index.php?sp=1">http://www.basnet.by/about/index.php?sp=1</a>
Croatia	<b>CARNet</b>	<a href="http://www.carnet.hr">http://www.carnet.hr</a>
Georgia	GRENA	<a href="http://www.grena.ge/english/about/index.html">http://www.grena.ge/english/about/index.html</a>
Israel	<b>IUCC</b>	<a href="http://www.iucc.ac.il">http://www.iucc.ac.il</a>
Jordan	NITC	<a href="http://www.nic.gov.jo">http://www.nic.gov.jo</a>
Lebanon	CNRS	<a href="http://www.cnrs.edu.lb">http://www.cnrs.edu.lb</a>
Macedonia, FYRo	<b>MARNet</b>	<a href="http://dns.marnet.net.mk">http://dns.marnet.net.mk</a>
Moldova	RENAM	<a href="http://www.renam.md">http://www.renam.md</a>
Montenegro	<b>MREN</b>	<a href="http://www.mren.ac.me/">http://www.mren.ac.me/</a>
Morocco	MARWAN	<a href="http://www.marwan.ma">http://www.marwan.ma</a>
Palestinian Territory	PADI2	<a href="http://www.padi2.ps">http://www.padi2.ps</a>
Russian Federation	RBNet/RUNNet	<a href="http://www.ripn.net">http://www.ripn.net</a> , <a href="http://www.runnet.ru">http://www.runnet.ru</a>
Serbia	<b>AMRES</b>	<a href="http://www.amres.ac.yu">http://www.amres.ac.yu</a>
Syria	SHERN	<a href="http://www.shern.net">http://www.shern.net</a>
Turkey	<b>ULAKBIM</b>	<a href="http://www.ulakbim.gov.tr">http://www.ulakbim.gov.tr</a>
Ukraine	URAN	<a href="http://www.uran.net.ua">http://www.uran.net.ua</a>
Ukraine	UARNet	<a href="http://www.uar.net">http://www.uar.net</a>

**Legend for Table 1.0.1 ,Table 1.0.2 and Table 1.0.3**

	Answers obtained
	Only partial answers obtained
	No answers obtained
	No NREN or no knowledge of NREN work in this country
	Outside the scope of the Compendium

**Table 1.0.2 Countries not included in the Compendium**

Country	NREN	URL
Albania		
Armenia		
Bosnia/Herzegovina		
Egypt	EUN	<a href="http://www.eun.eg">http://www.eun.eg</a>
Libya		
Tunisia	RNU	<a href="http://www.rnu.tn">http://www.rnu.tn</a>

**Table 1.0.3 NRENs from other countries that submitted data for the Compendium**

Country	NREN	URL
Australia	AARNet	<a href="http://www.aarnet.edu.au">http://www.aarnet.edu.au</a>
Canada	CANARIE	<a href="http://www.canarie.ca">http://www.canarie.ca</a>
Chile	REUNA	<a href="http://www.reuna.cl">http://www.reuna.cl</a>
Guatemala	RAGIE	<a href="http://www.ragie.org.gt">http://www.ragie.org.gt</a>
Malawi	MAREN	<a href="http://www.malico.mw/maren/">http://www.malico.mw/maren/</a>
Nepal	NREN	<a href="http://www.nren.net.np/">http://www.nren.net.np/</a>
New Zealand	REANNZ	<a href="http://www.karen.net.nz">http://www.karen.net.nz</a>
Taiwan	NCHC	<a href="http://www.nchc.org.tw/en">http://www.nchc.org.tw/en</a> , <a href="http://www.twaren.net/english">http://www.twaren.net/english</a>
Uganda	RENU	<a href="http://www.renu.ac.ug/">http://www.renu.ac.ug/</a>
United States	Internet2	<a href="http://www.internet2.edu">http://www.internet2.edu</a>

## 1.1 Legal Form of NRENs

NRENs have many different legal forms. Names and their translations may be misleading: what is called a 'foundation' in one country may be something very different from a 'foundation' in another country. The same is true for many other designations. In this section, two parameters are distinguished that together help to characterise the legal form of NRENs.

### Separate Legal Entity

Many NRENs operate as separate legal entities; many others form part of a larger organisation (often a ministry, a university or a research institution). In the past, a few NRENs had a special status in the sense that they did not operate as separate legal bodies but were not part of a larger organisation either; typically, these were transitional arrangements.

### Relationship with Government

Those NRENs that are a government agency or part of a government ministry are often controlled directly by the government, even though this is by no means always the case. A number of such agencies can enjoy a reasonable degree of autonomy, comparable to that of some of the NRENs that are separate legal entities.

A number of NRENs that are separate legal entities have governing boards that are at least half government-appointed. Those NRENs are marked with 'appoints' in the table. Many NRENs have a mixed model, being governed both by government representatives and representatives from the research and education community.

In the table, 'indirect' means an indirect relationship. Such a relationship exists if at least half the members of the NREN's governing body are appointed by research and education institutions that are themselves (largely) government-funded.

The table shows the relationship between the two parameters.

As can be seen from the table, the most common model in the EU and EFTA countries is an NREN which is a separate legal entity. This separate legal entity is controlled by the research and education community, which itself is (largely) government-funded. It must be noted, however, that several other models exist. In the other countries, there is a larger variety.

It seems clear that NREN development requires the commitment of all major stakeholders, such as funders and users. A governing model that allows the participation of these stakeholders would seem to be the most appropriate; such situation can be achieved in a number of different ways.

NRENs that can operate with a certain amount of independence from their respective governments may have certain advantages, such as easier decision-making procedures and the ability to recruit and retain suitably qualified staff, in part by setting salaries at competitive levels. This may help to explain why this model is more common in countries where research networking is now well-established.

Table 1.1.1 Relationship with Government

Country	NREN	Separate Legal Entity?	Relationship with Government	Remarks/Parent Organisation
<b>EU/EFTA Countries</b>				
Austria	ACOnet	no	indirect	University of Vienna
Belgium	BELNET	no	appoints	Belgian Federal Ministry of Science Policy
Bulgaria	BREN	yes	appoints	
Cyprus	CYNET	yes	other	
Czech Republic	CESNET	yes	indirect	
Denmark	UNI-C	no	appoints	For Forskningsnet: Danish ministry of Science, Technology and Innovation, For UNI-C: Danish ministry of Education
Estonia	EENet	yes	appoints	EENet is a public institution operating under the administration of the Estonian Ministry of Education and Research
Finland	FUNET	no	appoints	CSC - Scientific Computing Ltd.
France	RENATER	yes	indirect	
Germany	DFN	yes	indirect	
Greece	GRNET S.A.	yes	other	
Hungary	NIIF/HUNGARNET	yes	other	
Iceland	RHnet	yes	indirect	
Ireland	HEAnet	yes	indirect	
Italy	GARR	yes	indirect	
Latvia	SigmaNet	no	indirect	Institute of Mathematics and Computer sciences, University of Latvia
Lithuania	LITNET	no	indirect	Ministry of Science and Education of Lithuania
Luxembourg	RESTENA	yes	indirect	
Malta	UoM, IT Services	no		University of Malta
Netherlands	SURFnet	yes	indirect	Stichting SURF (English: SURF Foundation)
Norway	UNINETT	yes	other	
Poland	PIONIER	yes	indirect	
Portugal	FCCN	yes	indirect	
Romania	RoEduNet	yes	appoints	
Slovakia	SANET	yes	indirect	
Slovenia	ARNES	yes	appoints	
Spain	RedIRIS	no	appoints	Entidad pública empresarial RED.ES
Sweden	SUNET	no	appoints	Swedish Research Council

Table 1.1.1 - continued

Country	NREN	Separate Legal Entity?	Relationship with Government	Remarks/Parent Organisation
<b>EU/EFTA Countries</b>				
Switzerland	SWITCH	yes	indirect	
United Kingdom	JANET(UK)	yes	indirect	
<b>Other Countries</b>				
Belarus	BASNET	no	indirect	United Institute of Informatics Problems of the National Academy of Sciences of Belarus
Croatia	CARNet	yes	appoints	
Georgia	GRENA	yes	indirect	
Israel	IUCC	yes	indirect	
Macedonia	MARNet	no	indirect	University Ss. Cyril & Methodius in Skopje
Moldova	RENAM	yes	indirect	
Montenegro	MREN	no	appoints	University of Montenegro
Morocco	MARWAN	no	appoints	National Scientific and Technical Research Centre (CNRST)
Russian Federation	RBNNet/RUNNet	yes	indirect	
Serbia	AMRES	no	indirect	University of Belgrade
Turkey	ULAKBIM	no	other	The Scientific and Technological Research Council of Turkey (TUBITAK)
Ukraine	UARNet	yes	other	

## 1.2 History

In the near future, TERENA will publish a book on the history of research networking at European level, edited by Howard Davies and Beatrice Bressan.

At the national level, in most countries NRENs did not simply appear on the scene. Instead, their development was the result of a process that was influenced by technological developments, by government policies and by the visions of individuals in the research and education community. In the Compendium survey, NRENs were asked to identify three dates:

- when research network operations started;
- when research networking started as a dedicated organisational unit;
- when the NREN was founded in its current form.

As can be seen from the table below, in some countries research networking started first and became formalised later. In others, however, the organisation was created before operations began. Note that the function of the NREN has not been carried out by the same organisation in all countries; there may have been periods without any NREN in some countries.

In many countries in Western Europe, NRENs were formed in the early nineteen-eighties. Many countries in Eastern and Southern Europe followed ten or more years later, after 1990. For the countries of Eastern Europe, this is of course related to the end of the Cold War period.

**Table 1.2.1 NREN History**

Country	NREN	Start of research network operations	Start of research networking as a dedicated organisational unit	Year in which the NREN was founded in its current form	URL to history of the organisation
<b>EU/EFTA Countries</b>					
Austria	ACOnet	1990		1986	<a href="http://www.aco.net/geschichte.html?&amp;L=1">http://www.aco.net/geschichte.html?&amp;L=1</a>
Belgium	BELNET	1993	1989	2000	<a href="http://www.belnet.be/fr/index2.php?upnr=88">http://www.belnet.be/fr/index2.php?upnr=88</a>
Bulgaria	BREN	1989	1989	2006	
Cyprus	CYNET	1995	2000	2000	
Czech Republic	CESNET	1993	1996	1996	<a href="http://www.ces.net/doc/history.html">http://www.ces.net/doc/history.html</a>
Denmark	UNI-C	1985	1985	2000	<a href="http://www.denet.dk/history">http://www.denet.dk/history</a>
Estonia	EENet	1993	1993	1993	<a href="http://www.eenet.ee/englishEENet/">http://www.eenet.ee/englishEENet/</a>
Finland	Funet	1983	1983	1983	<a href="http://www.nic.funet.fi/index/FUNET/history/internet/en/etusivu-en.html">http://www.nic.funet.fi/index/FUNET/history/internet/en/etusivu-en.html</a>
Germany	DFN	1984	1984	1984	
Greece	GRNET S.A.	1995	1996	1998	<a href="http://www.grnet.gr/default.asp?pid=11&amp;la=2">http://www.grnet.gr/default.asp?pid=11&amp;la=2</a>
Hungary	NIIF/HUNGARNET	1987	1990	1992	<a href="http://www.niif.hu/en/story">http://www.niif.hu/en/story</a>
Iceland	RHnet	1986	2001	2001	<a href="http://www.rhnet.is/english">http://www.rhnet.is/english</a>

Table 1.2.1 - continued

Ireland	HEAnet	1983	1992	1997	<a href="http://www.heanet.ie/about/history.html">http://www.heanet.ie/about/history.html</a>
Italy	GARR	1988	1987	2002	<a href="http://www.garr.it/storia/">http://www.garr.it/storia/</a> (still work in progress!)
Latvia	SigmaNet	1993	1996	2007	
Lithuania	LITNET	1991	1995	1995	
Luxembourg	RESTENA	1990	1992	2000	<a href="http://www.restena.lu/restena/en/EN-History.html">http://www.restena.lu/restena/en/EN-History.html</a>
Malta	UoM, IT Services				<a href="http://www.um.edu.mt/about/uom/history">http://www.um.edu.mt/about/uom/history</a>
Netherlands	SURFnet	1985	1988	1989	
Norway	UNINETT	1978	1986	1993	
Poland	PIONIER	1997	1993	1997	
Portugal	FCCN	1990	1990	1987	<a href="http://www.fccn.pt">http://www.fccn.pt</a>
Romania	RoEduNet	1990	1994	1998	<a href="http://www.roedu.net/default.php?t=site&amp;lang=EN">http://www.roedu.net/default.php?t=site&amp;lang=EN</a>
Slovakia	SANET	1992	1991	1991	<a href="http://www.sanet.sk/en/historiasanetu.shtm">http://www.sanet.sk/en/historiasanetu.shtm</a>
Slovenia	ARNES	1992	1990	1992	
Spain	RedIRIS	1988	1988	1988	<a href="http://www.rediris.es/rediris/index.en.html">http://www.rediris.es/rediris/index.en.html</a> & <a href="http://www.red.es/sobre_red/index.html">http://www.red.es/sobre_red/index.html</a>
Sweden	SUNET	1985		1985	<a href="http://basun.sunet.se/html_docs/info_sunet/historia.html">http://basun.sunet.se/html_docs/info_sunet/historia.html</a>
Switzerland	SWITCH	1988	1987	1987	<a href="http://http://www.switch.ch/de/about/SWITCHjournal_Nov07_en.pdf">http://http://www.switch.ch/de/about/SWITCHjournal_Nov07_en.pdf</a>
United Kingdom	JANET(UK)	1984	1979	1993	
<b>Other Countries</b>					
Belarus	BASNET	1993	1997	1997	<a href="http://www.basnet.by/about/index.php?sp=1">http://www.basnet.by/about/index.php?sp=1</a>
Croatia	CARNet	1992	1991	1995	<a href="http://www.carnet.hr/history">http://www.carnet.hr/history</a>
Georgia	GRENA	1996	1999	1999	<a href="http://www.grena.ge/english/about/index.html">http://www.grena.ge/english/about/index.html</a>
Israel	IUCC	1985	1985	1985	<a href="http://www.iucc.ac.il/html/framesets_eng/about_iucc.html">http://www.iucc.ac.il/html/framesets_eng/about_iucc.html</a>
Macedonia	MARNet	1994	1994	1994	
Moldova	RENAM	2000	1999	1999	<a href="http://www.renam.md/index.php?option=com_content&amp;task=view&amp;id=2&amp;Itemid=8">http://www.renam.md/index.php?option=com_content&amp;task=view&amp;id=2&amp;Itemid=8</a>
Montenegro	MREN	1996	2002	2005	<a href="http://www.mren.cg.ac.yu/about_mren.php">http://www.mren.cg.ac.yu/about_mren.php</a>
Morocco	MARWAN	2000	1998	1998	<a href="http://www.marwan.ma/index.php?option=com_content&amp;task=view&amp;id=5&amp;Itemid=88">http://www.marwan.ma/index.php?option=com_content&amp;task=view&amp;id=5&amp;Itemid=88</a>
Russian Federation	RBNNet/RUNNet	1992	1993	1994	<a href="http://www.ripn.net/about/en/">http://www.ripn.net/about/en/</a>
Serbia	AMRES	1991		1991	<a href="http://www.amres.ac.yu/index.php?option=com_content&amp;task=view&amp;id=23&amp;Itemid=55&amp;lang=en">http://www.amres.ac.yu/index.php?option=com_content&amp;task=view&amp;id=23&amp;Itemid=55&amp;lang=en</a>
Turkey	ULAKBIM	1986	1986	1996	<a href="http://www.ulakbim.gov.tr/?lang=en">http://www.ulakbim.gov.tr/?lang=en</a>
Ukraine	UARNet	1993	1995	1998	

## 1.3 Major Changes in NRENs

NRENs were requested to give a short description of major changes that occurred in the network during the past year or that are foreseen for the coming year. The following tables present the answers that were given by the NRENs, only slightly edited for readability. Note that the fact that some NRENs did not answer does not necessarily mean that there are no major changes in those NRENs.

The table clearly shows that many NRENs have either completed or are starting to change over to dark fibre infrastructures. The capacity of these infrastructures can be increased fairly easily according to need. A few NRENs are introducing a dual structure for their network. They are continuing to provide the 'traditional' connections, based on the Internet Protocol. They are also planning to provide dedicated lightpaths to high-end users, allowing them to use whatever protocols or methods they want to use for transmitting data.

**Table 1.3.1 Major Changes in NRENs**

Country	NREN	Changes
<b>EU/EFTA Countries</b>		
Austria	ACOnet	Our CFP for a wavelength transparent fiber optic backbone, which was published in 2006, resulted in a framework contract with Telekom Austria, signed July 2007 ( <a href="http://www.aco.net/aconet07.html?&amp;L=1">http://www.aco.net/aconet07.html?&amp;L=1</a> ). We are currently (May 2008) just halfway on our migration path with a targeted completion date of December 2008 ( <a href="http://www.aco.net/technologie.html?&amp;L=1">http://www.aco.net/technologie.html?&amp;L=1</a> ).
Belgium	BELNET	2007: new backbone network was developed and implemented. BELNET acquired IRU's and manages the network. Q1 2008: new backbone network operational, Servicedesk & NOC outsourced & operational 2006-2007-2008 : a fibre connection for all Belgian Schools of Higher Education (ISCED Level 5 & 6 - around 50 institutions) to the NREN backbone has been realised.
Cyprus	CYNET	After the completion of the EUMEDCONNECT project, CyNet maintained its two GEANT2 connections for international connectivity whilst providing transit services to the Syrian NREN for connection to GEANT2 via CyNet and the EUMEDCONNECT PoP hosted at CyNet.
Czech Republic	CESNET	The major changes during the past year are: <ul style="list-style-type: none"> <li>• DWDM and static DWDM deployment to the new optical lines</li> <li>• multidegree ROADM implementation</li> <li>• multipoint ethernet transport over the DWDM (XPonder-L2/DWDM) and VPLS</li> </ul> The main planned changes for the coming year are: <ul style="list-style-type: none"> <li>• new terabit "carrier class" router deployment in the CESNET2 IP/MPLS network core</li> <li>• pilot 40Gbit/s IP/MPLS line Prague-Brno over DWDM network</li> <li>• static CLA DWDM over one fiber</li> <li>• network redundancy and reliability enhancement (splitting Prague PoP in two locations)</li> </ul>
Denmark	UNI-C	Next upgrade (autumn 2008) will be dark fibre infrastructure with dwdm instead of leased circuits.  Danish universities have been through a major consolidation, reducing the number of universities. This meant requests for using the NREN network to interlink universities at LAN-level.
Finland	FUNET	Internal restructuring of management: Funet now forms a separate organisational unit within CSC. Starting roll-out of IRU fiber based DWDM network in summer 2008.
France	RENATER	In 2007 we prepared the tender for RENATER 5 network which is starting to be deployed
Germany	DFN	The number of fibres for the X-WiN has been extended. Additional Cross-Border Fibres have been implemented.

Table 1.3.1 - continued

Country	NREN	Changes
<b>EU/EFTA Countries</b>		
Greece	GRNET S.A.	<p>GRNET S.A. has already acquired 15-year IRUs for Dark Fiber (DF) links. As of today GRNET owns 7476Km of dark fiber pairs and plans to extend it this year. In addition, Alcatel DWDM equipment is installed in our network backbone and Alcatel NG-SDH equipment is installed between Athens, Thessaloniki, Patras and Herakleon.</p> <p>GRNET S.A.'s goal with the planned migration to owned-fiber infrastructure is to operate a hybrid network that will continue to provide sound production-quality IP services to all users and at the same time provide Layer 1/Layer 2 services to its clients.</p>
Hungary	NIIF/HUNGARNET	<p>1. NIIFI has earlier been operating under the umbrella of the Ministry of Communication and Informatics, and later the Ministry of Economy and Transport for several years. From April-May 2008 the structure of the Hungarian Government has changed. Since then, NIIFI is operating under the umbrella of the Office of the Prime Minister.</p> <p>2. The research network in Hungary has been continuously developing during the last several years (backbone and access network extensions and upgrades + international connectivity upgrade to GEANT+). No considerable changes in organisational structure and mandate are foreseen for 2008-2009, while a considerable technical development (reconstruction and upgrade of the internal NIIF/Hungarnet network) is planned for 2008-2010. No remarkable change in the user base is forecast.</p>
Iceland	RHnet	<p>Two new sites connected well outside of the Reykjavik area. One of them educational / distance educational establishment up to and including University level. The other a research Institution. In the Reykjavik area two additional Research Institutions were connected recently. Further new connections are being planned.</p> <p>A major upgrade in international capacity is required, preferably before the end of this summer.</p> <p>We have reason to believe that this will be the year that the external connectivity will be upgraded to 2.5 Gb/s with the assistance of the Icelandic government.(The Icelandic authorities have never directly supported an Icelandic NREN, since the very beginning/initiation of research - and educational networking here in Iceland in 1986. So this will be a major "breakthrough" for this community and maybe the first of a few steps in our governments having a similar aims/views and giving similar support as most other governments in the world have been and are giving to their NREN.) This will also require an upgrade of our equipment in many parts of the network.</p> <p>If this will upgrade in external connectivity will come through the backbone will be upgraded to 10 Gb/s. Probably this will be done in several steps: by upgrading specific areas/connections first, etc.</p> <p>Nearly all connections between sites on RHnet are by dark fibre, there are only four exceptions. The exceptions being: the link between Reykjavik and Akureyri, the two newly connected sites well outside the Reykjavik area, as well as the international connectivity (submarine cable).</p>
Ireland	HEAnet	<p>The deployment of the schools broadband network and layered services has been completed. Rollout of dark fibre to most member institutions continues, with over 90% of end-users now in institutions connected by dark fibre. Full integration of 13 Institutes of Technology into the national network. Upgrade of backbone to 10Gbps. Cross-border fibre connectivity with JANET. This year, we have moved to 7x24 NOC support and hope to complete rollout of connectivity to almost 100 off-campus locations for our clients.</p>
Latvia	SigmaNet	<p>IMCS UL LATNET laboratory broke up long lasting partnership with LATNET Serviss Ltd. company. IMCS UL laboratory was renamed and now is called SigmaNet. Both organisations separated the network, the users, the staff.</p> <p>SigmaNet was left with very little network and less users. Now we procure links for our clients from other providers based on the wishes and requirements of clients. We have agreements with 6 providers who are providing Layer 2 connectivity to our customers.</p> <p>The amount of staff did not change much and the open positions were filled afterwards. The managers were changed. The activities have become more focused on real needs.</p>

Table 1.3.1 - continued

Country	NREN	Changes
<b>EU/EFTA Countries</b>		
Luxembourg	RESTENA	During 2008, the national optical fibre network will be extended alongside with the deployment of 10 GE interfaces.  Cross-Border Fibres (CBF) will be established to RENATER and BELNET.
Netherlands	SURFnet	The SURFnet6 network launched in 2006 was one of the first national hybrid networks. We have seen many other NRENs adopting this principle. In 2008 SURFnet plans to launch a new service that will enable users to set-up lightpaths on demand.  In September 2007 Boudewijn Nederkoorn stepped down as a managing director after nearly twenty years on the board of directors.
Norway	UNINETT	In the previous year, the company has deployed optical equipment to offer lambdas services in Norway's 4 main university cities. This offers a range of new services for the institutions, plus an increase in general internet capacity for these institutions.
Poland	PIONIER	In the past year we upgraded DWS bandwidth to 7.5 Gb/s. This year we should have Cross-Border Fibres towards Lithuania, Ukraine, Belarus, Kaliningrad region.
Portugal	FCCN	In 2007 the main effort of FCCN has been directed to the extension of our optical fiber infrastructure to Spain in the North and East borders. A new cable is already installed between Porto and the Portuguese-Spanish border in Valença. At the same time a new tender for another cable to Spain has been launched and as a result a new cable shall be installed, in October 2008, in the border Elvas-Badajoz
Romania	RoEduNet	Done: <ul style="list-style-type: none"> <li>• all backbone equipment (routers) upgraded</li> <li>• RENAM connection upgrade to 155 Mbps.</li> </ul> Future: <ul style="list-style-type: none"> <li>• there is a WDM project undergoing, probably in 2Q 2008 main nodes will be connected via a new structure, with 10 Gbps links;</li> <li>• GEANT connection(s) upgrade to 10 Gbps (new GEANT PoP in Bucharest, already installed but not operational)</li> </ul>
Spain	RedIRIS	Red.es has developed a project to fund a new dark-fibre backbone for RedIRIS. The project awaits final approval by the EU and national authorities. If approved, the new backbone would be deployed between 2009 and 2010.
Sweden	SUNET	In 2007, SUNET upgraded to a new network, called OptoSunet, with a new topology and the possibility to deliver transfer speeds up to 40 Gbit/s. Optical transport technology gives possibilities for large traffic transfers with a fibre handling up to 192 wavelengths and 40 Gbit/s.  For the first time, SUNET uses dark fibre in most connections and the optical transmission make it possible to provide point to point connections of different kinds at the requirement of the members.
Switzerland	SWITCH	SWITCH moved offices to its new location in downtown Zürich at Werdstrasse 2, finally gathering all SWITCH employees under one roof.  As a founding member of the newly established Swiss National Grid Association (SwiNG), SWITCH is making good progress in building up a grid infrastructure for the Swiss universities.
United Kingdom	JANET(UK)	Additional services added to the portfolio included JANETTxt service. We have undertaken a number of framework procurements which will benefit the UK's education and research community.  The JANET Talk trial has been launched. Third Party services have been launched. We now allow commercial organisations to connect Halls of Residence over JANET.  The further education funding council has agreed to provide the capital funding to upgrade the connection of English Further Education Colleges beyond 10Mbit/s. This is a major upgrade programme.

Table 1.3.1 - continued

Country	NREN	Changes
<b>Other European and Mediterranean Countries</b>		
Belarus	BASNET	In 2007 the National Centre of Information Resources and Technologies, former operator of BASNET network, was reorganised by joining the United Institute of Informatics Problems of the National Academy of Sciences of Belarus.
Croatia	CARNet	CARNet is implementing a major project of connecting all primary and secondary schools to the network. Also, extensive work is being done to implement the E-Islands project.
Georgia	GRENA	GRENA is actively participating in the Georgian secondary school connectivity programme "Deer Leap Georgia". According to this programme all 2300 schools of Georgia will receive Internet services via virtual private network (VPN) and GRENA is acting as a Network Operation Centre for this network. During 2008-2010 GRENA will participate in two EC FP7 projects: Black Sea Interconnection/BSI and SEE-GRID eInfrastructure for regional eScience/SEE-GRID-SCI.
Israel	IUCC	On the international aspect - we upgraded from 2x STM-4 links to GEANT2 to 1x STM-16 link. On the national aspect - we are in the midst of a tender to upgrade our national links.
Macedonia	MARNet	MARNet has built its own 20 km fiber optic infrastructure in the Skopje metropolitan area connecting 6 major campuses and a wireless network. International connectivity is upgraded from 4 to 34 mbps and from 1 Jan 2007, 68 mbps is in place. A significant role is given to MARnet in the national eMacedonia strategy and strategy for modernisation of the educational system adopted by the Parliament. Fibre optic connectivity is foreseen for connectivity to other two public major university towns Bitola and Tetovo.
Moldova	RENAM	<p>New optical connections were realized in the Chisinau MAN that allowed extending the own optical infrastructure up to 33 km.</p> <p>In the communication node that provides external connectivity the Cisco 7206 router was upgraded with the NPE-G2 communication engine and two new Cisco WS-C2960G-24TC-L switches were installed in REAM nodes.</p> <p>The radio-relay channel Chisinau (RENAM, Moldova) - Iasi (RoEduNet, Romania) was transferred to a new technical basis and its capacity upgraded in 2007 up to 155 Mbps. A new external back-up channel of 40 Mbps capacity was provided by local IDSP StarNet. The total external capacity (excluding local IX peering) from September 2007 achieved 155 + 40 Mbps.</p> <p>In 2007-2008 the development of DF backbone in Chisinau was continued. One new RENAM node was connected by fiber optics link that allowed improve connectivity for campuses of Technical University of Moldova. Connection to the National IX point was upgraded up to 1 Gbps. In 2008 the elaboration of the technical solution of DF link Chisinau - Iasi construction was continued and the terms of the practical realisation of this optical connection will be determined in 2008.</p> <p>RENAM CERT operation was promoted and appropriate services for NREN community are deployed in production mode.</p>
Russian Federation	RBNet/RUNet	<p>2006 - New SDH based infrastructure of network backbone in Russia</p> <p>2006 - 2,5Gb/s GEANT connectivity</p> <p>2007 - 10Gb Moscow - Amsterdam channel (GLORIAD project)</p> <p>2007 - (October) 10Gb/s Moscow - Saint-Petersburg Stockholm channel</p> <p>2009 - Cross-Border Dark fibre</p>
Turkey	ULAKBIM	<p>Access and backbone capacity upgrades were made</p> <p>Capacity of GEANT connectivity will be increased from 622 Mbps to 2x2.5 Gbps in 2008</p>
<b>Countries from Other Regions</b>		
Australia	AARNET	2009 will be a year of technological changes at AARNet. We're planning to: Light the fibre system to Western Australia, where one of the candidate sites for the Square Kilometer Array is located (approx. 1500km of fibre); Trial 40 Gbps DWDM transmission; Enable Dynamic Lightpath Capability on the AARNet optical network; Implement VPLS capability as an alternative technology to the Optical Private Networks built on a mesh of PtP circuits currently in use for customer campus interconnectivity.

Table 1.3.1 - continued

Country	NREN	Changes
<b>Countries from Other Regions</b>		
Guatemala	RAGIE	By the end of August we expect to have our link to RedCLARA changed to an STM-1 which will allow for immediate and future growth in BW. Also, our NREN local loop will be upgraded to 1 Gbps for all currently participating institutions.
New Zealand	REANNZ	<ul style="list-style-type: none"> <li>• Cutover of diverse Lower South Island 10Gb/s path - Dunedin - Invercargill - Queenstown - Christchurch (2008)</li> <li>• Establishment of physically diverse Upper South Island path - Christchurch - Lower Hutt (2009)</li> <li>• Trial of National Education Network (2008)</li> <li>• Deployment of National Education Network in 2009/2010</li> <li>• Procurement of upgraded capacity to Australia 2009</li> </ul>
Taiwan	NCHC	Next generation optical network technologies (NG-SDH, DWDM and ROADM) are planned to be implemented.
USA	Internet2	With the completed deployment of the Internet2 Network infrastructure, Internet2 Connectors and member institutions are developing, deploying, and exploring dynamic circuit networking as complementary to high-performance IP networking. Information on the Internet2 network is available at <a href="http://www.internet2.edu/network">http://www.internet2.edu/network</a> ; Organizationally, Internet2 is focused on implementing a community-driven strategic plan developed over the past year. The strategic plan was approved by the Internet2 Board of Trustees and is available at: <a href="http://www.internet2.edu/reinvent">http://www.internet2.edu/reinvent</a>

## 2 USERS/CLIENTS

This section starts with information in section 2.2 about the connection policies of NRENs (i.e., who is allowed to connect). Section 2.3 provides an indication of what proportion of the total access capacity that is available to an NREN is used by various user categories. The last sections look more closely at the bandwidth of universities and at the percentage of schools that are connected through NRENs. Note that the Compendium website contains additional information. More information about European educational systems in general can be found at <http://www.eurydice.org>.

