from Daniel Schien to Everyone: 5:57 AM
brb

from Daniel Schien to Everyone: 6:08 AM
that is a value-loaded question. it depends on political factors what we need
to know

from Dom Robinson to Everyone: 6:14 AM
:)

from Carsten Bormann to Everyone: 6:20 AM
What is the influence of the "internet"? What is the influence of what
people believe is the "internet"? What is the influence of the part that we
(IETF) actually can influence (more and less than the "internet")?

from Vesna Manojlovic to Everyone: 6:21 AM
Is this a question, or a suggestion? "If we can reduce the Internet's power
consumption by 10%..." per year? every year? I like that !
from Colin Perkins to Everyone: 6:21 AM
How many Norwegians are there? :)

from Eve Schooler to Everyone: 6:22 AM
Are there particular IETF standards you think we should scrutinize for these
savings?

from Dom Robinson to Everyone: 6:23 AM
I feel guilty of using the aviation comparison however i think we have ALL
been guessing for the past year or two. And i think the proprotionality of
the measures we are thinking about 'feel' relatively consistent in orders of
magnitude.

from Brendan Moran to Everyone: 6:23 AM
IMO, Absolutely! Encodings (which I'll talk about tomorrow) are a key target!

from Dom Robinson to Everyone: 6:24 AM
You only have to look at a large networks energy bill to know there is
consumption going on :)

from Bruce Nordman2 to Everyone: 6:24 AM
It would be better to refer to "E cons of network equipment' or "E cons of
Internet infrastructure' as "the Internet" could reasonably used to include
hosts which multiples the total by several times. Host energy use could be
influenced by IETF work

from Louise Krug to Everyone: 6:24 AM
you need to understand the interaction between network energy and the energy
needed to process the data - sometimes more data and less processing is
cheaper (in CO2 terms)

from Chris Adams to Everyone: 6:24 AM
hi folks. I'm so sorry for joining late, and and I hope this is a sensible
question. I can see recordings of these videos are being made. Would they be
sent a few weeks after these workshops, or earlier?

from Cindy Morgan to Everyone: 6:24 AM

Recordings will go up on YouTube within a day or so; I will send a link to the attendees list when they are all available

from Louise Krug to Everyone: 6:25 AM
communications could be order of magnitude more efficient

from Chris Adams to Everyone: 6:26 AM
cindy morgan: thank you!

from Louise Krug to Everyone: 6:26 AM
also the "wasted" energy – an email server wlil tend to power down when there is no emails to prcess whilst the network wont

from Chris Adams to Everyone: 6:26 AM
what operating system would the nics be running, if any?

from Chris Adams to Everyone: 6:27 AM
there are now a number of tools that can provide per process / thread level energy usage

from Romain to Everyone: 6:27 AM
usually something unix based afaik

from Rob Wilton to Everyone: 6:28 AM
@Chris do you mean the network card on a host, or what OSes are running on routers/switches?

from Louise Krug to Everyone: 6:29 AM
we understand breakdowns within the network – switches vs transmission, and within the switches – line cards vs route processeors etc

from Louise Krug to Everyone: 6:30 AM
how about standards that allow performance metrics to be evaluated so that a provider that sleeps portions of the network in idle time wont be penalised

from Chris Adams to Everyone: 6:32 AM
@rob wilton – the network card. there's some work that Mozilla has done to provide lots of visibility into power usage into linux machines, but I don't know about about networking hardware to form mental model for them

from Michael Welzl, University of Oslo to Everyone: 6:35 AM
@Vesna: Sorry, I didn't say that: these numbers are indeed per year – e.g., the UK contribution was 0.93% in the year 2021, and the number range I presented for "the Internet" is also yearly

from Rob Wilton to Everyone: 6:35 AM
I suspect that the network card (e.g. in a PC) isn't running any OS other that perhaps some bespoke microcode. For routers/switches then will run different things, but being unix/linux/bsd based is more likely. However, most of the power is going to be spent on the forwarding ASICs and optics.

