NREN Best Common Practice

Can we make our academic networks greener?

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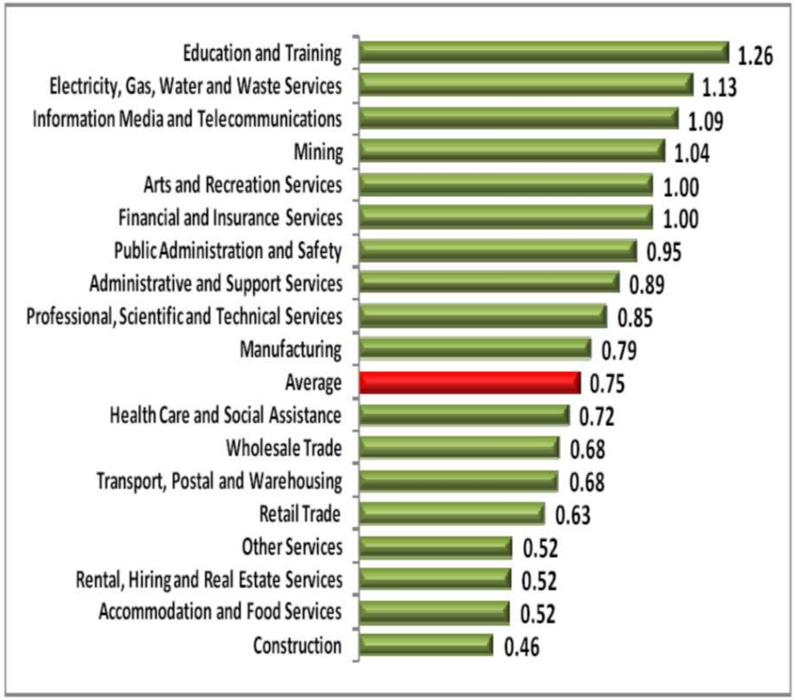
EUNIS 2011, Sustainable IT, 16 June 2011

ICT Carbon footprint

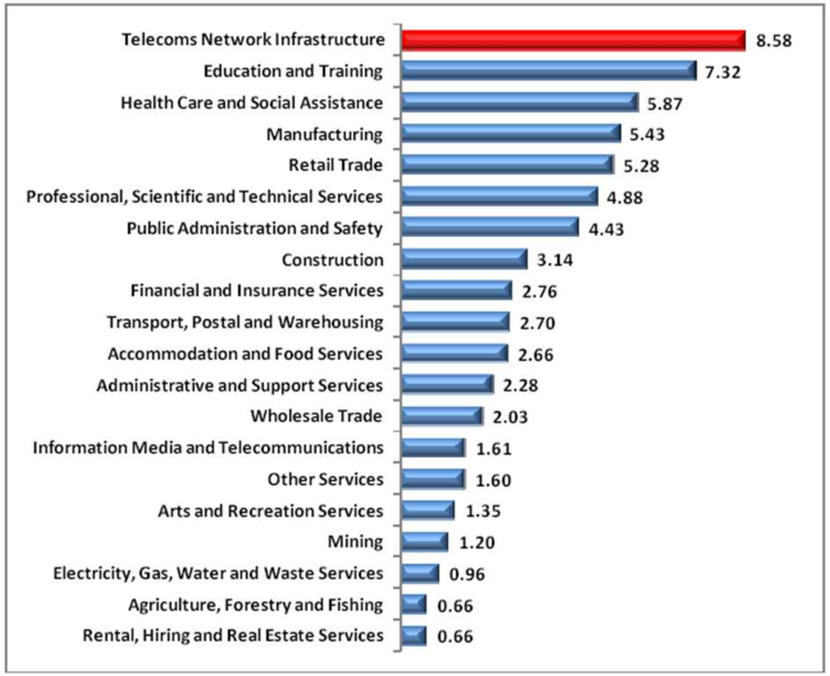
- Currently ~2% of total GHG emissions due to ICT
- Predicted to double by 2020 and reach 1.4 Gtons
- However, ICT can also reduce emissions in other sectors, potentially by 7.8 Gtons
- So ICT can save over **5 times** its own footprint

Example of main contributors



Per employee

Per sector



Australian Computer Society
Studyhttp://www.acs.org.au/attachments/ICFACSV4100412.pdf

MEASURING AND MONITORING OF THE GREENHOUSE GAS EMISSIONS

Objectives

- Baseline audit. Measurement and monitoring of GHG emissions:
  - HEAnet (Ireland)
  - NIIF Hungary)
  - NORDUnet (Denmark, Finland, Iceland, Norway, Sweden)
  - PSNC (Poland)
  - GÉANT
- Best practices. Direct and enabled reductions.
- Systemic effects

Methodology

- ISO 14064 – Specification with guidance at the organizational level for quantification and reporting of greenhouse gas emissions and removals

  - Organizational and operational boundaries
  - Direct GHG emissions and removals
  - Energy indirect GHG emissions
  - Other indirect GHG emissions

Auditing template

- The aim of the template is to assist in the early stages of producing a greenhouse gas (GHG) report for a NREN or similar organization
- The GHG emissions are divided into four classes, viz. office, data centre, backbone and transportation

Office

Excel office sheet

Office GHG accounting template							
Step 1 - energy consumptions						Step 2 - GHG calculation	
						CO_2 factor	Total
						(g/kWh)	(kg CO_2)
Office							
	Office space	Number of employees					
	(m2)	(total)	(full time equivalent)				
	300	25	18				
Heating/air condition (kWh/year)	26000					113	2938
Electricity (kWh/year)	9000					766	6894
0	**35000**	**0**	**0**	**0**	**0**	**879**	**9832**