The 2005 edition of the Compendium contained an overview of Acceptable Use Policies of NRENs. Because these policies do not change much over time, the information is not repeated this year. Information on NREN AUPs can be found on the Compendium website.

The overview section (2.1) gives aggregate data and tries to identify trends in all of these areas.

### 2.1 Overview

#### Connection Policies

Table 2.2.1 gives an overview of which types of institutions can be connected to the NREN (the Connection Policies).

As is clear from the table, all NRENs can connect universities, research institutes and, with four exceptions, institutes of higher education. For other institutions, there are great differences in policy between NRENs. Note that sometimes there are further restrictions, not included in the table. For example, some NRENs only connect government departments that have a relation to research and education.

For more details on individual NRENs, please consult the country entries on the website or the NREN websites themselves.

In the EU/EFTA countries, on average more than 80% of the access capacity is used for the tertiary education sector.

NRENs are quite diverse when it comes to methods of connecting institutions. Indeed, reference to previous Compendia shows that this has changed very little in recent years.

#### Bandwidth of Universities

Looking back five years, there is a clear trend in the bandwidth of universities. In 2003, the 'average' university was connected at Megabit capacity; by 2008, that had changed to Gigabit capacity.

This trend is less pronounced, in the countries outside of the EU/EFTA area.

It should be noted that increases are usually not gradual, but occur in steps, with the introduction of new technologies.

For institutions other than universities, it is reasonable to expect that capacities will have increased as well. Yet most secondary and primary schools are not (yet) connected at Gigabit capacities.

#### Connections to Primary and Secondary Schools

For a while, the expectation was that the number of connections by NRENs to primary and secondary schools would increase from year to year. This seems not to have happened – instead, the situation seems to be more or less stable overall. This is due not so much to the fact that connections to primary and secondary schools are not considered important, but rather to differences in national policies. In some countries, it has been decided that these connections should be a task of the NREN – and this is shown in the

Compendium. In other countries, however, this is a task that is performed by separate organisations.

No conclusions can be drawn about the situation in countries not included in the tables:

- The NREN may connect the relevant institutions, but may not have been able to answer these questions in the survey (see also the information in table 2.2.1);
- The institutions may be connected through a different organisation. For example, secondary schools in many countries are connected to the Internet through separate organisations and many of them collaborate through the European Schoolnet;
- Institutions may be connected through commercial ISPs;
- Institutions may not be connected to the Internet at all.

## 2.2 Connection Policies

Note that the percentages here show the percentage of the total number of institutions connected to the NREN. Institutions connected by other service providers are not taken into account.

**Table Legend**

+	Allowed, but percentage not reported
-	Not allowed

**Table 2.2.1 Connection Policies and Practice** – categories of institutions for which connection to the NREN is allowed

Country	NREN	Universities	Institutes of Higher/Further Education	Research Institutes	Secondary Schools	Primary Schools	Libraries, Museums, National Archives	Hospitals (Other than University Hospitals)	Government Departments (National, Regional, Local)	Others
<b>EU/EFTA Countries</b>										
Austria	ACOnet	100	50	50	+	+	20	20	10	-
Belgium	BELNET	95	5	80	30	35	5	5	10	+
Cyprus	CYNET	100	10	100	-	-	-	-	-	+
Czech Republic	CESNET	7	3	6	36	7	9	8	12	+
Denmark	UNI-C	100	80	50	-	-	5	10	-	+
Estonia	EENet	82	34	49	57	57	11	+	1	-
Finland	Funet	100	-	48.1	-	-	10	-	1	+
France	RENATER	100	+	+	+	-	+	+	+	-
Germany	DFN	98	98	93	+	+	+	+	+	-
Greece	GRNET S.A.	100	100	100	100	99.8	1	-	1	+
Hungary	NIIF/HUNGARNET	100	80	100	5	0.2	85	30	1	+
Iceland	RHnet	100	90	65	+	-	10	-	-	-
Ireland	HEAnet	100	100	60	96	96	1	-	2	+
Italy	GARR	100	100	98	0.5	1	7	12	5	+
Latvia	SigmaNet	70	5	19	2.5	-	3.2	1.8	+	+
Lithuania	LITNET	100	85	92	78	16	16	11	5	+
Luxembourg	RESTENA	100	100	100	100	80	50	90	3	-
Malta	UoM, IT Services	100	50	+	+	+	+			+
Netherlands	SURFnet	100	95	80	2	0.5	15	1	-	+
Norway	UNINETT	100	90	50	8	13	30	-	-	+
Poland	PIONIER	100	+	100	+	+	+	+	+	+
Portugal	FCCN	95	90	90	100	100	-	-	2	-

Table Legend

+	Allowed, but percentage not reported
-	Not allowed

Table 2.2.1 – continued

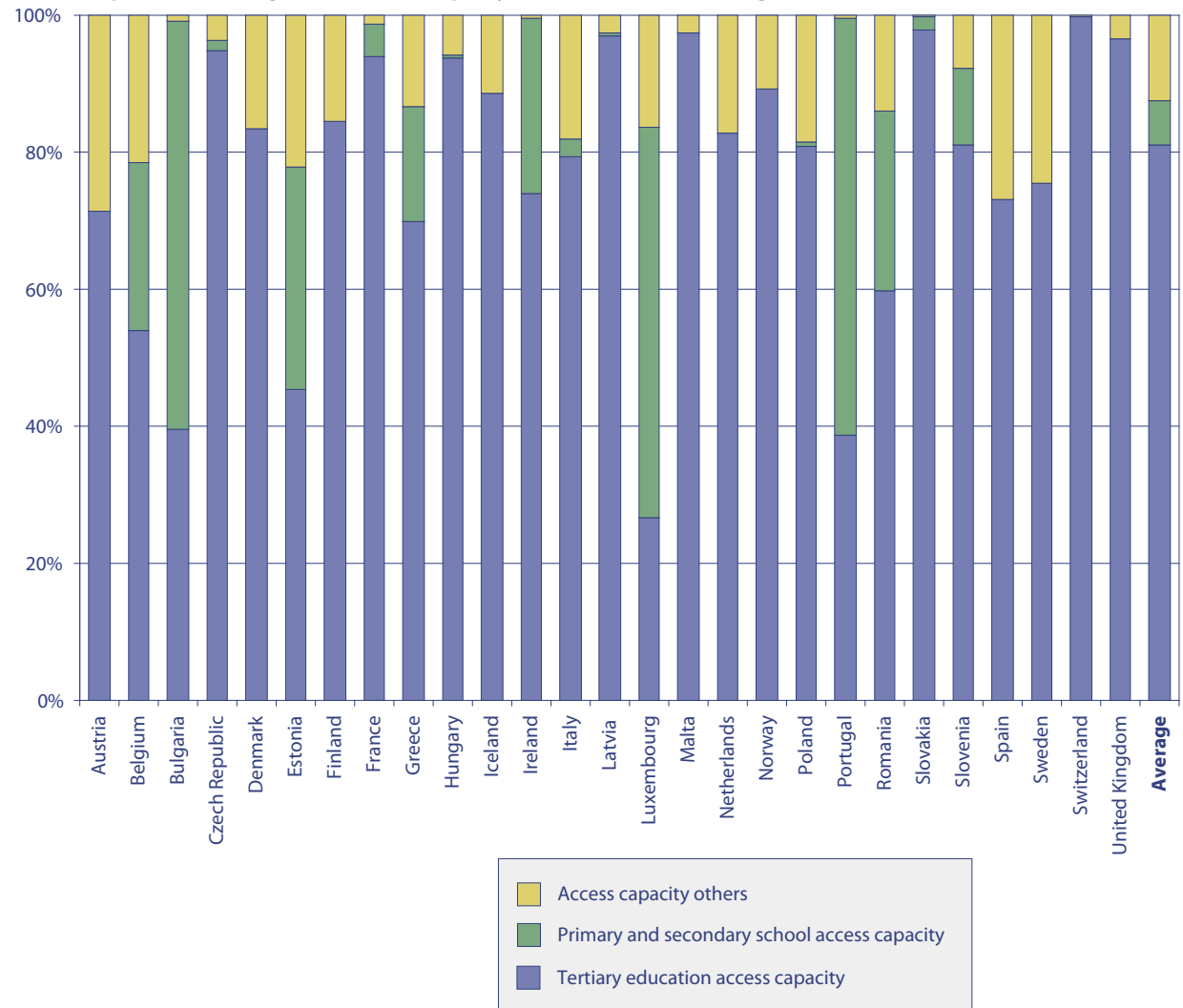
Country	NREN	Universities	Institutes of Higher/Further Education	Research Institutes	Secondary Schools	Primary Schools	Libraries, Museums, National Archives	Hospitals (Other than University Hospitals)	Government Departments (National, Regional, Local)	Others
<b>EU/EFTA Countries</b>										
Slovakia	SANET	100	100	100	10	5	10	-	10	-
Slovenia	ARNES	100	98	80	95	80	50	-	-	-
Spain	RedIRIS	100	-	95	-	-	3	35	5	+
Sweden	SUNET	100	+	+	-	-	+	-	+	+
Switzerland	SWITCH	100	5	15	5	+	10	+	10	+
United Kingdom	JANET(UK)	100	100	100	95	100	+	-	+	+
Romania	RoEduNet	100	80	85	75	20	70	-	25	-
Bulgaria	BREN	75	10	90	100	6	1	-	-	-
<b>Other Countries</b>										
Belarus	BASNET	35	+	31	+	+	14	2	1	-
Croatia	CARNet	100	100	100	50	50	1	0.5	0.5	+
Georgia	GRENA	50	40	75	30	-	1	0.5	0.5	+
Israel	IUCC	25	-	3	-	-	+	+	-	-
Macedonia	MARNet	20	+	38	+	+	34	+	10	+
Moldova	RENAM	62	25	80	+	+	30	5	5	+
Montenegro	MREN	70	-	50	20	20	20	-	10	-
Morocco	MARWAN	100	96	50	+	+	10	+	3	-
Russian Federation	RBNet/RUNNet	70	2	40	10	-	4	-	1	-
Serbia	AMRES	95	5	40	2	+	5	5	5	+
Turkey	ULAKBIM	95	-	60	-	-	1	-	1	-
Ukraine	UARNet	22	45	34	+	+	5	-	12	-

## 2.3 Percentage of Total Access Capacity Available for Different Categories of Users

Graph 2.3.1 gives the percentage of the total access capacity for each category. The graph shows three categories: tertiary education and research, primary and secondary schools, and all others. It seems logical that NRENs that connect a large proportion or all of the secondary and primary schools in their countries (e.g., BREN of Bulgaria, RESTENA of Luxembourg and FCCN of Portugal) also devote a large part of the access capacity to schools. However, this is not always and not necessarily the case: it is influenced, on the one hand, by the differences in access capacity between the different categories of institutions and, on the other hand, by the nature of access technology, which varies within and between these categories. Very often, schools are connected, nominally at 2Mb/s, but in such a way that hundreds of them might share a connection of 45 Mb/s in total (so-called ‘contended’ bandwidth, versus ‘uncontended’ bandwidth for most of the larger institutions). As a result, it is not surprising that the graph shows a wide diversity between the different NRENs.

For the EU/EFTA countries that have answered the relevant survey questions, on average (weighted), more than 80% of the access capacity is used for the tertiary education sector. This is similar to last year.

Graph 2.3.1 Percentage of Total Access Capacity Available for Different Categories of Users

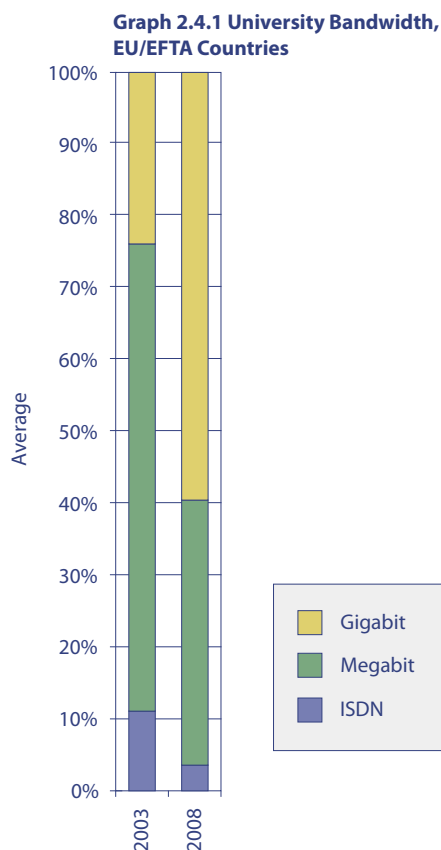


## 2.4 Number of Connections to Universities and Bandwidth

It should be noted that the organisational set-up of universities and other institutes can be very different from country to country. For example, in some countries research institutes are part of universities; in other countries, they are not. Some countries have relatively few but large universities; others have many, but smaller ones. Also, some universities have a single link to the NREN; in other cases, separate faculties or schools that form part of a university, but are geographically at different locations, have their own connections. All of that may obviously have an effect on university bandwidth requirements.

When looking at aggregated data over the past five years, it is possible to see a clear trend. In 2003, the 'average' university was connected at Megabit capacity. By 2008, that had changed to Gigabit capacity.

The trend is similar, though less pronounced, in the other countries.



## 2.5 Percentage of Schools Connected through the NREN

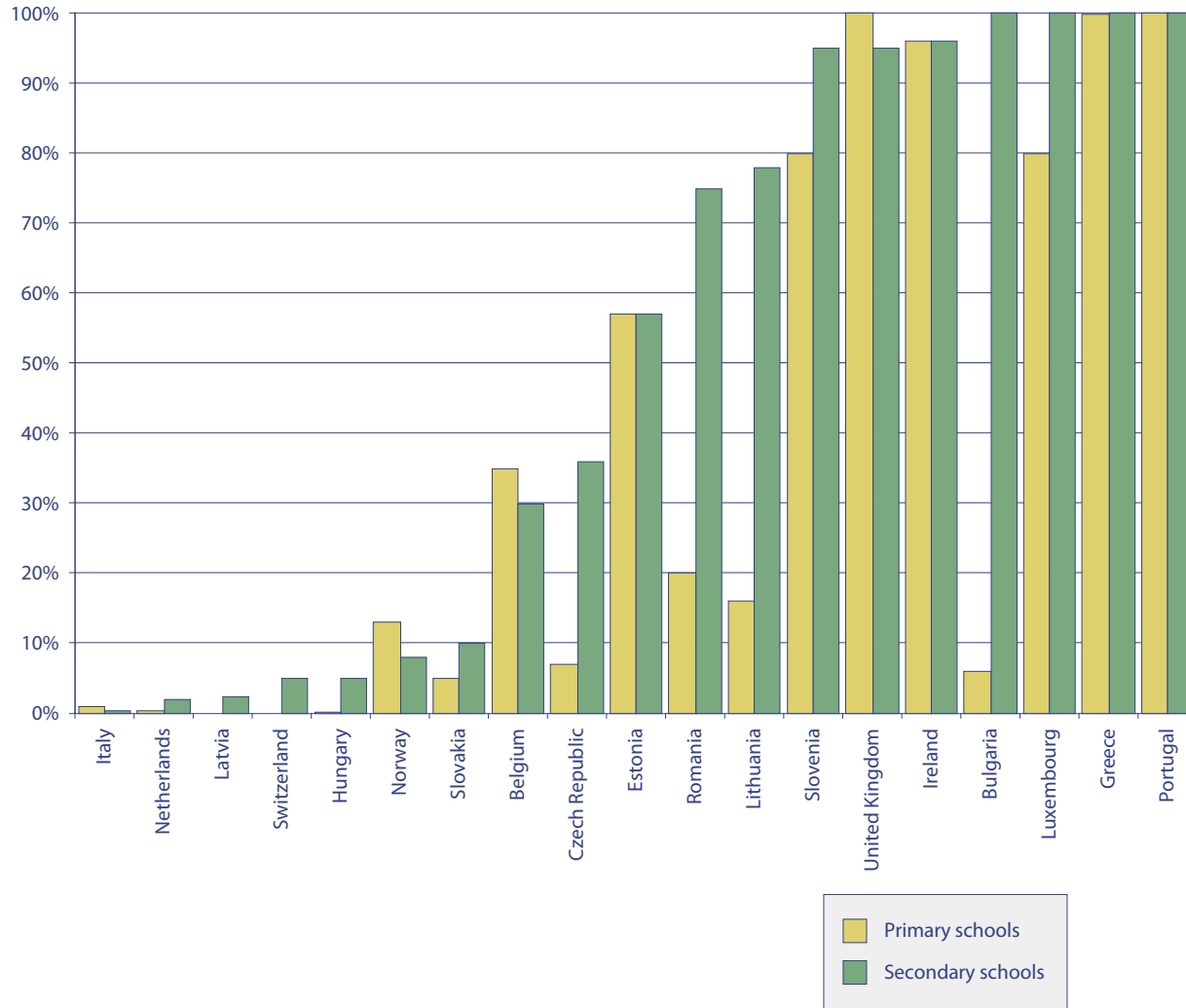
The following graphs provide information about the percentage of all secondary and primary schools that are connected through the NREN, according to estimates supplied by the NRENs.

Note that aside from the connection itself, the connection method and the type of services offered are also important. Thus, in the UK, schools are not connected directly to the NREN but via the regional broadband consortia or local authorities who use the NREN as their backbone. Schools receive a reduced set of services. In other countries, schools may be connected directly to the NREN backbone and may receive an extended set of services, tailored to the needs of schools.

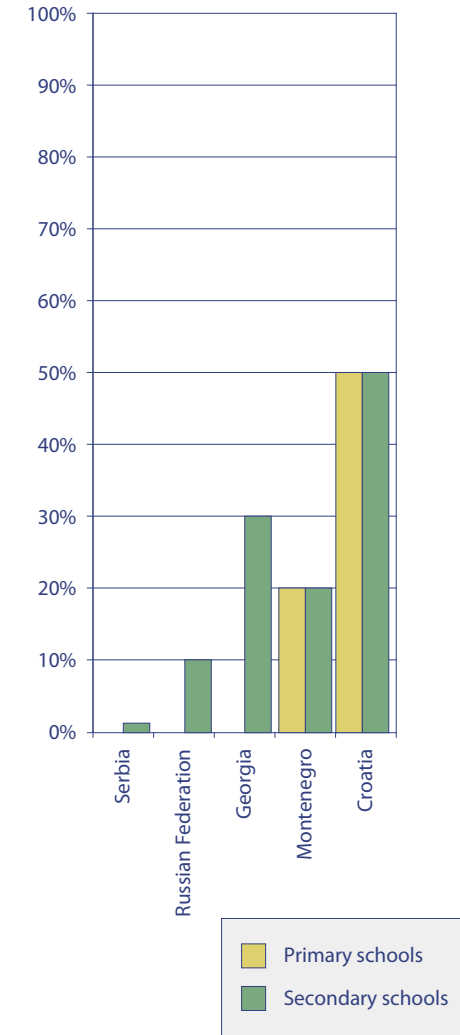
The graphs show that in a number of countries, the coverage is either 100% or close to it. In many countries, connections to schools are funded centrally through ministries of education. Note also that in some countries, such as Denmark, connecting primary and / or secondary schools is not done by the NREN itself but by another organisation; sometimes, as in Denmark, these two organisations are closely related.

Note that the information is sorted by percentage of secondary schools connected, in order to present an easier view of the differences between NRENs in this area.

**Graph 2.5.1 Percentage of Schools Connected through the NREN, EU/EFTA Countries**



**Graph 2.5.2 Percentage of Schools Connected through the NREN, Other Countries**





## 3A NETWORK AND CONNECTIVITY SERVICES

This section provides insights into a number of important network characteristics. Section 3A.2 starts with information about PoPs, managed links and managed sites on the network. Section 3A.3 provides information about core network size. Section 3A.4 documents core capacity on the networks. Section 3A.5 looks at the expected changes in this capacity over the next two years. Section 3A.6 is about external links that NRENs have. Section 3A.7 documents recent developments in the area of dark fibre and section 3A.8 gives information about cross-border dark fibre links. Section 3A.9 looks at networking equipment. The overview section, 3A.1, tries to identify key trends in the areas of core capacity, network size, external links and dark fibre.

### 3A.1 Overview

#### Core Network Size and Capacity

Over the past five years, there have been increases both in average core network size and in core backbone capacity. Average core network size has quadrupled in that period, whilst the average core backbone capacity has more than doubled. For non-EU/EFTA countries, the effect of the introduction of affordable Gigabit Ethernet technology is clearly visible.

For the coming period, the trend is clearly that in most countries, the core capacity will evolve to multiples of 10 Gb/s. It is interesting to note that many EU/EFTA countries foresee further upgrades in the next two years. Many other countries have also upgraded to Gigabit capacities.

It should be noted that this considerable growth has taken place in spite of the fact that on average, NREN budgets have remained fairly stable over the past period.

#### External links

The graphs in section 3A.6 clearly show that for many NRENs that are part of the GN2 project, the link to GÉANT is the most important in terms of capacity. Often NRENs also have peering arrangements at neutral Internet exchanges and many also have connections to commercial ISPs, but many of these do not have the same capacity as those to GÉANT.

It is interesting to note that a number of NRENs have their own links to other research bodies. Typically, these are dark fibre links. Some of these links are part of the emerging Global Lambda Integrated Facility, a world-scale wavelength-based laboratory for application and middleware development on emerging LambdaGrids (see [www.glif.is](http://www.glif.is) for more information).

The situation is different in countries that are not part of the GN2 project. For those countries, relatively low-bandwidth connections to commercial ISPs are most important (see also section 3B, for related information on traffic load). A number of NRENs that are part of the Silk/OCCASION project can make use of the satellite-based connectivity that is provided through that project (see <http://www.ist-occasion.org> for more information).

#### Dark Fibre

The maps in section 3A.7 illustrate the rapid developments in the area of dark fibre in recent years. Many (although not all) NRENs predict a further increase in the percentage of their network that is dark fibre by 2010.

A continuing development is the implementation of cross-border dark fibre links between NRENs. Section 3A.8 presents current and planned links of this type both in map and table format.

## 3A.2 Numbers of PoPs, Managed Links and Managed Sites on the Network

The number of Points of Presence (PoPs) on the network and the numbers of managed links and managed sites are indicators of the amount of resources needed for the NREN to maintain the network. A PoP is defined as a point on the NREN backbone which can connect client networks or aggregations of client networks, such as MANs or external networks. Note that this is different from, for example, managing a router in a secondary school (something which is also done by a number of NRENs).

The number of managed links is the number of NREN-managed links that carry production traffic. The number of managed sites is the number of sites where the NREN manages routing or switching equipment.

As can be seen from the table, NRENs vary considerably in this respect. Thus, ARNES of Slovenia manages the equipment at many secondary and primary schools and thus has 1198 managed links. In many other countries, the links from a PoP on the backbone or from a MAN to the end user are managed by other bodies.

The information about the number of optical PoPs on the network, together with other information e.g., about dark fibre on the network, gives an indication of the spread of optical networking in the NREN. For ease of comparison, we have shown the numbers of managed links and managed sites in 2007 as well. The darker colour indicates a significant change in those numbers.

**Table 3A.2.1 Numbers of PoPs and of Managed Links and Managed Sites on the Network**

Country	NREN	# of PoPs	# of Optical PoPs	# of Managed Links 2007	# of Managed Links 2008	# of Managed Sites 2007	# of Managed Sites 2008
<b>EU/EFTA Countries</b>							
Austria	ACOnet	17	8	22	24	15	15
Belgium	BELNET	21	21	29	63	16	21
Bulgaria	BREN	10	0	30	30	10	10
Cyprus	CYNET	3	0	15	23	3	3
Czech Republic	CESNET	39	14	45	51	29	39
Denmark	UNI-C	7	5	0	23	20	20
Estonia	EENet	16	4	20	20	16	16
Finland	Funet	18	6	100	100	16	18
France	RENATER	40				50	50
Germany	DFN	54	54	76	96	49	54
Greece	GRNET S.A.	38	22	62	78	63	79
Hungary	NIIF/ HUNGARNET	42	42	45	47	40	42
Iceland	RHnet	13	13	15	13	14	14
Ireland	HEAnet	8	0	90	100	10	12
Italy	GARR	42	8	53	52	38	42
Latvia	SigmaNet	1	0	79	40	1590	10
Lithuania	LITNET	31	6	200	200	200	200
Luxembourg	RESTENA	12	0	59	59	57	57
Malta	UoM, IT Services	2		0	17	1	2
Netherlands	SURFnet	256	256	336	336	262	256
Norway	UNINETT	40	4	240	240	385	385
Poland	PIONIER	35	71	28	31	23	25
Portugal	FCCN	9	5	11	11	9	9

### 3A.3 Core Network Size

Table 3A.2.1 - continued

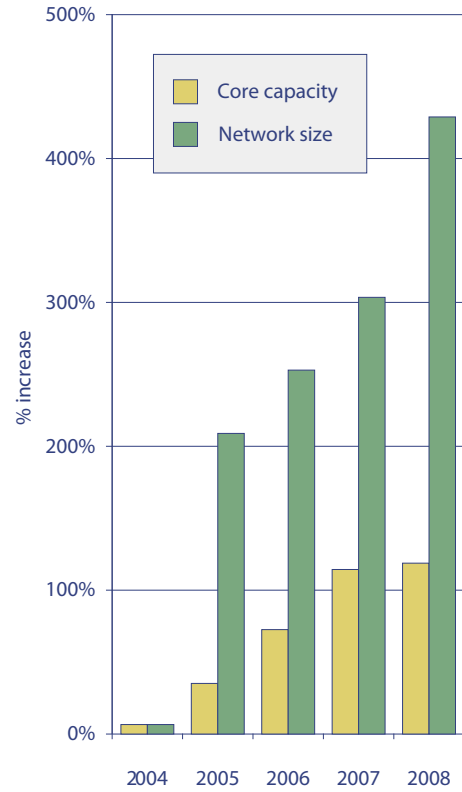
Country	NREN	# of PoPs	# of Optical PoPs	# of Managed Links 2007	# of Managed Links 2008	# of Managed Sites 2007	# of Managed Sites 2008
<b>EU/EFTA Countries</b>							
Romania	RoEduNet	41	3	53	53	40	40
Slovakia	SANET	26	26	30	30	26	26
Slovenia	ARNES	37	37	1200	1198	1107	1190
Spain	RedIRIS	20	0	60	67	20	20
Sweden	SUNET	22	22	120	190	60	3
Switzerland	SWITCH	30	30	50	51	34	35
United Kingdom	JANET(UK)	150	5	1500	1500	742	742
<b>Other Countries</b>							
Belarus	BASNET	20	20		41		38
Croatia	CARNet	647	456	700	613	570	613
Georgia	GRENA	13	7	10	10	13	13
Israel	IUCC	2	0	17	17	10	10
Macedonia	MARNet	1	20				
Moldova	RENAM	33	10	47	47	51	51
Montenegro	MREN	25	24	30	30	31	31
Morocco	MARWAN	15	10	33	34		
Russian Federation	RBNet/ RUNNet	12	4	15	15	12	12
Serbia	AMRES	52	52	120	153	40	52
Turkey	ULAKBIM	3	0	3	3	3	3
Ukraine	UARNet	29	140				850

As in previous years, NRENs were asked to estimate the total size of their networks by multiplying the length of the various links in the backbone by the capacity of those links in Mb/s. The resulting unit is network size in Mb/s x km. The quality of the data has improved, because the same question has been asked now for a number of years.

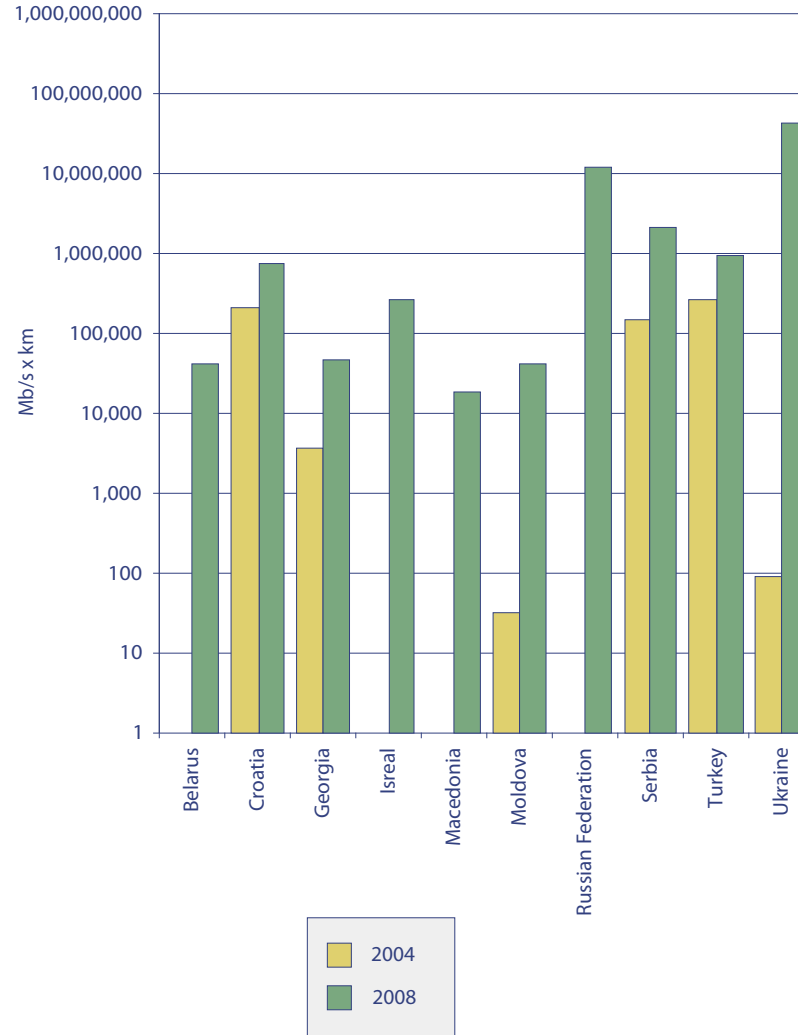
Perhaps not surprisingly, the largest growth rates have been achieved by NRENs from new EU countries, such as ARNES in Slovenia (a 60-fold increase), PIONIER in Poland (a 40-fold increase) and EENet in Estonia (a 25-fold increase). Other large increases were achieved by EU countries such as Portugal and Ireland. It is clear from graph 3A.3.3 that large increases were achieved in some other countries as well.