from Vesna Manojlovic to Everyone: 6:37 AM
@Michael – my clarifying question was about "reduction of 10%" —- I hope you meant "10% reduction *per year* " , as a continual de-growth...

from Michael Welzl, University of Oslo to Everyone: 6:37 AM
Yes, i meant that as "per year" too, in line with the other numbers

from Louise Krug to Everyone: 6:37 AM
forwarding cards rather than optics (although the location of functions can

vary)

from Michael Welzl, University of Oslo to Everyone: 6:39 AM
ah, continual de-growth, yes, that would be ideal :)   I admittedly didn't
think about it in this way :)

from Bruce Nordman2 to Everyone: 6:39 AM
Back in '95 I estimated that a typical sheet of office paper requires the
equivalent of about 16 Wh of elec. to produce — but is many times more
expensive to buy than electricity

from Alex Clemm to Everyone: 6:40 AM
@Michael nice goal but may be hard to achieve if e.g. protocol improvements
may offer "one-time effects" (but of course rollout may be over time)

from Michael Welzl, University of Oslo to Everyone: 6:40 AM
@Alex: not if we never stop improving :-D

from Bruce Nordman2 to Everyone: 6:42 AM
Average vs. marginal emissions is a huge distinction. The router will be on
whether or not you watch a TV show. Improvements can be made in PHY and
router E, but those are distinct from what a user can do or induces directly

from Rob Wilton to Everyone: 6:43 AM
On this picture, the home router power usage doesn't look great ...

from Romain to Everyone: 6:44 AM
I was thinking the same...

from Louise Krug to Everyone: 6:44 AM
indeed — wifi is a big part of that, getting good coverage around a home.

from Louise Krug to Everyone: 6:44 AM
also problems with FTTP protocols and sleep modes

from Rob Wilton to Everyone: 6:45 AM
So, that looks like approx 20W.

from Louise Krug to Everyone: 6:45 AM
and getting the hubs cheap

from Vesna Manojlovic to Everyone: 6:45 AM
For some more views on "what do we know" : visualisation tool for impact of
various changes scenarious: https://en-roads.climateinteractive.org/

from Louise Krug to Everyone: 6:45 AM
I would have guess 12W — but I think there may be a mixture of device types —
and 12W might be the average over a day — so higher in use

from Rob Wilton to Everyone: 6:46 AM
Looking at the latest public Cisco datasheets on the core routers, then they
are quoting 12.8Tb/s @288W typical system power.

from Chris Adams to Everyone: 6:47 AM
given that carbon intensity varies (either marginal or avg) if you have a.
steady 20W, how much more expensive would a 80USD router be to have say… 4hrs
of onboard power it can timeshift from cleaner times?

from Dom Robinson to Everyone: 6:50 AM
Yes. This.

from Louise Krug to Everyone: 6:50 AM
strictly — the traffic growth happened in the off peak times

from Louise Krug to Everyone: 6:50 AM
but yes wastage is obvious!

from Chris Adams to Everyone: 6:53 AM
Firefox has some nice stats that can show the power usage attributable to the
app itself now on a video call. You could use this to get a better idea
inside the browser of power usage for prsenting the video at least. https://
www.green-coding.org/blog/firefox-104-energy-measurements/

from Eric Voit to Everyone: 6:54 AM
Looking at total kWh over extended periods only indirectly matches to why the
capacity was installed in the first place. Network operators design capacity
to meet Service Levels during peak load. This is why the designers of old
phone networks used Erlang B calculators to install capacity for the busiest
hours of network calling during the year, such as Mother's Day.

from Alex Clemm to Everyone: 6:56 AM
This diagram shows the appeal of "peak shaving" if that can be used to defer
upgrades

from Chris Adams to Everyone: 6:59 AM
folks this is super interesting — thanks for this. I'll need to go but I'll
participate on the mailing list. Thanks!

from Carsten Bormann to Everyone: 7:00 AM
We do more than core networks.

