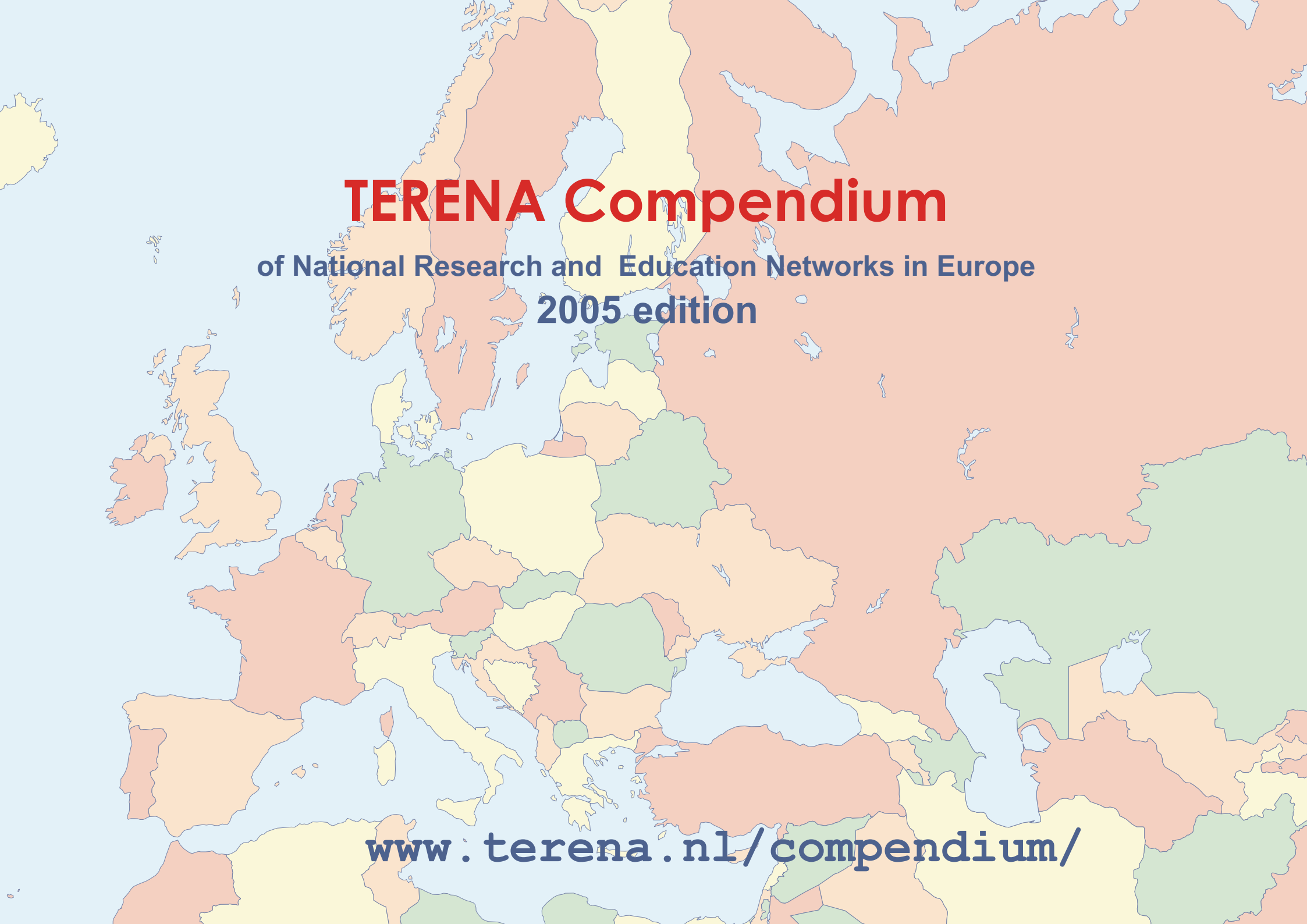


TERENA Compendium

of National Research and Education Networks in Europe

2005 edition

www.terena.nl/compendium/

Database and Website: Jeroen Houben
Design and Production: Carol de Groot
Editor: Bert van Pinxteren

For further information, please contact:
TERENA Secretariat
Singel 468 D
1017 AW Amsterdam, Netherlands
email: secretariat@terena.nl

TERENA Compendium
of Research and Education Networks in Europe
2005 Edition

ISSN: 1569-4496

http://www.terena.nl/compendium/

This publication has been made possible by a financial contribution from the Sixth Framework Programme for Research and Technological Development of the European Community.

Contents

Introduction

Since 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 first that is part of the GN2 (GÉANT2) project and that has benefited from the input from activity leaders in that project. This year, the Compendium has been expanded with a new chapter on Services, with additional tables in Appendix 1 and with a glossary in Appendix 2. For a number of key areas, an attempt has been made for the first time to aggregate data for groups of NRENs and to look at and partially explain multi-year trends. These aggregations and explanations are given in 'overview' sections on Users/Clients, Network and Traffic. Throughout the Compendium, such analytical or explanatory text has been highlighted. Some of the trends have again been summarised in the "Summary of key findings" below.

The production of the 2005 edition was overseen by a Review Panel composed of the following people: Lajos Bálint (Hungary), Marko Bonač (Slovenia), Peter Kaufmann (Germany), Urs Eppenberger (Switzerland), Sabine Jaume-Rajaonia (France) and Mike Norris (Ireland). Inputs were also received from a number of Activity Leaders in the GN2 project, from the the TERENA Technical Staff and from the TERENA Secretary General.

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 NRENs 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.nl/compendium`) and this publication.

Most tables and graphs first show the EU and EFTA countries and then other countries. In some cases, it was thought to be helpful to present slightly smaller groups of countries, in the following way:

* the EU-15 and EFTA countries;
* the new EU member states (that joined on 1 May 2004);
* those countries that are not part of the EU or EFTA but whose NRENs participate in the GN2 project;
* other countries.

A full list of the countries in each category is given below. In each category, the data is 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.

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

Bert van Pinxteren
TERENA Chief Administrative Officer

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**

Most tables and graphs first show the EU and EFTA countries and then other countries. In some cases, it was thought to be helpful to present slightly smaller groups of countries, in the following way:

* the EU-15 and EFTA countries;
* the new EU member states (that joined on 1 May 2004);
* those countries that are not part of the EU or EFTA but whose NRENs participate in the GN2 project;
* other countries.

Find a list of these countries below:

EU-15: European Union countries before 1 May 2004	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom
EFTA countries	Iceland, Norway, Switzerland
New member states: the countries that joined the European Union on the 1st of June 2004	Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia
Non-EU/EFTA GN2 partner countries: countries that participate in the GN2 project but that are outside of the EU and the EFTA	Croatia, Bulgaria, Israel, Russia, Romania, Turkey
Other countries	see the map and table in section 1.0 for a full overview of the countries that are included in the Compendium

Summary of key findings

Legal form

The most common (but by no means the only) legal model for an NREN in the 'EU-15/EFTA' group of 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.

NRENs that can operate with a certain amount of independence from government may have certain advantages, such as easier decision-making procedures and the ability better to attract and retain the needed 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.

In any case, 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 in a number of different ways.

Users/clients

In the 2003 – 2005 period, NRENs in the new EU member states have shown a remarkable increase in the number of universities connected at **Gigabit speeds**. From a position close to parity with the other EU members, they have taken the lead with more than twice the proportion of high-bandwidth connections.

The SERENATE study[1] 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 implemented in many countries now. It seems that fibre-optic technology is allowing NRENs to leapfrog immediately to much higher capacities. Gigabit Ethernet is being introduced by many hitherto less developed NRENs and 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.

There is clear evidence that the connection of **secondary and primary schools** to NRENs and also the provision of support and application services to schools features 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 this activity.

The **uptake of IPv6** is greater within EU/EFTA NRENs than in those of other countries. However, the situation varies greatly from country to country. Within NRENs of all types, the lead in IPv6 seems to be taken by the universities rather than research institutes. In the EU/EFTA NRENs, the respective figures are 15% and 5% take-up. In other NRENs, the mean figures are 3% and 1%, respectively.

IPv6 usage varies considerably from one NREN to another. While the usage by most NRENs is still less than 1% of total IP traffic, there are a few leaders, with levels of usage between 10% and 20%. Moreover, the growth in IPv6 traffic has been considerable, increasing by a factor of 14 from December 2003 to May 2005. As a proportion of total IP traffic, growth has been from 0.3% to 2.7%.

Network

The overall trend is that there is considerable **growth** year on year, with the new EU member states and the non-EU/EFTA countries to the fore in expansion. This trend is also visible when looking at core network size as defined in this Compendium. Growth in this area is never linear, but is always step-wise.

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. NRENs also often have peering

[1] **SERENATE Summary Report p.6**

arrangements at neutral Internet exchanges and many also have connections to commercial ISPs, but 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.

There are indications that more and more NRENs are switching over to **dark fibre** as the technology of the future, with the EU NRENs being in the lead. As well as providing NRENs with the ability to better control, manage and exploit their network infrastructures, dark fibre provides new opportunities to enable users to define their own dedicated end-to-end links across the network, and to do so within constant NREN budgets. In this sense, the uptake of dark fibre is to be commended where it is possible. Indeed, the procurement of the new GÉANT 2 network has endorsed this development and has provided a pan-European dark-fibre footprint, already linking fifteen countries in the first phase.

Regarding **core capacity** on the networks, the trend seems to be that in the more advanced countries, the core capacity will evolve to 10 Gb/s or multiples of that.

Traffic

Growth rates in the new EU member states and in non-EU/EFTA countries are clearly higher than those in the 'old' EU member states.

It seems that in the EU, **traffic growth** is slowing down. It seems that traffic is now determined more by (changes in) user demand, rather than by network capacity limitations. It is unclear if this trend towards slower growth will persist – new applications, for example in the Grids area, may change the picture. However, in that case growth will be driven by demand, rather than by changes in the network capacities. In any case, NRENs need to upgrade their external links from time to time in order to keep up with increasing demand.

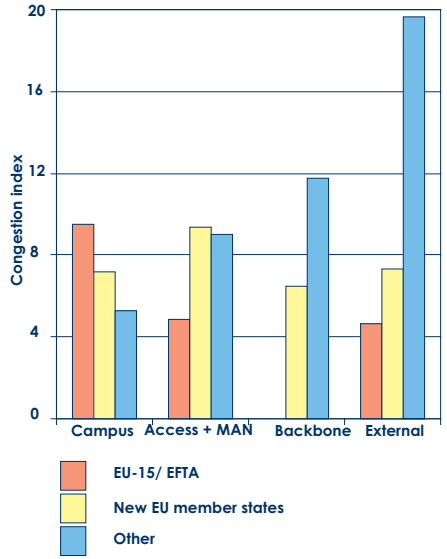
The longer-established NRENs from the EU and EFTA countries are mostly **net exporters** of data, while the other NRENs are net importers. The pattern has changed over time. In 2002, there was a more uniform distribution of importers and exporters among the EU/EFTA countries. The new EU member states tended to have importer NRENs; only two out of nine were exporters. So the trend has been towards more net export of data.

NRENs in the other countries, however, do not yet seem to follow this trend. In 2001, only one out of seven was a net exporter. In 2004, the proportion was more or less the same, at 2 NRENs out of 17.

In EU/EFTA countries, NRENs report relatively little **congestion** in the parts of the network that are within their domain of responsibility. Uniformly, they see no serious congestion on external circuits, virtually none in their core networks, and little in the MAN or regional network. Any serious congestion, they report, is largely confined to access networks or, to the campus LANs of connected institutions.

The 'other' NRENs report that most congestion is clearly on external connections. In those 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.

A 'congestion index' has been developed that summarises congestion by network level:



Services

There is an increased need for an **Authentication and Authorisation Infrastructure**. This is because:

* 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.

* Users travel much more and they 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.

* Various NRENs haven been developing AA tools over the past few years; these tools are now stable enough to look for inter-operability and to try to seek harmonisation.

Grid services are currently running in 15 out of the 27 EU/EFTA NRENs in the survey and in 5 out of the 16 NRENs from other countries in the survey.

Eight more EU/EFTA NRENs are planning to introduce such a service; a similar number of the NRENs from other countries have that plan.

NREN support is needed for running the service in the great majority of cases. Physics and chemistry are the most active disciplines, followed by biomedical applications and astroscience.

Funding

NREN budgets may fluctuate from year to year, because investments can vary considerably from year to year. 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, because they administer the country-code top-level domain or because they connect others who are clearly outside the research and education communities. 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, connected institutions pay for their line to the nearest NREN PoP, in others the NREN pays for this.

* Some NRENs spend a large part of their budget to connecting secondary and primary schools, others do not.

When comparing current budget data with data from previous versions of the Compendium, it becomes clear that NREN budgets tend to be stable over time. There are fluctuations from year to year, depending on whether or not an important investment takes place during that year. But on the whole, the trend is that budgets stay relatively stable and that NRENs are able to deliver more bandwidth and more services for roughly the same amount of money.

The exception to this general trend seems to be the situation in the less developed NRENs. There, new possibilities for significantly upgrading international bandwidth (for example under the GN2, EUMEDCONNECT or SEEREN projects) seems to act as a catalyst for increased national NREN budgets.

1 Basic Information

1.0 NRENs that have responded to the Questionnaire

49 NRENs responded to the survey, from 47 different countries*. Not all NRENs were able to answer all of the questions, but many were. The following map and table give an overview of the NRENs that sent their replies and gives 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 exist, but from which no replies were received.

NRENs have been asked to double-check and update their replies.

Two projects are relevant in this context:

* the EUMEDCONNECT project aims at the Mediterranean region. For more information see: **http://www.dante.net/eumedconnect/**;

* the Virtual Silk Highway project is aimed at Central Asian countries. For more information see: **http://www.silkproject.org/.**

CEENet maintains contacts and provides support to many NRENs in Central and Eastern Europe and the Former Soviet Union. For more information see: **http://www.ceenet.org/.**

* The full survey is at: **http://www.compendium/TSsec(05)Compq05.rtf**


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 available
Iceland 18
Norway 33
Finland 12
Sweden 42
Estonia 11
Latvia 24
Lithuania 26
Denmark 9
Russian Federation 37
Belarus 3
Ireland 19
United Kingdom 47
Netherlands 32
Belgium 4
Luxembourg 27
Germany 15
Poland 34
Czech Republic 8
Ukraine 45
Kazakhstan 22
France 13
Switzerland 43
Slovakia 39
Hungary 17
Moldova 30
Slovenia 40
Romania 36
Croatia 6
Serbia & Montenegro 38
Bulgaria 5
Italy 21
FYR Macedonia 28
Georgia 14
Uzbekistan 48
Kyrgyzstan 23
Azerbaijan 2
Spain 41
Portugal 35
Greece 16
Turkey 45
Malta 29
Cyprus 7
Syria 44
Lebanon 25
Algeria 1
Morocco 31
Israel 20
Egypt 10

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

#	Country	NREN	URL
1	**Algeria**	CERIST	http://www.cerist.dz
2	**Azerbaijan**	AzNET	http://www.aznet.org
	Azerbaijan	AzRENA	http://www.azrena.org/index_en.htm
3	**Belarus**	BASNET	http://www.basnet.by
4	**Belgium**	**BELNET**	http://www.belnet.be
5	**Bulgaria**	IST Foundation	http://www.ist.bg
6	**Croatia**	**CARNet**	http://www.carnet.hr
7	**Cyprus**	**CYNET**	http://www.cynet.ac.cy
8	**Czech Republic**	**CESNET**	http://www.cesnet.cz, http://www.ces.net
9	**Denmark**	**UNI•C**	http://www.forskningsnettet.dk/eng/
10	**Egypt**	EUN	http://www.eun.eg
11	**Estonia**	**EENet**	http://www.eenet.ee
12	**Finland**	**FUNET**	http://www.csc.fi/
13	**France**	**RENATER**	http://www.renater.fr
14	**Georgia**	GRENA	http://www.grena.ge
15	**Germany**	**DFN**	http://www.dfn.de
16	**Greece**	**GRNET**	http://www.grnet.gr/en
17	**Hungary**	**NIIF/ HUNGARNET**	http://www.hungarnet.hu http://www.niif.hu
18	**Iceland**	**RHnet**	http://www.rhnet.is
19	**Ireland**	**HEAnet**	http://www.heanet.ie
20	**Israel**	IUCC	http://www.iucc.ac.il
21	**Italy**	**GARR**	http://www.garr.it
22	**Kazakhstan**	KazRENA	http://www.kazrena.kz
23	**Kyrgyzstan**	KRENA-AKNET	http://aknet.kg
24	**Latvia**	LANET	http://www.lanet.lv
	Latvia	**LATNET**	http://info.latnet.lv/En/
25	**Lebanon**	CNRS	http://www.cnrs.edu.lb
26	**Lithuania**	**LITNET**	http://www.litnet.lt
27	**Luxembourg**	**RESTENA**	http://www.restena.lu/
28	**Macedonia, FYRo**	**MARNet**	
29	**Malta**	**CSC**	http://www.um.edu.mt/csc.html
30	**Moldova**	RENAM	http://www.renam.md
31	**Morocco**	MARWAN	http://www.marwan.ma
32	**Netherlands**	**SURFnet**	http://www.surfnet.nl
33	**Norway**	**UNINETT**	http://www.uninett.no
34	**Poland**	**PIONIER**	http://www.pionier.gov.pl
35	**Portugal**	**FCCN**	http://www.fccn.pt
36	**Romania**	**RNC**	http://www.rnc.ro
	Romania	RoEduNet	http://www.roedu.net/
37	**Russian Federation**	RBNet/ RUNNet	http://www.ripn.net http://www.runnet.ru
38	**Serbia / Montenegro**	**AMREJ**	http://amrej.rcub.bg.ac.yu
39	**Slovakia**	**SANET**	http://www.sanet.sk
40	**Slovenia**	**ARNES**	http://www.arnes.si/
41	**Spain**	**RedIRIS**	http://www.rediris.es http://www.red.es
42	**Sweden**	**SUNET**	http://www.sunet.se/
43	**Switzerland**	**SWITCH**	http://www.switch.ch
44	**Syria**	SHERN	http://www.shern.net
45	**Turkey**	**ULAKBIM**	http://www.ulakbim.gov.tr
46	**Ukraine**	UARNet	http://www.uar.net
	Ukraine	URAN	http://www.uran.net.ua
47	**United Kingdom**	**UKERNA**	http://www.ukerna.ac.uk
48	**Uzbekistan**	UzSciNet	http://www.uzsci.net

Table 1.0.2 NRENs not included in the Compendium

	Armenia	ARENA	http://www.arena.am
	Austria	ACOnet	http://www.aco.net/
	Iran	IRANET	http://www.iranet.ir
	Jordan	NITC	http://www.nic.gov.jo

1.1 Legal Form

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 that which is called 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 a separate legal entity; many others form part of a larger organisation (often either a Ministry, a University or a research institution). A few NRENs have a special status in the sense that they do not operate as a separate legal body 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 the Government

Those NRENs that are a government agency or part of a government ministry are typically directly controlled 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 the 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 'Government appoints at least half' in table 1.1.1 and with 'appoints' in table 1. 1.2. Many NRENs have a mixed model, being governed both by government representatives and representatives from the research and education community.

In Table 1.1.1, 'indirect' means an indirect relationship, for example if at least half the members of the NREN's Governing body are appointed by research and education institutions that in itself are (largely) government-funded.

Table 1.1.2. shows the relationship between the two parameters.

As can be seen from table 1.1.1, the most common model in the 'EU-15/EFTA' group of 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. This model is chosen by a small majority (53%) of the NRENs.

In the new member states and in the other GÉANT2 partner countries, a larger variety exists. The model described above is chosen by a third of the NRENs in these countries.

The largest variety exists in the other countries, with eight models found among 13 NRENs. The legal status of five of these NRENs has not yet been finally settled.

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 a situation can be achieved in a number of different ways.

NRENs that can operate with a certain amount of independence from Government may have certain advantages, such as easier decision-making procedures and the ability to offer staff attractive terms of employment. 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 Aggregated information on the legal form of NRENs

Relationship with Government	Separate legal entity	Part of larger organisation	Other	Total
EU – 15/EFTA				
Indirect	9			9
Government appoints at least half		1		1
Direct		3		3
Other	3	1		4
None				
Total	**12**	**5**		**17**
EU – new member states				
Indirect	3	2		5
Government appoints at least half	1			1
Direct	1	1		2
Other	2	1		3
None				
Total	**7**	**4**		**11**
Non-EU/EFTA – GÉANT2 partners				
Indirect	3			3
Government appoints at least half				
Direct	2			2
Other	1	1		2
None				
Total	**6**	**1**		**7**
Other countries				
Indirect	3	2	2	7
Government appoints at least half		1		1
Direct	1		2	3
Other			1	1
None	1			1
Total	**5**	**3**	**5**	**13**

Table 1.1.2 Relationship with Government

Country	NREN	Separate legal entity?	Relationship with Government	Remarks/Parent Organisation
'EU-15' and EFTA countries				
Belgium	BELNET	no	direct	Ministry of Science Policy
Denmark	UNI•C	no	direct	For Forskningsnet: Danish ministry of Science,Technology and Innovation, For UNI•C: Danish ministry of Education
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	appoints	GRNET was founded by Presidential Decree 29/1998 and is a property of the Ministry of Development, under the supervision of the General Secretariat of Research and Technology. The Ministry of Development assigns the Members of the Board of Directors. The Greek government provides funding for operation of GRNET.
Iceland	RHnet	yes	indirect	
Ireland	HEAnet	yes	indirect	
Italy	GARR	yes	indirect	
Luxembourg	RESTENA	yes	indirect	
Netherlands	SURFnet	yes	indirect	Stichting SURF (English: SURF Foundation)
Norway	UNINETT	yes	other	Limited company wholly owned by the Department of Education and Research
Portugal	FCCN	yes	indirect	
Spain	RedIRIS	no	direct	Entidad pública empresarial RED.ES
Sweden	SUNET	no	other	The Swedish Research Council (the parent organisation) is a government agency and part of the funding comes directly from the government
Switzerland	SWITCH	yes	other	The government has delegates in the governing body, the council of foundation.
United Kingdom	UKERNA	yes	indirect	
EU – new member states				
Cyprus	CYNET	yes	other	The governing body consists of representatives from education, research and government agencies.
Czech Republic	CESNET	yes	indirect	
Estonia	EENet	yes	direct	EENet is a public institution operating under the administration of the Estonian Ministry of Education and Research
Hungary	NIIF/ HUNGARNET	yes	other	Joint NREN function by HUNGARNET (independent) and NIIF (government supervised).
Latvia	LANET	no	indirect	Ministry of Education and Science
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	direct	Ministry of Science and Education of Lithuania

Country	NREN	Separate legal entity?	Relationship with Government	Remarks/Parent Organisation
Malta	CSC	no		University of Malta
Poland	PIONIER	yes	indirect	
Slovakia	SANET	yes	indirect	
Slovenia	ARNES	yes	appoints	
Non-EU/EFTA GÉANT2 partners				
Bulgaria	IST Foundation	yes	indirect	
Croatia	CARNet	yes	direct	
Israel	IUCC	yes	indirect	
Romania	RoEduNet	yes	direct	
Russian Federation	RBNet/RUNNet	yes	both	The NREN is controlled partly by the Government and partly by the research community.
Turkey	ULAKBIM	no	other	The Scientific and Technical Research Council of Turkey (TUBITAK). TUBITAK is a Semi independent government agency.
Other countries				
Algeria	CERIST	no	appoints	Ministry of higher education and scientific research
Azerbaijan	AzNET	neither	indirect	United Nations Development Programme (UNDP) Country Office in Azerbaijan
Azerbaijan	AzRENA		indirect	
Belarus	BASNET	no	indirect	National Academy of Sciences of Belarus
Georgia	GRENA	yes	indirect	
Kazakhstan	KazRENA		other	KazRENA works closely with the Ministry of Education and Science of Kazakhstan on a state programme.
Kyrgyzstan	KRENA-AKNET	yes	none	
Macedonia, FYRo	MARNet	no	none	Ss. Cyril & Methodius University in Skopje
Moldova	RENAM	yes	indirect	
Morocco	MARWAN	neither	direct	National Scientific and Technical Research Centre (CNRST)
Serbia / Montenegro	AMREJ	neither	direct	
Syria	SHERN	yes	direct	Ministry of Higher Education
Ukraine	URAN	no	indirect	Centre for European Integration Ltd. (CEI)
Uzbekistan	UzSciNet	yes	indirect	

2 Users/Clients

This section starts with information about the connection policies of NRENs (i.e. who is allowed to connect) (2.2) and about what is allowed on the connection, or the Acceptable Use Policies (2.3).

Section 2.4 looks at IPv6. The last sections look more closely at bandwidth of Universities, secondary schools and primary schools. Note that Appendix 1 contains additional information for other user categories.

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

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

As is clear from Table 2.2, all NRENs can connect Universities. 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, etc.

Acceptable Use Policies

Some NRENs have sent us summaries of their Acceptable Use Policies (AUPs) or have given us the URLs to the Acceptable Use Policies as published on their websites. This information is now available on-line at **http://www.terena.nl/compendium/2005/aup.php.**

Table 2.3 gives an overview of some key characteristics of the AUPs of NRENs.

Connection methods

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

Most NRENs provide for institutions to connect directly either to one of their Points of Presence (PoP) 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 UKERNA (UK), RENATER (France) and PIONIER (Poland).

Table 2.1.1 provides aggregated data on connection methods. Here the aggregation has been done from the perspective of NRENs, not from that of the institutions. Thus, the figures below 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

Type of institution	PoP or MAN run by NREN	MAN or regional network run by 3rd party	Via another institution	Some other way
University	87%	10%	0%	3%
University site	60%	4%	32%	4%
Institute of higher education	72%	18%	10%	0%
Research institute	82%	10%	8%	0%
Secondary school	58%	26%	7%	9%
Primary school	56%	21%	0%	13%
Other	74%	19%	7%	0%

There are some distinctions between the different types of institutions here. Note, for example, that the highest proportion of reported connections via another institution (32%) is by university sites. It seems that many such sites connect through their parent university rather than directly to the NREN PoP or MAN.

For reasons of space, the full tables are not made available in printed form but they can be consulted on the web by NRENs who have participated in the survey; they are available for others upon request.

Bandwidth of Universities

As part of the survey, NRENs have given the percentage of connections for each type of institution (university, research institute, secondary school, etc) to the network at each of a set of bandwidths.

These were given as ranges, such as "greater than 100Mbps and less than 1000Mbps". We have examined the bandwidth of university institutions a bit more in-depth, for two reasons. First, an NREN generally connects (almost) all Universities in its country; in most countries where the NRENs are well established, the numbers of connected universities is not going to vary much over time. Second, Universities tend to be the leaders in new and faster connectivity to NRENs, and we are interested in the trend of such connections in recent years.

For each access range, we have identified an average or typical bandwidth. Thus, for the example given above (>100Mbps and <1000Mbps) we select 155Mbps (STM-1) as being indicative of the type of connection. For each NREN, we have summed the product of the percentage of universities connected in that access range by the typical bandwidth for that range. This gives us an indicative weighted mean of university access bandwidth for the NREN.

Table 2.1.2 Access capacity increase for Universities in different groups of NRENs

Group of NRENs	Number of NRENs	Mean annual increase in University access capacity, 2003-2005[1]
EU-15/EFTA	18	41%
New member states	10	116%

[1] **See also the country-by-country data in section 2.5**

In the EU-15/EFTA countries, the largest increases were achieved in Switzerland (200%/year) and in Italy (114%/year). In Switzerland, there was a large increase in Gb/s connections and a decrease in connections of below 10 Mb/s. A similar, though less pronounced shift took place in Italy. Average bandwidth stayed at more or less the same level in Belgium, Portugal, Sweden and the U.K. Belgium and Sweden already had a significant proportion of Gb/s connections in 2003.

In the new member states, the largest increases were achieved in Estonia and Hungary (more than 300%/year). In both countries, there was a large increase in 1 Gb/s connections (and some 10 Gb/s connections were introduced in Hungary), with a corresponding decrease in connections of below 10 Mb/s. Average bandwidth stayed at more or less the same level in the Czech Republic and in Lithuania. Both of these countries already had a significant proportion of Gb/s connections in 2003.

In the other countries, the diversity was even greater. Therefore, these countries are not presented in the aggregated table. The largest increases were achieved in Moldova and no increases were reported in Algeria, Azerbaijan, Belarus, Turkey and Uzbekistan. In Moldova, the increase was due to the fact that two universities jumped from connections of up to 10 Mb/s to Gb/s connections.

