

TNO innovation
for life

NGON & DCI
World

GREENER OPTICAL NETWORKS



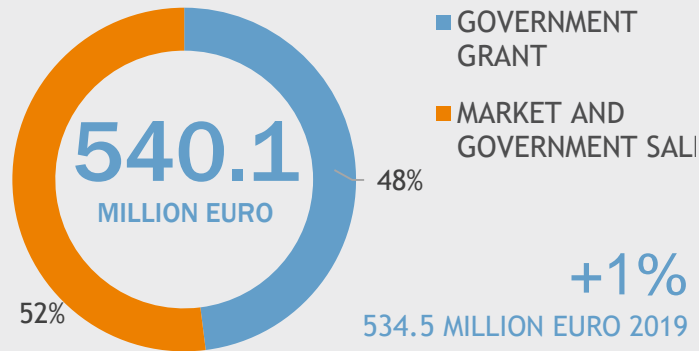
NGON & DCI WORLD

21 JUNE 2022

SANDESH MANGANAHALLI JAYAPRAKASH | SCIENTIST | TNO ICT

Photo
by fiercewireless.com

REVENUE ORGANISATION TNO
(INCL. GOVERNMENT GRANT)



NUMBER OF EMPLOYEES

3,562
TOTAL



3,431 2019

<p>HEALTHY LIVING</p> <p>'Promoting healthy working and living'</p>	<p>TRAFFIC & TRANSPORT</p> <p>'Making livable and sustainable cities a reality'</p>	<p>INFORMATION & COMMUNICATION TECHNOLOGY</p> <p>'Charting and accelerating the digital transformation'</p>
<p>ARTIFICIAL INTELLIGENCE</p> <p>'AI Technology and Applications'</p>	<p>DEFENCE, SAFETY & SECURITY</p> <p>'We're putting our knowledge and technology to work for safety and security'</p>	<p>ENERGY TRANSITION</p> <p>'Accelerating the Energy Transition'</p>
<p>INDUSTRY</p> <p>'Innovating for employment, prosperity and well-being'</p>	<p>BUILDINGS, INFRASTRUCTURE & MARITIME</p> <p>'Robust constructions, sustainable use'</p>	<p>CIRCULAR ECONOMY & ENVIRONMENT</p> <p>'Directing and accelerating sustainability'</p>
<p>STRATEGIC ANALYSIS & POLICY</p> <p>'Turning complex issues into sustainable innovations'</p>		

› TNO is an independent research organisation in The Netherlands that focuses on applied science

INTRODUCTION TO TNO ICT

Home > [About TNO](#) > [News](#) > TNO launches f...

NEWS

TNO LAUNCHES FULLY FLEDGED 5G TEST NETWORK

29 JUN 2020

Happy to share that TNO's 5G lab facilities (with a popular name Hi5) have been extended with a multi-vendor Open RAN base station (i.e. Accelleran's dRAX + 3rd party DU + 3rd Party RU).

[#5gnetworks](#) [#5g](#) [#oran](#) [#5gtechnology](#)



WHY GREEN NETWORKS ARE IMPORTANT

HOW MUCH ENERGY DOES A NETWORK CONSUME?