from Suresh Krishnan to Everyone: 7:00 AM
Good point Rob.

from Louise Krug to Everyone: 7:01 AM
access networks tend to use more power than core

from Louise Krug to Everyone: 7:01 AM
access network protocols also impact the energy use of the home routers

from Cedric Westphal to Everyone: 7:02 AM
does the capacity graph shows that the consumption
is power proportional? at least If we look from
afar

from Dom Robinson to Everyone: 7:05 AM
thanks Dan — good stuff

from Daniel Schien to Everyone: 7:05 AM
thanks.

from Brendan Moran to Everyone: 7:16 AM
Sorry, I have to drop off now.

from Louise Krug to Everyone: 7:19 AM
depending on the rate of growth in traffic and the rate of efficiency
improvement network energy can go up or down over time

from Dom Robinson to Everyone: 7:19 AM
really interesting

from Louise Krug to Everyone: 7:20 AM
but most energy savings today are coming (at least in UK) from simplish
optimisations and reduction of legacy — such as removal of telephony networks

from Daniel Schien to Everyone: 7:20 AM
staying still is not good enough

from Dom Robinson to Everyone: 7:22 AM
it WILL cost the CDNs more energy to deliver all that content.

from Wim Vanderbauwhede to Everyone: 7:23 AM
According to ITRS, CMOS scaling will stop in 2027. That was the primary
driver for power efficiency gains. We can't assume efficiency savings will be
free anymore.

from Wim Vanderbauwhede to Everyone: 7:24 AM
We will only deliver efficiency savings by actively pursuing them
from Romain to Everyone: 7:24 AM
I appreciate the data collection efforts a lot, that's very insightful. But I
can not agree with saying that "how much data you use does not matter"

from Louise Krug to Everyone: 7:24 AM
the primary drivers arent in CMOS scaling for networks — its slowed already
and the improvements are in the chip architecure

from Wim Vanderbauwhede to Everyone: 7:24 AM
According to IEA, by 2040, renewables will only be 70% and worse, this growth
will not reduce GHG emissions much

from Vesna Manojlovic to Everyone: 7:25 AM
@Jens, this sounds like a very scary statement... I hope that we can work
together to make a shared conclusion that I could agree with.

from Wim Vanderbauwhede to Everyone: 7:25 AM
Bloomberg New Energy Fund estimates it at only 50% of renewables by 2040

from Romain to Everyone: 7:25 AM
same here

from Wim Vanderbauwhede to Everyone: 7:25 AM
So please don't count on renewables to meet 1.5ºC

from Louise Krug to Everyone: 7:26 AM
no renewables will help but not quick enough agreed

from Louise Krug to Everyone: 7:28 AM
but the core network behind will be consuming more than that because of the
capacity

from Eve Schooler to Everyone: 7:28 AM
I would like to understand better WHY the graphs show that the numbers have
remained the same

from Eve Schooler to Everyone: 7:29 AM
what factors contribute to that? energy efficiency, removal of old equipment,
etc

from Alex Clemm to Everyone: 7:30 AM
+1 to Eve's question

from Wim Vanderbauwhede to Everyone: 7:30 AM
@Eve @Louise I would also like to know that, in particular how much of this
is due to overprovisioning a while back

from Fieke to Everyone: 7:30 AM
+1 to the worries on "the amount of data doesn't matter", cause we can not
see energy consumption in isolation. We have to think about the environmental
impact of internet infrastructure more holistically. There is a reason why
the slogan reduce, resuse, recycle starts with reduce. It a.o. is about
dependencies on raw materials energy, water, and its about waste. In
addition, renewable also rely on raw materials. + see the discussion of day 1
on green energy

from Louise Krug to Everyone: 7:30 AM
Basically for the first 50 years of telecoms, energy didnt matter.