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

We have looked at this also from the point of view of the average University (rather than of average NREN as in sesction 2.1.3). This gives a complementary picture:

Table 2.1.3 Average access capacity for Universities and average increases[2]

	2003		2005		
Group of NRENs	**Number of connected Universities**	**Average bandwidth (Mb/s)**	**Number of connected Universities**	**Average bandwidth (Mb/s)**	**Mean annual increase in University access capacity, 2003 - 2005**
EU-15/EFTA	637	254	639	410	27%
New member states	394	214	391	546	60%

Note that the figures in Table 2.1.3 and 2.1.4 don't take into account the data from France. RENATER has provided data about connections to individual university sites, including both campuses with larger access capacities and a large number of sites with relatively limited access capacities. This is partly due to capacity-based charging policies in RENATER. The situation may be similar in other NRENs.

Calculating a mean for the other countries would not yield a meaningful figure because of the more extreme diversity and the uneven availability of data[2].

A third way of looking at the trend in access speeds is to consider the change in Gigabit or higher links to universities over the period 2003 to 2005. This gives the following results:

Table 2.1.4 Gb connections of Universities

Group of NRENs	**Percentage of Universities connected at >= 1Gb/s[3]**	
	in 2003	**in 2005**
EU-15/EFTA	13%	18%
New member states	17%	42%
EU/EFTA	15%	24%

NRENs in the new member states have shown a remarkable increase in the number of universities connected at Gigabit speeds. From a position close to parity with the other EU members, they have taken the lead with more than twice the proportion of high bandwidth connections. This also helps to explain the increases in average bandwidth that are apparent from table 2.1.3. The SERENATE study[4] 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.

[2] See section 2.5 for more information
[3] Taken as a precentage of all connected Universities
[4] SERENATE Summary Report, p.6

The Compendium data suggest that the SERENATE recommendations on Gigabit networking are being implemented in many countries now. It seems that fibre optic technology is allowing NRENs to leapfrog immediately to much higher capacities. Gigabit Ethernet is being introduced by many hitherto less developed 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.

Bandwidth of secondary and primary 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 high on the agenda in many countries in very 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 this activity. Secure access by schools to the Internet is seen as key to the development of the Information Society.

The following table summarises the policy position of NRENs with regard to the connection of schools, both primary and secondary:

Table 2.1.5 Connection policies: secondary and primary schools

Group of NRENs	Allowed to serve secondary schools?		Allowed to serve primary schools	
	Yes	No	Yes	No
EU/EFTA	21	4	20	5
Other	17	4	10	11

For EU/EFTA countries, there is only one NREN which distinguishes between primary and secondary schools when it comes to permission to connect. In other countries, this distinction seems to be more widespread.

On the level of connection policies, not much has changed since 2003. However, there were significant changes in the actual connections. In the new EU member states, only Cyprus and Malta do not connect secondary schools. The total number of secondary schools connected in these countries has risen from 767 in 2003 to 1,187 in 2005. There has not been a similar increase in the 'old' member states yet, although several NRENs from these countries have reported that they have started with programmes to connect secondary schools[5].

[5] **See Country-by country information in section 2.6**

No conclusions can be drawn about the situation in countries not included in the tables. Various cases may apply:

* 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);

* The Institutions may be connected through a different organisation. For example, secondary schools in many countries are connected to the Internet through separate organisations.

* Institutions may be connected through commercial ISPs;

* Institutions may not be connected to the Internet at all.

A similar analysis has not been carried out for other categories of connected institutions (research institutes, institutions of higher/further education, other bodies). We have decided to focus on Universities because all NRENs provide connections to them and because by their nature, Universities contain good samples of users from all disciplines. Looking at Universities can thus indicate overall trends as well as important advances in networking technologies and applications. Secondary and primary schools are an emerging and potentially important new area for NRENs and therefore it seemed appropriate to feature them in this edition of the Compendium.

2.2 Connection Policies

Legend	
	100% connected
	≥ 75% connected
	≥ 50%, < 75% connected
	≥ 25%, < 50% connected
	≥ 1%, < 25% connected

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

Table 2.2 Connection policies – categories of institutions for which connection to the NREN is allowed and % connected to the NREN.

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
EU & EFTA countries										
Belgium	BELNET	yes	yes	yes	yes	yes	yes	yes	yes	yes
Cyprus	CYNET	yes	yes	yes	no	no	no	no	no	yes
Czech Republic	CESNET	yes	yes	yes	yes	yes	yes	yes	yes	yes
Denmark	UNI•C	yes	yes	yes	no	no	yes	no	no	yes
Estonia	EENet	yes	yes	yes	yes	yes	yes	yes	yes	no
Finland	FUNET	yes	no	yes	no	no	yes	no	yes	yes
France	RENATER	yes	yes	yes	yes	yes	yes	yes	yes	no
Germany	DFN	yes	yes	yes	yes	yes	yes	yes	yes	yes
Greece	GRNET	yes	yes	yes	yes	yes	yes	no	yes	yes
Hungary	NIIF/HUNGARNET	yes	yes	yes	yes	yes	yes	no	yes	yes
Iceland	RHnet	yes	yes	yes	yes	no	yes	no	no	no
Ireland	HEAnet	yes	yes	yes	yes	yes	yes	no	yes	yes
Italy	GARR	yes	yes	yes	yes	yes	yes	yes	yes	yes
Latvia	LANET	yes	yes	yes	yes	no	yes	yes	yes	
Latvia	LATNET	yes	yes	yes	yes	yes	yes	yes	yes	yes
Lithuania	LITNET	yes	yes	yes	yes	yes	yes	yes	yes	yes

Table 2.2 Connection policies (continued)

Legend	
	100% connected
	≥ 75% connected
	≥ 50%, < 75% connected
	≥ 25%, < 50% connected
	≥ 1%, < 25% connected

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
Luxembourg	RESTENA	yes	yes	yes	yes	yes	yes	no	yes	no
Malta	CSC	yes	yes	yes	yes	yes	yes			
Netherlands	SURFnet	yes	yes	yes	yes	yes	yes	yes	no	yes
Norway	UNINETT	yes	yes	yes	yes	yes	yes	no	no	yes
Poland	PIONIER	yes	yes	yes	yes	yes	yes	yes	yes	no
Portugal	FCCN	yes	yes	yes	yes	yes	no	no	yes	no
Slovakia	SANET	yes	yes	yes	yes	yes	yes	no	yes	no
Slovenia	ARNES	yes	yes	yes	yes	yes	yes	no	yes	yes
Spain	RedIRIS	yes	no	yes	no	no	yes	yes	yes	yes
Sweden	SUNET	yes	yes	yes	no	no	yes	no	yes	yes
Switzerland	SWITCH	yes	yes	yes	yes	yes	yes	yes	yes	no
United Kingdom	UKERNA	yes	yes	yes	yes	yes	yes	yes	yes	yes
Other countries										
Algeria	CERIST	yes	yes	yes	yes	no	yes	yes	yes	
Azerbaijan	AzNET	yes	no	no	yes	no	yes	no	no	yes
Azerbaijan	AzRENA	yes	no	yes	no	no	yes	no	yes	
Belarus	BASNET	yes	no	yes	yes	no	yes	yes	yes	no
Bulgaria	IST Foundation	yes	yes	yes	yes	yes	yes	no	no	no
Croatia	CARNet	yes	yes	yes	yes	yes	yes	yes	yes	yes
Georgia	GRENA	yes	yes	yes	yes	no	yes	yes	yes	no

Table 2.2 Connection policies (continued)

Country	NREN	Universities	Institutes of higher/ further education	Research institutes	Secondary schools	Primary schools	Libraries, museums, national archives	Hospitals (other than University hospitals)	Government departments (national, regional, local)	Others
Israel	IUCC	yes	yes	yes	no	no	yes	yes	no	no
Kazakhstan	KazRENA	yes	yes	yes	yes	yes	yes	yes	yes	yes
Kyrgyzstan	KRENA-AKNET	yes	yes	yes	yes	yes	yes	yes	no	yes
Macedonia, FYRo	MARNet	yes	yes	yes	yes	yes	yes	yes	yes	yes
Moldova	RENAM	yes	yes	yes	yes	yes	yes	yes	yes	yes
Morocco	MARWAN	yes	yes	yes	yes	yes	yes	yes	yes	no
Romania	RoEduNet	yes	yes	yes	yes	yes	yes	no	yes	no
Russian Federation	RBNet/RUNNet	yes	yes	yes	yes	no	yes	no	yes	no
Serbia / Montenegro	AMREJ	yes	yes	yes	yes	no	yes	yes	yes	yes
Syria	SHERN	yes	yes	yes	no	no	no	no	no	no
Turkey	ULAKBIM	yes	yes	yes	no	no	yes	no	yes	no
Ukraine	URAN	yes	yes	yes	yes	yes	no	no	yes	yes
Uzbekistan	UzSciNet	yes	yes	yes	yes	yes	yes	yes	yes	yes

Legend	
	100% connected
	≥ 75% connected
	≥ 50%, < 75% connected
	≥ 25%, < 50% connected
	≥ 1%, < 25% connected

2.3 Acceptable Use Policies

The following table summarises a number of key elements of the AUPs of NRENs:

- Does the NREN have an AUP?
- Does it describe what use of the network is allowed?
- Does it describe what use of the network is forbidden?
- Should it be signed by each institution that is connected to the network?
- Does it require institutions to designate a person in charge of security?
- Does it recommend or require connected institutions to develop their own AUPs?

Table 2.3 Acceptable use policies

	NREN	AUP?	Describes what is allowed?	Describes what is forbidden?	Signed?	Security person?	Own AUPs?
EU/EFTA countries							
Belgium	BELNET	yes	yes	yes	yes	no	no
Cyprus	CYNET	yes	yes	yes	no	no	no
Czech Republic	CESNET	yes	no	yes	yes	no	no
Denmark	UNI•C	yes	yes	yes	no	no	no
Estonia	EENet	yes	yes	yes	no	no	no
Finland	FUNET	yes	yes	yes	no	no	
France	RENATER	yes	yes	yes	yes	yes	yes
Germany	DFN	yes	yes	yes	yes	no	yes
Greece	GRNET	yes	yes	yes	yes	no	no
Hungary	NIIF/HUNGARNET	yes	yes	yes	yes	yes	yes
Iceland	RHnet	yes	yes	yes	no	no	no
Ireland	HEAnet	yes	yes	yes	yes	no	no
Italy	GARR	yes	yes	yes	yes	yes	no
Latvia	LANET	yes		yes			
Latvia	LATNET	yes	no	yes	yes	no	no
Lithuania	LITNET	yes	no	yes	yes	yes	no
Luxembourg	RESTENA	yes	yes	yes	no	no	no
Malta	CSC	yes	yes	yes	yes	yes	no
Netherlands	SURFnet	yes	no	no	yes	yes	yes
Norway	UNINETT	yes	yes	yes	no	no	no
Poland	PIONIER	yes	yes				
Portugal	FCCN	yes	yes	yes	yes	yes	no
Slovakia	SANET	yes	yes	yes	no	no	
Slovenia	ARNES	yes	no	yes	no	no	no
Spain	RedIRIS	yes	yes	yes	yes	yes	yes
Sweden	SUNET	yes	yes	yes	no	no	no
Switzerland	SWITCH	yes	yes	yes	no	no	yes
United Kingdom	UKERNA	yes	yes	yes	yes	no	yes

Table 2.3 Acceptable use policies (continued)

	NREN	AUP?	Describes what is allowed?	Describes what is forbidden?	Signed?	Security person?	Own AUPs?
Other countries							
Algeria	CERIST	yes	yes	yes	yes	no	no
Azerbaijan	AzNET	yes	no	yes	no	no	no
Azerbaijan	AzRENA	yes	no	yes	no	no	no
Belarus	BASNET	no					
Bulgaria	IST Foundation	yes	yes	yes	yes	no	yes
Croatia	CARNet	yes	yes	yes	no	no	yes
Georgia	GRENA	yes	no	no	no	yes	no
Israel	IUCC	yes	yes	yes	no	no	no
Kazakhstan	KazRENA	no	no	no	no	no	no
Kyrgyzstan	KRENA-AKNET	no	no	no	no	no	no
Macedonia, FYRo	MARNet	no					
Moldova	RENAM	yes	yes	yes	yes	no	no
Morocco	MARWAN	yes	yes	yes	yes	yes	no
Romania	RoEduNet	yes	yes	yes	no	yes	yes
Russian Federation	RBNet/RUNNet	yes	yes	yes	yes	no	no
Serbia / Montenegro	AMREJ	yes	yes	yes	no	no	no
Turkey	ULAKBIM	yes	yes	yes	yes	no	yes
Ukraine	URAN	no					
Uzbekistan	UzSciNet	yes	no	no	yes	yes	no

2.4 IPv6 uptake

The table 2.4 gives information about the IPv6 uptake in NRENs.

The uptake of IPv6 is greater within EU/EFTA NRENs than in those of other countries. The overall mean figures are that 10% and 2% of connected institutions, respectively, are also connected via IPv6.

These figures are probably understated, because not all NRENs that offer IPv6 connections have answered this question, partly because some NRENs do not have separate figures for IPv6 and IPv4 traffic.

There are wide variations within these averages, though. Within NRENs of all types, the lead in IPv6 seems to be taken by the universities rather than research institutes. In the EU/EFTA NRENs, the respective figures are 15% and 5% take-up. In other NRENs, the mean figures are 3% and 1%, respectively.

One cause of this disparity could be the relative size of universities and research institutes. By their very nature, universities encompass large numbers of students, teachers and researchers, from a range of disciplines and interests. It would not be unusual for at least some departments in a university to have a professional interest in a new Internet protocol.

There are other indicators of the uptake of IPv6. The GÉANT monthly reports give the volume of IPv6 traffic for each NREN access (or group of NRENs, as in the case of NORDUnet). Over time, there has been an increase in the overall level of IPv6 traffic within GÉANT.

Usage varies considerably from one NREN to another. While the usage by most NRENs is still less than 1% of total IP traffic, there are a few leaders, with levels of usage between 10% and 20%. Moreover, the growth in IPv6 traffic has been considerable, increasing by a factor of 14 between December 2003 and May 2005.

As a proportion of total IP traffic, the growth in IP traffic has been from 0.3% to 2.7% of the total traffic.

The following table provides information on IPv6 connections for Universities and for Research Institutes. The first two columns give the total number of connected institutions in each category and the number that has an IPv6 connection. The other columns give information on which percentage of all the institutions that have an IPv6 connection are connected, respectively, via native IPv6, via tunneled IPv6, connected using 6to4 or via tunnel brokers. Note that unfortunately, because of the way the data was gathered, a zero can mean either a true zero or no reply.

Table 2.4 IPv6 uptake

	NREN	Total Universities connected to the NREN	Number connected via IPv6	% native	% tunnelled	% 6to4	% brokers	Total Research Institutes connected to the NREN	Number connected via IPv6	% native	% tunnelled	% 6to4	% brokers
EU/EFTA countries													
Belgium	BELNET	18	3	100	0	0	0	34	1	100	0	0	0
Cyprus	CYNET	1						3					
Czech Republic	CESNET	37	11	100	0	0	0	21	1	100	0	0	0
Denmark	UNI•C	12						25					
Estonia	EENet	11	2	100	0	0	0	15	5	40	60	0	0
Finland	FUNET	49	10	50	50	0	0	15	1	0	100	0	0
France	RENATER	406						244					
Germany	DFN	70	18	11	89	0	0	127	18	0	100	0	0
Greece	GRNET	20	7	57	29	14	0	20	1	0	100	0	0
Hungary	NIIF/ HUNGAR-NET	24	12	100	0	0	0	66	1	100	0	0	0
Iceland	RHnet	8	1	0	100	0	0	7	0	0	0	0	0
Ireland	HEAnet	7	2	50	0	0	50	10	1	100	0	0	0
Italy	GARR	85	13	70	30	0	0	106	5	60	40	0	0
Latvia	LANET	27						36					
Latvia	LATNET	22						18					
Lithuania	LITNET	20	5	40	60	0	0	54	1	100	0	0	0
Luxembourg	RESTENA	6						16					
Malta	CSC	5	1	0	100	0	0	1	0	0	0	0	0
Netherlands	SURFnet	60	60	83	17	0	0	65	50	33	17	0	0
Norway	UNINETT	4	4	100	0	0	0	83	10	50	50	0	0
Poland	PIONIER	95						160					
Portugal	FCCN	22	7	57	43	0	0	12	1	0	100	0	0
Slovakia	SANET	52	3	100	0	0	0	25	0	0	0	0	0

Table2.4 IPv6 uptake (continued)

	NREN	Total Universities connected to the NREN	Number connected via IPv6	% native	% tunnelled	% 6to4	% brokers	Total Research Institutes connected to the NREN	Number connected via IPv6	% native	% tunnelled	% 6to4	% brokers
Slovenia	ARNES	10	1	0	100	0	0	57	1	0	100	0	0
Spain	RedIRIS	66	11	36	64	0	0	150	0	0	0	0	0
Sweden	SUNET	40						5					
Switzerland	SWITCH	31	4	100	0	0	0	2	1	100	0	0	0
United Kingdom	UKERNA	120	30	10	90	0	0	50	0	0	0	0	0
	Total	**1,328**	**205**					**1,427**	**78**				
			15.4%						**5.5%**				
Other countries													
Azerbaijan	AzNET	4											
Azerbaijan	AzRENA	16						24					
Belarus	BASNET	10						180					
Bulgaria	IST Foundation	20						72	1	100	0	0	0
Croatia	CARNet	190	3					50					
Georgia	GRENA	10	0	100	0	0	0	30	0	0	0	0	0
Israel	IUCC	8	2					5	0	0	0	0	0
Kazakhstan	KazRENA	6	0	0	100	0	0	21	0	0	0	0	0
Kyrgyzstan	KRENA-AKNET	16						2					
Macedonia, FYRo	MARNet	10						5					
Moldova	RENAM	6						35					
Morocco	MARWAN	13						2					
Romania	RoEduNet	50	10					35	6	85	15	0	0
Russian Federation	RBNet/ RUNNet	168	0	80	20	0	0	270	0	0	0	0	0

	NREN	Total Universities connected to the NREN	Number connected via IPv6	% native	% tunnelled	% 6to4	% brokers	Total Research Institutes connected to the NREN	Number connected via IPv6	% native	% tunnelled	% 6to4	% brokers
Serbia/ Montenegro	AMREJ	5	1					22	0	0	0	0	0
Syria	SHERN	5	0	100	0	0	0	3	0	0	0	0	0
Turkey	ULAKBIM	80	5	100	0	0	0	14	1	100	0	0	0
Ukraine	URAN	25	0	100	0	0	0	6	0	0	0	0	0
Uzbekistan	UzSciNet	80						24					
	Total	**758**	**21**					**811**	**8**				
			2.8%						**1.0%**				

2.5 Number of connected Universities and bandwidth

The organisational setup 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 relatively many, but smaller ones.

Also, some NRENs have listed entire Universities as one institution, others have counted faculties or schools that form part of a University but are geographically at different locations as different institutions.

In this section, information is provided for 2003 and 2005, showing the evolution over the past years. The 2005 information is also provided in table format in Appendix 1.

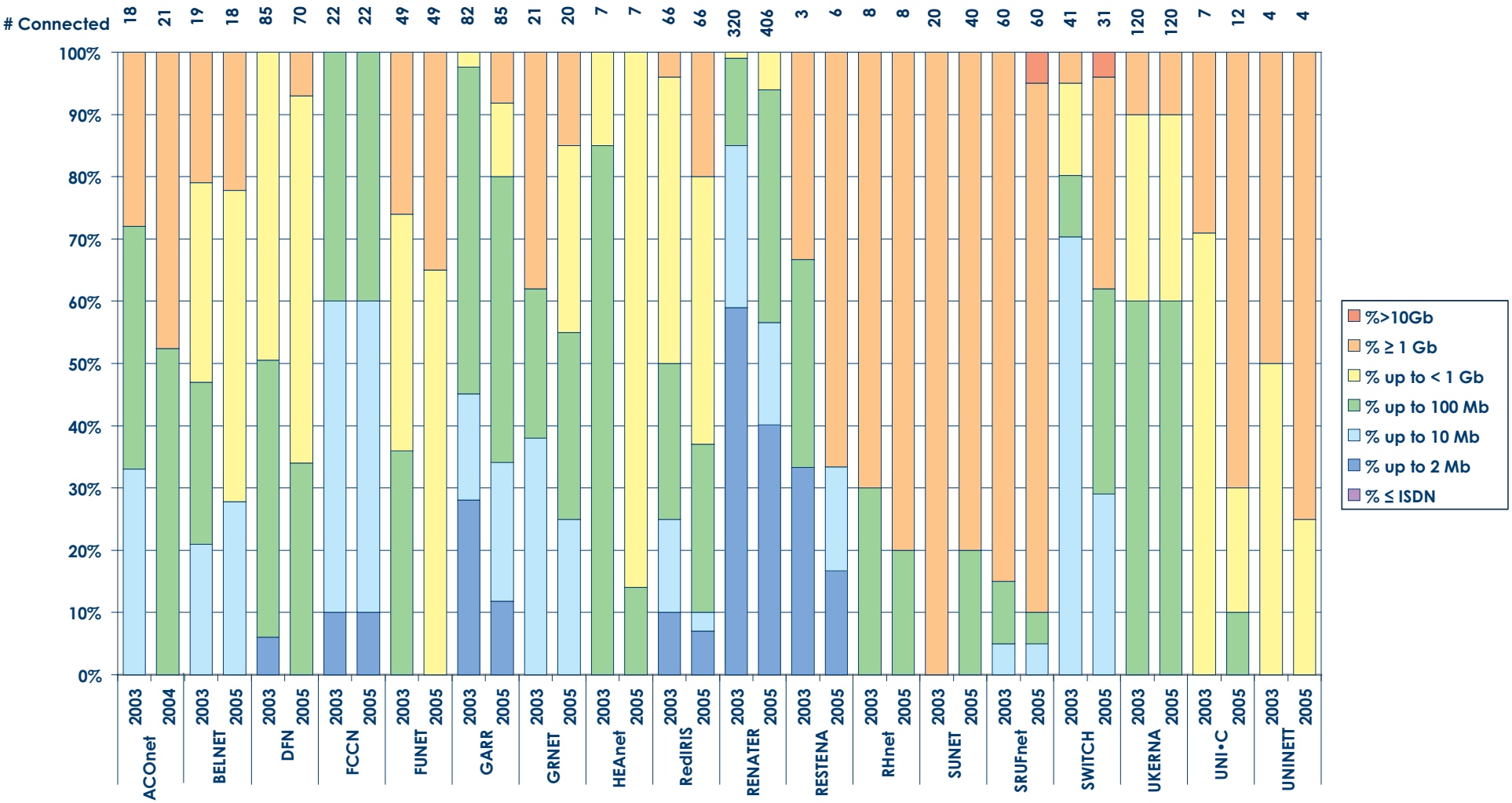
Note that the Polish information from 2005 was extrapolated from data gathered from 13 out of the 20 MANs that together form the PIONIER network.

RENATER (France) has given the information on the number of separate institutions that are connected. DFN (Germany) has instead given information about the number of connected Universities. France does not have four times the number of Universities that Germany has.

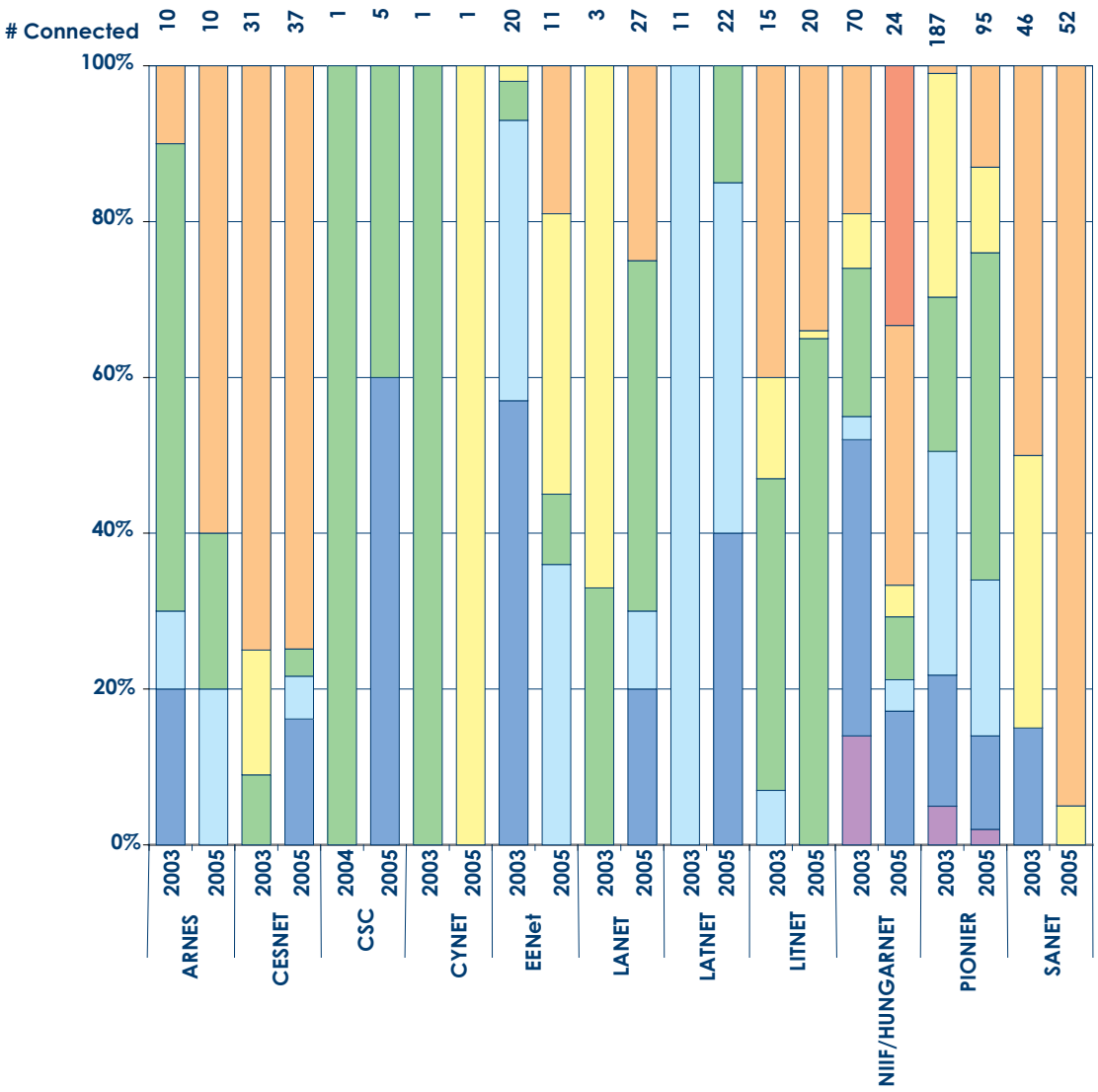
The information of some NRENs in 2003 (e.g., AMREJ, HUNGARNET, SWITCH) concerns the number of connected institutions, whereas in 2005 it concerns the number of connected Universities.
In some cases (e.g., CARNet) the reverse applies: the information from 2003 concerns the number of connected Universities as such, the information from 2005 concerns rather the connections to the separate institutions that are part of those Universities.

It may not be possible to normalize this completely, because not all NRENs are able to supply the data in both ways.