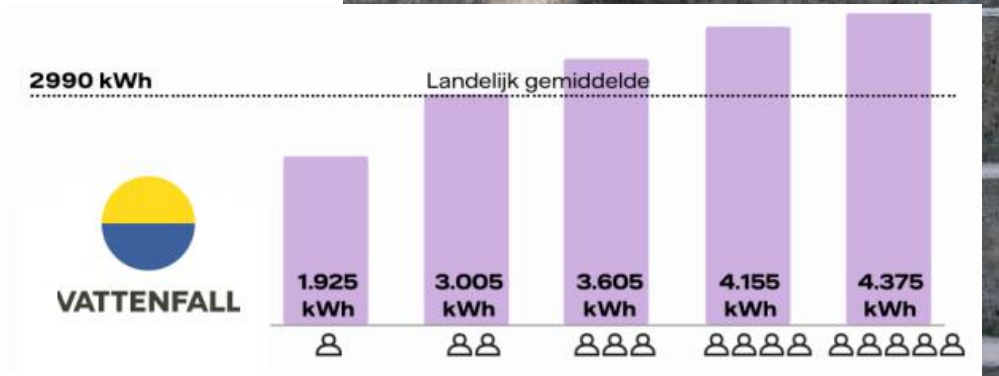
NS used 1,346 GWh in 2019



KPN Networks used 580 GWh in 2019



VDF Ziggo Networks used 295 GWh in 2019



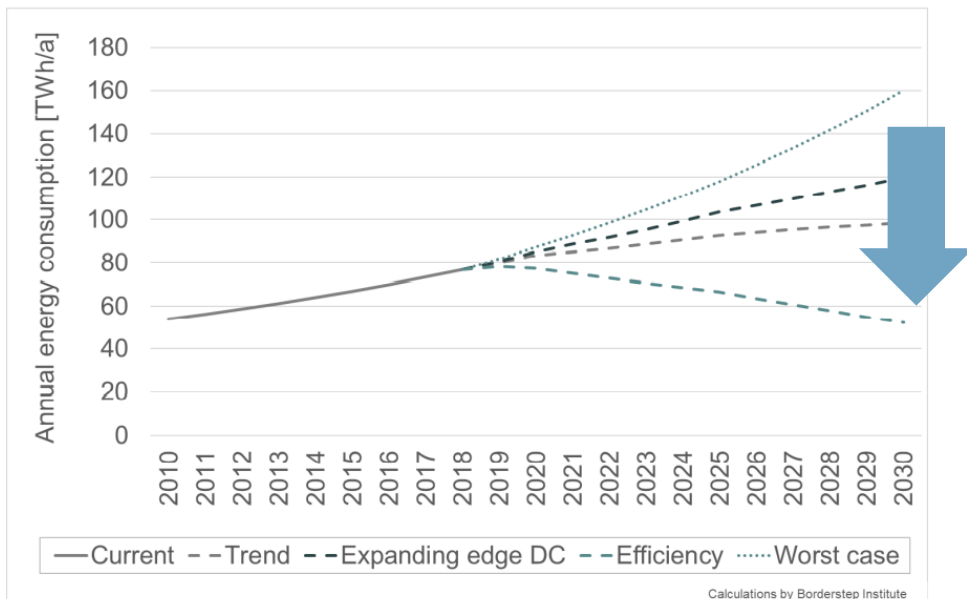
~290.000 Dutch houses use in a year

≈

Equivalent to 5th largest Dutch city between Utrecht and Eindhoven

GREEN CLOUD: ENERGY-EFFICIENT CLOUD COMPUTING NEEDS GREEN NETWORK

- › Growth of cloud computing, and trend towards edge computing
- › Cloud computing = data centers + (access) networks to reach ‘cloud’
 - › Energy consumption of (access) networks is almost 50% of cloud computing
 - › Edge data centers share to increase: 2% in 2018 to 12% in 2030



- Energy efficiency is necessary!
- New technologies with improved kWh/GB

› FIBRE NETWORKS ARE ENERGY EFFICIENT



Fibre is the most energy efficient broadband technology



* [Fibre is the most energy efficient broadband technology | Shaping Europe's digital future \(europa.eu\)](#)

› LOT TO GAIN WITH FIBRE NETWORKS

Green ICT: Optical transport networks are crucial to enable green ICT –
But in itself is not sufficient.



In two ways:



**1 New applications indirectly
saving energy**

**2 Saving energy in optical
networks**

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Use case #1

› SOCIAL XR BREAKS THE BARRIERS OF DISTANCE VIRTUAL PRESENCE USING XR

VIRTUAL PRESENCE with Social XR

work, learn, and interact while remaining physically distant; enable contact when physical distancing