from Louise Krug to Everyone: 7:31 AM
We are taking out equipment that was installed in the 80s at present

from Louise Krug to Everyone: 7:31 AM
if it look at the energy use of our "strategic" systems — thats growing
strongly driven by traffic

from Eve Schooler to Everyone: 7:32 AM
@Dom that is a great additional point that CDNs is yet another reason why the
numbers may be static. It also underscores the original question: what is
included in the definition of the Internet (and therefore these studies)?

from Louise Krug to Everyone: 7:32 AM
I am worried about the core!

from Wim Vanderbauwhede to Everyone: 7:32 AM
@Fieke++ more data means higher storage needs, and the embodied carbon of
that is very large

from Maya Richman to Everyone: 7:35 AM
and higher storage needs means more data centers, displacement and resource
use beyond energy

from Wim Vanderbauwhede to Everyone: 7:35 AM
@Maya++

from Louise Krug to Everyone: 7:35 AM
FTTP network — high bandwidth users — core network cost is greater than the
access network part

from Pernilla Bergmark Ericsson to Everyone: 7:35 AM
@Eve — Jens resutls refers to "ICT" not to "internet" (although they are of
course overlpapping. ITU—T L.1450 is specifiying the system boundaries for
"ICT"

from Suresh Krishnan to Everyone: 7:36 AM
@Jens: Moore's law advances account of most of the improvements. I think in
the future such "easy" improvements might be harder to come by

from Wim Vanderbauwhede to Everyone: 7:37 AM
There is a fundamental physical limit, Landauer's limit, on the efficiency of
non—reversible computations (i.e. all of our electronics). With the current
trend we will hit this by 2040

from Daniel Schien to Everyone: 7:38 AM
Good read on Landauer's limit: Paul Sen. Einstein's Fridge: The Science of
Fire, Ice and the Universe

from Pernilla Bergmark Ericsson to Everyone: 7:38 AM
@Louise — I don´t think that could be stated as a general situations (FTTP
network cost more) — would vary with the setup of networks and differ
between operators

from Maya Richman to Everyone: 7:38 AM
just because some things are smaller and more efficient doesn't mean we don't
need to

from Maya Richman to Everyone: 7:38 AM
change the systems

from Ali Rezaki to Everyone: 7:39 AM
@Pernilla: What is the demarcation/differentiation between ICTs and the
Internet?

from Louise Krug to Everyone: 7:40 AM
the cost (energy) of a core network depends on how much bandwidth is
provisioned which depends on service agreements/ expectataions of network
performace at peak times

from Louise Krug to Everyone: 7:40 AM
so yes that will vary by operator etc

from Pernilla Bergmark Ericsson to Everyone: 7:41 AM
@Suresh — in my understanding we are far from being at the level where system
improvements benefit fully from Moore´s law. At a system level where are
still many parameters that have not yet been optimized and would make great
difference. ITU—T L.1470 or L.1450 discusses the different parameters that
impacts which are not connected to any decline of Moore´s law

from Fieke to Everyone: 7:41 AM
Just like the first speaker argued we need to be careful about not making
comparisons between sending emails and flights I think we need to be careful
in making comparisons between internet is better than aviation industry,
cause it is not an either or, it is an and and. People are flying and using
the internet. Limits and reductions need to happen across the board, I think
the question for each industry is how to best approach this, and not how to
be less bad than the others.

from Louise Krug to Everyone: 7:42 AM
the second issue is around resilience — how do we provide resilience and
basic service levels (999 calls) in face of various challenges — service
disruption from electricity supply issues etc without necessrily keeping the
whole system powreed

from Louise Krug to Everyone: 7:43 AM
ie how does the internet work with the electricty grid both under normal
future conditions with lots of unreliable green electcity) and under stress
conditions severe storm caused by climate change)

from Vesna Manojlovic to Everyone: 7:43 AM
About the concerns for the increase in use of land/materials/rare metals :
here's a book that deals with it: ""The Rare Metals War: The Dark Side of
Clean Energy and Digital Technologies", book by Guillaume Pitron https://

www.nhbs.com/the-rare-metals-war-book "

from Dom Robinson to Everyone: 7:45 AM
Good point Suresh — one of our members has a great test setup that can
evaluate which audio and video streaming codec option is most energy
efficient on a browser by browser and OS by OS basis... more needs to be done
in wider spaces.