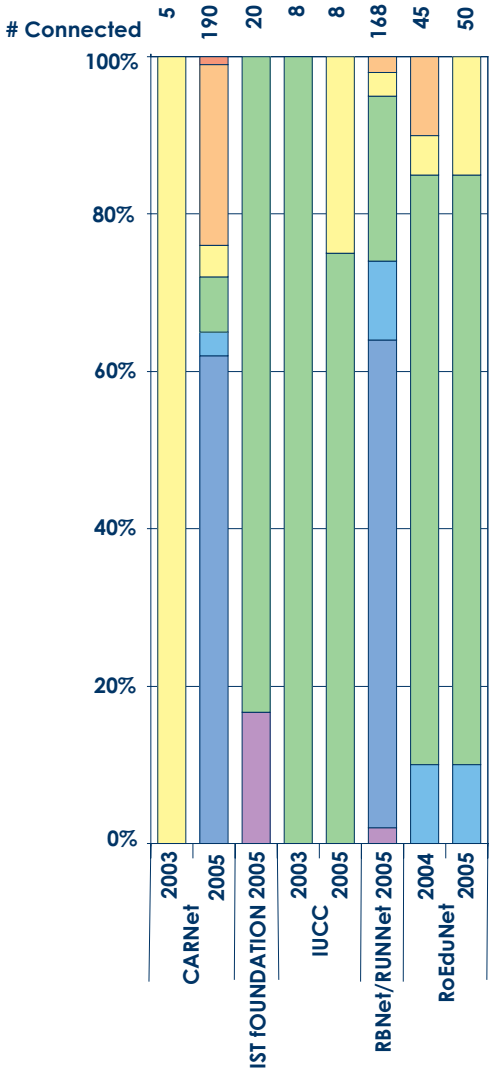
Graph 2.5.1 University bandwidth, EU-15/EFTA countries, 2003 and 2005



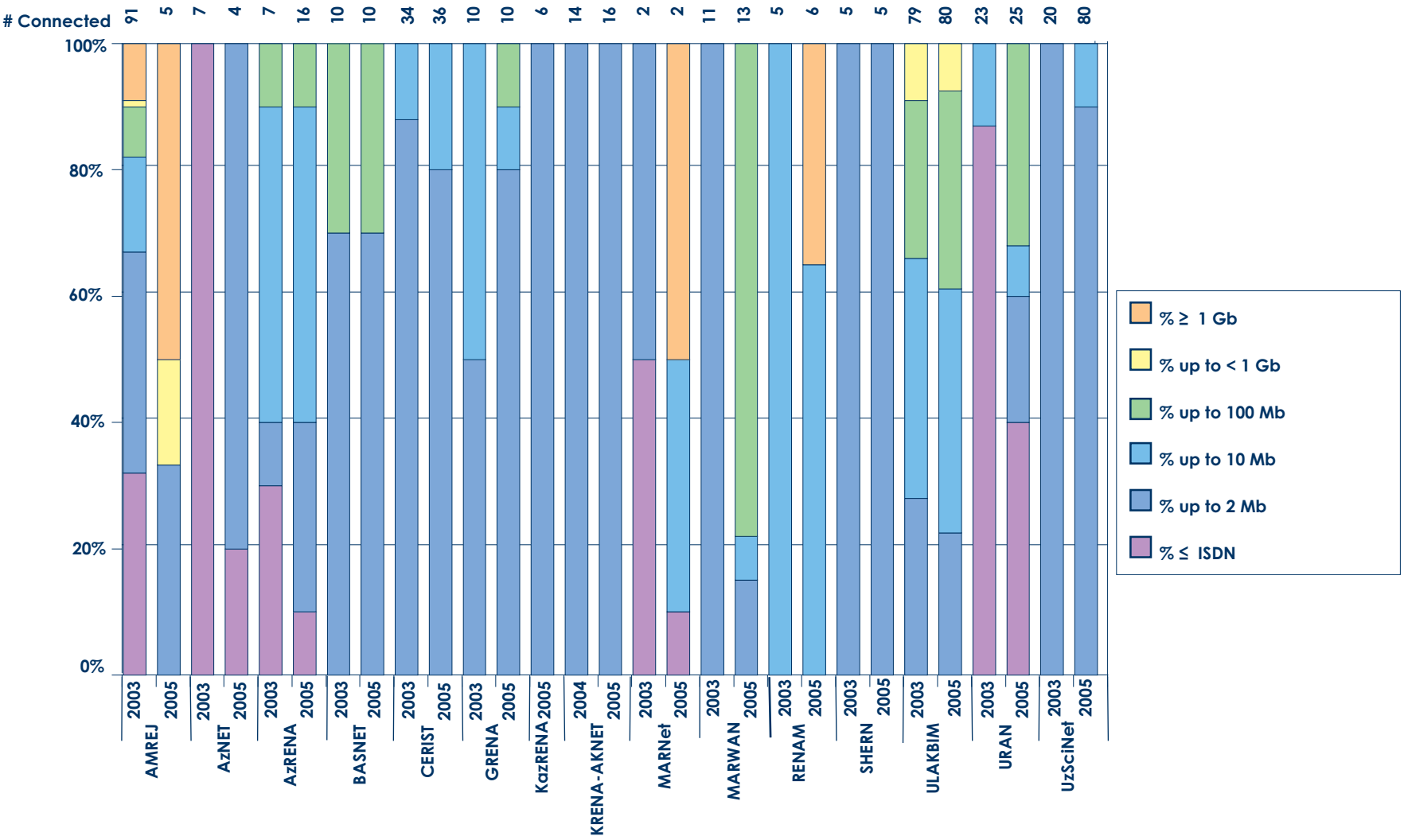
Graph 2.5.2 University bandwidth, new EU member states



Graph 2.5.3 University bandwidth, non-EU/EFTA GN2 partners



Graph 2.5.4 University bandwidth, other countries

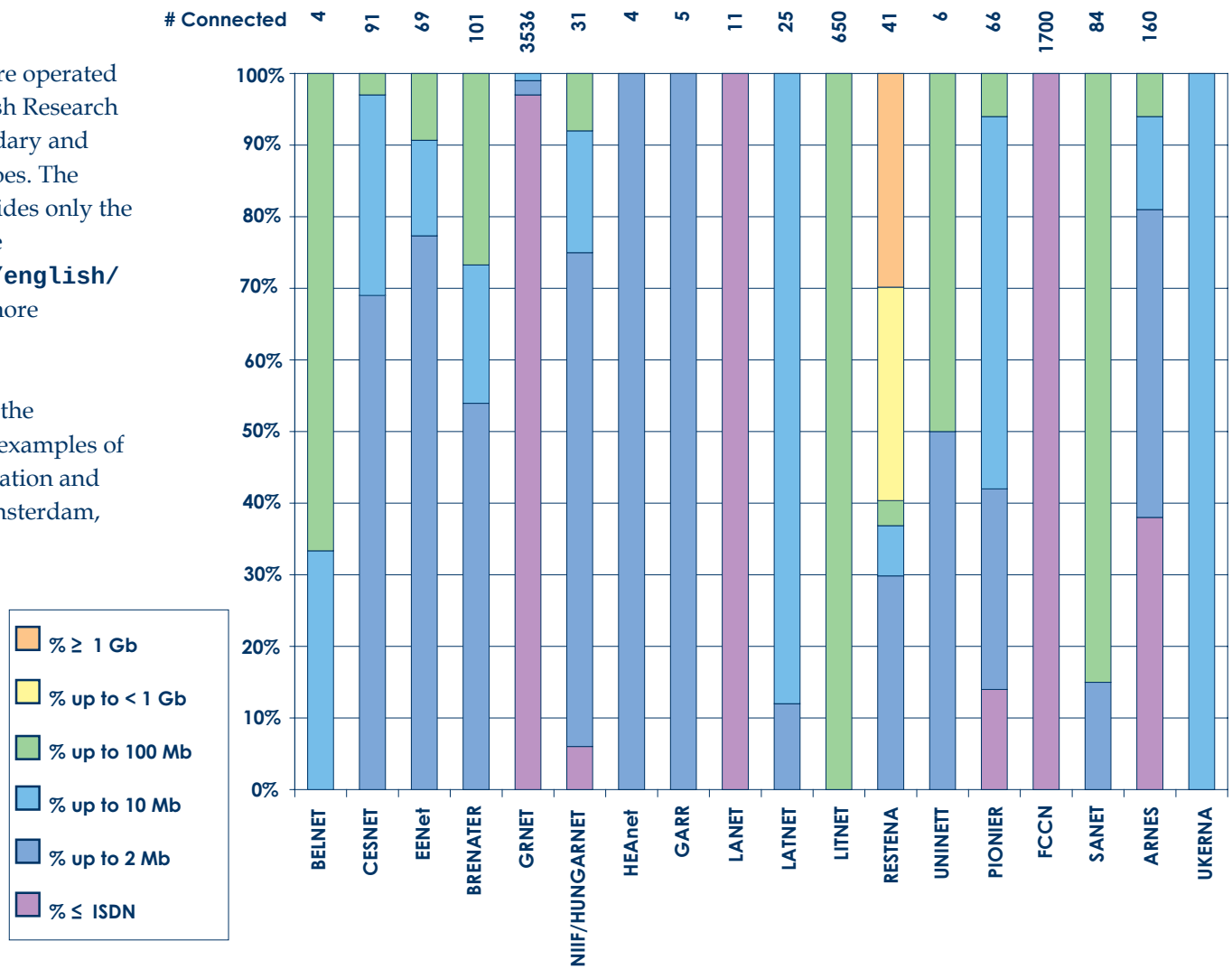


2.6. Number of connected secondary schools and bandwidth

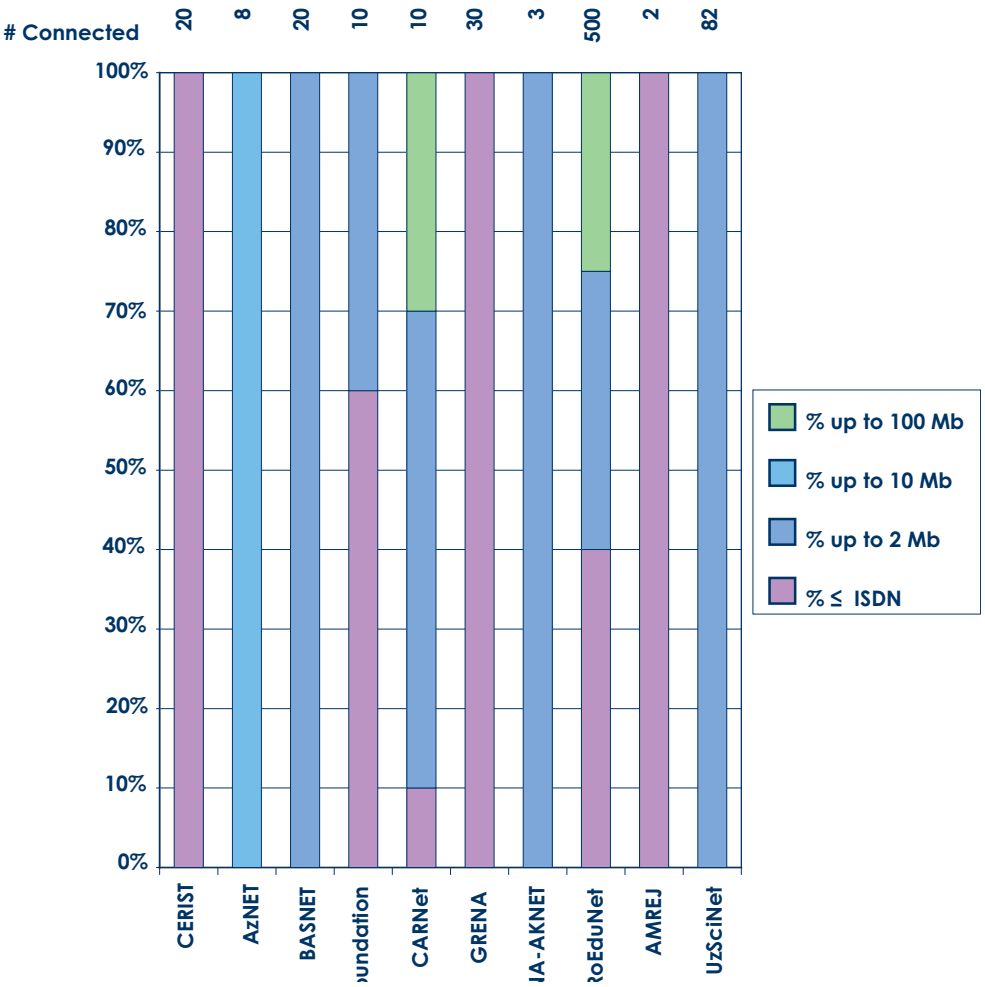
Note that in Denmark, two networks are operated by UNI•C: Forskningsnettet (the Danish Research Network), that does not connect secondary and primary schools, and Sektornet, that does. The information in this Compendium provides only the information from Forskningsnettet. See **http://www.uni-c.dk/generelt/english/education/sektornet.html** for more information.

More information can also be found in the SERENATE deliverable 15, 'Report on examples of extension of research netowrks to education and other user communities', TERENA, Amsterdam, October 2003, ISBN 90-77559-05-1

Graph 2.6.1 Secondary school bandwidth, EU/EFTA countries



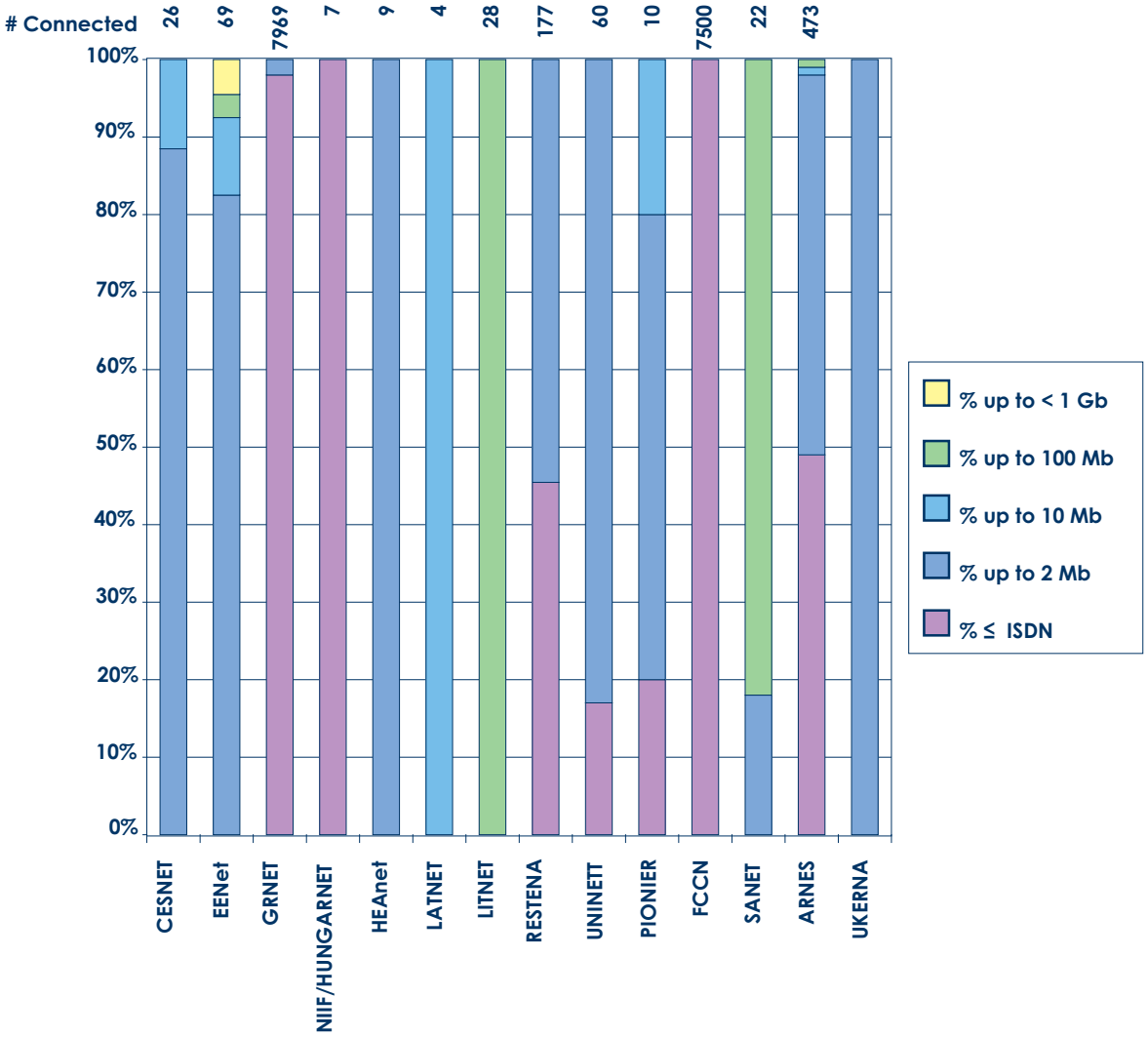
Graph 2.6.2 Secondary school bandwidth, other countries



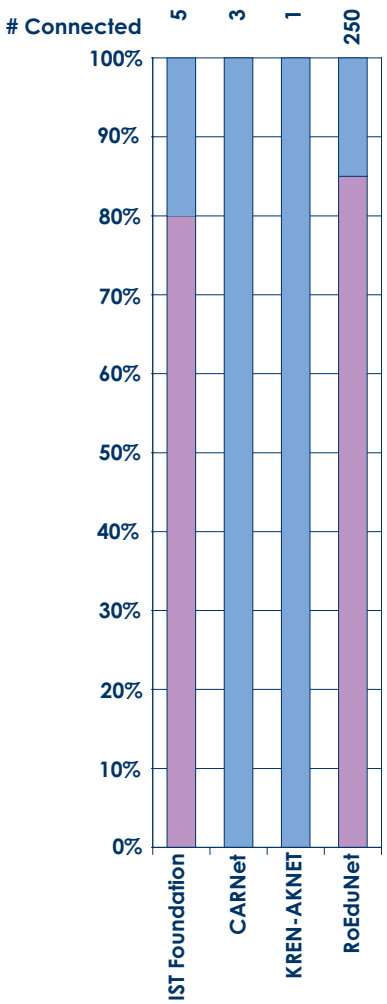
Note that RBNet/RUNNet (Russia) is not included in this graph because it did not provide information about the division of the bandwidth over secondary schools. However, it connects 5,000 secondary schools.

2.7 Number of connected primary schools and bandwidth

Graph 2.7.1 Primary schools bandwidth, EU/EFTA countries. (See the remark in section 2.6 about UNI•C, Denmark.)



Graph 2.7.2 Primary schools bandwidth, other countries

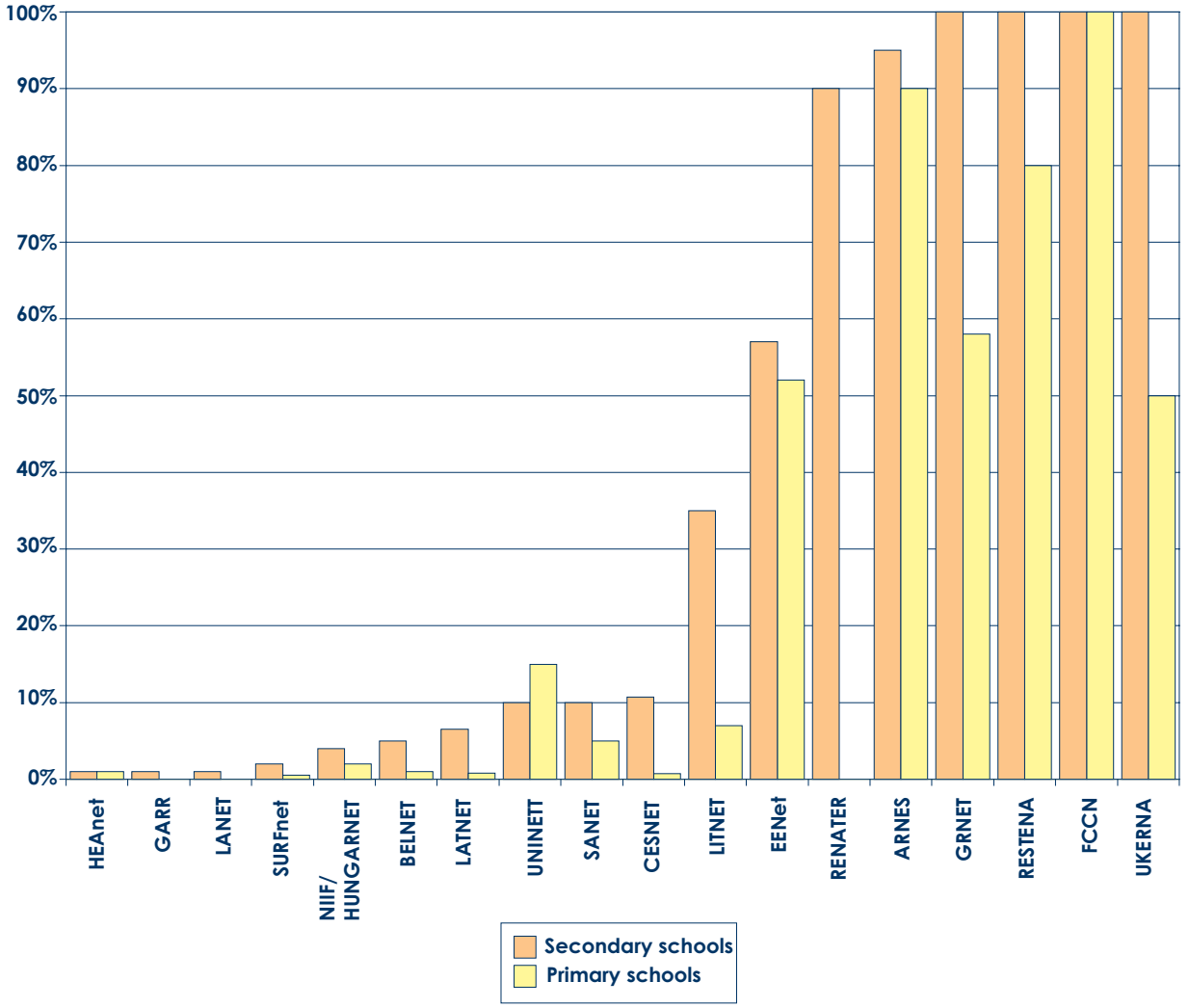


2.8 Percentage of schools connected to the NREN

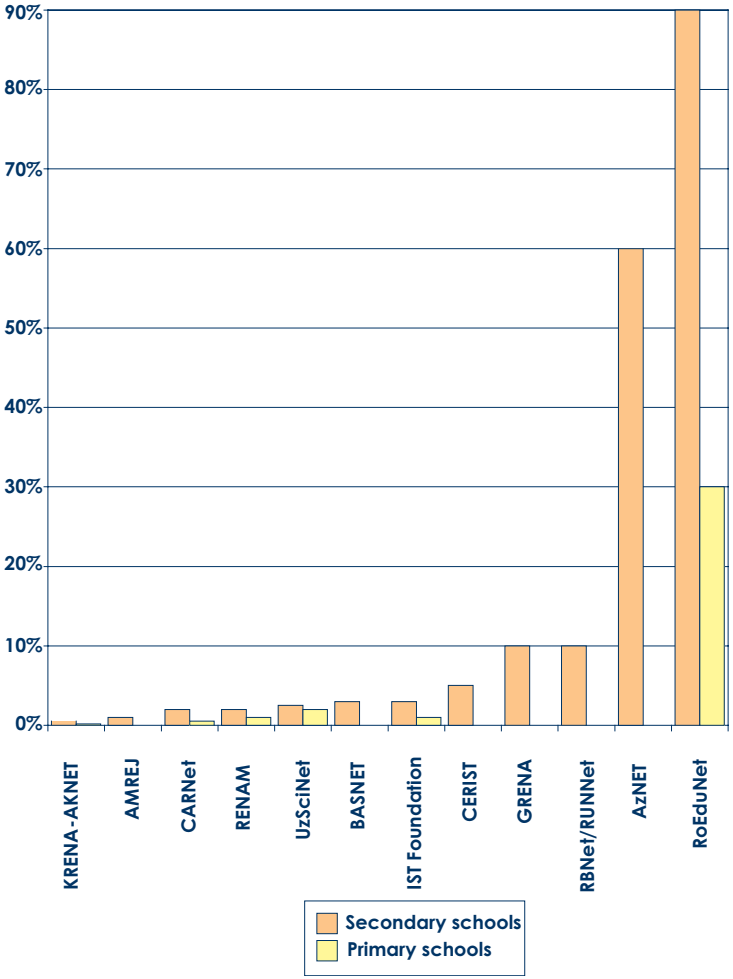
The following graphs provide information about the percentage of all secondary and primary schools that is connected to the NREN, according to estimates supplied by the NRENs.

Note that aside from the connection itself, also the connection method and the type of services offered are 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.

Graph 2.8.1 Percentage of schools connected through the NREN, EU/EFTA countries



Graph 2.8.2 Percentage of schools connected through the NREN, other countries



3 Network

This section provides insights 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 and section 3.6 looks at the relatively new area of dark fibre.

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 provides information about the core usable backbone capacity of NRENs. By this, 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 that case, 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.

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, 5 out of 17 NRENs the EU-15/EFTA countries already had a core capacity of 2.5 Gb/s – this was also the maximum capacity at that time. Al the others, except RESTENA of Luxembourg, had a capacity of at least 155 Mb/s. In 2005, all 18 NRENs have a capacity of at least 1 Gb/s; the maximum is 10 Gb/s; 6 NRENs operate at this capacity.

In the new EU member states, in 2001, only 1 out of 8 NRENs already had a core capacity of 2.5 Gb/s (CESNET). Only two had a capacity of 155 Mb/s, all the others were operating at a lower capacity. In 2005, 5 of these NRENs had a capacity of at least 1 Gb/s; the lowest capacity was 45 Mb/s.
In the non-EU/EFTA GN2 partners, the situation is a bit less good, with only 2 out of 6 NRENs in this category operating at a capacity of at least 1 Gb/s.

We have data from 15 other NRENs. In 2005, 5 of these operated 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 stages that the EU/EFTA NRENs went through.

The overall trend is that there is considerable growth year on year, with the new EU member states and the non-EU/EFTA countries to the fore in expansion[1].

[1] **See section 3.2.3 for country-by country data.**

Network size

The same trend is also visible when looking at overall network size. By summing the product of bandwidth by distance for each link in a backbone network, we get a rough indicator of the size of a network, in terms both of geographic scale and transmission capacity. Of course it is a rough metric. Nonetheless, it can be useful in monitoring trends within NRENs and across many NRENs over time.

The 2005 survey shows some big changes in the Bandwidth x Distance metric for some countries, while others have remained the same, even since 2001. This may reflect the relatively long time-scale associated with backbone re-design. The average per annum per NREN growth is 136%, and this figure covers a range from 0%/year (no change in network scale) to over 400%/year scale-up. Note that growth in this area is never linear, but is always step-wise.

Table 3.1.1 Bandwidth growth 2001 - 2005[2]

Group of NRENs	Annual growth of Bandwidth x Distance
EU-15/EFTA	77%
New EU member states	201%
EU/EFTA	119%
Other	166%
ALL	136%

[2] See See section 3.4 for country-by-country data

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 by far the most important in terms of capacity. NRENs also often have peering arrangements at neutral Internet exchanges and many also have connections to commercial ISPs, but these do not have the same capacity as those to GÉANT.

It is interesting to note that some NRENs (SURFnet, CESNET, SANET, SWITCH) have their own fibre links. Some of these links are part of the emerging Global Lambda Integrated Facility, a world-scale Lambda-based Laboratory for application and middleware development on emerging LambdaGrids (see www.glif.is for more information).

The situation is different in the countries that are not part of GN2. 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 Highway project can make use of the satellite-based connectivity that is provided through that project.
http://www.silkproject.org/

Dark fibre

There are indications that more and more NRENs are switching over to dark fibre as the technology of the future, with the EU NRENs being in the lead. The table below shows the number of NRENs that currently has at least two-thirds of its backbone as dark fibre, as well as the prediction for early 2007.

Table 3.1.2 Dark fibre on NREN backbones[3]

Group of NRENs	Number of NRENs in the survey	Proportion with at least two-thirds dark-fibre back-bone now	Proportion with at least two-thirds dark-fibre back-bone, early 2007
EU-15/EFTA	17	24%	53%
New EU member states	9	44%	44%
Non-EU/EFTA GN2 partners	6	0%	33%

[3] See See section 3.6 for country-by-country data. Data from other countries ws not fully reliable and has therefore not been included

As well as providing NRENs with the ability to better control, manage and exploit their network infrastructures, dark fibre provides new opportunities to enable users to define their own dedicated end-to-end links across the network, and to do so within fixed NREN budgets. In this sense, the uptake of dark fibre where it is possible is to be commended. Indeed, the procurement of the new GÉANT2 network has endorsed this development and has provided a pan-European dark fibre footprint, already linking fifteen countries.

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.