XR MEETINGS



XR VISITS



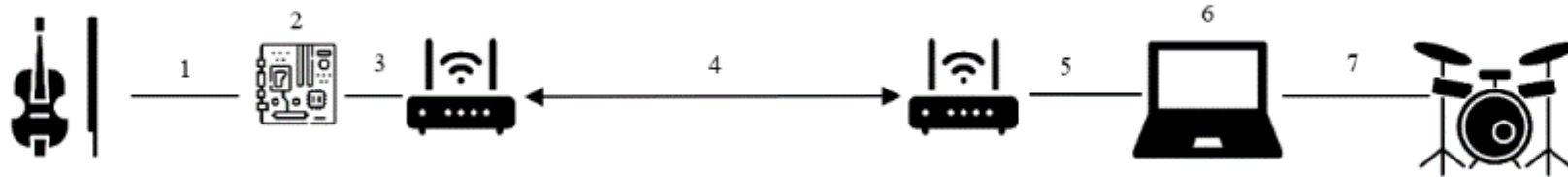
REMOTE EXPERTISE



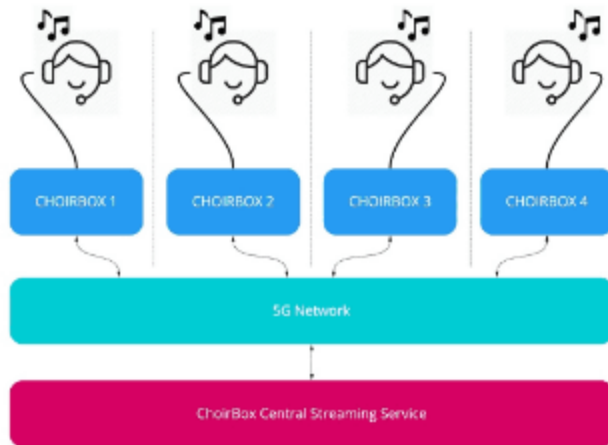
See also www.tno.nl/en/smart-society/

Use case #2

VIRTUAL MUSIC REQUIRES < 30 MS END-TO-END LATENCY



E2E chain for virtual music



IMEC/VRT research on choir box via 5G



Ensemble bouwt zelf aan superstream voor livemuziek

Livestream Samen musiceren vanaf verschillende locaties, via Zoom gaat dat niet. Ensemble insomnio bouwt daarom zelf aan een supernetwerk.

Rehul Gandelshage 4 mei 2021 Leestijd 3 minuten



Dutch national newspaper NRC
("Music ensemble develops superstream for live music")



Switzerland Connected

BLAY, Flavie Léa and Swisscom team up for Switzerland's first decentralised live music experiment

Swisscom

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WHERE TO START: AT THE CPE

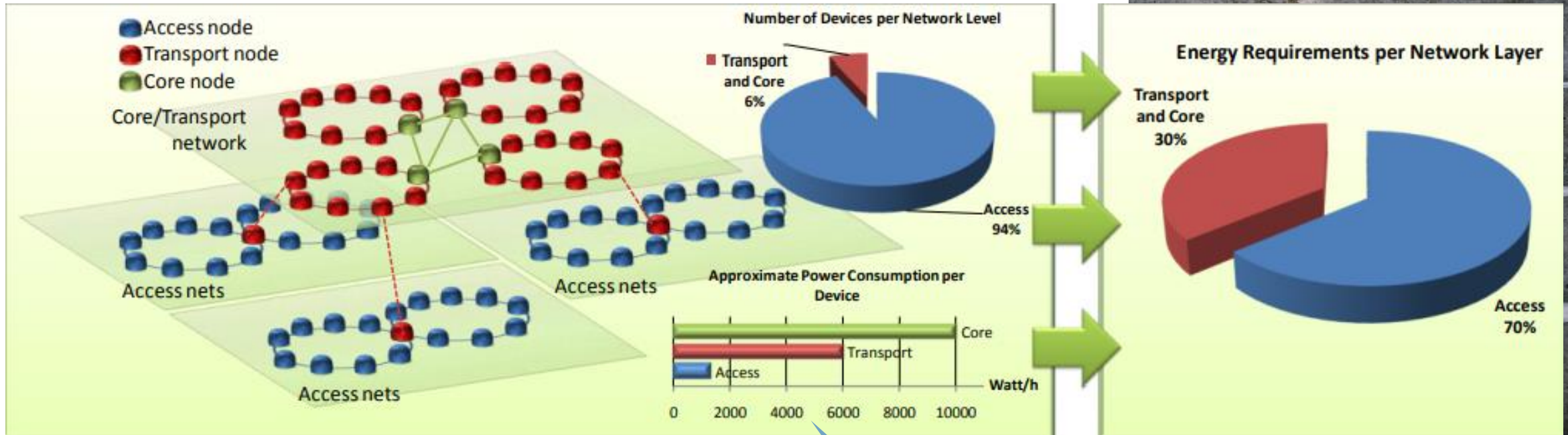
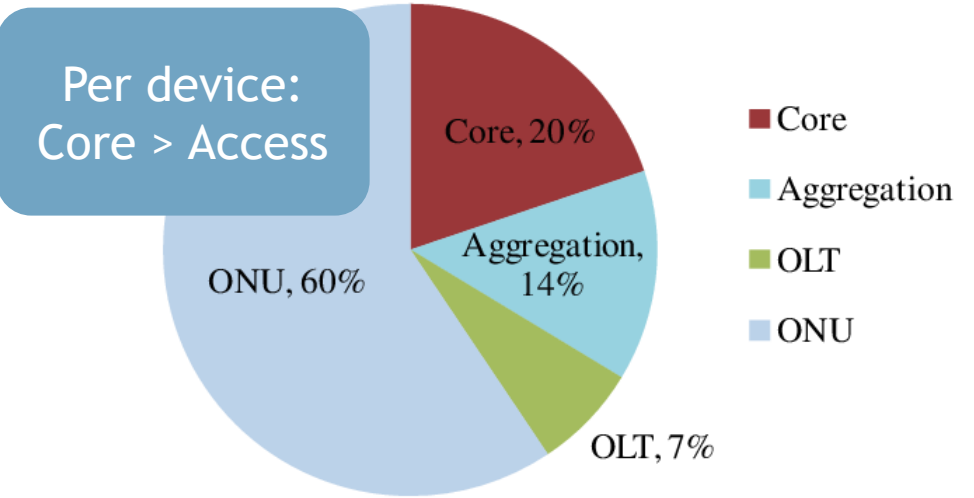