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Data centre

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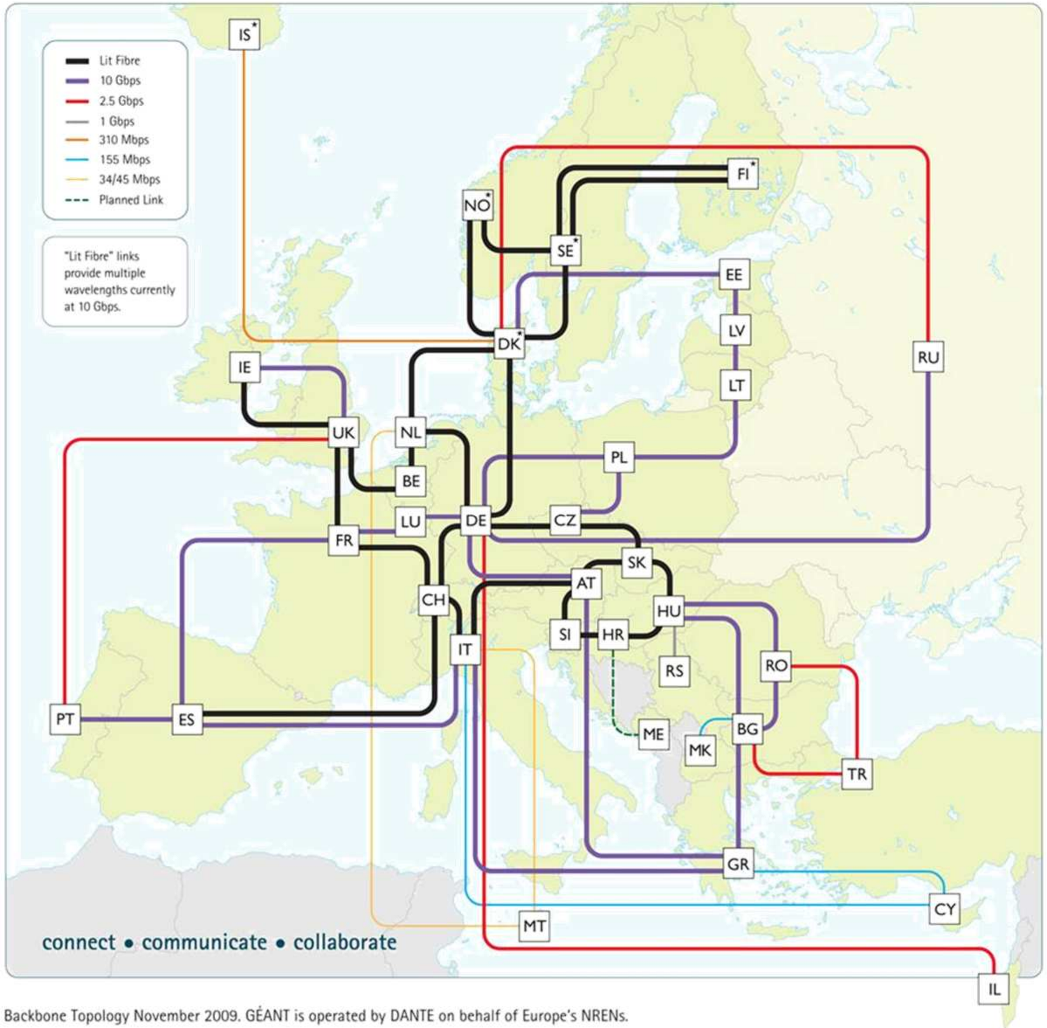
Excel Data Centre Sheet

Data Centre GHG accounting template							
Step 1 - energy consumptions						Step 2 - GHG calculation	
						CO_2 factor (g/kWh)	Total (kg CO_2)
Data center servers (NREN services)							
	Eduroam	Video conferencing	FTP				
Equipment (kWh/year)	2500	3000	2500			766	
PUE factor	1,7	1,5	1,7				**9958**

PUE factor?

- Power usage effectiveness (PUE)
- PUE is the total power consumption in the datacentre (incl. UPS, cooling etc.) divided by the consumption from the IT equipment
- Accounts for the electricity consumption of the data centre exceeding the direct consumption of the equipment
- Mostly due to cooling requirements
- To improve this factor is an obvious goal for any data centre
- A typical value in older datacentres is a PUE-value between 2,0 and 2,5
- PUE=2 means that for each Watt spend on the IT equipment, another Watt is used in UPS, cooling etc.

Backbone (GÉANT topology)



Backbone Topology November 2009. GÉANT is operated by DANTE on behalf of Europe's NRENs.

UNI•C DANMARKS IT-CENTER FOR UDDANNELSE OG FORSKNING

HEAnet IRELAND'S NATIONAL EDUCATION & RESEARCH NETWORK

SUPERCOMPUTING POZNAN NETWORKING

Excel Backbone Sheet

Backbone GHG accounting template							
Step 1 - energy consumptions						Step 2 - GHG calculation	
						CO_2 factor	Total
						(g/kWh)	(kg CO_2)
Backbone							
	PoP equipment	Routers & switches	ILAs				
kWh/year	3500	4500	43500			766	
PUE factor	1,7	1,7	1,4				**57067**

Transportation

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SUPERCOMPUTING POZNAN NETWORKING