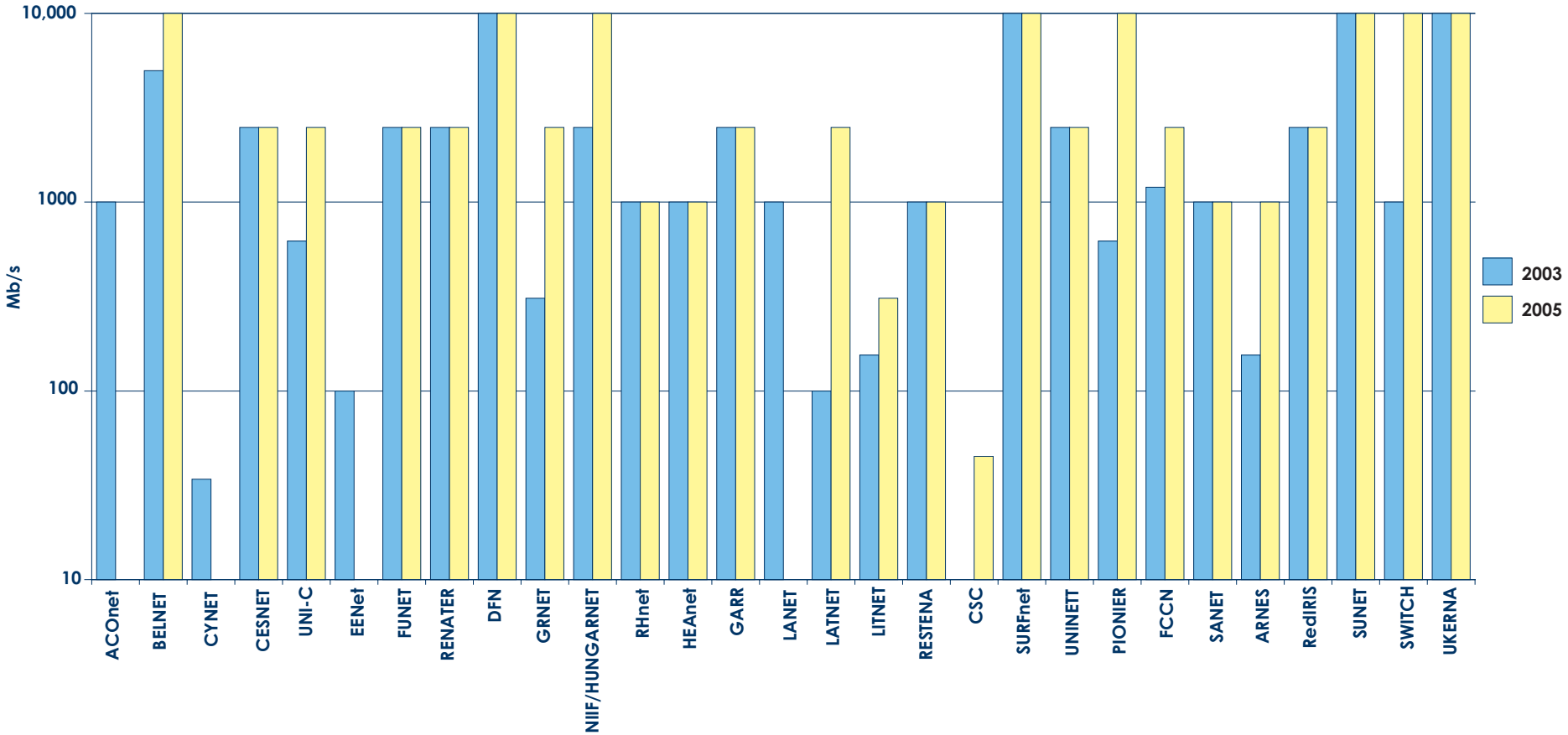
Some NRENs have dark fibre with a very high theoretical capacity. In those cases, we have asked for the usable IP capacity.

Graphs 3.2.1 and 3.2.2 give an idea of the evolution of network capacity from 2003 to 2005. For presentational purposes, the information is given in two graphs: 3.2.1 for the EU and EFTA countries, graph 3.1.2 for the other countries.

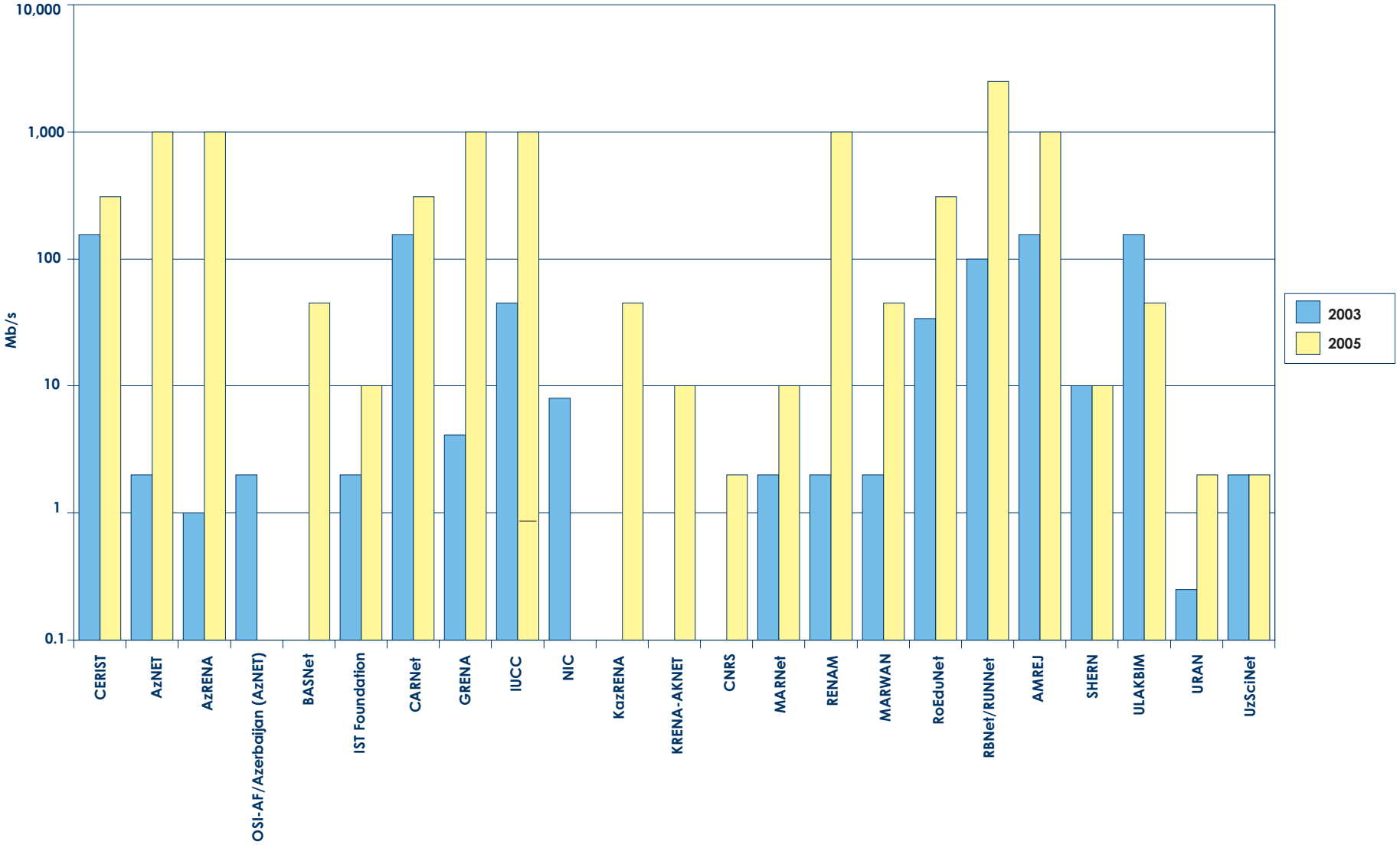
Note that the scales are logarithmic and not the same for the two graphs !

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 2005.

Graph 3.2.1 Core capacity on the networks, 2003 – 2005, EU and EFTA countries



Graph 3.2.2 Core capacity on the networks, 2003 – 2005, other countries



In the table below, capacities of over 1 Gb/s have been colour-coded for increased readability.

Table 3.2.3 Core capacity on the network, 2001 – 2005

	NREN	2001	2002	2003	2004	2005
EU-15/EFTA countries						
Austria	ACOnet	155	1000	1000	1000	
Belgium	BELNET	622	1000	4976	4976	10000
Germany	DFN	622	2488	10000	10000	10000
Portugal	FCCN	180	180	1200	1200	2488
Finland	FUNET	2488	2488	2488	2488	2488
Italy	GARR		2488	2488	2488	2488
Greece	GRNET		310	310	2488	2488
Ireland	HEAnet	155	310	1000	1000	1000
Spain	RedIRIS	155	155	2488	2488	2488
France	RENATER	2488		2488	2488	2488
Luxembourg	RESTENA	10	1000	1000	1000	1000
Iceland	RHnet		1000	1000	1000	1000
Sweden	SUNET	622	10000	10000	10000	10000
Netherlands	SURFnet	2488	10000	10000	10000	10000
Switzerland	SWITCH	310		1000	1000	10000
United Kingdom	UKERNA	2488	2488	10000	10000	10000
Denmark	UNI•C	622	622	622	1000	2488
Norway	UNINETT	2488	2488	2488	2488	2488
New EU member states						
Slovenia	ARNES	100	100	155	310	1000
Czech Republic	CESNET	2488	2488	2488	2488	2488
Malta	CSC				100	45
Cyprus	CYNET			34	34	
Estonia	EENet	24	60	100	100	1000
Latvia	LANET			1000	1000	
Latvia	LATNET	100	100	100	100	2488
Lithuania	LITNET	4	155	155	155	310
Hungary	NIIF/HUNGARNET	155	2488	2488	2488	10000
Poland	PIONIER	155	155	622	10000	10000
Slovakia	SANET	4	1000	1000	1000	1000
Non-EU/EFTA GN2 partners						
Croatia	CARNet	155	155	155	155	310
Bulgaria	IST Foundation			2	100	10
Israel	IUCC			45	45	1000
Russian Federation	RBNet/RUNNet			100		2488
Romania	RoEduNet			34	155	310
Turkey	ULAKBIM	34	34	155	155	45
Other countries						
Azerbaijan	AzNET			2	1000	1000
Azerbaijan	AzRENA			1	5	1000
Belarus	BASNet					45
Algeria	CERIST			155	155	310
Lebanon	CNRS				0.448	2
Georgia	GRENA	0.896	2.048	4.1	4	1000
Iran	IRANET				56	
Kazakhstan	KazRENA					45
Kyrgyzstan	KRENA-AKNET				4	10
Macedonia, FYRo	MARNet	0.5	2	2		10
Morocco	MARWAN			2	34	45
Jordan	NIC		18	8	8	
Moldova	RENAM			2	4	1000
Serbia/Montenegro	AMREJ		2	155	500	1000
Syria	SHERN			10		10
Ukraine	URAN		0.128	0.25	0.128	2
Uzbekistan	UzSciNet		2	2	2	2

3.3 Expected change in the core capacity in two years' time

The following table gives the current core capacity, the expected increase in two years' time and the expected (computed) core capacities for early 2007. Note that, typically, the core capacity goes up in leaps, involving the change of 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 and pricing and the availability of sufficient funds for investment.

For improved readability, capacities of over 1 Gb/s have been colour-coded.

The trend seems to be that in the more advanced countries, the core capacity will evolve to 10 Gb/s or multiples of that.

Table 3.3.1 Expected change in the core capacity in two years' time

	NREN	2005	Increase or comment	2007
EU-15/EFTA Countries				
Belgium	BELNET	> 5 Gb/s ≤10 Gb/s	20 Gb/s	20000
Denmark	UNI•C	> 1.2 Gb/s ≤ 5 Gb/s	10Gb/s	10000
Finland	FUNET	> 1.2 Gb/s ≤ 5 Gb/s	network will be upgraded if (and where) needed to the next step	
France	RENATER	> 1.2 Gb/s ≤ 5 Gb/s		
Germany	DFN	> 5 Gb/s ≤ 10 Gb/s	more than 10 Gb/s	20000
Greece	GRNET	> 1.2 Gb/s ≤ 5 Gb/s	Dark fiber will be leased for serving the GRNET backbone. The PoP connections will be served via multimedia (C/DWDM) connections. The total capacity for each backbone link is expectedto be nX10Gbps	10000
Iceland	RHnet	> 622 Mb/s ≤ 1.2 Gb/s	<=10Gb	10000
Ireland	HEAnet	> 622 Mb/s ≤1.2 Gb/s	10 Gb/s	10000
Italy	GARR	> 1.2 Gb/s ≤ 5 Gb/s		
Luxembourg	RESTENA	> 622 Mb/s ≤ 1.2 Gb/s	same	1000
Netherlands	SURFnet	> 5 Gb/s ≤ 10 Gb/s	Multiples of 10 Gbit/s per link	20000
Norway	UNINETT	> 1.2 Gb/s ≤ 5 Gb/s	One 10 Gbit/s, parallel, 2,5 Gbit/s, Gigabit Ethernet	10000
Portugal	FCCN	> 1.2 Gb/s ≤ 5 Gb/s	> 10 Gbps	20000
Spain	RedIRIS	> 1.2 Gb/s ≤ 5 Gb/s	n * 10 Gbps	20000
Sweden	SUNET	> 5 Gb/s ≤ 10 Gb/s	4 x 10 Gbit/s	40000
Switzerland	SWITCH	> 5 Gb/s ≤ 10 Gb/s	still 10 Gb/s on the backbone links, may be backbone links, may be multiple parallel 10 Gb/s links	10000
United Kingdom	UKERNA	> 5 Gb/s ≤ 10 Gb/s	10 - 40Gb/s	20000
New EU member states				
Cyprus	CYNET	2 Mbit/s or below	Increase by a factor of 3	6
Czech Republic	CESNET	> 1.2 Gb/s ≤ 5 Gb/s	10	10000
Hungary	NIIF/HUNGARNET	> 5 Gb/s ≤ 10 Gb/s	No drastical change	

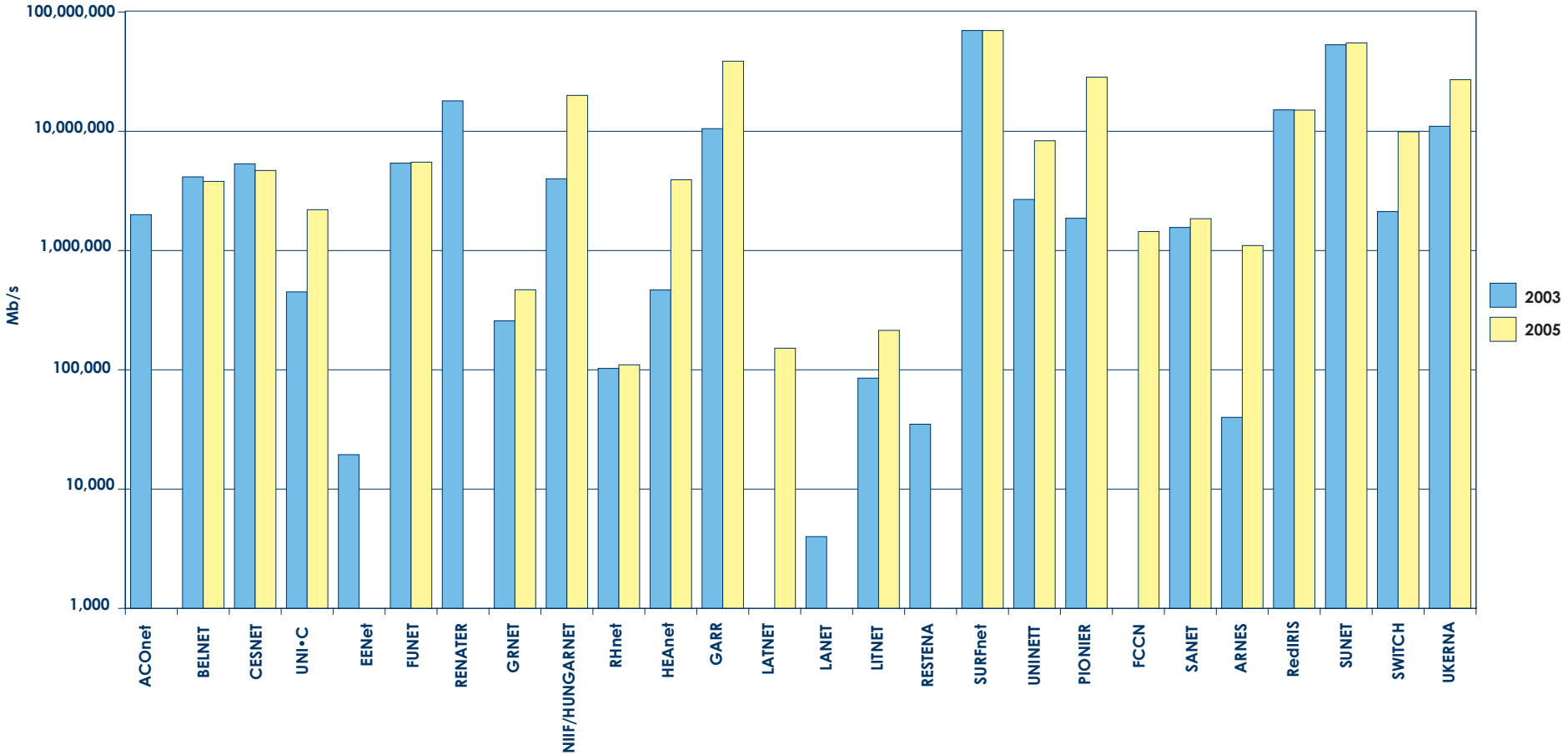
	NREN	2005	Increase or comment	2007
Latvia	LATNET	> 1.2 Gb/s =< 5 Gb/s		
Lithuania	LITNET	> 155 Mb/s =< 622 Mb/s	622 Mb/s-1.2 Gb/s	1000
Malta	CSC	> 34 Mb/s ≤ 155 Mb/s		
Poland	PIONIER	> 5 Gb/s ≤ 10 Gb/s		
Slovakia	SANET	> 622 Mb/s ≤ 1.2 Gb/s	10 Gbps	10000
Slovenia	ARNES	> 622 Mb/s ≤ 1.2 Gb/s	10 Gbit/s	10000
Non-EU/EFTA GN2 partners				
Bulgaria	IST Foundation	> 2 Mb/s ≤ 34 Mb/s	> 155 Mb/s ≤ 622 Mb/s	310
Croatia	CARNet	> 155 Mb/s ≤ 622 Mb/s	1 Gb/s	1000
Israel	IUCC	> 622 Mb/s ≤ 1.2 Gb/s	1Gb/sec	1000
Romania	RoEduNet	> 155 Mb/s ≤ 622 Mb/s	> 5 Gb/s ≤ 10 Gb/s	10000
Russian Federation	RBNet/RUNNet	> 1.2 Gb/s ≤ 5 Gb/s	5Gb/s	
Turkey	ULAKBIM	> 34 Mb/s ≤ 155 Mb/s	>622 Mb/s ≤ 1.2 Gb/s	1000
Other Countries				
Algeria	CERIST	> 155 Mb/s ≤ 622 Mb/s	between 622 Mb/s and 1.2 Gb/s	1000
Azerbaijan	AzNET	> 622 Mb/s ≤ 1.2 Gb/s		
Azerbaijan	AzRENA	> 622 Mb/s ≤ 1.2 Gb/s		
Belarus	BASNet	> 34 Mb/s ≤ 155 Mb/s	Will be a growth by a factor **of five**	
Georgia	GRENA	> 622 Mb/s ≤ 1.2 Gb/s		
Kazakhstan	KazRENA	> 34 Mb/s ≤ 155 Mb/s		
Kyrgyzstan	KRENA-AKNET	> 2 Mb/s ≤ 34 Mb/s	30% Increase	34
Lebanon	CNRS	2 Mbit/s or below	3 Mbit/s	3
Macedonia, FYRo	MARNet	> 2 Mb/s ≤ 34 Mb/s	We will have gigabit MAN in Skopje University	
Moldova	RENAM	> 622 Mb/s ≤ 1.2 Gb/s	factor 1,5	1244
Morocco	MARWAN	> 34 Mb/s ≤155 Mb/s	155 Mb/s ≤ 622 Mb/s	310
Serbia / Montenegro	AMREJ	> 622 Mb/s ≤ 1.2 Gb/s		
Syria	SHERN	> 2 Mb/s ≤ 34 Mb/s	the same	10
Ukraine	URAN	2 Mbit/s or below	34...155 Mbit/s	45
Uzbekistan	UzSciNet	2 Mbit/s or below	2	2

3.4 Core network size

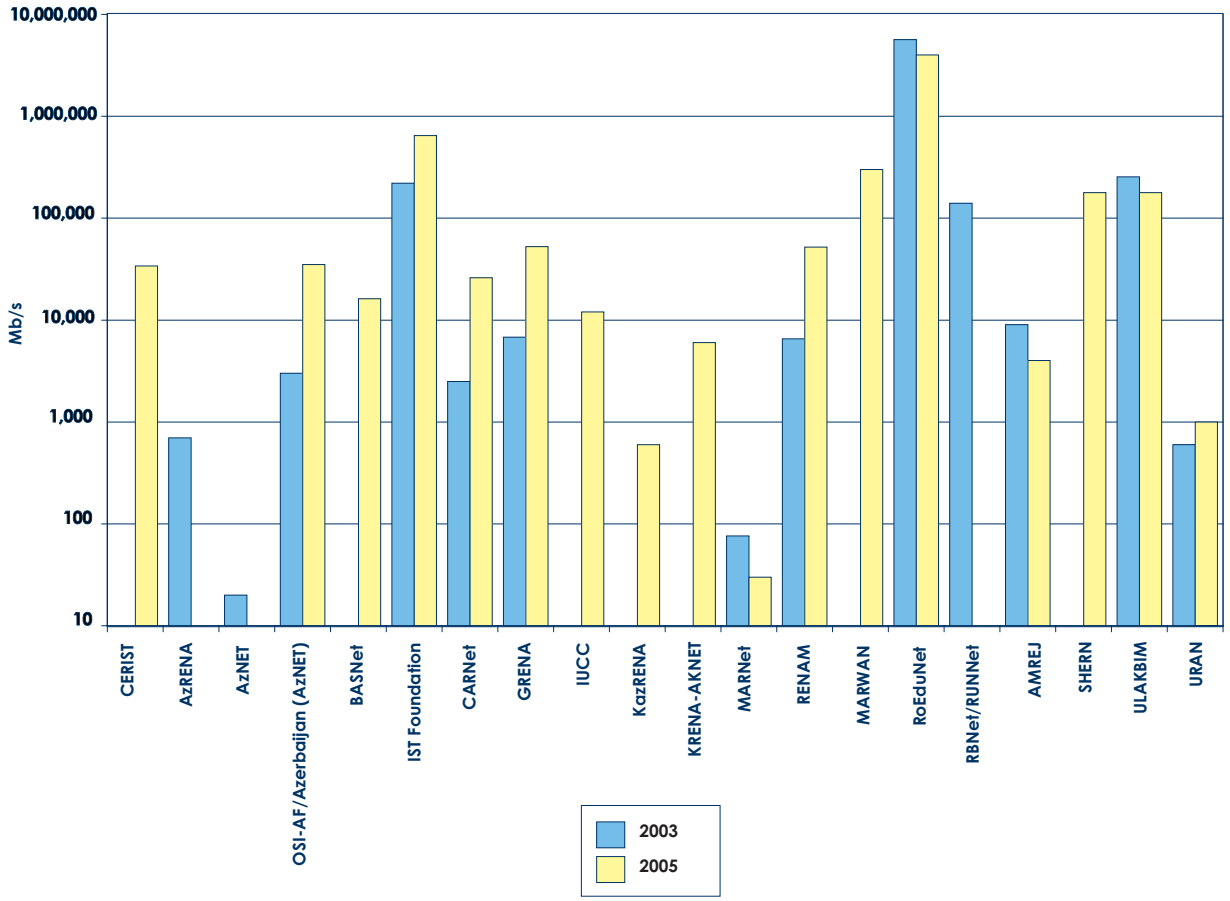
Like earlier years, we have asked NRENs to estimate the total size of their networks by multiplying the length of the various links in the backbone with the capacity of those links in Mb/s. The resulting unit is network size in Mb/s x km. This question is difficult to answer for some NRENs, but because it has been asked for a number of years, the answers have improved..

Note that the scales of the graphs are logarithmic and not the same for the two graphs!

Graph 3.4.1 Core Network size 2003 - 2005: EU and EFTA countries



Graph 3.4.2 Core Network size 2003 - 2005: other countries



3.5 External connectivity: total external links

NRENs have been asked to list all of their external connections in January 2005.

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**.

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 (BASNET, RENAM). Note that some NRENs connect to the wider Internet through the DANTE World Service, which makes use of the GÉANT network.

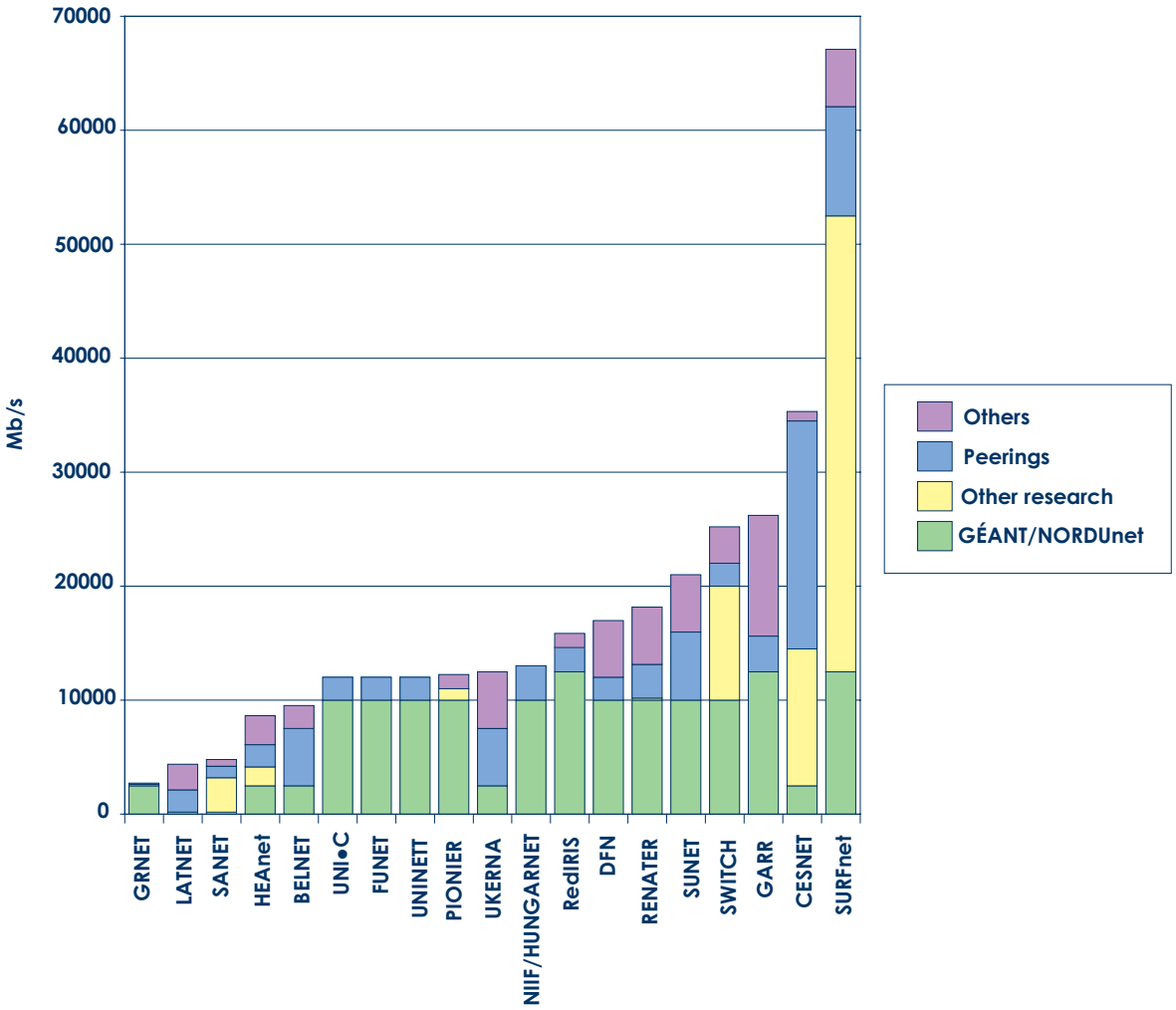
'Other research' includes links to other NRENs, the links of several Central Asian NRENs to DFN via the Silk Highway project and connections to CERN, Starlight and similar.

A peering is an exchange of IP routes in order to optimise traffic[4] . Often, traffic is exchanged; no money changes hands. In some cases, restrictions may apply to such traffic.

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

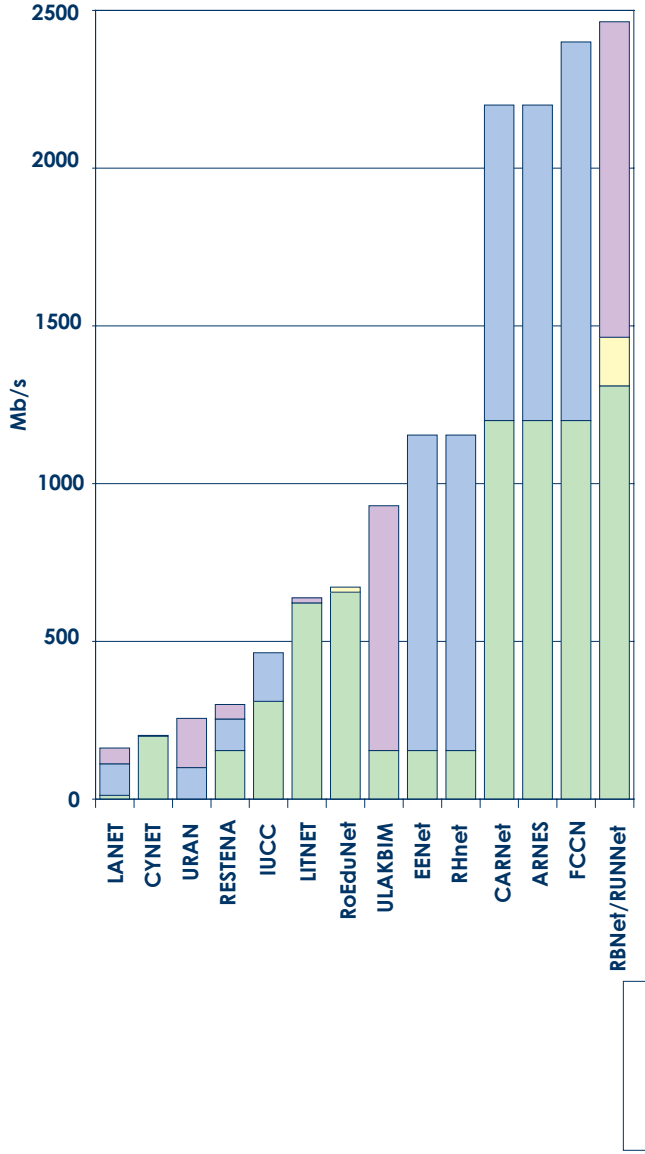
For presentational purposes, three graphs are presented.