In order to illustrate the progress that has been made, we have added a graph showing both the increase in average core network size and in core backbone capacity in EU/EFTA countries for the countries for which we have the data. As is seen from the graph, the average core network size quadrupled (taking 2003 as the base year), while the average core backbone capacity more than doubled.

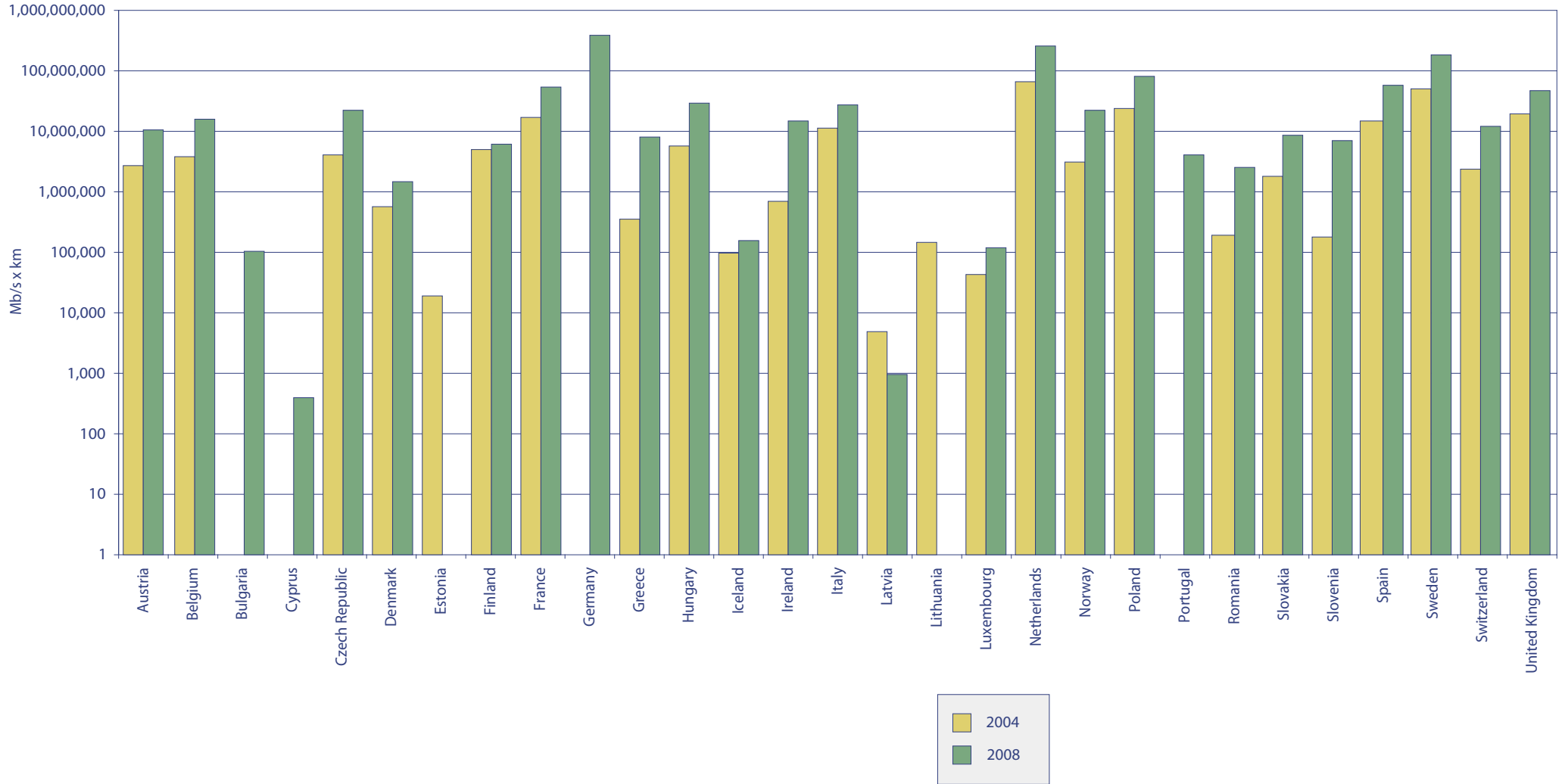
**Graph 3A.3.1 Cumulative Increase in Average Core Capacity and Network Size 2004 – 2008, EU/EFTA Countries (2003 = 0)**



**Graph 3A.3.3 Core Network Size 2004 – 2008, Other Countries**  
Note that the scale in this graph is logarithmic.



**Graph 3A.3.2 Core Network Size 2004 – 2008, EU/EFTA Countries**  
 Note that the scale in this graph is logarithmic.



## 3A.4 Core Capacity on the Network

By 'core usable backbone capacity' we mean the typical core capacity of the linked nodes in the core. Some networks do not have a core backbone, for example, because they have a star topology. In those cases, we have asked for the maximum capacity into the central node of the network.

Some NRENs have dark fibre with a very high theoretical capacity. In those cases, we have asked for the usable IP capacity.

Graphs 3A.4.1 and 3A.4.2 give an idea of the evolution of network capacity from 2004 to 2008. For presentational purposes, the information is given in two graphs: 3A.4.1 for EU/EFTA and graph 3A.4.2 for other countries. Note that the scales are logarithmic.

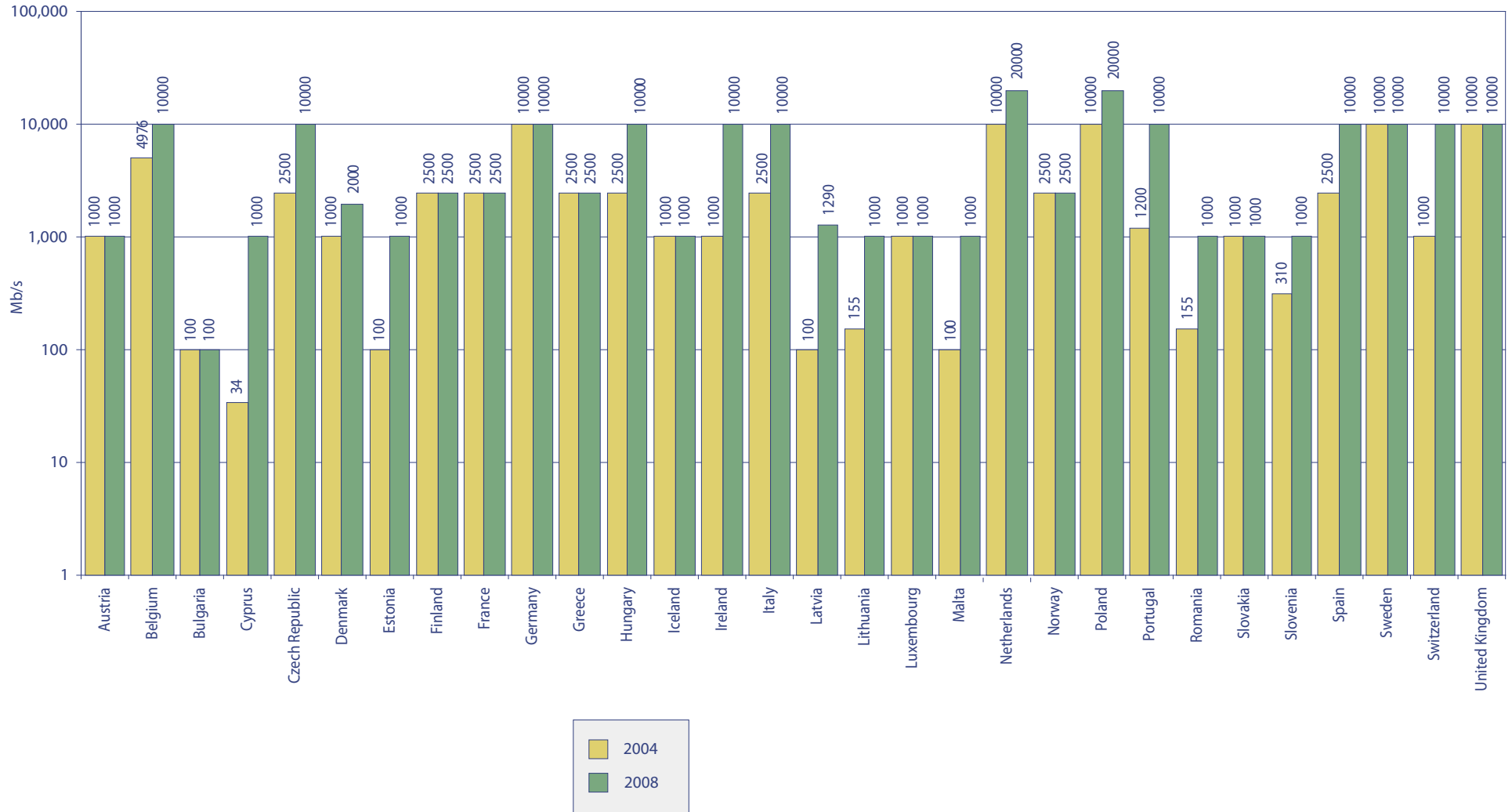
For the EU/EFTA countries, the average core capacity doubled. However, for some NRENs the capacity stayed the same, whereas for others (CyNet and ARNES) it increased a hundred-fold or more. The highest average core capacities in Europe now are 20 Gb/s; in 2006, the highest capacity was 10 Gb/s. In 2007, CANARIE of Canada had a core capacity of 50 Gb/s.

In the 'Other' countries, the effect of the introduction of affordable Gigabit Ethernet technology is clearly visible. Many countries are now using this. No NREN in this category has stayed at the same level since 2004.

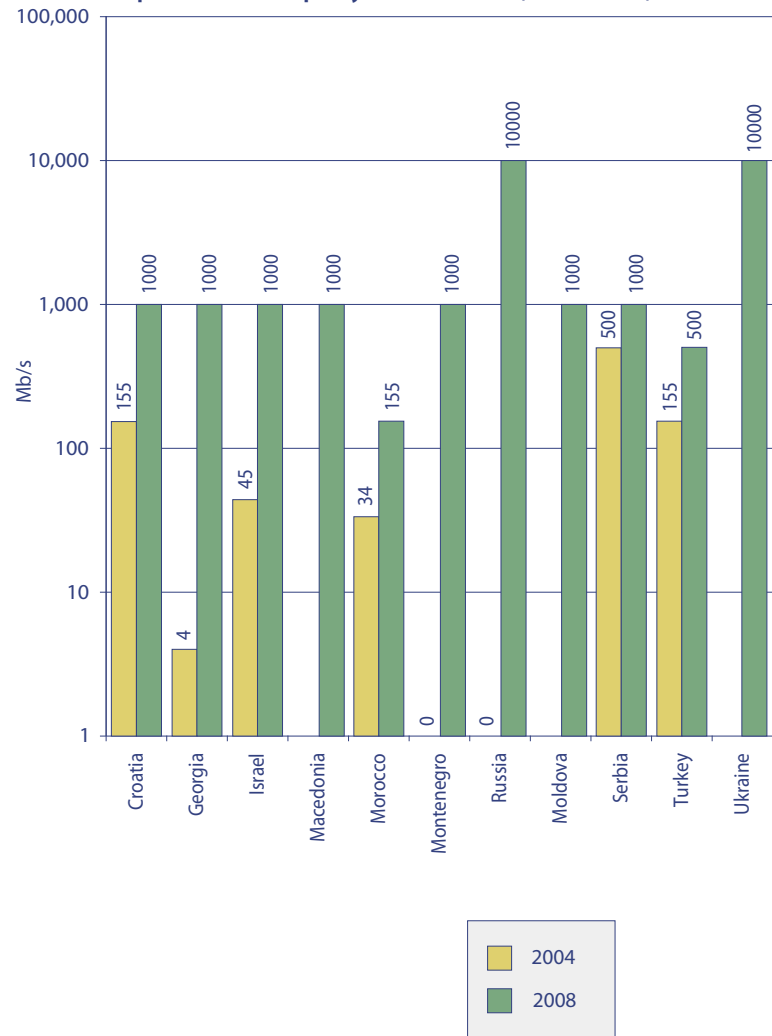
For a number of NRENs, we have data going back to 2001. Table 3A.4.3 gives the increase in core capacity on the networks between 2001 and 2008 for those countries.

**Graph 3A.4.1 Core Capacity on the Networks, 2004 – 2008, EU/EFTA Countries**

Note that the scale in this and the next graph is logarithmic.



**Graph 3A.4.2 Core Capacity on the Networks, 2004 – 2008, Other Countries**



In table 3A.4.3, capacities of 10 Gb/s and above have been colour-coded for increased readability. Note that in a number of cases, the information from earlier years refers to the capacity of external connections, NOT to the capacity of the backbone.

**Table 3A.4.3 Core Capacity on the Network in Mb/s, 2001 – 2008**

Country	NREN	2001	2002	2003	2004	2005	2006	2007	2008
<b>EU/EFTA Countries</b>									
Austria	ACOnet	155	1000	1000	1000	1000	1000	1000	1000
Belgium	BELNET	622	1000	4976	4976	4976	10000	10000	10000
Bulgaria	BREN	0	0	2	100	10	155	100	100
Cyprus	CyNet	0	0	2	34	2	2	1000	1000
Czech Republic	CESNET	2488	2488	2500	2488	2488	10000	10000	10000
Denmark	UNI-C	622	622	622	1000	2488	2488	2000	2000
Estonia	EENet	24	60	100	100	1000	1000	1000	1000
Finland	Funet	2488	2488	2488	2488	2488	2488	2500	2500
France	RENATER	2488	0	2488	2488	2488	2488	2500	2500
Germany	DFN	622	2488	10000	10000	10000	10000	10000	10000
Greece	GRNET	0	310	310	2488	2488	2488	2500	2500
Hungary	NIIF/ HUNGARNET	155	2488	2488	2488	10000	10000	10000	10000
Iceland	RHnet	0	1000	1000	1000	1000	1000	1000	1000
Ireland	HEAnet	155	310	310	1000	1000	1000	10000	10000
Italy	GARR	0	2488	7500	2488	2488	10000	10000	10000
Latvia	SigmaNet	100	100	100	100	2488	10000	1000	1290
Lithuania	LITNET	4	155	155	155	310	310	1000	1000
Luxembourg	RESTENA	10	1000	1000	1000	1000	1000	1000	1000
Malta	UoMalta	0	0	0	100	45	1000	1000	1000
Netherlands	SURFnet	2488	10000	10000	10000	10000	10000	20000	20000
Norway	UNINETT	2488	2488	2488	2488	2488	2488	2500	2500
Poland	PIONIER	155	155	622	10000	10000	10000	20000	20000

Table 3A.4.3 - continued

Country	NREN	2001	2002	2003	2004	2005	2006	2007	2008
<b>EU/EFTA Countries</b>									
Portugal	FCCN	180	180	1200	1200	2488	2488	10000	10000
Romania	RoEduNet	0	0	34	155	310	310	1000	1000
Slovakia	SANET	4	1000	1000	1000	1000	1000	1000	1000
Slovenia	ARNES	100	100	10	310	1000	1000	1000	1000
Spain	RedIRIS	155	155	2488	2488	2488	2488	10000	10000
Sweden	SUNET	622	10000	10000	10000	10000	10000	10000	10000
Switzerland	SWITCH	310	0	1000	1000	10000	10000	10000	10000
United Kingdom	JANET(UK)	2488	2488	10000	10000	10000	10000	10000	10000
<b>Other Countries</b>									
Algeria	CERIST	0	0	155	155	310	310	34	
Azerbaijan	AzNET	0	0	0	1000	1000	1000	1000	
Croatia	CARNet	155	155	155	155	310	310	1000	1000
Georgia	GRENA	0.896	2.048	4.1	4	1000	1000	1000	1000
Israel	IUCC	0	0	34	45	1000	1000	1000	1000
Jordan	JuNET	0	0	0	0	0	1000	2000	
Macedonia	MARnet	0.5	2	2	0	10	1000	1000	1000
Moldova	RENAM	0	0	2	0	0	1000	1000	1000
Montenegro	MREN	0	0	0	0	0	0	1000	1000
Morocco	MARWAN	0	0	2	34	45	155	155	155
Palestinian Territory	PADI2	0	0	0	0	0	0	100	
Russia	RBNet/ RUNNet	0	0	100	0	2488	2488	2488	10000
Serbia	AMRES	0	2	155	500	100	1000	1000	1000
Turkey	ULAKBIM	34	34	155	155	45	310	500	500

### 3A.5 Expected Change in Core Capacity in Two Years' Time

The following table gives the current core capacities, the expected increase in two years' time and the estimated core capacities for early 2009.

Note that, typically, the core capacity goes up in leaps, sometimes involving a change from one type of technology to another. Note also that it is not always easy to predict the evolution in core capacity. This is because this evolution depends on many factors, such as developments in technology, pricing and the availability of sufficient funds for investment.

The trend is clearly that, in most countries, the core capacity will evolve to multiples of 10 Gb/s. It is interesting to note that many EU/EFTA countries foresee further upgrades in the next two years. Many other countries have also upgraded to Gigabit capacities.

**Table 3A.5.1 Expected Change in the Core Capacity in Two Years' Time**

Country	NREN	2008	2010
<b>EU/EFTA Countries</b>			
Austria	ACOnet	10Gb/s Vienna Core, 1Gb/s Austrian Backbone	multi10Gb/s Vienna Core, 10Gb/s Austrian Backbone
Belgium	BELNET	between 5 and 10 Gb/s	between 10 and 20 Gb/s
Bulgaria	BREN	100 Mb/s	2.5 - 10 Gb/s
Cyprus	CYNET	1Gb/s Ethernet Network	1Gb/s Ethernet Network
Czech Republic	CESNET	10 Gb/s	10-40 Gb/s
Denmark	UNI-C	2 Gb/s level 2 ring structure	dwdm ring with multiple 10G
Estonia	EENet	Gigabit Ethernet	10 Gb/s
Finland	Funet	2.5 Gb/s between major PoPs	10G in most cases (IP service); lightpath availability to most PoPs

**Table 3A.5.1 - continued**

Country	NREN	2008	2010
<b>EU/EFTA Countries</b>			
France	RENATER	2.5 Gb/s	10 Gb/s
Germany	DFN	10	similar
Greece	GRNET S.A.	2.5 Gb/s	nx10Gb/s
Hungary	NIIF/HUNGARNET	10 Gb/s	10 Gb/s
Iceland	RHnet	1 Gb/s	10 Gb/s
Ireland	HEAnet	10 Gb/s	n x 10Gb/s
Italy	GARR	10 Gb/s	40 Gb/s
Latvia	SigmaNet	1290 Mbit	3500 Mbit
Lithuania	LITNET	1 Gb/s	
Luxembourg	RESTENA	1000Mb/s	10Gb/s
Malta	UoM, IT Services	1Gb	2 Gb/s
Netherlands	SURFnet	20 Gb/s	40 Gb/s
Norway	UNINETT	2.5 Gb/s	10 Gb/s
Poland	PIONIER	20 Gb/s	40 Gb/s
Portugal	FCCN	10G	40G
Romania	RoEduNet	1 Gb/s	10 Gb/s
Slovakia	SANET	10 GE on 1/2 of backbone, 1 GE on the rest	whole backbone 10GE or n*10GE
Slovenia	ARNES	1 Gb/s	1 Gb/s
Spain	RedIRIS	10Gb/s	nx10Gb/s
Sweden	SUNET	10 Gb/s per customer	Same
Switzerland	SWITCH	10 Gb/s	2*10 Gb/s in parallel
United Kingdom	JANET(UK)	10Gb/s	40Gb/s
<b>Other Countries</b>			
Belarus	BASNET	100 Mb/s	1 Gb/s
Croatia	CARNet	1 Gb/s	The bandwidth will be upgraded in the MANs and the number of POPs will increase.

Table 3A.5.1 - continued

Country	NREN	2008	2010
<b>Other Countries</b>			
Georgia	GRENA	1 Gb/s in Tbilisi, 2 Mb/s in regions	1 Gb/s in Tbilisi, 10 Mb/s in regions
Israel	IUCC	1Gb/s	1Gb/s
Macedonia	MARNet	1 Gb/s We have gigabit MAN for university in Skopje	
Moldova	RENAM	1 Gb/s	In 2009 - 10% of the fibre backbone connections will be transferred to 10 Gb/s Ethernet technology; In 2010 - 25% of the fibre backbone connections will be transferred to 10 Gb/s Ethernet technology.
Montenegro	MREN	Lokal 1Gb/s, MAN 100Mb/s and between towns 2Mb/s	
Morocco	MARWAN	155 Mb/s	
Russian Federation	RBNet/RUNNet	10,000	40,000
Serbia	AMRES	1 Gb/s	same bandwidth with more optical POPs and backbone distance to 2700 km.
Turkey	ULAKBIM	500 Mb/s	10 Gb/s
Ukraine	UARNet	10GE	n x 10GE

### 3A.6 External Connectivity: Total External Links

NRENs were asked to list all of their external connections in January 2008.

The Nordic NRENs (Funet of Finland, RHnet of Iceland, SUNET of Sweden, UNINETT of Norway and UNI-C [Forskningsnettet] of Denmark) share their external connections through NORDUnet. What is listed in the graphs is the connection of the individual NRENs to NORDUnet. In addition, their other connections (peerings, connections to the commercial Internet) have been listed. For more information about the external connections of NORDUnet, see <http://www.nordu.net/kartg/last/>.

In the graph, GÉANT/NORDUnet also includes the connections to GÉANT via the SEEREN and EUMEDCONNECT projects as well as connections to GÉANT based on bilateral agreements (RENAM). Note that some NRENs connect to the wider Internet through the DANTE World Service, which makes use of the GÉANT network; others do not.

'Other Research' includes links to other NRENs (including cross-border dark fibre links, which have increased significantly in recent years), the links of several Central Asian NRENs to DFN via the Silk Highway project and connections to CERN, Starlight and similar.

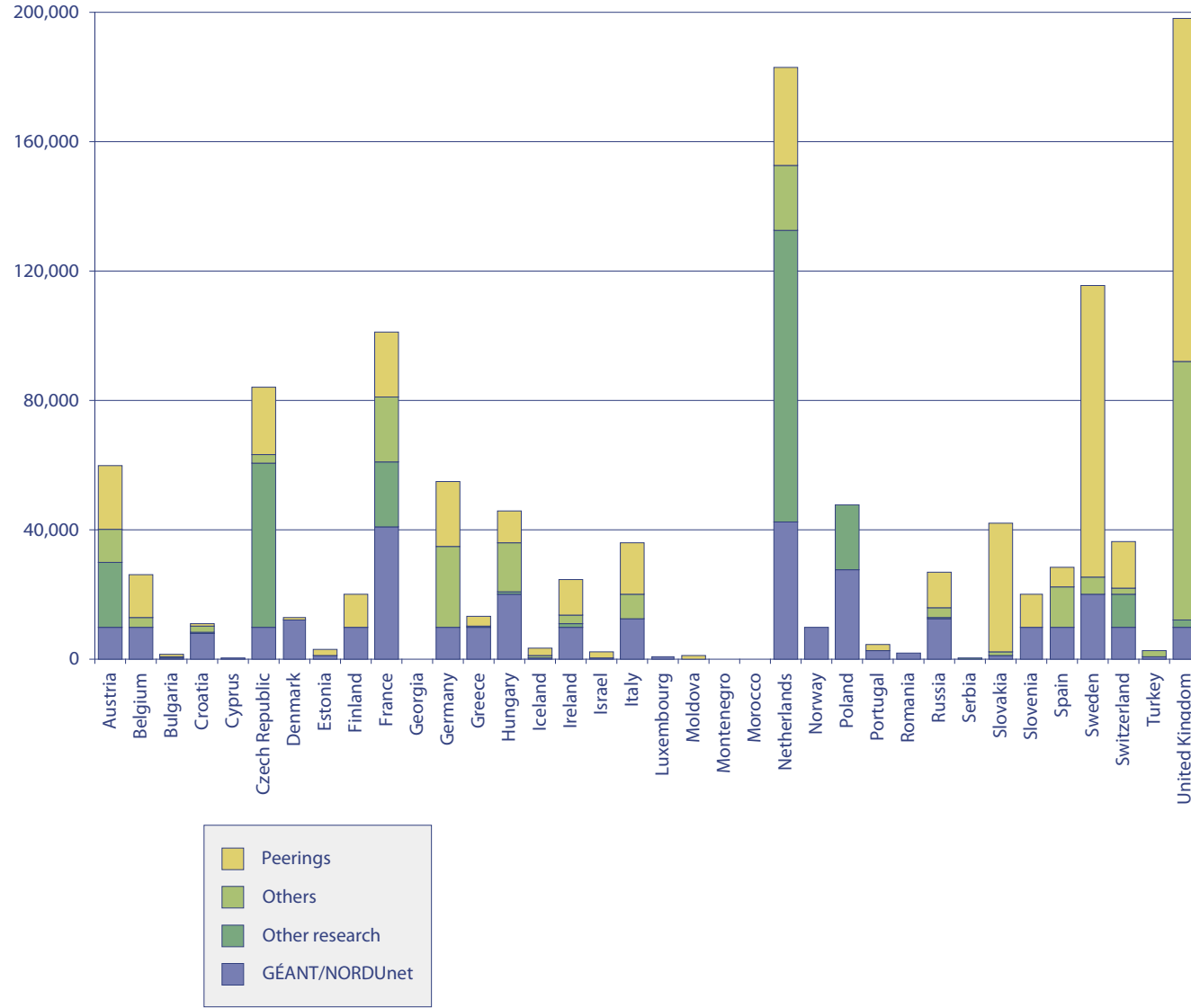
A peering is an exchange of IP routes in order to optimise traffic<sup>1</sup>. Often traffic is exchanged, although no money changes hands. In some cases restrictions may apply to such traffic.

The 'Others' category is used for connections with commercial ISPs.

In general, connections to GÉANT and to other NRENs carry education and research traffic, while peerings and other connections convey traffic to and from the general Internet. The former can be very specialised data, often transmitted in huge volumes in very short time frames; for instance, real-time observations from a radio telescope which must be transmitted over large distances for

<sup>1</sup> See for example <http://whatis.techtarget.com>

Graph 3A.6.1 Division of External Connectivity Over the Categories, January 2008

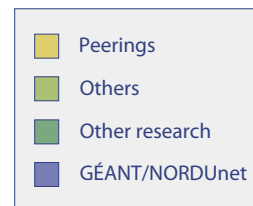
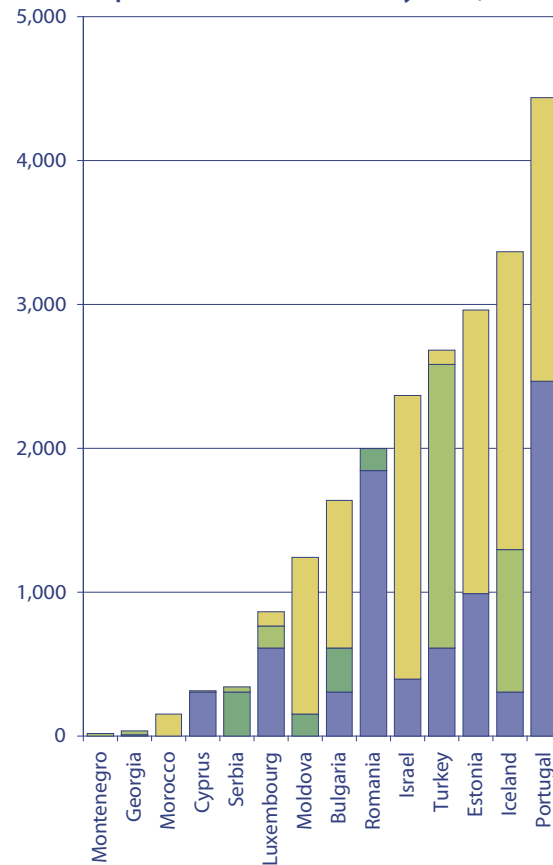


pre-processing and storage. In other words, one can expect high traffic peaks on such links and they must, in consequence, be dimensioned to cater for large bursts of traffic; it is not unusual to see a flow of 1 Gb/s generated by a single high-end researcher. Thus, the average volume of traffic is not a good guide to the required capacity of the link.

Traffic with the general Internet, on the other hand, tends to be aggregated and smooth. It comprises a large number of small to modest data flows, which combine to provide a fairly predictable traffic pattern. The required capacity can therefore be related to the average flow of data. These two categories of traffic are, however, combined in the graphs that follow.

For presentational purposes, two graphs are shown. Graph 3A.6.1 presents the division of external connectivity over the categories. For improved readability, graph 3A.6.2 presents this information separately for countries with total external connectivity below 5 Gb/s.