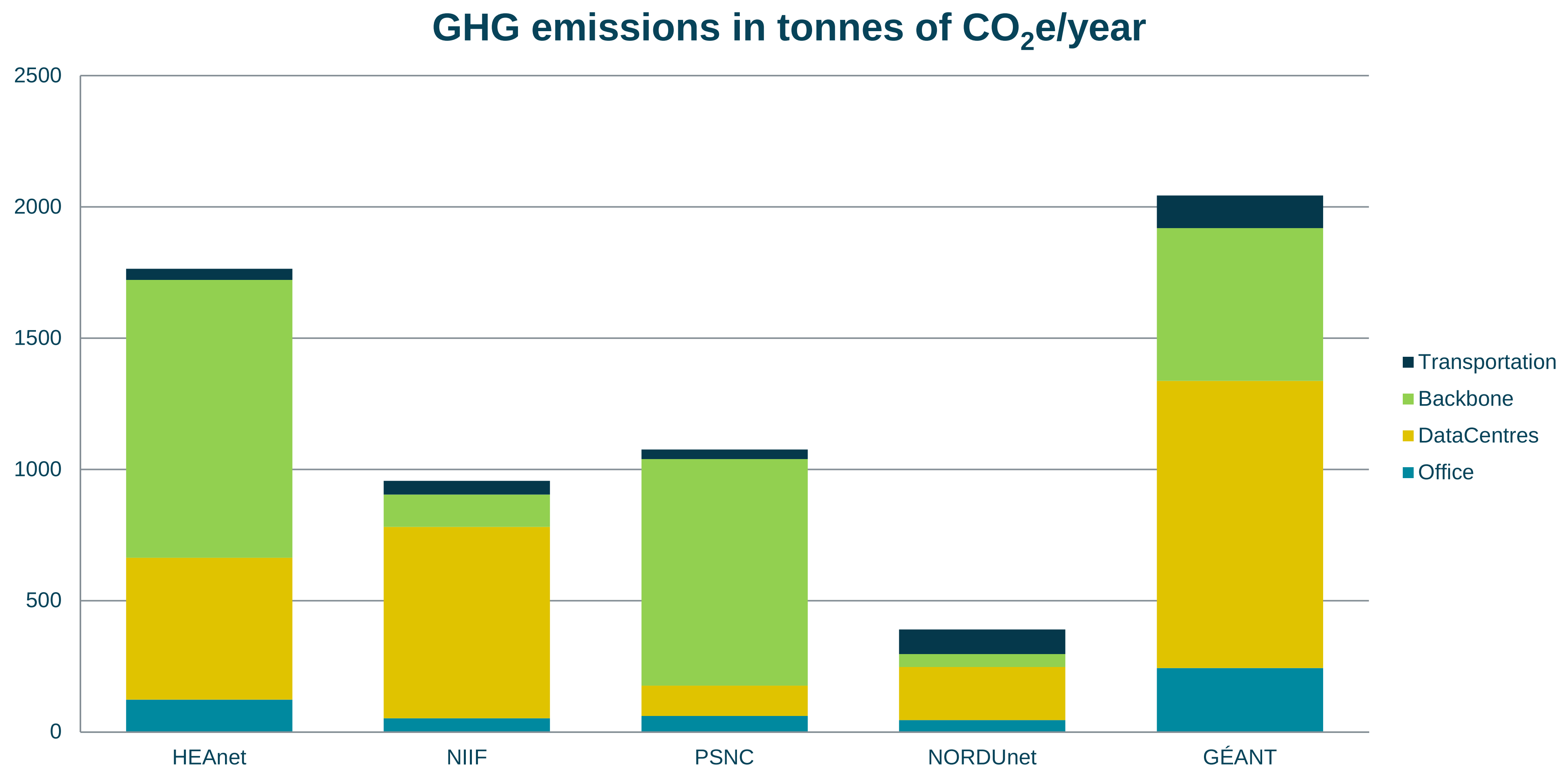
Transportation questionnaire

Transportation questionnaire(km/year)											
Name of employee											
Means of transport	Own car	Motorcycle	Bicycle	Walk	Taxi	Regional train	Bus	Subway Metro	Local train	Flight, short-haul	Flight, long-haul
Business											
Commuting											

Excel Transportation Sheet

Transportation GHG accounting template							
Step 1 - Energy consumptions measured in travelled distances						Step 2 - GHG calculation	
						CO_2 factor (g/kWh)	Total (kg CO_2)
Transportation							
Business							
Flight	45.000					110	4950
Taxi	1.000					199	199
Own car	0					175	0
Train	600					40	24
Bus	0					90	0
Total business							5173
Commuting	0						
Taxi	200					199	40
Own car	2.200					175	385
Train	3.000					40	120
Bus	400					90	36
Total commuting							581
Grand total							**5754**

Results 2009



CASE STUDY OF GREEN MANAGEMENT SYSTEM IN PSNC, POLAND

Background

- IT systems in large organizations such as Universities, e-commerce platforms, Internet banks, travel portals and others are of complex nature and typically utilize many elements to provide the service, such as:
  - Network infrastructure: PoE switches, routers, firewalls, load balancers and others.
  - Servers: hardware, virtual machines, terminal servers, clusters, database servers and others.
  - Storage and backup: RAID arrays, SAN devices, tape storage and others.
  - Software: databases, application /web servers, user applications (as ERP, CRM, Business Intelligence systems)
  - Voice infrastructure: softswitches, phone system, PSTN gateways and others.
- Power consumption is an important part of OPEX.