from Pernilla Bergmark Ericsson to Everyone: 7:45 AM
@Ali — since "ICT" is defined from an assessment perspective and "internet"
is not I cannot answer — I think that is something that needs to be
standardized as different people would use different system boundaries for
internet (also for ICT but there you could at least review boundaries based
on the standard)

from Wim Vanderbauwhede to Everyone: 7:46 AM
Sorry, I have to go. This session was super interesting, thanks everyone!

from Vesna Manojlovic to Everyone: 7:48 AM
And then there is a usage of water...

from Romain to Everyone: 7:48 AM
@jens: I don't think it is responsible to say "it's fine, just use more data"
from Dom Robinson to Everyone: 7:49 AM
DSP decoding will typically take a couple of watts. Decoding in software can
add 40W, and if you have a smart tv that does HD at 85 watts it can jump to
135W if you add HDR — potenitally addint 10s of £$ to monthly bills.

from Vesna Manojlovic to Everyone: 7:51 AM
I think we need to think about systems, rather than personal usage. (when I
head "if i personally watch youtube, the energy measured does not increase")
=> @Pernilla ++++1 it's about our responsibility to the "sector" of Internet.

from Vesna Manojlovic to Everyone: 7:51 AM
Sorry for all the mis-spelling...

from Louise Krug to Everyone: 7:51 AM
I think there is short term — whilst the grid decarbinises

from Jens Malmodin to Everyone: 7:51 AM
Of course we should keep improving things.

from Fieke to Everyone: 7:51 AM
@Pernilla I agree comparisons are good for people's understanding of the
different impacts, but these arguments are often used to slow down or ignore
the responsibility of looking at the core of the industry itself

from Louise Krug to Everyone: 7:51 AM
on going — embodied

from Ali Rezaki to Everyone: 7:51 AM
@Pernilla: Thanks! Indeed, given this difficulty with definitions, I wouldn't
feel comfortable to say that "all has been going well, we can continue as
before". Let's put up good definitions and standardize measurements. I know
this has been within the focus in ITU-T SG5 as well.

from Daniel Schien to Everyone: 7:51 AM
+Louise — embodie!!

from Vesna Manojlovic to Everyone: 7:52 AM

We are missing *water usage* !

from Louise Krug to Everyone: 7:52   AM
and longer term when the grid is green what does that mean if energy supply
is less reliable / could be more expensive (on the basis that it needs to be
heavily over provisioened to give the kind of on demand response that we are
used to

from Suresh Krishnan to Everyone: 7:53   AM
+1 Marisol

from Jari Arkko to Everyone: 7:54   AM
Vesna — yes too much focus on used energy only. Agree that embedded energy,
raw materials, water, etc. is important.

from Fieke to Everyone: 7:55   AM
+1 to Jari and Vesna

from Michael Welzl to Everyone: 7:56   AM
reducing embodied energy = increasing lifetime = using SDN and NFV?

from Pernilla Bergmark Ericsson to Everyone: 7:56   AM
@Fieke — maybe it still is in some parts of the industry — for me that kind
of reasonsing is oldfashoined and was popular around 2015. I think these
days people would be more mindful with such as SBTi, Race to Zero making it
hard to use the individual perspective as an excuse to do your part

from Pernilla Bergmark Ericsson to Everyone: 7:57   AM
@Jari, Vesna, Fieke — I agree. ANd as COP15 just started remember also
biodiversity (we have started to look at that both as Ericsson Research and
in ITU)

from Alex Clemm to Everyone: 7:57   AM
To state the obvious (to not lose sightof): it can't be only about
decarbonization — easy, just switch everything off — it also has to be while
providing the benefits.

from Vesna Manojlovic to Everyone: 7:58   AM
@Pernilla — thanks for brining up biodiversity!