Image from: Bolla, Raffaele, et al. "Energy efficiency in the future internet: a survey of existing approaches and trends in energy-aware fixed network infrastructures." IEEE Communications Surveys & Tutorials 13.2 (2010): 223-244.



› WHERE TO START: AT THE CPE

	VDSL2-Vectoring	HFC	FTTH – PtP	FTTH – GPON
Active network elements in the access network	538 street cabinets + 6 central offices	794 fibre nodes + 12 CMTS	36 PoPs	36 PoPs
Power consumption access network [kW]	142	114	64	19
Power consumption CPE [kW]	253	335	341	341
Total power consumption [kW]	396	469	406	360
Total energy consumption [MWh/year]	3,465	4,987	3,557	3,156

1: VDSL is higher than PON

3. CPE uses bulk of the energy!

2: Total usage by PON is close to VDSL

Figure 30: Comparison of the number of active network elements and the power consumption of the examined access technologies.

Source: Prysmian group energy consumption of telecommunication access networks
<https://www.prysmiangroup.com/staticres/energy-consumption-whitepaper/index.html>

› WHERE TO START: OTHER OPPORTUNITIES

SNEAK PREVIEW OF ETSI F5G WHITE PAPER

Key Technologies

- Energy aware switching/routing
- Application specific energy reduction
- Self healing network
- Power saving algorithms in the access network



See ETSI F5G resources on [ETSI - Our group Fifth Generation Fixed Network \(F5G\)](#)



KEY MESSAGE: ADVANCE EXISTING LITERATURE

How to Save Energy in Passive Optical Networks

L. Valcarenghi, *Member, IEEE*, D. Pham Van, P. Castoldi, *Member, IEEE*

Energy Aware Routing and Aggregation in Multilayer Optical Networks

Artur Lason, Jacek Rzasa, Andrzej Szymanski and Andrzej Jajszczyk

Energy-Aware Algorithms for IP Over WDM Optical Networks

Georgia A. Beletsioti, Georgios I. Papadimitriou, *Senior Member, IEEE*,
and Petros Nicopolitidis, *Senior Member, IEEE*

ENERGY EFFICIENT APPROACHES IN PASSIVE OPTICAL NETWORK: A REVIEW

**Nurazmina Lingas¹, M. Rakib Uddin¹, Shah Newaz², and Hasnul Hashim¹*

› MAKING FIBRE GREEN

NEXT GENERATIONS SHOULD BE GREEN

Innovation in fibre networks should be “green”

- We need to reduce CO2 emissions everywhere
- The ICT and telco sector is well aware of this
- A lot to gain in Optical networks

The next generation of fibre networks can have a positive impact in various ways:

- The networks themselves consume less energy
- The energy they consume is renewable
- And: they support novel use cases reducing energy consumption in various verticals

You can support this development:

- Prove and show what is possible in research and development
- Contribute to industry standardisation such as F5G with a green ambition

Let's put some energy in making fibre green

› **THANK YOU
FOR YOUR TIME**

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Scientist

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TNO innovation
for life

› INTRODUCTION TO TNO ICT

- › ICT key areas for broadband networks
 - › Fast and open infrastructures
 - › Data sharing
 - › Trusted ICT
- › Track record
 - › Open 5G standalone testbed already in 2020
 - › Open RAN testbed
 - › Longer ago: xDSL and G.fast innovations
- › TNO and SDOs in the context of broadband networks
 - › Developing use cases and requirements
 - › Building Proof-of-concepts and trials
 - › Exchange with standardisation organisations

