

# **TERENA COMPENDIUM**

of National Research  
and Education Networks  
in Europe

**2007 Edition**



[www.terena.org/activities/compendium/](http://www.terena.org/activities/compendium/)







« *networking the networkers* »

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# 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 third that has been published as part of the GN2 (GÉANT2) project and it has benefited from the input from activity leaders in that project. 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.

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

The production of the 2007 edition was overseen by a Review Panel composed of the following people: Claudio Allocchio (Italy), Tryfon Chiotis (Greece), Mike Norris (Ireland), Lars Skogan (Norway) and Shirley Wood (UK). Guy van den Bergh participated as member of the TERENA Technical Staff. Input was also received from a number of Activity Leaders in the GN2 project, from other members of the TERENA Technical Staff, the Secretary General and the Executive Committee. Bertine Lokhorst, 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 double-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 2. 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. In addition, APAN, the regional organisation of NRENs from the Asia/Pacific region, has conducted a survey that is very similar to the TERENA Compendium survey in the Asia/Pacific region in the first few months of 2007. Where relevant, reference has been made to the results of this survey. (For more information, see <http://www.apan.net/documents/Survey2007Revised070522c-2.pdf>.)

Note that unless otherwise specified, the data describe the situation at or close to the 31<sup>st</sup> of January, 2007.

It is hoped that this seventh 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!

Bert van Pinxteren  
TERENA Chief Administrative Officer

<sup>1</sup> On the first of 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 SERENATE studies. The SERENATE project was an Accompanying Measure in the Information Society Technologies programme of the Fifth Framework Programme and was supported as such by the European Union. The summary report, 'Networks for Knowledge and Innovation', ISBN 90-77559-01-9 is available from the TERENA Secretariat and on the Web, at <http://www.serenate.org/publications/d21-serenate.pdf>.

The SERENATE studies have been succeeded by EARNEST. The EARNEST studies run from March 2006 to October 2007 (see <http://www.terena.org/activities/earnest/>). 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 31st of January, 2007.

## Legal Form

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 three 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.

Over the past years, NRENs in the EU states have shown a steady increase in the number of universities connected at **Gigabit speeds**. The picture is mixed in

other categories. Typically, secondary and primary schools are not yet connected at these capacities. For the EU/EFTA countries that have answered the relevant survey questions, on average more than 80% of the access capacity is used for the tertiary education sector.

The SERENATE study<sup>3</sup> recommended the promotion of Gigabit networking services. Gigabit connections can be seen as a necessary, though by no means sufficient, condition for a university to engage in high-end research and learning programmes.

The Compendium data suggest that the SERENATE recommendations on Gigabit networking are being followed in many countries. It seems that fibre optic technology is allowing NRENs to leap-frog immediately to much higher capacities.

There is clear evidence that the connection of **secondary and primary schools** to the Internet via NRENs and also the provision of support and application services to schools feature high on the agenda in many countries. The commitment by EU heads of government in Lisbon in 2000 to making Europe 'the most dynamic and competitive knowledge-based economy in the world' by 2010 is a common factor underlying these activities.

In a number of countries, the percentage of coverage of connected schools is either 100% or close to it. In many countries, connections to schools are funded centrally through ministries of education. The percentage of connections is expected to rise sharply in some countries because implementation of schemes to connect most or all schools has just started.

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<sup>3</sup> SERENATE summary report, p.6

## Network

The overall trend is that there is considerable **growth** year on year. In 2007, all but two of the EU/EFTA NRENs have a capacity of at least 1 Gb/s; the most common capacity is 10 Gb/s or a multiple of this and fourteen NRENs operate at this capacity.

This seems to be more or less in line with the rest of the developed world. The conclusion of the APAN survey is that in Asia, “the major band classes on the network are between 5 Gb/s and 10 Gb/s, and many narrower band classes exist. It is expected that, in two years, the 10 Gb/s class will become the norm and the backbones be further improved in Asia.” However, Internet2 in the USA now has 100 Gb/s available and CANARIE of Canada operates at 50 Gb/s, capacities not yet attained in Europe.

From the data from the sixteen other NRENs, in 2007, nine of these operate at 1 Gb/s. What is interesting to note here is that these NRENs have typically made a larger jump than the EU/EFTA NRENs, thus skipping one or more of the network development stages that the EU/EFTA NRENs went through. The trend is clear that in the more advanced countries, the core capacity will evolve to multiples of 10 Gb/s. Many other countries have upgraded to Gigabit capacities, but do not foresee or cannot predict a further upgrade in the next two years.

The Compendium shows that for most NRENs that are part of the GN2 project, the **external link** to GÉANT is by far 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. The situation is obviously different in the countries that are not part of GN2 project.

The migration to **dark fibre** continues apace, as does the deployment of services which exploit switched networks and wave division multiplexing. In the EU/EFTA area, thirteen NRENs list plans to start or to continue the deployment of dark fibre networks and layered services among their major changes.

The data show a steady increase in the number of NRENs that currently have at least two-thirds of their backbone as **dark fibre**. The proportion of EU/EFTA NRENs with at least two-thirds of their backbone as dark fibre will increase by 20% over the coming two years. This increase is greater than the increase predicted for the other countries.

In the EU/EFTA countries, in the five-year period from 2003 to 2007, the average core network size has quadrupled, whilst the average core backbone capacity has more than doubled.

A continuing development is the implementation of **cross-border dark fibre links** between NRENs. The Compendium provides an overview of these links.

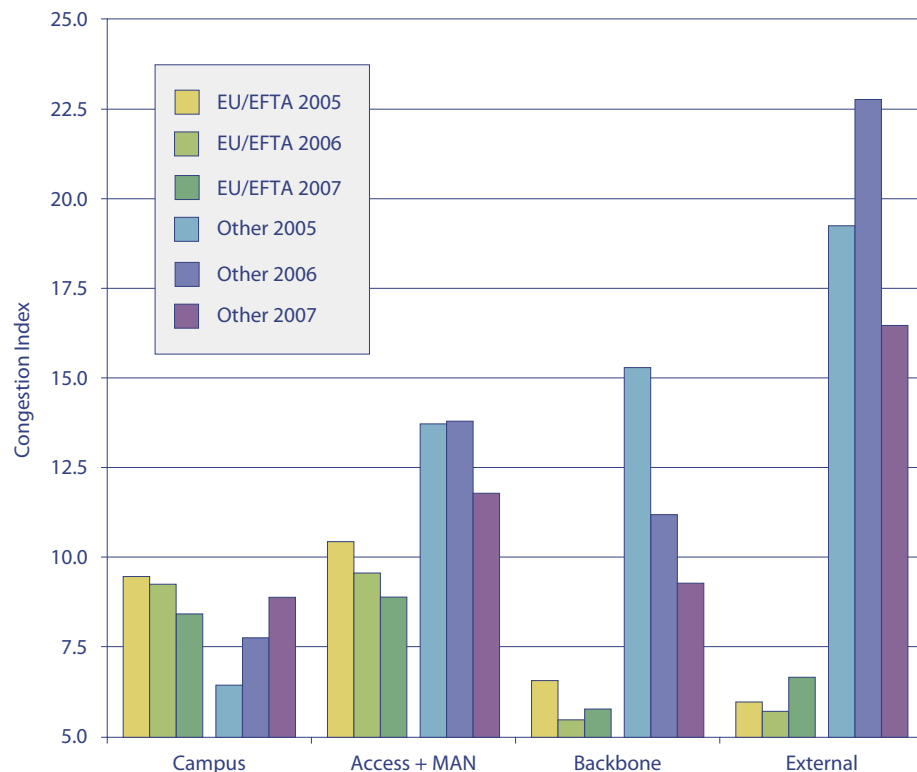
## Traffic

In earlier years, the growth rates for the countries that joined the EU after 1 January 2004 was consistently higher than that of the ‘old’ EU/EFTA countries. However, since 2004/2005, they have converged. It is difficult, if not impossible, to predict what the future will bring – new applications relative to Grids, for example, may change the picture. However, in that case, growth will be driven by demand, rather than by changes in network capacities. In addition, changes in technology (such as the introduction of lightpaths for certain categories of users) may change the picture.

A single metric was derived for the level of congestion in each network element from the subjective levels reported by NRENs.

For the EU/EFTA countries, the average estimated congestion at the campus level has gone down somewhat, but it has gone up a little at the Backbone and External Connections levels. 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, congestion seems to have increased at the Campus and Access Network levels, but it has gone down at the other levels, even though the picture in External Connections is mixed. This is in line with expectations formulated last year.



On average, EU/EFTA NRENs now provide almost 30% of the Universities in their countries with native IPv6 connectivity. Last year, the data seemed to suggest that the growth of IPv6 traffic on the GÉANT backbone had peaked. However, since then there has been some further growth. It now seems that the growth of IPv6 traffic is roughly proportional to the growth of IPv4 traffic. In 2006, the proportion of IPv6 traffic to IPv4 traffic was the highest in the 3<sup>rd</sup> quarter of 2006, with IPv6 traffic amounting to just under 2% of IPv4 traffic.

## Services

Services are receiving more attention from NRENs. There are a few trends that can be noted from the data:

- 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 the additional operational tasks within their conventional (IP) NOC. Others have separated these functions and may have outsourced some of these new tasks.
- There is an increased need for an authorisation and authentication infrastructure (AAI) in the NREN environment and many NRENs are taking steps to develop such an infrastructure. However, the work is by no means finished. Currently deployed AAI's have very different capabilities, ranging from simple username/password-based authentication systems to sophisticated middleware for granting or denying access to resources.
- There is renewed and increasing interest in the Public Key Infrastructure (PKI) area.
- Almost all from the EU/EFTA countries have now introduced eduroam, a facility that provides roaming access for users to wireless networks.
- A related area is that of security incident response. The figures indicate that in this area, there is still a large gap between the EU/EFTA countries and the other countries in the region.
- Approximately 25% of the NRENs are currently offering a Bandwidth on Demand service; approximately the same percentage is planning to introduce it in the next two years, with a significant percentage of NRENs still in doubt.
- Grid services are currently running at most NRENs – several others are planning to introduce such a service. There has been a clear increase over the past year.

A striking element in the responses is that the take up of Grid technology has widened beyond the initial high-energy physics and biomedical communities. All disciplines seem to be well represented.

- 56% of the EU/EFTA countries reported IP Telephony deployments (a slight increase from last year), but it should be noted that 85% of these deployments were isolated islands of VoIP.

## **Funding**

It is almost impossible to compare NRENs by staff or budget size. This is because NREN budgets are structured differently, NRENs have different tasks in different countries and the same things are not funded through the NREN budget in the same way in different countries.

When comparing current budget data with data from previous 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. 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.

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 innovation 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 four countries, there are no NRENs or we do not have knowledge of NREN work in those countries. 47 NRENs responded to the survey, from as many countries. Not all NRENs were able to answer all of the questions, but many were; two NRENs only answered the mini-version of the questionnaire. 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.

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/index.htm>. Worldwide coordination is performed through the CCIRN, <http://www.ccirn.org>.

**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.forskningsnett.dk/eng">http://www.forskningsnett.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.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/en">http://www.grnet.gr/en</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>LATNET</b>	<a href="http://www.latnet.lv">http://www.latnet.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>CSC</b>	<a href="http://www.um.edu.mt/csc.html">http://www.um.edu.mt/csc.html</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>
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>

**Table 1.0.1 NRENs and urls - continued**

Country	NREN	URL
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> <sup>4</sup>	<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>
Croatia	<b>CARNet</b>	<a href="http://www.carnet.hr">http://www.carnet.hr</a>
Georgia	GRENA	<a href="http://www.grena.ge">http://www.grena.ge</a>
Israel	<b>IUCC</b>	<a href="http://www.iucc.ac.il">http://www.iucc.ac.il</a>
Jordan	JUNet	<a href="http://www.junet.edu.jo">http://www.junet.edu.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.cg.ac.yu">http://www.mren.cg.ac.yu</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	AMRES	<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>

**Legend**

	Answers obtained
	NREN not fully functional or 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		
Belarus	BASNET	<a href="http://www.basnet.by">http://www.basnet.by</a>
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>
Colombia	RENATA	<a href="http://www.renata.edu.co">http://www.renata.edu.co</a>
Ecuador	CEDIA	<a href="http://www.cedia.ec">http://www.cedia.ec</a>
Guatemala	RAGIE	<a href="http://www.ragie.org.gt">http://www.ragie.org.gt</a>
Mozambique	MoRENet	<a href="http://morenet.mct.gov.mz">http://morenet.mct.gov.mz</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>
United States	Internet2	<a href="http://www.internet2.edu">http://www.internet2.edu</a>
Uzbekistan	UzSciNet	<a href="http://www.uzsci.net">http://www.uzsci.net</a>
Venezuela	REACCIUN	<a href="http://www.reacciun2.edu.ve">http://www.reacciun2.edu.ve</a>

<sup>4</sup> UKERNA changed its name to JANET(UK) in the course of this year.

## 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). A few NRENs have a special status in the sense that they do not operate as separate legal bodies but are not part of a larger organisation either, for example, because they operate on a project basis. Typically, the final institutional identity of these NRENs has not yet been decided.

### Relationship with Government

Those NRENs that are a government agency or part of a government ministry are typically controlled directly by the government, even though in some cases (e.g., Turkey) such agencies can enjoy a reasonable degree of autonomy, comparable to that of some of the NRENs that are separate legal entities (marked 'direct' in table 1.1.1).

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. 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.

**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., owned by the Ministry of Education
France	RENATER	yes	indirect	
Germany	DFN	yes	indirect	
Greece	GRNET	yes	other	
Hungary	NIIF/HUNGARNET	yes	other	
Iceland	RHnet	yes	indirect	
Ireland	HEAnet	yes	indirect	
Italy	GARR	yes	indirect	
Latvia	LATNET	no	indirect	The LATNET network is working as a financially independent subunit (department) of the Institute of Mathematics and Computer Science that is an independent unit of Latvia University.
Lithuania	LITNET	no	indirect	Ministry of Science and Education of Lithuania
Luxembourg	RESTENA	yes	indirect	
Malta	CSC	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

Country	NREN	Separate Legal Entity?	Relationship with Government	Remarks/Parent Organization
<b>EU/EFTA Countries</b>				
Sweden	SUNET	no	appoints	Swedish Research Council
Switzerland	SWITCH	yes	indirect	
United Kingdom	JANET(UK)	yes	indirect	
<b>Other Countries</b>				
Algeria	CERIST	no	appoints	Ministry of higher education and scientific research
Azerbaijan	AzNET	other	indirect	United Nations Development Programme (UNDP) Country Office in Azerbaijan
Croatia	CARNet	yes	appoints	
Georgia	GRENA	yes	indirect	
Israel	IUCC	yes	indirect	
Lebanon	CNRS	Yes	direct	
Macedonia	MARNet	no	indirect	University Ss. Cyril & Methodius University in Skopje
Moldova	RENAM	yes	indirect	
Montenegro	MREN	no	indirect	University of Montenegro
Morocco	MARWAN	other	appoints	National Scientific and Technical Research Centre (CNRST)
Russia	RBNet/RUNNet	yes	indirect	
Serbia	AMRES	no	indirect	University of Belgrade
Syria	SHERN	yes	appoints	Ministry of Higher Education
Turkey	ULAKBIM	no	other	The Scientific and Technological Research Council of Turkey (TUBITAK)
Ukraine	URAN	yes	other	

## 1.2 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.

Although the answers are by no means complete, the table clearly shows that many NRENs are upgrading to dark fibre infrastructures. The capacity of these infrastructures can be increased fairly easily according to need. Several NRENs are introducing, or have already introduced a dual structure for their network. On the one hand, they are continuing to provide the 'traditional' connections, based on the Internet Protocol. On the other hand, they are also planning to provide dedicated light paths to high-end users, allowing them to use whatever protocols or methods they want to use for transmitting data.

**Table 1.2.1 Major Changes in NRENs**

Country	NREN	Changes
<b>EU/EFTA Countries</b>		
Austria	ACOnet	- In 2006, a CFP for a wavelength transparent fibre optic backbone has been published. Currently (April 2007) the evaluation process is being completed.
Belgium	BELNET	- 2007: new backbone network will be built and BELNET will acquire (IRU) and manage it's own dark fibre - operational: Q4 2007-Q1 2008 - 2007: customer relations unit will be enlarged with 4,5 FTE extra - objective: towards user oriented service offer/ better integration of user needs - operational: Q4 2007-Q1 2008 - 2006-2007: a fibre connection for all Belgian Schools of higher education (ISCED Level 5 & 6 - # ca. 50 institutions) to NREN backbone
Bulgaria	BREN	BREN is currently taking over the responsibilities from ISTF, including in projects like GÉANT2 and SEEREN2.
Cyprus	CYNET	A second connection to GÉANT2 has been put in place, bringing the total capacity of the links from CYNET to GÉANT2 to 300Mbps. The connection to the Cyprus Internet Exchange has been increased by a factor of 5. In the national network, a new PoP has been established in the second largest city on the island.
Czech Republic	CESNET	The major changes during the past year are : - DWDM based on Cisco ONS15454 MSTP extension (new spans deployment) - static DWDM (based on Cesnet CLA technology) deployment on new lines - new PoPs migration to 10 Gbps (based on DWDM deployment) - CBF line Ostrava-Cieszyn migration (based on Cisco ONS15454 MSTP) - CBF line Brno-Vienna migration (based on Cesnet CLA static DWDM technology) - E2E service deployment  The main planned changes for the coming year are: - DWDM and static DWDM deployment to the new optical lines - 3-way ROADM deployment - native ethernet transport via the DWDM
Denmark	UNI-C	- The core backbone was changed from being routed (in NREN responsibility) to being switched. However universities were being addressed by using bgp instead of OSPF. Next upgrade 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 poses requests for using the NREN network to interlink universities at LAN-level.
Estonia	EENet	External connection via GÉANT2 Tallinn PoP from May 2006. Backbone between Tallinn and Viljandi upgraded from 8 Mbps to 20 Mbps in May 2006, the same time 5 organisations connected via fibre optic connections in Viljandi. External connection to GÉANT2 upgraded from 622 Mbps to 1 Gbps in June 2006. Jõgeva fibre network launched at the end of 2006. From the beginning of 2007 connection to other networks via GÉANT2 upgraded from 310 Mbps to 500 Mbps. Porta Optica Study (lasted 15 months) has finished in April 2007.
Finland	Funet	No major changes in past year. Planning/preparing the roll-out of IRU fibre-based DWDM network.

Country	NREN	Changes
<b>EU/EFTA Countries</b>		
Germany	DFN	The current generation of network (X-WiN) has been extended and upgraded with new router equipment.
Greece	GRNET	GRNET has already acquired 15 year IRUs for Dark Fibre (DF) links. As of today GRNET owns 5964 Km of dark fibre pairs and plans to extend it in 2007. In addition, Alcatel DWDM equipment will be installed in our network backbone for transmission purposes while Alcatel NG-SDH equipment will be installed in Athens, Thessaloniki, Patra and Herakleion, in order to provide switched services. GRNET aims to deploy a "hybrid" network that will continue to provide Layer 1/Layer 2 services to its clients in addition to production-quality IP services to all users.
Hungary	NIIF/HUNGARNET	<ul style="list-style-type: none"> <li>- In May 2006 the legal status of NIIFI has changed. Earlier it was the National Information Infrastructure Development Office, now it is the National Information Infrastructure Development Institute.</li> <li>- NIIFI has been operating under the umbrella of the Ministry of Communication and Informatics for several years. From June 2006 the structure of the Hungarian Government has changed. Since then, NIIFI is operating under the umbrella of the Ministry of Economy and Transport.</li> <li>- The research network in Hungary has been continuously developing during the last several years (backbone and access network extensions and upgrades). International connectivity has been upgraded to GÉANT+. No considerable changes in organisational structure, mandate, technology and user base occurred/foreseen in 2007.</li> </ul>
Iceland	RHnet	<ul style="list-style-type: none"> <li>- Two universities outside the Reykjavik area had their connectivity upgraded to 1 Gb/s through leased dark fibre. Security was increased in the northern part of the country with the establishment of a fibre ring in the Akureyri area. (1 Gb/s connectivity is the lowest offered when fibre are available.)</li> <li>- All connections between sites on RHnet are now by dark fibre, with only two exceptions. The exceptions being the link between Reykjavik and Akureyri, as well as the international connectivity (submarine cable).</li> <li>- A major upgrade in international capacity is required. It is still (beginning of May 2007) uncertain whether this will be accomplished this year. Aid from the government is required. This aid was promised in 2006, but the members of RHnet are still waiting for the government to fulfil their promise.</li> </ul>
Ireland	HEAnet	The deployment of the schools broadband network has been completed. Rollout of dark fibre to most member institutions continues, with over 80% of end-users now in institutions connected by dark fibre. Full integration of 13 Institutes of Technology into the national network.
Lithuania	LITNET	In 2006 powerful backbone routing system based on five Juniper M320 routers was introduced.
Netherlands	SURFnet	In January 2006 our new network, SURFnet6, was launched. Besides first grade IP connectivity this network offers light path services. Later this year SURFnet plans to experiment with setting up dynamic lightpaths - e.g., light path connections that can be set up on short notice for a relatively short period of time.
Norway	UNINETT	Based on a previous IRU arrangement on fibre/transmission with the Norwegian carrier BaneTele, UNINETT will begin to deploy optical equipment to offer lambda services from autumn 2007. Add/drop will be possible in the 4 main university cities; Oslo, Trondheim, Bergen and Tromsø, but also in numerous cities along the fibre path. Redundant fibre paths will be used. Both 1G, 2.5G and 10G lambdas will be offered and within 2009 also 40G lambdas.
Poland	PIONIER	We have been increasing the core network capacity to 2x10Gb/s using two lambdas.
Romania	RoEduNet	<p>Done:</p> <ul style="list-style-type: none"> <li>- almost all backbone equipment (routers) upgraded</li> <li>- backbone links upgraded to 1 Gbps</li> <li>- connections to POPs upgrade</li> </ul> <p>Future:</p> <ul style="list-style-type: none"> <li>- there is a WDM project, probably 4Q 2007 main nodes will be connected via a new structure, with 10 Gbps links</li> <li>- GÉANT connection(s) upgrade to 10 Gbps</li> <li>- RENAM connection upgrade to 155 Mbps (tender already started by RENAM)</li> </ul>
Spain	RedIRIS	<ul style="list-style-type: none"> <li>- In January 2007, the new backbone of RedIRIS was deployed. It has a core of 10 Gbps (which can be upgraded to several 10 Gbps links, already available at some locations).</li> <li>- 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 2008 and 2009.</li> </ul>

Table 1.2.1 - continued

Country	NREN	Changes
<b>EU/EFTA Countries</b>		
Sweden	SUNET	<ul style="list-style-type: none"> <li>- In 2006, SUNET has prepared the transition to a new network, called OptoSunet, with a new topology and the possibility to deliver clear 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.</li> <li>- For the first time, SUNET uses dark fibre in most connections and the optical transmission makes it possible to provide point-to-point connections of different kinds at the requirement of the members.</li> </ul>
Switzerland	SWITCH	<ul style="list-style-type: none"> <li>- In year 2006 SWITCH continued to migrate away from leased circuits and connected more organisations by dark fibre.</li> <li>- The bandwidth of all major backbone links has been upgraded to 10 GE.</li> <li>- New offering: Ethernet point-to-point circuits between dark fibre PoPs. Only a few users.</li> </ul>
United Kingdom	JANET(UK)	<ul style="list-style-type: none"> <li>- The implementation of SuperJANET5 was completed during 2006/2007.</li> <li>- Additional services added to the portfolio included the JANET Roaming Service, JANET Web Hosting, JANET Voice Advisory Service, JANET Voice Collaboration Services, UK Access Management Federation service and the Server Certificate Service. Other services such as the SMS service are due to be released in the summer.</li> <li>- The Network Operation Centre staff were integrated into the company as of the 1 January 2007.</li> </ul>
<b>Other European and Mediterranean Countries</b>		
Albania		A Technical Board in charge of creating the Academic Network of Albania (ANA) was formed in 2006. In the meantime INIMA, the Institute for Informatics and Applied Mathematics of the Academy of Science of Albania, had been involved in a number of networking and e-infrastructure projects (SEEREN, SEEFIRE, SEE-Grid). INIMA was dissolved in the spring of 2007. <sup>5</sup>
Algeria	CERIST	During 2006, upgrade of capacities of ARN PoPs and part of universities and research centres. This upgrade programme of capacity is still continuing during this year. In terms of service, many events have used visioconference and streaming facilities on the network.
Armenia		There is an initiative to harmonise NREN work under the framework of a new organisation, CAMREN. <sup>6</sup>
Belarus	BASNET and UNIBEL	BASNET and UNIBEL are the two organisations that provide computer networking facilities aimed at the research and educational sector in Belarus. There are plans for the two organisations to merge. <sup>6</sup>
Bosnia/Herzegovina		BIHARNET is a separate legal entity officially in charge of operating the research and education network of Bosnia and Herzegovina. BIHARNET has been involved in a number of networking and e-infrastructure projects (SEEREN, SEEFIRE, SEE-Grid) in the past years. However, for a few years the organisation has had no budget nor staff to run the network. There is no single research and education network connecting universities in Bosnia and Herzegovina. As part of its work under the GÉANT2 project TERENA started in 2007 to coordinate efforts to revive research and education networking in the country. <sup>5</sup>
Croatia	CARNet	CARNet is implementing a major project of connecting all primary and secondary schools to the network. Out of 1343 schools so far 910 have been connected.
Georgia	GRENA	We introduced CERT service in our network. 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 a virtual private network (VPN) and GRENA is acting as the Network Operation Centre for this network.
Macedonia	MARNet	MARNet has built its own fibre optic infrastructure in the Skopje metropolitan area connecting 6 major campuses, also with wireless networks. International connectivity is upgraded from 4 to 34 mbps and from January 2007, 68 mbps is in place. Significant role is given to MARNet in the national eMacedonia strategy and strategy for modernisation of the educational system adopted by national parliament. Fibre optic connectivity is foreseen for connectivity to two other public major university towns, Bitola and Tetovo.

<sup>5</sup> Information from Valentino Cavalli, TERENA<sup>6</sup> Information obtained from CEENet



Country	NREN	Changes
<b>Other European and Mediterranean Countries</b>		
Moldova	RENAM	<ul style="list-style-type: none"> <li>- The deployment of wireless backbone networks in Chisinau and Belti cities was finalised according to programme that was approved in 2005 by RENAM Council. Now wireless network unites 17 nodal points in Chisinau and 4 nodes in Belti.</li> <li>- Two new optical connections were realised in the Chisinau MAN that allowed wider ownership of optical infrastructure up to 30 km.</li> <li>- In five nodes of total the 12 in Chisinau City the routing equipment was upgraded by replacing old Cisco routers by new Cisco 3775 and Cisco 2651 devices.</li> <li>- The radio-relay channel Chisinau (RENAM, Moldova) - Iasi (RoEduNet, Romania) was upgraded in 2006 up to 32 Mbps and the summarised external channels capacity (excluding local IX peering) at the beginning of 2007 achieved 42 Mbps.</li> <li>- In 2007 the development of DF backbone in Chisinau will be continued. Two new RENAM campuses and National IX Point Plan to be connected by new fibre optics links of 1 Gbps capacity.</li> <li>- The existing radio-relay channel Chisinau - Iasi is planned to be transferred to a new technical basis and its capacity can be upgraded in 2007 up to 155 Mbps. At the same time the designing of the technical solution of DF link Chisinau - Iasi construction will be continued and the terms of the practical realisation of this optical connection will be determined at the end of 2007.</li> <li>- In the second half of 2007 RENAM CSIRT operation will be started and appropriate services for the NREN community will be deployed in production mode.</li> <li>- There is a programme of starting in RENAM Cisco Academy courses in the autumn 2007, that would significantly increase the training of well-skilled specialists for universities and research centers LANs.</li> </ul>
Morocco	MARWAN	Upgrade of the link to EumedConnect from 34Mbps to 155Mbps
Russian Federation	RBNNet/RUNNet	<ul style="list-style-type: none"> <li>- 2006: New SDH-based infrastructure of network backbone in Russia</li> <li>- 2006: 2.5Gb/s GÉANT connectivity</li> <li>- 2007: 10Gb Moscow - Amsterdam channel (GLORIAD project)</li> <li>- 2007(October): 10Gb/s Moscow - Saint-Petersburg Stockholm channel</li> <li>- 2008-2009: Dark cross border fibre</li> </ul>
Serbia	AMRES	The new organisational model for NREN is defined through the AMRES project.
<b>Countries from other regions</b>		
Australia	AARNet	<ul style="list-style-type: none"> <li>- In 2006, AARNet completed the regional optical network which now stretches from Brisbane to Adelaide with potential capacity extending well beyond 300 gigabits per second and passing more than 80 key regional towns and centres and more than 100 other smaller towns. AARNet is now a fully fledged network operator in its own right.</li> <li>- Also in 2006, fibre links to Australia's major radio telescopes (at Parkes, Narrabri and Coonabarabran (Mopra)) were completed, enabling their use for eVLBI. Our capacity to the Northern Territory was upgraded to dual 155Mbps circuits from Adelaide to Darwin along diverse paths through Western Australia and via our new PoP site at Alice Springs. The PoP sites in Singapore and Frankfurt, and the tributary links that connect our peerings at AMS-IX and LINX to our Frankfurt PoP, were taken into production.</li> </ul>
Colombia	RENATA	We created the organisation RENATA as an independent legal institution. Our NREN is made out of regional (local) networks: RUANA, RUMBA, RUMBA, RUAV, RUP and UNIREN. This year a new NREN became part of RENATA. It is RADAR with 12 Universities connected.
Ecuador	CEDIA	We are working to upgrade the capacity of our network to 45 Mbps, and to upgrade the last mile connections to 2 Mbps. We hope to have 2 new members for 2007 and we are looking for cooperation of Ecuadorian government for the international connection to RedCLARA.