Green Steps

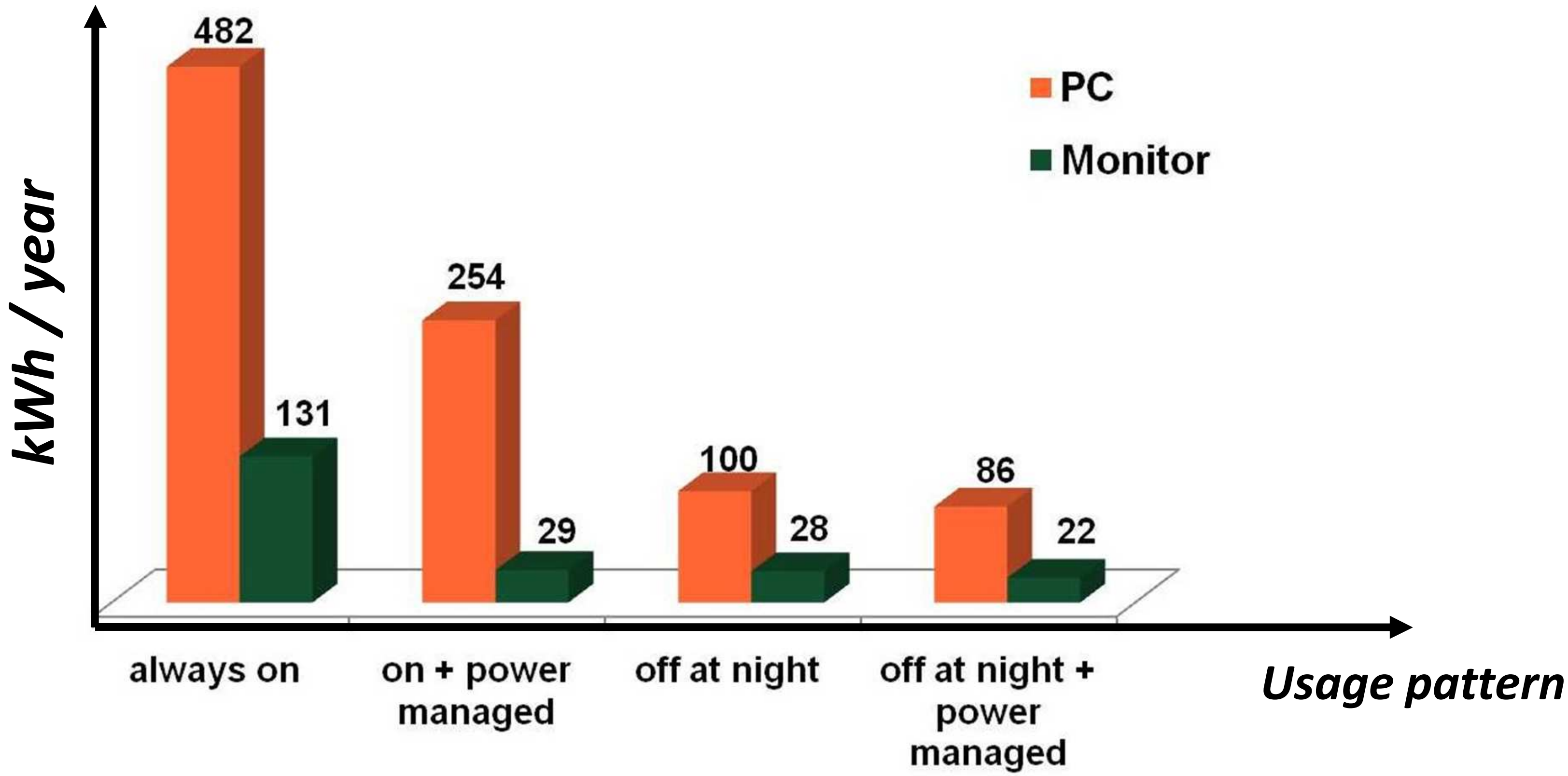
- Power management for unused computers
- Use more energy efficient computers first
- Optimize load distribution between servers
- Replace suboptimal computers
- Optimize / replace suboptimal software
- Eliminate underutilized network devices
- React to abnormal energy consumption

Power management for unused computers

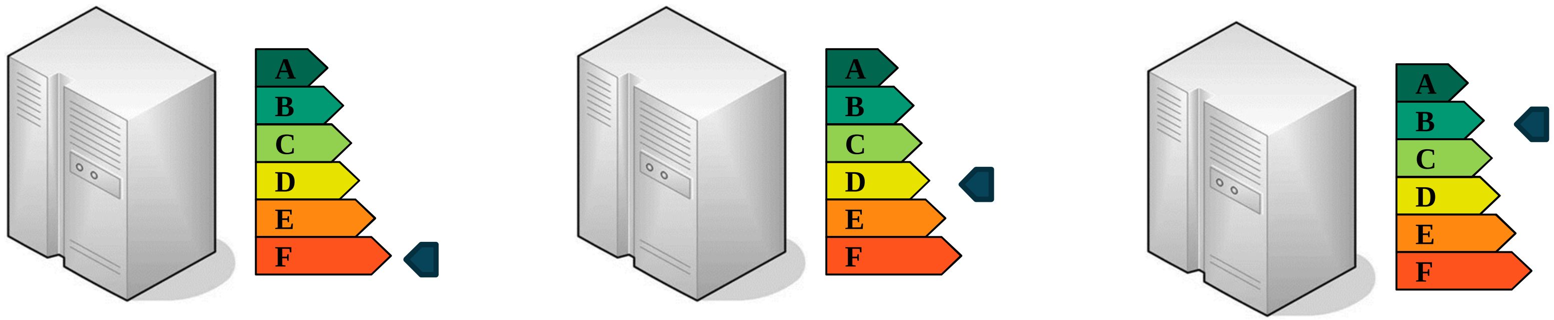
- Workstations / monitors:
  - Switch off / hibernate when unused
  - Standby mode when inactive

- Servers:
  - Based on current usage, usage record and planned / forecast usage switch active servers on, put ones ready to be used in stand-by and switch all the rest off.