**Graph 3A.6.2 External Connectivity < 5 Gb, January 2008**



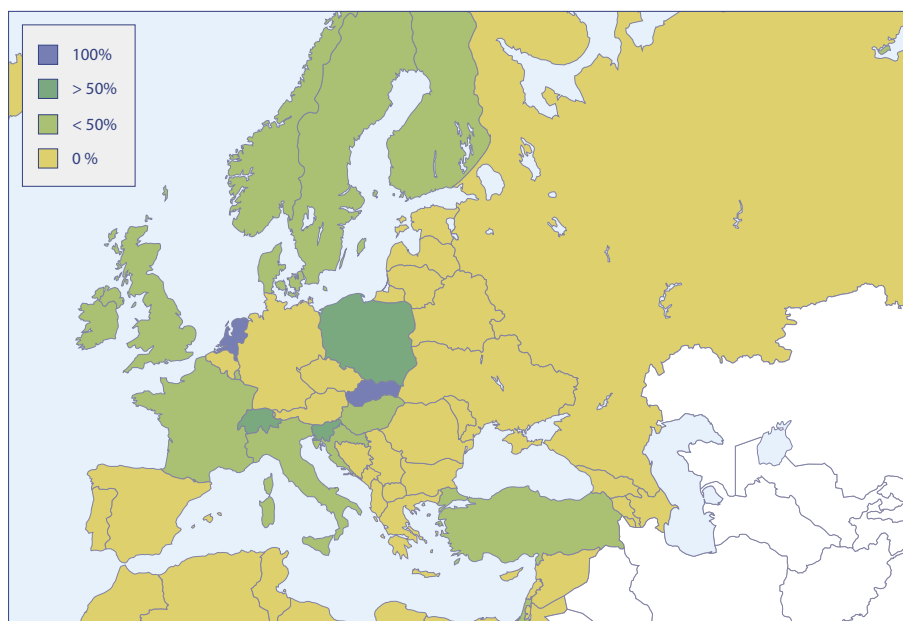
### 3A.7 Dark Fibre

Some NRENs own dark fibre or have IRUs<sup>2</sup> or lease dark fibre and can decide themselves what technology and what capacity to use on their fibre. NRENs were asked if they currently have IRUs or own dark fibre, or if they plan to get it during the coming two years. NRENs were also asked approximately what percentage of their backbone is dark fibre, in km, in point-to-point distances.

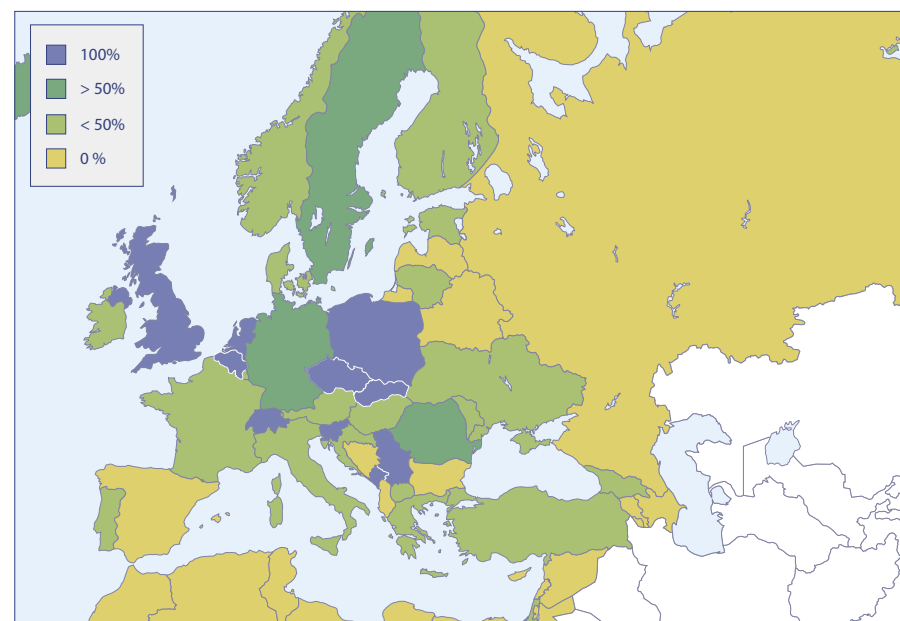
The maps below<sup>3</sup> illustrate the rapid developments in this area in recent years. Many (although not all) NRENs predict a further increase in the percentage of their network that is dark fibre by 2010.

Legend: dark blue is 100% dark fibre; yellow is either no dark fibre or no information from that country for that year. Note that for 2008, 2007 data has been used for some countries that did not answer this year.

**Map 3A.7.1 Dark Fibre on NREN backbones, 2005**



**Map 3A.7.2 Dark Fibre on NREN backbones, 2008**



<sup>2</sup> IRU stands for 'Indefeasible Right of Use'. This is the effective long-term lease (temporary ownership) of a portion of the capacity of a cable. See, for example, <http://whatis.techtarget.com> for more information. The distinction between an IRU and a lease is becoming less clear; therefore, these two categories have been combined.

<sup>3</sup> Idea developed by RedIRIS, Spain.

## 3A.8 Cross-border Dark Fibre

A number of countries have or are planning to install cross-border dark fibre links from one neighbouring NREN to another. A relatively recent development, cross-border dark fibre “is optical fibre dedicated to use by a single organisation – where the organisation is responsible for attaching the transmission equipment to ‘light’ the fibre”.<sup>4</sup> Table 3A.8.1 provides an overview of current and planned cross-border dark fibre links.

The map shows the same information in schematic format – note that the links as shown on the map are *not* meant to indicate their geographical locations.

As the table and map suggest, the majority of the cross-border links are concentrated in central Europe. Being a recent development, any additional conclusions about the development of cross-border dark fibre would be misplaced.

Map 3A.8.2 Cross-border Dark Fibre



<sup>4</sup> ‘Networks for Knowledge and Innovation’, SERENATE Summary Report, pg. 34-5

Table 3A.8.1 Cross-border Dark Fibre

NREN to NREN	Current	Start date
ACOnet - SANET	Vienna, Austria - Bratislava, Slovakia	Aug-02
ACOnet - CESNET	Brno, Czech Republic - Vienna, Austria	2006
AMRES - University of Banja Luka	Sabac, Serbia - Dobo, Bosnia/Herzegowina	
AMRES - NIIF/HUNGARNET	Subotica, Serbia - Szeged, Hungary	2006
CESNET - PIONIER	Ostrava, Czech Republic - Cieszyn, Poland	
CESNET - SANET	Brno, Czech Republic - Bratislava, Slovakia	Apr-03
DFN - PIONIER	Gubin, Poland - Guben, Germany	May-06
DFN – PIONIER	Frankfurt (Oder), Germany – Slubice, Poland	
DFN - RENATER	Kehl, Germany - Strasbourg, France	Jun-06
DFN - SURFnet	Muenster, Germany - Enschede, Netherlands	
DFN - SURFnet	Aachen, Germany - Maastricht, Netherlands	Q2 2007
DFN - SURFnet	Hamburg, Germany - Amsterdam, Netherlands	Q2 2007
DFN - SWITCH	Lorrach, Germany (BelWu) - Basel, Switzerland	Jun-06
GARR - SWITCH	Milano, Italy - Manno, Switzerland	
HEAnet - JANET(UK)	Dublin, Ireland - Belfast, UK	Nov-06
PIONIER - SANET	Bielsko Biala, Poland - Žilina, Slovakia	Oct 2007
NREN to NREN	Planned	Start date
BELNET – RESTENA		2008
DFN - RESTENA		2008
FCCN - RedIRIS	Porto, Portugal - Vigo, Spain	2007
FCCN - RedIRIS	Lisbon, Portugal - Badajoz, Spain	2008
LITNET - PIONIER	Kaunas, Lithuania - Ogrodniki, Poland	2008
PIONIER – BASNET	Kuznica, Poland – Grodno, Belarus	2008
PIONIER – RBNet/RUNnet	Granowo, Poland – Mamonovo, Russia	2008
PIONIER - URAN	Hrebenne, Poland – Rava Ruska, Ukraine	2008
RENAM - RoEduNet	Chisinau, Moldova - Lasi, Romania	2009
RENATER - RESTENA		2008

## 3A.9 Networking Equipment

A router is a device or, in some cases, software in a computer that determines the next network point to which a packet should be forwarded toward its destination.<sup>5</sup>

Routers are thus important pieces of equipment for any NREN. Table 3A.9.1 provides an overview of routers and switches currently used by NRENs. Note that several NRENs use routers and switches from more than one manufacturer. Information for each NREN is available from the Compendium website.

**Table 3A.9.1 Routers and Switches**

EU/EFTA Countries	29	NRENs in the survey										
Vendor	Cisco	Juniper	HP	Foundry	Nortel	Extreme	PC routers	Catalyst	D-Link	Allied Telesyn	Tellabs	MikroTik
Number of NRENs	27	16	2	1	1	1	1	0	0	0	0	0
Other Countries	12	NRENs in the survey										
Number of NRENs	11	1	1	1	0	0	0	1	1	1	1	1

This year, we also asked NRENs about the transmission technology that they manage on their backbone. DWDM is the most common technology. ADVA, Alcatel-Lucent, Cisco, Ciena and Nortel are the suppliers that are mentioned most frequently.

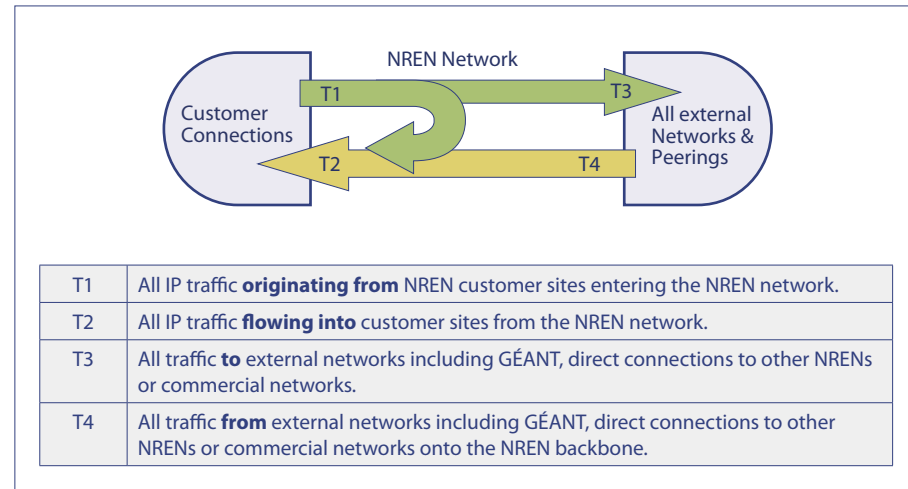
<sup>5</sup> Source: [whatis.techtarget.com](http://whatis.techtarget.com)

## 3B TRAFFIC

For the purposes of this compendium distinct traffic flows at the ingress and egress points of NREN networks have been identified.

These are defined in the diagram below.

Figure 3B.0.1 Elements of Traffic Flow on NREN Networks



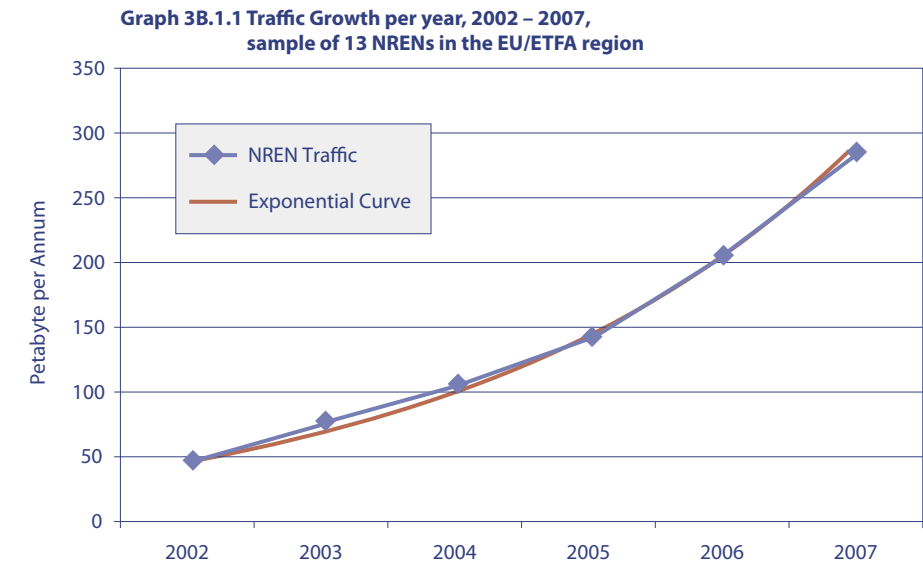
Section 3B.1 gives an overview and focuses on general traffic trends over recent years. Section 3B.2 looks at traffic in 2007 and section 3B.3 analyses traffic load. Section 3B.4 looks at congestion and the chapter finishes with a look at IPv6 in section 3B.5.

### 3B.1 Overview

#### General IP Traffic Trends

The graph below illustrates IP traffic growth over the past five-year period based on the total traffic figure from 13 NRENs. These NRENs were selected purely on the basis that they are the only NRENs that have submitted a complete set of T1,T2,T3,T4 data for the entire period 2002-2007.

The total traffic figure has been calculated as  $(T1+T2+T3+T4)/2$  so as to avoid double counting.



The year-on-year growth rate for **total IP traffic on a sample of 13 NRENs** shows continued exponential traffic growth with a doubling time of around two years. This doubling period represents a year-on-year growth rate of approximately 46% per annum.

This growth is broadly in agreement with the CISCO prediction for Global IP Traffic 2006-2012 that appears in CISCO White Papers<sup>1,2</sup>.

<sup>1</sup> Cisco Visual Networking Index, Forecast and Methodology, 2007–2012, June 2008

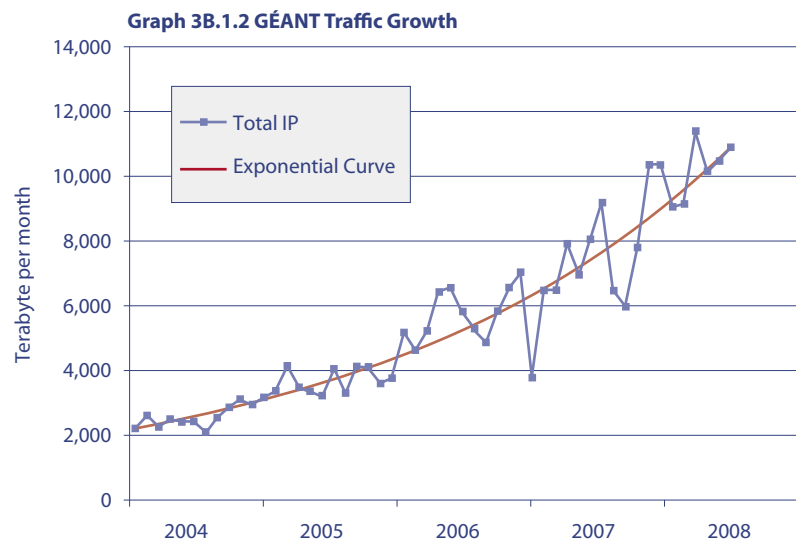
<sup>2</sup> Approaching the Zettabyte Era, Cisco Systems Inc, 2008

The CISCO studies predict a growth of 46% in 2007, falling slowly until 2012 when they expect annual growth to have dropped to 37% per annum.

There is evidence in graph 3B.1.1 that, in the past year (2007), the rate of growth of IP traffic on the NRENs showed signs of dropping slightly below the 46% annual growth figure, but it is too early to tell if this will be a sustained trend as predicted by the CISCO study.

For the majority of NRENs more than 75% of all of their external IP traffic is between their customer sites and destinations on the commercial Internet. In some cases this traffic to and from the commercial Internet accounts for more than 90% of NRENs' total IP traffic. Consequently it is not surprising that external NREN IP traffic growth closely mirrors the growth of IP traffic on the global Internet.

These trends are matched by GÉANT traffic growth. As seen in graph 3B.1.2, the growth of IP traffic on the GÉANT network closely approximates **exponential growth** with a doubling time of 22 months.



As is shown in section 3B.5, IPv6 traffic is growing in real terms, but it does not grow as quickly as IPv4 and therefore the total percentage of traffic that is IPv6 is actually dropping.

### Other NREN Traffic

Most NRENs measure all of the IP traffic at the ingress and egress points of their networks so it is relatively easy to gain a reasonable understanding of the trends.

In general, the traffic traversing point-to-point (P2P) lightpaths is not inspected or measured at present so figures cannot be reported here.

Eleven NRENs currently have operational P2P links in use either to carry production traffic or to support specific projects. The capacity of these links ranges from 1Gb/s to 10Gb/s. These links are in addition to any cross-border fibre links used for production traffic.

Table 3B.1.3 Optical P2P links

NREN	Number of P2P optical links currently operational
JANET(UK)	30
DFN	19
SURFnet	18
PIONIER	8
GARR	6
SUNET	4
GRNET	2
RedIRIS	2
SWITCH	2
FUNET	1
HEAnet	1

## Traffic Load

As can be seen from section 3B.3, there are a few typical patterns that emerge when examining the evolution of traffic and capacity over the years.

If NRENs are to fulfil their role as enablers of innovation it is vital that students, teachers and researchers are not discouraged from experimenting with novel and innovative uses of the network. A good way of encouraging innovation is to keep traffic loads consistently low. This needs constant monitoring of traffic, good capacity planning and funding, well in advance of need.

## Congestion

For the EU and EFTA countries, the average estimated congestion at the campus level has gone down for the second year in a row, but it has gone up a little at the external connections level. In a way, this is a logical phenomenon: many NRENs have recently invested in backbone upgrades thus reducing congestion, but traffic increases will probably lead to increased congestion levels ahead of the next round of investments.

### 3B.2 Traffic in 2007

Two graphs are presented: graph 3B.2.1 shows the information for those NRENs with external traffic above 1000 Terabytes per year; graph 3B.2.2 gives the same information for NRENs with external traffic below 1000 Terabytes.



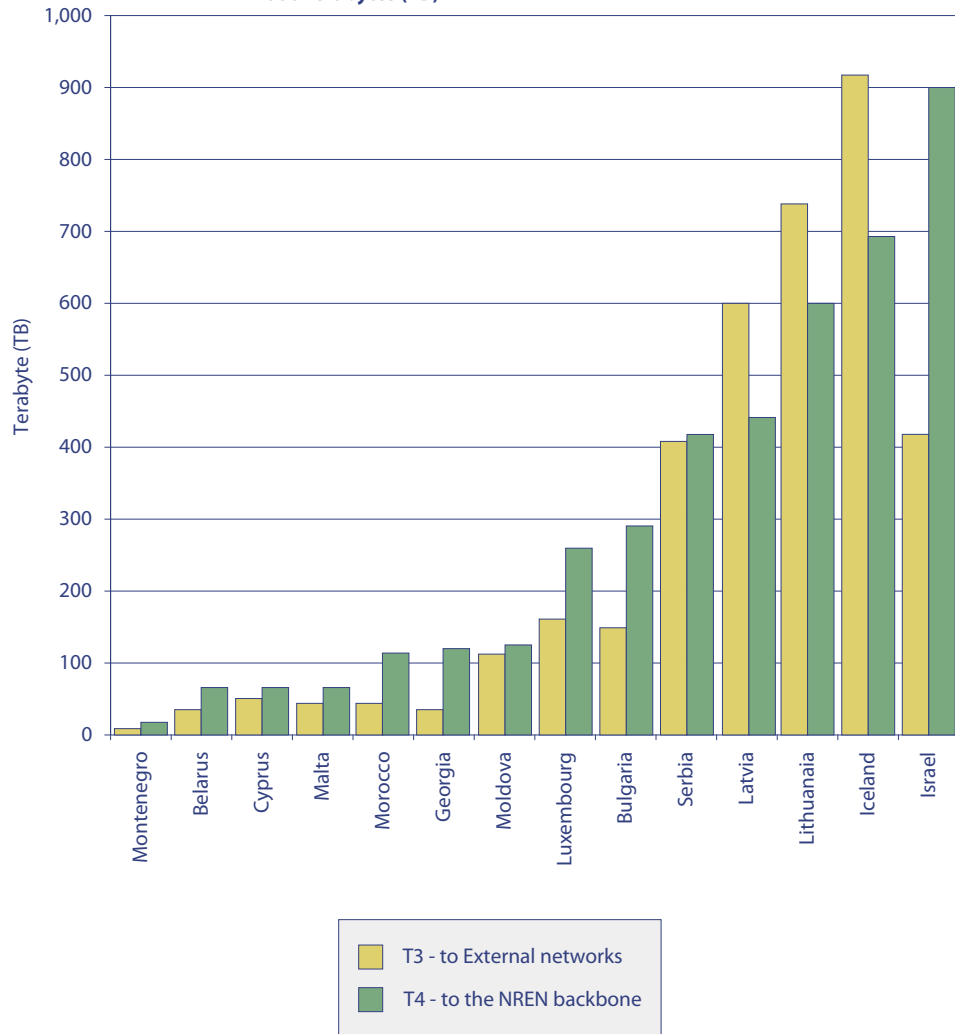
### 3B.3 Traffic Load

It is very difficult to represent the true level of loading on an NREN network and its effect on the users' perception of network performance. It is even more difficult to represent the load as a single value in time. Each node in the network will have its own characteristics of bandwidth and demand. Usage frequently changes by time of day, day of the week, month or season. The only true measure is monitoring the traffic on each link in the network on an individual basis.

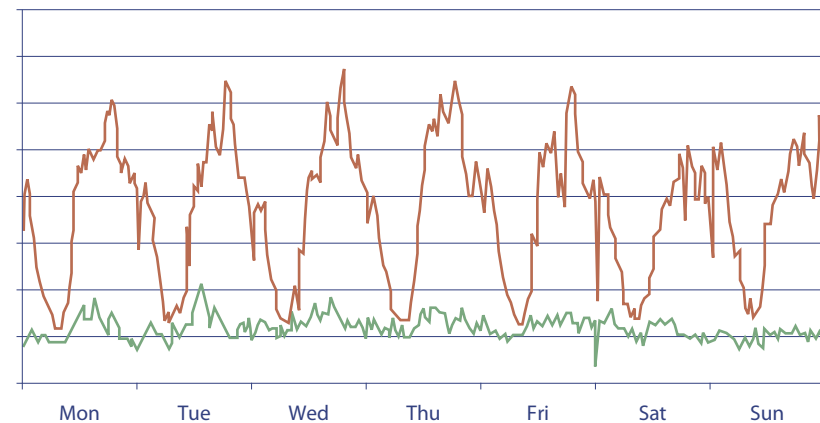
For a publication such as the TERENA Compendium it is not practical or indeed desirable to delve into such detail. What can be established with a great degree of certainty is the total traffic that flows over links into and out of the NREN networks during measured periods. The sum of  $(T1+T2+T3+T4)/2$  has been found to be a reliable indicator of total network traffic.

The chosen measurement period is the month of January each year for no other reason than that it is the first month. Whilst the total traffic over the month in Terabytes is known, the distribution of the load over the month is unknown. It is therefore necessary to make some assumptions. Provided the link is lightly loaded, end users are unlikely to experience any drop in performance over time.

**Graph 3B.2.2 Outgoing (T3) and Incoming (T4) External Traffic 2007, < 1000 Terabytes (TB)**



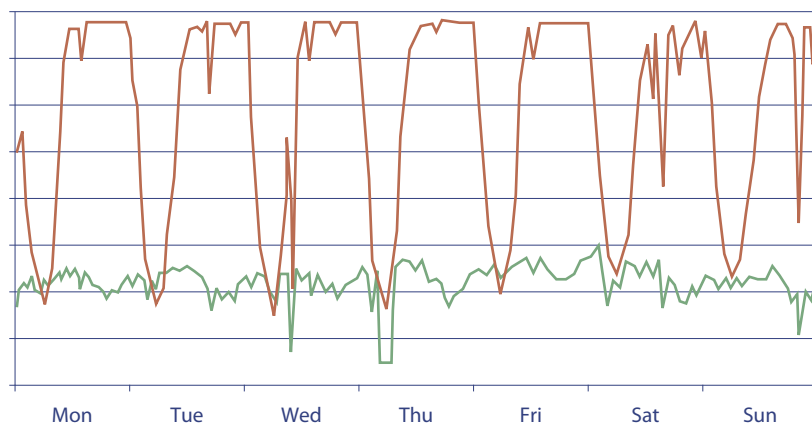
**Graph 3B.3.1 Daily traffic variations on a lightly loaded network<sup>3</sup>**



<sup>3</sup> Graphs intended as illustrations, they do not represent answers from specific NRENs. Green line is average load, red line is instantaneous load.

In cases where links are more heavily loaded, it is possible that the bandwidth is saturated at certain times of day. Under these conditions users may experience a real reduction in performance as congestion leads to packet loss and retries. Under these conditions the throughput per month is not a good indicator.

**Graph 3B.3.2 Daily traffic variations on a network displaying saturation**



Overall the NRENs' approach to providing a good quality of service is to ensure that links are lightly loaded, an approach known as over-provisioning. This approach avoids heavy traffic engineering, that can might adversely affect the development and performance of innovative applications.

For most NRENs, link utilisation is less than 10% , so for the purposes of this evaluation it is reasonable to assume that the links are not saturated.

By undertaking the measurements each January, it is has become possible to plot the values over the years and to observe trends in loading.

We have observed that most traffic to and from NREN user sites is exchanged with sites off the home NREN network – what we here call external networks.

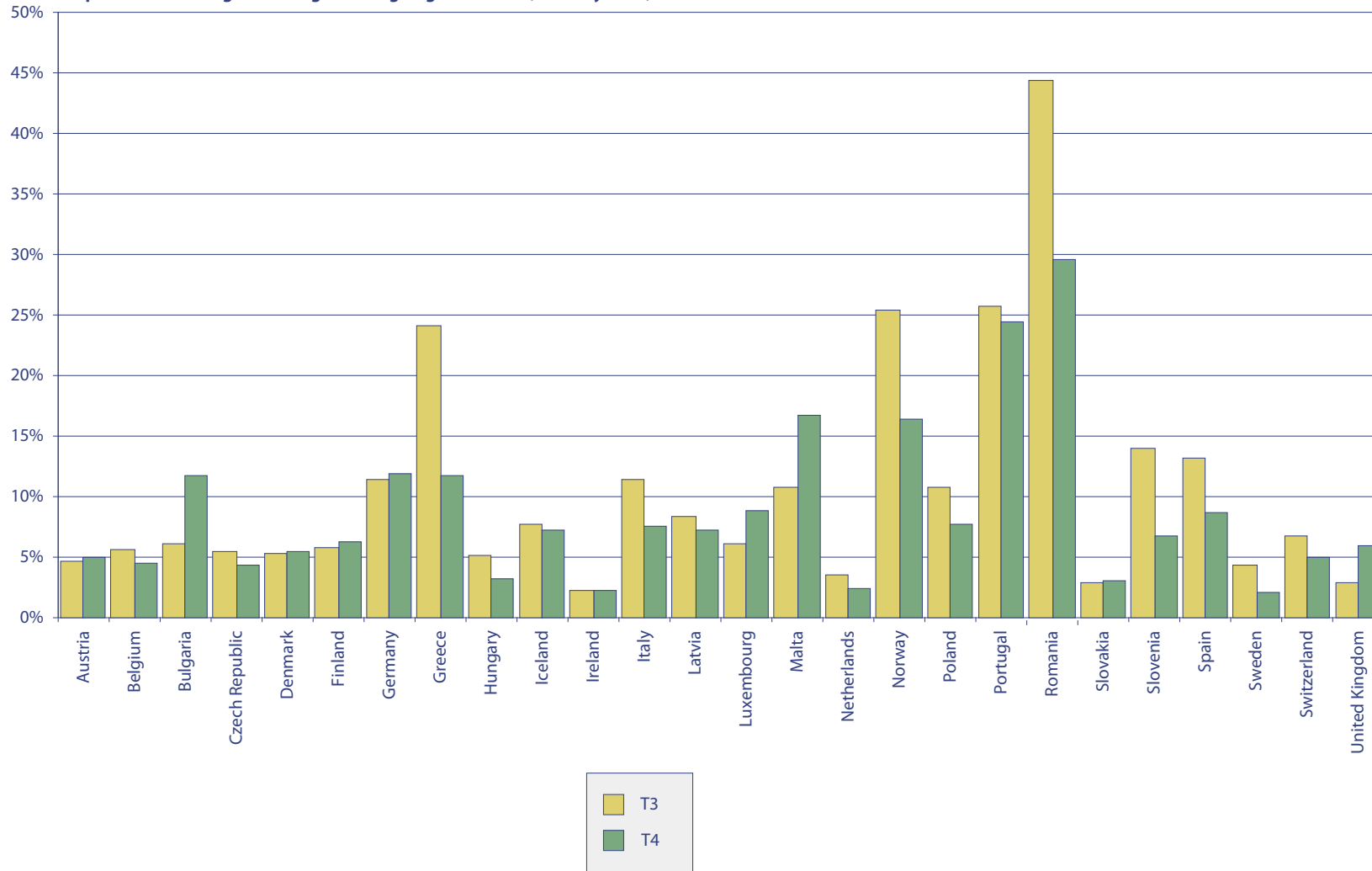
In this context, the term external is taken to mean all of the NREN connections to GÉANT, commercial peerings, direct connections to other NRENs, cross border fibres etc. In many cases the percentage of traffic that is exchanged with commercial networks exceeds 75% of external NREN traffic, although there are some marked exceptions.

We asked each NREN to report the total amount of external bandwidth available in January of each year and also the total traffic that flowed over that bandwidth in the month of January.