**Table 1.2.1** - Continued

Country	NREN	Changes
<b>Countries from other regions</b>		
Guatemala	RAGIE	<ul style="list-style-type: none"> <li>- We are working on recruiting at least 6 new members for this year, thus doubling our membership. Among these institutions are Universities, the National Council Of Science and Technology (which will be our liaison with the government) and a "health" hub consisting of three hospitals and a regional research institute in Nutrition.</li> <li>- We also expect to install a POP in the country's second largest city to serve several of the external campuses of Universities.</li> </ul>
Mozambique	MoRENet	The MoRENet is currently going through the technical specification and service provider evaluation phase. The implementation of the network is foreseen to start during the last quarter of 2007 and to cover six national universities first.
Taiwan	NCHC	In order to maximise the availability of our network, TWAREN (Taiwan Advanced Research and Education Network), the backbone architecture has been modified in late 2006 from its originally star-shape topology into a ring-enhanced structure.
United States	Internet2	<ul style="list-style-type: none"> <li>- Internet2 is currently in the process of rolling out the final pieces of a completely new national network infrastructure. Information on the Internet2 network is available at <a href="http://www.internet2.edu/network">http://www.internet2.edu/network</a>. This network is based on a dedicated fibre pair. At the outset we will deploy ten 10Gbps wavelengths across the entire footprint. The network rollout is expected to be completed by September 2007.</li> <li>- Organisationally, Internet2 and the US-based National Lambda Rail (NLR) organisation are engaged in merger discussions. Information is available at <a href="http://www.internet2-nlr.org">http://www.internet2-nlr.org</a></li> </ul>

## 2 USERS/CLIENTS

This section starts with information about the connection policies of NRENs (i.e., who is allowed to connect) in section 2.2. 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 three 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.

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

#### Connection Methods

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

Most NRENs provide connection for institutions directly either to one of their Points of Presence (PoPs) or, in some cases, to a Metropolitan Area Network or regional network run by the NREN. There are some exceptions, with separate Metropolitan Area Network/Access Network (MAN/AN) layers run by third parties. This is the case, for example, with RENATER (France) and PIONIER (Poland).

The following table provides aggregated data on connection methods, where the aggregation has been done from the perspective of NRENs, not from that of the institutions. Thus, the figures show the connection method for the different types of institutions for the 'average' NREN. These are averages across NRENs, not weighted by their size or the number of institutions they connect.

**Table 2.1.1 Connection Methods** (aggregated by NREN)

Type of Institution	NREN PoP or MAN	3 <sup>rd</sup> party MAN or regional network	Via another institution	Some other way
Universities, Institutes of further education, Research Institutes	80%	9%	9%	2%
Secondary and Primary schools	49%	22%	12%	17%

These figures are not significantly different from those provided last year.

For reasons of space, the full tables are not available in printed form.

## Bandwidth of Universities

A good way of looking at the trend in access speeds is to consider the change in Gigabit or higher links to universities over the past two years. This gives the results as listed in table 2.1.2.

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

Note that the figures in Table 2.1.2 do not take into account the data from France. Note also that the group of NRENs that gave answers to this question is not exactly the same for both years.

As can be seen from the table, the percentage of Gigabit connections for Universities is increasing. In other areas, the picture is mixed. Most secondary and primary schools are not connected at these capacities.

The SERENATE study<sup>1</sup> recommended the promotion of Gigabit networking services. Gigabit connections can be seen as a necessary, though not necessarily sufficient, condition for a university to engage in high-end research and learning programmes.

The Compendium data suggest that the SERENATE recommendations on Gigabit networking are being followed in many countries. It seems that fibre optic technology is allowing NRENs to leap-frog immediately to much higher capacities. Gigabit Ethernet is being introduced by NRENs such as AMREJ, MARNET and RENAM and thus seems to make it possible, for the first time, to quickly address an important aspect of what was termed the 'digital divide' in Europe in the SERENATE study.

**Table 2.1.2 Bandwidths  $\geq 1$  Gb/s**

Sites of:	Group of NRENs	Percentage of Connections at $\geq 1$ Gb/s	
		In 2006	In 2007
Universities (ISCED 5+6)	EU/EFTA	32.8%	37.2%
	Other Countries	14.6%	16.2%
Institutes of further education (ISCED 4)	EU/EFTA	8.1%	8.0%
	Other Countries	0.8%	5.0%
Research institutes	EU/EFTA	16.5%	13.9%
	Other Countries	2.7%	4.4%
Secondary schools (ISCED 2+3)	EU/EFTA	0.3%	0.4%
	Other Countries	0.0%	0.0%
Primary schools (ISCED 1)	EU/EFTA	0.1%	0.0%
	Other Countries	0.0%	0.0%
Libraries, Museums, National Archives, Cultural institutions	EU/EFTA	2.8%	5.4%
	Other Countries	4.2%	1.5%
Hospitals (other than University hospitals)	EU/EFTA	2.5%	9.1%
	Other Countries	0.0%	0.0%
Government departments (national, regional, local)	EU/EFTA	3.6%	4.2%
	Other Countries	5.6%	2.0%

<sup>1</sup> SERENATE summary report, p.6

## Connections to Primary and Secondary Schools

There is clear evidence from many sources that the connection of secondary and primary schools to the Internet via NRENs and also the provision of support and application services to schools features highly on the agenda in many countries in recent years. The commitment by EU heads of government in Lisbon in 2000 to making Europe “the most dynamic and competitive knowledge-based economy in the world” by 2010 is a common factor underlying these activities. Secure access by schools to the Internet is seen as key to the development of the Information Society.

On the level of connection policies, not much has changed since 2003. However, the total number of connections did increase significantly.

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 that is connected to the NREN. Institutions connected by other service providers are not taken into account.

### Legend

100	100% connected
75	≥ 75% connected
50	≥ 50%, < 75% connected
25	≥ 25%, < 50% connected
10	> 0, < 25% connected
+	Allowed, but percentage not reported
-	Not allowed

**Table 2.2.1 Connection Policies** - 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	+	+	10	+	10	-
Belgium	BELNET	75	10	75	25	25	10	10	50	+
Bulgaria	BREN	75	10	75	100	10	+	-	-	-
Cyprus	CYNET	10	+	100	-	-	-	-	-	+
Czech Republic	CESNET	50	10	10	10	10	10	10	10	+
Denmark	UNI-C	100	75	50	-	-	10	10	no	+
Estonia	EENet	50	25	25	50	50	10	+	10	-
Finland	Funet	75	-	50	-	-	10	-	10	+
France	RENATER	100	+	+	+	-	+	+	+	-
Germany	DFN	75	75	75	+	+	+	+	+	-
Greece	GRNET	100	100	100	100	75	+	-	+	+
Hungary	NIIF/HUNGARNET	100	75	100	10	10	75	-	10	+
Iceland	RHnet	100	75	50	+	-	10	-	no	-
Ireland	HEAnet	100	100	50	75	75	10	-	10	+
Italy	GARR	100	100	75	10	10	10	10	10	+
Latvia	LATNET	25	10	10	10	10	10	10	10	+
Lithuania	LITNET	100	75	75	75	10	10	10	10	+
Luxembourg	RESTENA	100	100	100	100	75	50	75	10	-

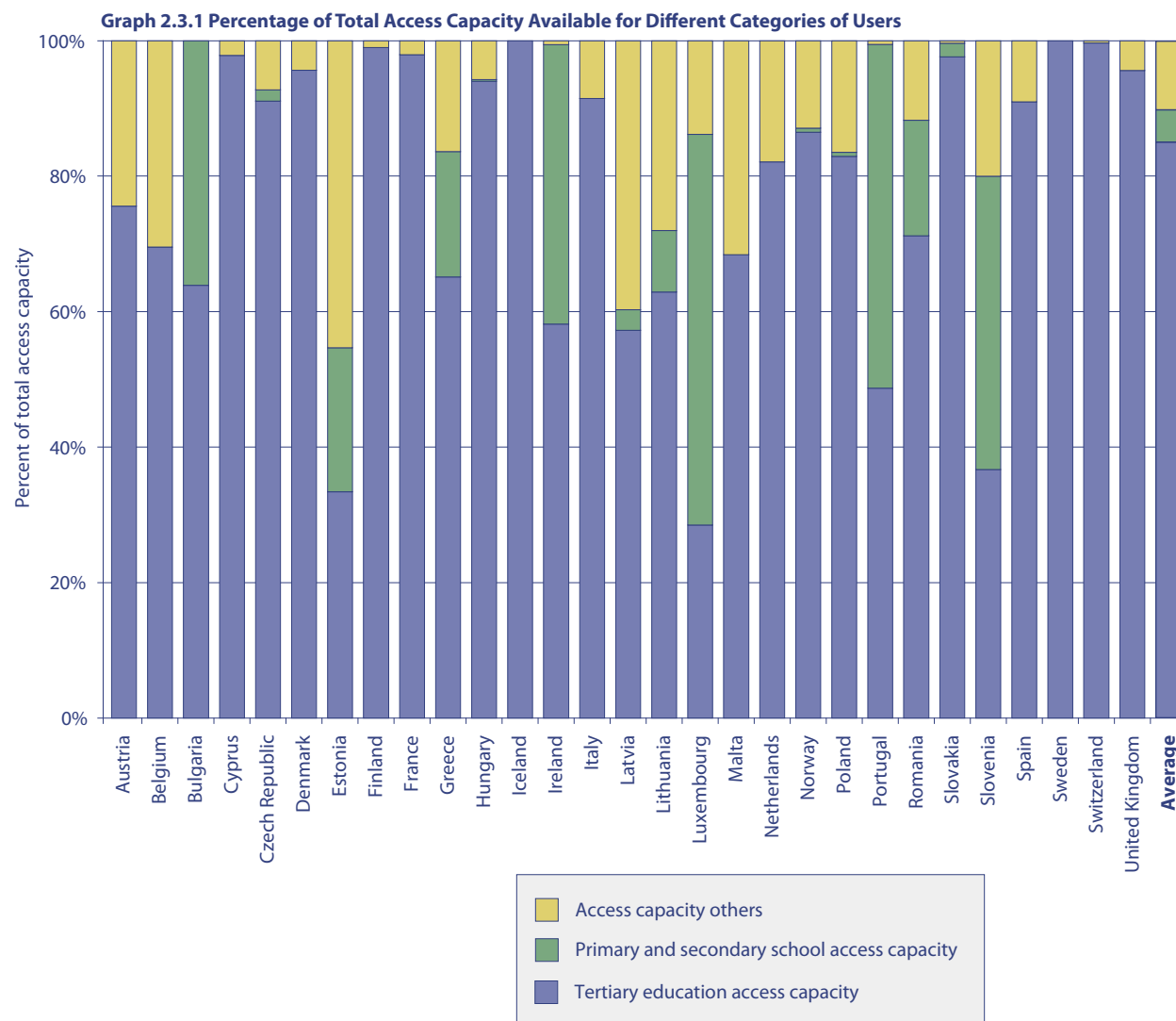
**Table 2.2.1** - Continued

Malta	CSC	100	50	+	+	+	+	-	-	+
Netherlands	SURFnet	100	75	75	10	10	10	10	-	+
Norway	UNINETT	100	75	50	10	10	25	-	+	+
Poland	PIONIER	100	+	100	+	+	+	+	10	+
Portugal	FCCN	75	75	75	100	100	-	-	25	-
Romania	RoEduNet	100	75	75	75	25	50	-	10	-
Slovakia	SANET	100	100	100	10	10	10	-	-	-
Slovenia	ARNES	100	100	75	75	75	50	-	10	-
Spain	RedIRIS	100	-	75	-	-	10	25	+	+
Sweden	SUNET	100	+	10	-	-	+	-	10	+
Switzerland	SWITCH	100	10	10	10	+	10	+	+	+
United Kingdom	JANET(UK)	100	100	100	75	100	+	-	10	+
<b>Other Countries</b>										
Algeria	CERIST	100	100	100	-	-	-	-	10	-
Azerbaijan	AzNET	10	10	10	50	+	10	+	10	+
Croatia	CARNet	100	100	100	50	50	10	10	10	+
Georgia	GRENA	50	25	75	10	-	10	10	-	+
Israel	IUCC	25	-	10	-	-	+	+	10	-
Jordan	JUNet	25	+	+	-	-	-	-	10	-
Lebanon	CNRS	10	-	75	-	-	-	-	-	-
Macedonia	MARNet	10	+	25	+	+	25	+	10	+
Moldova	RENAM	50	25	75	+	+	25	10	-	+
Montenegro	MREN	50	+	10	-	-	10	-	10	+
Morocco	MARWAN	100	75	50	+	+	10	+	-	-
Palestinian Territory	PADI2	25	+	+	-	-	-	-	10	-
Russia	RBNNet/RUNNet	50	+	25	10	-	10	-	10	-
Serbia	AMRES	75	10	25	10	+	10	10	10	+
Syria	SHERN	100	10	75	-	-	-	-	-	-
Turkey	ULAKBIM	75	75	50	-	-	10	-	10	-
Ukraine	URAN	25	10	10	10	-	10	10	10	-

## 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 as reported for institutions connected to the NREN for each category of institution. 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., GRNET of Greece 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, because 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.





## 2.4 Number of Connections to Universities and Bandwidth

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. Note that some NRENs have provided the data for entire universities for 2003 but for separate connections in 2007; in other cases, it has been the reverse.

In this section, information is provided for 2003 and 2007, showing the evolution over the past years. The 2007 information is also published in table format on the Compendium website.

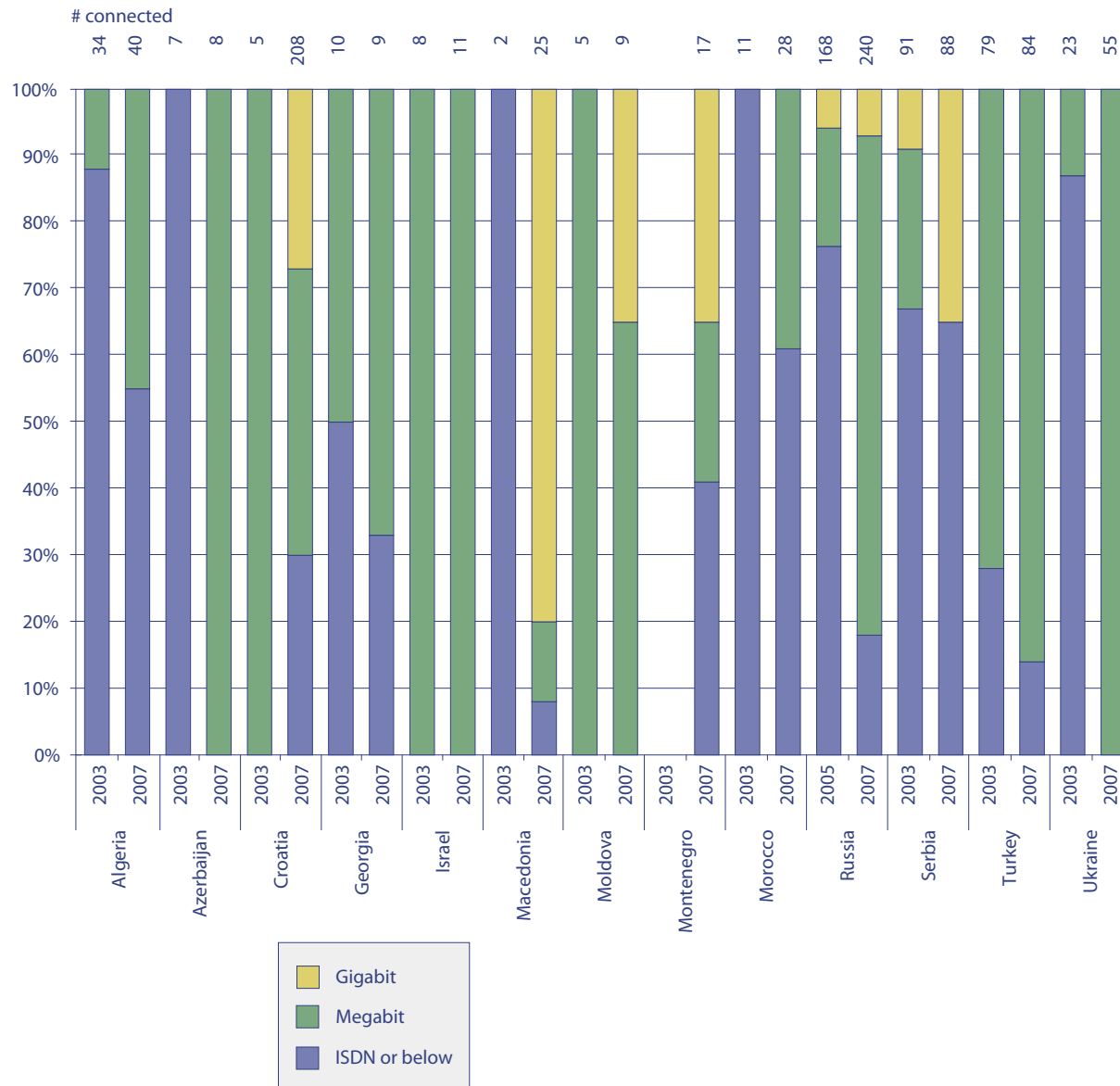
Note that the Polish information from 2007 was extrapolated from data gathered from seventeen out of the twenty-one MANs that form the PIONIER network.

**Graph 2.4.1 University Bandwidth, EU/EFTA Countries**



## 2.5 Percentage of Schools Connected through the NREN

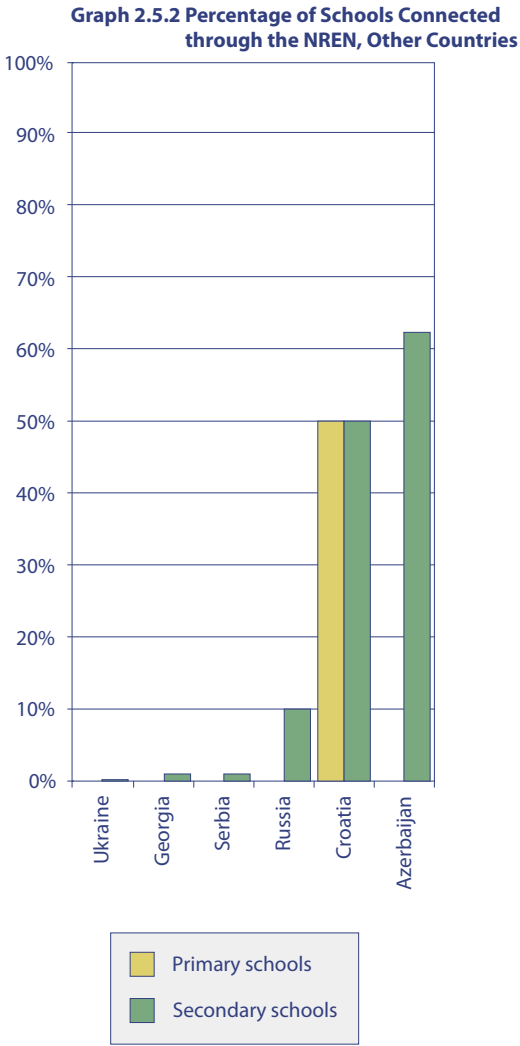
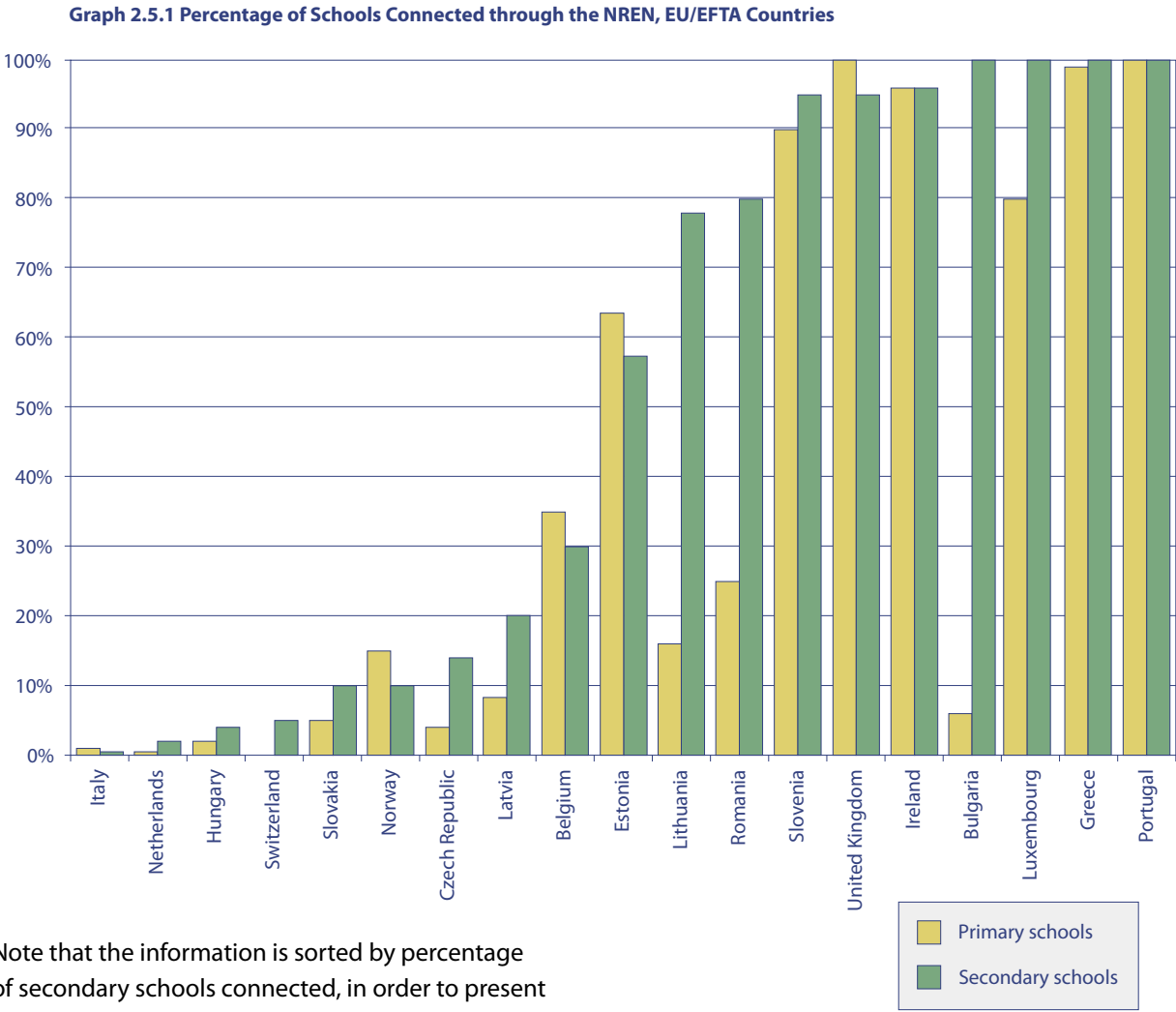
Graph 2.4.2 University Bandwidth, Other Countries



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. The percentage of connections is expected to rise sharply in some countries (e.g., Italy) because implementation of schemes to connect most or all schools has just started. 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.



## 3 NETWORK

This section provides an insight into a number of important network characteristics. Section 3.2 starts with the core capacity on the networks. Section 3.3 looks at the expected changes in this capacity over the next two years. Section 3.4 provides information about core network size. Section 3.5 is about external links that NRENs have. Section 3.6 looks at the relatively new area of dark fibre and section 3.7 gives information about cross-border dark fibre links. Section 3.8 provides information about the routers, switches and technologies used on the network. Section 3.9 looks at PoPs and Managed Links on the network.

The overview section, 3.1, provides information about different groups of NRENs and tries to identify key trends in the areas of core capacity, network size, external links and dark fibre.

### 3.1 Overview

#### Core Capacity

Table 3.2.3 provides information about the change in core usable backbone capacity of NRENs. By this, we mean the typical core capacity of the linked nodes in the core.

Many NRENs employ a range of capacities on their backbone. For more information about individual NRENs, please refer to the topology maps that many of them provide on their websites.

In 2001, five out of seventeen NRENs in the EU-15/EFTA countries already had a core capacity of 2.5 Gb/s – this was also the maximum capacity at that time. All the others, except RESTENA of Luxembourg, had a capacity of at least 155 Mb/s. In 2007, all but two of the EU/EFTA NRENs have a capacity of at least 1 Gb/s; the most common capacity is 10 Gb/s or a multiple of this; fourteen NRENs operate at this capacity.

This seems to be more or less in line with the rest of the developed world. The conclusion of the APAN survey is that in Asia, “the major band classes on the network are between 5 Gb/s and 10 Gb/s, and many narrower band classes exist. It is expected that, in two years, the 10 Gb/s class will become the norm and the backbones be further improved in Asia.” However, Internet2 in the USA now has 100 Gb/s available and CANARIE of Canada operates at 50 Gb/s, capacities not yet attained in Europe.

From the data from the sixteen other NRENs, in 2007, nine of these operated at 1 Gb/s. Russia now has a backbone with at least one 2.5 Gb/s link. What is interesting to note here is that these NRENs have typically made a larger jump than the EU/EFTA NRENs, thus skipping one or more of the network development stages that the EU/EFTA NRENs went through.

The overall trend is that there is considerable growth in spite of the fact that on average, NREN budgets have remained almost static over time.<sup>1</sup>

As is seen from graph 3.4.1, in the five-year period from 2003 to 2007, the average core network size has quadrupled, whilst the average core backbone capacity has more than doubled.

#### External links

The graphs in section 3.5 clearly show that for most 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

<sup>1</sup> See section 3.2.3 for country-by-country data.

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 the countries that are not part of the GN2 project. For those countries, relatively low-bandwidth connections to commercial ISPs are the most important (see also section 4, 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).

The trend is that in the more advanced countries, the core capacity will evolve to multiples of 10 Gb/s. Many EU/EFTA countries foresee further upgrades in the next two years. Many other countries have upgraded to Gigabit capacities, but do not foresee or cannot predict a further upgrade in the next two years.

## Dark Fibre

The migration to dark fibre continues apace, as does the deployment of services which exploit switched networks and wave division multiplexing. In the EU/EFTA area, thirteen NRENs list plans to start or to continue the deployment of dark fibre networks and layered services among their major changes.