Sample savings



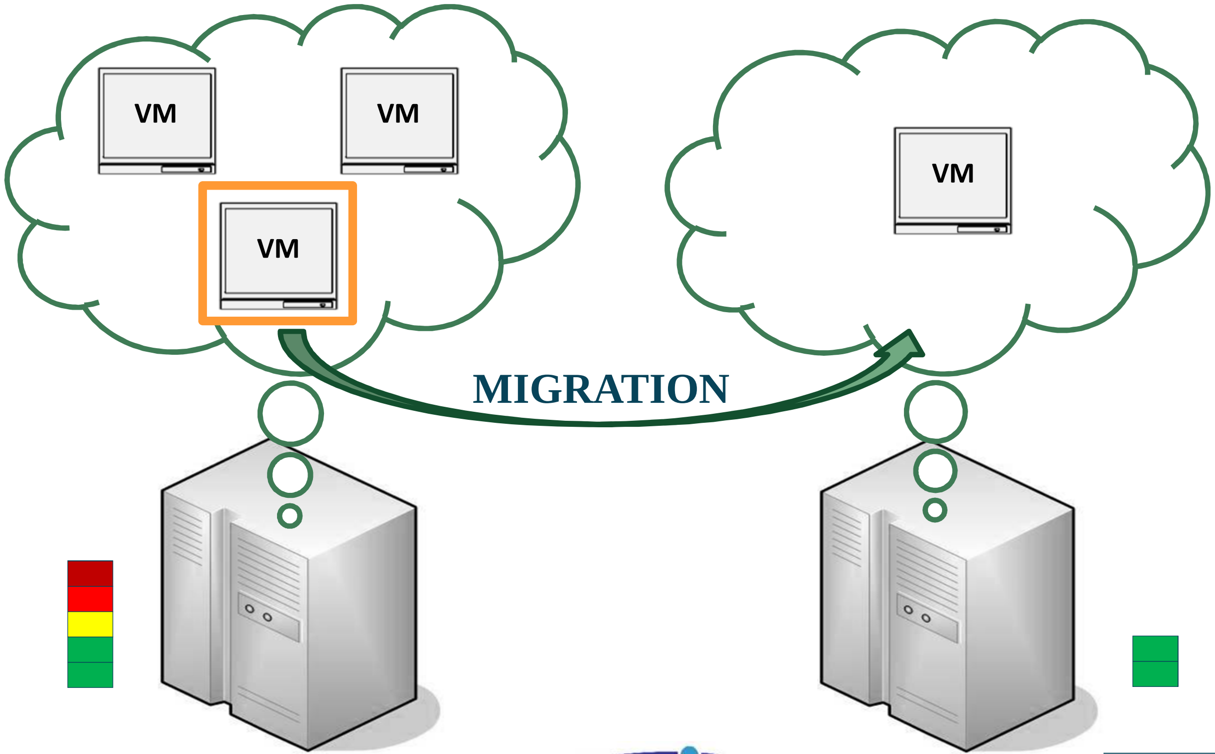
Which server to activate / deactivate first?



When deciding which sever to activate / deactivate first, use more energy efficient servers first. (Real energy efficiency examined by independent scientific institution.)

Optimize load distribution between servers

Optimize load distribution between servers based on current resource utilization, historical resource utilization and planned / forecast resource utilization taking into account the energy consumption aspects.



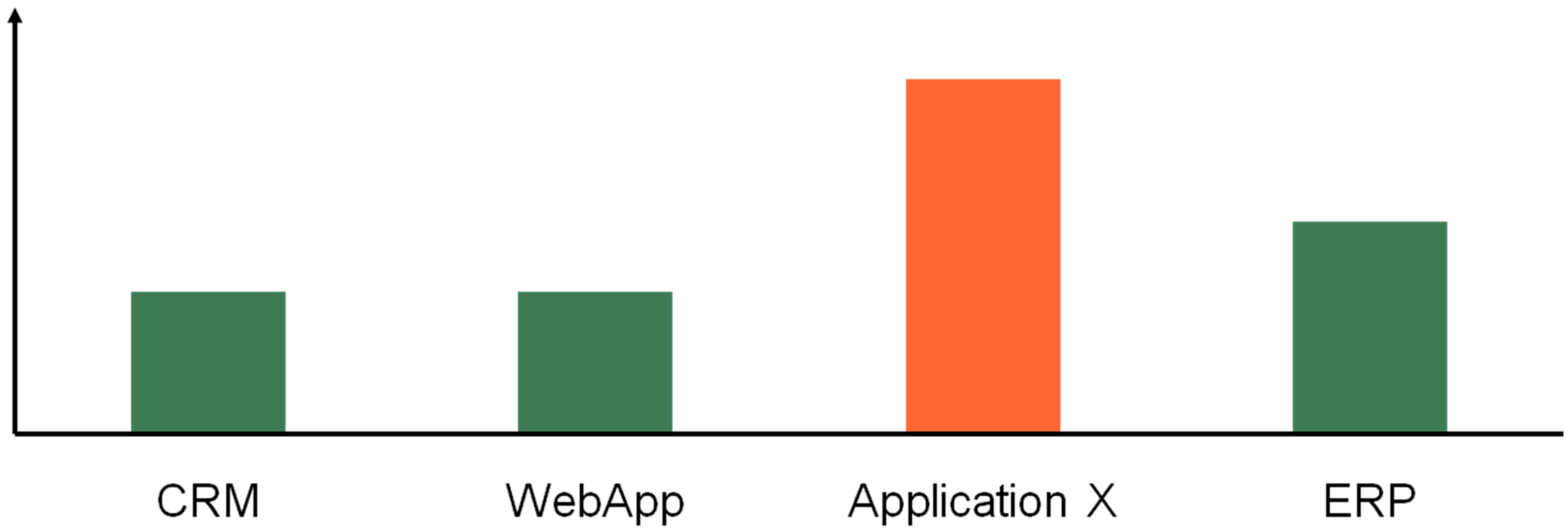
Computer replacement simulation

Replace least energy efficient computers if it pays off. Simulation needed to examine the impact on the overall energy consumption. Return on investment calculated based on:

- real energy efficiency examined by independent scientific institute,
- required capacity,
- usage record,
- planned usage.

Software

Monitor energy consumption on the software level, identify bottle necks and consider optimizing / replacing least efficient applications.