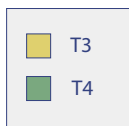
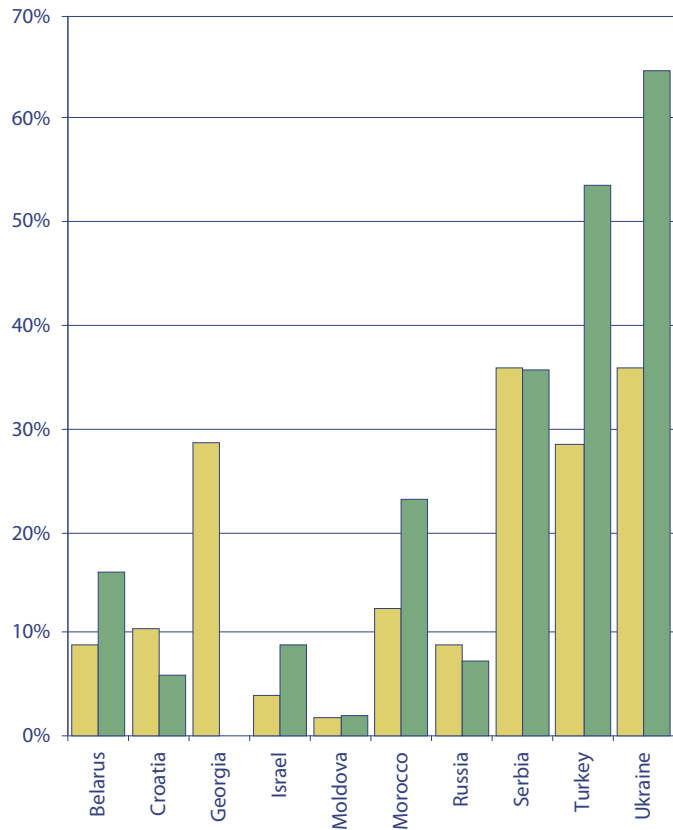
From this it is a simple matter to compute the total number of Terabytes that the links are theoretically able to transfer in one month and compare it with the total number of Terabytes actually transferred. The percentage of traffic over the maximum possible transfer is taken to be the load.

$$\% \text{ LOAD} = \frac{\text{actual traffic in January}}{\text{Maximum transfer capability}}$$

Graph 3B.3.3 – Average Incoming and Outgoing Traffic Load, January 2008, EU/EFTA Countries



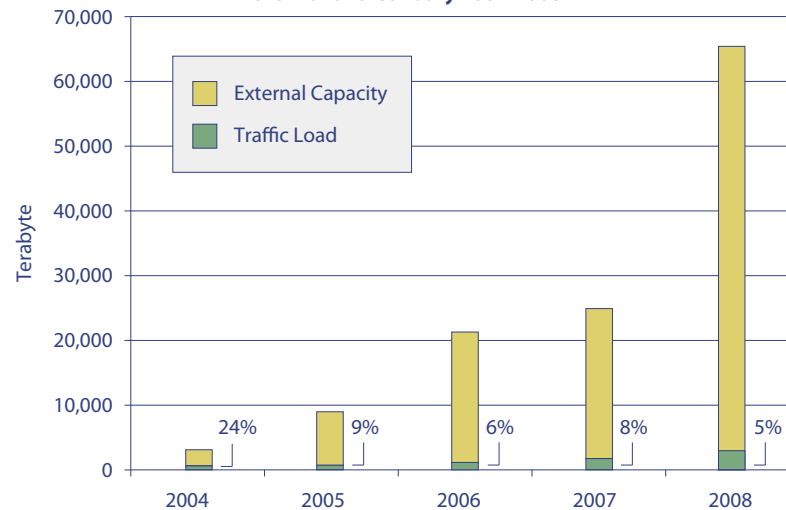
**Graph 3B.3.4 Average Outgoing Traffic Load, January 2008, Other Countries**



A few typical patterns emerge:

In the example of graph 3B.3.5, user demand has been steadily increasing as might be expected, however the external bandwidth has been increasing at a much faster rate. The consequence of this is that the load percentage has dropped to 5% from its high of 24% in 2004. This will have increased the perceived performance of the network and, more critically, provided sufficient headroom for innovation and novel uses of the network.

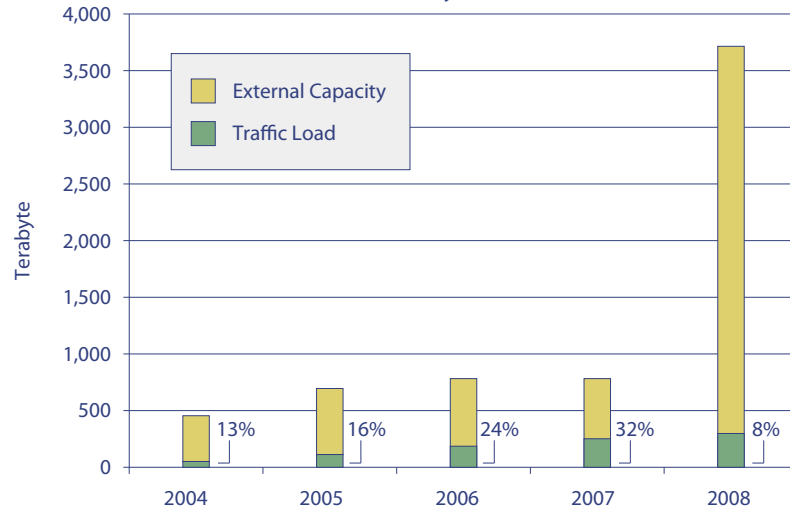
**Graph 3B.3.5 JANET (UK) - United Kingdom Traffic load and external capacity during the month of January 2004-2008**



In the example of graph 3B.3.6, the NREN has seen a consistent growth in user demand, but for many years been unable to increase the external capacity. The resultant load eventually reached a point where some users were undoubtedly seeing congestion at some times of day.

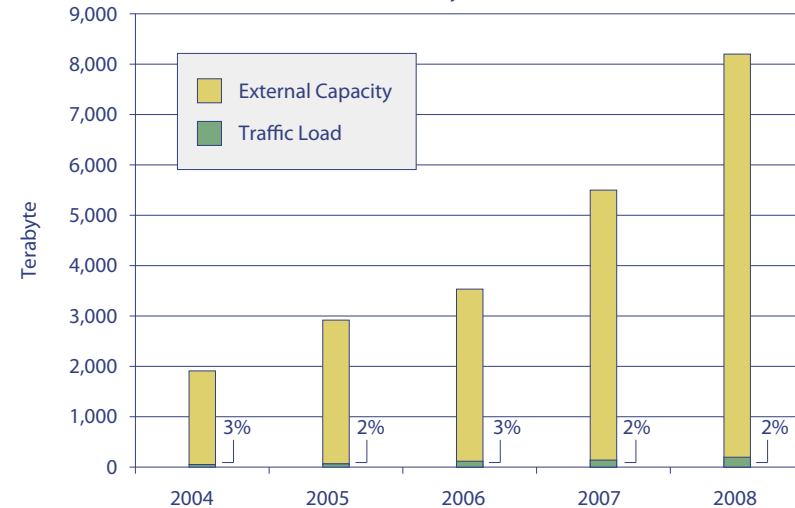
This has been remedied by a fourfold increase in available bandwidth, bringing with it a load reduction on the external links.

**Graph 3B.3.6 CARNet - Croatia**  
Traffic load and external capacity during the month of January 2004-2008



In the final example on the right we can see a NREN that has consistently increased the capacity of its network connections to keep pace with growing user demand. This will offer the end users a consistent good quality of network performance with an average load of 2%.

**Graph 3B.3.7 HEAnet - Ireland**  
Traffic load and external capacity during the month of January 2004-2008



If NRENs are to fulfil their role as enablers of innovation it is vital that students, teachers and researchers are not discouraged from experimenting with novel and innovative uses of the network. A good way of encouraging innovation is to keep traffic loads consistently low. This needs constant monitoring of traffic, good capacity planning and funding, well in advance of need.

### 3.B.4 Congestion

NRENs were asked to give a rough estimate of the percentage of institutions connected to their network that experience congestion at the different network levels.

From the subjective levels reported by NRENs a single metric was derived for the level of congestion in each network element using the following formula<sup>4</sup>:

$$\text{Congestion Index} = 0.05 \cdot \text{little} + 0.2 \cdot \text{some} + 0.5 \cdot \text{serious}$$

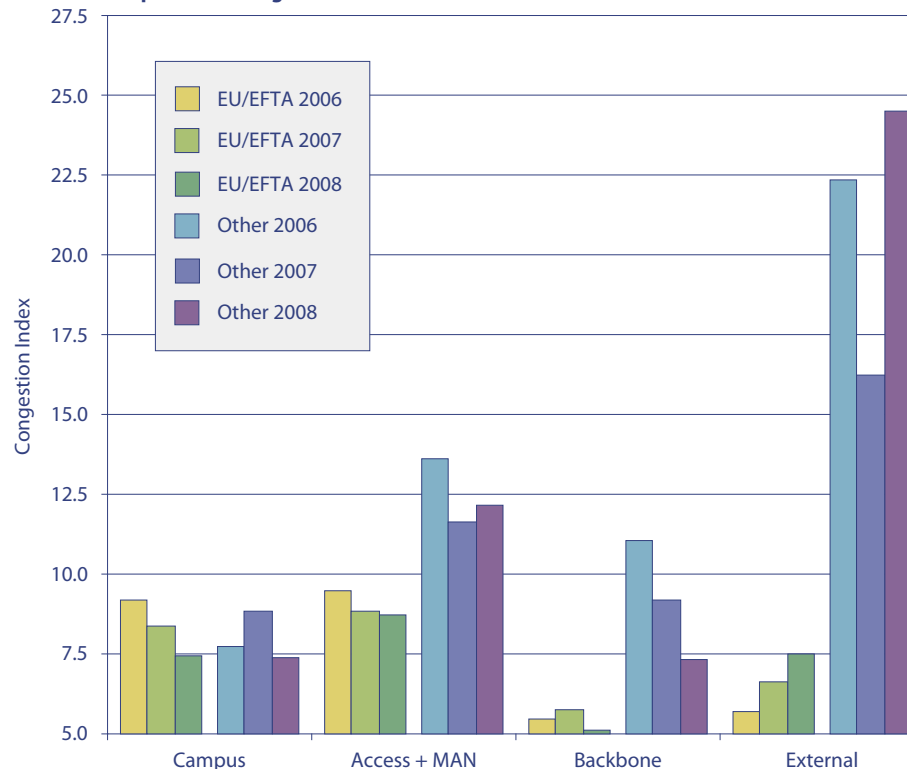
The minimum value of congestion on the network, based on the Congestion Index is 5.

The data for MANs and for access networks were combined. Applied to all the reported values, this formula provides a single uniform metric.

For the EU and EFTA countries, the average estimated congestion at campus level has gone down for the second year in a row, but it has gone up a little at the external connections level. In a way, this is a logical phenomenon: many NRENs have recently invested in backbone upgrades thus reducing congestion, but traffic increases will probably lead to increased congestion levels ahead of the next round of investments.

For the 'other' countries, the picture is mixed. Upgrades to the backbone seem to lead to perceived increased congestion at the external connections level, although it should be taken into account that the group of countries is not the same in all three years.

Graph 3B.4.1 Congestion Index



<sup>4</sup>This index has been developed for the Compendium by Mike Norris, HEAnet

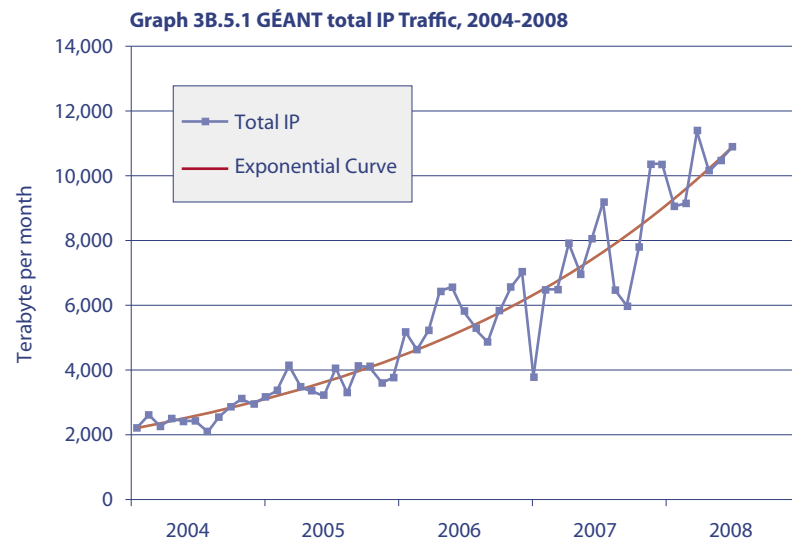
### 3.B.5 IPv6

Data on which proportion of IP traffic is IPv4 and which is IPv6 is not widely available from NRENs at the moment.

Fortunately, statistics on the proportion of NREN traffic that flows across the GÉANT network are available.

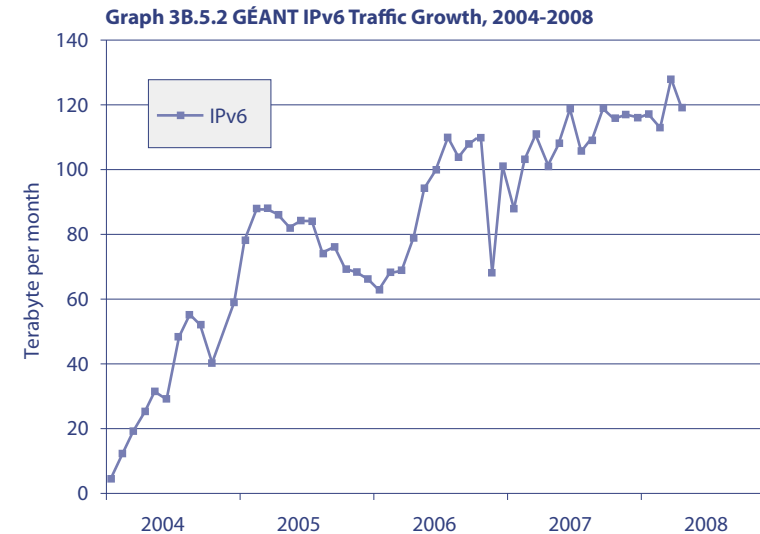
Traffic statistics from the combination of all inbound and outbound traffic from the GÉANT network show consistent and sustained growth over the last four years. Although there is considerable fluctuation, the underlying trend is exponential growth with a doubling time of just under two years.

A small drop in traffic may be observed during the summer months of each year when many Europeans take their vacation.



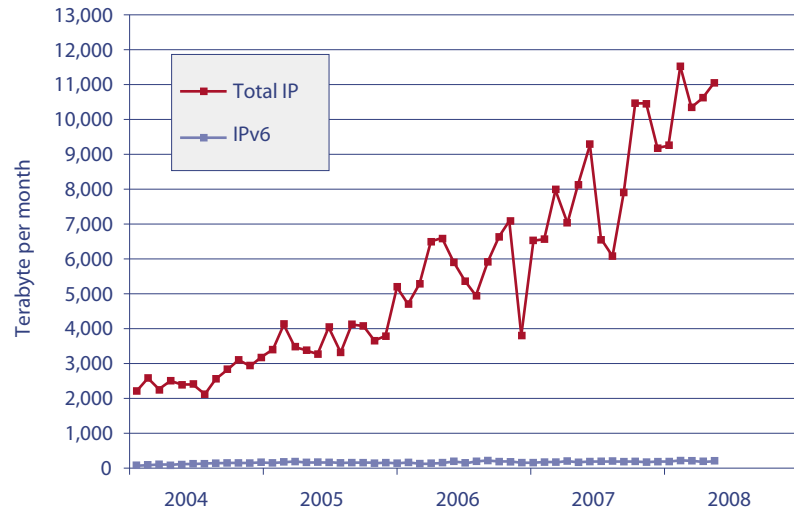
The level of IPv6 traffic on GÉANT over the same period is erratic, to the extent that a simple exponential or indeed linear 'best-fit' does not adequately describe the underlying trend.

Please note that the scales of graph 3B.5.1 (total IP traffic) and graph 3B.5.2 (IPv6 traffic) are plotted on scales that are different by two orders of magnitude.



When plotted on the same axis, the level of IPv6 traffic barely registers and is represented by a nearly horizontal line along the baseline.

Graph 3B.5.3 GÉANT IPv6 Traffic Compared to total IP Traffic, 2004-2008

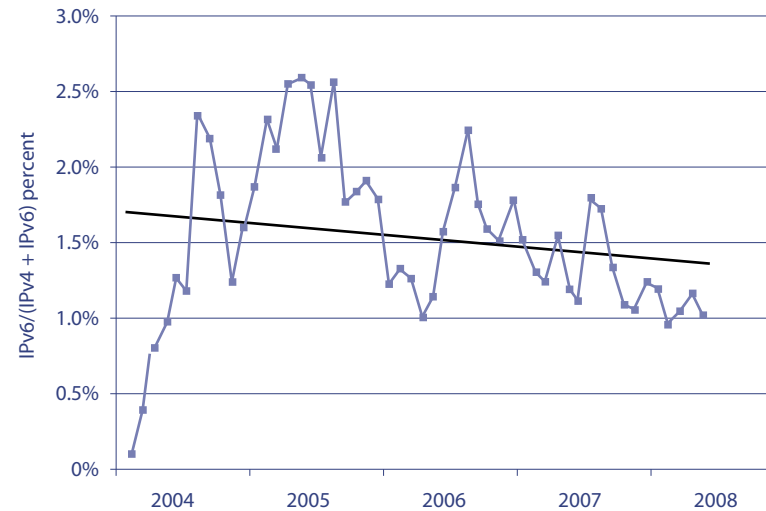


The amount of IPv6 traffic compared with the total traffic (IPv4 plus IPv6) is small, representing only 2.6% of total traffic as a maximum (2005) during this four year period.

Whilst IPv6 traffic is growing in real terms, it does not grow as quickly as IPv4 and therefore the total percentage of traffic that is IPv6 is actually dropping.

This can be demonstrated by plotting the percentage of all IP traffic that is IPv6 over time.

Graph 3B.5.4 GÉANT IPv4 Traffic Compared to IPv6 Traffic, 2004-2008



It should be noted that this analysis explores only the traffic statistics at the ingress and egress of the GÉANT network and may not reflect the growth or level of IPv6 that is found within NREN networks or across peerings with other providers.

**Table 3B.5.5 Percentage of sites with native IPv6 connectivity**

Country	NREN	Percentage of connected sites that have native IPv6 connectivity
<b>EU/EFTA Countries</b>		
Austria	ACOnet	70
Belgium	BELNET	6
Bulgaria	BREN	32
Cyprus	CYNET	0
Denmark	UNI-C	5
Finland	Funet	8.75
Germany	DFN	13
Greece	GRNET S.A.	42
Hungary	NIIF/HUNGARNET	4
Iceland	RHnet	5
Ireland	HEAnet	16
Latvia	SigmaNet	0
Luxembourg	RESTENA	1.34
Netherlands	SURFnet	13
Poland	PIONIER	64.86
Portugal	FCCN	22
Romania	RoEduNet	90
Sweden	SUNET	100
Switzerland	SWITCH	29
<b>Other Countries</b>		
Israel	IUCC	1
Moldova	RENAM	0
Russian Federation	RBNet/RUNNet	2
Serbia	AMRES	26.5
Turkey	ULAKBIM	1

## 3C OTHER SERVICES

Many NRENs are involved in providing a number of important services to their customers, layered on top of the connectivity service. This section provides brief information about NREN services in the following areas: Network Operating Centres (3C.2), Performance Monitoring (3C.3), Optical Services (3C.4), Quality of Service (3C.5), Security (3C.6), Authorisation and Mobility (3C.7), Housing / Storage (3C.8), Network Communication Tools (3C.9), Network Computing Resources (3C.10), e-learning (3C.11), user and client support (3C.12) and PR and communications (3C.13). Section 3C.14 documents recent and planned changes in services. The last section, 3C.15, pays some attention to the 'digital divide'.

### 3C.1 Overview

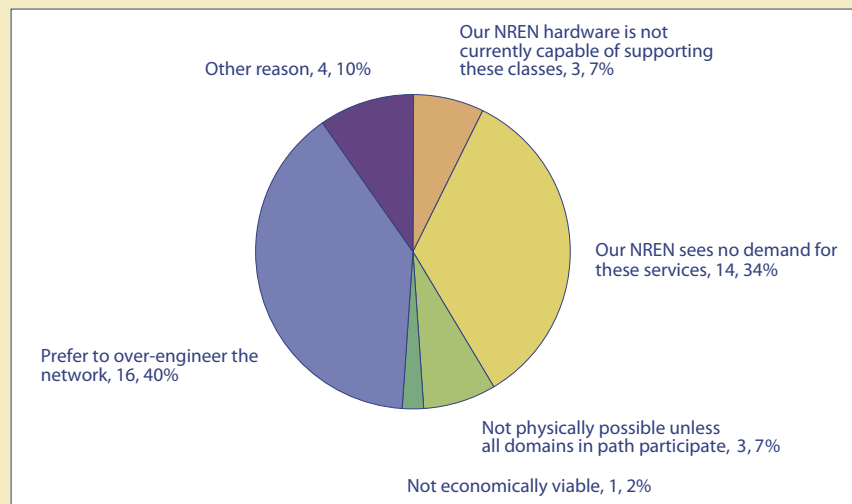
In the EU and EFTA countries, 23% of the NOCs are outsourced; in the other countries, 18% of the NOCs are outsourced. Ninety percent of NOCs in the EU and EFTA countries serve all of the NREN customers.

At the moment, 16 out of the 30 EU/EFTA countries have PERTs. Four are planning to establish one within the next year and a further six plan to do this within the next three years. Many NRENs from other countries also either have a PERT or are planning to establish one.

Most NRENs reported that they do not have optical links that carry non-IP traffic, but some do. In all cases, such links then carry traffic based on Ethernet technology. A further question was asked about the technology used to monitor traffic on such links. NRENs mentioned a variety of tools; a number of NRENs have developed or are developing their own tools.

Most NRENs from the EU/EFTA countries prefer to over-engineer the network, so that congestion does not occur. Therefore, they do not offer the Quality of Service classes that were defined in the GN2 project.

Graph 3C.5.1 Reasons for not providing QoS levels



In the area of security, there is still a large difference between EU/EFTA NRENs and NRENs in other countries. This has not changed since last year.

The growth in the number of NRENs putting a federation in place is an indicator of the growing importance of such an approach to authorisation and authentication. Similarly, the number of NRENs operating a certification authority is now over 60% of all the NRENs in the EU/EFTA region.

The majority of European NRENs that run a federation (70%) use Shibboleth to support it, but individual NRENs also report the use of Liberty Alliance (1), PAPI (1), A-select (1), or others (2).

For the majority of NRENs that provided data on their federations there is a close correspondence between the number of institutions that participate and the number of identity providers. A major exception is FEIDE, which is the national identity management system for the education sector in Norway.

## 3C.2 Network Operating Centres (NOCs)

Last year, the Compendium looked at IP telephony deployments in general. The survey found that a small majority of EU/EFTA NRENs had these. This year, the survey asked more specifically about IP telephony as a service that is offered to their customers. Eight out of the 30 EU/EFTA NRENs (27%) reported having such a service. Only four EU/EFTA NRENs have peerings with other institutions for the interconnection of IP telephony deployments. Such peerings depend to a large extent on national legislations and policies.

Twenty-one out of the 30 EU/EFTA NRENs offer a videoconferencing service, either directly or via a third party. Many NRENs also offer additional services, such as archiving of videoconferences and user support for the service.

In the past year, there have been few changes in the area of Grid services.

Most NRENs in the EU/EFTA area have at least one part-time person working on PR and communications. In other countries only a minority of NRENs provide effort for PR and communications.

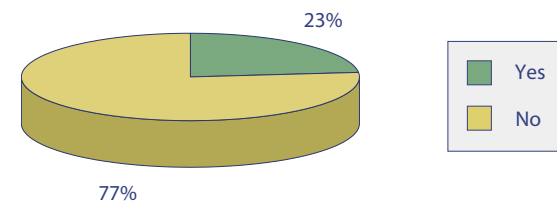
The services portfolios of NRENs are evolving constantly. It is clear that more services are being added than are being phased out. Commercial paid or 'free' alternatives are clearly not yet an alternative for the full spectrum of NREN services, even though in a few countries universities have started to make use of free email services for their students.

Some NRENs manage the physical centre of their network operations in house; others have it outsourced, for example to a supercomputing centre. Also, some NOCs serve all the customers of NRENs; in other NRENs, certain categories of customers (such as secondary schools) receive those services from other organisations. In some cases, that may mean that there are separate NOCs for different categories of customers.

As more and more NRENs invest in dark fibre infrastructure, they are faced with the task of lighting the dark fibre and thus providing the necessary signalling at the transmission layer. Some NRENs have taken on these additional operational tasks within their conventional (IP) NOC. Others have separated these functions and outsourced some of these new tasks.

In the EU and EFTA countries, 23% of the NOCs are outsourced; in the other countries, 18% of the NOCs are outsourced. Ninety percent of NOCs in the EU and EFTA countries serve all of the NREN customers.

**Graph 3C.2.1 NOC Outsourced, EU/EFTA Countries**



**Graph 3C.2.2 NOC Outsourced, Other Countries**

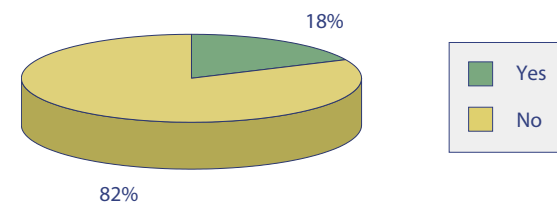


Table 3C.2.3 NOCs

Country	NREN	NOC Outsourced?	NOC serves all customers?
<b>EU/EFTA countries</b>			
Austria	ACOnet	no	yes
Belgium	BELNET	no	yes
Bulgaria	BREN	no	yes
Cyprus	CYNET	yes	yes
Czech Republic	CESNET	no	yes
Denmark	UNI-C	no	no
Estonia	EENet	no	yes
Finland	Funet	no	yes
France	RENATER	yes	yes
Germany	DFN	no	yes
Greece	GRNET S.A.	yes	yes
Hungary	NIIF/HUNGARNET	no	yes
Iceland	RHnet	no	yes
Ireland	HEAnet	no	no
Italy	GARR	no	no
Latvia	SigmaNet	no	yes
Lithuania	LITNET	yes	yes
Luxembourg	RESTENA	no	yes
Malta	UoM, IT Services	no	yes
Netherlands	SURFnet	yes	yes
Norway	UNINETT	no	yes
Poland	PIONIER	no	yes
Portugal	FCCN	no	yes
Romania	RoEduNet	no	yes
Slovakia	SANET	yes	yes
Slovenia	ARNES	no	yes
Spain	RedIRIS	no	yes
Sweden	SUNET	yes	yes

Country	NREN	NOC Outsourced?	NOC serves all customers?
<b>EU/EFTA countries</b>			
Switzerland	SWITCH	no	yes
United Kingdom	JANET(UK)	no	yes
<b>Other countries</b>			
Belarus	BASNET	no	yes
Croatia	CARNet	yes	yes
Georgia	GRENA	no	yes
Macedonia	MARNet	no	yes
Moldova	RENAM	no	yes
Montenegro	MREN	no	yes
Morocco	MARWAN	yes	yes
Israel	IUCC	no	yes
Russian Federation	RBNet/RUNNet	no	yes
Serbia	AMRES	no	yes
Turkey	ULAKBIM	no	yes

### 3C.3 Performance Monitoring

Even with a high-quality infrastructure, end users may not always get the performance they might expect from the network. In order to deal with such issues, the GN2 project has set up a system involving a central Performance Enhancement and Response Team (PERT) and teams at the national level. A PERT provides assistance with the resolution of end-to-end performance problems for networked applications and contributes to research in the area of end-to-end performance issues.

At the moment, 16 out of the 30 EU/EFTA countries have PERTs. Four are planning to establish one within the next year and a further six plan to do this within the next three years. Many NRENs from other countries also either have a PERT or are planning to establish one.

**Table 3C.3.1 Performance Monitoring**

Country	NREN	PERT?	URL:	No, but plan to deploy:	URL to monitoring tools (traffic map, etc.):
<b>EU/EFTA Countries</b>					
Austria	ACOnet	no		within 3 years	<a href="http://www.aco.net/weathermap.html?&amp;L=1">http://www.aco.net/weathermap.html?&amp;L=1</a>
Belgium	BELNET	no		within 3 years	yes, but only for customers - <a href="http://monitor.belnet.be">http://monitor.belnet.be</a>
Bulgaria	BREN	yes			<a href="http://netmon.acad.bg/">http://netmon.acad.bg/</a>
Cyprus	CYNET	no			<a href="http://www.cynet.ac.cy/english/CyNet_Network_Tools.htm">http://www.cynet.ac.cy/english/CyNet_Network_Tools.htm</a>
Czech Republic	CESNET	yes			<a href="https://perfmon.cesnet.cz">https://perfmon.cesnet.cz</a>
Denmark	UNI-C	no		within 1 year	
Estonia	EENet	no			<a href="http://muhutaja.eenet.ee/">http://muhutaja.eenet.ee/</a>
Finland	Funet	yes	<a href="http://www.csc.fi/english/funet/networkservices/usersupport/pert">http://www.csc.fi/english/funet/networkservices/usersupport/pert</a>		<a href="http://www.csc.fi/english/funet/status/">http://www.csc.fi/english/funet/status/</a>
France	RENATER	yes			<a href="http://www.renater.fr/rubrique.php3?id_rubrique=84&amp;lang=en">www.renater.fr/rubrique.php3?id_rubrique=84&amp;lang=en</a>
Germany	DFN	no		within 1 year	<a href="http://www-win.rrze.uni-erlangen.de">http://www-win.rrze.uni-erlangen.de</a>
Greece	GRNET S.A.	yes			<a href="http://netmon.grnet.gr/">http://netmon.grnet.gr/</a> , <a href="http://www.grnet.gr/monitoringtools">http://www.grnet.gr/monitoringtools</a>
Hungary	NIIF/HUNGARNET	yes			<a href="https://ugyeletes.vh.hbone.hu">https://ugyeletes.vh.hbone.hu</a> (password protected)
Iceland	RHnet	no		within 3 years	<a href="http://www.rhnet.is/english">www.rhnet.is/english</a>
Ireland	HEAnet	no		never	<a href="http://www.heanet">http://www.heanet</a>
Italy	GARR	yes	<a href="https://www.noc.garr.it/GINS/">https://www.noc.garr.it/GINS/</a>		
Latvia	SigmaNet	no		never	<a href="http://gridimon.balticgrid.org/latvia.htm">http://gridimon.balticgrid.org/latvia.htm</a>
Lithuania	LITNET	yes			<a href="http://83.171.9.12:9191/weather/index.php">http://83.171.9.12:9191/weather/index.php</a>
Luxembourg	RESTENA	yes	<a href="http://www.restena.lu/pert">http://www.restena.lu/pert</a>		<a href="http://www.restena.lu/restena/netservices.html">http://www.restena.lu/restena/netservices.html</a>
Malta	UoM, IT Services	no		within 3 years	
Netherlands	SURFnet	no		within 3 years	
Norway	UNINETT	no		within 3 years	<a href="http://drift.uninett.no/">http://drift.uninett.no/</a>

Table 3C.3.1 - continued

Country	NREN	PERT?	URL:	No, but plan to deploy:	URL to monitoring tools (traffic map, etc.):
<b>EU/EFTA Countries</b>					
Poland	PIONIER	yes	<a href="http://noc.pionier.gov.pl/ang/polaczenia_a.html">http://noc.pionier.gov.pl/ang/polaczenia_a.html</a>		
Portugal	FCCN	yes			<a href="http://www.fccn.pt/index.php?module=pagemaster&amp;PAGE_user_op=view_page&amp;PAGE_id=70&amp;MMN_position=26:1">http://www.fccn.pt/index.php?module=pagemaster&amp;PAGE_user_op=view_page&amp;PAGE_id=70&amp;MMN_position=26:1</a>
Romania	RoEduNet	no		within 1 year	<a href="https://admin.roedu.net/">https://admin.roedu.net/</a>
Slovakia	SANET	yes			<a href="http://www.sanet.sk/">http://www.sanet.sk/</a>
Slovenia	ARNES	yes			
Spain	RedIRIS	no		within 1 year	<a href="http://www.rediris.es/red/">http://www.rediris.es/red/</a>
Sweden	SUNET	no			<a href="http://stats.sunet.se/">http://stats.sunet.se/</a>
Switzerland	SWITCH	yes	<a href="http://www.switch.ch/network/PERT/">http://www.switch.ch/network/PERT/</a>		
United Kingdom	JANET(UK)	no			<a href="http://www.ja.net/services/network-services/netsight/index.html">http://www.ja.net/services/network-services/netsight/index.html</a>
<b>Other Countries</b>					
Belarus	BASNET	yes			
Croatia	CARNet	no		within 1 year	<a href="https://hrelja.srce.hr/">https://hrelja.srce.hr/</a>
Georgia	GRENA	yes			
Israel	IUCC	no		within 3 years	<a href="http://noc.ilan.net.il/">http://noc.ilan.net.il/</a>
Macedonia	MARNet	no		within 1 year	
Moldova	RENAM	no		within 3 years	<a href="http://noc.renam.md">http://noc.renam.md</a>
Montenegro	MREN	no		within 3 years	<a href="http://netmon.cg.ac.yu">http://netmon.cg.ac.yu</a>
Morocco	MARWAN	no		within 1 year	<a href="http://www.marwan.ma/supervision">http://www.marwan.ma/supervision</a>
Russian Federation	RBNet/RUNNet	yes			<a href="http://noc.runnet.ru">noc.runnet.ru</a>
Serbia	AMRES	yes	<a href="http://netiis.rcub.bg.ac.yu/">http://netiis.rcub.bg.ac.yu/</a>		
Turkey	ULAKBIM	no		within 3 years	<a href="http://www.ulakbim.gov.tr/ulaknet/istatistik/">http://www.ulakbim.gov.tr/ulaknet/istatistik/</a>

## 3C.4 Optical Services

Optical networking makes it possible, in principle, to give users access to a dedicated lightpath. Users are then free to use whatever protocol suits them best in order to transport data via that path. There is no requirement to use the Internet Protocol (IP). The survey asked if NRENs have any optical links that carry non-IP based traffic.