The table below shows a steady increase in the number of NRENs that currently have at least two-thirds of their backbone as dark fibre. EU/EFTA NRENs indicate that the proportion of NRENs with at least two-thirds of their backbone as dark fibre will increase by 20% over the coming two years. This increase is greater than the increase predicted for the other countries.

Sometimes, these transitions can be very quick. A case in point is HEAnet (Ireland), which in 2006 predicted it would have 58% of its backbone as dark fibre by 2008. However, as a result of a successful procurement, HEAnet already has 95% as of its backbone as dark fibre this year. Developments can also go the other way around: FCCN (Portugal) thought it would have 50% of its backbone as dark fibre in 2008, but the 2007 prediction is that it will have 25% of its backbone as dark fibre by 2009. Note that in addition to the figures quoted below, JANET(UK) is changing to dark fibre and plans to have 60% of its backbone as dark fibre by 2008.

**Table 3.1.1 Aggregated Dark Fibre on NREN Backbones<sup>2</sup>**

Group of NRENs	Proportion with at Least Two-thirds Dark Fibre Backbone				
	2005	2006	2007	2008 (prediction from 2006)	2009 (prediction from 2007)
<b>EU/EFTA</b>	24%	36%	38%	44%	58%
<b>Other Countries</b>			30%		40%

As well as providing NRENs with the ability to better control, manage and exploit their network infrastructures, dark fibre provides opportunities that enable users to define their own dedicated end-to-end links across the network, and to do so within fixed NREN budgets. It also provides a number of NRENs in countries that were less-privileged to take important steps towards bridging the 'digital divide'. Therefore, the uptake of dark fibre is to be encouraged. The procurement of the new GÉANT2 network has endorsed this development and has provided a pan-European dark fibre footprint.

A continuing development is the implementation of cross-border dark fibre links between NRENs. Section 3.7 presents current and planned links of this type in a table.

<sup>2</sup> See section 3.6 for country-by-country data. Data for other countries from different years represent different country sets and are therefore not comparable. EU/EFTA countries for 2007 and 2009 also include Bulgaria and Romania.

## 3.2 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 3.2.1 and 3.2.2 give an idea of the evolution of network capacity from 2003 to 2007. For presentational purposes, the information is given in two graphs: 3.2.1 for the EU/EFTA and graph 3.2.2 for the other countries. Note that the scales are logarithmic and not the same for the two graphs.

For the EU/EFTA countries, the average core capacity increased tenfold. However, for some NRENs, the capacity stayed the same, whereas for others (CyNet and ARNES) it increased a hundred-fold or more<sup>3</sup>. The highest average core capacities in Europe now are 20 Gb/s; in 2006, the highest capacity was 10 Gb/s. CANARIE of Canada now has a core capacity of 50 Gb/s.

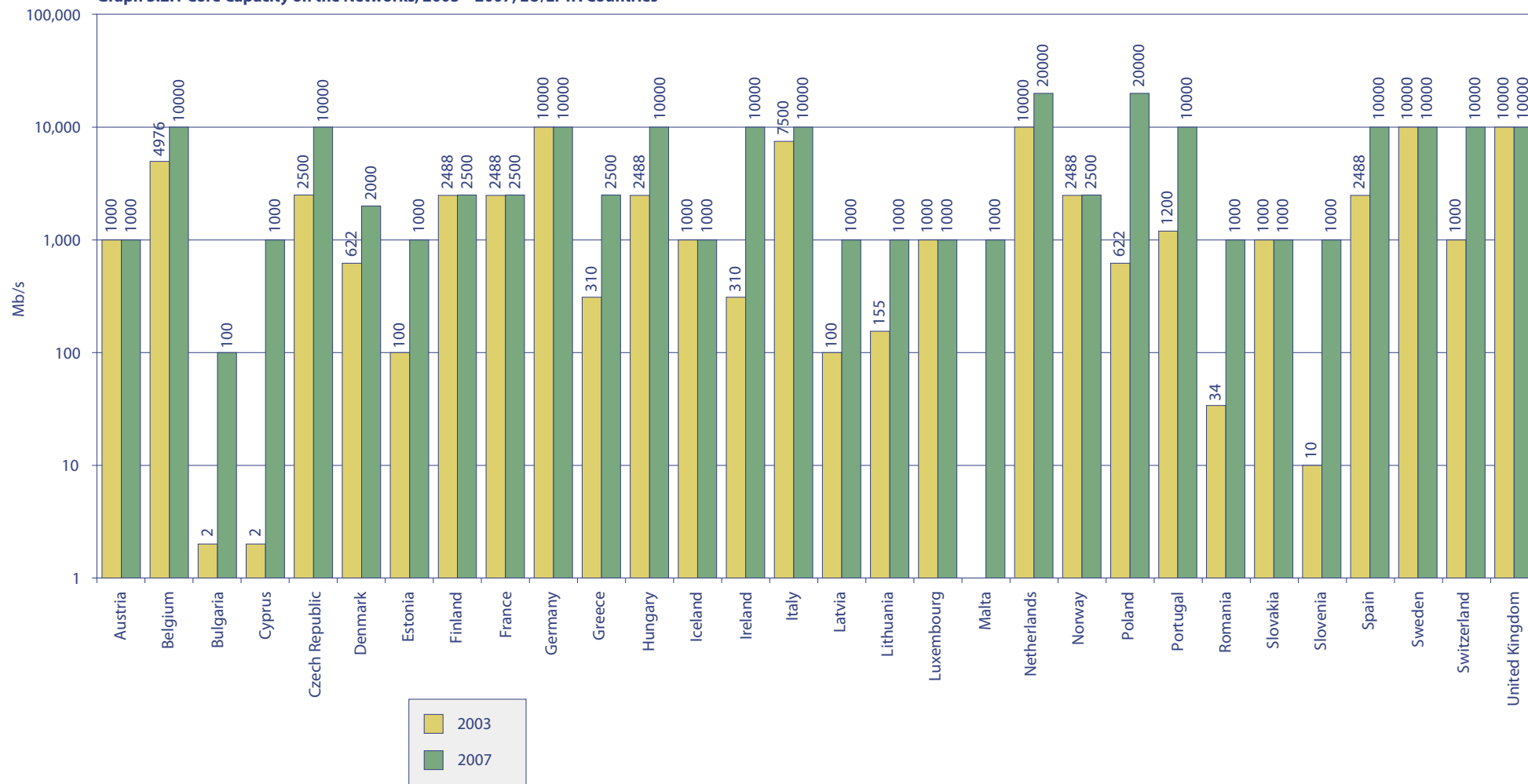
In the 'Other' countries, the effect of the introduction of affordable Gigabit Ethernet technology is clearly visible. Many countries are now using this. No NREN in this category has stayed at the same level since 2003.

For a number of NRENs, we have data going back to 2001. Table 3.2.3 gives the increase in core capacity on the networks between 2001 and 2007 for those countries.

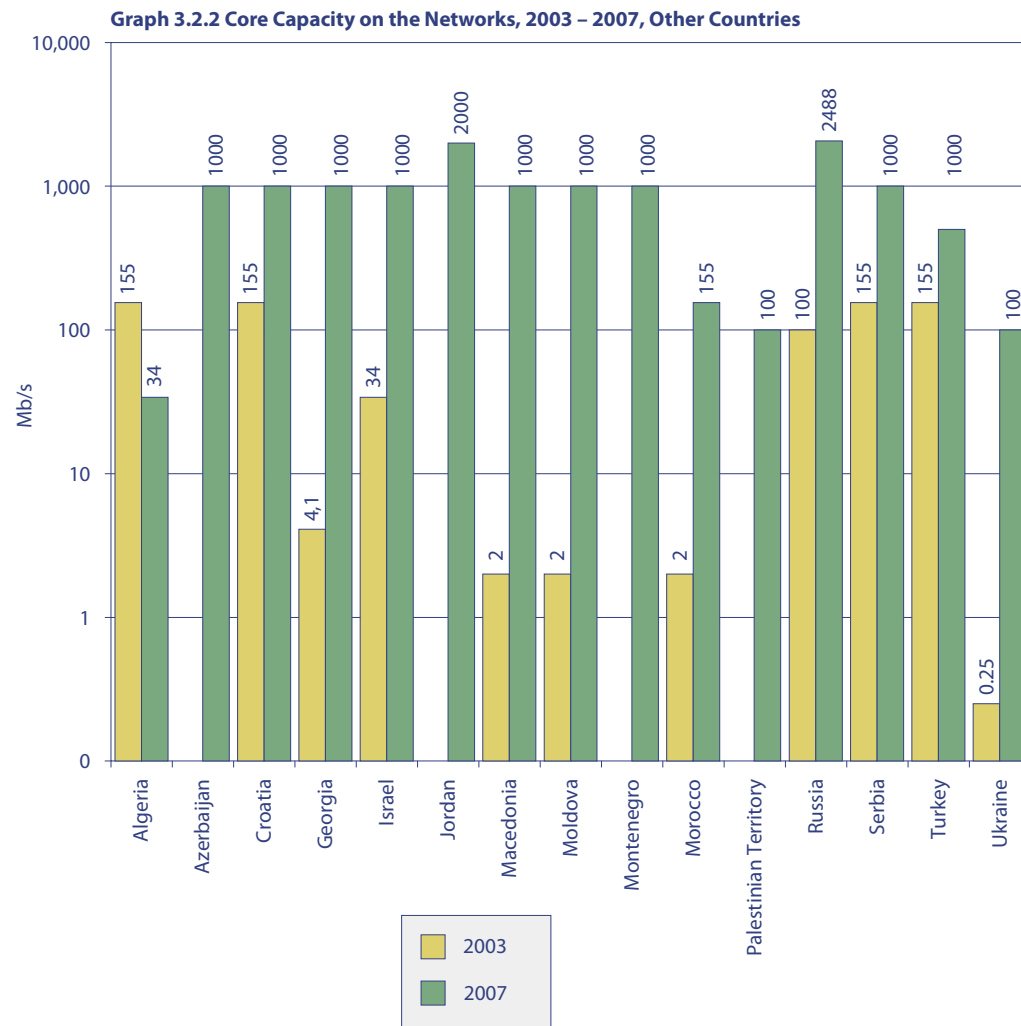
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<sup>3</sup> For LATNET, the 2006 edition erroneously reported an increase to 10 Gb/s.

Graph 3.2.1 Core Capacity on the Networks, 2003 – 2007, EU/EFTA Countries







In table 3.2.3, 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 the external connections, NOT to the capacity of the backbone.

**Table 3.2.3 Core Capacity on the Network in Mb/s, 2001 – 2007**

Country	NREN	2001	2002	2003	2004	2005	2006	2007
<b>EU/EFTA Countries</b>								
Austria	ACOnet	155	1000	1000	1000	1000	1000	1000
Belgium	BELNET	622	1000	4976	4976	4976	10000	10000
Bulgaria	BREN	0	0	2	100	10	155	100
Cyprus	CyNet	0	0	2	34	2	2	1000
Czech Republic	CESNET	2488	2488	2500	2488	2488	10000	10000
Denmark	UNI-C	622	622	622	1000	2488	2488	2000
Estonia	EENet	24	60	100	100	1000	1000	1000
Finland	Funet	2488	2488	2488	2488	2488	2488	2500
France	RENATER	2488	0	2488	2488	2488	2488	2500
Germany	DFN	622	2488	10000	10000	10000	10000	10000
Greece	GRNET	0	310	310	2488	2488	2488	2500
Hungary	NIIF/HUNGARNET	155	2488	2488	2488	10000	10000	10000
Iceland	RHnet	0	1000	1000	1000	1000	1000	1000
Ireland	HEAnet	155	310	310	1000	1000	1000	10000
Italy	GARR	0	2488	7500	2488	2488	10000	10000
Latvia	LATNET	100	100	100	100	2488	10000	1000
Lithuania	LITNET	4	155	155	155	310	310	1000
Luxembourg	RESTENA	10	1000	1000	1000	1000	1000	1000
Malta	CSC	0	0	0	100	45	1000	1000
Netherlands	SURFnet	2488	10000	10000	10000	10000	10000	20000
Norway	UNINETT	2488	2488	2488	2488	2488	2488	2500
Poland	PIONIER	155	155	622	10000	10000	10000	20000
Portugal	FCCN	180	180	1200	1200	2488	2488	10000
Romania	RoEduNet	0	0	34	155	310	310	1000

Country	NREN	2001	2002	2003	2004	2005	2006	2007
<b>EU/EFTA Countries</b>								
Slovakia	SANET	4	1000	1000	1000	1000	1000	1000
Slovenia	ARNES	100	100	10	310	1000	1000	1000
Spain	RedIRIS	155	155	2488	2488	2488	2488	10000
Sweden	SUNET	622	10000	10000	10000	10000	10000	10000
Switzerland	SWITCH	310	0	1000	1000	10000	10000	10000
United Kingdom	JANET(UK)	2488	2488	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
Georgia	GRENA	0.896	2.048	4.1	4	1000	1000	1000
Israel	IUCC	0	0	34	45	1000	1000	1000
Jordan	JuNET	0	0	0	0	0	1000	2000
Macedonia	MARnet	0.5	2	2	0	10	1000	1000
Moldova	RENAM	0	0	2	0	0	1000	1000
Montenegro	MREN	0	0	0	0	0	0	1000
Morocco	MARWAN	0	0	2	34	45	155	155
Palestinian Territory	PADI2	0	0	0	0	0	0	100
Russia	RBNet/RUNNet	0	0	100	0	2488	2488	2488
Serbia	AMREJ	0	2	155	500	100	1000	1000
Turkey	ULAKBIM	34	34	155	155	45	310	500
Ukraine	URAN	0	0.128	0.25	0.128	2	34	100

### 3.3 Expected Change in the Core Capacity in Two Years' Time

The following table gives the current core capacity (in Mb/s), the expected increase in two years' time and the expected (computed) core capacities for early 2009.

Note that, typically, the core capacity goes up in leaps, sometimes involving the 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 the more advanced 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 upgraded to Gigabit capacities, but do not foresee or cannot predict a further upgrade in the next two years.

**Table 3.3.1 Expected Change in the Core Capacity in Two Years' Time**

Country	NREN	2007	2009
<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	more than 20 Gb/s
Bulgaria	BREN	50 - 100 Mb/s	1 - 10 Gb/s
Cyprus	CYNET	10Mb/s Ethernet Network	100Mb/s Ethernet Network
Czech Republic	CESNET	10 Gb/s	10-40 Gb/s
Denmark	UNI-C	2 Gb/s level 2 ring structure	10 Gb/s DWDM-ring structure
Estonia	EENet	Gigabit Ethernet	10 Gigabit Ethernet
Finland	Funet	2.5 Gb/s between major PoPs	upgraded to 10Gb/s (where/when/if needed)
France	RENATER	For the leased lines it is 2,5 Gb/s, for dark fibres it is 10 Gb/s	multiple 10 Gb/s lambdas (or maybe 40 Gb/s or more)
Germany	DFN	10 Gb/s	As now
Greece	GRNET	500 Mb/s	1 Gb/s
Hungary	NIIF/HUNGARNET	10 Gb/s	As now
Iceland	RHnet	1 Gb/s	10 Gb/s
Ireland	HEAnet	10 Gb/s	40 Gb/s
Italy	GARR	10 Gb/s	40 Gb/s
Latvia	LATNET	100Mb/s	We expect that capacities increase up to 1-10Gb/s
Lithuania	LITNET	100	
Luxembourg	RESTENA	1 Gb/s	As now
Malta	CSC	1Gb/s	2 Gb/s
Netherlands	SURFnet	20 Gb/s	As now
Norway	UNINETT	2.5 Gb/s	10 Gb/s
Poland	PIONIER	20 Gb/s	40 Gb/s between supercomputing centers
Portugal	FCCN	10 Gb/s	40 Gb/s
Romania	RoEduNet	1 Gb/s	10 Gb/s

Table 3.3.1 - continued

Country	NREN	2007	2009
<b>EU/EFTA Countries</b>			
Slovakia	SANET	10 Gb/s Ethernet on 1/3 of backbone, 1 Gb/s Ethernet on the rest	10 Gb/s Ethernet everywhere
Slovenia	ARNES	1 Gb/s	10 Gb/s
Spain	RedIRIS	10Gb/s	n * 10Gb/s
Sweden	SUNET	10 Gb/s per university customer	10 Gb/s per customer
Switzerland	SWITCH	10 Gb/s	n * 10Gb/s, where n = 1 to 3
United Kingdom	JANET(UK)	10 Gb/s	40 Gb/s
<b>Other European and Mediterranean Countries</b>			
Algeria	CERIST	60 Mb/s	140 Mb/s
Azerbaijan	AzNET	1Gb/s	
Croatia	CARNet	1 Gb/s	As now
Georgia	GRENA	1 Gb/s in Tbilisi, 2 Mb/s in regions	As now
Israel	IUCC	1Gb/s	As now
Jordan	JUNet	2 Gb/s	
Macedonia	MARNet	1 Gb/s We have a Gigabit MAN for the University in Skopje	As now
Moldova	RENAM	1 Gb/s	As now
Montenegro	MREN	Local 1 Gb/s, MAN 100 Mb/s and between towns 2 Mb/s	As now
Morocco	MARWAN	155 Mb/s	As now
Palestinian Territory	PADI2	Our current network consists of one router connecting individual members in a star topology. The bandwidth of the connections varies from 2Mb/s to 100Mb/s.	

Country	NREN	2007	2009
<b>Other European and Mediterranean Countries</b>			
Russia	RBNNet/RUNNet	2.5 Gb/s	
Serbia	AMRES	1 Gb/s	As now
Turkey	ULAKBIM	500 Mb/s	As now
Ukraine	URAN	MANs: 100 Mb/s, intercity: 15 Mb/s	As now
<b>Some non-European Countries</b>			
Australia	AARNet	10 Gb/s	
Canada	CANARIE	50 Gb/s	
Chile	REUNA	Bandwidth: Core of 310 Mb/s in the middle part, 155 Mb/s at the rest.	
Colombia	RENATA	10 Mb/s	
Ecuador	CEDIA	The backbone capacity of our network is 10 Mb/s. This backbone is completely used just for advanced applications, not for commercial Internet. Each of the members has a 1 Mb/s link to the backbone.	
Guatemala	RAGIE	All institutions are connected at 100 Mb/s	
Taiwan	NCHC	20Gb/s	
United States	Internet2	10 x 10 Gb/s	
Uzbekistan	UzSciNet	2 Mb/s	
Venezuela	REACCIUN	34 Mb/s	

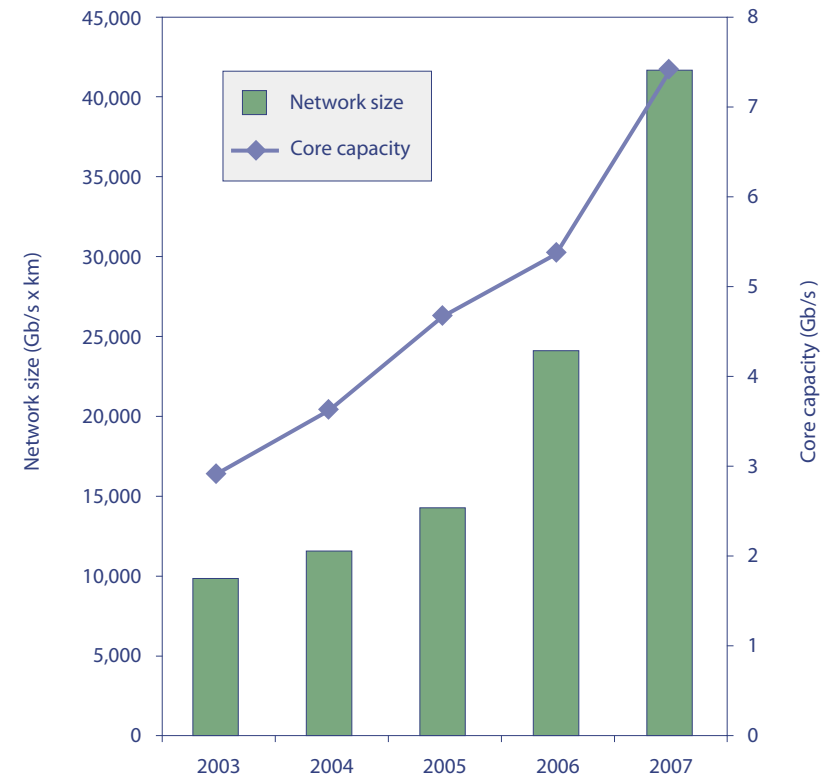
### 3.4 Core Network Size

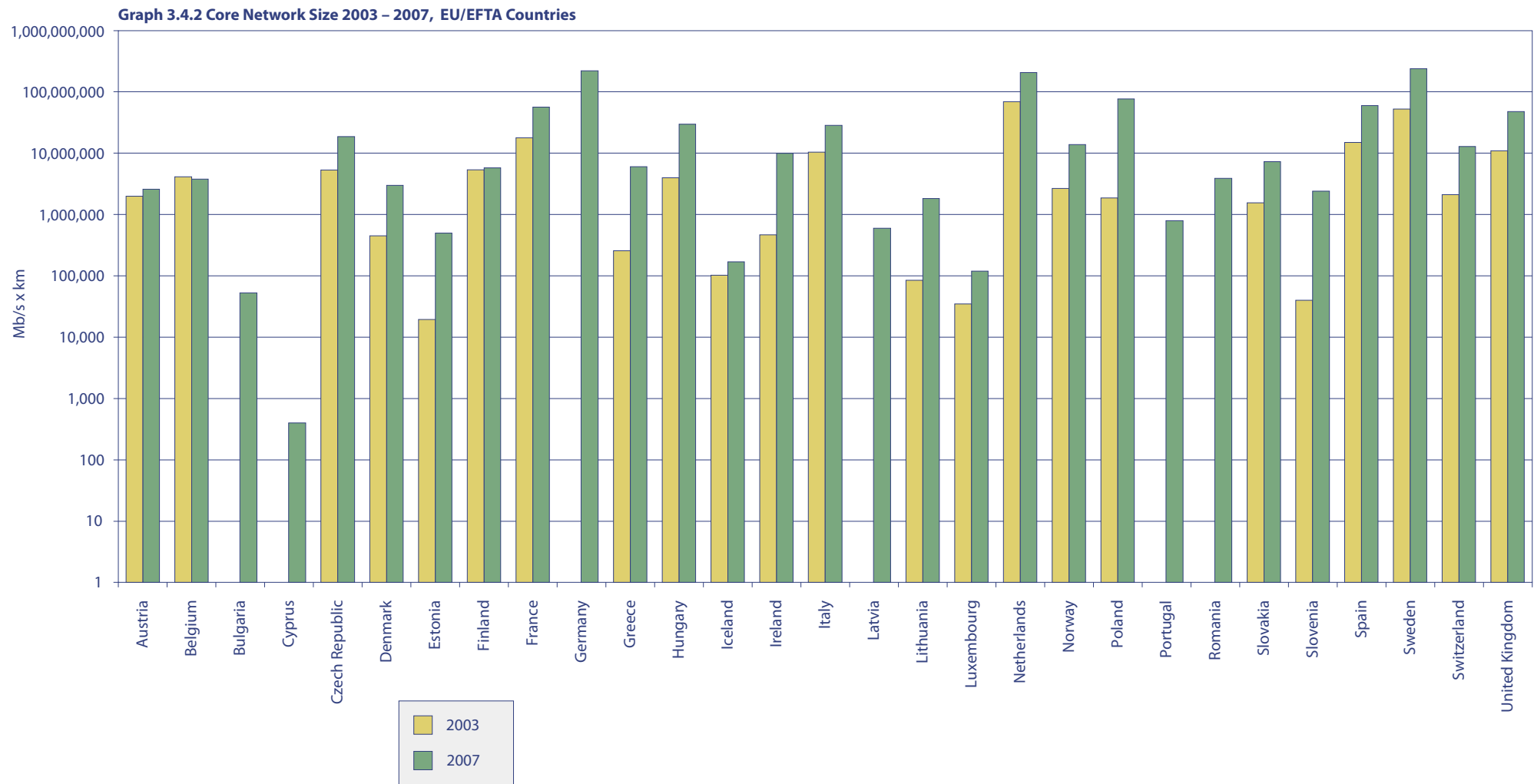
As in previous years, NRENs were asked to estimate the total size of their networks by multiplying the length of the various links in the backbone with the capacity of those links in Mb/s. The resulting unit is network size in Mb/s x km. This question is difficult to answer for some NRENs, but because it has been asked for a number of years, the answers are improving. Double-checking revealed some important errors in the 2006 edition, which have now been corrected. Thus, the correct value for DFN was approximately 80,000 Gb/s x km, instead of 148 Gb/s x km. The correct value for GARR was approximately 22,939 Gb/s x km instead of 394,000 Gb/s x km. In the case of LITNET, the correct value for 2006 was 273 instead of 273,000 Gb/s x km.

Perhaps not surprisingly, the largest growth rates have been achieved by NRENs from new EU countries, such as ARNES, Slovenia (a 60-fold increase), PIONIER, Poland (a 40-fold increase) and EENet, Estonia (a 25-fold increase). Other large increases were achieved by EU countries such as Portugal and Ireland. It is clear from graph 3.4.3 that large increases were achieved in some other countries as well, with MARNET of Macedonia as the absolute champions.

In order to illustrate the progress that has been made, we have added a graph that shows both the increase in average core network size and in core backbone capacity in the EU/EFTA countries over the 2003-2007 period for the countries for which we have the data. As is seen from the graph, in the five-year period from 2003 to 2007, the average core network size has quadrupled, whilst the average core backbone capacity has more than doubled.

**Graph 3.4.1 Average Core Network Size and Average Core Capacity, 2003 – 2007, EU/EFTA Countries**





### 3.5 External Connectivity: Total External Links

NRENs were asked to list all of their external connections in January 2007.

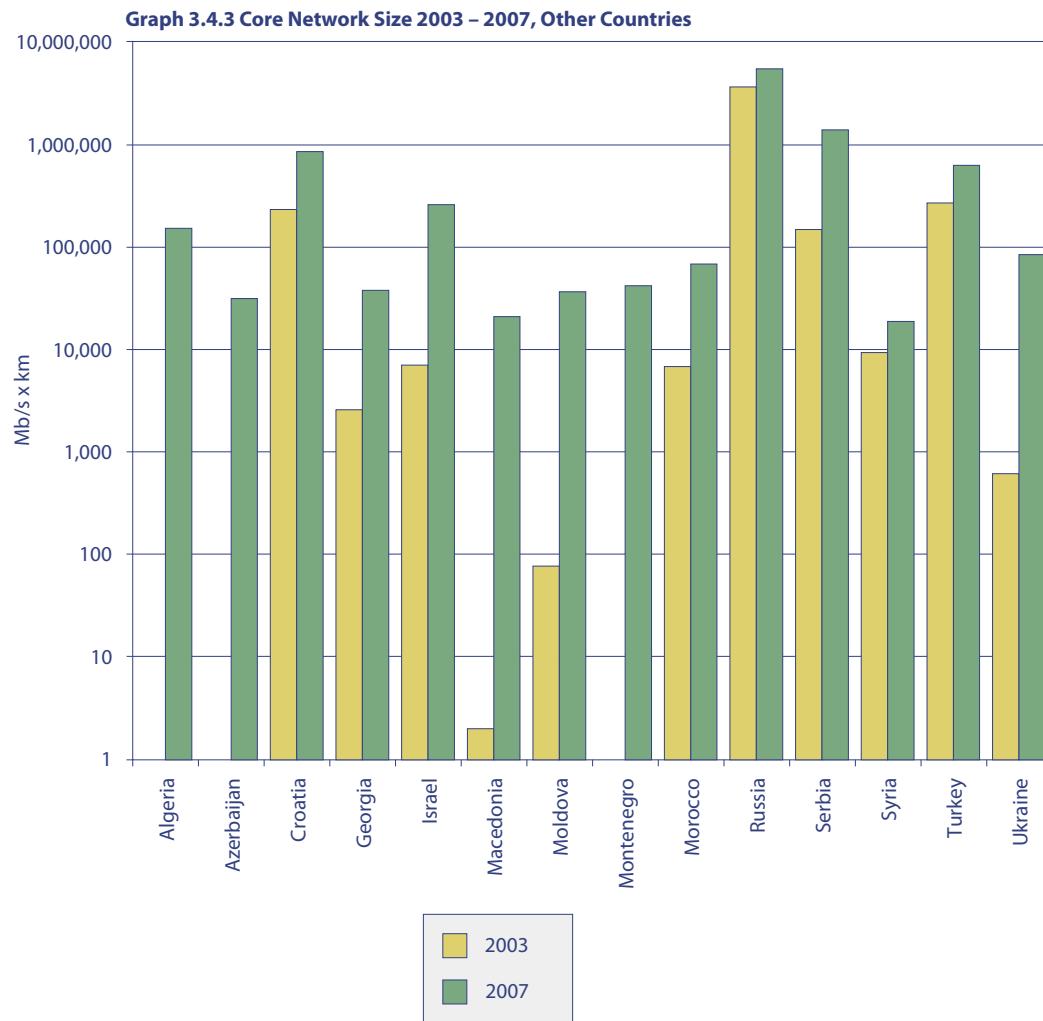
The Nordic NRENs (Funet of Finland, RHnet of Iceland, SUNET of Sweden, UNINETT of Norway and UNI-C [Forskningsnettet] of Denmark) share their external connections through NORDUnet. What is listed in the graphs is the connection of the individual NRENs to NORDUnet. In addition, their other connections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

In the graph, GÉANT/NORDUnet also contains 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.