Graph 3.5.1 External connectivity > 2.4 Gb, January 2005

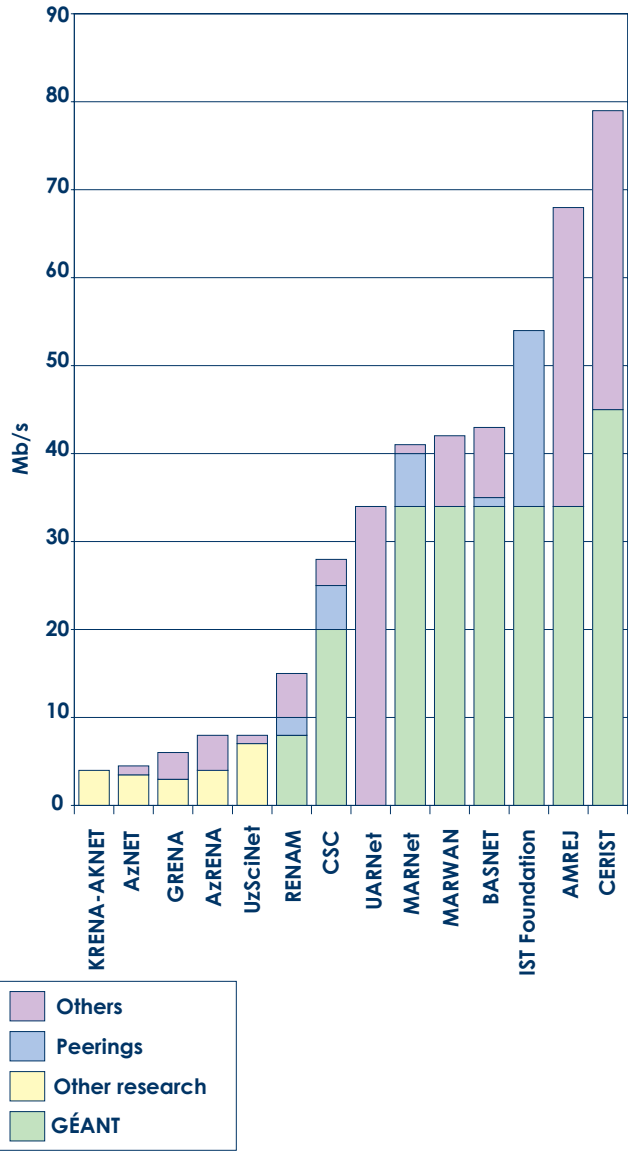


[4] See http://www.euro-ix.net for information on nearly all European Internet exchanges

Graph3.5.2 Exteral Connectivity > 100 Mb, < 2400 Mb, January 2005



Graph3.5.3 External Connectivity < 100 Mb, January 2005



3.6 Dark Fibre

Some NRENs own dark fibre of have IRUs[5] or lease dark fibre and can decide themselves what technology and what speeds to use on their fibre. We have asked NRENs if they currently have IRUs or lease or own dark fibre, or if they plan to get it during the coming two years. We have 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 draw attention to significant changes that are expected over the next two years. UKERNA is currently in the process of procuring its next generation network and cannot yet predict how much of it will be dark fibre.

[5] IRU stands for 'Indefeasible Right of Use'. This is the effective long-term lease (temporary ownership) of a portion of a cable. See, for example, http://whatis.techtarget.com for more information. The distinction between IRUs and lease is becoming less clear.

Table 3.6, Dark Fibre, 2005 and 2007 (darker colour highlights a significant change)

	NREN	2005			2007		
		% own	% IRUs	% leased	% own	% IRUs	% leased
EU-15/EFTA countries							
Belgium	BELNET	0	0	0	0	5	5
Denmark	UNI•C	0	25	0	0	90	0
Finland	FUNET	0	0	5	0	0	15
France	RENATER	0	0	5	0	0	33
Germany	DFN	0	0	0	0	0	95
Greece	GRNET	0	0	0	0	100	0
Iceland	RHnet	0	0	15	0	0	15
Ireland	HEAnet	0	10	0	0	80	10
Italy	GARR	0	3	0	0	15	10
Luxembourg	RESTENA	4	0	47	5	0	55
Netherlands	SURFnet	0	50	50	0	100	0
Norway	UNINETT	2	90	8	2	90	8
Portugal	FCCN	30	5	65	40	10	50
Spain	RedIRIS	0	0	0	0	0	10
Sweden	SUNET	0	0	5	0	0	100
Switzerland	SWITCH	2	20	65	2	20	78
United Kingdom	UKERNA	0	0	2	0	0	?
New EU member states							
Cyprus	CYNET	0	0	0	0	0	0
Czech Republic	CESNET	0	0	100	0	0	100
Hungary	NIIF/HUNGARNET	0	1	10	0	2	50
Latvia	LATNET	0	0	0	0	0	0
Lithuania	LITNET	0	0	0	5	0	0
Malta	CSC	0	0	0	0	0	0
Poland	PIONIER	73	0	0	100	0	0
Slovakia	SANET	3	97	0	3	97	0
Slovenia	ARNES	0	0	80	0	0	80
Non EU/EFTA GN2 partners							
Bulgaria	IST Foundation	0	0	0	0	0	0
Croatia	CARNet	0	0	5	30	30	40
Israel	IUCC	0	2	6	0	2	6
Romania	RoEduNet	0	0	0	10	30	60
Russian Federation	RBNet/RUNNet	10	0	0	10	0	0
Turkey	ULAKBIM	0	0	0	0	0	0

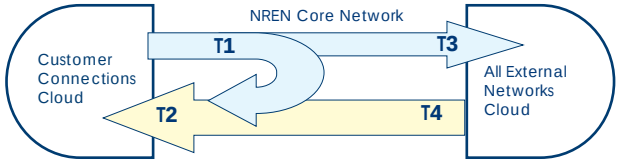
Highlights a significant percentage of dark fibre

Indicates anticipation of a significant change in the next two years

4 Traffic

In this section, a distinction is made between internal and external networking and network traffic. The figure below illustrates how these terms are being used for the purpose of the Compendium.

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



T1	**all traffic from customer sites (outbound)**
T2	**all from customer sites (inbound)**
T3	**all traffic to external network clouds (outbound)**
T4	**all traffic to the NREN backbone (inbound)**

Section 4.2 provides information about traffic volume, comparing 2002 with 2004. Section 4.3 looks at 'T3' (outgoing) traffic load and provide data from January 2002 through to January 2005. Section 4.4 provides further information about congestion. 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

From the data that is presented in section 4.2, it is possible to quantify trends in traffic for the various NRENs. Grouping NRENs, we get the following summary of mean growth per annum, calculated using figures for 2002, 2003 and 2004. In each group of NRENs, the growth figures are weighted.

Table 4.1.1 Traffic Growth

	'T3' (Outbound) growth per year		'T4' (Inbound) growth per year		'T3' growth per year	'T4' growth per year
Group of NRENs	**2002-2003**	**2003-2004**	**2002-2003**	**2003-2004**	**2002-2004**	**2002-2004**
EU-15/EFTA[1]	56%	30%	53%	39%	42%	46%
New EU member states[2]	119%	85%	119%	79%	101%	98%
EU/EFTA	67%	42%	63%	48%	54%	56%
Other[3]	235%	17%	168%	40%	98%	94%
ALL	74%	40%	69%	47%	56%	58%

[1] Based on data from 11 out of 15 NRENs
[2] Based on data from 8 out of 11 NRENs
[3] Based on data from 8 NRENs (AMREJ, CARNet, GRENA, MARWAN, RBNet/RUNNet, RENAM. ULAKBIM, and URAN)

The distinction between the results for the different groups is significant. Growth rates in the new EU member states and in non-EU/EFTA countries are clearly higher than those in the 'old' EU member states.

NRENs were also asked to report the volumes of inbound and outbound traffic during the month of January 2005. The results here, while only a small and probably not entirely representative sample of annual traffic, seem to confirm the finding that the growth rate is slowing down.

It seems that in the EU, traffic is now determined more by (changes in) user demand, rather than by network capacity limitations. In the 'Other' group of countries, this is probably not yet the case. Thus, the high growth from 2002 to 2003 can be explained by important bandwidth upgrades for CARNet and RBNet/RUNNet in that period.

Even for the EU/EFTA countries, it is unclear if the trend towards lower growth will persist – new applications, for example in the Grids area, may change the picture. However, in that case growth will be driven by demand, rather than by changes in the network capacities.

It is important to note that traffic growth is not a natural phenomenon, but can be and is being influenced by the policies both of NRENs and of their users. One noteworthy example in this context is that of FUNET (Finland), where traffic decreased more than 10% between 2003 and 2004. FUNET staff offered the following explanation for this: "*Last year was really exceptional for Funet. Our traffic decreased first time in our 20-year history. The reason is that some universities started to filter traffic that they suspect to include illegal copyrighted material. Another motivation was our charging policy, which punishes heavy-users.*" There may be other factors at work here as well, such as the adoption of anti-spam measures.

Traffic: outbound versus inbound

The figures on traffic, as given in section 4.2 have been used to provide an indication of the asymmetry of the data flows. By comparing inbound with outbound traffic, we can assign an NREN to one of the categories 'net importer', 'balanced' or 'net exporter'. This is somewhat analogous to the concept of trade balance as used in international macro-economics. If the difference between inbound and outbound traffic is within 5% of the lower of these, we assign the NREN to the 'balanced' category.

The results from the 2002 survey, which give traffic figures for the whole of 2001, are as follows:

Table 4.1.2 Aggregated traffic import and export, 2002[4]

Group of NRENs	Importers	Balanced	Exporters
EU-15/EFTA	5	2	5
New EU member states	6	1	2
Other	6	0	1
ALL	17	3	8

The results from the current survey give traffic figures for calendar year 2004 and produce the following summary:

[4] Based on the Compendium 2003, chapter 4.1

Table 4.1.3 Aggregated traffic import and export, 2004[5]

Group of NRENs	Importers	Balanced	Exporters
EU-15/EFTA	4	1	9
New EU member states	1	1	7
Other	16	1	2
ALL	21	3	18

Our findings are that the longer-established set of NRENs from the EU and EFTA countries are mostly net exporters of data, while the other NRENs are net importers. There seems to be a dynamic at work here, as the pattern has changed over time. Three years previously, there was a more uniform distribution of importers and exporters among the EU/EFTA countries. The new EU member states, tended to have importer NRENs; only two out of nine were exporters. So the trend has been towards more net export of data.

NRENs in the other countries, however, do not yet seem to follow this trend. In 2001, only one out of seven was a net exporter. In 2004, the proportion was more or less the same, at 2 NRENs out of 17.

One reason for this difference between the two populations is probably the fact that the EU/EFTA NRENs have been in operation

[5] See section 4.2 for country-by-country data

for longer than the other NRENs, indeed for longer than most commercial networks. They are thus established as well-known repositories of educational and research resources, as well as hosting many distributed mirror sites of popular archives.

Another factor is the reality that established NRENs include institutions such as universities, research institutes and libraries with valuable and often unique resources. Many of these are now online and are much sought after by Internet users.

In the case of many of the emerging NRENs, there are factors that make access difficult. These include heavily used and often saturated external links, which inhibits access from the rest of the world, and also the fact that online resources are often confined to the native language.

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 table shows this as between groupings of NRENs:

Table 4.1.4 Traffic with general Internet as % of total 'T4' traffic [6]

Group of NRENs	Traffic with general Internet as % of total 'T4' traffic
EU-15/EFTA	76%
New EU member states	82%
EU/EFTA	78%
Other	79%

Note that the proportion has been calculated for each NREN, and a simple average has been derived for each grouping.

For the EU/EFTA NRENs, the traffic to the general Internet exceeds traffic from the general Internet (80% of total versus 76%). This tallies with the findings on asymmetry of traffic above.

[6] **Country-by country data are in Appendix 1**

Congestion

We have asked NRENs 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. Table 4.1.5 shows the average percentage given by NRENs of institutions experiencing serious congestion[7].

[7] **Section 4.4 shows the country-by-country data.**

Table 4.1.5 Serious congestion

Group of NRENs	Campus LAN	MAN or regional	Access network	NREN backbone	External connections
EU-15/EFTA	6%	3%	6%	0%	0%
New EU member states	1%	2%	17%	2%	0.5%
EU/EFTA	4%	2%	10%	1%	0.2%
Other	0.3%	6%	7%	10%	25%

In EU/EFTA countries, NRENs report relatively little congestion in those parts of the network within their domain of responsibility. Uniformly, they see no serious congestion on external circuits, virtually none in their core networks and little in the MAN or regional network. Any serious congestion, they report, is largely confined to Access networks or to the campus LANs of connected institutions.

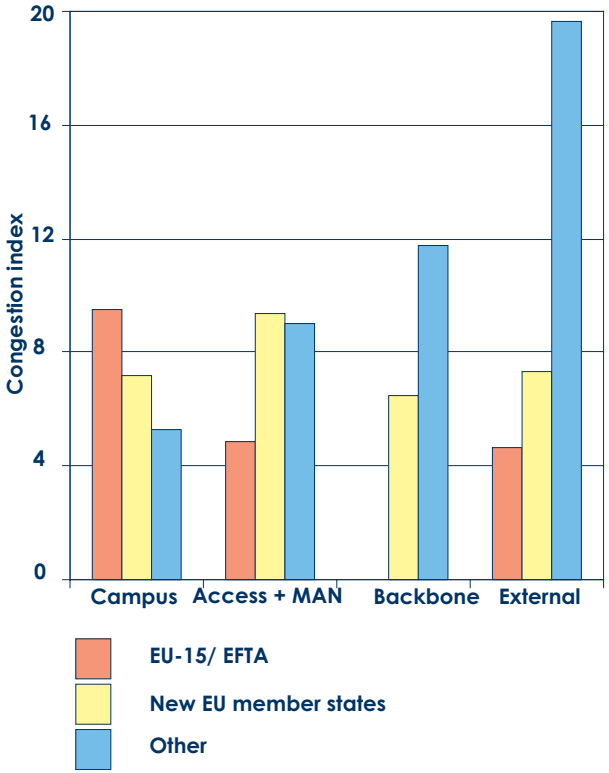
The 'Other' NRENs report most congestion is clearly on external connections. In those countries, the restrictions imposed by low-capacity external connections mean that constraints at the campus and other levels are less apparent. It is to be expected that these constraints will show up as soon as the problems at other levels have been solved.

To derive a single metric for the level of congestion in each network element from the subjective levels reported by NRENs, we use the following formula:

Congestion Index = 0.05*little + 0.2*some + 0.5*serious

We have combined the data for MANs and for Access Networks. Applied to all the reported values, this formula provides a single uniform metric. We believe that this is a better metric than looking only at serious congestion as in table 4.1.5 above, because it weighs all levels of congestion. The results confirm the analysis given above.

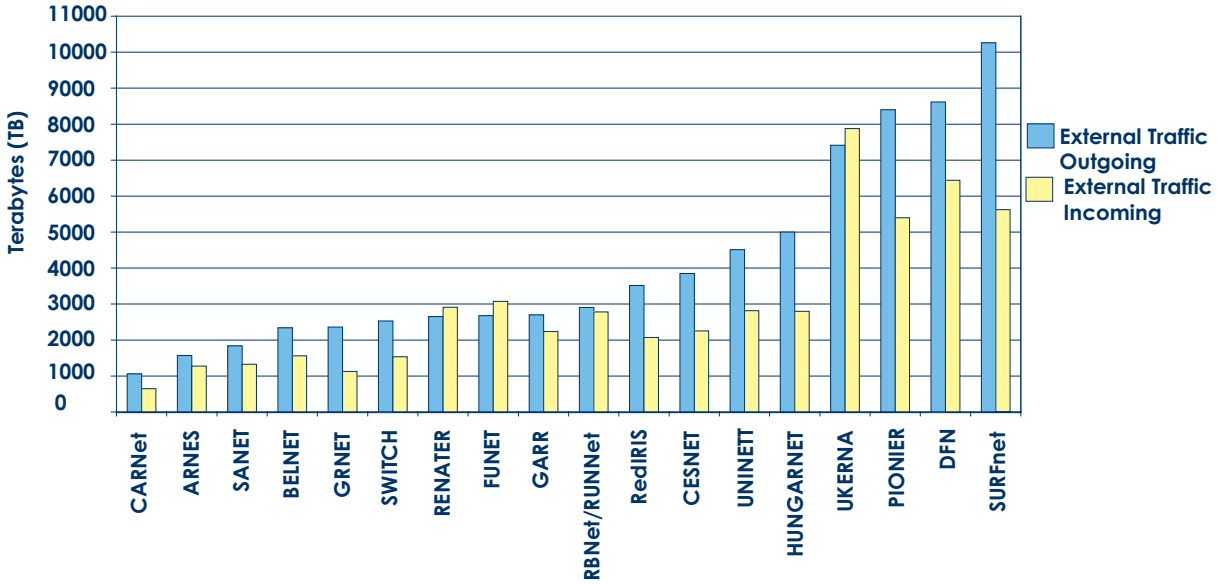
Graph 4.1.6 Congestion index



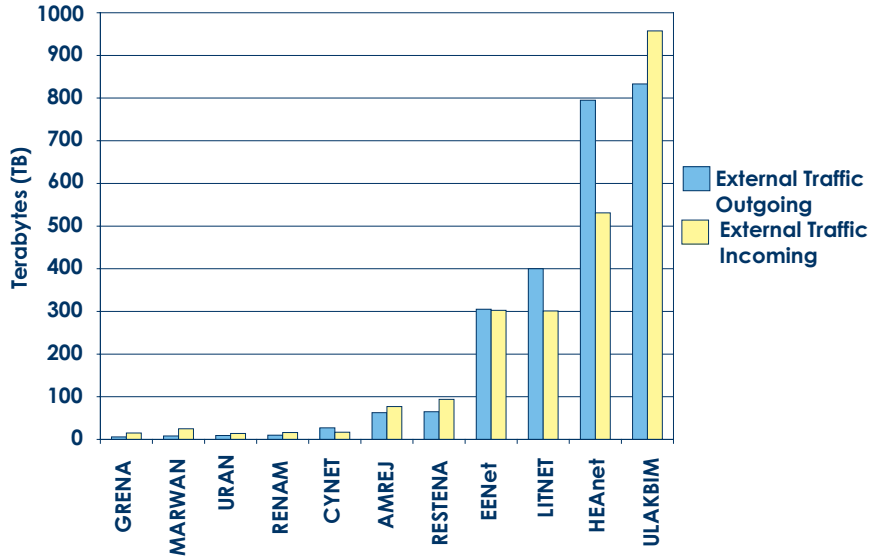
4.2 Incoming and outgoing traffic, 2002 and 2004

For presentation purposes, 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 4.2.1 Incoming and outgoing external traffic 2004, > 1000 Terabytes (TB)



Graph 4.2.2 Incoming and outgoing external traffic 2004, < 1000 Terabytes (TB)



4.3 Traffic load

Measuring the traffic load on the network is one potential way of measuring congestion and thus also an indicator of the extent in 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 practise, it is impossible to reach the theoretical maximum capacity and therefore it is impossible to reach a 100% traffic load. This is because traffic is typically not evenly distributed over the hours in a day and over the days of the week.

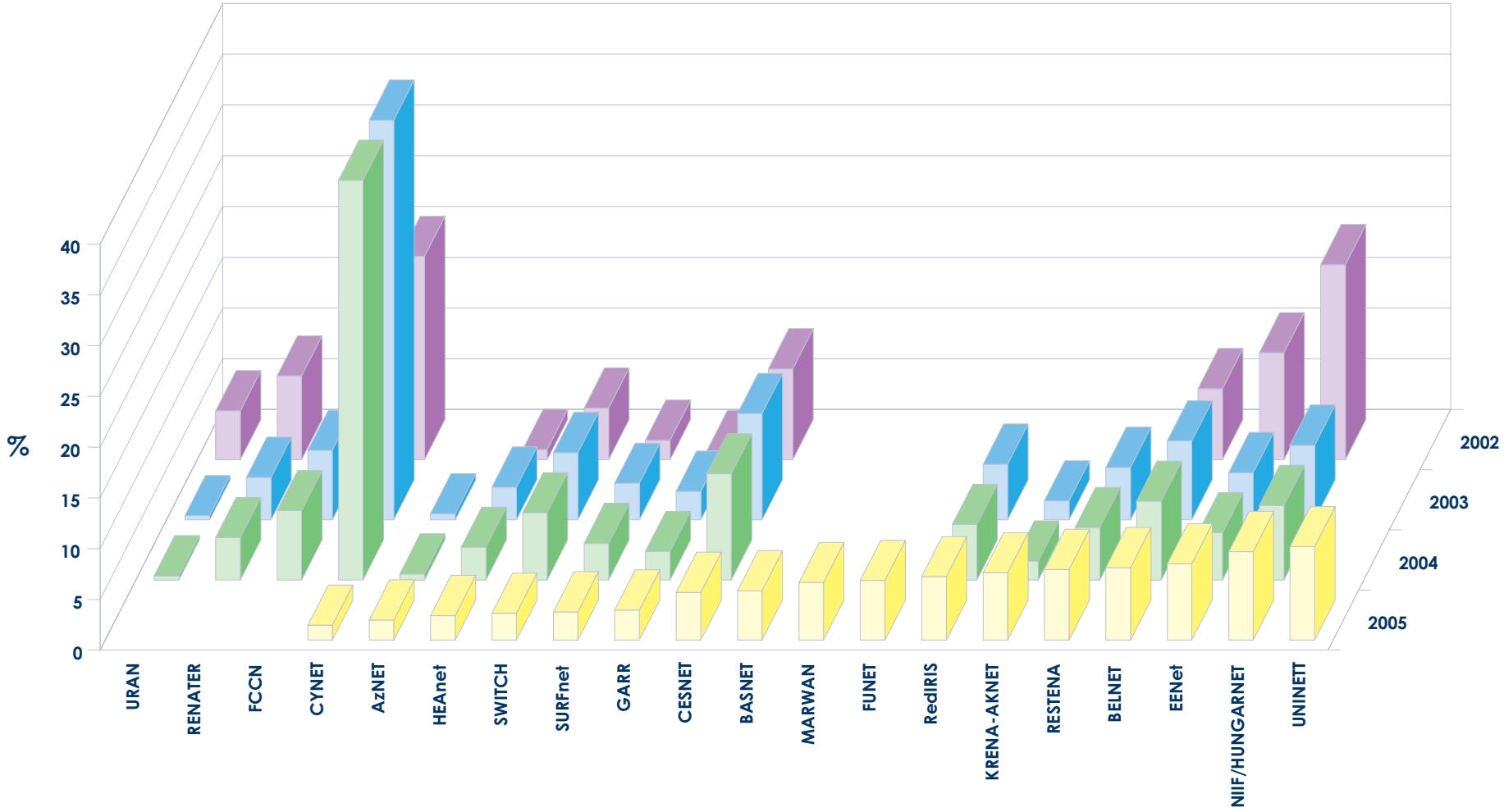
For an indication of sustained peak usage, the load figures in the table should typically be multiplied by three. In other words, users will certainly experience serious congestion if the traffic load is above 33%; even at lower loads, users may sometimes experience congestion in network performance.

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.

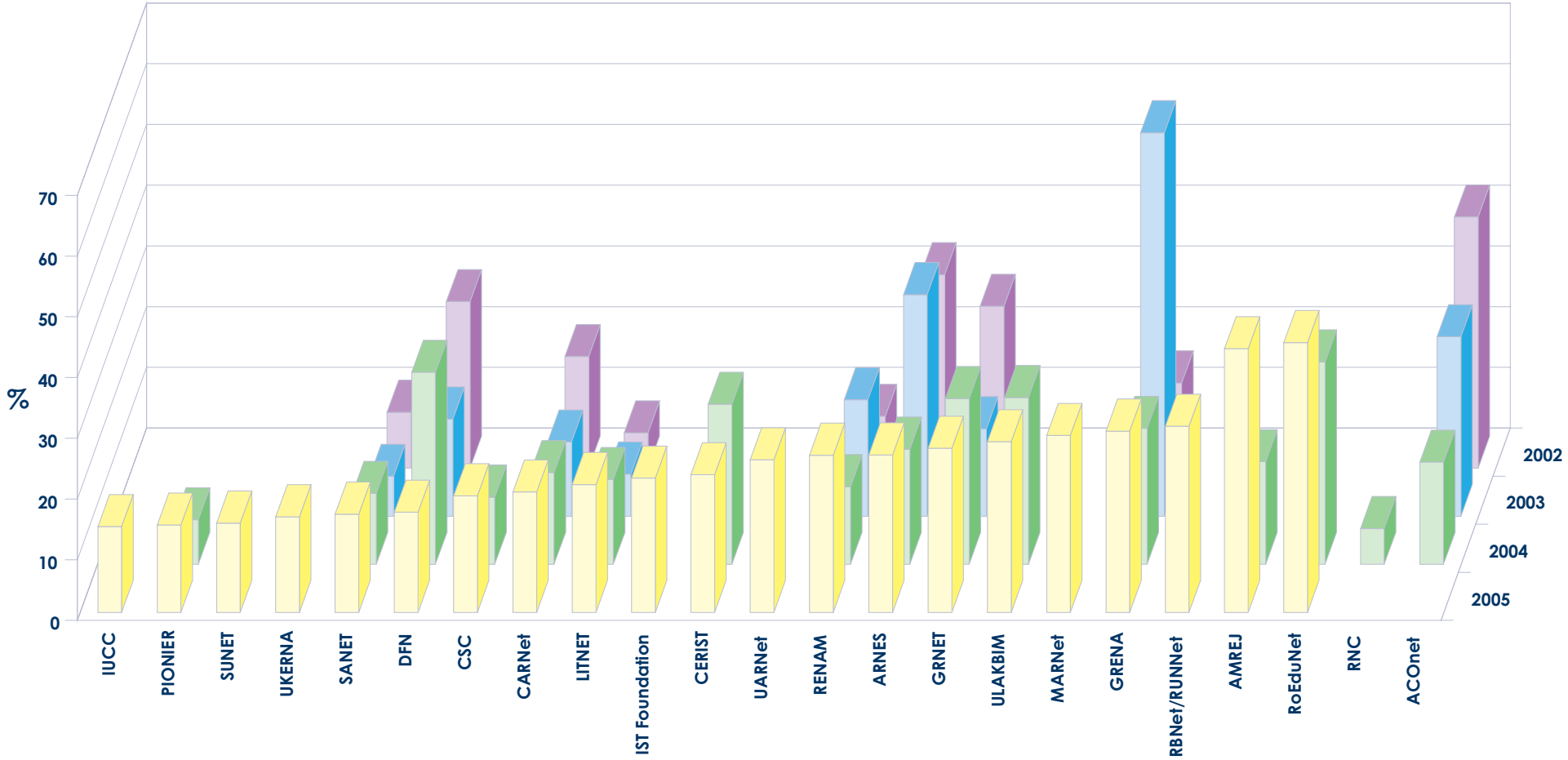
The graphs illustrate that NRENs need to upgrade their external links from time to time in order to keep up with increasing demand.

The fall in the traffic load for CYNET between 2004 and 2005 is largely due to the upgrade of the GÉANT connection from 34 Mb/s to 155 Mb/s and the addition of a 45 Mb/s EUMEDCONNECT link. Likewise, in January 2004 DFN's total external links were 6.5 Gb/s. In January, 2005 that figure was 17 Gb/s, more than double the previous capacity. In the same period, traffic had gone up by 37%.

Graph 4.3.1. Average outgoing traffic load January 2002 - 2005, NRENs with < 10% traffic load (as percentage of the theoretical maximum capacity) in January, 2005



Graph 4.3.2 Average outgoing traffic load January 2002 – January 2005, NRENs with >10% traffic load (as percentage of the theoretical maximum capacity) in January 2005.