Network devices

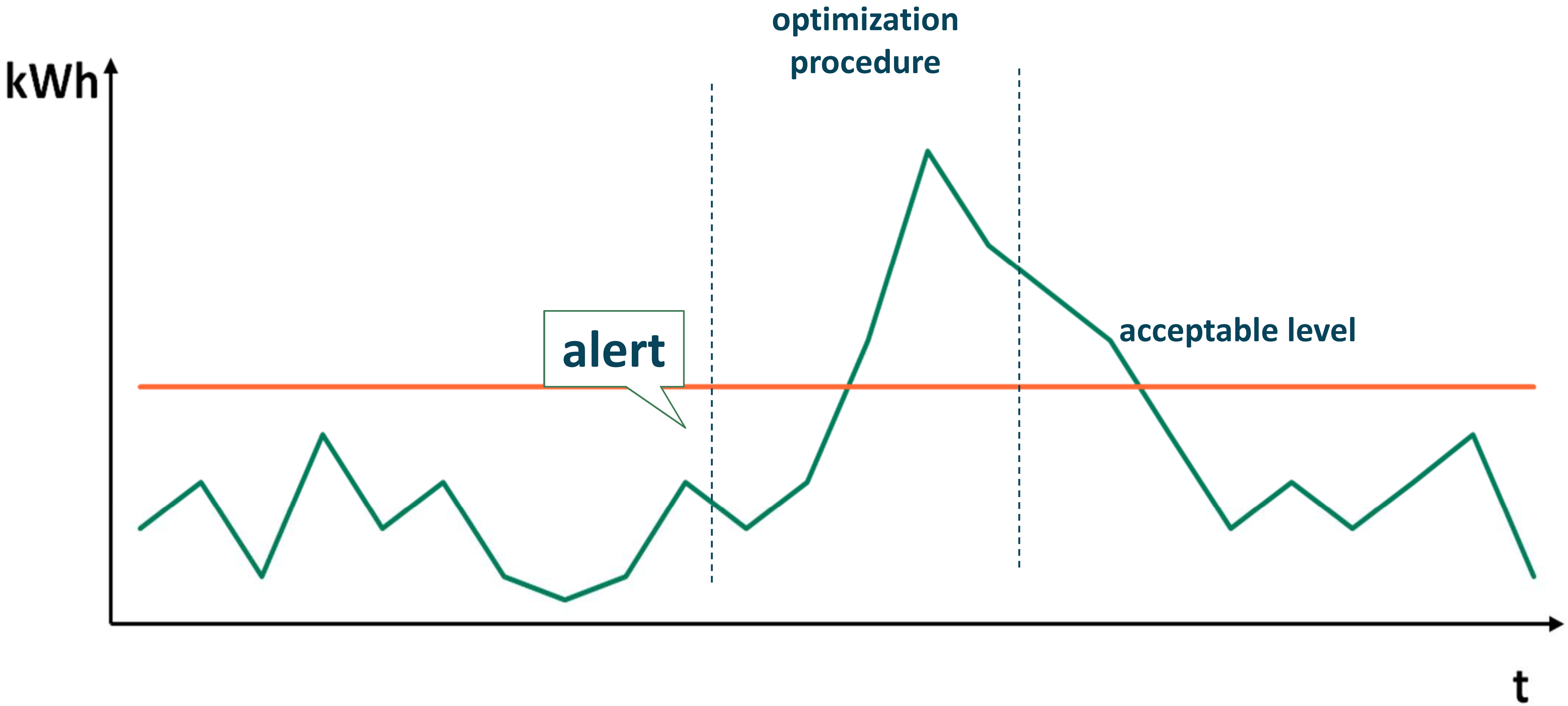
Monitor network devices utilization and the related energy consumption. Identify least efficient devices and consider eliminating them.

Location	Devices	Ports	Used ports	Used ports %	Unused ports	Unused ports %	Total power (kW)	Power per used port (W)
France	11	237	115	48	131	46	3.6	36
Germany	20	623	72	42	531	88	1.1	18.5

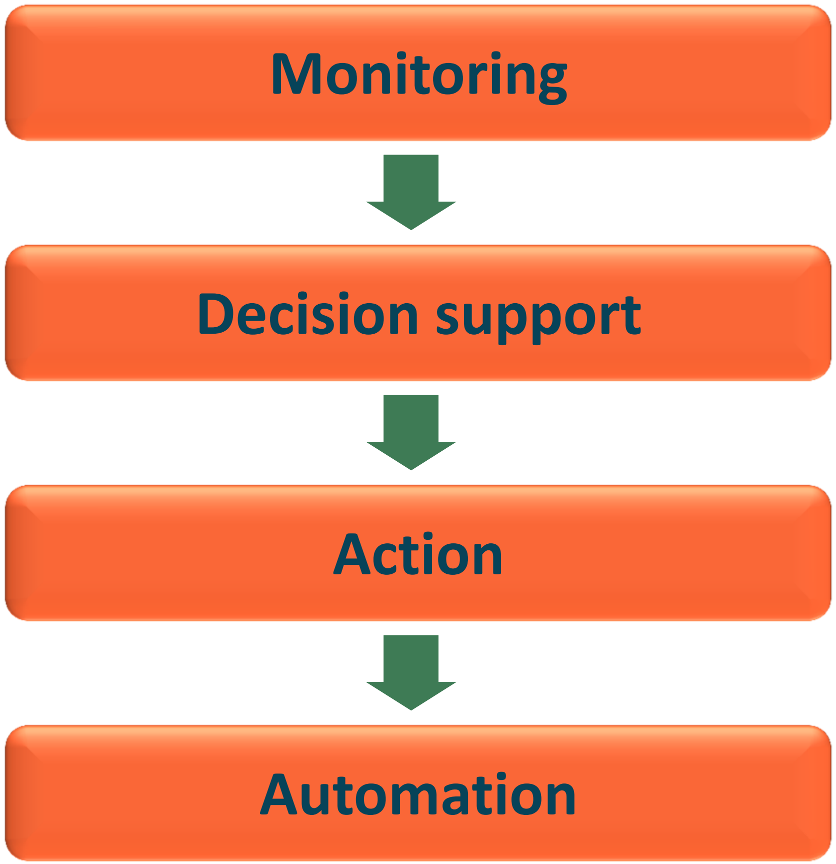
Device name	Description	Ports	Unused ports	Unused ports %	Device power (W)	Power per used port (W)
Berlin_Switch_1	ZKO-32	100	50	50.1	400	33.33
Hannover_Switch_3	SWW-123	6	0	0	120	20
…						

Abnormal energy consumption behaviour

Monitor current energy consumption, define rules for alarms in case of abnormal behavior.