‘Other Research’ includes links to other NRENs, the links of several Central Asian NRENs to DFN via the Silk Highway project and connections to CERN, Starlight and similar.

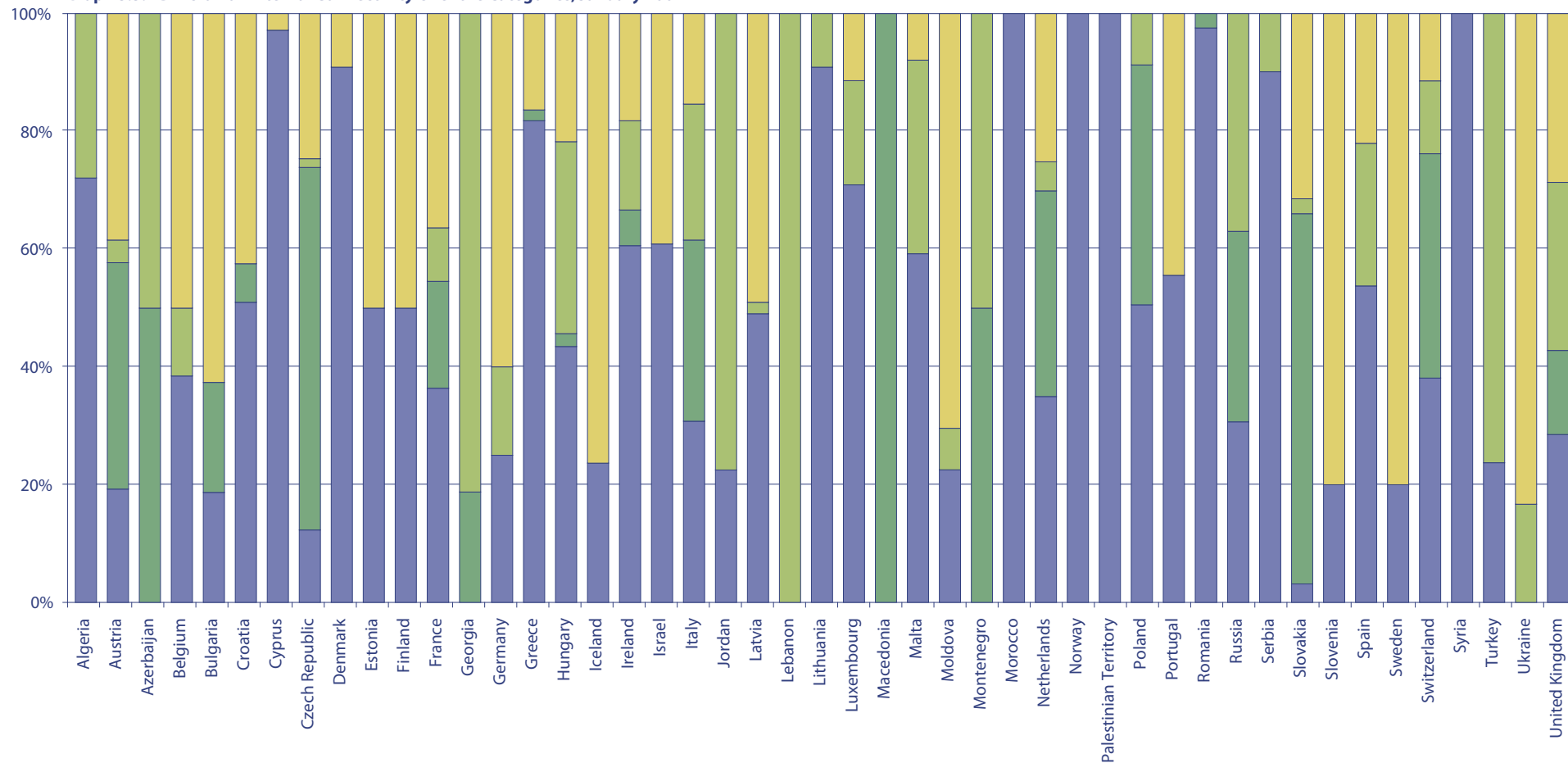
A peering is an exchange of IP routes in order to optimise traffic<sup>4</sup>. Often, traffic is exchanged, although no money changes hands. In some cases, restrictions may apply to such traffic.

The ‘Others’ category is used for connections with commercial ISPs.



<sup>4</sup> See for example <http://whatis.techtarget.com>

Graph 3.5.1 Division of External Connectivity Over the Categories, January 2007

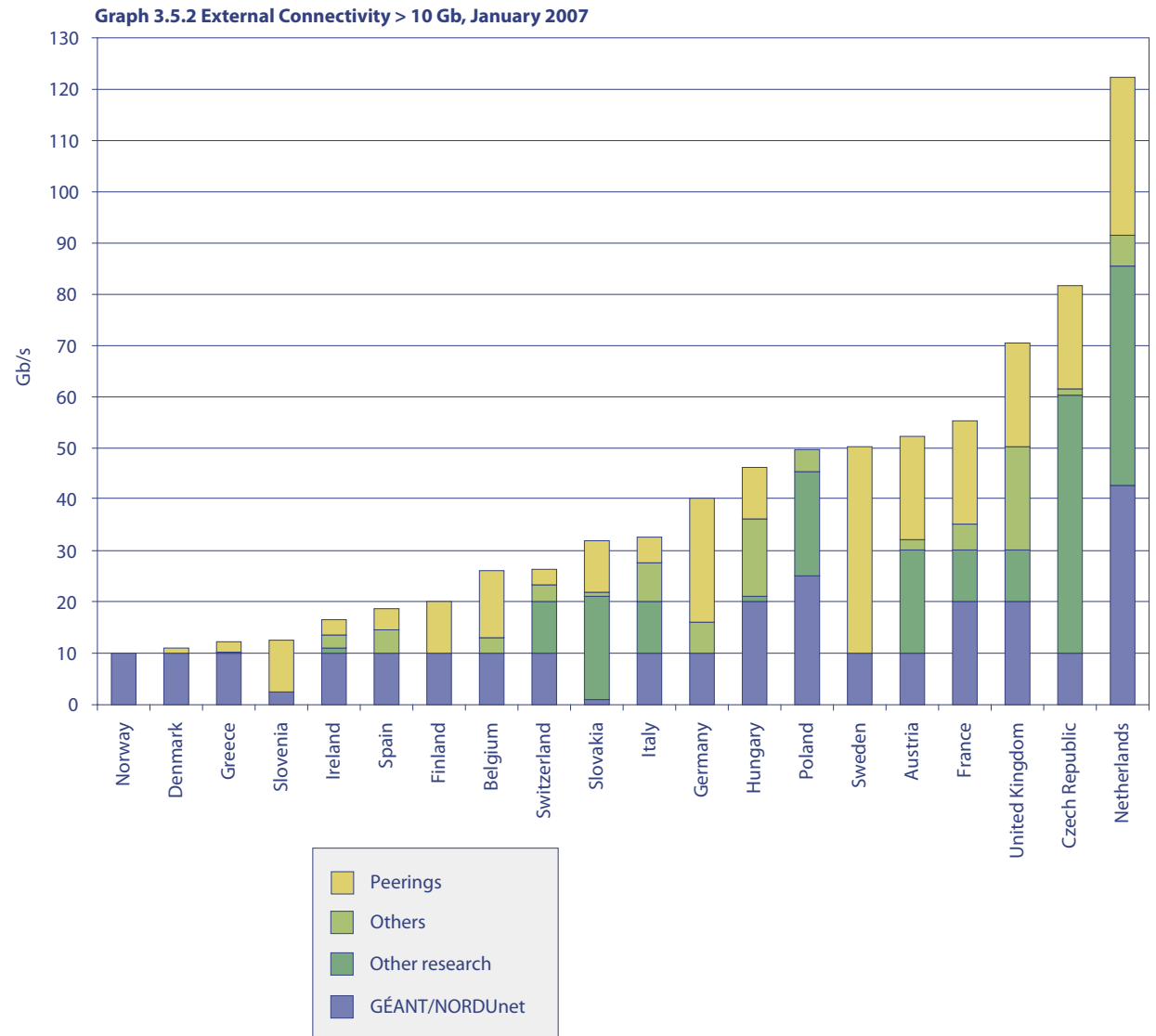


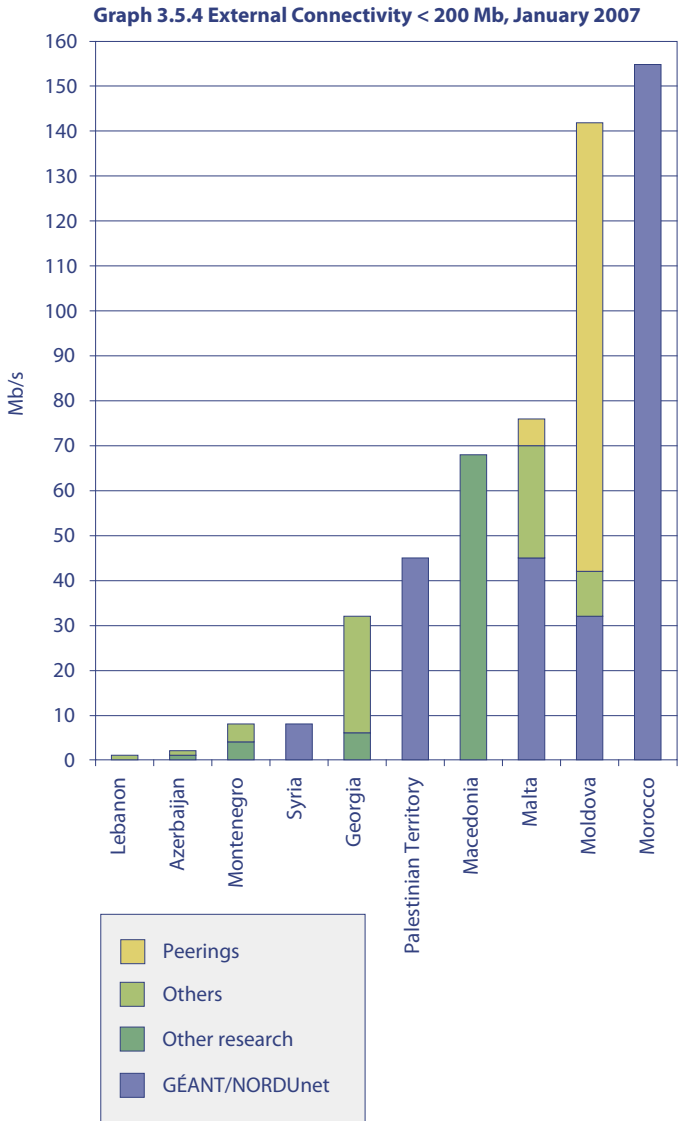
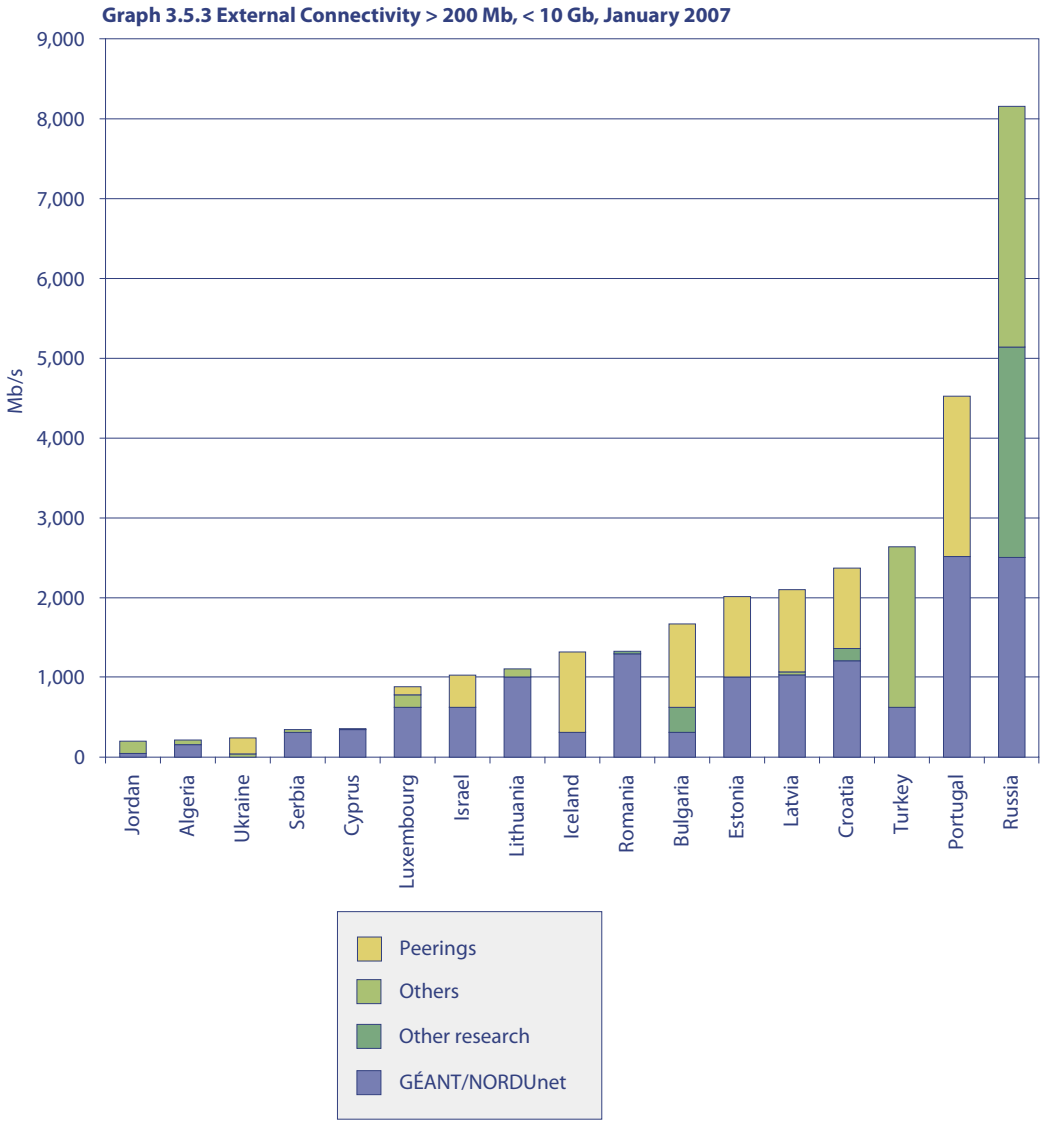


In general, connections to GÉANT and to other NRENs carry education and research traffic, while peerings and other connections convey traffic to and from the general Internet. The former can be very specialised data, often transmitted in huge volumes in very short time frames; for instance, real-time observations from a radio telescope which need to be transmitted over large distances for 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, four graphs are shown. Graph 3.5.1 presents the division of external connectivity over the categories, in percentages. The other three graphs give the total connectivity.





## 3.6 Dark Fibre

Some NRENs own dark fibre or have IRUs<sup>5</sup> or lease dark fibre and can decide themselves what technology and what speeds 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 coloured squares indicate where an NREN has a significant percentage of dark fibre and draws attention to significant changes that are expected over the next two years.

**Table 3.6.1 Percentage of network as Dark Fibre, 2005 to 2009**  
(darker colour highlights a significant change)

Country	NREN	2005	2006	2007	2008 Prediction from 2006	2009 Prediction from 2007
<b>EU/EFTA Countries</b>						
Austria	ACOnet		1	1	90	90
Belgium	BELNET		3	3	90	100
Czech Republic	CESNET	0	100	100	100	100
Denmark	UNI-C	25	11	10	81	90
Estonia	EENet		20	20	40	20
Finland	Funet	5	8	20	25	90
France	RENATER	5	25	25		
Germany	DFN	0	90	90		
Greece	GRNET	0	100	15	100	100
Hungary	NIIF/	1	11	11	51	31
Iceland	RHnet	0	15	30	30	30
Ireland	HEAnet	10	18	95	58	98
Italy	GARR	3	3	2	12	
Lithuania	LITNET	0	14	18	40	27
Luxembourg	RESTENA	51	55	55	70	70
Netherlands	SURFnet	100	100	100	100	100

Country	NREN	2005	2006	2007	2008 Prediction from 2006	2009 Prediction from 2007
<b>EU/EFTA Countries</b>						
Norway	UNINETT	97	100	3	100	3
Poland	PIONIER	73	100	100	100	100
Portugal	FCCN		26	20	60	25
Romania	RoEduNet	0	1	5	65	85
Slovakia	SANET	100	100	100	100	100
Slovenia	ARNES	80	68	75	90	95
Spain	RedIRIS	0	0		5	80
Sweden	SUNET	5	100	100	100	100
Switzerland	SWITCH	87	100	100	100	
United Kingdom	JANET(UK)	2	50		60	
<b>Other Countries</b>						
Croatia	CARNet	5	5	5		10
Georgia	GRENA		7	6	35	8
Israel	IUCC	2	2	6	2	6
Macedonia	MARNet		10	10	70	100
Moldova	RENAM		7	14	50	
Montenegro	MREN			100		100
Serbia	AMRES		100	91	100	97
Turkey	ULAKBIM	12	2	0	15	30
Ukraine	URAN			6		15

<sup>5</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 IRUs and lease is becoming less clear; therefore, these two categories have been combined.

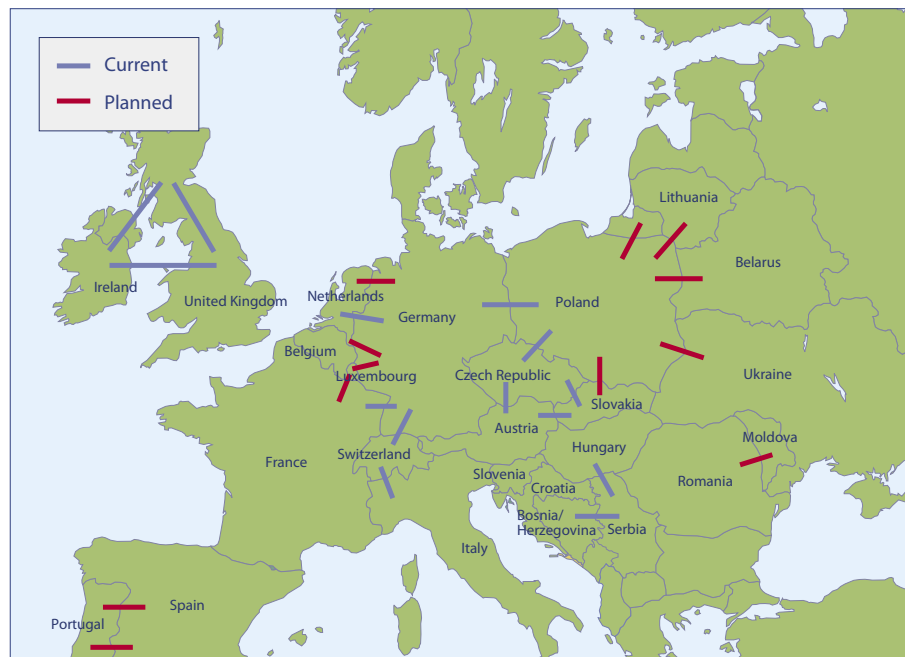
### 3.7 Cross-border Dark Fibre

A number of countries have or are planning to install cross-border dark fibre links from one neighbouring NREN to the other. 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>6</sup> Table 3.7.1 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 3.7.2 Cross-border Dark Fibre**



<sup>6</sup> ‘Networks for Knowledge and Innovation,’ SERENATE Summary Report, p. 34-5

**Table 3.7.1 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 - Doboj, Bosnia/Herzegovina	
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 - RENATER	Kehl, Germany - Strasbourg, France	Jun-06
DFN - SURFnet	Muenster, Germany - Enschede, Netherlands	
DFN - SWITCH	Lorrach, Germany (BelWu) - Basel, Switzerland	Jun-06
GARR - SWITCH	Milano, Italy - Manno, Switzerland	
HEAnet - JANET(UK)	Dublin, Ireland - Belfast, UK	Nov-06
Planned		
DFN - RESTENA		2008
DFN - SURFnet	Aachen, Germany - Maastricht, Netherlands	Q2 2007
DFN - SURFnet	Hamburg, Germany - Amsterdam, Netherlands	Q2 2007
FCCN - RedIRIS	Porto, Portugal - Vigo, Spain	2007
FCCN - RedIRIS	Lisbon, Portugal - Badajoz, Spain	2008
LITNET - PIONIER	Kaunas, Lithuania - Ogdzniki, Poland	Q4 2007
PIONIER - BASNET	Kuznica, Poland - Grodno, Belarus	2007
PIONIER - RBNNet/RUNnet	Granowo, Poland - Mamonovo, Russia	2007
PIONIER - SANET	Bielsko Biala, Poland - Žilina, Slovakia	null
PIONIER - URAN	Lublin, Poland - Lviv, Ukraine	Oct 2007
RENAM - RoEduNet	Chisinau, Moldova - Lasi, Romania	2008
RENATER - RESTENA		2008

### 3.8 Routers and Switches, Transmission Technology and Transport 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>7</sup> Routers are thus important pieces of equipment for any NREN. Table 3.8.1 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.

This year, we have also asked NRENs about the transmission technology and the transport equipment that NRENs manage on their backbone. All NRENs from the EU/EFTA countries and 13 other NRENs answered the question about the transmission technology managed on the backbone. The full answers are available from the Compendium website.

In total, 23 NRENs gave information about their transport equipment. The information is available from the Compendium website.

### 3.9 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 links managed by the NREN 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 below, NRENs vary considerably in this respect. Thus, ARNES of Slovenia manages the equipment at many secondary and primary schools and thus has 1200 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.

For the first time, we have also added a question about the number of optical PoPs on the network. This gives an indication, together with other information e.g. about dark fibre on the networks, of the spread of optical networking in the NREN. For ease of comparison, we have added the number of managed links in 2006 as well. The darker colour indicates a significant change in that number.

**Table 3.8.1 Routers and Switches**

EU/EFTA Countries (30 NRENs in the survey)												
Vendor	Cisco	Juniper	HP	Avici	Nortel	Extreme	Foundry	MikroTik	Tellabs	3Com	Planet	Allied Telesyn
Number of NRENs	28	13	2	1	1	1	1	0	0	0	0	0
Other Countries (13 NRENs in the survey)												
Number of NRENs	13	0	2	0	0	0	0	1	1	1	1	1

<sup>7</sup> Source: [whatis.techtarget.com](http://whatis.techtarget.com)

**Table 3.9.1 Numbers of PoPs and of Managed Links and Managed Sites on the Network**

Country	NREN	# of PoPs	# of Optical PoPs	# of Managed links 2006	# of Managed links 2007	# of Managed sites
<b>EU/EFTA Countries</b>						
Austria	ACOnet	15		22	22	15
Belgium	BELNET	16	0	29	29	16
Bulgaria	BREN	10	0	30	30	10
Cyprus	CYNET	3	0	1	15	3
Czech Republic	CESNET	39	10	44	45	29
Denmark	UNI-C	7	5	0	0	20
Estonia	EENet	16	0	20	20	16
Finland	Funet	16	0	23	100	16
France	RENATER	40	11	80	90	50
Germany	DFN	49	40	102	76	49
Greece	GRNET	12	5	14	62	63
Hungary	NIIF/HUNGARNET	40	40	38	45	40
Iceland	RHnet	13	13	11	15	14
Ireland	HEAnet	8	0	26	90	10
Italy	GARR	38	8	60	53	38
Latvia	LATNET	48	0	60	79	1590
Lithuania	LITNET	31	6	200	200	200
Luxembourg	RESTENA	12		59	59	57
Malta	CSC	1		0	0	1
Netherlands	SURFnet	262	262	306	336	262
Norway	UNINETT	40	0	240	240	385
Poland	PIONIER	31	31	29	28	23
Portugal	FCCN	9	5	16	11	9

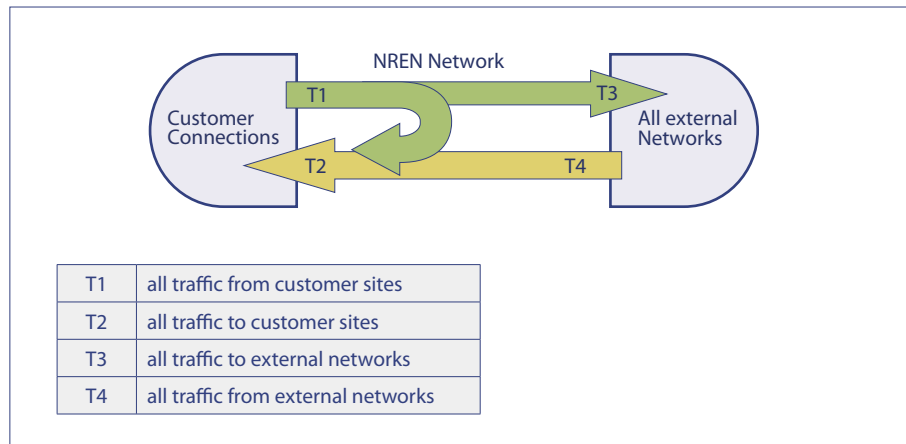
Country	NREN	# of PoPs	# of Optical PoPs	# of Managed links 2006	# of Managed links 2007	# of Managed sites
<b>EU/EFTA Countries</b>						
Romania	RoEduNet	41	3	53	53	40
Slovakia	SANET	26	26	26	30	26
Slovenia	ARNES	34	34	983	1200	1107
Spain	RedIRIS	20	0	34	60	20
Sweden	SUNET	25	24	60	120	60
Switzerland	SWITCH	27	27	46	50	34
United Kingdom	JANET	150	5	1500	1500	742
<b>Other Countries</b>						
Algeria	CERIST	4	4	3	3	4
Azerbaijan	AzNET	16	12	13		13
Croatia	CARNet	500		350	700	570
Georgia	GRENA	13	7	17	10	13
Israel	IUCC	2	0	16	17	10
Macedonia	MARNet	1	20	0		
Moldova	RENAM	33	10	31	47	51
Montenegro	MREN	25	24		30	31
Morocco	MARWAN	15	10		33	
Russia	RBNet/RUNet	12	4	15	15	12
Serbia	AMRES	40	40	60	120	40
Syria	SHERN	5	3		0	5
Turkey	ULAKBIM	3		3	3	3
Ukraine	URAN	133	131	31	145	29

## 4 TRAFFIC

In this section, a distinction is made between different types of traffic by source or destination. Figure 4.0.1 illustrates how the terms are used for the purposes of the Compendium.

External traffic is all traffic to GÉANT, the commercial Internet, Internet exchanges, etc. (made up of T3 and T4 in Figure 4.0.1).