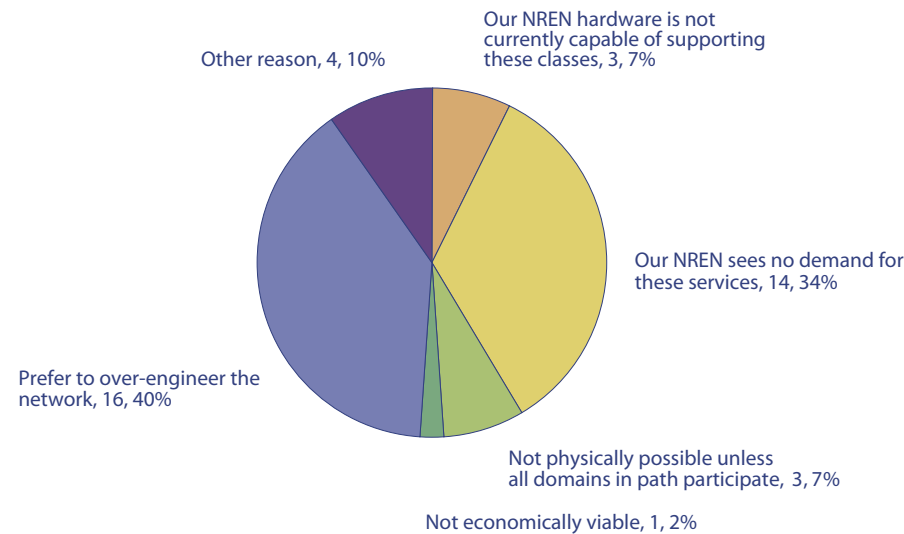
Most NRENs reported that they do not have optical links that carry non-IP traffic, but some do. In all cases, such links then carry traffic based on Ethernet technology. A further question was asked about the technology used to monitor traffic on such links. NRENs mentioned a variety of tools: Cacti, Nagios, MRTG, TNMS and SNMP queries. A number of NRENs, such as SURFnet and SWITCH have developed or are developing their own tools.

### 3C.5 Quality of Service

The GN2 project defines three levels of Quality of Service, termed 'Premium', 'Best Effort' and 'Less than Best Effort'. On congested networks, implementing Quality of Service allows premium traffic to pass through unhindered, whereas other traffic might experience problems. NRENs were asked if they provide these levels of Quality of Service. Only a minority do (eight out of 28 EU/EFTA NRENs and one out of nine NRENs from other countries). The graph below gives the reasons why NRENs do not provide this.

Most NRENs from the EU/EFTA countries prefer to over-engineer the network, so that congestion does not occur and therefore there is little requirement for Quality of Service. Other NRENs do not see the demand for such a service which could be due to the fact that these NRENs have no congestion on their networks.

Graph 3C.5.1 Reasons for not providing QoS levels



### 3C.6 Security

Security incident response is increasingly being considered as vital to the end users. They expect NRENs to provide such services or to make sure that somebody else provides them.

Table 3C.6.1 summarises the information about whether security incident response is provided by the NREN itself, or if it is outsourced. Often, special Computer Security Incident Response Teams (CSIRTs) are formed to ensure a timely response to (potential) security threats. International collaboration is of key importance to CSIRTs. A precondition for such collaboration is that CSIRTs have to be able to trust one another. In order to facilitate such trust relationships, TERENA has been instrumental in setting up the Trusted Introducer scheme (see [www.ti.terena.org](http://www.ti.terena.org) for more information). The table shows which NRENs have CSIRTs that are either accredited with the scheme or candidates for accreditation (note that only the information that is at [www.ti.terena.org](http://www.ti.terena.org) is fully up-to-date and authoritative).

The table clearly shows that there is still a large difference in this area between EU/EFTA NRENs and NRENs in other countries in the region. The situation has not changed since last year.

Table 3C.6.1 Security Incident Response Teams

	Security Incident Response by NREN	Outsourced
<b>EU/EFTA Countries</b>	90%	10%
(n = 29)	Accredited CSIRT: 57%	
<b>Other Countries</b>	100%	0%
(n = 9)	Accredited CSIRT: 13%	

### 3C.7 Authorisation and Mobility Services<sup>1</sup>

The internet is an essential tool in many walks of life, not just for those in research and education but also for the delivery of commercial services and products. As the community of internet users increases and use more closely resembles the transactions of ordinary daily life, digital proof of identity and trust becomes increasingly important.

The use of multiple usernames and passwords to access a range of different services and systems is inherently unsafe for many reasons and often lead to the compromise of integrity of security. Amongst the alternative solutions is the concept of identity management systems, which can be used to provide accreditation of services, individuals and their identities.

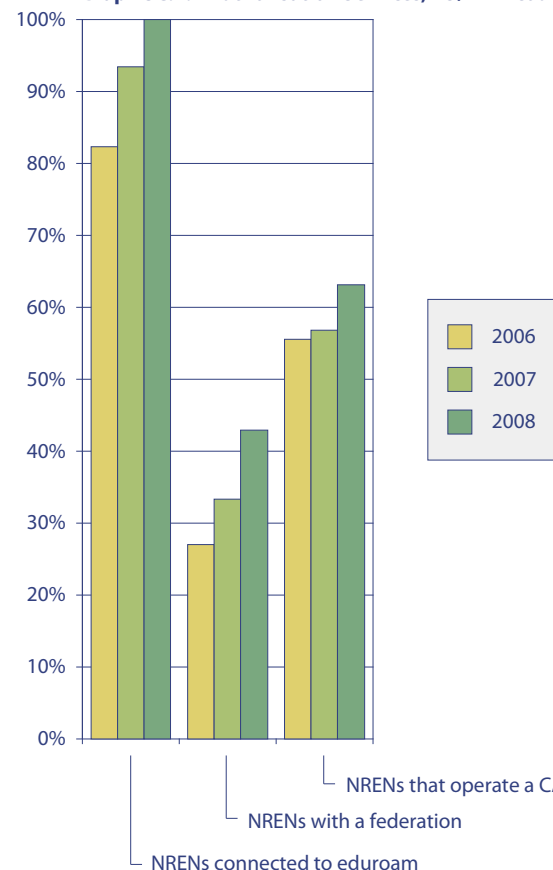
Identity management is normally undertaken in a federation with end user data being collected and administered by local identity providers. Over the last few years the European research and education networks have been making steady progress in developing and putting in place systems that support federated identity management and certification.

Three major indicators that have been surveyed over the past three years show consistent growth.

eduroam is a practical example of federated access, with mobile users able to gain authenticated access to wireless networks right across Europe and beyond, using the credentials issued by their home institution.

The growth in the number of NRENs putting a federation in place is an indicator of the growing importance of such an approach to authorisation and authentication. Similarly over 60% of all the NRENs in the EU/EFTA region operate a certification authority. This is another positive indicator of the growth and uptake of AAI.

Graph 3C.7.1 Authorisation Services, EU/EFTA countries



Whilst there have been no statistics collected in previous years on the number of certificates issued or in use, NRENs in the EU/ETFA area reported for the year up until January 2008 that they issued over 16,000 certificates. By comparison only 350 certificates were reported by non-EU/EFTA countries in the survey over the same period with approximately half of this number being issued in Croatia.

<sup>1</sup> With contributions by Licia Florio, TERENA.

Of the 16,000 certificates issued during 2007, 64% were issued by the TERENA Server Certificate Service (SCS). The SCS itself has issued more than 16,000 server certificates since its inception in January 2006. The prediction is that by 2008, this number will increase to around 23,000.

The majority of European NRENs that run a federation (70%) use Shibboleth to support it, but individual NRENs also report the use of Liberty Alliance (1), PAPI (1), A-select (1), or others (2). Interworking between the different systems can be supported using federations of federations (known as confederations) and exchange of data with Security Assertion Markup Language (SAML).

In the majority of NRENs that provided data on their federations, there is a close correspondence between the number of institutions that participate

and the number of identity providers. A major exception is FEIDE, which is the national identity management system for the education sector in Norway. FEIDE operates a single identity provider for all institutions in the federation.

### 3C.8 Housing, Storage, Hosting, Content Delivery Services

Table 3C8.1 below provides information on distributed storage, mirroring services and web hosting services being offered by NRENs.

Mirroring services are the most common, being offered by 16 out of the 30 EU/EFTA NRENs. Many NRENs also offer some web hosting services to their clients.

**Table 3C.8.1 Storage, Hosting**

Country	NREN	Distributed storage?	Description or URL	Mirroring services?	Description or URL	Web hosting services?
<b>EU/EFTA Countries</b>						
Austria	ACOnet	no		no		no
Belgium	BELNET	no		yes	ftp.belnet.be	no
Bulgaria	BREN	no		no		yes
Cyprus	CYNET	no		no		
Czech Republic	CESNET	yes	Part of the national grid activities, <a href="http://meta.cesnet.cz">http://meta.cesnet.cz</a> ; more extensive deployment planned	no		yes
Denmark	UNI-C	no		no		yes
Estonia	EENet	yes	GRID storage (gLite 2 TB)	yes	ftp.eenet.ee	yes
Finland	FUNET	no		yes	<a href="http://ftp.funet.fi/pub/mirrors/">http://ftp.funet.fi/pub/mirrors/</a>	yes
France	RENATER	no		no		no
Germany	DFN	no		yes		no
Greece	GRNET S.A.	yes	Only for Grid users, <a href="http://www.hellasgrid.gr/infrastructure/index.php?language=en">http://www.hellasgrid.gr/infrastructure/index.php?language=en</a>	yes	Only for Grid users, <a href="http://www.hellasgrid.gr/infrastructure/index.php?language=en">http://www.hellasgrid.gr/infrastructure/index.php?language=en</a>	no
Hungary	NIIF/HUNGARNET	yes	<a href="http://www.niif.hu/en/storage">http://www.niif.hu/en/storage</a>	yes	Mirror servers operated beyond the Hungarian border providing easy access to the contents of the Hungarian Digital Library (MEK).	yes

Table 3C.8.1 - continued

Country	NREN	Distributed storage?	Description or URL	Mirroring services?	Description or URL	Web hosting services?
<b>EU/EFTA Countries</b>						
Iceland	RHnet	no		yes	<a href="http://ftp.rhnet.is">http://ftp.rhnet.is</a>	no
Ireland	HEAnet	no		yes	<a href="http://www.heanet.ie/services/services.php?serID=50&amp;subID=4">http://www.heanet.ie/services/services.php?serID=50&amp;subID=4</a>	yes
Italy	GARR	no		yes	<a href="http://mirror.garr.it">http://mirror.garr.it</a>	no
Latvia	SigmaNet	yes	It's in development phase, in the framework of Grid project.	no		yes
Lithuania	LITNET			yes	<a href="http://ftp.litnet.lt">http://ftp.litnet.lt</a>	yes
Luxembourg	RESTENA	no		no		yes
Malta	UoM, IT Services	no		no		
Netherlands	SURFnet	no		yes	<a href="http://www.surfnet.nl/nl/diensten/cc/Pages/ftp.aspx">http://www.surfnet.nl/nl/diensten/cc/Pages/ftp.aspx</a>	no
Norway	UNINETT	yes	<a href="http://www.norstore.no/">http://www.norstore.no/</a>	no		no
Poland	PIONIER	yes	none	yes	none	yes
Portugal	FCCN	no		no		yes
Romania	RoEduNet	no		yes	<a href="http://ftp.iasi.roedu.net/">http://ftp.iasi.roedu.net/</a>	no
Slovakia	SANET	no		no		no
Slovenia	ARNES	no		yes	<a href="ftp://ftp.arnes.si/">ftp://ftp.arnes.si/</a>	yes
Spain	RedIRIS	no	In its initial stage, prototype at <a href="http://sicsis01.uco.es/consigna_ssp">http://sicsis01.uco.es/consigna_ssp</a>	yes	<a href="http://ftp.rediris.es/">http://ftp.rediris.es/</a>	no
Sweden	SUNET	no		no		no
Switzerland	SWITCH	no		yes	<a href="http://mirror.switch.ch/">http://mirror.switch.ch/</a>	no
United Kingdom	JANET(UK)	no		no		yes
<b>Other Countries</b>						
Belarus	BASNET	no		no		yes
Croatia	CARNet	no		yes		yes
Georgia	GRENA	no		yes	<a href="http://ge.archive.ubuntu.com">http://ge.archive.ubuntu.com</a>	yes
Israel	IUCC	no		no		yes
Moldova	RENAM	no		no		yes
Montenegro	MREN	no		no		yes
Morocco	MARWAN	no		no		yes
Russian Federation	RBNet/RUNNet	no		yes	We have mirrors of Federal Web-sites with educational resources in regions	yes
Serbia	AMRES	no		no		yes
Turkey	ULAKBIM	yes	Via GRID infrastructure (Integrated with EGEE)	yes	<a href="ftp.ulakbim.gov.tr">ftp.ulakbim.gov.tr</a>	yes

## 3C.9 Network Communication Tools

### 3C.9.1 IP Telephony

Table 3C9.1.1 summarises the answers that were received with respect to IP telephony deployments. The last column provides URLs to NREN websites with additional information about particular deployments.

Last year, the Compendium looked at IP telephony deployments in general. The survey found that a small majority of EU/EFTA NRENs had this facility in house. This year, the survey asked more specifically about IP telephony as a service offered by the NRENs to their customers. Eight out of the 30 EU/EFTA NRENs (27%) had such a service. Only four EU/EFTA NRENs have peerings with other institutions for the interconnection of IP telephony deployments. Such peerings depend to a large extent on national legislations and policies.

**Table Legend**

Used?	Is the NREN offering a telephony service to their customers (outside the NREN offices)?
Protocols?	On what protocols is the service based?
Peerings?	Are there peering relationships with other institutions for the interconnection of IP telephony deployments?

**Table 3C.9.1.1 IP Telephony**

Country	NREN	Used?	Protocols?	Peerings?	Description or URL
<b>EU/EFTA Countries</b>					
Austria	ACOnet	no			
Belgium	BELNET	no	SIP & H323		
Bulgaria	BREN	no	SIP		
Cyprus	CYNET	no			
Czech Republic	CESNET	yes	SIP & H323	Yes	<a href="https://sip.cesnet.cz/">https://sip.cesnet.cz/</a>
Denmark	UNI-C	no	SIP & H323 - at rude test level only		
Estonia	EENet	no	Skype		
Finland	FUNET	no		Yes	<a href="http://www.csc.fi/english/funet/videtechnology/videoconferencing/cscgate">http://www.csc.fi/english/funet/videtechnology/videoconferencing/cscgate</a>
France	RENATER	yes	SIP		
Germany	DFN	yes	SIP & H323		<a href="http://www.dfn.de/dienstleistungen/dfnfernsprechen/">http://www.dfn.de/dienstleistungen/dfnfernsprechen/</a>
Greece	GRNET S.A.	yes	SIP & H323		<a href="http://www.grnet.gr/default.asp?pid=42&amp;la=2">http://www.grnet.gr/default.asp?pid=42&amp;la=2</a>
Hungary	NIIF/HUNGARNET	yes	SIP, H.323, Skinny	Yes	<a href="http://www.voip.niif.hu">www.voip.niif.hu</a>
Iceland	RHnet	no			
Ireland	HEAnet	no			

Table 3C9.1.1 - continued

Country	NREN	Used?	Protocols?	Peerings?	Description or URL
<b>EU/EFTA Countries</b>					
Italy	GARR	no	SIP & H323		
Latvia	SigmaNet	no			
Lithuania	LITNET	no	SIP	Yes	
Luxembourg	RESTENA	no	SIP		
Malta	UoM, IT Services	yes			
Netherlands	SURFnet	no	SIP		
Norway	UNINETT	no	SIP		
Poland	PIONIER	yes	SIP		
Portugal	FCCN	no	SIP		
Romania	RoEduNet	no	SCCP		
Slovakia	SANET	no	SIP		
Slovenia	ARNES	no	Cisco Skinny		
Spain	RedIRIS	no	SIP		
Sweden	SUNET	no	SIP		
Switzerland	SWITCH	no	SIP, Cisco Skinny		
United Kingdom	JANET(UK)	yes	SIP & H323		
<b>Other Countries</b>					
Belarus	BASNET	no			
Croatia	CARNet	yes	SIP, IAX2	Yes	
Georgia	GRENA	no			
Israel	IUCC	no			
Macedonia	MARNet	no			
Moldova	RENAM	no	Skype		
Montenegro	MREN	no			
Morocco	MARWAN	no			
Russian Federation	RBNet/RUNNet	no			
Serbia	AMRES	no			
Turkey	ULAKBIM	yes	H.323	Yes	

### 3C.9.2 Video Streaming and Video Conferencing

As is shown in the table, 21 out of the 30 EU/EFTA NRENs offer a videoconferencing service, either directly or via a third party. Many NRENs also offer additional services, such as archiving of videoconferences and user support for the service.

**Table legend:**

Direct	a videoconferencing service is provided directly by the NREN
3 <sup>rd</sup> Party	a videoconferencing service is provided by a third party under some central agreement
MCU service	users can make use of MCU services

**Table 3C.9.2.1 Video Streaming and Video Conferencing**

Country	NREN	Direct?	3 <sup>rd</sup> Party	MCU services	Number of MCUs	Number of individual MCU ports	Maximum number of concurrent conferences	Are members of other communities able to book the MCUs?	Is there an online booking system?	Does the NREN offer centrally provided archiving of conference/streaming?	Is there centrally provided support for users?	Is GDS supported?
<b>EU/EFTA Countries</b>												
Austria	ACOnet	no	no	no				no	no	no	no	no
Belgium	BELNET	yes	yes	yes	2	40	10	no	yes	no	yes	yes
Bulgaria	BREN	no	no	no				no	no	no	no	no
Cyprus	CYNET	no	yes	yes	1			yes	no	no	no	yes
Czech Republic	CESNET	yes	no	yes	1	24	12	no	yes	no	no	yes
Denmark	UNI-C	yes	no	yes	3		50	no	no	no	no	no
Estonia	EENet	yes	no	no						yes	no	
Finland	FUNET	no	yes	no				no	no	yes	no	yes
France	RENATER	yes		no								yes
Germany	DFN	yes	no	yes	3	120	120	no	no	yes	yes	yes
Greece	GRNET S.A.	yes		yes	2 hardware and 2 software MCUs	32 hardware MCU ports and 100 software MCU ports	66	yes	yes	no	yes	yes
Hungary	NIIF/HUNGARNET	yes	no	yes	1	64	64	yes	yes	yes	yes	yes
Iceland	RHnet	yes	no	yes	1	48	24	yes	yes	no	yes	no
Ireland	HEAnet	yes	no	yes	2	40	40	yes	no	yes	yes	yes
Italy	GARR	yes		yes	1	40	40	no	yes	no	yes	yes
Latvia	SigmaNet	no	no	no				no	no	no	no	no

Table 3C.9.2.1 - continued

Country	NREN	Direct?	3rd Party	MCU services	Number of MCUs	Number of individual MCU ports	Maximum number of concurrent conferences	Are members of other communities able to book the MCUs?	Is there an online booking system?	Does the NREN offer centrally provided archiving of conference/streaming?	Is there centrally provided support for users?	Is GDS supported?
<b>EU/EFTA Countries</b>												
Lithuania	LITNET	no	no	no				no	no	no	no	no
Luxembourg	RESTENA	no	no	no				no	no	no	no	no
Malta	UoM, IT Services	yes	no	no					yes	no	yes	
Netherlands	SURFnet	yes	no	yes	1	30	10	yes	yes	yes	yes	yes
Norway	UNINETT	no	no	no				no	no	no	no	no
Poland	PIONIER	no	no	no				no	no	no	no	no
Portugal	FCCN	yes	no	yes	1	25	12	yes	yes	yes	yes	yes
Romania	RoEduNet	no	no	no				no	no	no	no	no
Slovakia	SANET	no	yes	no				no	no	no	no	no
Slovenia	ARNES	yes	no	yes	2	80	40	yes	no	yes	yes	yes
Spain	RedIRIS	yes		yes	1	64	4	no	no	no	no	yes
Sweden	SUNET	no	no	no				no	no	no	no	no
Switzerland	SWITCH	yes	no	yes	1	20	6 (conference = 3 participants)	no	yes	yes	yes	yes
United Kingdom	JANET(UK)	no	yes	yes	4	96	48	no	yes	no	yes	yes
<b>Other Countries</b>												
Belarus	BASNET	no	no	no				no	no	no	no	no
Croatia	CARNet	yes	no	yes	3	56	32	yes	yes	yes	yes	yes
Georgia	GRENA	yes	no	no				no	no	no	yes	no
Israel	IUCC	yes	no	yes	1	8	32	no	no	no	yes	no
Moldova	RENAM	no	no	no				no	no	no	no	no
Montenegro	MREN	yes	yes	yes	5	20	5	yes	no	no	yes	no
Morocco	MARWAN	no	no	no				no	no	no	no	no
Russian Federation	RBNet/RUNNet	yes		yes	2	48		yes	no	no	yes	
Serbia	AMRES	yes	no	no				no	no	no	no	no
Turkey	ULAKBIM	no	no	no				no	no	no	no	no

### 3C.10 Network Computing Resources

Network computing resources (mostly Grid services) are now an important area for NRENs. Projects such as EGEE, DEISA and others aim to introduce a production Grid service for scientific research purposes, making use of distributed computing services. In many cases, the NRENs provide the networking infrastructure for such services.

Compared to 2007, the situation has not changed much. Therefore, only summary information is provided here for this year.

### 3C.11 e-Learning

Even though a number of NRENs are active in the area of e-learning, no questions were asked about this aspect in the 2008 Compendium survey. Valuable information on e-learning is available, among other places, at <http://www.elearningeuropa.info>.

**Table 3C.10.1 Disciplines that Are Running Grid-enabled Applications**

Country	NREN	High-energy Physics	Other Physics	Computational Chemistry	Other Chemistry	Biomedical	Astroscience	Earth Science	Climatology	Arts and Humanities
<b>EU/EFTA Countries</b>										
	<ul style="list-style-type: none"> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: yellow; border: 1px solid black; margin-right: 5px;"></span> Now</li> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: lightgreen; border: 1px solid black; margin-right: 5px;"></span> Planned</li> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: green; border: 1px solid black; margin-right: 5px;"></span> Don't know</li> </ul>									
<b>Other Countries</b>										
	<ul style="list-style-type: none"> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: yellow; border: 1px solid black; margin-right: 5px;"></span> Now</li> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: lightgreen; border: 1px solid black; margin-right: 5px;"></span> Planned</li> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: green; border: 1px solid black; margin-right: 5px;"></span> Don't know</li> </ul>									

The data shows that Grid services are currently running in twenty-three (85%) of the EU/EFTA NRENs; this will rise to nearly 100% over the next two years. Grid services are also running in six of the ten NRENs from other countries in the survey. The other NRENs from these countries foresee such services being developed in the next two years.

NREN support is involved in running the service in the great majority of cases. The geographical extent of the service is, in almost all cases, international.

## 3C.12 User and Client Support

Support services are very much in demand, and an increasing range of these is provided by NRENs. From the survey, the picture that emerges is one that combines generic support and information functions with differentiated support for specific user groups, and often the development of professional service units.

**Table 3C.12.1 User and client support**

Country	NREN	Support for specific groups of users?	Details	National User Conference, when?	Training courses?	URL	
<b>EU/EFTA countries</b>							
Austria	ACOnet	no		yes	June, November	yes	Sometimes small technical workshops are held before an user conference.
Belgium	BELNET	yes	<ul style="list-style-type: none"> <li>• Extra support for Schools of higher education who have recently been connected in 2007/2008</li> <li>• Advice &amp; support for building &amp; rollout of 10Gbit/s supercomputing network between 4 universities over the BELNET Backbone</li> <li>• Extra support &amp; advice for GRID users.</li> <li>• General: BELNET recruited 2 technical customer advisors and a customer content developer in 2007/2008 to better support &amp; advice customers &amp; users.</li> </ul>	yes	annually in Q4	yes	E.g. GRID workshops, layer 2 VPN's, CSIRT training, Multicast, Ipv6, Eduroam, Vulnerability Scanner ... (around 6 a year)
Bulgaria	BREN	no		no		no	
Cyprus	CYNET	no		no		no	
Czech Republic	CESNET	yes	High Energy physics: E2E and Lambda services/Grid enabled application Chemistry: Grid enabled application Medical: Videoconference and streaming Medimed - CA and hi-speed network infrastructure POSN (Private Optical Network of Hospitals) - DWDM network infrastructure PIM EMEA - pilot infrastructure MediGRID - distributed processing of medical data	yes	once in two years	yes	as part of the Grid activities, see <a href="http://egee.cesnet.cz/en/events/actions.html">http://egee.cesnet.cz/en/events/actions.html</a>
Denmark	UNI-C	yes	Mostly e-learning/video-based learning stuff. UNIVID - <a href="http://old.forskningsnettet.dk/univid">http://old.forskningsnettet.dk/univid</a> , EDUMEDIA (a video archive) - <a href="http://www.forskningsnettet.dk/da/edumedia">http://www.forskningsnettet.dk/da/edumedia</a> , Online conferencing via Adobe Connect, The golden Cut (a competition on video-based learning) - <a href="http://www.forskningsnettet.dk/da/dgs?q=node/563">http://www.forskningsnettet.dk/da/dgs?q=node/563</a>	yes	Autumn	no	

Table 3C.12.1 - continued

Country	NREN	Support for specific groups of users?	Details	National User Conference, when?	Training courses?	URL
<b>EU/EFTA countries</b>						
Estonia	EENet	no		no		
Finland	Funet	yes		yes	end of November	yes <a href="http://www.csc.fi/english/funet/networkservices/usersupport/training">http://www.csc.fi/english/funet/networkservices/usersupport/training</a>
Germany	DFN	no		yes	Two times per year there is a customer conference.	yes e.g. Video Conferencing, Security
Greece	GRNET S.A.	yes	The aim of the user support service (Helpdesk) is to handle problems concerning connection to the GRNET backbone network. Moreover, it monitors its customer's network stability and offers them services like backup MX, secondary DNS, etc. GRNET mainly consists of, Hellenic academic institutions and departments of Hellenic public services.	yes	Yearly	yes <a href="http://to.grnet.gr/">http://to.grnet.gr/</a> , <a href="http://vnoc.grnet.gr/g-tech/">http://vnoc.grnet.gr/g-tech/</a>
Hungary	NIIF/HUNGARNET	yes	Special Sections of Hungarnet	yes	April or May each year	yes <a href="http://www.ipszilon.niif.hu/">http://www.ipszilon.niif.hu/</a>
Iceland	RHnet	no		no		yes <a href="http://www.icegrid2007.hi.is">www.icegrid2007.hi.is</a> This is a recent development: Both a user conference and a Grid workshop in collaboration with the University of Iceland and colleagues at the Nordic NRENs.
Ireland	HEAnet	yes	Library group - LIR - see <a href="http://lirgroup.heanet.ie/">http://lirgroup.heanet.ie/</a>	yes	November	yes
Italy	GARR	yes	Medical Science Arts and Humanities	yes	once per year	yes <a href="http://www.garr.it/workshop/garr-b-workshop.shtml">http://www.garr.it/workshop/garr-b-workshop.shtml</a>
Latvia	LANET	null				
Latvia	SigmaNet	yes	We are open to support them, there have been some queries, but nothing concrete.	no		yes We organise seminars on Grids and security issues.
Lithuania	LITNET	yes		yes	"LITNET activities and developments", August	yes Distance learning training courses for LITNET users, <a href="http://webct.liedm.lt/">http://webct.liedm.lt/</a>
Luxembourg	RESTENA	no		no		no
Malta	UoM, IT Services	yes				
Netherlands	SURFnet	yes	Special attention and support (e.g. workshops) is given to researchers and teaching staff of connected institutions.	yes	Every two years.	yes <a href="http://www.surfnet.nl/nl/bijeenkomsten/">http://www.surfnet.nl/nl/bijeenkomsten/</a>

Table 3C.12.1 - continued

Country	NREN	Support for specific groups of users?	Details	National User Conference, when?	Training courses?	URL	
<b>EU/EFTA countries</b>							
Norway	UNINETT	yes	Met.no (Weather Forecast), Norwegian Mapping Authority (eVLBI, Ny-Ålesund), National Library, various projects at universities and research institutions.	yes	At colleges and university premises	yes	Various subjects,
Poland	PIONIER	yes	We provide network connectivity for groups of users like VLBI, GRID users, etc.	no		yes	Security trainings, GRID applications courses
Portugal	FCCN	yes	GRID, PIP, H.323, IPv6 projects, Federica project.	yes	Twice a year	no	
Romania	RoEduNet	yes		yes	Usually in cities with NOCs	yes	<a href="http://netacad.iasi.roedu.net/">http://netacad.iasi.roedu.net/</a>
Slovakia	SANET	no		no		no	
Slovenia	ARNES	yes	Help desk for individual users, technical support for organizations	yes	April	yes	Workshops on videoconferencing, wireless networks, local networks and computer security.
Spain	RedIRIS	yes	Upon specific requests. The requested activity must be covered by a project funded by the Local or National Governments or the EC.	yes	October - November	yes	Specific hands-on courses in particular technologies: Grid, AAI...
Sweden	SUNET	no		yes	In April and October	yes	
Switzerland	SWITCH	yes	We organize workshops for specific topics, for example e-learning services.  We partially support end users for specific services, e.g. in the field of e-conferencing (no general 1st level support, but consultancy and emergency support)	yes	October	yes	on specific topics, e.g. AAI, Security, Streaming
United Kingdom	JANET(UK)	yes	We work with different groups of users when there is a requirement to do so.	no		yes	<a href="http://www.ja.net/services/training/index.html">http://www.ja.net/services/training/index.html</a>
<b>Other Countries</b>							
Belarus	BASNET	yes	Support of telecommunication network of Byelorussian Space System of the Remote Sensing of Earth	no		no	
Croatia	CARNet	yes	Education of system engineers and E-Learning Academy	yes	During November each year	yes	<a href="http://www.carnet.hr/edupoint">http://www.carnet.hr/edupoint</a>
Georgia	GRENA	yes	GRENA is involved in distance learning and GRID activities.	no		yes	Cisco Academy IT essentials, CCNA, Network Security, Linux
Israel	IUCC	no		no		no	

**Table 3C.12.1** - continued

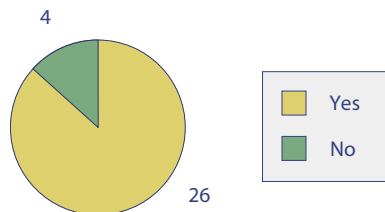
Country	NREN	Support for specific groups of users?	Details	National User Conference, when?	Training courses?	URL	
<b>Other countries</b>							
Moldova	RENAM	yes	RENAM operates a help desk aimed at providing support to its constituency.  Also there is a CERT operating for the benefits of all the scientific and educational institutions and their employees.	yes	May or December, yearly	yes	NOC administrators training events, implemented services oriented user training and support activities
Montenegro	MREN	no		no		yes	<a href="http://www.mren.cg.ac.yu/dt_event.php">http://www.mren.cg.ac.yu/dt_event.php</a>
Morocco	MARWAN	no		yes	Every Year in May-June	yes	<a href="http://www.marwan.ma/jm2007">http://www.marwan.ma/jm2007</a>
Russian Federation	RBNet/RUNNet	yes	School sector	yes	2 times a year June and October	yes	Staff education in Cisco Academy
Serbia	AMRES	no	helpdesk support, 24/7	no		no	
Turkey	ULAKBIM	no		yes	Spring	yes	Training courses according to the needs of end users in ad hoc basis.