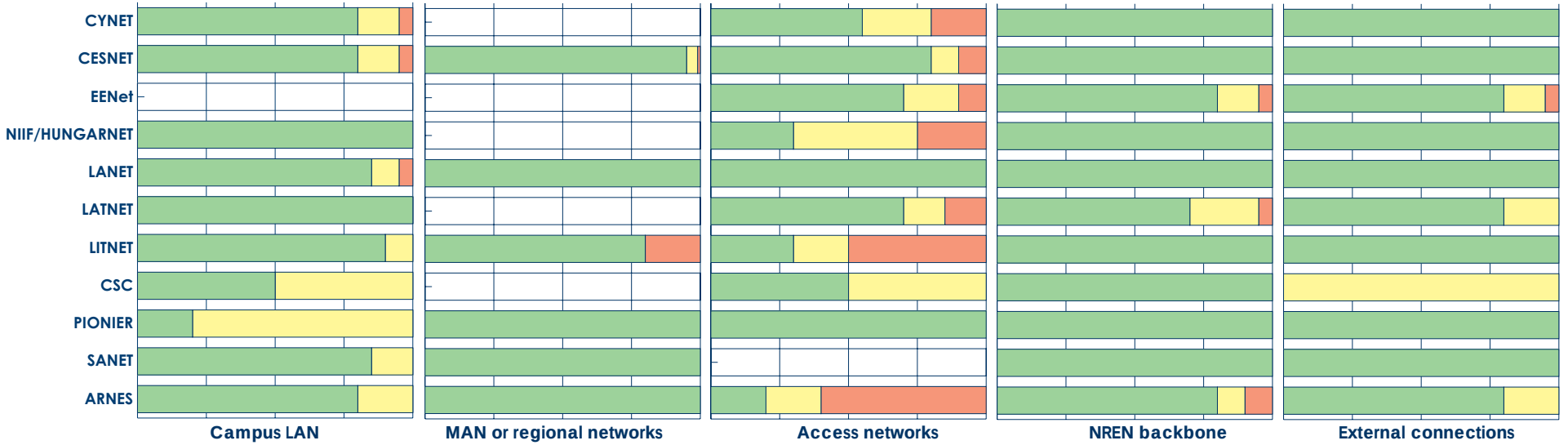


4.4 Congestion

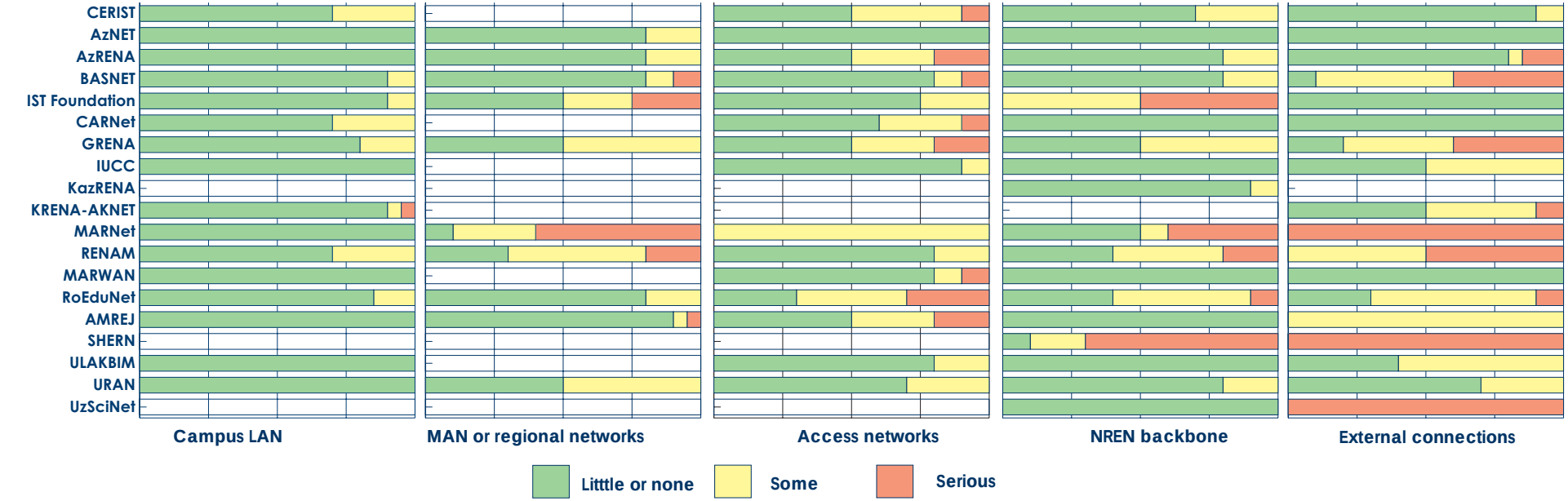
NRENs were asked to give an estimate of where there is congestion (if any) in their networks and of the percentage of client institutions that are affected by congestion at that level. Note that not all NRENs gave an answer for all of the network levels and note also that not all levels exist in all networks (see also 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).

Graph 4.4.1 Reported Congestion: EU-15 and EFTA countries

Graph 4.4.1 Reported Congestion: New EU countries



Graph 4.4.1 Reported Congestion: Other countries



5 Services

Many NRENs are involved in providing a number of important services to their customers, in addition to providing the connectivity. This section provides information about NREN work in four service areas: authorisation and authentication (5.1), security incident response (5.2), bandwidth on demand (5.3) and Grid services (5.4).

5.1 Authorisation and Authentication Infrastructure (AAI)[1]

Authorisation and Authentication have always been important topics on the campus level, with an emphasis for the last couple of years on campus-wide identity management systems. These campus-wide systems have brought inter-institutional and international federated authentication and authorisation within reach. 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 the NREN environments reflects a number of tendencies:

* users travel much more and they demand their familiar environment, services and privileges available whenever they move from one site to another.
* 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.
* Although still improving, the network has reached a good level of stability, so that it is becoming easier to offer reliable services.
* Various NRENs haven 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.

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.

To address the need for an AA Infrastructure, 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.

NRENs have been asked questions about their current AAI situation: whether they run the

[1] Text contributed by Licia Florio, TERENA

infrastructure or they outsource it, what kind of AAI they have, if it 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 5.1 summarises the answers that have been received. The last column provides URLs to more information on NREN websites.

There seems to be a trend toward increased interest in the PKI area. This is due to the fact that Grids services make heavy use of PKI. Many NRENs increased the operation of their sometimes dormant CAs or in some case have established a CA to issue certificates to work with the Grid middleware. The increasing popularity of AA Infrastructures and eduroam will most likely increase the demand for PKIs even more.

Table 5.1 shows another interesting and new result: many NRENs say that they have eduroam and that they see this as a federation. Eduroam is the pan-European educational roaming infrastructure to provide wireless access to visited institutions. Eduroam is not a classical example of federation. It is important to point out that Shibboleth-like infrastructures and eduroam are used for different purposes: Shibboleth-like infrastructures provide federated access to applications, whereas eduroam provides access to a (wireless) network.

NRENs that employ Shibboleth or similar technologies also need to define a national schema. The table below shows this.

Note that for many NRENs, this is still a relatively new subject; therefore, not all NRENs have answered these questions.

Table 5.1 Authorisation and Authentication Infrastructures

	NREN	NREN or outsourced?	AA federation?	Schema used / what kind?	CA?
EU/EFTA countries					
Belgium	BELNET	**nren**	**no**		**yes**
Cyprus	CYNET		**no**		**no**
Czech Republic	CESNET	**nren**	**no**		**yes**
Estonia	EENet	**nren**	**no**		**yes**
Finland	FUNET	**nren**	**Shibboleth-based**	**funet-edu-person**	**no**
Germany	DFN	**nren**	**no**		**yes**
Hungary	NIIF/HUNGARNET	**outsourced**	**no**		**yes**
Ireland	HEAnet	**nren**	**no**		**yes**
Italy	GARR	**outsourced**	**no**		**yes**
Latvia	LATNET	**nren**	**no**		**no**
Malta	CSC	**nren**	**no**		**no**
Netherlands	SURFnet	**nren**	**yes**		**yes**
Norway	UNINETT	**nren**	**Yes, Shibboleth-compliant**		**no**
Poland	PIONIER	**nren**			**yes**
Slovenia	ARNES	**nren**	**yes**	**siEduPerson**	**no**
Spain	RedIRIS	**nren**	**Yes**	**LDAP-based (see http://www.rediris.es/ldap/esquemas/index.en.html)**	**yes**
Sweden	SUNET	**outsourced**	**No**		**yes**
Switzerland	SWITCH	**nren**	**Yes, Shibboleth-based**	**swissEduPerson derived from eduPerson**	**yes**

	NREN	NREN or outsourced?	AA federation?	Schema used / what kind?	CA?
Other countries					
Algeria	CERIST	**nren**	**no**		**no**
Azerbaijan	AzNET	**nren**	**no**		**no**
Azerbaijan	AzRENA	**nren**	**no**		**no**
Belarus	BASNET	**nren**	**no**		**no**
Bulgaria	IST Foundation	**nren**	**no**		**no**
Croatia	CARNet	**nren**	**no**	**Yes, hrEduPerson i hrEduOrg.**	**no**
Georgia	GRENA	**nren**	**no**		**no**
Kazakhstan	KazRENA	**nren**	**no**		**no**
Kyrgyzstan	KRENA-AKNET	**outsourced**	**no**		**no**
Moldova	RENAM	**nren**	**no**		**no**
Morocco	MARWAN		**no**		**no**
Romania	RoEduNet	**nren**	**no**		**no**
Slovakia	SANET		**no**		**no**
Turkey	ULAKBIM		**no**		**yes**
Ukraine	URAN	**nren**	**no**		**yes**

5.2 Security Incident Response

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

Table 5.2 below provides information on whether Security Incident Response is provided by 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 **http://ti.terena.nl** 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 ti.terena.nl is fully up-to-date and authoritative).

The last column provides URLs to more information on NREN websites.

Table .5.2 Security Incident Response

	NREN	Security incident response?	Accredited CSIRT?
EU/EFTA countries			
Belgium	BELNET	**nren**	**yes**
Cyprus	CYNET	**nren**	**no**
Czech Republic	CESNET	**nren**	**no**
Denmark	UNI•C	**nren**	**yes**
Estonia	EENet	**nren**	**no**
Finland	FUNET	**nren**	**yes**
France	RENATER	**nren**	**yes**
Germany	DFN	**outsourced**	**yes**
Hungary	NIIF/HUNGARNET	**nren**	**no**
Iceland	RHnet	**nren**	**no**
Ireland	HEAnet	**outsourced**	**no**
Italy	GARR	**outsourced**	**yes**
Latvia	LATNET	**nren**	**no**
Lithuania	LITNET	**outsourced**	**yes**
Malta	CSC	**nren**	**no**
Netherlands	SURFnet	**nren**	**yes**
Norway	UNINETT	**nren**	**yes**
Poland	PIONIER	**nren**	**no**
Portugal	FCCN	**nren**	**yes**
Slovakia	SANET	**outsourced**	**no**
Slovenia	ARNES	**nren**	**yes**
Spain	RedIRIS	**nren**	**yes**
Sweden	SUNET	**outsourced**	**yes**
Switzerland	SWITCH	**nren**	**yes**
United Kingdom	UKERNA	**nren**	**yes**

	NREN	Security incident response?	Accredited CSIRT?
Other countries			
Algeria	CERIST	**nren**	**no**
Azerbaijan	AzNET	**nren**	**no**
Azerbaijan	AzRENA	**nren**	**no**
Belarus	BASNET	**nren**	**no**
Bulgaria	IST Foundation	**nren**	**no**
Croatia	CARNet	**nren**	**yes**
Georgia	GRENA	**nren**	**no**
Israel	IUCC	**nren**	**no**
Kazakhstan	KazRENA	**nren**	**no**
Kyrgyzstan	KRENA-AKNET	**outsourced**	**no**
Moldova	RENAM	**nren**	**no**
Morocco	MARWAN	**nren**	**no**
Romania	RoEduNet	**nren**	**no**
Serbia / Montenegro	AMREJ		**no**
Turkey	ULAKBIM	**nren**	**no**
Ukraine	URAN		**no**

5.3 Bandwidth on Demand

Bandwidth on Demand (point-to-point dedicated bandwidth services at layer 2 or below) is being introduced as a new service as part of the GN2 project. The following table provides information on which NRENs 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 and again others are not planning to introduce such a service.

Table .5.3 Bandwidth on Demand

	NREN	Plans?
EU/EFTA countries		
Belgium	BELNET	yes if demand
Cyprus	CYNET	no
Czech Republic	CESNET	yes
Denmark	UNI•C	yes if demand
Estonia	EENet	yes if demand
Finland	FUNET	no
France	RENATER	yes
Germany	DFN	yes
Hungary	NIIF/HUNGARNET	yes
Iceland	RHnet	no
Ireland	HEAnet	yes
Italy	GARR	yes
Latvia	LANET	no
Latvia	LATNET	yes if demand
Lithuania	LITNET	yes
Luxembourg	RESTENA	yes if demand
Malta	CSC	yes if demand
Netherlands	SURFnet	yes
Norway	UNINETT	yes if demand
Poland	PIONIER	yes
Portugal	FCCN	no
Slovakia	SANET	no
Spain	RedIRIS	yes
Sweden	SUNET	no
Switzerland	SWITCH	yes if demand
United Kingdom	UKERNA	no
Other countries		
Algeria	CERIST	yes if demand
Azerbaijan	AzNET	no
Azerbaijan	AzRENA	no
Belarus	BASNET	yes if demand
Bulgaria	IST Foundation	no
Croatia	CARNet	yes if demand
Georgia	GRENA	yes if demand
Israel	IUCC	no
Kazakhstan	KazRENA	yes if demand
Kyrgyzstan	KRENA-AKNET	yes
Moldova	RENAM	yes if demand
Morocco	MARWAN	yes if demand
Romania	RoEduNet	yes if demand
Serbia / Montenegro	AMREJ	no
Turkey	ULAKBIM	yes if demand
Ukraine	URAN	yes

5.4 Grid services

Grid services have recently become an important area for NRENs. Projects such as the EGEE project 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 5.4.1 gives information on whether or not Grid services are currently running over the NREN 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 or 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.

As is clear from the table, Grid services are currently running in 15 out of the 27 EU/EFTA NRENs in the survey and in 5 out of the 16 NRENs from other countries in the survey. Eight more EU/EFTA NRENs are planning to introduce such a service; a similar number of the NRENs from other countries have that plan.

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

Table 5.4.2 provides an overview of the disciplines that are running Grid-enabled applications.

From the table, it seems that physics and chemistry are the most active disciplines, followed by biomedical applications and astroscience.

Table 5.4.1 Grid services

	NREN	Currently running?	Planned within the next year or two?	Who runs the service?	Geographical extent	URL
EU/EFTA countries						
Belgium	BELNET	yes		nren support	national	http://grid.belnet.be
Cyprus	CYNET	no	yes			
Czech Republic	CESNET	yes		nren	international	http://meta.cesnet.cz
Denmark	UNI•C	no	yes	nren support		
Estonia	EENet	yes		nren support	international	http://grid.eenet.ee/
Finland	FUNET	yes		nren support	international	
France	RENATER	yes			international	http://www.grid5000.org, http://www.deisa.
Germany	DFN	yes	no	nren support	international	
Hungary	NIIF/ HUNGARNET	yes		nren	international	http://www.clustergrid.niif.hu
Iceland	RHnet	no				
Ireland	HEAnet	yes		nren support	international	no
Italy	GARR	yes		nren support	international	-
Latvia	LANET	no	yes			
Latvia	LATNET	no	yes		international	
Lithuania	LITNET	no	yes			no

	NREN	Currently running?	Planned within the next year or two?	Who runs the service?	Geographical extent	URL
Luxembourg	RESTENA	no	no			
Malta	CSC	no	yes	nren		
Netherlands	SURFnet	yes		nren support	international	http://www.netherlight.net
Norway	UNINETT	no	yes	nren support		http://www.norgrid.no/
Poland	PIONIER	yes		nren	international	
Portugal	FCCN	no	yes	nren support	regional	
Slovakia	SANET	no				
Slovenia	ARNES		yes			
Spain	RedIRIS	yes		nren support	international	http://irisgrid.rediris.es/
Sweden	SUNET	yes		nren support	international	http://www.swegrid.se/
Switzerland	SWITCH	yes		Distributed groups or virtual organisations	international	
United Kingdom	UKERNA	yes				
Other countries						
Algeria	CERIST	no	yes	other		
Azerbaijan	AzNET	no				
Azerbaijan	AzRENA	no				
Belarus	BASNET	no	yes			
Bulgaria	IST Foundation	yes		nren	international	
Croatia	CARNet	yes		institutions alone	national	http://www.srce.hr/crogrid/infrastruktura/
Georgia	GRENA	no	yes			
Israel	IUCC	yes		nren support	international	http://iag.iucc.ac.il/
Kazakhstan	KazRENA	no	yes			
Kyrgyzstan	KRENA-AKNET	no	no		regional	
Moldova	RENAM	no	yes			
Morocco	MARWAN	no	yes	nren support	international	http://www.eumedgrid.org/
Romania	RoEduNet	no	yes			
Serbia / Montenegro	AMREJ	yes		nren support	international	
Turkey	ULAKBIM	yes		nren	international	
Ukraine	URAN	no	yes	institutions alone	regional	

The answers in the table below are 'now' (service is currently running), 'planned' or '-', the NREN is not currently aware of the situation in that discipline.

Table 5.4.2 Disciplines that are running Grid-enabled applications

	NREN	High-energy physics	Other physics	Computational chemistry	Other chemistry	Biomedical	Astroscience	Earth science	Climatology	Other disciplines:
EU/EFTA countries										
Belgium	BELNET	-	-	-	-	-	-	-	-	
Cyprus	CYNET	-	-	-	planned	planned	-	-	-	
Czech Republic	CESNET	now	now	now	now	planned	-	planned	-	material science - running, technical simulations - running, visual rendering - planned
Estonia	EENet	now	now	now	planned	planned	planned	-	-	
Finland	FUNET	now	now	now	-	planned	-	planned	-	material physics
Germany	DFN	now	-	-	-	-	-	-	-	
Hungary	NIIF/ HUNGARNET	now	now	now	now	now	now	now	planned	
Ireland	HEAnet	planned	now	now	null	now	now	now	now	
Italy	GARR	now	now	now	now	now	now	now	-	hydrology - planned
Lithuania	LITNET	planned	planned	-	-	planned	planned	-	-	
Netherlands	SURFnet	planned	-	-	-	-	now	-	planned	
Norway	UNINETT	planned	-	-	-	-	-	planned	planned	
Poland	PIONIER			now						
Portugal	FCCN	planned				planned	planned		planned	
Slovenia	ARNES	planned								
Spain	RedIRIS	now	now	now	now	now	now	now	now	neural networks; circuit design; biology-ecology, research into Grid itself
Sweden	SUNET	now	now	now	-	now	-	-	-	
Switzerland	SWITCH	planned	-	-	-	planned	-	-	planned	

Table 5.4.2 Disciplines that are running Grid-enabled applications (continued)

	NREN	High-energy physics	Other physics	Computational chemistry	Other chemistry	Biomedical	Astroscience	Earth science	Climatology	Other disciplines:
Other countries										
Algeria	CERIST	-	planned	-	planned	-	-	-	planned	
Bulgaria	IST Foundation	planned	planned	planned	-	planned	planned	planned	planned	
Georgia	GRENA	planned				planned	planned			
Israel	IUCC	now	-	-	-	planned	-	planned	-	
Kazakhstan	KazRENA		-			planned				
Kyrgyzstan	KRENA-AKNET	-	-	-	-	-	-	-	-	
Moldova	RENAM							planned		
Morocco	MARWAN	planned	planned	planned	-	planned	planned	planned	-	
Serbia / Montenegro	AMREJ	planned	planned	-	-	-	-	-	-	medicine
Turkey	ULAKBIM	planned	planned	planned	planned	planned	-	-	-	

6 Tasks, staffing, funding

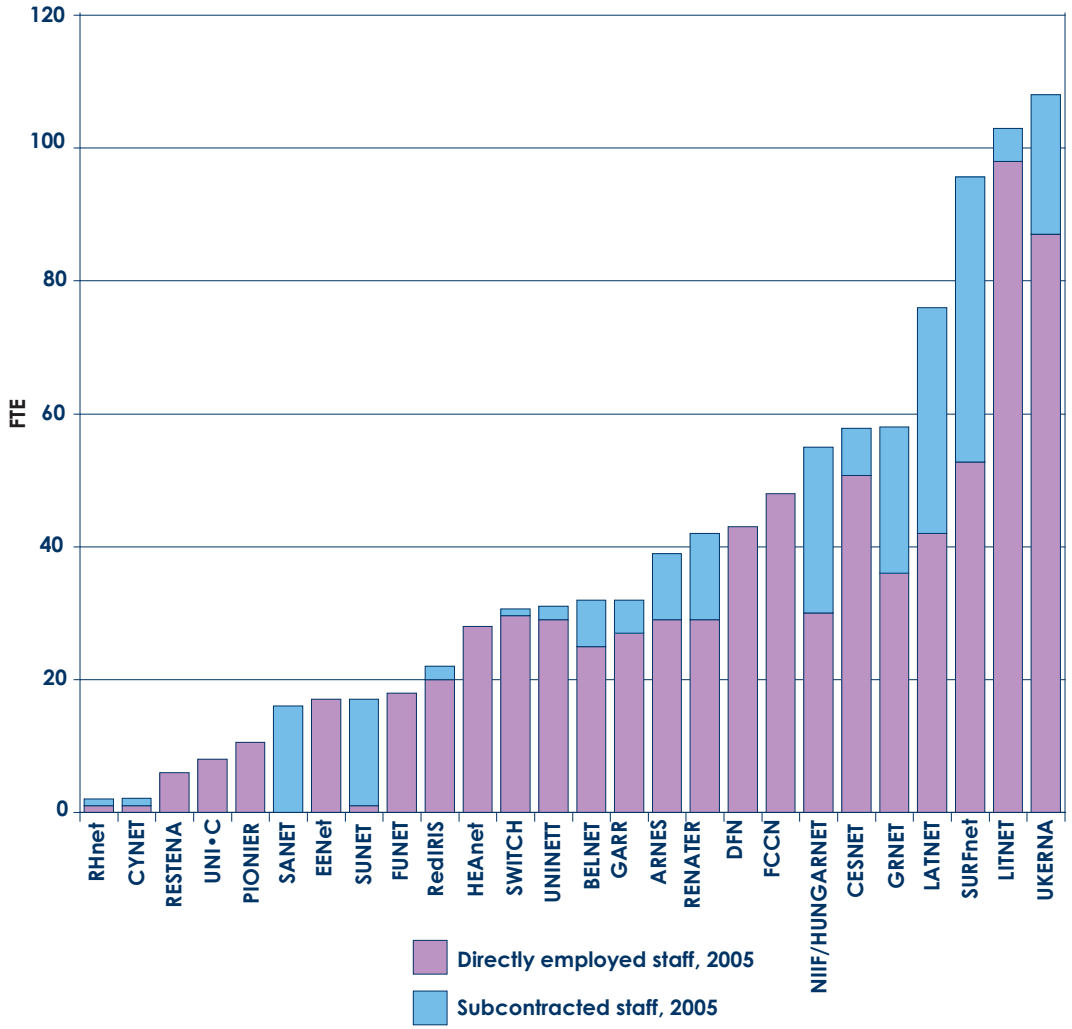
Note that some NRENs provide services only to the Research or Education communities in their country. Others provide other services as well, for example, because they administer the country-code tld or because they connect companies or institutions that are clearly outside of the Research or Education 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'.

Section 6.1 provides information about various aspects of NREN staffing. Section 6.2 contains a table with some information on NREN staff effort for general research projects and for services to secondary and primary schools. Section 6.3 deals with NREN budgets and 6.4 and 6.5 provide more information about income sources and expenditure categories, respectively.

6.1. Staffing

Because many NRENs contract out part of their work, the staff size in itself is not a reliable measure of the amount of person-power that is available to an NREN. This section gives an overview of the

Graph 6.1.1 Total NREN staff in FTE, EU/EFTA countries



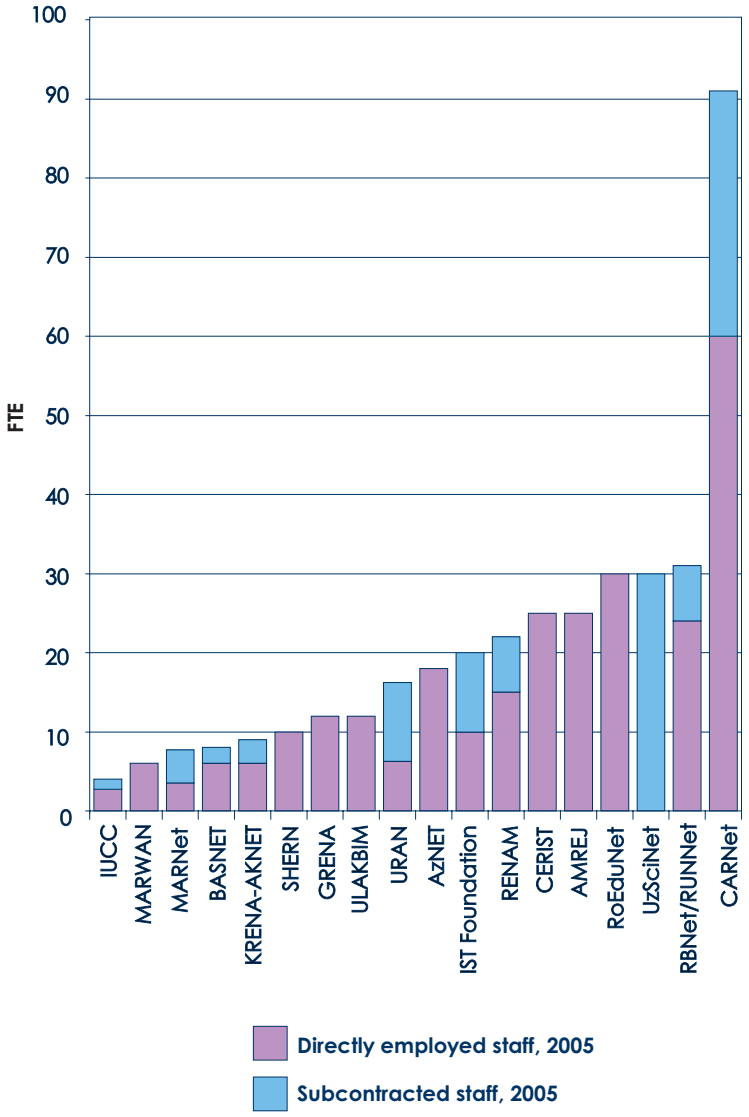
staff that is directly employed in NREN activities, plus subcontracted staff, in Full-Time Equivalents (FTE).

Graph 6.1.3 provides that information specifically for technical staff.

The tasks performed by individual NRENs are 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. Also, the connection policies of NRENs (see 2.2) are different, for example, with respect to secondary and primary schools. This explains some of the differences as seen in the graphs.

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. This may also be a factor explaining why some NRENs have a high proportion of technical staff to total staff.