**Figure 4.0.1 Elements of Traffic Flow on NREN Networks**



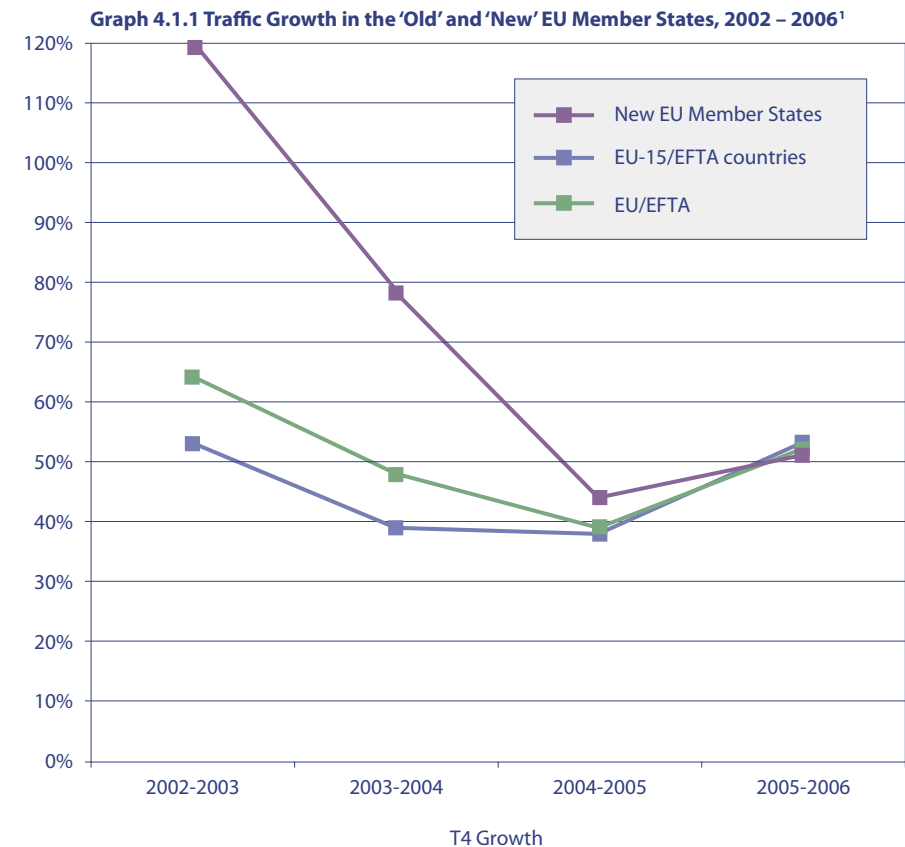
Section 4.2 provides information about the traffic volume in 2006. Section 4.3 looks at traffic load and provides data from January 2003 through to January 2007. Section 4.4 provides information about IPv6. The overview section, 4.1, looks at all these and a few other aspects, provides information about NRENs from different groups of countries and tries to identify key trends.

### 4.1 Overview

#### Traffic Trends

The graph below illustrates traffic growth patterns over the past five-year period. Note that this graph compares total traffic growth across countries; it is not the average traffic growth per NREN.

Because the total traffic in the 15 states that formed the EU up to 2004 is higher than that of the 10 countries that joined in 2004, total growth is similar to the growth in the 'old' EU member states.



<sup>1</sup> In this graph, the EU-15/EFTA figure is lower than in the graph of last year; this is because of a correction to the earlier data.

In earlier years, the growth rates for the countries that joined the EU after 1 January 2004 were consistently higher than that of the 'old' EU/EFTA countries. However, since 2004/2005, they have converged. It is difficult, if not impossible, to predict what the future will bring – new applications relative to Grids, for example, may change the picture. However, in that case, growth will be driven by demand, rather than by changes in network capacities. In addition, changes in technology (such as the introduction of lightpaths for certain categories of users) may change the picture.

It is important to note that traffic growth is not a natural phenomenon, but can be and is being influenced by the policies of both NRENs and their users. One noteworthy example in this context is that of Funet (Finland), where traffic decreased more than 10% between 2003 and 2004 and a further 9% between 2004 and 2005. Between 2005 and 2006, however, it grew by 55%. Funet staff explained the decrease in earlier years by pointing to restrictions put in place by universities. The recent growth is attributed to different factors, including data intensive research over general purpose academic networks, increased file sharing, an increased proportion of new applications like video services and games, a gradual shift from text to other formats in web pages and emails, and increased average time spent on the Internet in general (more and more with portable devices).

Note that at least twenty-four NRENs from the EU/EFTA region have traffic monitoring tools on their website; twenty-one publish traffic statistics. (In addition, a few NRENs have password-protected pages or pages for customers only.) Many NRENs from other countries do this as well. A list of all URLs is available from the Compendium website.

## Traffic with the General Internet

The level of NREN traffic with the general Internet, as distinct from inter-NREN traffic, is quite uniformly high. The overall average proportion across all NRENs in the survey is a little more than 75%. The spread between NRENs is not big, even though there are a few exceptions.

## Congestion

NRENs were asked to give a rough estimate of the percentage of institutions connected to their network that experience none or little, some or moderate, or serious congestion at the different network levels.

A single metric was derived for the level of congestion in each network element from the subjective levels reported by NRENs, using the following formula<sup>2</sup>:

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

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

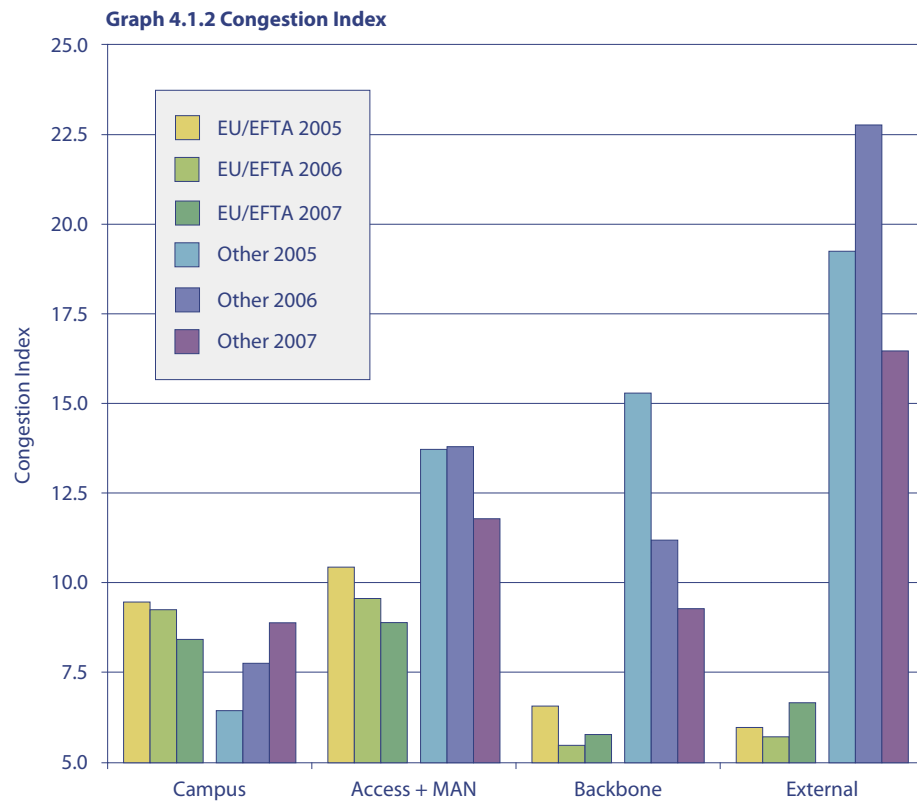
The data for MANs and for access networks were combined. Applied to all the reported values, this formula provides a single uniform metric.

For the EU and EFTA countries, the average estimated congestion at the campus level has gone down somewhat, but it has gone up in a little at the Backbone and External Connections levels. 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.

<sup>2</sup> This index has been developed for the Compendium by Mike Norris, HEAnet.



For the 'other' countries, congestion seems to have increased at the Campus and Access Network levels, but it has gone down at the other levels, even though the picture in External Connections is mixed. This is in line with the expectation that was formulated last year: in the 'other countries', *"the restrictions imposed by low-capacity external connections mean that constraints at the campus and other levels are less apparent. It is to be expected that these constraints will show up as soon as the problems at other levels have been solved."*

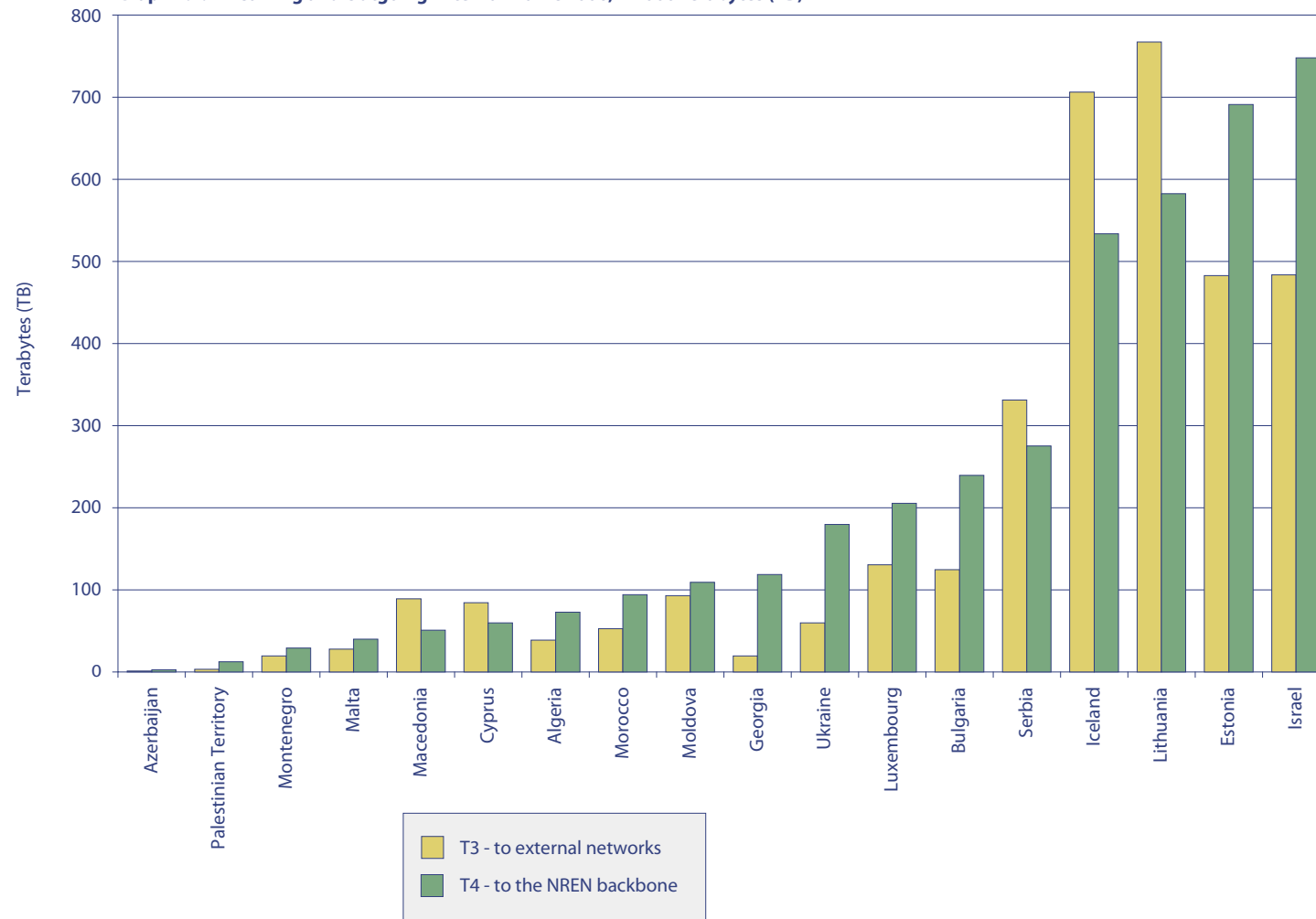


## 4.2 Traffic in 2006

Two graphs are presented: graph 4.2.1 shows the information for those NRENs with external traffic above 1000 Terabytes; graph 4.2.2 gives the same information for NRENs with external traffic below 1000 Terabytes.



Graph 4.2.2 Incoming and Outgoing External Traffic 2006, &lt; 1000 Terabytes (TB)



## 4.3 Traffic Load

Measuring the traffic load on the network is one potential way of measuring congestion and thus is also an indicator of the extent to which customer demand for bandwidth is being satisfied. For the following graphs, the traffic load has been calculated by dividing the actual traffic in January of each year by the theoretical maximum capacity of all external links of an NREN in that month. The theoretical maximum capacity is calculated by multiplying the total capacity of the external links in Mb/s by the number of seconds in January.

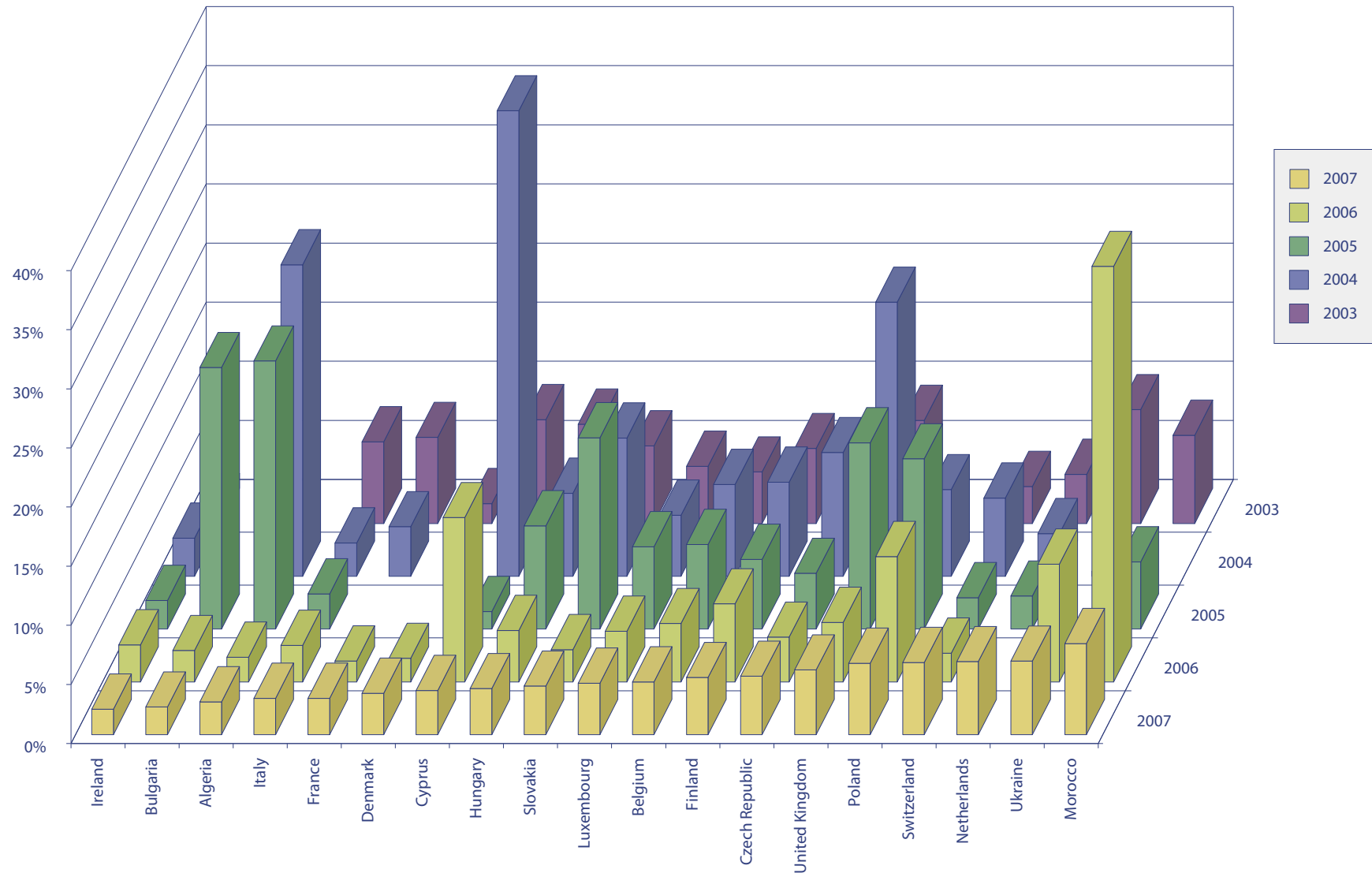
In practice, it is impossible to reach the theoretical maximum capacity and therefore it is impossible to reach 100% traffic load. This is because traffic is not evenly distributed over the hours in a day and over the days of a week.

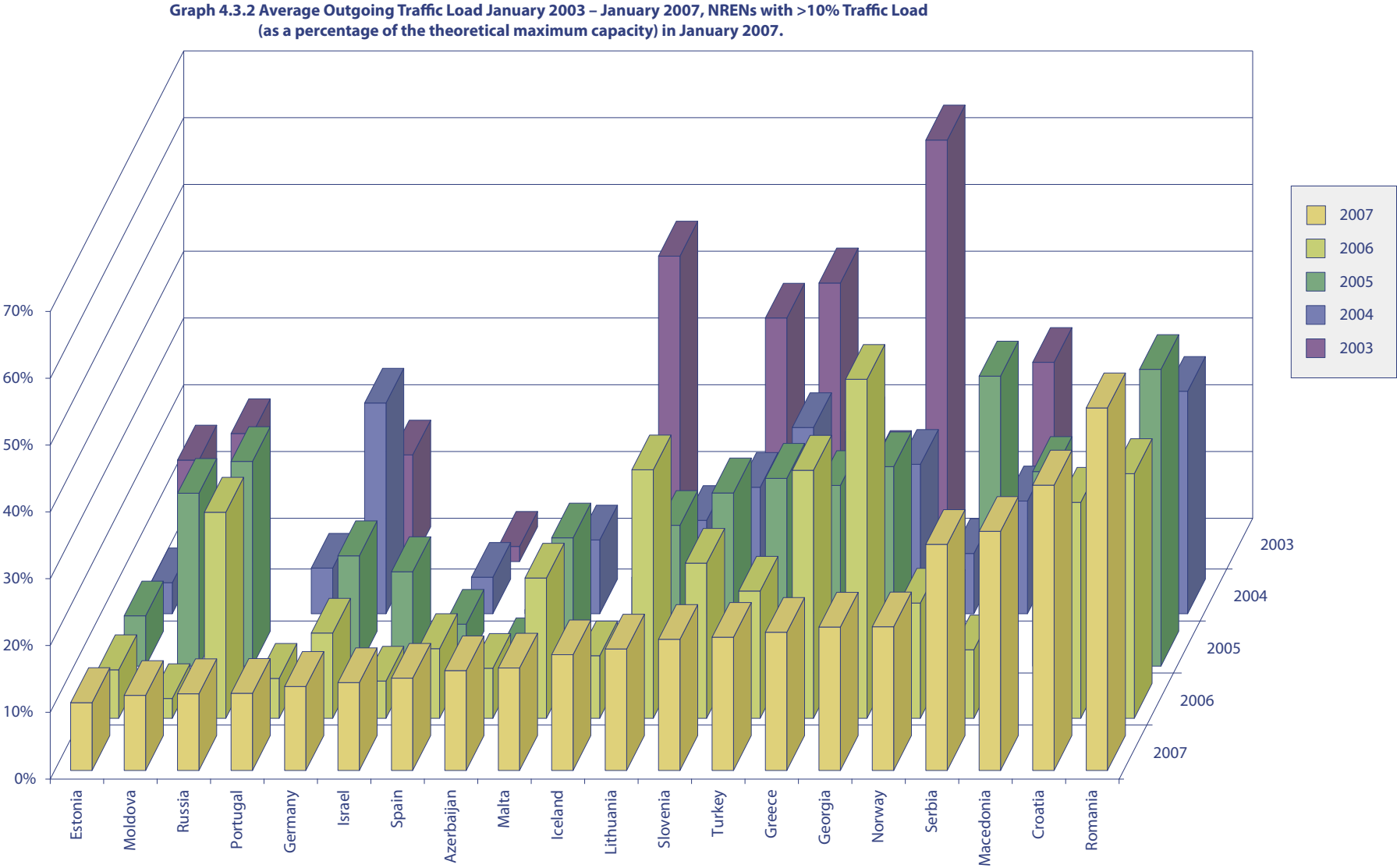
For an indication of sustained peak usage, the load figures in the table should typically be multiplied by three. In other words, users will certainly experience serious congestion if the traffic load is above 33%; even at lower loads, users may sometimes experience congestion in network performance.

In addition, traffic is not distributed evenly over all the external links of an NREN, because not all links offer the same possibilities. Thus, it could be that the overall traffic load, as computed here, is low but that certain links are still overloaded.

The graphs illustrate in a very general way that NRENs need to upgrade their external links from time to time in order to keep up with increasing demand.

**Graph 4.3.1 Average Outgoing Traffic Load January 2003 - 2007, NRENs with < 10% Traffic Load  
(as a percentage of the theoretical maximum capacity) in January, 2007.**





## 4.4 IPv6

Universities are the institutions that have taken a lead in IPv6. The 2006 Compendium showed that in the EU/EFTA countries, almost 35% of the Universities had some sort of IPv6 connectivity. This year, we have focused on the native IPv6 connectivity of Universities only.

As can be seen from table 4.4.1, EU/EFTA NRENs now provide, on average, almost 30% of the Universities in their countries with native IPv6 connectivity.

**Table 4.4.1 Average Percentage of Universities Connected via Native IPv6 per NREN**

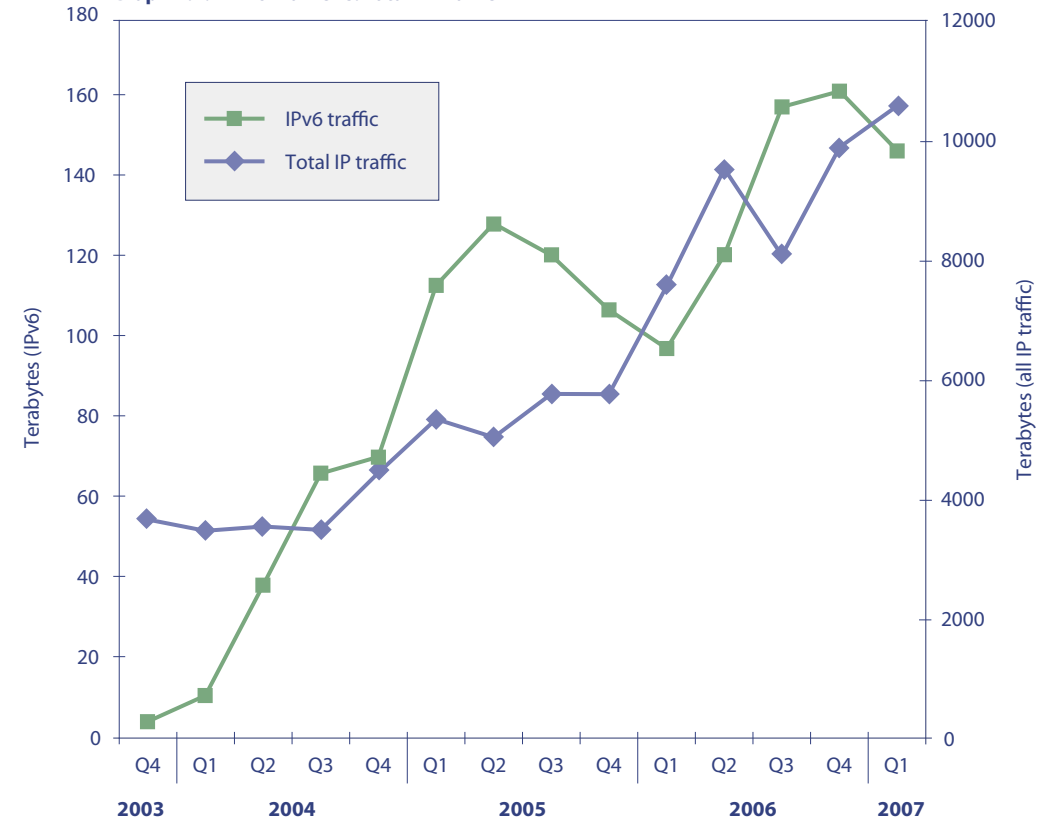
	EU/EFTA	Other countries
% of Universities per NREN with native IPv6 connectivity	28%	5%

Note that the spread between NRENs is considerable, ranging from NRENs with only a single University with native IPv6 connectivity to Hungary, where two-thirds of the Universities have this.

There are other indicators of the uptake of IPv6, particularly within the NREN community. The GÉANT monthly reports give the volume of IPv6 traffic for each NREN access (or group of NRENs, as in the case of NORDUnet).

Last year, the data seemed to suggest that the growth of IPv6 traffic on the GÉANT backbone had peaked. However, since then there has been some further growth. It now seems that the growth of IPv6 traffic is roughly proportional to the growth of IPv4 traffic. In 2006, the proportion of IPv6 traffic to IPv4 traffic was the highest in the 3rd quarter of 2006, with IPv6 traffic amounting to just under 2% of IPv4 traffic.

**Graph 4.4.2 IPv6 Traffic vs. Total IP Traffic<sup>3</sup>**



<sup>3</sup> Note that the scale for IPv6 traffic (at the left of the graph) is not the same as that for total IP traffic (at the right of the graph).





## 5 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 information about NREN work in nine service areas: Network Operations Centres (5.2), Authorisation and Authentication Infrastructure (5.3), Security Incident Response (5.4), Bandwidth on Demand (5.5), Premium IP (5.6), Grid Services (5.7), IP Telephony (5.8), User/client Support (5.9) and Other Services (5.10). The Compendium website provides more detailed information in a number of cases.

### 5.1 Overview

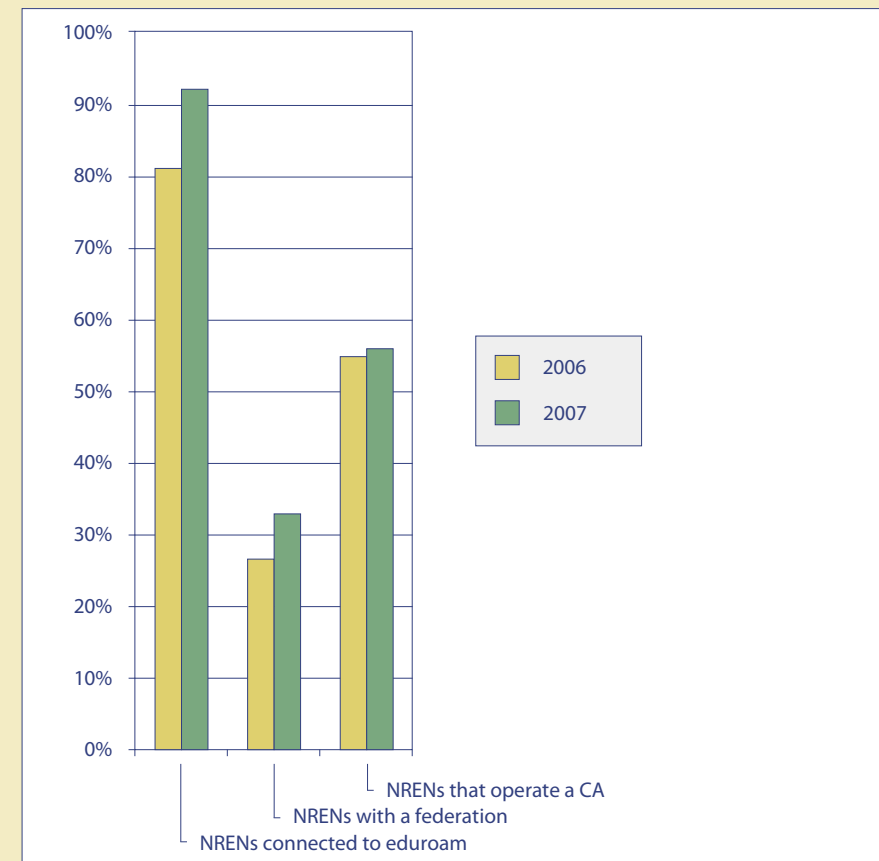
Layered services are receiving more and more attention from NRENs. There are a few trends that can be noted from the data:

- 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 the additional operational tasks within their conventional (IP) NOC. Others have separated these functions and may have outsourced some of these new tasks.
- There is an increased need for an authorisation and authentication infrastructure (AAI) in the NREN environment and many NRENs are taking steps to develop such an infrastructure. However, the work is by no means finished. Currently deployed AAI's have very different capabilities, ranging from simple username/password-based authentication systems to sophisticated middleware for granting or denying access to resources.
- There is renewed and increasing interest in the Public Key Infrastructure (PKI) area.