### 3C.13 PR and Communications

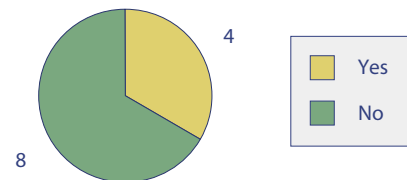
As is clear from the graphs below, most NRENs in the EU/EFTA area have at least one part-time person working on PR and communications. It is the case in only a minority of the other countries.

Similarly, in most EU/EFTA NRENs, there is a separate budget that has been set aside for PR and communications purposes, whereas this is not the case in most other countries.

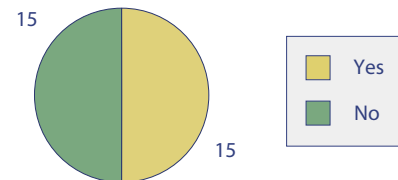
**Graph 3C13.1 PR Staff, EU/EFTA countries**



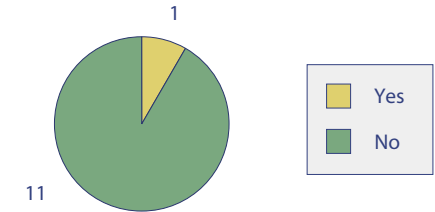
**Graph 3C13.2 PR Staff, Other countries**



**Graph 3C13.3 PR Budget, EU/EFTA countries**



**Graph 3C13.4 PR Budget, Other countries**



### 3C.14 Changes in Services

The services portfolios of NRENs are evolving constantly. It is clear that more services are being added than are being phased out. Commercial paid or 'free' alternatives are clearly not yet an alternative for the full spectrum of NREN services, even though in a few countries universities have started to make use of free email services for their students.

**Table 3C.14.1 Changes in Services**

Country	NREN	New services launched in 2007	New services planned for 2008	Phased out service 2007	Does the NREN plan to phase out some services during the coming two years? Expected services and date:	Will any NREN or institutional services be replaced by publicly available 'free' or commercial bought-in alternatives?
<b>EU/EFTA Countries</b>						
Austria	ACOnet	Certification Authority for Server Certificates			no	No
Belgium	BELNET	None	Vulnerability Scanner, Federation, AntiSPAM	none	yes	NNTP, probably end 2008
Bulgaria	BREN				no	
Cyprus	CYNET					
Czech Republic	CESNET	eduroam become routine service	none	none	no	No
Denmark	UNI-C		Better spamfiltering centrally based	DK-AAI		
Estonia	EENet	WIRIS	HAVIKE, <a href="http://havike.eenet.ee/">http://havike.eenet.ee/</a>		yes	Generic webhosting, ~2010
Finland	Funet	Funet Antenna: A service in which digital TV broadcasts as well as user organizations' own content are aired through the Funet network as multicast distribution.  Funet Black List: A service in which the email traffic can be filtered based on the IP-address of the sending server. This way, the load on the mail server of the organisation can be decreased.	ePoste Restante: File transfer from an authenticated user to the server and then from the server to an unauthenticated user.  ePort Payé: File transfer from an unauthenticated user to an authenticated user.	Backup service for customer emails.	no	Maybe the email service for students at universities.

Table 3C.14.1 - continued

Country	NREN	New services launched in 2007	New services planned for 2008	Phased out service 2007	Does the NREN plan to phase out some services during the coming two years? Expected services and date:	Will any NREN or institutional services be replaced by publicly available 'free' or commercial bought-in alternatives?	
<b>EU/EFTA Countries</b>							
Germany	DFN	AAI (from pilot to production service)		no	no	No	
Greece	GRNET S.A.	Provide MPLS L3 VPNs and MPLS L2 VPNs QoS Policy Propagation via BGP Bandwidth on Demand Routing Policy through BGP AAI Services - Shibboleth (Helpdesk, Wiki, IPTV, RTS, VoIP) IPv6 in Greek School Network Multicast Broadcasting of Greek Parliament (High Definition) Provide DSL connections to students	Archiving/Streaming of conferences Optical VPNs Web Services for L2 P2P VPNs and Carrier-Supporting-Carrier (CSC) VPNs	none	no	No	
Hungary	NIIF/HUNGARNET	eduroam, storage, AAI	TERENA SCS	none	yes	ftp mirror	Not for now.
Iceland	RHnet				no	No. (We have not heard of any such plans. But we have not been asking either.)	
Ireland	HEAnet	Netflow, wiki hosting	Large file transfer, 7x24 NOC cover, SSL certificates, e-mail spam scanning service			Publicly available e-mail is in widespread use. One member institution has adopted this for its students.	
Italy	GARR		centralised videoconferencing (MCU) Launched.		no	No	
Latvia	SigmaNet	Security incident response in a new level. Help in grid enabling of applications important to our users.		Making webpages. Radiolinks.	no	Some institutions are switching their email to Google accounts.	
Lithuania	LITNET		Certification Authority Request Tracker- ticketing system				
Luxembourg	RESTENA	PERT, CSIRT	Perfsonar	none	no	no	

Table 3C.14.1 - continued

Country	NREN	New services launched in 2007	New services planned for 2008	Phased out service 2007	Does the NREN plan to phase out some services during the coming two years? Expected services and date:	Will any NREN or institutional services be replaced by publicly available 'free' or commercial bought-in alternatives?
<b>EU/EFTA Countries</b>						
Netherlands	SURFnet	SURFfederatie, a federative identity management service that allows users to access several online services using the same user credentials.	SURFmedia, an online videoplatform that allows users to upload, view and search in media content.	In the beginning of 2008 two services were phased out:  SURFkit, a cd-rom and websites with knowledge, information and tools for end users.  SURFdetective, a software tool that provides insight in the quality of any network connection using a series of tests.	yes	No definite plans yet.
Norway	UNINETT		Service portal, "file exchange for big files", backup disaster recovery, "digital public notary"	no		
Poland	PIONIER		Video-conferencing, VoIP		no	
Portugal	FCCN	None	VPN-L2Optical VPNPERT Service	News service (Usenet news)	no	No
Slovakia	SANET				no	no
Slovenia	ARNES	GVS - virtual servers hosting	Web Video conferencing, Pilot - Educational portal, P2P Circuts	yes	CATV direct access for individual users.	Not yet.
Spain	RedIRIS	Native Ethernet VPN (point to point)	RBL (Reputation Block List)	- direct network connections ≤ 2Mbps.	no	

Table 3C.14.1 - continued

Country	NREN	New services launched in 2007	New services planned for 2008	Phased out service 2007	Does the NREN plan to phase out some services during the coming two years? Expected services and date:	Will any NREN or institutional services be replaced by publicly available 'free' or commercial bought-in alternatives?
<b>EU/EFTA Countries</b>						
Sweden	SUNET	None	None	None	no	yes
Switzerland	SWITCH	SLCS - Short lived credential service for grid use SWITCHcast - Lecture recording and streaming service	SWITCHeduhub - Community service hub LOR - Learning Object Repository		no	
United Kingdom	JANET(UK)	Wireless Advisory Service Voice Advisory Service JANETtxt JANET Lightpath NHS JANET Gateway NLN materials Additional training courses JANET Collaborate (this is a pilot)	JANET Aurora Edlab Third party services for halls of residence	Mirror Service		Some connected organisations are looking at the outsourcing of in-house services.
<b>Other Countries</b>						
Belarus	BASNET	streaming media content instant messaging service based on Jabber-server	On-demand file download service	IRC service		No
Georgia	GRENA	Distance learning	GRID		no	
Moldova	RENAM	CSIRT service Helpdesk Service GRID	IP Telephony and VoIP services AAI and PKI Certification Authority	No	no	No
Montenegro	MREN		CA			
Morocco	MARWAN	IPv6 (tunnels)				
Russian Federation	RBNNet/RUNNet				yes	IP telephony
Serbia	AMRES	Multicast	video-streaming	-	no	No
Turkey	ULAKBIM	eduroam, honeypot	videoconferencing	recursive DNS query	yes	web proxy
Ukraine	UARNet	internal VoIP PBX	video & audio conferencing	UUCP	yes	DialUP

### 3C.15 Indexation of the Digital Divide

Within the framework of the EARNEST studies, an attempt was made to develop an index to measure the state of research and education networking in a country and which allows comparisons between countries. The final report of the sub-study is due to be published by TERENA towards the end of 2008.

The index, termed the REDI (Research and Education Networking Development Index), is based on five sub-indices, addressing:

- infrastructure;
- usage;
- affordability;
- knowledge;
- quality.

These sub-indices are based in part on Compendium data and in part on generally available data such as Gross Domestic Product, country size, number of inhabitants and school / university enrolment figures. In other parts, further work is needed. Thus, in the area of quality, it is proposed to measure items such as packet loss, TCP throughput, round-trip time, and jitter. These measurements are not yet readily available for all NRENs.

For the infrastructure index, the study makes certain assumptions about the number of users per country that need to be further tested.

The EARNEST Summary Report recommends further work in this area and recommends that NRENs provide online measurement of traffic data<sup>2</sup> (as many already do).

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<sup>2</sup> EARNEST Summary Report, TERENA, 2008, p. 40.

## 4 FUNDING AND STAFFING

Note that some NRENs provide services only to the research and / or education communities in their country. Some provide additional services as well; for example, they administer the country-code top level domain or they connect companies or institutions that are clearly outside the research or education communities. For the sake of comparability, we asked NRENs to provide information only about the activities for the research or education communities. For short, we have called these 'NREN activities'.

After the overview section (4.1), section 4.2 provides information about various aspects of NREN staffing. Section 4.3 deals with NREN budgets and 4.4 and 4.5 provide more information about income sources and expenditure categories, respectively. Lastly, section 4.6 provides information about how different network levels are funded in different NRENs.

### 4.1 Overview

It is almost impossible to compare NRENs by staff or budget size. This is because NREN budgets are structured differently; they have different tasks, which are also funded in different ways.

Section 4.2 details the considerable differences in the number of staff NRENs have and the types of staff they employ, and provides an explanation for some of the differences.

Section 4.3 provides similar information for NREN budgets. It explains that NREN budgets may fluctuate considerably from year to year and they have different funded activities in each country.

When comparing current budget data with data from past editions of the Compendium, it becomes clear that NREN budgets tend to be stable over time. There are fluctuations from year to year, depending on whether or not

an important investment takes place during that year. But on the whole, the trend is that budgets stay relatively stable and that NRENs are able to deliver more bandwidth and more services for roughly the same amount of money.

This trend is illustrated by the following table, which shows traffic increase vs. budget increase (or decrease) over the 2003-2007 period. Note that the table and graph are meant to illustrate the general trend – because of the difficulties in comparing NREN budgets, the data are not suitable for making direct comparisons between NRENs.

**Table 4.1.1 Traffic Growth and Budget Growth, 2003 – 2008**

	Total traffic, 2003 (TB)	Total traffic, 2008 (TB)	Total budgets, 2003 (MEUR)	Total budgets, 2008 (MEUR)	Traffic increase, 2003 - 2008	Budget increase, 2003 - 2008
<b>EU/EFTA Countries</b>	40,165	168,372	311	341	319%	10%
<b>Other Countries</b>	3,101	13,411	28	38	332%	34%
<b>All Countries</b>	43,266	181,782	339	379	320%	12%

The situation is not as clear in the less developed NRENs. There, new possibilities for significantly upgrading international bandwidth (for example, under the GN2, EUMEDCONNECT or SEEREN2 projects) could act as a catalyst for increased national NREN budgets.

The data suggests that in these countries a modest increase in budget, in many cases, leads to a significant increase in traffic. However, as is clear from Chapter 3, there is not always a commensurate increase in services.

## 4.2 Staffing

Since many NRENs use subcontractors, staff size is not a reliable measure of the amount of person-power that is available to an NREN. Therefore, this section gives an overview of the staff that is directly employed in NREN activities, plus subcontracted staff, in Full Time Equivalentents (FTE).

Graph 4.2.3 provides that information specifically for technical staff.

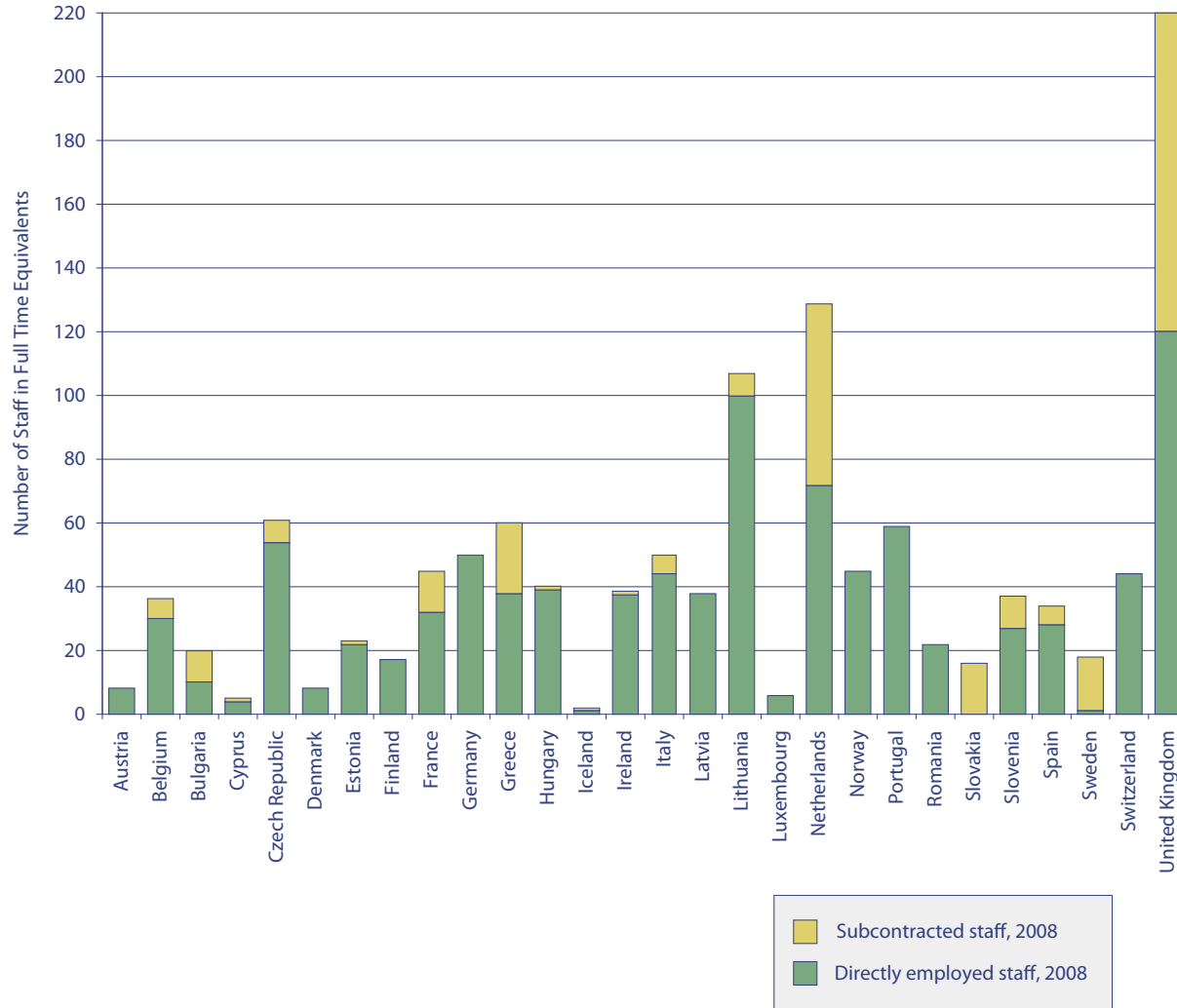
As in previous years, there are considerable differences in the number of staff employed by NRENs, and their skill set.

One explanation is that in some NRENs, the research network is provided as a service by a parent organisation; it is not possible for all those NRENs to give a specific estimate of the non-technical staff time devoted to the NREN functions (e.g., accounting, personnel, etc.). This helps to explain why some NRENs have a high proportion of technical staff to total staff.

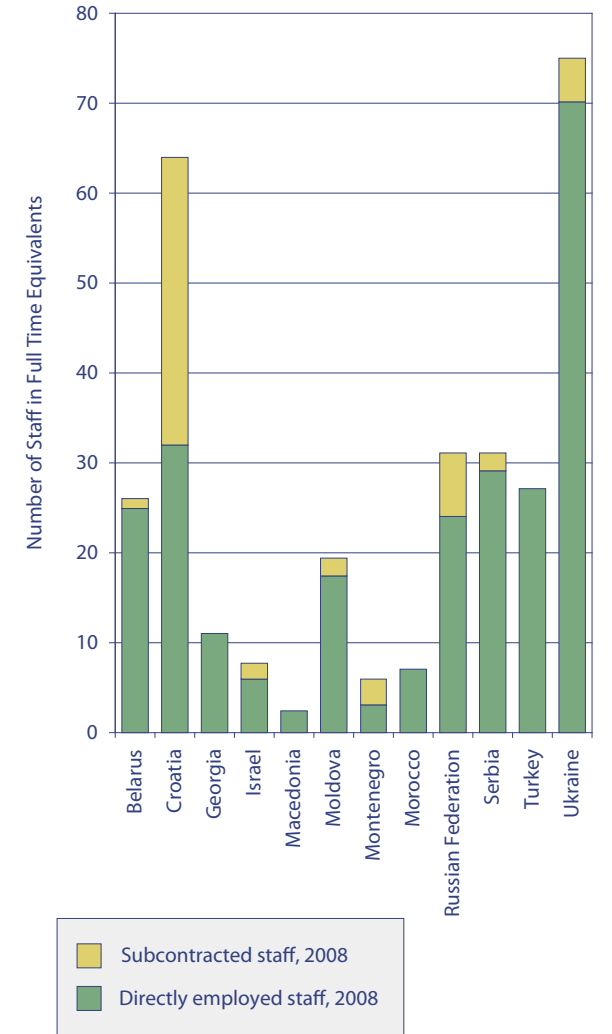
In addition, it should be noted that the tasks performed by individual NRENs are very different. Some NRENs, for example, provide connection to metropolitan area networks or to access networks, which in turn connect the institutions. Other NRENs connect institutions directly and some also manage Metropolitan Area Networks themselves. The connection policies of NRENs (see section 2.2) are different, for example with respect to secondary and primary schools, which affects the remit of the NREN. This also explains some of the differences seen in the graphs.

Finally, some NRENs provide support to individual end users at institutions, some provide limited customer support and many have service levels that are somewhere in between. This would have a significant effect on staff levels.

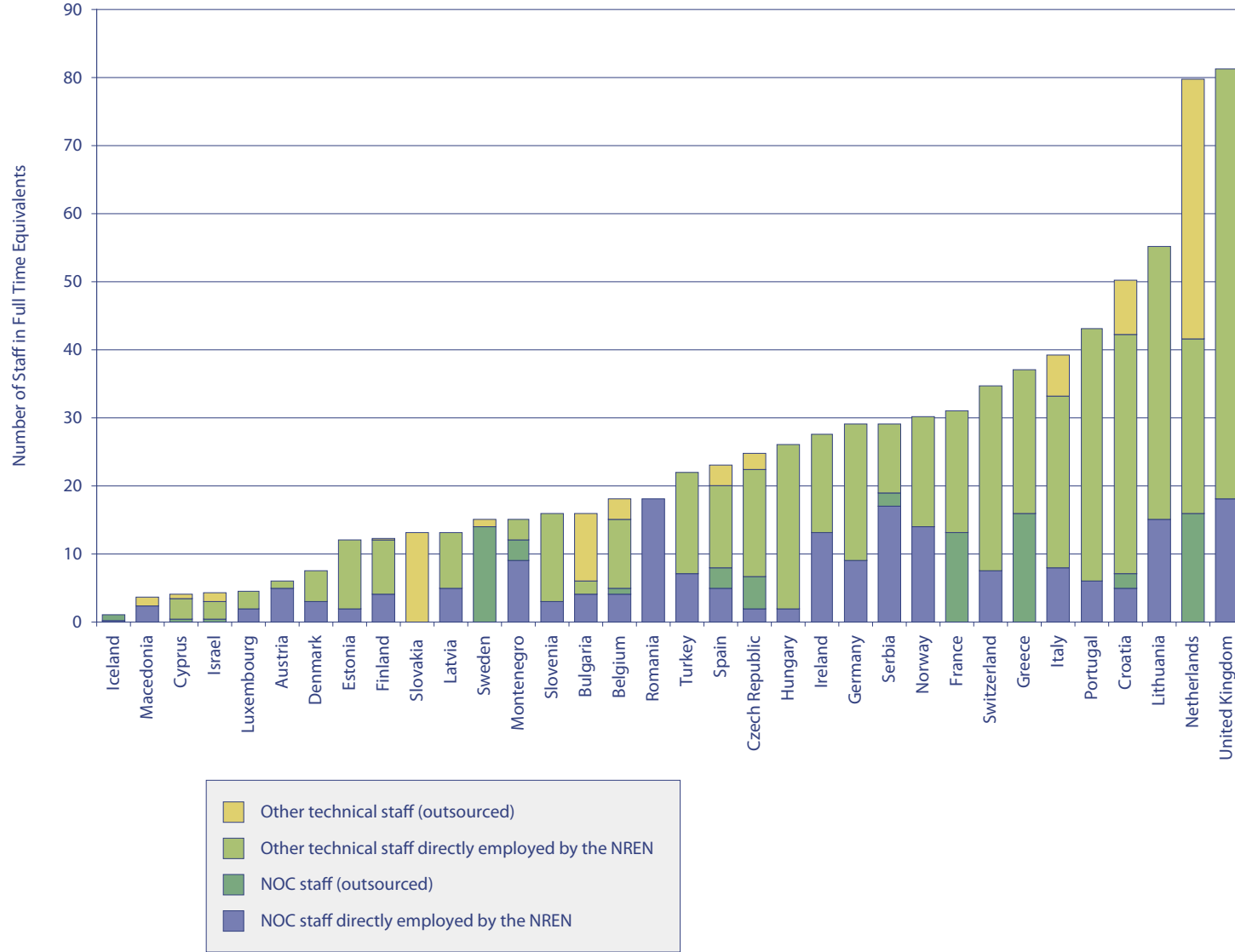
Graph 4.2.1 Total NREN Staff in FTE, EU/EFTA Countries



Graph 4.2.2 Total NREN Staff in FTE, Other Countries



Graph 4.2.3 NREN Technical Staff in FTE



### 4.3 Total Budgets, 2004 and 2008

The following graphs give the total NREN budgets for 2004 and 2008.

NREN budgets may fluctuate from year to year, because investments can vary considerably. Note that the financial year for JANET(UK) runs from August to July. In that case, the 2008 budget is really the 2007/2008 figure.

As explained in section 4.2, NRENs have different remits and are organised in a variety of ways. Some NRENs provide services only to the research and / or education communities in their country while others provide additional services; for example, they administer the country-code top-level domain or they connect others who are clearly outside the research or education communities. For the sake of comparability, we have asked NRENs to provide information only about the budget for the activities for the research and education communities in their countries.

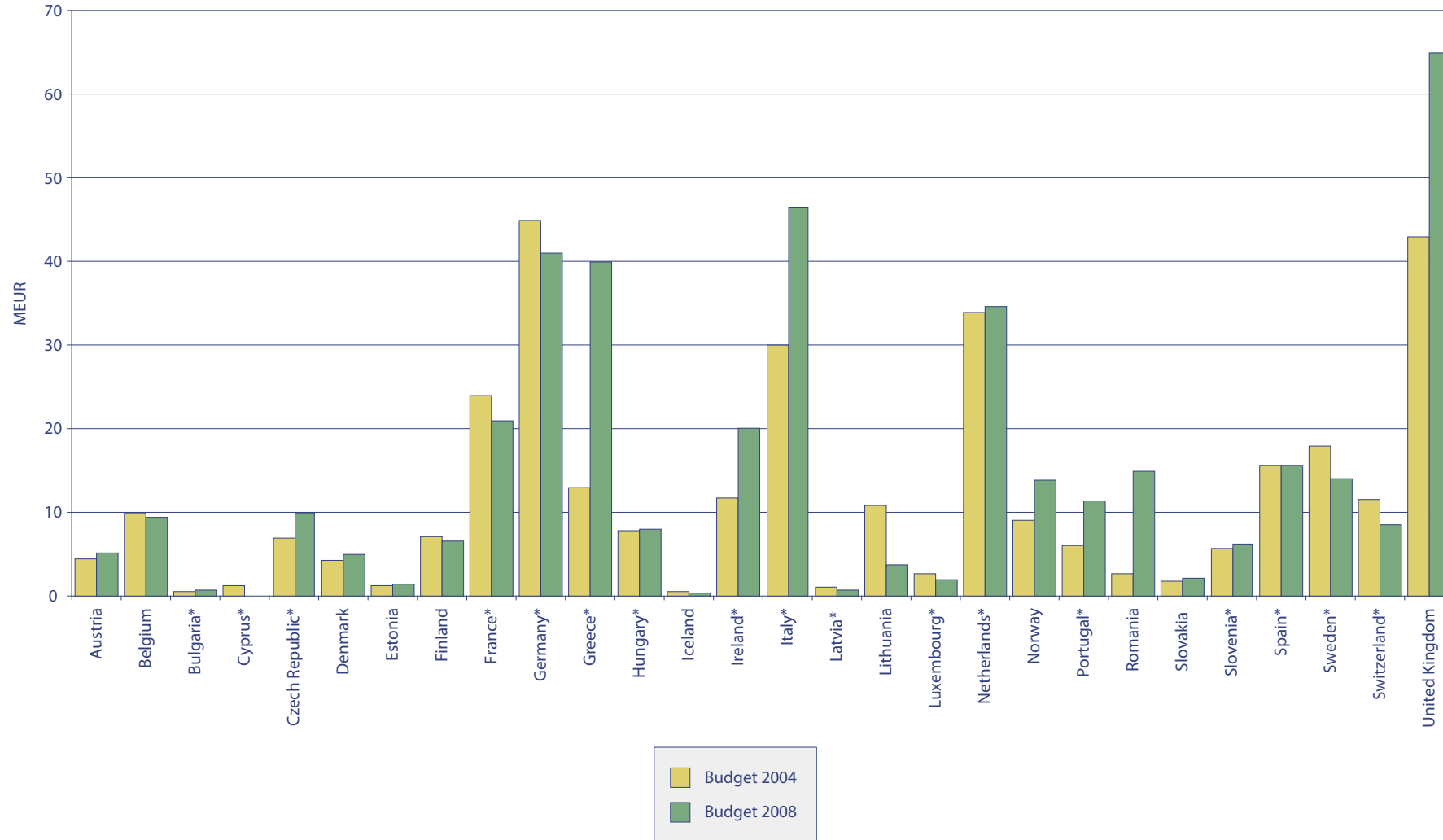
Even so, a comparison between the budgets of different NRENs is fraught with difficulty. We asked NRENs if the budget figure given includes the EU grant for the GÉANT activity - for some NRENs, this grant is shown in the budget. For others, it appears as a reduced cost and is not shown in the budget.