Graph 6.1.2 Total NREN staff in FTE, other countries



Graph 6.1.3 NREN technical staff in FTE

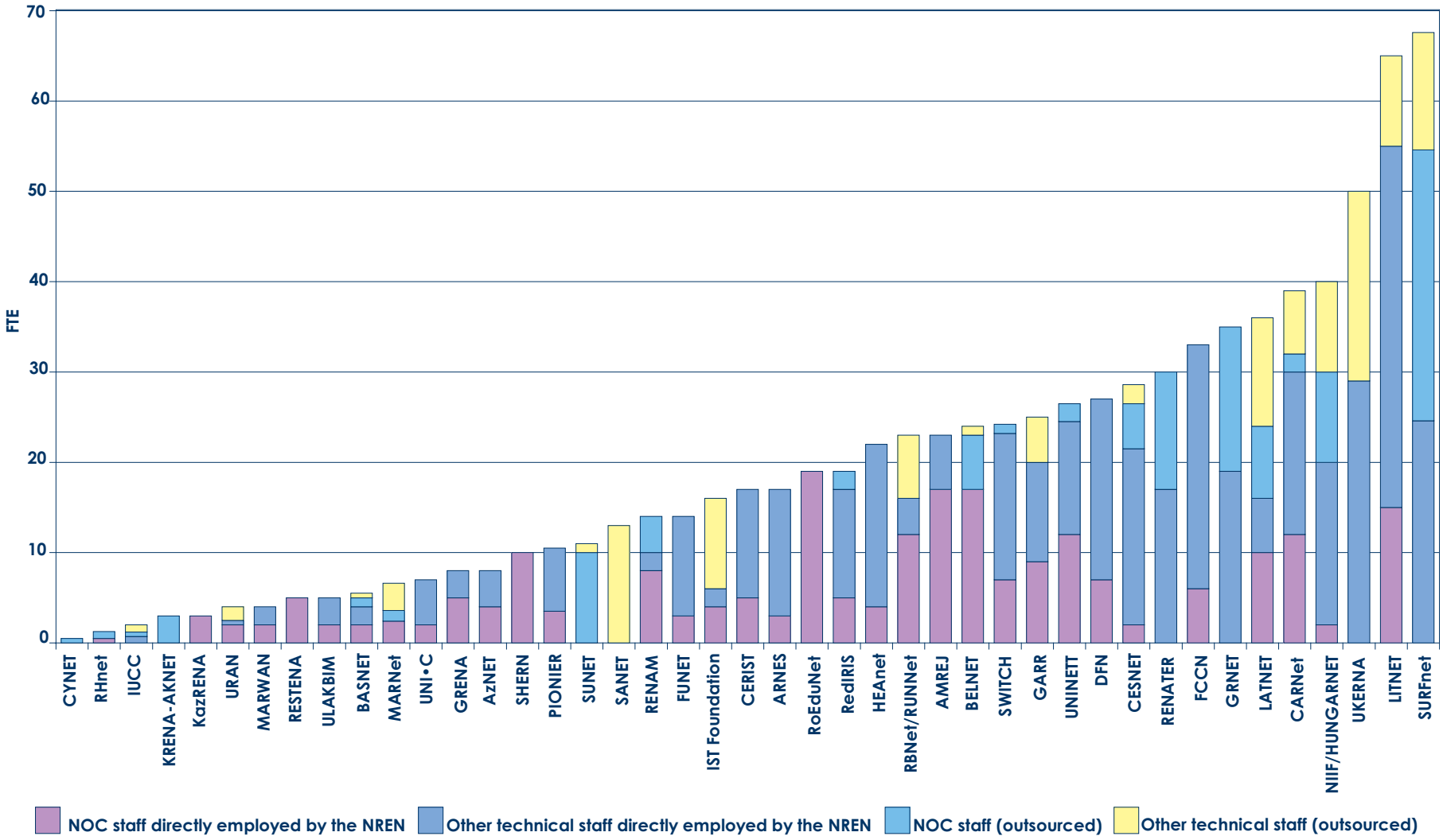


Table 6.1.4 Proportion of technical staff to total staff

	NREN	Total staff			Technical staff			Technical staff as % of total staff
		Directly employed	Outsourced	Total	Directly employed	Outsourced	Total	
EU/EFTA countries								
Belgium	BELNET	25	7	32	17	7	24	75%
Cyprus	CYNET	1	1.1	2.1	0	0.5	0.5	24%
Czech Republic	CESNET	50.7	7.1	57.8	21.5	7.1	28.6	49%
Denmark	UNI•C	8	0	8	7	0	7	88%
Finland	FUNET	18	0	18	14	0	14	78%
France	RENATER	29	13	42	17	13	30	71%
Germany	DFN	43	0	43	27	0	27	63%
Greece	GRNET	36	22	58	19	16	35	60%
Hungary	NIIF/ HUNGARNET	30	25	55	20	20	40	73%
Iceland	RHnet	1	1	2	0.5	0.75	1.25	63%
Ireland	HEAnet	28	0	28	22	0	22	79%
Italy	GARR	27	5	32	20	5	25	78%
Latvia	LATNET	42	34	76	16	20	36	47%
Lithuania	LITNET	98	5	103	55	10	65	63%
Luxembourg	RESTENA	6	0	6	5	0	5	83%
Netherlands	SURFnet	52.7	43	95.7	24.6	43	67.6	71%
Norway	UNINETT	29	2	31	24.5	2	26.5	85%
Poland	PIONIER	10.5	0	10.5	10.5	0	10.5	100%
Portugal	FCCN	48	0	48	33	0	33	69%
Slovakia	SANET	0	16	16	0	13	13	81%
Slovenia	ARNES	29	10	39	17	0	17	44%
Spain	RedIRIS	20	2	22	17	2	19	86%
Sweden	SUNET	1	16	17	0	11	11	65%
Switzerland	SWITCH	29.6	1	30.6	23.2	1	24.2	79%
United Kingdom	UKERNA	87	21	108	29	21	50	46%

Table 6.1.4 Proportion of technical staff to total staff (continued)

	NREN	Total staff			Technical staff			Technical staff as % of total staff
		Directly employed	Outsourced	Total	Directly employed	Outsourced	Total	
Other countries								
Algeria	CERIST	25	0	25	17	0	17	68%
Azerbaijan	AzNET	18	0	18	8	0	8	44%
Belarus	BASNET	6	2	8	4	1.5	5.5	69%
Bulgaria	IST Foundation	10	10	20	6	10	16	80%
Croatia	CARNet	60	31	91	30	9	39	43%
Georgia	GRENA	12	0	12	8	0	8	67%
Israel	IUCC	2.7	1.3	4	0.7	1.3	2	50%
Kyrgyzstan	KRENA-AKNET	6	3	9	0	3	3	33%
Macedonia, FYRo	MARNet	3.5	4.2	7.7	2.4	4.2	6.6	86%
Moldova	RENAM	15	7	22	10	4	14	64%
Morocco	MARWAN	6	0	6	4	0	4	67%
Romania	RoEduNet	30	0	30	19	0	19	63%
Russian Federation	RBNet/RUNNet	24	7	31	16	7	23	74%
Serbia / Montenegro	AMREJ	25	0	25	23	0	23	92%
Syria	SHERN	10	0	10	10	0	10	100%
Turkey	ULAKBIM	12	0	12	5	0	5	42%
Ukraine	URAN	6.25	10	16.25	2.5	1.5	4	25%

6.2 Percentage of staff effort for secondary and primary schools and for research

We have asked NRENs to estimate how much of their staff effort is going towards connections, production services and support for secondary and primary schools. We have also asked them how much is going towards general research projects.

As can be seen from the table, the percentage of effort for secondary and primary schools varies greatly, from nothing in many countries to 80% with ARNES in Slovenia (which also manages the equipment at the end sites).

Differences are equally great for the general research effort, with percentages varying between nothing and 50% for CESNET and SURFnet and 86% for RedIRIS.

One factor that explains the high percentage for RedIRIS is that RedIRIS probably does not fully account for the overhead staff effort of its parent organisation in its work. Another factor may be that not all NRENs apply the same interpretation to the term 'general research projects'. The conclusion seems to be justified that research is an important aspect of the work of many NRENs.

Table 6.2

	NREN	% of staff effort towards:	
		Secondary and primary schools	General research
EU/EFTA countries			
Belgium	BELNET	0	10
Cyprus	CYNET	0	0
Czech Republic	CESNET	0	50
Denmark	UNI•C	0	5
Estonia	EENet	0	0
Finland	FUNET	0	5
France	RENATER	0	0
Germany	DFN	0	6
Greece	GRNET	67	7
Hungary	NIIF/HUNGARNET	1	50
Iceland	RHnet	0	0
Ireland	HEAnet	30	30
Italy	GARR	2	10
Latvia	LATNET	10	5
Lithuania	LITNET	50	10
Luxembourg	RESTENA	50	10
Netherlands	SURFnet	0	50
Norway	UNINETT	10	25
Poland	PIONIER	0	0
Portugal	FCCN	6	35
Slovakia	SANET	0	20
Slovenia	ARNES	80	5
Spain	RedIRIS	0	86
Sweden	SUNET	0	2
Switzerland	SWITCH	0	0
United Kingdom	UKERNA	0	0

	NREN	% of staff effort towards:	
		Secondary and primary schools	General research
Other countries			
Algeria	CERIST	0	60
Azerbaijan	AzNET	80	20
Belarus	BASNET	0	70
Bulgaria	IST Foundation	0	0
Croatia	CARNet	10	10
Georgia	GRENA	10	10
Israel	IUCC	0	5
Kazakhstan	KazRENA	0	0
Kyrgyzstan	KRENA-AKNET	12	10
Macedonia, FYRo	MARNet	0	40
Moldova	RENAM	5	20
Morocco	MARWAN	0	0
Romania	RoEduNet	20	30
Russian Federation	RBNet/RUNNet	0	0
Serbia / Montenegro	AMREJ	0	20
Syria	SHERN	0	0
Turkey	ULAKBIM	0	10
Ukraine	URAN	0	25

6.3 Total budgets, 2004 and 2005

The following graphs give the total NREN budgets for 2004 and 2005.

Note that the budget year of CERIST (Algeria) runs from March to February; that of UKERNA (UK) runs from August to July. In those cases, the 2004 budget is really the 2004/2005 figure.

NREN budgets may fluctuate from year to year, because investments can vary considerably from year to year.

Note that 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, because they administer the country-code top-level domain or because 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 tedious. 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 graph 6.3.1, the NRENs that include the GÉANT subsidy in their budget have been marked with an asterisk.

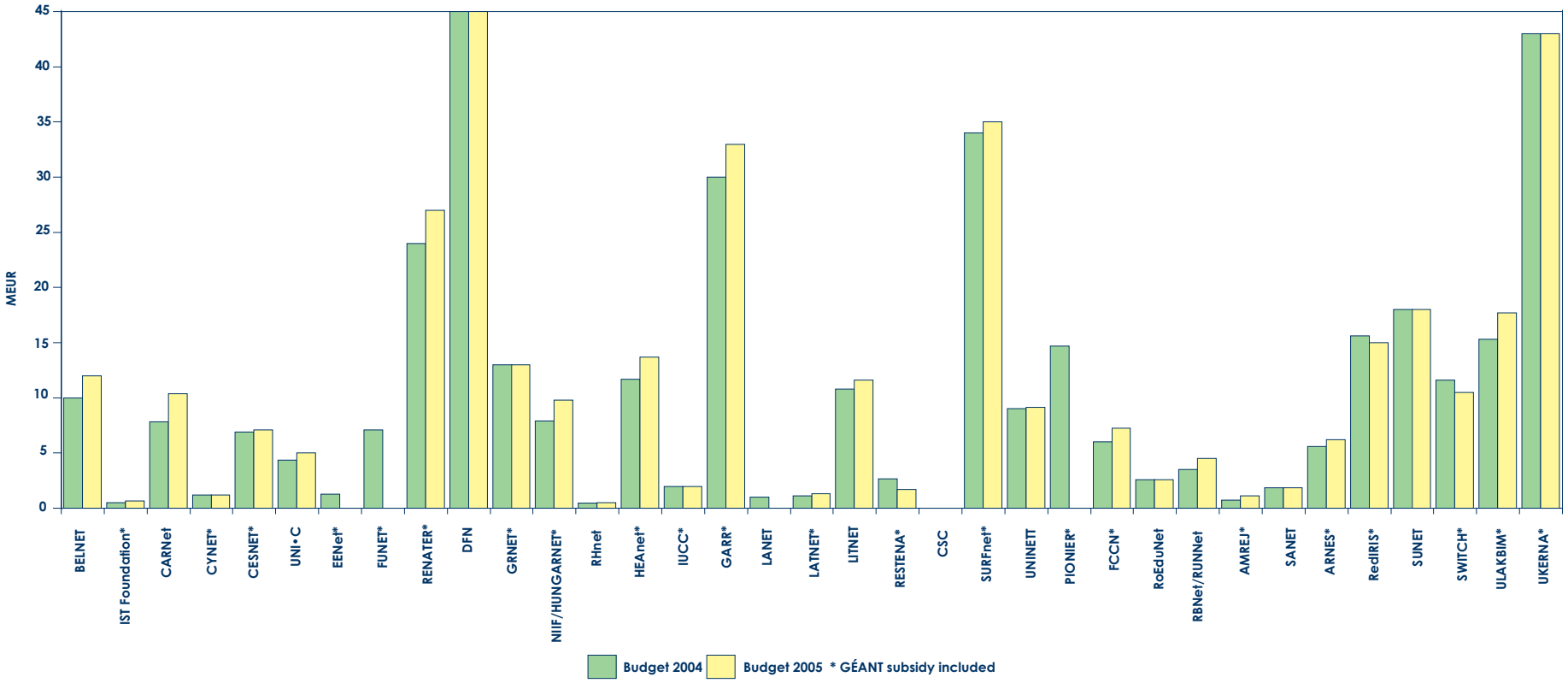
There are also other reasons why comparisons are difficult:

* 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 NRENs spend a large part of their budget on connecting secondary and primary schools, others do not;
* In section, 6.5 it seems that some NRENs do not spend money on salaries. Yet, they do have staff, but this staff is not paid from the NREN budget. Similar situations may apply for other budget categories as well.

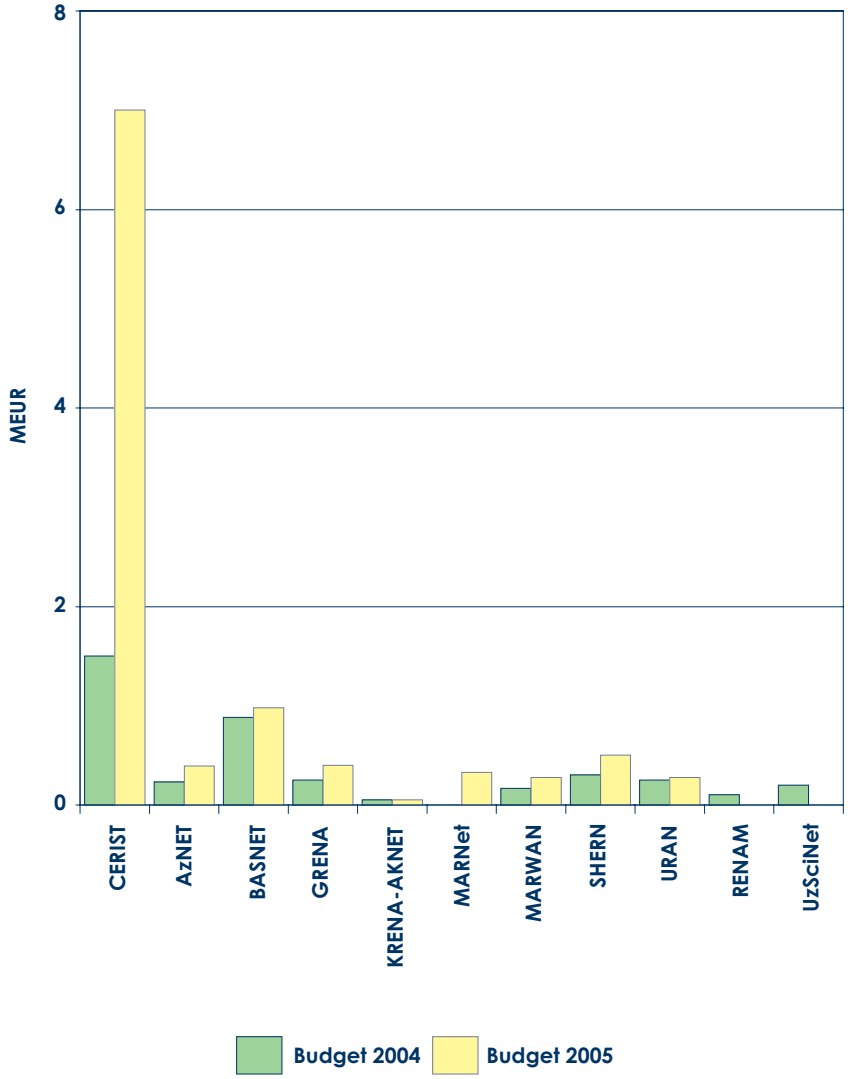
When comparing current budget data with data from previous versions of the Compendium, it becomes clear that NREN budgets tend to be stable over time. There are fluctuations from year to year, depending on whether or not an important investment takes place during that year. But on the whole, the trend is that budgets stay relatively stable and that NRENs are able to deliver more bandwidth and more services for roughly the same amount of money.

The exception to this general trend seems to be the situation in the less developed NRENs. There, new possibilities for significantly upgrading international bandwidth (for example under the GN2, EUMEDCONNECT or SEEREN projects) seem to act as a catalyst for increased national NREN budgets. A case in point is CERIST of Algeria. For 2005, it has received extra funding for a major upgrade of its backbone and of the access network. It could be that this increase has in fact been catalysed in part by the improved international connectivity that has become available to CERIST through the EUMEDCONNECT project.

Graph 6.3.1 Total budget 2004 and 2005, GN2 partner countries



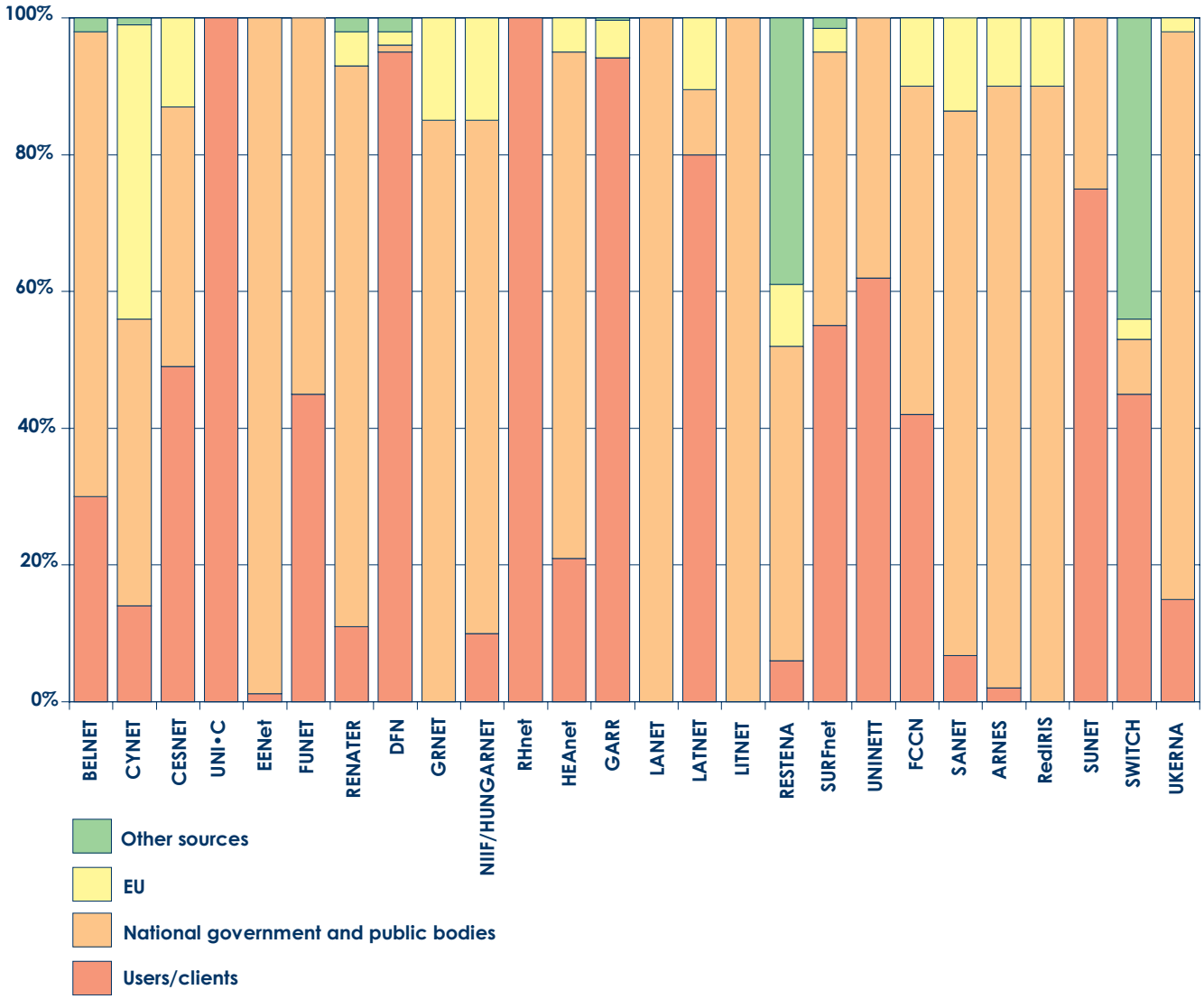
Graph 6.3.2 Total budget, 2004 and 2005, other countries



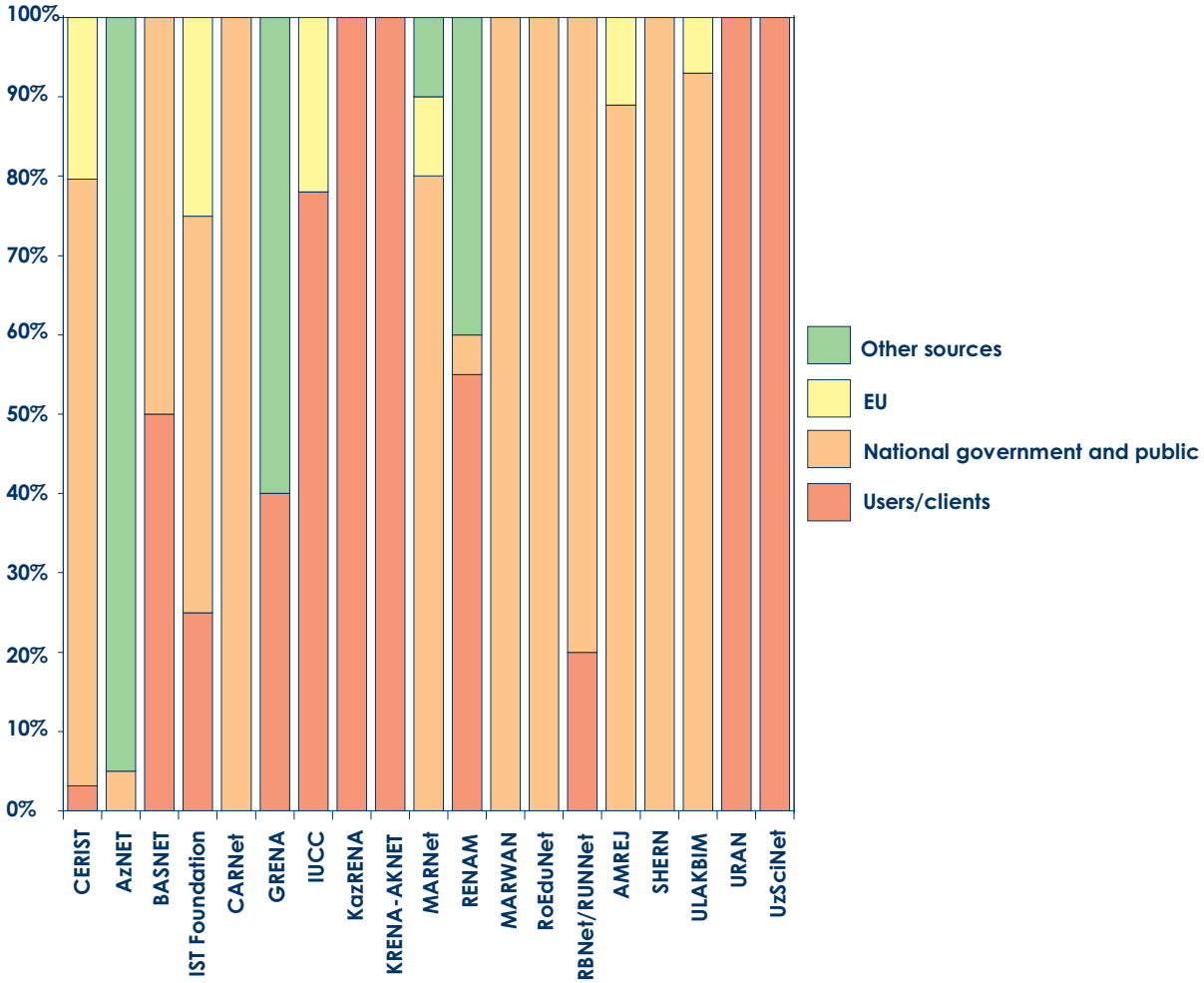
6.4. Income sources

NRENs are funded in different ways: some receive their funding directly from the National Government, others are funded by their users (who may in turn be government funded). Graphs 6.4.1 and 6.4.2 give information on what percentage of NREN funds come from which source and clearly show the differences. Note that in many cases (see also table 6.3.1) the amount of funding received from the EU is not shown in this table.

Graph 6.4.1 Income sources, EU and EFTA countries



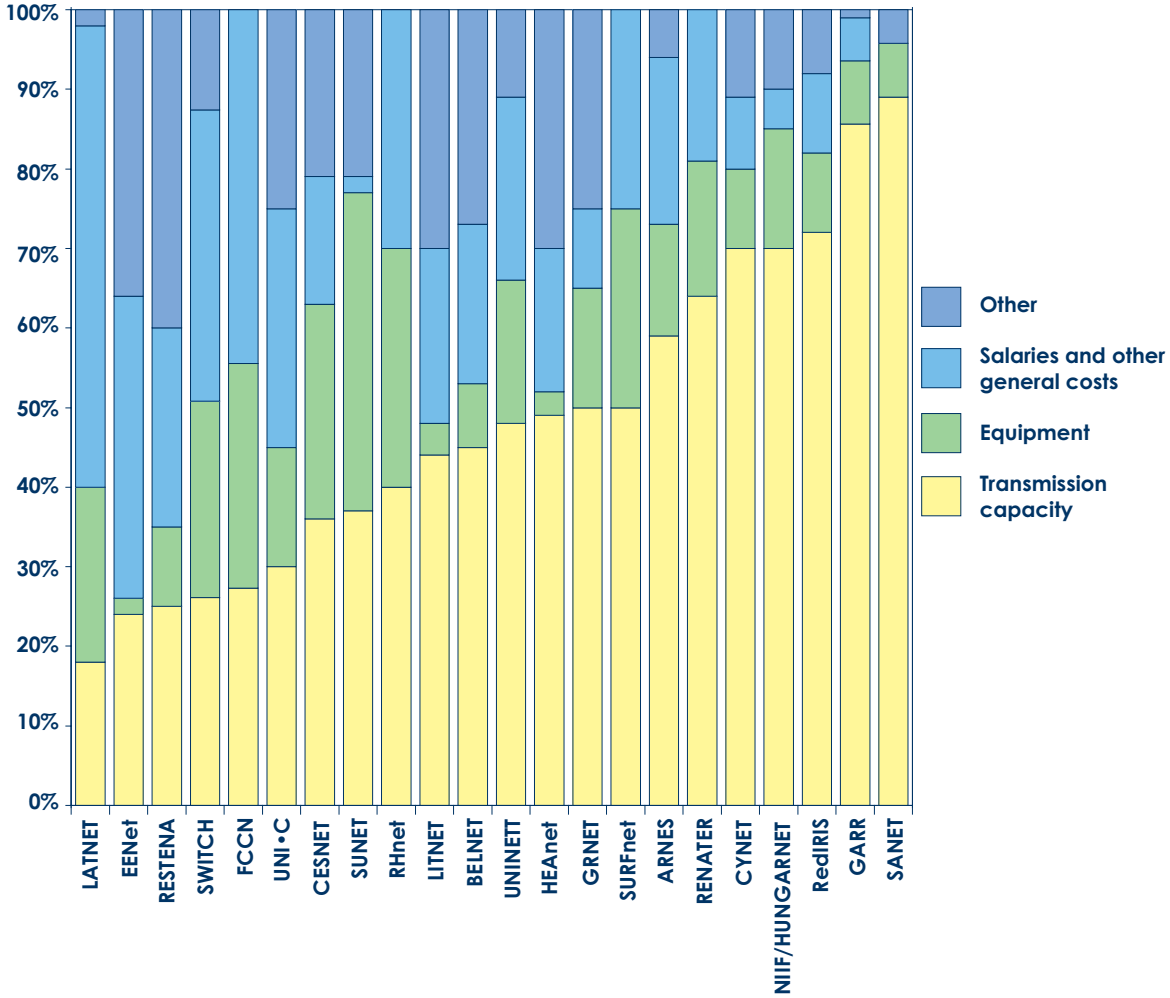
Graph 6.4.2 Income sources, other countries



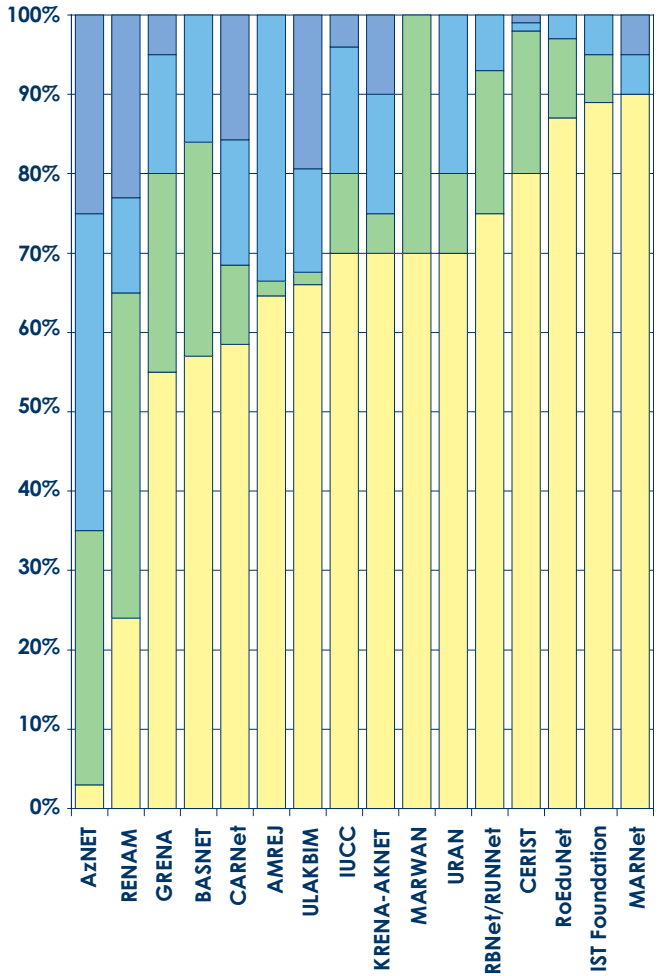
6.5 Expenditure by category

Graphs 6.5.1 and 6.5.2 show which percentage of NREN income is spent on which categories of expenditure. For ease of readability, the data has been sorted in the order of the largest expenditure category, which for most NRENs is the transmission capacity. Note that not everything may be funded through the NREN budget in all countries. 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.