- Almost all NRENs from the EU/EFTA countries have now introduced eduroam®, a facility that provides roaming access for users to wireless networks.

The current uptake of AAI in the EU/EFTA countries can be summarised as follows:

**Graph 5.1.1 AAI in the EU/EFTA Countries**



- A related area is that of security incident response. The figures indicate that in this area, there is still a large gap between the EU/EFTA countries and the other countries in the region.
- Approximately 25% of the NRENs are currently offering a Bandwidth on Demand service; approximately the same percentage are planning to introduce it in the next two years, with a significant percentage of NRENs still in doubt.
- Grid services are currently running at most NRENs – several others are planning to introduce such a service. There has been a clear increase over the past year. A striking element in the responses is that the take up of Grid technology has spread beyond the initial high-energy physics and biomedical communities. All disciplines seem to be well represented.
- Several NRENs have introduced IP Telephony services on their network; however, the scale and types of implementation vary widely, depending on different national situations.

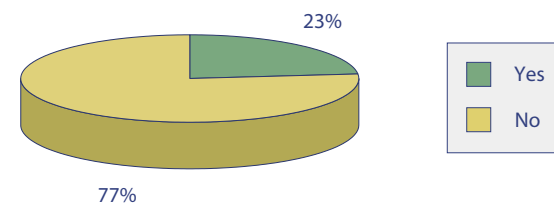
## 5.2 Network Operations Centres (NOCs)

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.

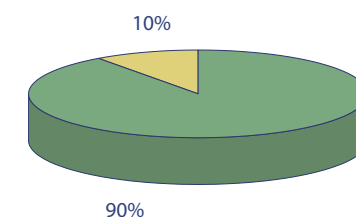
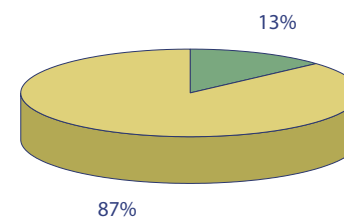
As more and more NRENs invest in dark fibre infrastructure, they are faced with the task of lighting the dark fibre and thus providing the necessary signalling at the transmission layer. Some NRENs have taken on the additional operational tasks within their conventional (IP) NOC. Others have separated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

In the EU and EFTA countries, 77% of the NOCs are not outsourced; in the other countries, 87% of the NOCs are not outsourced. Ninety percent of the NOCs in the EU and EFTA countries serve all of the NREN customers. In the other countries, this percentage is at 100% (pie chart not pictured). The Compendium website provides full country-by-country information.

**Graph 5.2.1 NOC Outsourced, EU/EFTA Countries**



**Graph 5.2.2 NOC Outsourced, Other Countries**      **Graph 5.2.3 NOC Serves All Customers, EU/EFTA Countries**



### 5.3 Authorisation and Authentication Infrastructure (AAI)<sup>1</sup>

Authorisation and Authentication have always been important topics at the campus level, with an emphasis for the last few years on campus-wide identity management systems.

An **identity management system (IdM)** is a system that combines technologies and policies to allow institutions to store users' personal information and keep them up-to-date. An IdM is the first building block to providing and controlling users' access to critical on-line resources whilst at the same time protecting resources from unauthorised access.

When an identity management system is used by different administrative domains within the same campus, it also reduces the overhead of user management when users move from one place to another.

The movement of users from one place to another makes it necessary to share resources between different administrative domains. At the same time, there is a need to reduce user management overheads. This has led to the creation of **federations**.

Within federations, individual entities agree to allow access to each others' resources; they adopt compatible technologies enabling them to do so. A federation makes it possible for end users to access information from another entity (which is also part of the federation) without the necessity of requesting new credentials from this entity. The benefit of this is a reduced number of credentials that users are requested to manage.

In addition, different federations can make agreements to share resources (known as **confederations**), but the workings of the requisite trust models and how to manage the increased complexity are still an open question.

This leads to an important new role for NRENs: facilitating such federations through harmonisation, standardisation and implementation of the necessary trust fabric.

The increased need for an Authentication and Authorisation Infrastructure (AAI) in NREN environments reflects a number of tendencies:

- Users travel more and demand to have their familiar environment, services and privileges available whenever they move from one site to another.
- The network, although still improving, has reached a good level of stability, so that it is becoming easier to offer reliable services.
- Security has become more important due to the increasing number of resources accessible on-line and the increasing level of sophistication of hackers.
- Various NRENs have been developing AA tools over the past few years; these tools are now stable enough to look for inter-operability among the various pieces and to try to seek harmonisation.
- Grid applications are being used by more scientists and due to the nature of Grids (typically distributed computers and resources in different geographical locations) authentication and authorisation play a key role.
- More generally, there is a need to share and to make accessible some very expensive publicly-funded resources.

AAI solutions can deliver significant service improvements and cost reductions, in particular, as key enablers of important continent-wide initiatives like the Bologna Process.

It is important to note that the currently deployed AAI's have very different capabilities, ranging from simple username/password-based authentication systems to sophisticated middleware for granting or denying access to resources.

<sup>1</sup> Text contributed by Licia Florio, TERENA

To address the need for an AA Infrastructure at European level, the GN2 project has set up a dedicated Joint Research Activity to focus on the creation of a European AAI infrastructure.

The following definitions have been developed in this Joint Research Activity:

- **Authentication:** The process of verifying the identity of an entity, either in person or electronically, where credentials are requested and checked to verify or disprove an entity's claimed identity;
- **AAI:** An infrastructure that supports Authentication and Authorisation Services. The minimum service components would be the management of identities and privileges specific to users or resources;
- **Authorisation:** The assignment of rights and capabilities granted to a specific principal (such as a person). Normally authorisation takes place when a user has been authenticated;
- **Federated AAI:** An AAI that supports multiple Identity and Privilege Providers, trusted by the members of the federation;
- **eduroam®** is the pan-European educational roaming infrastructure to provide wireless access to visited institutions. eduroam® allows users visiting another institution connected to eduroam® to log on to the WLAN using the same credentials he would use if he were at his home institution.

NRENs have been asked questions about their current AAI situation: whether they run the infrastructure or outsource it; what kind of AAI they have if they run a federation in the country and if so, whether it is Shibboleth-based or not; if the NREN uses a schema and if so, what kind it is; and if the NREN operates a Certification Authority (CA).

Table 5.3 summarises the results that have been received. The last column provides URLs to more information on NREN websites.

One of the trends is renewed and increasing interest in the PKI (Public Key Infrastructure) area. This is due to several factors, some of which are listed.

- One of the factors is the requirement for trust relationships when building federations; PKI is a good candidate to provide a high level of security. The increasing popularity of AA Infrastructures and **eduroam®** will most likely increase the demand for PKIs even more.
- The greater involvement of NRENs in Grid projects and the need to support Grid applications. The widest end-user PKI community is represented by Grid users, where the access to the Grid resources is granted to the users upon verification of their digital X.509 certificates. Many NRENs increased the operation of their sometimes dormant CAs or, in some cases, have established a CA to issue certificates to work with the Grid middleware.
- The demand for server certificates has increased over the last years, due to more demand for security triggered by awareness of possible security incidents when users access sensitive data on-line.

The other trend is a tendency to establish federations. Factors that drive this trend are listed above. Technology-wise, we see a convergence towards the same standards. This makes inter-operability among the various federations or parts of them much easier.

The following table shows another interesting and new result: many NRENs say that they are part of **eduroam®** and that they see this as a federation in their country.

As the table shows, almost all the EU/EFTA countries are connected to eduroam®. It is important to point out that Web-enabled infrastructures (like Shibboleth) and eduroam® are used for different purposes: the first provides federated access to applications, whereas eduroam® provides access to a (wireless) network.

NRENs that employ Web-enabled infrastructures or similar (like Shibboleth) technologies also need to define a national schema. The following table shows this.

Note that for many NRENs, AAI is still a relatively recent undertaking; therefore, not all NRENs have answered these questions.

**Table 5.3.1 AAI overview**

EU/EFTA Countries	NREN	AAI Managed by NREN or Outsourced?	AA Federation?	Schema Used / What Kind?	eduroam® <sup>2</sup>	Do You Run a CA?
Austria	ACOnet	outsourced	no		yes	no
Belgium	BELNET	nren	no		yes	yes
Bulgaria	BREN	nren	no		yes	yes
Cyprus	CYNET		no		no	no
Czech Republic	CESNET	nren	yes		yes	yes
Denmark	UNI-C	nren	no		yes	no
Estonia	EENet	nren	no		yes	yes
Finland	Funet	nren	yes	funet-edu-person	yes	no
France	RENATER	outsourced	no		yes	yes
Germany	DFN	nren	yes		yes	yes
Greece	GRNET	nren	yes		yes	yes
Hungary	NIIF/HUNGARNET	nren	no		yes	yes
Iceland	RHnet	nren	no		yes	no
Ireland	HEAnet	nren	no		yes	no
Italy	GARR	outsourced	no	-	yes	yes
Latvia	LATNET	nren	no		no	no
Lithuania	LITNET	nren	no		yes	yes
Luxembourg	RESTENA		no		yes	yes
Malta	CSC	nren	no		yes	no
Netherlands	SURFnet	nren	yes	tbd	yes	yes
Norway	UNINETT	nren	yes	Yes, eduPerson	yes	no
Poland	PIONIER	nren	no		yes	yes
Portugal	FCCN	nren	no		yes	no

<sup>2</sup> The column reports whether there is a national Top Level RADIUS Server in the country and whether it is connected to the European Top Level RADIUS Server operated on behalf of TERENA by SURFnet and UNI-C. All results in the table depict the situation as of March 2007.

**Table 5.3.1 AAI overview** - continued

EU/EFTA Countries	NREN	AAI Managed by NREN or Outsourced?	AA Federation?	Schema Used / What Kind?	eduroam®	Do You Run a CA?
Romania	RoEduNet	nren	no		yes	no
Slovakia	SANET		no		yes	no
Slovenia	ARNES	nren	yes	siEduPerson	yes	no
Spain	RedIRIS	nren	yes	LDAP-based (see <a href="http://www.rediris.es/ldap/esquemas/index.en.html">http://www.rediris.es/ldap/esquemas/index.en.html</a> )	yes	yes
Sweden	SUNET	outsourced	no		yes	yes
Switzerland	SWITCH	nren	yes	swissEduPerson derived from eduPerson	yes	yes
United Kingdom	JANET(UK)	nren	yes		yes	yes
<b>Other countries</b>						
Algeria	CERIST	nren	no		no	no
Azerbaijan	AzNET	nren	no		no	no
Croatia	CARNet	outsourced	no	Yes, hrEduPerson i hrEduOrg.	yes	no
Georgia	GRENA	nren	no		no	no
Israel	IUCC		no		no	yes
Macedonia	MARNet				no	
Moldova	RENAM	nren	no		no	no
Montenegro	MREN				no	no
Morocco	MARWAN		no		no	yes
Russia	RBNet/RUNNet	nren			no	no
Serbia	AMRES		no		no	
Turkey	ULAKBIM		no		no	yes
Ukraine	URAN	nren	no		no	no

## 5.4 Security Incident Response

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. In June 2007, a Security Service Specification for GÉANT has been published, as part of the GÉANT2 project.<sup>3</sup>

Table 5.4 summarises the information on whether security incident response is provided by the NREN itself, or if it has been 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.

**Table 5.4.1 Security Incident Response Teams**

	Security Incident Response by NREN	Outsourced
<b>EU/EFTA Countries</b>	89%	11%
(n=28)	Accredited CSIRT: 59%	
<b>Other Countries</b>	100%	0%
(n=11)	Accredited CSIRT: 10%	

## 5.5 Bandwidth on Demand

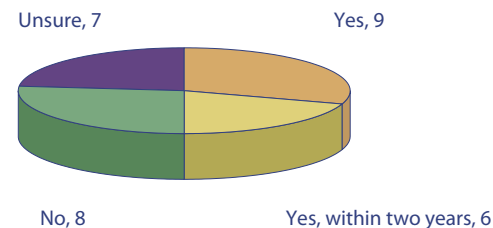
Bandwidth on demand (point-to-point dedicated bandwidth services at layer 2 or below) has been introduced as a new service as part of the GN2 project. The following table provides information on how many NRENs have introduced or are planning to introduce such a service. Some NRENs have definite plans for this, others would like to find out first what the demand is for such services. Others are not planning to introduce such a service.

Approximately 25% of the NRENs currently offer such a service; approximately the same percentage is planning to introduce it in the next two years, with a significant percentage of NRENs still in doubt.

**Table 5.5.1 Bandwidth on Demand**

Service offered		Service planned, within two years		Only if there is a demand	
Country	NREN	Country	NREN	Country	NREN
<b>EU/EFTA countries</b>					
Czech Republic	CESNET	Belgium	BELNET		
France	RENATER	Finland	Funet		
Germany	DFN	Norway	UNINETT		
Greece	GRNET	Romania	RoEduNet		
Ireland	HEAnet	Slovenia	ARNES		
Italy	GARR	Spain	RedIRIS		
Netherlands	SURFnet				
Poland	PIONIER				
United Kingdom	JANET(UK)				
<b>Other countries</b>					
Azerbaijan	AzRENA	Croatia	CARNet	Morocco	MARWAN
Russia	RBNNet/RUNNet	Macedonia	MARNet		
Ukraine	URAN	Moldova	RENAM		
		Turkey	ULAKBIM		

<sup>3</sup> Deliverable DJ2.3.2, see [http://www.geant2.net/upload/pdf/GN2-07-127v3-DJ2-3-2\\_Security\\_Service\\_Specification.pdf](http://www.geant2.net/upload/pdf/GN2-07-127v3-DJ2-3-2_Security_Service_Specification.pdf)

**Graph 5.5.2 Bandwidth on Demand, EU/EFTA Countries**

## 5.6 Premium IP

Premium IP is a service that ensures that specific traffic flows receive preferential treatment over non-specific flows. This service is now available on the GÉANT2 backbone but is offered by some NRENs as well<sup>4</sup>. Table 5.6.1 provides information on the current state of deployment of this service.

**Table 5.6.1 Premium IP service**

Country	NREN	Premium IP Service?	Can Users Make Advanced Reservations of PIP?	Offer Multi-domain PIP in Future?
<b>EU/EFTA Countries</b>				
Czech Republic	CESNET	yes	no	no
France	RENATER	yes	no	1 year
Greece	GRNET	yes	Yes, <a href="http://anstool.grnet.gr/">http://anstool.grnet.gr/</a>	1 year
Hungary	NIIF/HUNGARNET	no	no	1 year
Italy	GARR	yes	no	1 year
Latvia	LATNET	yes	no	3 years
Lithuania	LITNET	yes		1 year
Malta	CSC	yes		no
Portugal	FCCN	yes	no	no
Slovenia	ARNES	yes	yes	1 year
Spain	RedIRIS	no	no	3 years
<b>Other Countries</b>				
Georgia	GRENA	yes	no	no
Russia	RBNet/RUNNet	yes	no	
Turkey	ULAKBIM	no	no	3 years
Ukraine	URAN	yes	no	3 years

<sup>4</sup> See <http://www.geant2.net/server/show/conWebDoc.1603> for more information.



## 5.7 Grid Services<sup>5</sup>

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.

Table 5.7.1 gives information on whether or not Grid services are currently running over the NREN's network and if such services are planned over the next year or two. The table also lists who provides the Grid service – either the NREN itself, the institutions concerned together with the NREN, the concerned institutions alone, discipline-based groups, virtual organisations or some other body. The geographical extent of the service is also listed. The last column provides URLs to more information on NREN websites.

The data shows that Grid services are currently running in twenty-three (or 85%) of the EU/EFTA NRENs (two years ago, the figure was 56%); 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.

Table 5.7.1 provides an overview of the disciplines that are running Grid-enabled applications. Note that many NRENs indicate that they are not aware of Grid services in certain disciplines. That does not necessarily mean they do not exist; therefore, it seems clear that the responses given do not present the full picture.

The most striking element in the responses is that the uptake of Grid technology has spread very much beyond the initial high energy physics and biomedical communities. All disciplines seem to be well represented.

The answers in the following table are 'now' (service is currently running), 'planned' or a hyphen where the NREN is not currently aware of the situation in that discipline. Changes in comparison with last year have been highlighted.

<sup>5</sup> Information for this section has been contributed by John Dyer, TERENA

**Table 5.7.1 Disciplines That Are Running Grid-enabled Applications**  
(darker colour highlights a significant change)

Country	NREN	High-energy Physics	Other Physics	Computational Chemistry	Other Chemistry	Biomedical	Astroscience	Earth Science	Climatology	Arts and Humanities
<b>EU/EFTA Countries</b>										
Austria	ACOnet	now	-	-	-	now	now	now	now	
Belgium	BELNET	now	now	now	-	now	-	now	now	-
Bulgaria	BREN	now	now	planned	planned	now	-	-	-	-
Cyprus	CYNET	planned	planned	-	-	now	-	now	now	now
Czech Republic	CESNET	now	now	now	now	planned	now	planned	-	-
Denmark	UNI-C	planned	-	-	-	planned	-	-	-	
Estonia	EENet	now	now	now	now	now	planned	-	planned	planned
Finland	FUNET	now	now	now	planned	now	now	planned	planned	-
France	RENATER									
Germany	DFN	now	-	-	-	-	now	now	now	now
Greece	GRNET	now	now	now	-	now	now	now	now	now
Hungary	NIIF/HUNGARNET	now	now	now	now	now	now	now	planned	
Ireland	HEAnet	now	now	now	now	now	now	now	now	-
Italy	GARR	now	now	now	now	now	now	now	planned	planned
Latvia	LATNET	-	now	-	planned	planned	planned	-	-	
Lithuania	LITNET	now	now	-	-	planned	planned	now	-	now
Malta	CSC	planned				now		planned		
Netherlands	SURFnet	now	now	-	-	planned	now	-	planned	-
Norway	UNINETT	now	planned	planned	-	-	planned	planned	planned	-
Poland	PIONIER	now	now	now	-	now	now	now	now	now
Portugal	FCCN	planned				planned	planned		planned	
Romania	RoEduNet	planned	planned	planned	-	-	-	planned	planned	
Slovenia	ARNES	now								
Spain	RedIRIS	now	now	now	now	now	now	now	now	planned

Country	NREN	High-energy Physics	Other Physics	Computational Chemistry	Other Chemistry	Biomedical	Astroscience	Earth Science	Climatology	Arts and Humanities
<b>EU/EFTA Countries</b>										
Sweden	SUNET	now	now	now	-	now	now	now	planned	
Switzerland	SWITCH	planned	-	-	-	planned	-	-	planned	-
United Kingdom	JANET(UK)	now	now	now	now	now	now	now	now	
<b>Total</b>	<div> <div></div> Now <div></div> Planned <div></div> Don't know </div>									
<b>Other Countries</b>										
Algeria	CERIST	planned	planned	planned	planned	planned	-	planned	planned	
Croatia	CARNet	now	now	now	now	now	planned	planned	planned	planned
Georgia	GRENA	planned			planned	planned	planned			
Israel	IUCC	now	-	-	-	planned	-	planned	-	
Macedonia	MARNet			planned		now		planned		
Moldova	RENAM	planned	-	-	-	planned	-	planned	planned	-
Morocco	MARWAN	planned	now	planned	-	now	planned	now	now	planned
Russia	RBNet/RUNNet	now	now	-	-	-	now	now	now	-
Serbia	AMRES	planned	planned	-	-	-	-	-	-	
Turkey	ULAKBIM	now	now	now	planned	now	now	now	planned	planned
<b>Total</b>	<div> <div></div> Now <div></div> Planned <div></div> Don't know </div>									

## 5.8 IP Telephony<sup>6</sup>

Table 5.8 summarises the answers that were received with respect to IP Telephony deployments. The last column provides URLs to additional information on particular deployments from the NREN websites.

56% of the EU/EFTA countries reported IP Telephony deployments (a slight increase from last year), but it should be noted that 85% of these deployments were isolated islands of VoIP. This is not surprising: VoIP telephony has proven to be successful within enterprise environments, but in many cases these deployments are connected to the outside world through gateways to PSTN lines. In the particular case of NRENs as service providers for a large community of users, peering at VoIP level with a commercial provider is highly dependent on national legislation and policies.

In addition to the standards-based IP Telephony services, the 2007 Compendium gathered data about the support for two experimental (or pilot) services: sip.edu and nrenum.net. In an IP Telephony context, the SIP.edu initiative (started by Internet2) allows for an email address in an incoming SIP call to be translated to a PSTN phone number associated to a particular user. ENUM (Electronic Numbering, RFC 3761) defines how a telephone number could be translated onto a domain name accessible via standard DNS technology within the e164.arpa

**Table 5.8.1 IP Telephony**

Country	NREN	Running IP Telephony?	Pilot Services?	Interconnection of IP Telephony?	URL to More Information
<b>EU/EFTA Countries</b>					
Austria	ACOnet	no			<a href="http://www.at43.at/">http://www.at43.at/</a>
Belgium	BELNET	yes		no	
Bulgaria	BREN	no			
Cyprus	CYNET	no		no	
Czech Republic	CESNET	yes	sip.edu	yes	<a href="http://www.ces.net/project/05/">http://www.ces.net/project/05/</a>
Denmark	UNI-C	no			
Estonia	EENet	yes		no	
Finland	FUNET	no		no	
France	RENATER	yes			
Germany	DFN	no			
Greece	GRNET	yes	nrenum.net, sip.edu	no	<a href="http://www.grnet.gr/index.php?op=modload&amp;module=Sitemap&amp;action=sitemapviewpage&amp;pageid=198&amp;language=en">http://www.grnet.gr/index.php?op=modload&amp;module=Sitemap&amp;action=sitemapviewpage&amp;pageid=198&amp;language=en</a>
Hungary	NIIF/HUNGARNET	yes	nrenum.net	yes	<a href="http://www.voip.niif.hu/">http://www.voip.niif.hu/</a>
Iceland	RHnet	no		no	
Ireland	HEAnet	no			
Italy	GARR	yes	nrenum.net	no	<a href="http://www.garr.it/voIP/">http://www.garr.it/voIP/</a> (in Italian)
Latvia	LATNET	no			
Lithuania	LITNET	yes		no	
Luxembourg	RESTENA	yes		no	
Malta	CSC	no			
Netherlands	SURFnet	yes	nrenum.net, sip.edu	yes	<a href="http://groepscommunicatie.surfnet.nl">http://groepscommunicatie.surfnet.nl</a>
Norway	UNINETT	yes	sip.edu	yes	<a href="http://forskningstnett.uninett.no/sip/">http://forskningstnett.uninett.no/sip/</a>
Poland	PIONIER	yes			
Portugal	FCCN	yes		no	
Romania	RoEduNet	yes		no	
Slovakia	SANET	yes	nrenum.net	yes	

<sup>6</sup> Text contributed by Cătălin Meiroșu, TERENA.

Country	NREN	Running IP Telephony?	Pilot Services?	Interconnection of IP Telephony?	URL to More Information
<b>EU/EFTA Countries</b>					
Slovenia	ARNES	no		no	
Spain	RedIRIS	no	nrenum.net	no	
Sweden	SUNET	yes			<a href="http://basun.sunet.se/aktuell/ITtelupph.html">http://basun.sunet.se/aktuell/ITtelupph.html</a>
Switzerland	SWITCH	yes	sip.edu	no	
United Kingdom	JANET(UK)	yes			<a href="http://www.ja.net/development/voip/">http://www.ja.net/development/voip/</a>
<b>Other Countries</b>					
Algeria	CERIST	no			
Azerbaijan	AzNET	no		no	
Croatia	CARNet	yes		yes	
Georgia	GRENA	no			
Israel	IUCC	no		no	
Macedonia	MARNet	no			
Moldova	RENAM	no		no	N/A
Montenegro	MREN	no		no	
Morocco	MARWAN	no			
Russia	RBNet/RUNNet	no			
Serbia	AMRES	no			
Turkey	ULAKBIM	yes		no	
Ukraine	URAN	no			

domain. For NRENs in countries where the e164.arpa domain is not available yet, the nrenum.net initiative provides a possibility to publish ENUM data in an alternative domain (nrenum.net). This allows VoIP service administrators to experiment with ENUM deployments and prepare for the moment when the e164.arpa tree will be available in their countries. Currently, 15% of the EU/EFTA countries participate in the nrenum.net trials.

## 5.9 User/client Support

Not all NRENs have interpreted this question in the same way; some NRENs (such as JANET(UK)) understood the question to refer to end users, while others took it to refer to institutional clients as well.