In graphs 4.3.1 and 4.3.2, the NRENs that include the GÉANT subsidy in their budget have been marked with an asterisk. As can be seen in 4.4, the proportion of funds received from the EU (not always for GÉANT only) varies considerably between NRENs.

There are other reasons why comparisons are difficult:

- funding for regional and / or metropolitan area networks is handled differently in different countries;
- in some countries, clients pay for their line to the nearest NREN Point of Presence; in others the NREN pays for this;
- some spend a large part of their budget connecting primary and secondary schools; others do not, or may account separately for this;
- in section 4.4, it appears that some NRENs do not spend money on salaries. Yet, they do have staff, but the staff is not paid from the NREN budget. Similar situations may apply for other budget categories as well.

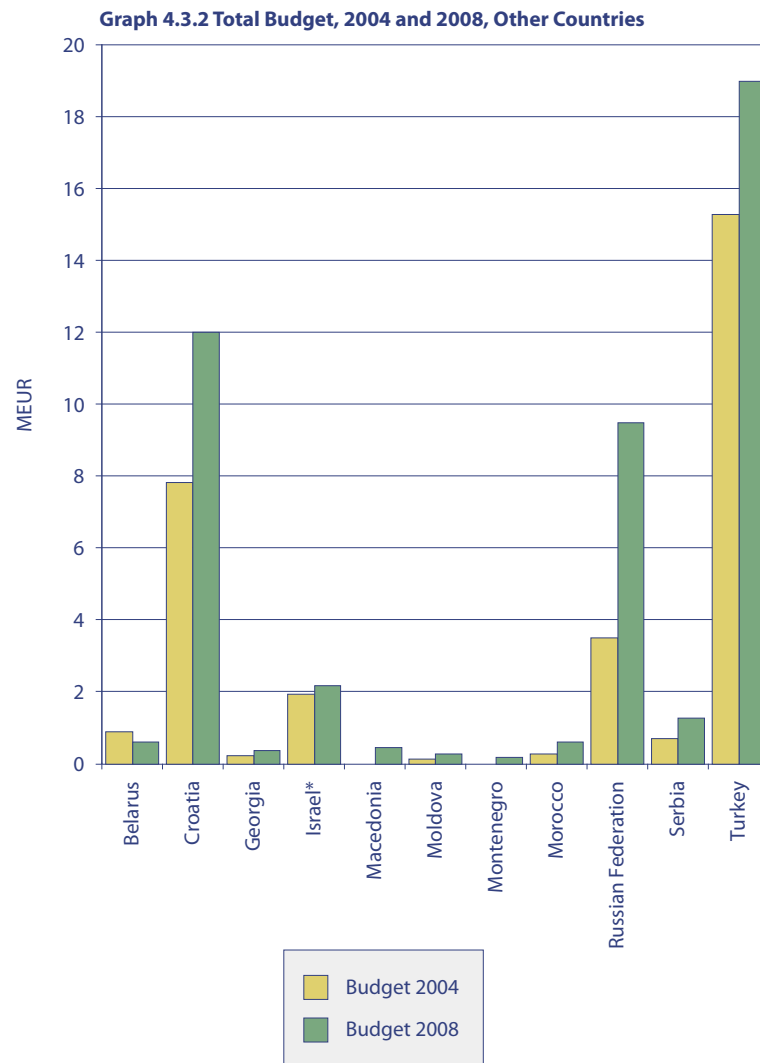
Graph 4.3.1 Total Budget 2004 and 2008, EU/EFTA Countries



\* Budget includes GÉANT subsidy

## 4.4 Income Sources

NRENs are funded in different ways: some receive all of their funding directly from the national government (RoEduNet of Romania, LITNET of Lithuania, CARNet of Croatia and MARWAN of Morocco), while others are funded entirely by their users (who may, in turn, be government-funded) (UNI-C of Denmark, RHnet of Iceland). Many varieties exist in between those extremes. Graphs 4.4.2 and 4.4.3 give information about what percentage of NREN funds comes from which source. Note that in many cases (see also graph 4.3.1 and 4.3.2) the amount of funding received from the EU is not shown in this table.



It is impossible to provide general recommendations for NREN funding mechanisms. However, it would seem that a model that involves the various stakeholders of NRENs in some way provides the best guarantees for an NREN's continued success. It should be noted that many NRENs are involved in innovative developments in their fields. Such innovations are often steered by separate funding mechanisms. It would seem important for NRENs to try to make use of such funds wherever they exist.

In this context, the recent EARNEST Study on Organisational and Governance Issues, by Robin Arak<sup>1</sup>, is relevant. A number of recommendations from this study have been summarised in the EARNEST Summary Report. That text is quoted below, with recommendations highlighted.

*"A well-known debate is the question of central funding (direct financing by the government or a government agency) versus user charging (i.e., payments by the connected institutions). It has been argued that at the early stages of the establishment of a national research and education network it is essential that the activity is almost entirely centrally funded. Once the research and education networking organisation and its services have become well established, the organisation can be positioned more at arm's length of the government and a certain amount of user-institution funding can be introduced, thereby also giving the connected institutions more influence on decision making. EARNEST indeed found a trend towards a higher proportion of user-institution funding in a few countries,*

\* Budget includes GÉANT subsidy

<sup>1</sup> TERENA, Amsterdam, 2007, ISBN 978 - 90 - 77559 - 11 - 6

but in most countries the funding models, although mutually very different, seem quite stable. In one country, the plan was to slightly reduce the proportion of user-institution funding.

Partial funding by connected institutions is a viable model, but it needs to be treated carefully. For upgrades of the network and for the development and deployment of innovative services, a certain amount of central funding is often indispensable.

*If connected institutions are charged for the connectivity and services provided by NRENs, this should be done in such a way that it is not a disincentive for innovation.*

In a changing economic environment, it is important that the development and enhancement of research and education networks is planned on an appropriate time scale and that forward budget planning over several years is carried out, so that the necessary resources, both human and financial, are available when required. EARNEST found that many national research and education networking organisations only plan budgets on an annual basis. That is not sufficient for planning major network and service infrastructure developments. Involving

major users of research and education networks in the planning is also important, particularly when some of them may need additional dedicated connections or services, or significant enhancements to existing infrastructure, to achieve their research and education objectives.

*NRENs should reassess their planning and budgeting periods. They should plan and budget over a period of several years, in line with best practice in the planning of major infrastructure projects.”<sup>2</sup>*

In the 2008 survey, NRENs were asked if they already have the possibility for multi-annual budgeting. No NRENs from outside the EU/EFTA area responded that they can do this.

Of the 26 NRENs from the EU/EFTA area who responded, 58% report some possibilities in this area; the remaining 42% cannot do multi-year budgeting. A full overview is given below.

**Table 4.4.1 Multi-Annual Budgeting**

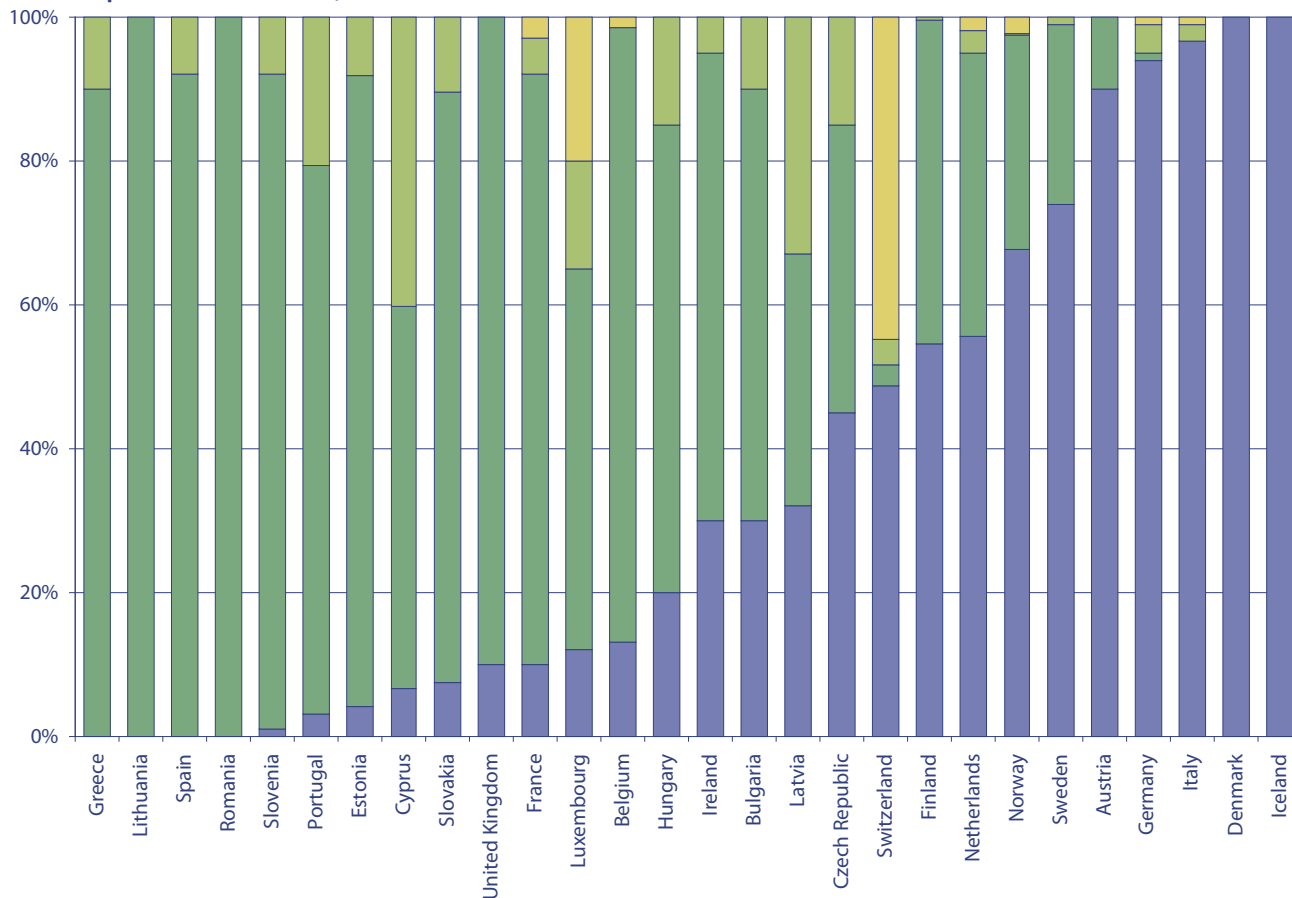
Country	NREN	Able to develop multi-annual budgets or multi-annual plans?	Description
<b>EU/EFTA Countries</b>			
Austria	ACOnet	yes	
Belgium	BELNET	yes	BELNET develops multi-annual budgets via accountancy software which takes into account our multi-annual financial contractual engagements.
Czech Republic	CESNET	yes	CESNET has obtained institutional support for the development of the NREN and its services for the period 2004-2010, which is a significant part of CESNET's budget.
Denmark	UNI-C	yes	We do things step by step. Larger investments are funded by government.
Estonia	EENet	no	
Finland	Funet	yes	Limited possibility for multi-annual plans in major investments like network upgrades, together with Ministry of Education (utilizing ministry strategies etc.).

<sup>2</sup> EARNEST Summary Report, TERENA, Amsterdam, 2008, p. 31

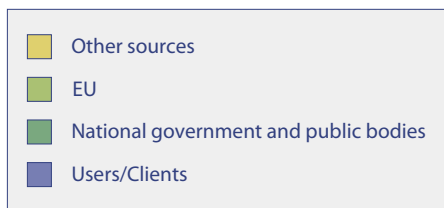
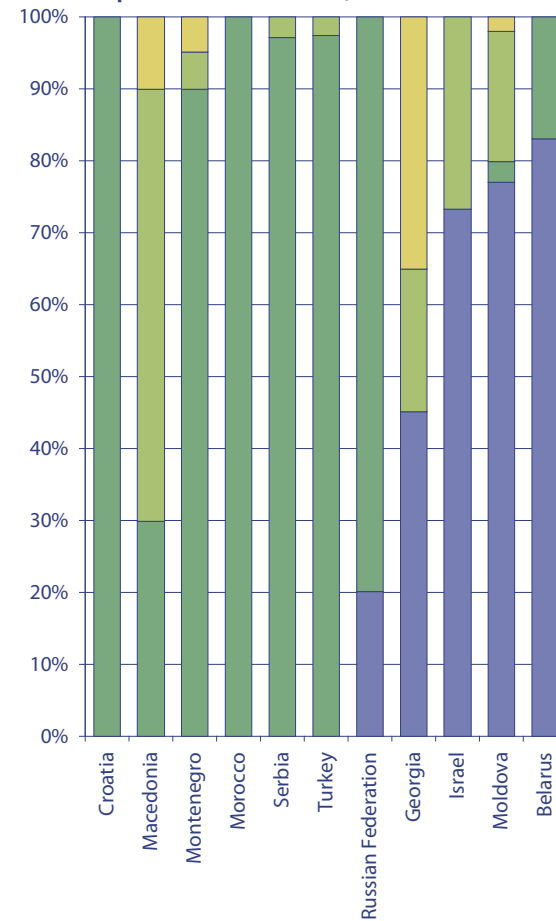
Table 4.4.1 - continued

Country	NREN	Able to develop multi-annual budgets or multi-annual plans?	Description
<b>EU/EFTA Countries</b>			
France	RENATER	yes	
Germany	DFN	yes	
Greece	GRNET S.A.	no	
Hungary	NIIF/HUNGARNET	yes	Multi-annual plans (strategic plans) are prepared and regularly revisited. The annual plans are derived, with due modifications, from these strategic plans. However, multi-annual budgeting is not possible.
Iceland	RHnet	yes	Yes, it is possible and has been done several times. Mostly in the first years of operation when the operation (cash flow, expenses, etc.) was more insecure than now. ;-)
Ireland	HEAnet	yes	We set ideas of budgets for several years ahead e.g. 2008-2013, and report these to funding bodies. Yearly budgets still need to be finalised, however.
Italy	GARR	no	
Latvia	SigmaNet	no	
Lithuania	LITNET	no	
Luxembourg	RESTENA	no	
Netherlands	SURFnet	yes	
Norway	UNINETT	yes	The company (a plc) has a long-term policy of non-profit, but may run a surplus or a deficit from year to year. Funds for multi-year projects may be allocated over a number of years.
Portugal	FCCN	no	
Romania	RoEduNet	no	
Slovakia	SANET	yes	We are asking to prepare projected budget for SANET activities for the next period of 3 /4 years, but the donation coming from the Ministry of education is still on an annual basis.
Slovenia	ARNES	no	
Spain	RedIRIS	yes	The Ministry for Science and Innovation, which funds most of RedIRIS activity and hires the backbone, can develop multi-annual budgets following the procedures established at the Budget Law.
Sweden	SUNET	no	
Switzerland	SWITCH	no	
United Kingdom	JANET(UK)	yes	Major upgrades to the network are planned with spend over a number of years from new money.

Graph 4.4.2 Income Sources, EU/EFTA Countries



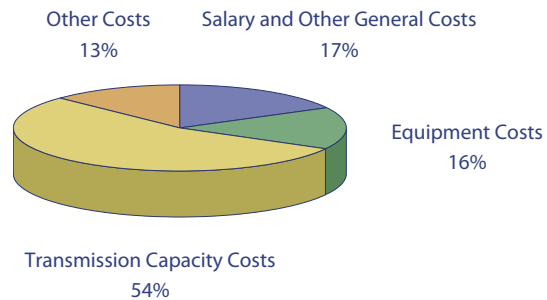
Graph 4.4.3 Income Sources, Other Countries



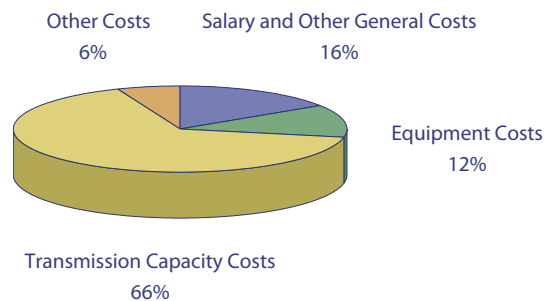
## 4.5 Expenditure by Category

Graphs 4.5.1 and 4.5.2 show the average percentage of NREN income spent on which categories of expenditure. Note that considerable variations exist between NRENs.

**Graph 4.5.1 Expenditure by Category 2008, EU/EFTA Countries**



**Graph 4.5.2 Expenditure by Category 2008, Other Countries**

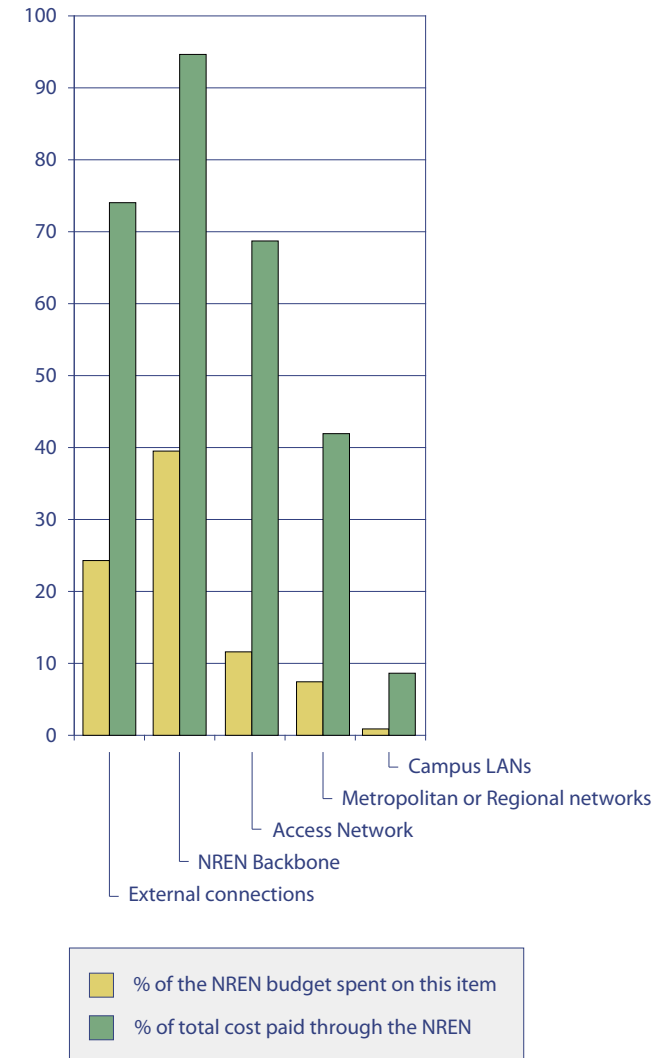


## 4.6 Expenditure by Network Level

There are important differences between NRENs in terms of what parts of the network are funded specifically through the NREN budget.

As can be seen from the graph below, on average NRENs spend 24% of their annual budget on external connectivity and pay for 73% of its total cost. However, the differences between NRENs are great. Most NRENs pay for their external connections and this may consume as much as 61% of the NREN's budget. Others, such as UNINETT (Norway) do not pay for this at all. Likewise, JANET(UK) spends 42% of its budget on metropolitan or regional networks. Metropolitan networks exist in France as well (although they have different functions from those in the UK), but they are not paid for through the RENATER budget. Most NRENs do not concern themselves with the campus Local Area Networks, but in Lithuania and Norway they do. These types of difference make it extremely difficult to compare NREN budgets.

**Graph 4.6.1 NREN spend per network level, EU/EFTA averages**



# APPENDICES

## 1 Alphabetical Lists of NRENs

Note that the country entries at

<http://www.terena.org/activities/compendium> contain additional information, including the full name of the NREN in English and in the national language(s).

Table 1.1.1 provides the name of the parent organisation where relevant.

NREN Acronym in English	NREN Acronym in the National Language(s) if Different	Country
ACOnet		Austria
AMRES		Serbia
ARNES		Slovenia
AzNET		Azerbaijan
BASNET		Belarus
BELNET		Belgium
BREN	BIOM	Bulgaria
CARNet		Croatia
CERIST		Algeria (operates the ARN network)
CESNET		Czech republic
CNRS		Lebanon
CYNET	KEAD	Cyprus
DFN		Germany
EENet		Estonia
EUN		Egypt
FCCN		Portugal
Funet		Finland
GARR		Italy
GRENA		Georgia
GRNET S.A.	EDET	Greece
HEAnet		Ireland
IUCC	MACHBA	Isreal

NREN Acronym in English	NREN Acronym in the National Language(s) if Different	Country
JANET(UK)		UK
LITNET		Lithuania
JUNET		Jordan
MARNet		Former Yugoslav Republic of Macedonia
MARWAN		Morocco
MREN		Montenegro
NIIF/HUNGARNET		Hungary
PADI2		Palestine
PIONIER		Poland
RBNet/RUNNet		Russian Federation
RedIRIS		Spain
RENAM	ARSEM	Moldova
RESTENA		Luxembourg
RHnet		Iceland
RNU		Tunesia
RoEduNet		Romania
SANET		Slovakia
SHERN		Syria
SigmaNet		Latvia
SUNET		Sweden
SURFnet		Netherlands
SWITCH		Switzerland
UARNet		Ukraine
ULAKBIM		Turkey
UNI-C		Denmark
UNINETT		Norway
UoM/RicerkaNet	UoM/RičerkaNet	Malta

## 2 Glossary of Terms

Terms not listed in this glossary are either explained in the text or are too specialised to be included here. A good on-line glossary can be found at <http://whatis.techtarget.com>.

<b>AAI</b>	Authentication and Authorisation Infrastructure. Such an infrastructure typically makes use of a scheme (or 'schema') and transmits information about certain relevant attributes of a person to other institutions (such as in the 'eduPerson' scheme). When several providers of attributes decide to trust each other, they form a 'federation'
<b>APAN</b>	Asia-Pacific Advanced Network- a non-profit international consortium established on 3 June 1997. APAN is designed to be a high-performance network for research and development on advanced next generation applications and services. APAN provides an advanced networking environment for the research and education community in the Asia-Pacific region, and promotes global collaboration.
<b>AUP</b>	Acceptable Use Policy
<b>Bit or b</b>	Binary digit - the smallest unit of data in a computer – in the compendium: kilobit (kb), Megabit (Mb), Gigabit (Gb)
<b>Byte or B</b>	8 bits – in the compendium: TB (Terabyte)
<b>CA</b>	Certification Authority
<b>CCIRN</b>	Coordinating Committee for Intercontinental Reserch Networking
<b>CEENet</b>	Central and Eastern European Networking Association
<b>CERN</b>	l'Organisation Européenne pour la Recherche Nucléaire - European Organisation for Nuclear Research
<b>CLARA</b>	<i>Latin American Advanced Networks Cooperation</i> in English, is an international organisation whose aim is to connect Latin America's academic computer networks. <a href="http://www.redclara.net">http://www.redclara.net</a>
<b>Confederation</b>	An agreement by different Federations to share certain resources
<b>Congestion index</b>	A measure of congestion at different levels of network access. Developed by Mike Norris of HEAnet
<b>country name tld</b>	Country-name top-level domain: designation of country names (or 'country domains') used in the Internet, such as .uk, .de or .fr
<b>CSIRT</b>	Computer Security Incident Response Team
<b>CWDM</b>	Coarse Wavelength Division Multiplexing
<b>DANTE</b>	The company, owned by European NRENs, that plans, builds and operates pan-European networks for research and education

<b>Dark Fibre</b>	Optic fibre cable that is not connected to transmission equipment by the vendor or owner of the cable and therefore has to be connected ('lit') by the NREN or the client institution
<b>DEISA</b>	Distributed European Infrastructure for Supercomputing Applications
<b>DWDM</b>	dense-wavelength division multiplexing
<b>eduroam<sup>®</sup></b>	A pan-European educational roaming infrastructure that provides wireless access to visited institutions. Eduroam allows users visiting another institution connected to eduroam to log on to the WLAN using the same credentials the user would use if he or she were at his or her home institution.
<b>EARNEST</b>	The Education And Research Networking Evolution Study - activity coordinated by TERENA in the framework of the GN2 project. <a href="http://www.terena.org/activities/earnest">Http://www.terena.org/activities/earnest</a>
<b>EFTA</b>	European Free Trade Association
<b>EU</b>	European Union
<b>EUMEDCONNECT</b>	A project to connect NRENs in the Mediterranean region to the GÉANT network. <a href="http://www.eumedconnect.net">http://www.eumedconnect.net</a>
<b>European Schoolnet (EUN)</b>	A not-for-profit organisation that represents 28 ministries of education in Europe and promotes the use of technology in the classroom. <a href="http://www.eun.org">http://www.eun.org</a>
<b>Feide</b>	National identity management system for the education sector in Norway. <a href="http://feide.no/content.ap?thisId=1307">http://feide.no/content.ap?thisId=1307</a>
<b>FTE</b>	Full-Time Equivalent
<b>GBE</b>	Gigabit Ethernet
<b>GÉANT</b>	A project mainly to develop the multi-gigabit pan-European data communications network 'GÉANT', used specifically for research and education.
<b>GÉANT2</b>	The second generation of the GÉANT network.
<b>GN2</b>	The project to develop the GÉANT2 network and to carry out a number of other, related tasks. <a href="http://www.geant2.net">http://www.geant2.net</a>
<b>Grid computing</b>	Applying the resources of many computers in a network to a single problem.
<b>Identity Management System</b>	A system that combines technologies and policies to allow institutions to store users' personal information and keep it up to date. An IdM is the first step to providing and controlling users' access to critical online resources and to protecting resources from unauthorised access.
<b>IP</b>	Internet Protocol: the method by which data, in the form of packets, is sent over the Internet. Currently, the dominant protocol is IPv4, but the next generation, IPv6, is being implemented.

<b>IPv4</b>	Internet Protocol version 4 is the fourth iteration of IP and was the first version to be widely deployed. IPv4 is the dominant Internet layer protocol: apart from IPv6 it is the only standard Internet layer protocol used on the Internet.
<b>IPv6</b>	The latest generation of the Internet Protocol. Institutions can have different types of IPv6 connections: 'native' - direct connection to the NREN via IPv6; 'tunneled' - sends IPv6 data packets encapsulated in IPv4 packets.
<b>IRU</b>	Indefeasible Right to Use: the granting of temporary ownership of a fibre optic cable.
<b>ISP</b>	Internet Service Provider
<b>LAN</b>	Local Area Network
<b>MAN</b>	Metropolitan Area Network
<b>NOC</b>	Network Operations Centre: a place from which a network is supervised, monitored, and maintained.
<b>NORDUnet</b>	An international collaboration between the Nordic NRENs. It interconnects these networks with the world-wide network for research and education and the general purpose Internet
<b>NREN</b>	National Research and Education Network (or the organisation that runs the network)
<b>PAPI</b>	Performance Application Programming Interface: a portable interface (in the form of a library) to hardware performance counters on modern microprocessors. It is widely used to collect low-level performance metrics (e.g. instruction counts, clock cycles, cache misses) of computer systems running UNIX/Linux operating systems.
<b>PERT</b>	Performance Enhancement and Response Team
<b>PKI</b>	Public Key Infrastructure: enables the use of encryption and digital signature services across a wide variety of applications
<b>PoP</b>	Point of Presence: the location of an access point to the Internet.
<b>REDI</b>	Research and Education networking Development Index
<b>ROADM</b>	Reconfigurable Optical Add/Drop Multiplexing: allows the switching of wavelengths using remote software.
<b>SAML</b>	Security Assertion Markup Language
<b>SCS</b>	Server Certificate Services
<b>SDH</b>	Synchronous Digital Hierarchy: the European standard for using optical media as the physical transport for high speed long-haul networks.
<b>SEEREN</b>	South-Eastern European Research & Education Network: a project to creating the next generation of the southeast European segment of GEANT.

<b>SERENATE</b>	Study into European Research and Education Networking As Targeted by eEurope: a strategic study to provide input to the European Commission on initiatives to keep European research networking at the forefront of world-wide development. The SERENATE project started in May 2002 and was completed in December 2003.
<b>Shibboleth</b>	Standards-based, open-source middleware software which provides Single Sign On (SSO) across or within organisational boundaries.
<b>TCP</b>	Transmission Control Protocol: one of the core protocols of the Internet Protocol suite.
<b>UbuntuNet Alliance</b>	A not-for-profit association of NRENs that aims to provide a research and education backbone network for Africa.
<b>University</b>	Institution providing an education equivalent to ISCED levels 5 and 6. 'higher/further education' is equivalent to ISCED level 4; 'secondary education' corresponds to ISCED levels 2 and 3 and 'primary education' to ISCED level 1. For more information on ISCED levels, consult <a href="http://www.uis.unesco.org">http://www.uis.unesco.org</a>
<b>VoIP</b>	Voice-over-Internet Protocol: a protocol for the transmission of voice via the Internet or other packet-switched networks. VoIP is often used to refer to the actual transmission of voice (rather than the protocol implementing it). This concept is also referred to as <i>IP telephony</i> , <i>Internet telephony</i> , <i>voice over broadband</i> , <i>broadband telephony</i> , or <i>broadband phone</i> .



« *networking the networkers* »

## What is TERENA?

TERENA, the Trans-European Research and Education Networking Association, fosters the development of computer network technology, infrastructure and services to be used by the research and education community. TERENA offers a forum for collaboration, innovation and knowledge sharing. The primary members of the association are National Research and Education Networking organisations (NRENs) from countries in and around Europe. They offer advanced, high-speed and high-performance connectivity and associated services to universities, research institutions and schools in their countries.

The membership of TERENA encompasses not only national research and education networking organisations but also regional research networking organisations, research organisations that are large users of networking infrastructure and services, and equipment vendors and telecommunication operators.

The development and deployment of computer network infrastructures and technology have been led by the academic community since the very beginning of the Internet, some forty years ago. Although much has changed in those decades, the academic community remains a pioneer at the forefront of networking developments. In recent years, Europe has become a world leader in important aspects of research and education networking. This leading role has been made possible by co-operation and collaboration between network engineers, managers and researchers in the research and education networking community all over the region. TERENA plays a crucial role by facilitating the co-ordination of policies and activities, the planning and execution of joint initiatives, and the collaboration between experts from its member organisations and the wider research networking community.

The TERENA Compendium of National Research and Education Networks in Europe documents that research networks are at the leading edge of technological and service developments, and that Europe is at the forefront in research networking. At the same time, it also documents areas where more work is needed, work that is undertaken in part through the various TERENA activities.

The TERENA Compendia form a series of annual publications that was started in the year 2000. They are used as a valuable source of information for researchers and policy makers in various countries.