Green Process

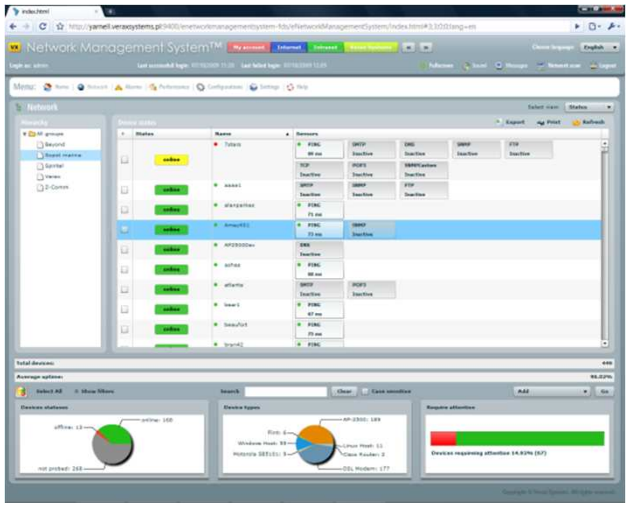


Challenge

- Whereas most of individual hardware elements provide some kinds of energy saving mechanisms, it is difficult to manage energy consumption on the service level.
- A holistic approach can lead to further, significant savings on consumed energy.
- An exemplary scenario can look as follows:
  - If the number of active sessions drops below a certain threshold, move one of the virtual machines from server X to server Y, as this will produce more energy-efficient load distribution.
- As can be seen from the example above, in order to execute even such a simple scenario, complex interaction between hardware, software and the network is required.

Solution

- A Network Management System seems to be the best place for implementation of service power management because:
  - It already provides sensor functionality: probes and performance counters.
  - Probe and performance counter data is typically persistent and contains aggregated historical data.
  - Commercial NMS systems also contain effectors, allowing configuration actions on network element management.
- In order to provide service power management, a typical NMS would have to be extended with a rules-based engine which would communicate with NMS core internals.



Energy consumption control

- Verax Green NMS monitor and control energy consumption of individual devices and allow for custom-defined energy management policies:
  - Remote hibernation for workstations.
  - Switch to standby mode or off for servers.
  - Use more energy efficient servers first.
  - Optimize load distribution between devices.
  - Replace least energy efficient computers and other devices.
  - Replace suboptimal software.
  - React to abnormal power consumption.

CASE STUDY OF TELEWORKING IN UNI-C, DENMARK

Background

- “SMART 2020” report of the Climate Group of the Global eSustainability Initiative (GeSI, 2008) claims:
- Enabled by wired or wireless networks teleworking may save 0,26 Gt CO2e/year out of 51,9 Gt in 2020
- Try to support this claim by a small pilot study at UNI-C Lyngby

Pilot Study Details

- 30+ employees at UNI-C's data centre in Kgs. Lyngby, Denmark
- All have employer-provided broadband connection at home
- Each employee kept a record of the number of days working at home in the period from 28. January 2010 to 28. February 2010 (5 weeks)
- Public Danish emission factors are used:
  - Car – 175 g CO2e / km
  - Bus – 90 g CO2e / passenger km
  - Regional train – 42 g CO2e / passenger km
  - S-tog – 16 g CO2e / passenger km
  - Metro – 16 g CO2e / passenger km

Results

Employee	Walk (km)	Bike (km)	Car (km)	Bus (km)	Regional train (km)	S-tog (km)	Metro (km)	Days at home	CO2-saving (kg)	Guess (kg)
PE	2	14		10	200	80			0,000	1084
FL			44					5	33,880	200
KMO			32					1	5,600	300
BV			20					8	28,000	
SWP			5					3	2,625	
ADU	2			6				1	0,540	1234
FH		5						4	0,000	
BSS			15					3	7,875	
JM		11			54	37		11	31,460	
AHG			30					1	5,250	
TF			63					2	22,050	150
SØN			50					1	8,750	320
TH								0	0,000	256
UHS								0	0,000	325
MIK				24				5	10,800	
MW			25					2	8,750	600
TQ								0	0,000	1100
HUB				28				4	10,080	1000
SOH					280			3	35,280	45000
NTH			50					5	43,750	
NIE			16			16		4	12,224	4200
EM			13					5	11,375	5000
JD			166					1	29,050	149
JKS			15	2		13		4	12,052	500
ØAA								0	0,000	400
FTH								0	0,000	120
Total								73	319	

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Discussion

- 319 kg in 5 weeks scales to about 3 tonnes per year for 30 employees
- Each Dane emits about 10 tonnes of CO_2e per year
- 3 tonnes is a 1% reduction of the 300 tonnes for 30 employees
- The SMART 2020 claim is ½% of the "business as usual" estimate of year 2020.
- Our study thus supports this claim
- An extra gain of this study has been to raise the GHG emission awareness of UNI-C's employees

CASE STUDY OF VIDEOCONFERENCING IN HEANET, IRELAND

Videoconferencing

- Major improvements in recent years:

  - HD standards, aspect ratios etc

  - MCUs, MOS standards

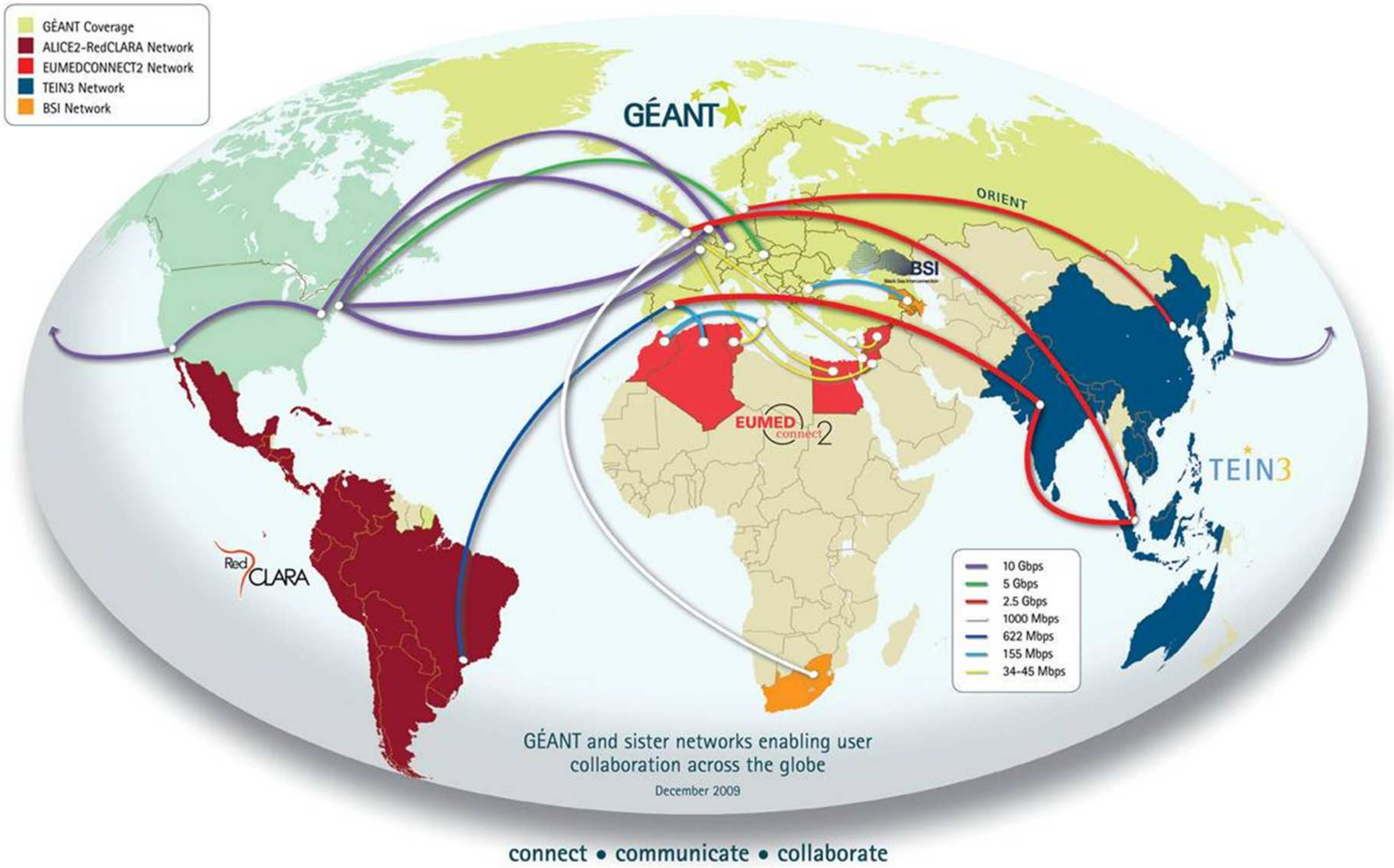
  - network capacity, dedicated R&E bandwidth

- Results are more applications and products at all levels:

  - Skype, SIP, telepresence

  - webcams, smart phones

GÉANT: dedicated R&E bandwidth



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HEAnet IRELAND'S NATIONAL EDUCATION & RESEARCH NETWORK

POZNAN SUPERCOMPUTING NETWORKING

HEAnet case study

- Use of videoconferencing by closed group
- NDLR Board, national e-learning project (now a service)
- Members from Higher Education institutions around the country
- Decision to use ICT at all levels
- Venue for Board meetings rotated between members
- Members attended by VC whenever possible

Matrix of distances (in km)

	Cork	Dublin	Galway	Limerick	Maynooth
Cork	-	215	166	93	206
Dublin	215	-	188	175	24
Galway	166	188	-	171	164
Limerick	93	175	71	-	158
Maynooth	206	24	164	159	-

Attendance at Board meetings (with induced and avoided travel)

Date	Venue	Members present	Members via VC	Distance travelled (km)	Distance not travelled (km)
7th Nov 2008	NUIG (G)	4xD, 2xG	4xD, 2xL, 1xC	1504	2120
9th Jan 2009	TCD (D)	6xD, 1xM	1xD, 1xC, 1xG, 1xL	48	1156
5th Feb 2009	UL (L)	4xD, 2xL, 1xC	2xD, 1xG, 1xM	1586	1158
2nd Apr 2009	TCD (D)	7xD, 1xC, 1xL, 1xM	1xD, 1xG, 1xL	828	726
18th Jun 2009	UCC (C)	1xC, 1xL	5xD, 1xG, 1xL, 1xM	186	3080
18th Sep 2009	NUIM (M)	3xD, 1xL, 1xM	1xD, 1xG, 1xC	460	788
Total distance (km)				**4612**	**9028**

GHG emissions induced by travel and avoided by VC

Transportation mode	GHG emissions (kg CO_2 equiv.) induced by travelling to Board meetings	GHG emissions (kg CO_2 equiv.) avoided by using videoconferencing equipment
Train	203	397
Car	784	1535

Outcomes

- Savings of 66% in direct emissions of GHG due to videoconferencing
- Absolute saving of between 0.4 and 1.5 tons of CO_2 equivalent in a year
- Savings still significant when indirect emissions (e.g. use of electricity) are included
- Global mitigation of 140 Megatons of GHG due to VC, telepresence (Smart 2020 estimate)
- Time dividend of ~2 working days per person

Thank You!