**Table 5.9.1 User/client support**

Country	NREN	Support for specific groups of users?	Details	National User Conference, when?	Training courses?	URL		
EU/EFTA Countries								
Austria	ACOnet	no						
Belgium	BELNET	yes	For example: * Experimental collaboration: free connection to the backbone for collaboration research groups who do research on new network technology (project -based) * Provide fibre connection for schools of higher education (ISCED level 5 & 6) in collaboration with co-financing with regional governing bodies	yes	annually in Q4	yes	For example: layer 2 VPN's, CSIRT training, Multicast, Ipv6, eduroam®, ... (around 6 a year)	<a href="http://support.belnet.be">http://support.belnet.be</a>
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	May	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>	<a href="http://www.ces.net/">http://www.ces.net/</a>
Denmark	UNI-C	no						
Estonia	EENet	yes	Teachers' webpages dedicated to educational content	no		no		<a href="http://www.eenet.ee/EENet/koolielu_eng.html">http://www.eenet.ee/EENet/koolielu_eng.html</a>
Finland	Funet	yes	University security managers; VideoFunet (video conference and distance learning staff); campus AAI managers; university/polytechnic IT director's groups/meetings; "Funet club" (informal association and discussion group for member organisations, representatives are IT managers/directors)	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>	<a href="http://www.csc.fi/english/funet/about/customers">http://www.csc.fi/english/funet/about/customers</a>

Country	NREN	Support for specific groups of users?	Details	National User Conference, when?	Training courses?	URL		
EU/EFTA Countries								
France	RENATER	yes		yes	every 2 years, in October or November see www.jres.org	yes	<a href="http://www.renater.fr/spip.php?rubrique45&amp;lang=en">http://www.renater.fr/spip.php?rubrique45&amp;lang=en</a>	
Germany	DFN	no		no		no		
Greece	GRNET	yes	The aim of the user support service (Helpdesk) is to manipulate 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://www.grnet.gr/g-tech/">http://www.grnet.gr/g-tech/</a>	
Hungary	NIIF/HUNGARNET	yes	Special Sections of Hungarnet	yes	April or May each year	yes	<a href="http://vod.niif.hu/index.php?lg=en&amp;mn=archive&amp;eid=63&amp;sm=listevent">http://vod.niif.hu/index.php?lg=en&amp;mn=archive&amp;eid=63&amp;sm=listevent</a>	
Iceland	RHnet	no		no		no		
Ireland	HEAnet	yes	NDLR - digital learning repository, supporting communities of practice CHEC - high-end computing users LIR - librarians' user group Geo Storage Health Atlas - run by the national Health Service Executive	yes	November	yes		
Italy	GARR	yes	GRID users Laura.Leone@garr.it Arts, Humanities, Social Sciences, Medial Sciences Claudio.Allocchio@garr.it	yes	Normally in June, in 2007 in October.	yes	<a href="http://www.garr.it/workshop/garr-b-workshop.shtml">http://www.garr.it/workshop/garr-b-workshop.shtml</a>	
Latvia	LATNET	no		no		yes	<a href="http://bgss2007.lumii.lv/">http://bgss2007.lumii.lv/</a>	
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	CSC	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/info/bijeenkomsten/home.jsp">http://www.surfnet.nl/info/bijeenkomsten/home.jsp</a>	
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,	

Table 5.9.1 - continued

Country	NREN	Support for specific groups of users?	Details	National User Conference, when?		Training courses?		URL
EU/EFTA countries								
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	yes	once a year	no		
Romania	RoEduNet			yes		yes	<a href="http://netacad.iasi.roedu.net/">http://netacad.iasi.roedu.net/</a>	
Slovakia)	SANET	no						
Slovenia	ARNES	yes	Help desk for individual users, technical support for organisations	yes	April	yes	Workshops on videoconferencing, wireless networks and computer security.	<a href="http://www.arnes.si/help/">http://www.arnes.si/help/</a> , <a href="http://www.arnes.si/dostop/organizacije/">http://www.arnes.si/dostop/organizacije/</a>
Spain	RedIRIS	yes	Upon specific requests. The requesting activity must be covered by a project funded by the Local or National Governments or the EC.	yes	Autumn	yes	Specific hands-on courses in particular technologies: IDS, AAI, Grid,...	
Sweden	SUNET	no		yes	In April and October	yes		
Switzerland	SWITCH	yes	We organise 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	no		<a href="http://econf.switch.ch">http://econf.switch.ch</a>
United Kingdom	JANET(UK)	no		no	We organise an annual technical workshop each year plus a number of specific one day events on different technical subjects	yes	<a href="http://www.ja.net/services/training/index.html">http://www.ja.net/services/training/index.html</a>	
Other countries								
Algeria	CERIST	no						
Azerbaijan	AzNET	yes		no		yes	<a href="http://www.aznet.org/">http://www.aznet.org/</a>	<a href="http://www.erider.aznet.org/">http://www.erider.aznet.org/</a>
Croatia	CARNet	no		yes	During November each year	yes	<a href="http://www.carnet.hr/edupoint">http://www.carnet.hr/edupoint</a>	
Georgia	GRENA	yes	secondary schools	no		yes	Cisco Academy IT essentials, CCNA	<a href="http://hotline.grena.ge/">http://hotline.grena.ge/</a>
Israel	IUCC	no						
Macedonia	MARNet			no		no		



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 it's 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	<a href="http://cert.acad.md">http://cert.acad.md</a>
Montenegro	MREN	no		no	no	
Morocco	MARWAN	no		yes Every Year in May-June	yes <a href="http://www.marwan.ma/jm2007">http://www.marwan.ma/jm2007</a>	
Russia	RBNet/RUNNet	yes	school sector	yes 2 times a year June and October	yes <a href="http://www.runnet.ru/news/59/">http://www.runnet.ru/news/59/</a>	<a href="http://school-sector.relarn.ru/prava/index.html">http://school-sector.relarn.ru/prava/index.html</a>
Serbia	AMRES	yes	helpdesk department works 365 days a year, 24/7.	no		
Turkey	ULAKBIM	no		yes February	yes Training courses according to the needs of end users in ad hoc basis.	
Ukraine	URAN	no		yes each april	yes <a href="http://www.i-master.uran.net.ua/">http://www.i-master.uran.net.ua/</a>	

## 5.10 Other services

Table 5.10 below provides information on distributed storage, mirroring services and other services being offered by NRENs. Note that especially the area of distributed storage is a very dynamic one and the information contained here only provide information that was valid in the spring of 2007.

**Table 5.10.1 Other services**

Country	NREN	Distributed Storage?	Mirroring Services?	Brief Description / URL	Other Services
<b>EU/EFTA Countries</b>					
Austria	ACOnet	no	no		
Belgium	BELNET	no	yes	ftp.belnet.be	Distributed storage should be offered later this year.
Bulgaria	BREN	no	no		
Cyprus	CYNET	no	no		
Czech Republic	CESNET	yes	no	part of the national grid activities, <a href="http://meta.cesnet.cz">http://meta.cesnet.cz</a> ; more extensive deployment planned	To some universities we offer (as a pilot) backup services (to some extent part of the grid services). Started to offer operation of local clusters (when they are incorporated into the national grid infrastructure) -- currently three such clusters (three different organisations) integrated
Denmark	UNI-C	no	no		
Estonia	EENet	no	no		
Finland	Funet	no	no		national video conference gatekeeper service "Value added" services for emailWiki/AAI integration
France	RENATER	no	no		We run a GIX located in 2 PoPs (called SFINX) and we host anycast copies of root servers on the SFINX
Germany	DFN		no		
Greece	GRNET	no	no		videoconference QoS: <a href="http://rts.grnet.gr/vc-qos.php">http://rts.grnet.gr/vc-qos.php</a> Multilayer Network Mapping: <a href="http://netmon.grnet.gr/networkmap/">http://netmon.grnet.gr/networkmap/</a> JRA3 pilot BOD Services: <a href="http://anstool.grnet.gr">http://anstool.grnet.gr</a>
Hungary	NIIF/HUNGARNET	yes	yes	storage: <a href="http://www.niif.hu/en/storagemirroring">http://www.niif.hu/en/storagemirroring</a> services: Mirror servers operated beyond the Hungarian border providing easy access to the contents of the Hungarian Digital Library (MEK).	see <a href="http://www.niif.hu">http://www.niif.hu</a>
Iceland	RHnet	no	yes	<a href="http://ftp.rhnet.is">http://ftp.rhnet.is</a>	
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>	large file transfer, distributed storage, high definition video conferencing, client Wiki, security scanning, IPTV, commodity IP
Italy	GARR	no	yes	<a href="http://mirror.garr.it">http://mirror.garr.it</a>	A pilot implementation for an AAI Federation (based on Shibboleth) is under way.

Country	NREN	Distributed Storage?	Mirroring Services?	Brief Description / URL	Other Services
<b>EU/EFTA Countries</b>					
Latvia	LATNET	no	no		hosting and colocation
Luxembourg	RESTENA	no	no		
Malta	CSC	no	no		
Netherlands	SURFnet	no	yes	<a href="http://www.surfnet.nl/info/diensten/cc/ftp.jsp">http://www.surfnet.nl/info/diensten/cc/ftp.jsp</a>	dynamic lightpaths
Norway	UNINETT	yes	no		under establishment
Poland	PIONIER	yes	yes		
Portugal	FCCN	no	no		distributing storage and mirroring services
Romania	RoEduNet	no	yes	<a href="http://ftp.iasi.roedu.net/">http://ftp.iasi.roedu.net/</a>	
Slovakia	SANET	no	no		
Slovenia	ARNES	no	yes	<a href="ftp://ftp.arnes.si/">ftp://ftp.arnes.si/</a>	
Spain	RedIRIS	no	yes	<a href="http://ftp.rediris.es/">http://ftp.rediris.es/</a>	a federated portal for multimedia content access ( <a href="http://www.rediris.es/pruebas/arca/">http://www.rediris.es/pruebas/arca/</a> )
Sweden	SUNET	no	no		
Switzerland	SWITCH	no	yes	<a href="http://mirror.switch.ch/">http://mirror.switch.ch/</a>	learning object repository services for the management of virtual organizations
United Kingdom	JANET(UK)	no	yes	It is going to be stopped as of July 2007	There are a number of services being developed such as the SMS and TALK services but they are in procurement.
<b>Other Countries</b>					
Algeria	CERIST	no	no		
Azerbaijan	AzNET	no	no		
Croatia	CARNet	no	yes		
Georgia	GRENA	no	no		
Israel	IUCC	no	no		
Moldova	RENAM	no	no		web hosting, instrumental support, advanced network monitoring services (NetIIS)
Morocco	MARWAN	no	no		
Russia	RBNNet/RUNNet	no	yes	Traffic and equipment control based on smtp, netflow etc.	
Turkey	ULAKBIM	no	yes	<a href="ftp.ulakbim.gov.tr">ftp.ulakbim.gov.tr</a>	
Ukraine	URAN	no			



## 6 TASKS, STAFFING, FUNDING

Note that some NRENs provide services only to the research 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 of the research or education communities. For the sake of comparability, we have 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 (6.1), section 6.2 provides information about various aspects of NREN Staffing. Section 6.3 deals with NREN Budgets and 6.4 and 6.5 provide more information about Income Sources and Expenditure Categories, respectively. Lastly, section 6.6 provides information about how different network levels are funded in different NRENs.

### 6.1 Overview

It is almost impossible to compare NRENs by staff or budget size. This is because NREN budgets are structured differently, NRENs have different tasks in different countries and the same things are not funded through the NREN budget in the same way in different countries.

Section 6.2 details the considerable differences in the number of staff NRENs have and the types of staff they employ, and provides some factors that explain these differences.

Section 6.3 provides similar information for NREN budgets. It explains that NREN budgets may fluctuate considerably from year to year and that they cover different things in different countries.

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 and graph, which show 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 that have been explained, this graph is not suitable for making direct comparisons between NRENs.

**Table 6.1.1 Traffic Growth and Budget Growth, 2003 - 2007**

	Total traffic, 2003 (TB)	Total traffic, 2007 (TB)	Total budgets, 2003 (MEUR)	Total budgets, 2007 (MEUR)	Traffic increase, 2003 – 2007	Budget increase, 2003 - 2007
<b>EU/EFTA Countries</b>	34,715	108,222	311	330	212%	6%
<b>Other Countries</b>	3,208	8,338	31	41	160%	32%
<b>All Countries<sup>1</sup></b>	37,922	116,561	342	372	207%	9%

<sup>1</sup> For countries with available data for both years.

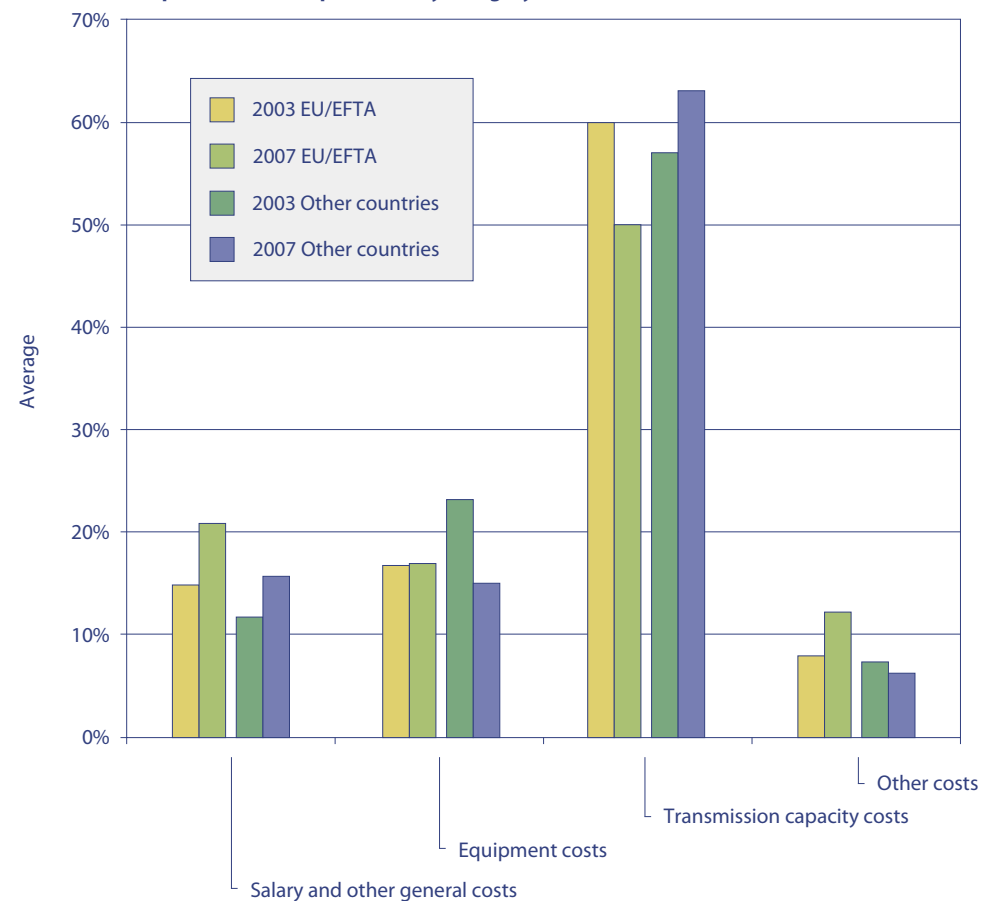
The situation is not as clear in the less developed NRENs. There, new possibilities for significantly upgrading international bandwidth (for example, under the GN2, EUMEDCONNECT or SEEREN projects) could act as a catalyst for increased national NREN budgets.

The data suggests that in these countries a modest increase in budget leads, in many cases, to a great leap in traffic. However, as is clear from Chapter 5, often there is not yet a commensurate increase in services.

It is possible to examine average expenditure of all NRENs and its evolution over time. Graph 6.1.2 presents the average expenditure by category for the EU/EFTA and other countries in 2003 and 2007.

The graph shows that for the EU/EFTA countries, the expenditure on salaries has gone up. This seems to be in line with the increased attention to services. On the other hand, the expenditure on transmission capacity has gone down. The dramatic increases in capacity over the past five years has been coupled with a decrease in costs. For the other countries, expenditure on transmission capacity has gone up. However, in those countries in general the jump in capacities has been even more pronounced than in the EU/EFTA countries.

**Graph 6.1.2 Total Expenditure by Category, 2003 and 2007**



## 6.2 Staffing

Since many NRENs contract out part of their work, staff size is not a reliable measure of the amount of person-power that is available to an NREN. This section gives an overview of the staff that is directly employed in NREN activities, plus subcontracted staff, in Full Time Equivalents (FTE).

Graph 6.2.3 provides that information specifically for technical staff.

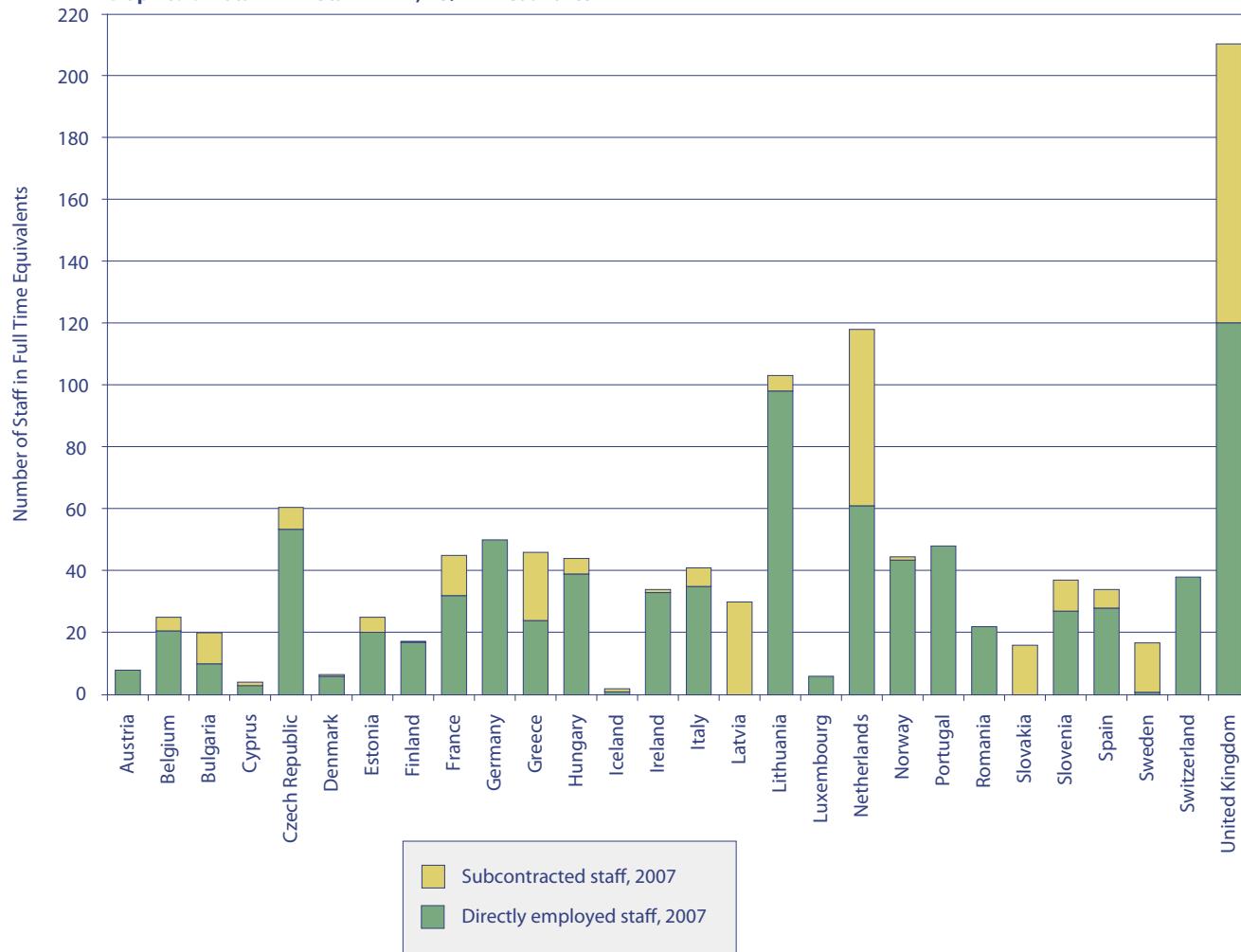
The graphs demonstrate considerable differences in the size of staff NRENs have and in the types of staff they employ.

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.

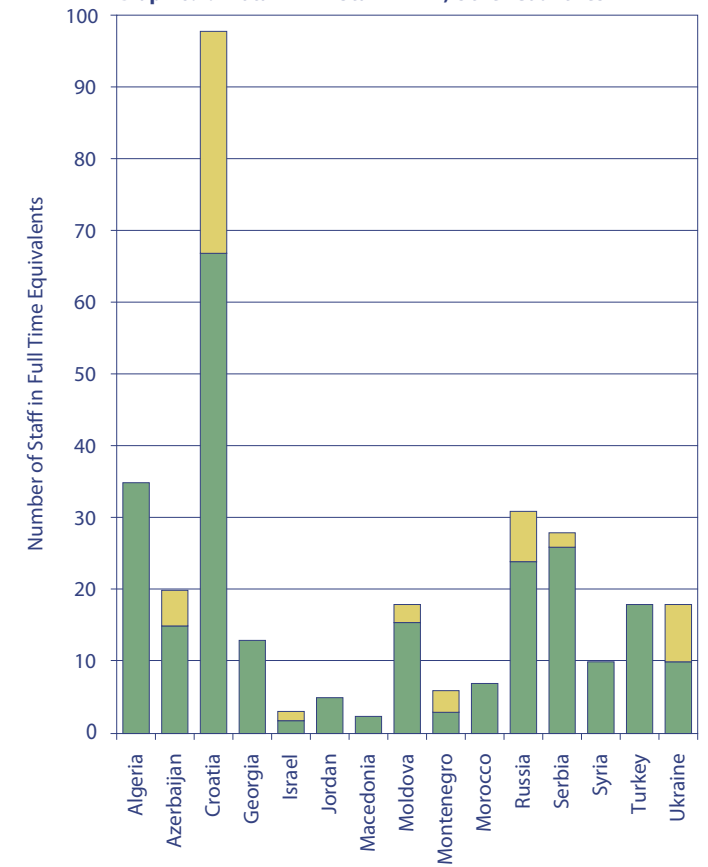
In addition, it should be noted that the tasks performed by individual NRENs are very different. Some NRENs, for example, provide connection to Metropolitan Area Networks or to Access Networks, who, in turn, connect the institutions. Other NRENs connect institutions directly and some also manage MANs themselves. Also, the connection policies of NRENs (see 2.2) are different, for example with respect to secondary and primary schools. 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. Of course, this can also have an important effect on necessary staff levels.

Graph 6.2.1 Total NREN Staff in FTE, EU/EFTA Countries

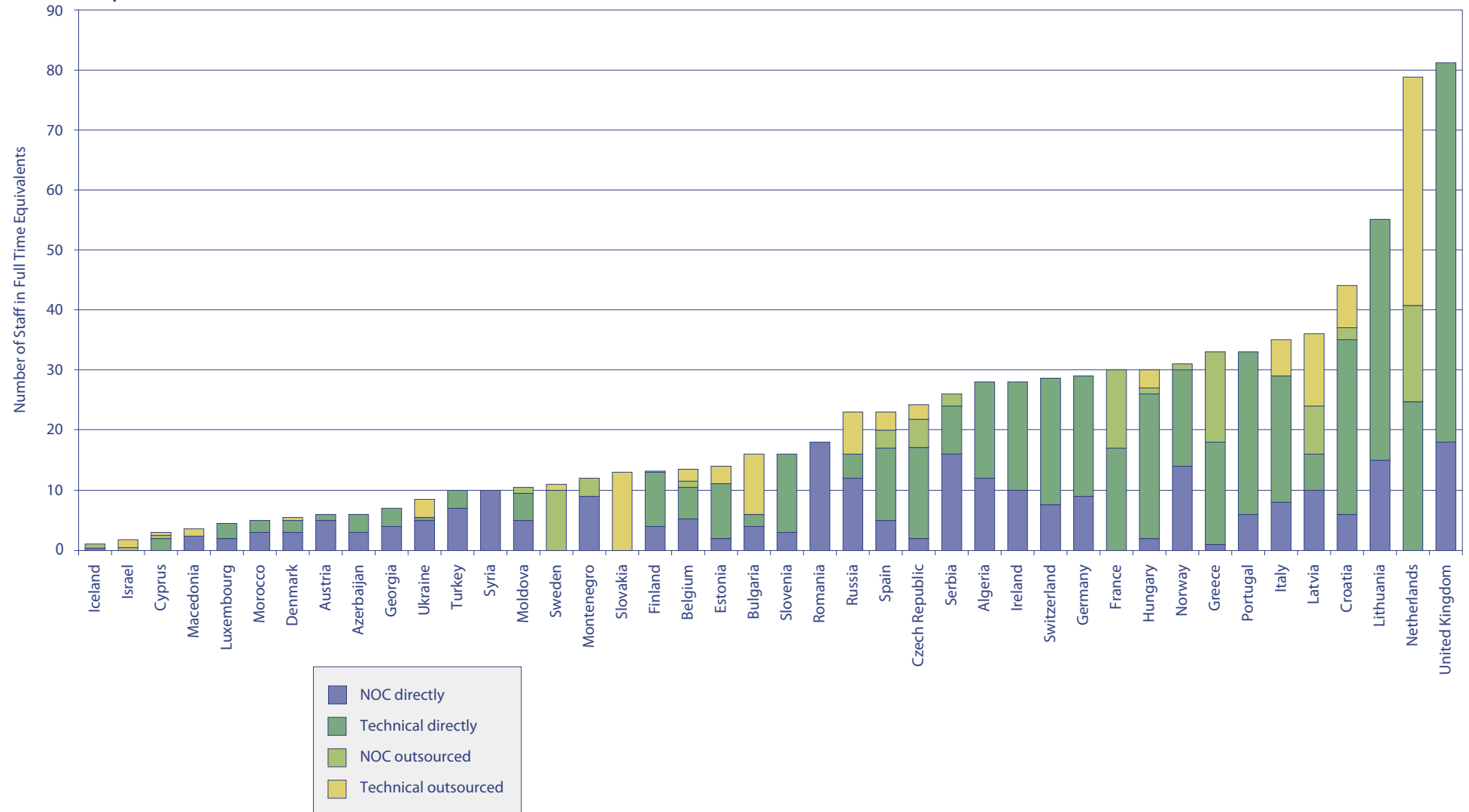


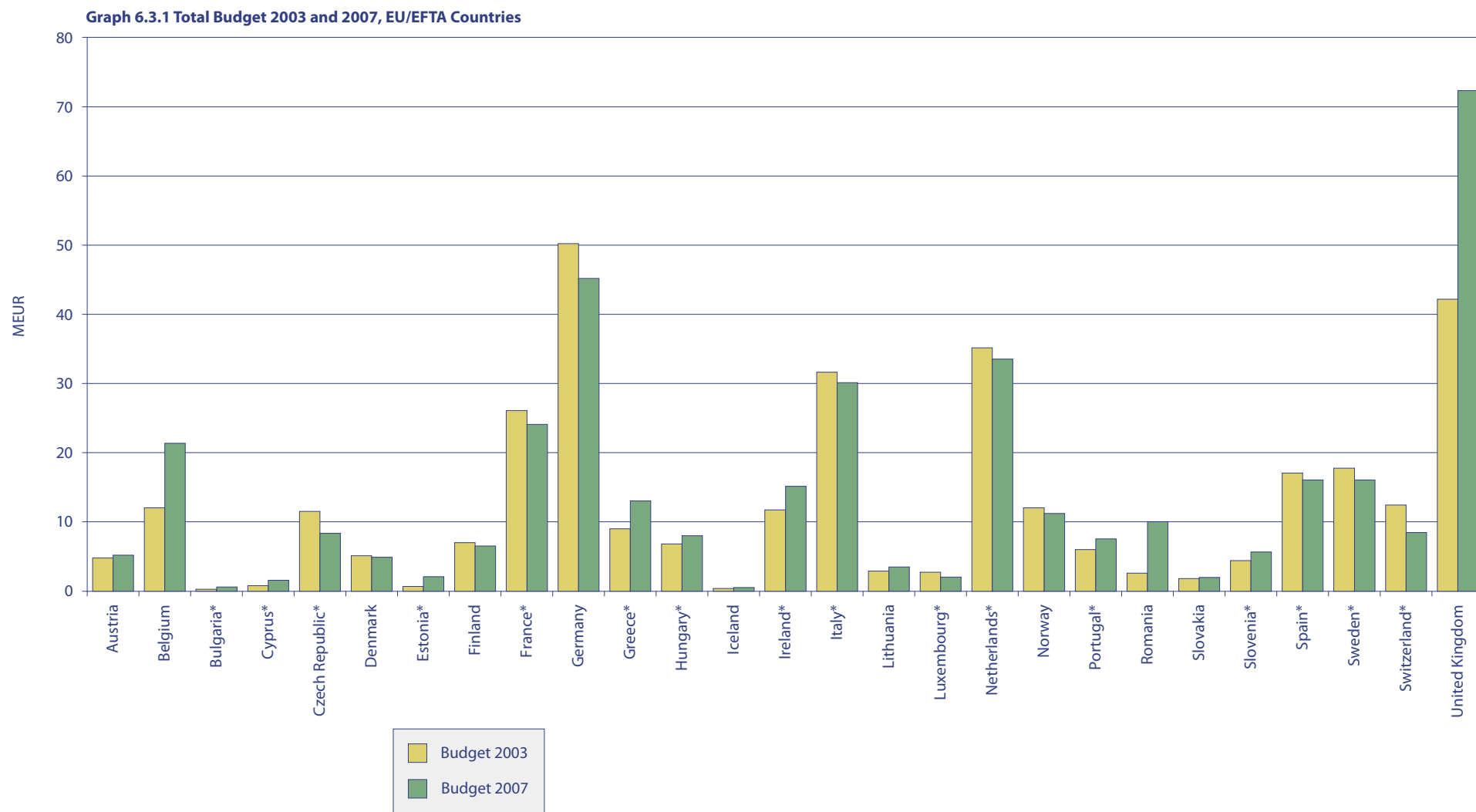
Graph 6.2.2 Total NREN Staff in FTE, Other Countries





Graph 6.2.3 NREN Technical Staff in FTE





\* Budget includes GÉANT subsidy.

## 6.3 Total Budgets, 2003 and 2007

The following graphs give the total NREN budgets for 2003 and 2007.

NREN budgets may fluctuate from year to year, because investments can vary considerably. Note that the budget year of CERIST (Algeria) runs from March to February; while that of JANET(UK) runs from August to July. In those cases, the 2007 budget is really the 2007/2008 figure.

As explained in section 6.2, NRENs have many different tasks and are organised in different ways. Some NRENs provide services only to the research or education communities in their country. Others provide additional services as well; for example, they administer the country-code top-level domain or they connect others who are clearly outside of 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.