Graph 6.5.1 Expenditure by category, EU and EFTA countries



Graph 6.5.2 Expenditure by category, other countries



1 Additional Tables

Note to tables 1.1 – 1.7:
Some NRENs may connect institutions in these categories, but may not have provided the relevant information in the survey

Table 1.1 Number of connected Universities and bandwidth

	NREN	Total # connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb	% ≥ 10 Gb
EU/EFTA countries									
Belgium	BELNET	18	0	0	28	0	50	22	0
Cyprus	CYNET	1	0	0	0	0	100	0	0
Czech Republic	CESNET	37	0	16	5.5	4	0	75	0
Denmark	UNI•C	12	0	0	0	10	20	70	0
Estonia	EENet	11	0	0	36	9	36	19	0
Finland	FUNET	49	0	0	0	0	65	35	0
France	RENATER	406	0	40	17	37	6	0	0
Germany	DFN	70	0	0	0	34	59	7	0
Greece	GRNET	20	0	0	25	30	30	15	0
Hungary	NIIF/ HUNGARNET	24	0	17	4	8	4	33	33
Iceland	RHnet	8	0	0	0	20	0	80	0
Ireland	HEAnet	7	0	0	0	14	86	0	0
Italy	GARR	85	0	12	22	46	12	8	0
Latvia	LANET	27	0	20	10	45	0	25	0
Latvia	LATNET	22	0	40	45	15	0	0	0
Lithuania	LITNET	20	0	0	0	65	1	34	0
Luxembourg	RESTENA	6	0	17	17	0	0	66	0
Malta	CSC	5	0	60	0	40	0	0	0
Netherlands	SURFnet	60	0	0	0	0	0	95	5
Norway	UNINETT	4	0	0	0	0	25	75	0

Table 1.1 Number of connected Universities and bandwidth (continued)

	NREN	Total # connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb	% ≥ 10 Gb
Poland	PIONIER	95	2	12	20	42	11	13	0
Portugal	FCCN	22	0	10	50	40	0	0	0
Slovakia	SANET	52	0	0	0	0	5	95	0
Slovenia	ARNES	10	0	0	20	20	0	60	0
Spain	RedIRIS	66	0	7	3	27	43	20	0
Sweden	SUNET	40	0	0	0	20	0	80	0
Switzerland	SWITCH	31	0	0	29	33	0	34	4
United Kingdom	UKERNA	120	0	0	0	60	30	10	0
Other countries									
Algeria	CERIST	36	0	80	20	0	0	0	0
Azerbaijan	AzNET	4	20	80	0	0	0	0	0
Azerbaijan	AzRENA	16	10	30	50	10	0	0	0
Belarus	BASNET	10	0	70	0	30	0	0	0
Bulgaria	IST Foundation	20	0	0	100	0	0	0	0
Croatia	CARNet	190	0	62	3	7	4	23	1
Georgia	GRENA	10	0	80	10	10	0	0	0
Israel	IUCC	8	0	0	0	75	25	0	0
Kazakhstan	KazRENA	6	0	100	0	0	0	0	0
Kyrgyzstan	KRENA-AKNET	16	0	100	0	0	0	0	0
Macedonia, FYRo	MARNet	10	10	0	40	0	0	50	0
Moldova	RENAM	6	0	0	65	0	0	35	0
Morocco	MARWAN	13	0	15	7	78	0	0	0
Romania	RoEduNet	50	0	0	10	75	15	0	0
Russian Federation	RBNet/RUNNet	168	2	62	10	21	3	2	0
Serbia / Montenegro	AMREJ	5	0	33	0	0	17	50	0
Syria	SHERN	5	0	100	0	0	0	0	0
Ukraine	URAN	25	40	20	8	32	0	0	0
Uzbekistan	UzSciNet	80	0	90	10	0	0	0	0
Turkey	ULAKBIM	78	0	23	39	31	7	0	0

Table 1.2 Number of connected research institutes and bandwidth

	NREN	Total number connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb	% ≥ 10 Gb
EU/EFTA countries									
Belgium	BELNET	34	0	0	79.4	11.8	5.9	2.9	0
Cyprus	CYNET	3	0	100	0	0	0	0	0
Czech Republic	CESNET	21	0	42	47.6	10.4	0	0	0
Denmark	UNI•C	25	0	50	35	15	0	0	0
Estonia	EENet	15	0	33	0	47	20	0	0
Finland	FUNET	15	0	0	10	15	65	10	0
France	RENATER	244	0	45.5	29.5	24.2	0.8	0	0
Germany	DFN	127	0	28	46	24	2	0	0
Greece	GRNET	20	0	20	70	5	5	0	0
Hungary	NIIF/ HUNGARNET	66	12	50	3	23	0	12	0
Iceland	RHnet	7	0	0	0	0	0	100	0
Ireland	HEAnet	10	0	70	0	30	0	0	0
Italy	GARR	106	0	48.1	9.4	30.2	3.8	8.5	0
Latvia	LANET	36	0	0	0	100	0	0	0
Latvia	LATNET	18	0	18	73	9	0	0	0
Lithuania	LITNET	54	0	2	0	90	0	8	0
Luxembourg	RESTENA	16	18.8	31.3	18.8	12.5	0	18.8	0
Malta	CSC	1	0	100	0	0	0	0	0
Netherlands	SURFnet	65	0	5	0	10	5	80	0
Norway	UNINETT	83	0	19	7	62	1	10	0
Poland	PIONIER	160	12	40	30	12	5	1	0
Portugal	FCCN	12	0	60	40	0	0	0	0
Slovakia	SANET	25	0	0	7	50	33	10	0
Slovenia	ARNES	57	7	42	21	23	0	7	0
Spain	RedIRIS	150	5	36	30	20	3	6	0

	NREN	Total number connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb	% ≥ 10 Gb
Sweden	SUNET	5	0	0	0	60	20	20	0
Switzerland	SWITCH	2	0	0	0	50	0	50	0
United Kingdom	UKERNA	50	0	10	35	40	10	5	0
Other countries									
Algeria	CERIST	11	0	100	0	0	0	0	0
Azerbaijan	AzRENA	24	10	20	0	40	30	0	0
Belarus	BASNET	180	0	60	35	5	0	0	0
Bulgaria	IST Foundation	72	0	0	50	50	0	0	0
Croatia	CARNet	50	2	86	2	2	0	8	0
Georgia	GRENA	30	10	90	0	0	0	0	0
Israel	IUCC	5	0	40	60	0	0	0	0
Kazakhstan	KazRENA	21	0	100	0	0	0	0	0
Kyrgyzstan	KRENA-AKNET	2	0	100	0	0	0	0	0
Macedonia, FYRo	MARNet	5	80	0	20	0	0	0	0
Moldova	RENAM	35	0	0	60	30	0	10	0
Morocco	MARWAN	2	0	100	0	0	0	0	0
Romania	RoEduNet	35	0	20	20	50	0	10	0
Russian Federation	RBNet/RUNNet	270	10	60	20	10	0	0	0
Serbia / Montenegro	AMREJ	22	0	59	14	0	0	27	0
Syria	SHERN	3	0	100	0	0	0	0	0
Turkey	ULAKBIM	14	0	64.3	21.5	14.2	0	0	0
Ukraine	URAN	6	33	0	67	0	0	0	0
Uzbekistan	UzSciNet	24	0	90	0	10	0	0	0

Table 1.3 Number of connected institutions of higher/further education and bandwidth

	NREN	Total number connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb	% ≥ 10 Gb
EU/EFTA countries									
Belgium	BELNET	36	0	0	44	50	5.6	0	0
Cyprus	CYNET	5	0	100	0	0	0	0	0
Czech Republic	CESNET	21	0	38	38	24	0	0	0
Denmark	UNI•C	74	0	35	45	15	5	0	0
Estonia	EENet	22	0	36	14	18	32	0	0
France	RENATER	272	0	39	3,7	5	3.3	0	0
Germany	DFN	102	0	10	17	70	3	0	0
Greece	GRNET	158	87	2	8	1	1	1	0
Hungary	NIIF/HUNGARNET	38	4	32	11	13	24	16	0
Ireland	HEAnet	21	0	0	0	100	0	0	0
Italy	GARR	2	0	100	0	0	0	0	0
Latvia	LATNET	15	0	50	50	0	0	0	0
Lithuania	LITNET	93	0	0	92	8	0	0	0
Luxembourg	RESTENA	6	0	50	16.7	0	0	33.3	0
Malta	CSC	2	0	100	0	0	0	0	0
Netherlands	SURFnet	15	0	10	0	0	0	90	0
Norway	UNINETT	64	0	31	17	14	31	6	0
Poland	PIONIER	11	30	70	0	0	0	0	0
Portugal	FCCN	24	0	50	50	0	0	0	0
Slovakia	SANET	12	0	25	0	0	75	0	0
Slovenia	ARNES	10	0	50	10	40	0	0	0
Sweden	SUNET	0	0	0	0	0	0	0	0
Switzerland	SWITCH	1	0	0	0	100	0	0	0
United Kingdom	UKERNA	560	0	0	80	20	0	0	0

Table 1.3 Number of connected institutions of higher/further education and bandwidth (continued)

	NREN	Total number connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb	% ≥ 10 Gb
Other countries									
Algeria	CERIST	21	0	100	0	0	0	0	0
Azerbaijan	AzRENA	2	100	0	0	0	0	0	0
Bulgaria	IST Foundation	1	0	100	0	0	0	0	0
Croatia	CARNet	21	0	52	0	19	5	24	0
Georgia	GRENA	20	0	100	0	0	0	0	0
Israel	IUCC	4	0	50	50	0	0	0	0
Kazakhstan	KRENA-AKNET	2	0	100	0	0	0	0	0
Kyrgyzstan	KazRENA	5	0	100	0	0	0	0	0
Moldova	RENAM	2	0	0	100	0	0	0	0
Morocco	MARWAN	10	0	100	0	0	0	0	0
Serbia / Montenegro	AMREJ	80	0	0	0	0	0	0	0
Syria	SHERN	4	0	100	0	0	0	0	0
Turkey	ULAKBIM	293	0	100	0	0	0	0	0
Ukraine	URAN	1	0	0	0	100	0	0	0

Table 1.4 Number of connected libraries, museums and national archives and bandwidth

Country	NREN	Total number connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb
Algeria	CERIST	10	100	0	0	0	0	0
Azerbaijan	AzNET	1	0	100	0	0	0	0
Azerbaijan	AzRENA	0	0	0	100	0	0	0
Belarus	BASNET	10	0	50	50	0	0	0
Belgium	BELNET	10	0	0	100	0	0	0
Bulgaria	IST Foundation	5	60	40	0	0	0	0
Croatia	CARNet	18	6	72	6	11	5	0
Czech Republic	CESNET	21	0	33.3	42.8	19.1	0	4.8
Denmark	UNI•C	5	0	0	0	100	0	0
Estonia	EENet	95	0	90	1	2	7	0

Country	NREN	Total number connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb
Finland	FUNET	3	0	33.3	33.3	33.3	0	0
France	RENATER	4	0	25	75	0	0	0
Georgia	GRENA	10	10	90	0	0	0	0
Hungary	NIIF/ HUNGARNET	287	40	55	1	1	2	1
Iceland	RHnet	0	0	0	0	0	0	100
Ireland	HEAnet	1	0	100	0	0	0	0
Italy	GARR	27	0	100	0	0	0	0
Kazakhstan	KazRENA	1	0	0	0	0	0	0
Kyrgyzstan	KRENA-AKNET	1	0	100	0	0	0	0
Latvia	LANET	0	0	0	0	0	0	0
Latvia	LATNET	24	4	16	68	12	0	0
Lithuania	LITNET	89	0	1.2	1.2	96	0	1.2
Luxembourg	RESTENA	10	60	10	30	0	0	0
Macedonia, FYRo	MARNet	1	100	0	100	0	0	0
Moldova	RENAM	14	0	0	100	0	0	0
Morocco	MARWAN	1	0	0	100	0	0	0
Netherlands	SURFnet	10	0	0	0	0	10	90
Norway	UNINETT	14	0	80	7	7	7	0
Poland	PIONIER	38	0	31	53	16	0	0
Romania	RoEduNet	20	0	10	10	70	5	0
Russian Federation	RBNet/RUNNet	26	0	0	0	0	0	0
Serbia / Montenegro	AMREJ	5	0	20	0	60	0	20
Slovakia	SANET	10	0	0	0	100	0	0
Slovenia	ARNES	145	32	44	15	9	0	0
Spain	RedIRIS	15	0	80	20	0	0	0
Sweden	SUNET	15	0	0	0	100	0	0
Turkey	ULAKBIM	2	0	100	0	0	0	0
Uzbekistan	UzSciNet	9	0	0	0	0	0	0

Table 1.5 Number of connected hospitals (other than University hospitals) and bandwidth

Country	NREN	Total number connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb
Algeria	CERIST	30	100	0	0	0	0	0
Belarus	BASNET	15	0	100	0	0	0	0
Belgium	BELNET	8	0	0	50	37.5	12.5	0
Czech Republic	CESNET	24	0	20.8	45.8	25	8.4	0
France	RENATER	7	0	71.5	28.5	0	0	0
Georgia	GRENA	5	0	100	0	0	0	0
Italy	GARR	6	0	100	0	0	0	0
Kyrgyzstan	KRENA-AKNET	2	0	100	0	0	0	0
Latvia	LATNET	1	0	0	100	0	0	0
Lithuania	LITNET	11	0	4	0	96	0	0
Moldova	RENAM	3	0	35	65	0	0	0
Netherlands	SURFnet	1	0	0	0	0	0	100
Poland	PIONIER	29	0	10	55	24	3	8
Serbia / Montenegro	AMREJ	1	0	100	0	0	0	0
Spain	RedIRIS	41	0	90	10	0	0	0
Uzbekistan	UzSciNet	7	0	0	0	0	0	0

Table 1.6 Number of connected government departments (national, regional, local) and bandwidth

Country	NREN	Total # connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb
Algeria	CERIST	50	80	20	0	0	0	0
Belarus	BASNET	14	0	40	60	0	0	0
Belgium	BELNET	35	0	0	42.9	34.3	14.3	8.5
Croatia	CARNet	6	0	33	0	0	0	67
Czech Republic	CESNET	38	0	31.6	55.3	13.1	0	0
Estonia	EENet	17	0	82	0	0	18	0

Country	NREN	Total # connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb
Finland	FUNET	2	0	0	50	50	0	0
France	RENATER	14	0	78.5	21.5	0	0	0
Georgia	GRENA	3	0	33	0	66	0	0
Greece	GRNET	8	0	25	75	0	0	0
Hungary	NIIF/HUNGARNET	3	0	33	0	67	0	0
Ireland	HEAnet	6	0	84	16	0	0	0
Italy	GARR	3	0	0	0	33.4	66.6	0
Latvia	LATNET	5	0	70	15	15	0	0
Lithuania	LITNET	65	0	1.5	1.5	89	0	8
Luxembourg	RESTENA	2	0	50	0	0	0	50
Macedonia, FYRo	MARNet	1	0	0	100	0	0	0
Moldova	RENAM	5	0	0	100	0	0	0
Morocco	MARWAN	2	0	100	0	0	0	0
Poland	PIONIER	28	6	39	47	8	0	0
Portugal	FCCN	12	0	100	0	0	0	0
Romania	RoEduNet	20	0	5	15	80	0	0
Russian Federation	RBNet/RUNNet	48	0	0	0	0	0	0
Serbia / Montenegro	AMREJ	2	0	50	0	0	0	50
Slovakia	SANET	8	0	0	0	100	0	0
Spain	RedIRIS	12	0	0	30	70	0	0
Sweden	SUNET	5	0	0	0	100	0	0
Turkey	ULAKBIM	11	0	72.7	9.1	9.1	9.1	0
Ukraine	URAN	1	0	0	0	0	0	0
Uzbekistan	UzSciNet	18	0	0	0	0	0	0

Table 1.7 Number of connected others and bandwidth

Country	NREN	Total number connected	% ≤ isdn	% up to 2 Mb	% up to 10 Mb	% up to 100 Mb	% up to 1 Gb	% ≥ 1 Gb
Azerbaijan	AzNET	5	0	80	20	0	0	0
Azerbaijan	AzRENA	2	50	50	0	0	0	0
Belgium	BELNET	1	0	0	0	0	100	0
Croatia	CARNet	25	16	60	4	12	0	8
Czech Republic	CESNET	25	0	48	36	16	0	0
Denmark	UNI•C	15	0	40	30	30	0	0
Estonia	EENet	65	0	26	12.5	21.5	40	0
Finland	FUNET	13	0	0	15	35	50	0
France	RENATER	9	0	77.8	11.1	11.1	0	0
Greece	GRNET	1265	93	5	2	1	0	0
Hungary	NIIF/HUNGARNET	72	36	52	3	6	0	3
Italy	GARR	76	0	77.6	10.5	7.9	1.3	2.7
Kazakhstan	KazRENA	4	0	100	0	0	0	0
Kyrgyzstan	KRENA-AKNET	3	0	100	0	0	0	0
Latvia	LATNET	2	0	100	0	0	0	0
Lithuania	LITNET	146	0	0	0	100	0	0
Netherlands	SURFnet	20	0	30	5	5	0	60
Norway	UNINETT	8	100	0	0	0	0	0
Poland	PIONIER	179	6	36	42	15	0	1
Serbia / Montenegro	AMREJ	11	0	27	36	27	0	9
Slovenia	ARNES	158	30	46	8	16	0	1
Spain	RedIRIS	1	0	0	0	0	100	0
Sweden	SUNET	10	0	0	20	60	20	0
Switzerland	SWITCH	2	0	0	0	100	0	0
Ukraine	URAN	2	0	0	0	100	0	0
Uzbekistan	UzSciNet	41	0	100	0	0	0	0

1.8 Number of PoPs and of managed links on the network

The number of Points of Presence (PoPs) on the network and the number of managed links are both indicators of the amount of resources that is needed for the NREN to maintain the network. The number of PoPs was defined more explicitly than in 2004 as the 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 800 institutions (many of them secondary and primary schools) and thus has 800 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.

Table 1.8

	NREN	# of PoPs	# of Managed links
EU & EFTA countries			
Belgium	BELNET	15	29
Cyprus	CYNET	2	1
Czech Republic	CESNET	22	46
Denmark	UNI•C	15	30
Finland	FUNET	15	21
France	RENATER	39	70
Germany	DFN	27	52
Greece	GRNET	12	14
Hungary	NIIF/HUNGARNET	35	38
Iceland	RHnet	10	13
Ireland	HEAnet	9	11
Italy	GARR	39	50
Latvia	LANET	21	21
Latvia	LATNET	42	50
Lithuania	LITNET	25	23
Luxembourg	RESTENA	12	13
Malta	CSC	1	0
Netherlands	SURFnet	138	150
Norway	UNINETT	60	80
Poland	PIONIER	22	25
Portugal	FCCN	20	25
Slovakia	SANET	22	23
Slovenia	ARNES	800	800
Spain	RedIRIS	19	32
Sweden	SUNET	23	30
Switzerland	SWITCH	30	35
United Kingdom	UKERNA	28	34
Other countries			
Algeria	CERIST	4	3
Azerbaijan	AzNET	8	8
Azerbaijan	AzRENA	8	8
Belarus	BASNET	14	13
Bulgaria	IST Foundation	10	30
Croatia	CARNet	250	300
Georgia	GRENA	17	26
Israel	IUCC	10	18
Kazakhstan	KazRENA	6	6
Kyrgyzstan	KRENA-AKNET	30	30
Macedonia, FYRo	MARNet	1	0
Moldova	RENAM	15	25
Morocco	MARWAN	1	0
Romania	RoEduNet	41	53

Table 1.8

	NREN	# of PoPs	# of Managed links
Russian Federation	RBNet/RUNNet	40	60
Syria	SHERN	5	4
Turkey	ULAKBIM	3	3
Ukraine	URAN	11	10
Uzbekistan	UzSciNet	13	22

Table 1.9 Traffic with the general Internet

	NREN	% of 'T3' traffic that is with the general Internet	% of 'T4' traffic that is with the general Internet
EU/EFTA countries			
Cyprus	CYNET	90	90
Czech Republic	CESNET	83	70.4
Estonia	EENet	90	90
Finland	FUNET	80	80
France	RENATER	90	80
Germany	DFN	90	83
Greece	GRNET	82.2	82.2
Hungary	NIIF/ HUNGARNET	70	70
Ireland	HEAnet	88	81
Italy	GARR	49	43
Luxembourg	RESTENA	85	80
Malta	CSC	80	80
Poland	PIONIER	88	87
Portugal	FCCN	70	70
Slovakia	SANET	75	75
Slovenia	ARNES	70	65
Spain	RedIRIS	90	86
Switzerland	SWITCH	61	58
United Kingdom	UKERNA	95	86
Other countries			
Algeria	CERIST	50	50
Azerbaijan	AzNET	100	100
Azerbaijan	AzRENA	100	100
Belarus	BASNET	15	85
Bulgaria	IST Foundation	25	50
Croatia	CARNet	95	95
Georgia	GRENA	50	50
Israel	IUCC	95	95
Kyrgyzstan	KRENA-AKNET	100	100
Lithuania	LITNET	90	89
Macedonia, FYRo	MARNet	85	88
Netherlands	SURFnet	55.2	51.6
Romania	RNC	60	60
Russian Federation	RBNet/RUNNet	62	55
Serbia / Montenegro	AMREJ	80	80
Turkey	ULAKBIM	97	94
Ukraine	UARNet	91	93
Ukraine	URAN	90	95

2

1. Alphabetical list of NRENs

Note that the country entries at **http://www.terena.nl/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
AMREJ		Serbia/Montenegro
ARENA		Armenia
ARNES		Slovenia
AzNET		Azerbaijan
AzRENA		Azerbaijan
BASNET		Belarus
BELNET		Belgium
CARNet		Croatia
CERIST		Algeria
CESNET		Czech Republic
CNRS		Lebanon
CSC		Malta
CYNET	KEAD	Cyprus
DFN		Germany
EENet		Estonia
EUN		Egypt
FCCN		Portugal
FUNET		Finland

NREN Acronym in English	NREN Acronym in the national language(s) if different	Country
GARR		Italy
GRENA		Georgia
GRNET	EDET	Greece
HEAnet		Ireland
IRANET		Iran
IST Foundation	FTIO	Bulgaria
JANET		United Kingdom (in the UK, the network is called JANET; it is operated by UKERNA)
IUCC	MACHBA	Israel
KazRENA		Kazakhstan
KRENA-AKNET	AKNOKS-AKNET	Kyrgyzstan
LANET		Latvia
LATNET		Latvia
LITNET		Lithuania
MARNet		Former Yugoslav Republic of Macedonia
MARWAN		Morocco
NIIF/ HUNGARNET		Hungary
NITC		Jordan

NREN Acronym in English	NREN Acronym in the national language(s) if different	Country
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		Russia
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
RNC		Romania
RoEduNet		Romania
SANET		Sovakia
SHERN		Syria
SUNET		Sweden
SURFnet		Netherlands
SWITCH		Switzerland
UARNet		Ukraine
UKERNA		United Kingdom - operates the JANET network
ULAKBIM		Turkey
UNINETT		Norway
URAN		Ukraine
UzSciNet		Uzbekistan

2. Glossary of Terms

Terms not listed in this glossary are either explained in the text or are too specialist 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.nl/**.

AAI	Authentication and Authorisation Infrastructure. Such an infrastructure typically makes use of a scheme (or 'schema') and transmits information about certain relevant attributes of a person to other institutions (such as in the 'eduPerson' scheme). When several providers of attributes decide to trust each other, they form a 'federation'
AUP	Acceptable Use Policy
Bit or b	Binary digit - the smallest unit of data in a computer – in the compendium: kilobit (kb), Megabit (Mb), Gigabit (Gb)
Byte or B	8 bits – in the compendium: TB (Terabyte)
CA	Certification Authority
CEENet	Central and Eastern European Networking Association – see **http://www.ceenet.org**
CERN	l'Organisation Européenne pour la Recherche Nucléaire - European Organisation for Nuclear Research
country name tld	Country-name top-level domain: designation of country names (or ' country domains') used in the Internet, such as .uk, .de or .fr
CSIRT	Computer Security Incident Response Team
DANTE	The company, owned by European NRENs that plans, builds and operates pan-European networks for research and education – see **http://www.dante.net**
Dark Fibre	Optic fibre cable that is not connected to transmission equipment by the vendor or owner of the cable and therefore has to be connected ('lit') by the NREN or the client institution
DEISA	Distributed European Infrastructure for Supercomputing Applications project – see **http://www.deisa.org**
DWDM	dense-wavelength division multiplexing
EFTA	European Free Trade Association – see **http://www.efta.int**
EGEE	Enabling Grids for E-science project – see **http://public.eu-egee.org/**
EU	European Union – see **http://www.europa.eu.int/**
EUMEDCONNECT	A project to interconnect NRENs in the Mediterranean region to the GÉANT network – see **http://www.eumedconnect.net/**
FTE	Full-Time Equivalent
GbE	Gigabit Ethernet
GÉANT	A project mainly to develop the GÉANT network, the multi-gigabit pan-European data communications network, reserved specifically for research and education use

GÉANT2	The next generation of the GÉANT network – see **http://www.geant2.net**
GN2	The project to develop the GÉANT2 network and carry out a number of other, related tasks
Grid computing	Applying the resources of many computers in a network to a single problem at the same time
IP	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.
IPv6	The latest generation of the Internet Protocol. Institutions can have different types of IPv6 connections:
	- native: direct connection to the NREN via IPv6;
	- tunneled, 6to4 and tunnel brokers: techniques for sending IPv6 data packets encapsulated in IPv4 packets
ISP	Internet Service Provider
LAN	Local Area Network
MAN	Metropolitan Area Network
NOC	Network Operations Centre - a place from which a network is supervised, monitored, and maintained
NORDUnet	An international collaboration between the Nordic NRENs. It interconnects these networks and connects them to the worldwide network for research and education and to the general purpose Internet – see **http://www.nordu.net**
NREN	National Research and Education Network
PKI	Public-Key Infrastructure - enables the use of encryption and digital signature services across a wide variety of applications
SEEREN	South-Eastern European Research & Education Networking project – see **http://www.seeren.org**
Shibboleth	An infrastructure for building federations and for transferring authentication and authorisation information between sites
University	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 **http://www.uis.unesco.org**

What is TERENA?

Nowadays research and education depend increasingly on electronic media and computer networks. Networking services for research institutes and educational establishments are provided by dedicated research and education networks. These networking organisations collaborate at the European level, thus creating a high-quality international information and telecommunications infrastructure. TERENA is the association in which the research and education networking organisations from countries in and around Europe collaborate. TERENA's objectives translate into four main categories of activities:

* providing an environment for fostering new initiatives of the European research networking community;
* supporting joint European work in developing, evaluating, testing, integrating and promoting new networking, middleware and application technologies through the TERENA Technical Programme;
* organising conferences, workshops and seminars for the exchange of information in the European research networking community, and pursuing knowledge transfer to less advanced networking organisations;
* promoting members' interests by representing the common interests and opinions of the membership in contacts with governments, funding bodies, industry and other organisations.

www.terena.nl/compendium/