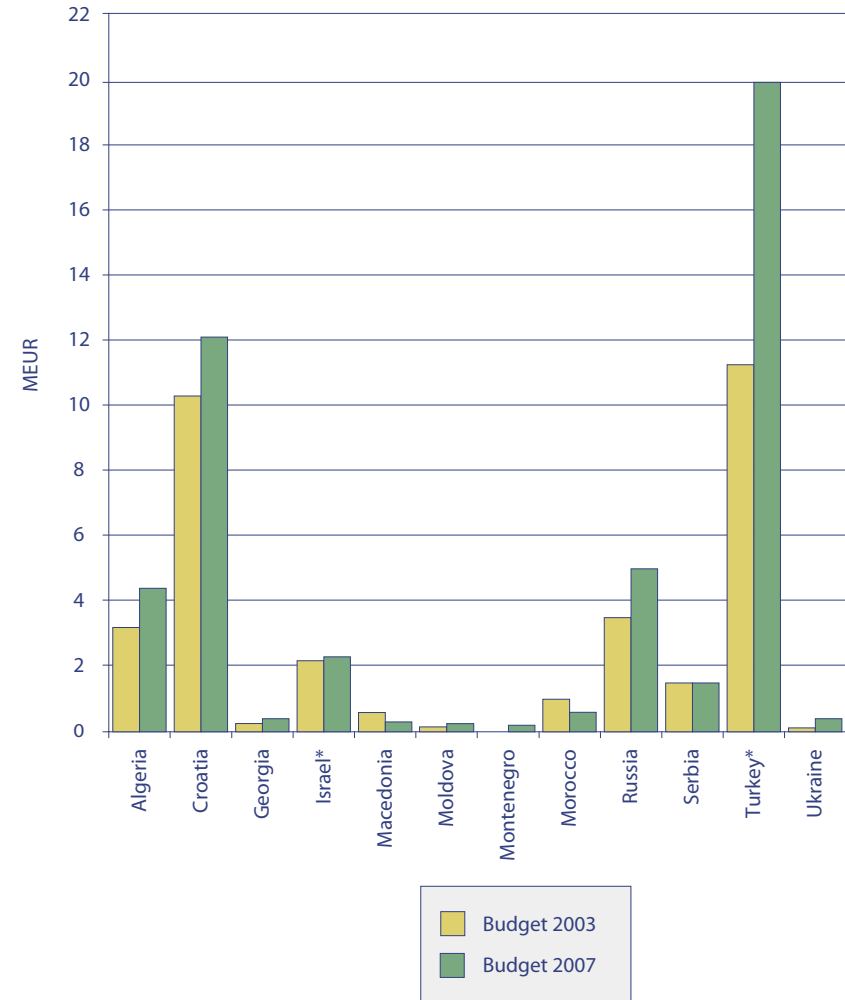
Even so, a comparison between the budgets of different NRENs is fraught with difficulty. We have asked NRENs if the budget figure given includes the EU grant for the GÉANT activity - for some NRENs, this grant is shown in the budget. For others, it appears as a reduced cost and is not shown in the budget.

In graphs 6.3.2 and 6.3.4, the NRENs that include the GÉANT subsidy in their budget have been marked with an asterisk. As can be seen in 6.4, the proportion of funds received from the EU (not always for GÉANT only) varies considerably between NRENs.

There are also 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 PoP; 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 6.4, it appears that some NRENs do not spend money on salaries. Yet,

Graph 6.3.2 Total Budget, 2003 and 2007, Other Countries



they do have staff, but the staff is not paid from the NREN budget. Similar situations may apply for other budget categories as well.

\* Budget includes GÉANT subsidy.

## 6.4 Income Sources

NRENs are funded in different ways: some receive all of their funding directly from the national government (RoEduNet of Romania, 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, JUNet of Jordan). Many varieties exist in between those extremes. Graphs 6.4.1 and 6.4.2 give information on what percentage of NREN funds come from which source. Note that in many cases (see also graph 6.3.1 and 6.3.2) 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 innovation 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.

The SERENATE studies provided a more general analysis of NREN funding models, which still seems relevant to quote here:

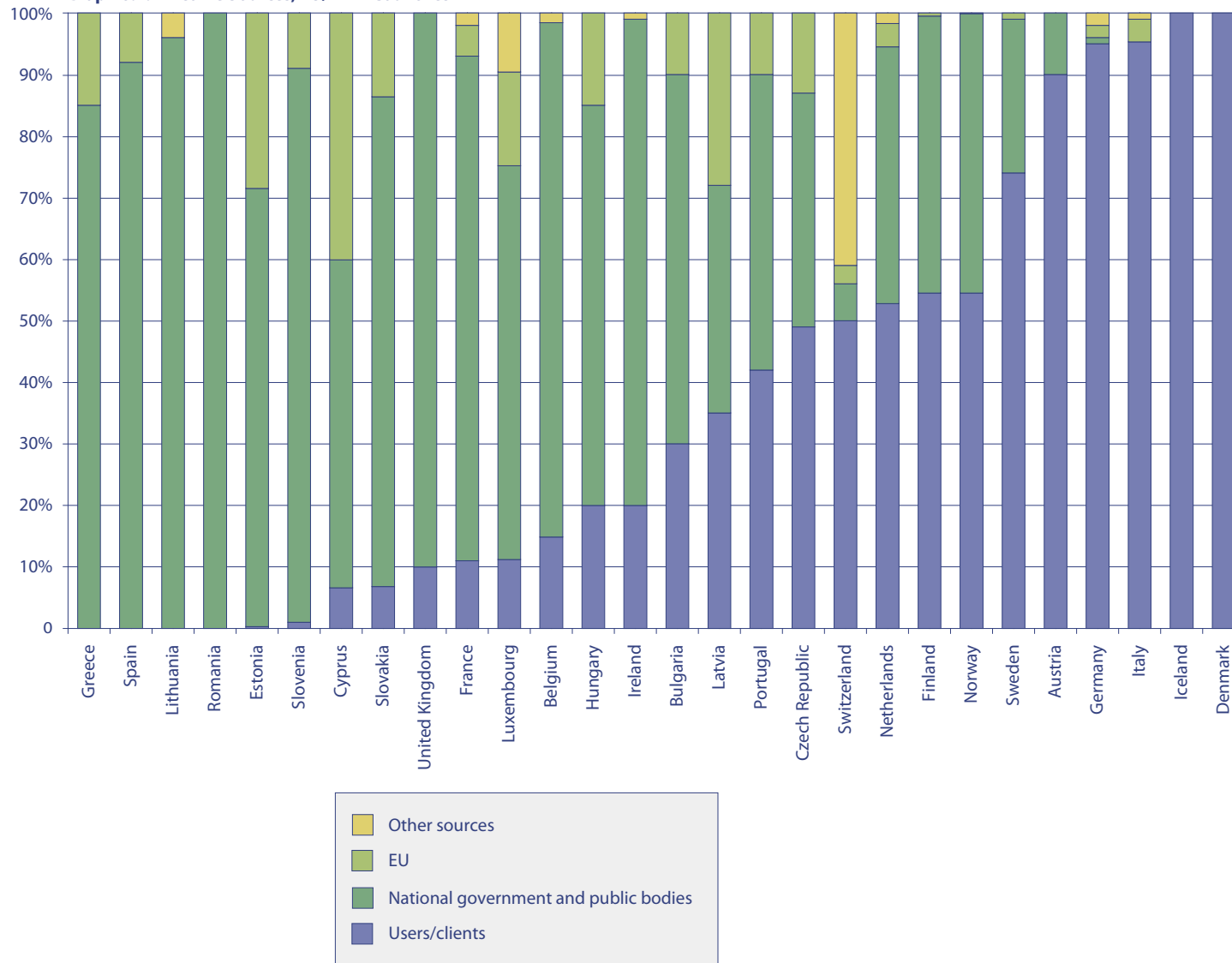
*"Central funding can be very appropriate in three cases. When an NREN is in its start-up phase, it can be helpful if all necessary funding is provided centrally, since decisions can then be taken quickly. There may also be an argument for central funding of research networks in countries that are economically less developed or where funding for research and/or education is under strong pressure, because there may then be particular problems to strike the correct balance between essential network infrastructure and equally important improvements to other poorly funded activities. Finally, central funding may be appropriate for the testing of new technologies and the development of new services that are for the long-term benefit of users in general, but bring no direct short-term return to individual connected institutions.*

*Funding through the connected institutions, either on the basis of their access capacity or on the basis of actual use (or a combination of both), has the advantage that it provides a strong incentive to NRENs to keep adapting the services that they offer to the actual needs of users.*

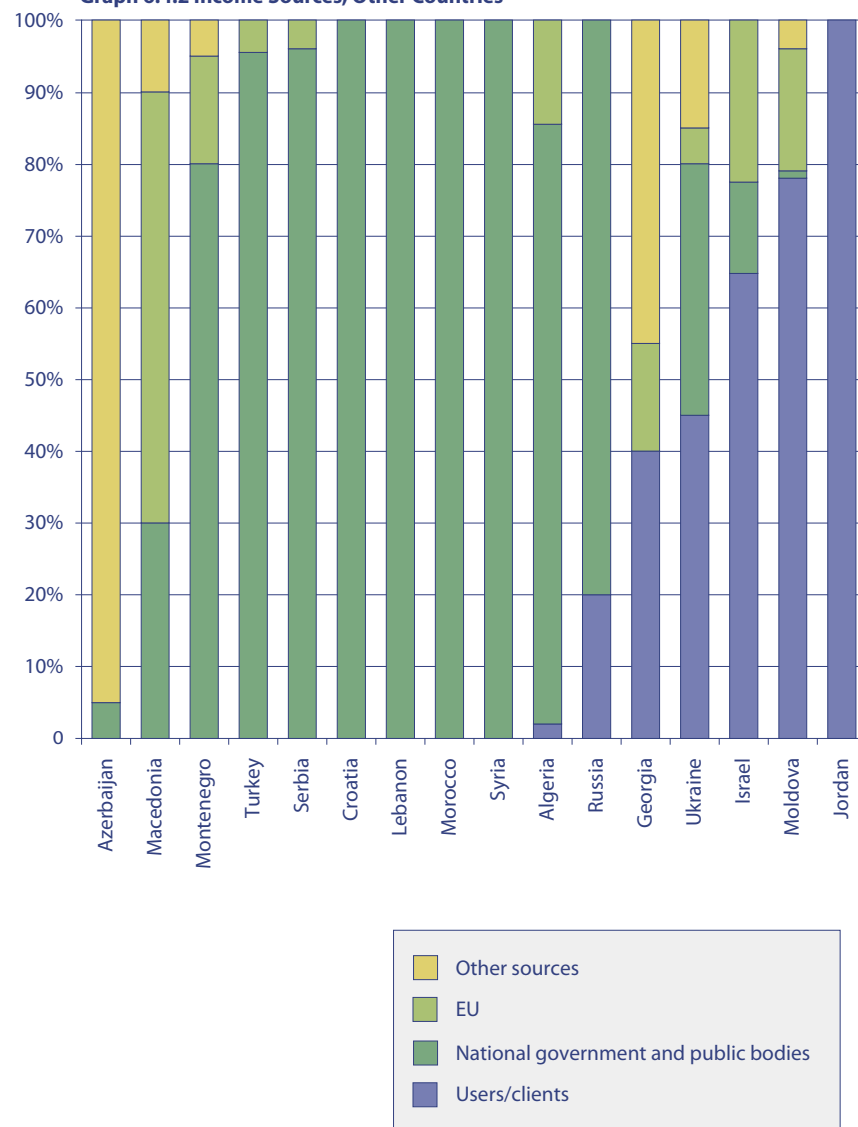
*(...) The optimal solution clearly depends on national circumstances. A large majority of countries have a mixed system, which can work well if expenditures of long-term benefit are centrally funded and some of the services whose costs can be directly related to individual connected institutions are funded through those institutions.*

*Funding by connected institutions, if any, is usually provided from the central budgets of those organisations. In general, it is not desirable to introduce charging at a lower level in the organisation, such as institutes within a university, research groups or even individual end-users. For one thing, the total annual expenditure of an NREN divided by the number of end-users is typically in the range of 20 to 40 euro; in case of end-user charging the costs of accounting and billing would therefore lead to a very substantial increase of the overall costs. However, the emergence of classes of network users with very high requirements may mean that the model of charging at the level of institutions may no longer scale. (...) New funding mechanisms will need to be developed to enable the provision of services to end-users of this kind."*<sup>2</sup>

<sup>2</sup> SERENATE Summary Report, TERENA, Amsterdam, 2003, p. 11-12.

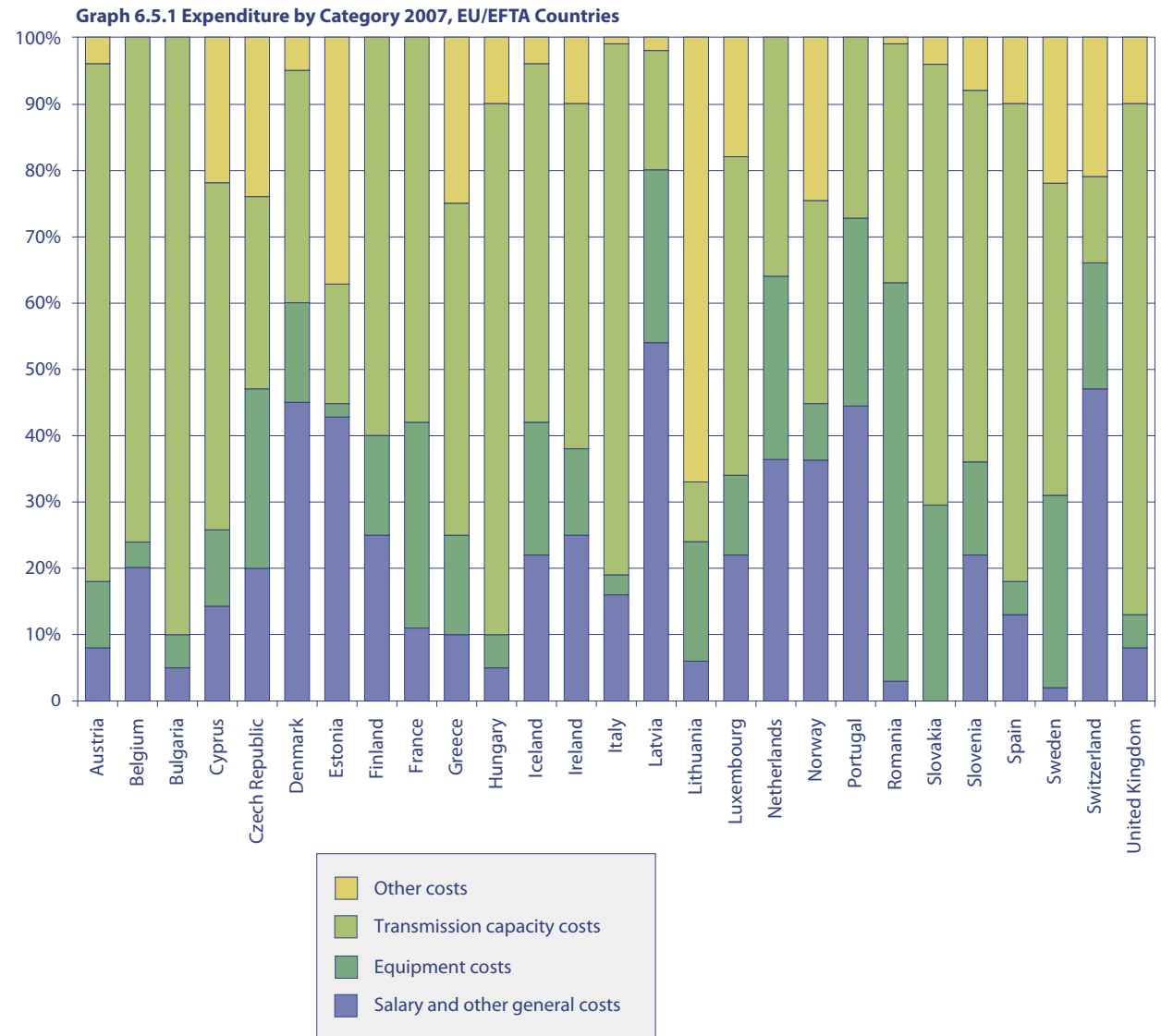
**Graph 6.4.1 Income Sources, EU/EFTA Countries**

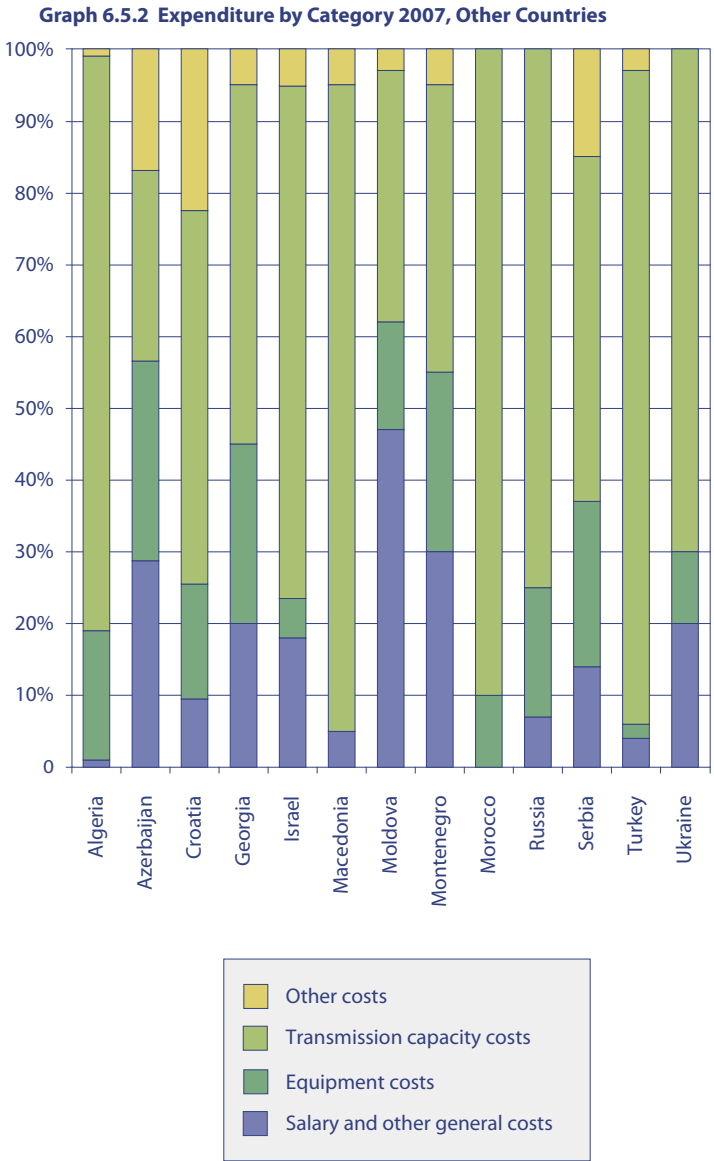
**Graph 6.4.2 Income Sources, Other Countries**



## 6.5 Expenditure by Category

Graphs 6.5.1 and 6.5.2 show which percentage of NREN income is spent on which categories of expenditure. Because of the influence of multi-year capital investments, these expenditures can fluctuate considerably from year to year. Note that not everything may be funded through the NREN budget in all countries (see also section 6.6). More information about this can also be found in the “Focus Study on Funding, Management and Operation of European Research Networks: analysed by network hierarchy” by John Martin and Baiba Kaškina, TERENA, May 2004.







## 6.6 Expenditure by Network Level

The following table illustrates the 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 table, 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. These types of difference make it extremely difficult to compare NREN budgets.

**Table 6.6.1 Expenditure by network level**

		External connections		NREN Backbone		Access Network		Metropolitan or Regional Networks		Campus LANs	
Country	NREN	% of the NREN budget spent on this item	% of total cost paid through the NREN	% of the NREN budget spent on this item	% of total cost paid through the NREN	% of the NREN budget spent on this item	% of total cost paid through the NREN	% of the NREN budget spent on this item	% of total cost paid through the NREN	% of the NREN budget spent on this item	% of total cost paid through the NREN
EU/EFTA Countries											
Austria	ACOnet	22	100	46	100	8	100	4	100		
Belgium	BELNET	10	75	70	100	20	10	0	0	0	0
Cyprus	CYNET	60.9	100	5.7	100	0	0	n/a	n/a	0	0
Czech Republic	CESNET	14.9	100	21.7	100	13.6	100	n/a	n/a	n/a	n/a
Denmark	UNI-C	33	100	2	100	1	100	2	100	0	0
Estonia	EENet	71.6	60.4	28.3	39.5	0.01	0.01	n/a	n/a	n/a	n/a
Finland	Funet	28	100	72	100	n/a	n/a	n/a	n/a	0	0
France	RENATER	18		82							
Germany	DFN		100		100		100		0		0
Greece	GRNET	30	100	60	100	10	50	0	0	0	0
Hungary	NIIF/HUNGARNET	20	100	40	100	20	100	0	0	0	0
Iceland	RHnet	18	12	20	100	3	100	15	100	n/a	n/a
Ireland	HEAnet	35	90	30	100	15	100				
Italy	GARR	9	100	33	100	41	100	0		0	
Latvia	LATNET		50		100		70		25		
Lithuania	LITNET		43		11		3		5		1
Luxembourg	RESTENA	29.2	100	17.8	100	3.2	100				
Netherlands	SURFnet	25	100	72	100	3	100	0		0	
Norway	UNINETT	0	0	19.5	100	5.3	30	0	0	5,3	20

Table 6.6.1 Expenditure by network level - continued

		External connections		NREN Backbone		Access Network		Metropolitan or Regional Networks		Campus LANs	
Country	NREN	% of the NREN budget spent on this item	% of total cost paid through the NREN	% of the NREN budget spent on this item	% of total cost paid through the NREN	% of the NREN budget spent on this item	% of total cost paid through the NREN	% of the NREN budget spent on this item	% of total cost paid through the NREN	% of the NREN budget spent on this item	% of total cost paid through the NREN
EU/EFTA Countries											
Portugal	FCCN		21		21		21	n/a	n/a	n/a	n/a
Romania	RoEduNet	15	50	60	100	20	100	5	100	n/a	n/a
Slovakia	SANET	21.1		42.4		n/a	n/a	1.1		n/a	n/a
Slovenia	ARNES	20	60	50	100	0	0	0	0	0	0
Spain	RedIRIS	17	100	59	100	0	0	0	0	0	0
Sweden	SUNET	13	100	68	100			0	0	0	0
Switzerland	SWITCH	7	60	9	100	1	80	n/a	0	n/a	0
United Kingdom	JANET(UK)	5.5	100	20	100	32.5	100	42	100	n/a	n/a
Other Countries											
Algeria	CERIST	35	60	65	100	n/a	n/a	n/a	n/a	n/a	n/a
Georgia	GRENA	35		10				5			
Israel	IUCC	48.7	100	22.5	100						
Macedonia	MARNet		100								
Moldova	RENAM	40	80	35	100	10	40	15	70	0	0
Montenegro	MREN	40	30								
Morocco	MARWAN	90	60								
Serbia	AMRES	15	35	36	100						
Turkey	ULAKBIM	8	65	24	100	68	95				
Ukraine	URAN	35	100	25	100	2	100	2	90	0	0

# APPENDICES

## 1 Alphabetical List 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 1.1.2 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
BIHARNET		Bosnia/Herzegovina
BREN	BIOM	Bulgaria
CARNet		Croatia
CERIST		Algeria (operates ARN, the Academic Research Network)
CESNET		Czech Republic
CNRS		Lebanon
CSC		Malta (Computing Services Centre of the University of Malta)
CyNet	KEAD	Cyprus
DFN		Germany
EENet		Estonia
EUN		Egypt
FCCN		Portugal
Funet		Finland (operated by CSC, the Centre for Scientific Computing)
GARR		Italy

NREN Acronym in English	NREN Acronym in the National Language(s) if Different	Country
GRENA		Georgia
GRNET	EDET	Greece
HEAnet		Ireland
JANET		UK (in the UK, the network is called JANET; it is operated by JANET(UK))
IUCC	MACHBA	Israel
JUNet		Jordan
LATNET		Latvia
LITNET		Lithuania
MARNet		Former Yugoslav Republic of Macedonia
MARWAN		Morocco (operated by the CNRST)
MREN		Montenegro
NIIF/HUNGARNET		Hungary
PADI2		Palestine
PIONIER		Poland (in Poland, the network is called PIONIER; it is operated by the Poznań Supercomputing and Networking Centre)
PSNC	PCSS	Operates PIONIER, the Polish network
RBNet/RUNNet		Russian Federation
RED.ES		Spain (in Spain, the network is called RedIRIS; it is operated by RED.ES)
RedIRIS		Spain, see above
RENAM		Moldova
RENATER		France
RESTENA		Luxembourg
RHnet		Iceland
RNU		Tunesia
RoEduNet		Romania
SANET		Slovakia

NREN Acronym in English	NREN Acronym in the National Language(s) if Different	Country
SHERN		Syria
SUNET		Sweden
SURFnet		Netherlands
SWITCH		Switzerland
ULAKBIM		Turkey
UNI-C		Denmark; operates the Forskningsnettet
UNINETT		Norway
URAN		Ukraine

## 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>. A basic introduction to the Internet in general is at <http://gnrt.terena.org/>.

<b>AAI</b>	Authentication and Authorisation Infrastructure. A system (infrastructure) that makes it possible to verify that a given user name is valid (authentication) and to verify that the authenticated user is allowed access to the requested resources (authorisation).
<b>AUP</b>	Acceptable Use Policy
<b>Bandwidth on Demand</b>	Point-to-point dedicated bandwidth services
<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 Research 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>Confederation</b>	An agreement by different Federations (see below) to share certain resources
<b>Congestion index</b>	Is a measure of congestion at different levels of network access. It was 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 client institution
<b>DEISA</b>	Distributed European Infrastructure for Supercomputing Applications.
<b>DWDM</b>	Dense Wavelength Division Multiplexing.

<b>eduroam®</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>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
<b>European Schoolnet (EUN)</b>	A not-for-profit organisation that represents twenty-eight ministries of education in Europe that aims to promote the use of technology in the classroom – <a href="http://www.eun.org">http://www.eun.org</a>
<b>FTE</b>	Full Time Equivalent
<b>GBE</b>	Gigabit Ethernet
<b>GÉANT</b>	A project mainly to develop the GÉANT network, the multi-gigabit pan-European data communications network, reserved for research and education
<b>GÉANT2</b>	GÉANT2 is the seventh generation of pan-European research and education network, successor to the pan-European multi-gigabit research network GÉANT.
<b>GN2</b>	The project to develop the GÉANT2 network and carry out a number of other, related tasks
<b>Grid computing</b>	Applying the resources of many computers in a network to a single problem at the same time
<b>Hybrid Networking</b>	The seamless integration of two different networking technologies on a network
<b>Identity Management System</b>	A system that combines technologies and policies to allow institutions to store users' personal information and keep them up-to-date. An IdM is the first building block to provide and control users' access to critical on-line resources and at the same time to protect resources from unauthorised access.
<b>IP</b>	Internet Protocol: the method by which data – in the form of data packets - is sent over the Internet. Currently, the dominant protocol is IPv4. The next generation, IPv6, is currently being implemented.
<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; - tunnelled, 6to4 and tunnel brokers: techniques for sending IPv6 data packets encapsulated in IPv4 packets

<b>IRU</b>	Indefeasible Right of Use
<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 and connects them to the greater research and education community and to the commercial Internet
<b>NREN</b>	National Research and Education Network
<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
<b>RedCLARA</b>	A non-governmental association in Latin America that aims to improve the infrastructure for NRENs in the region and foster their development
<b>ROADM</b>	Reconfigurable Optical Add/Drop Multiplexing – offers the ability to switch at the wavelength level with the use of remote software
<b>SDH</b>	Synchronous Digital Hierarchy, an international standard for synchronous data transmission
<b>SEEREN</b>	South-Eastern European Research & Education Networking project
<b>Shibboleth</b>	Shibboleth is standards-based, open source middleware software which provides Web Single SignOn (SSO) across or within organisational boundaries
<b>UbuntuNet</b>	A not-for-profit organisation of NRENs that aims to provide the tertiary research and education community in sub-Saharan Africa with increases in connectivity
<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>

