

**UiO** : **Department of Technology Systems**  
University of Oslo

**VGS - Elektromøte 28Mar2022, Hønefoss**

# **5G og IoT**

## **Teknologi som driver vår samfunnet**

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# Outline

*“The last time I was connected by wire was at birth”*

- “Det er gøy å forstå”
  - min vei
- Kjeller og Norden
  - Internett
  - Tingenes Internett
  - (Cyber-, IoT-)sikkerhet,
  - Samfunnssikkerhet og våre globale utfordringer
- Bærekraftig innovasjon
  - digital inkludering
  - Return on SDGs (RoSDGs)
- “våre utfordringer” - oppsummert



**Internet of Things (IoT)**

**5G (6G)**

**Energi og Elektro**

**Bærekraftsmålene**

# Internet of Things (IoT)

5G (6G)

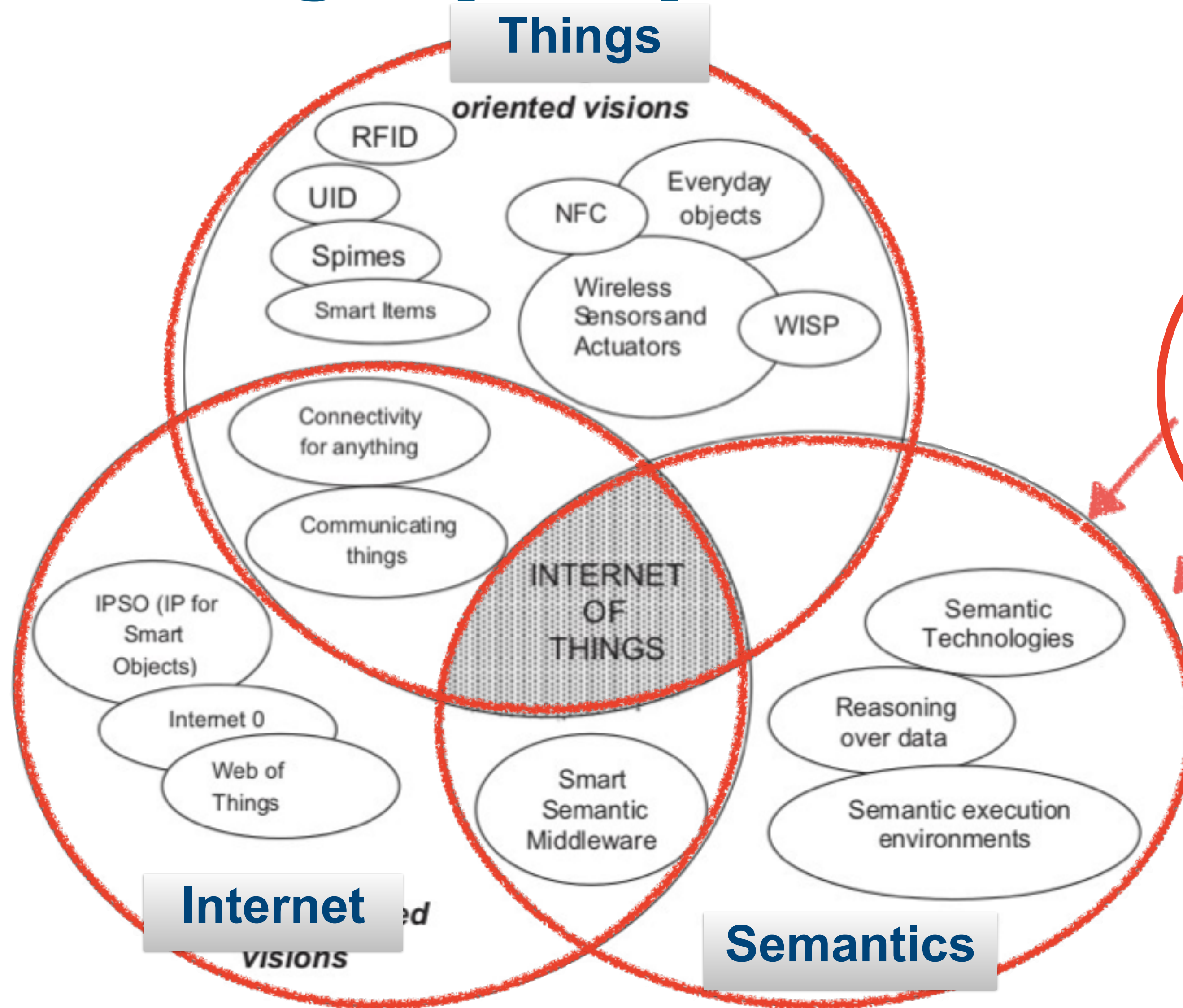
Energi og Elektro

Bærekraftsmålene



# The Internet of Things (IoT)

Things



Internet

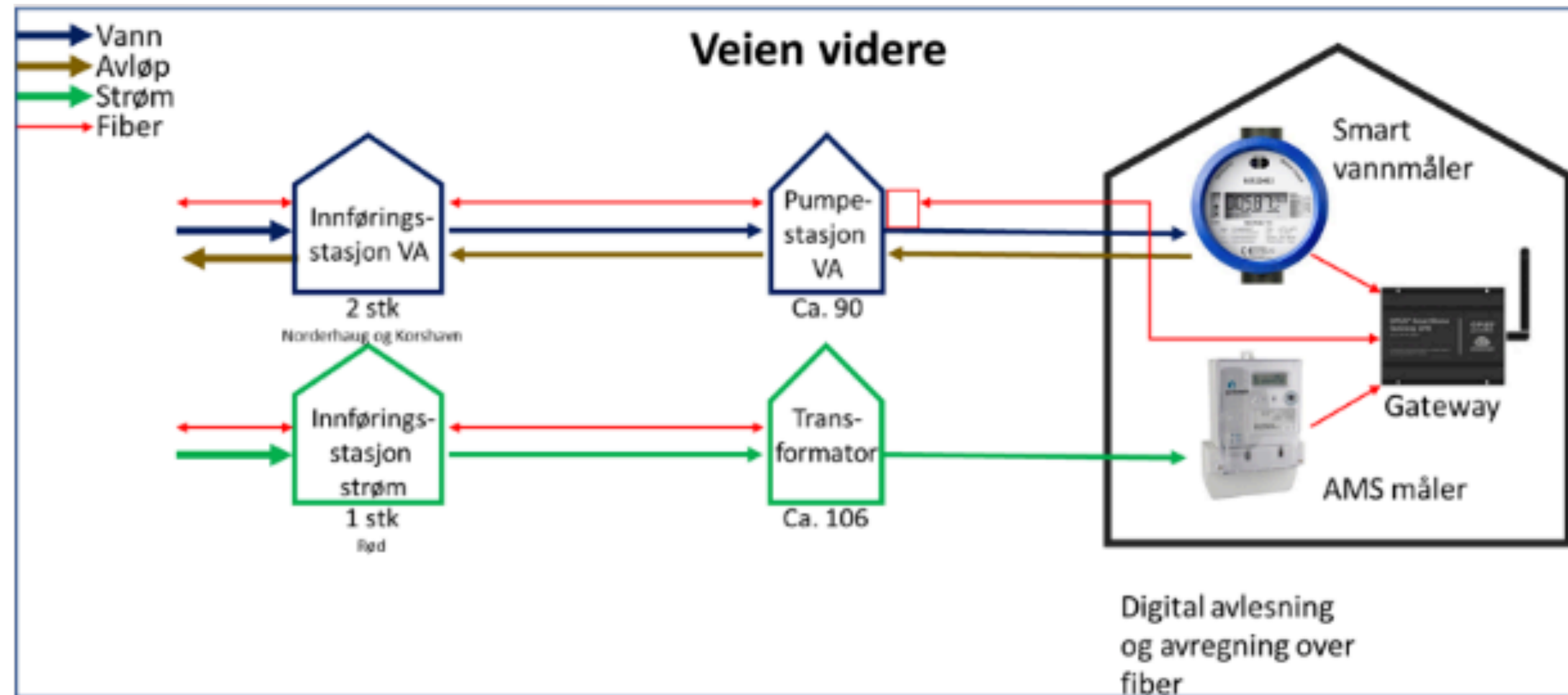
Semantics

- \* security
- \* privacy
- \* dependability
- \* context-aware
- \* personalised

- IoT =
- Things +
- Internet +
- **Semantics**
- Things that communicate
- with Things: computer,
- understand the meaning,
- takes own decisions

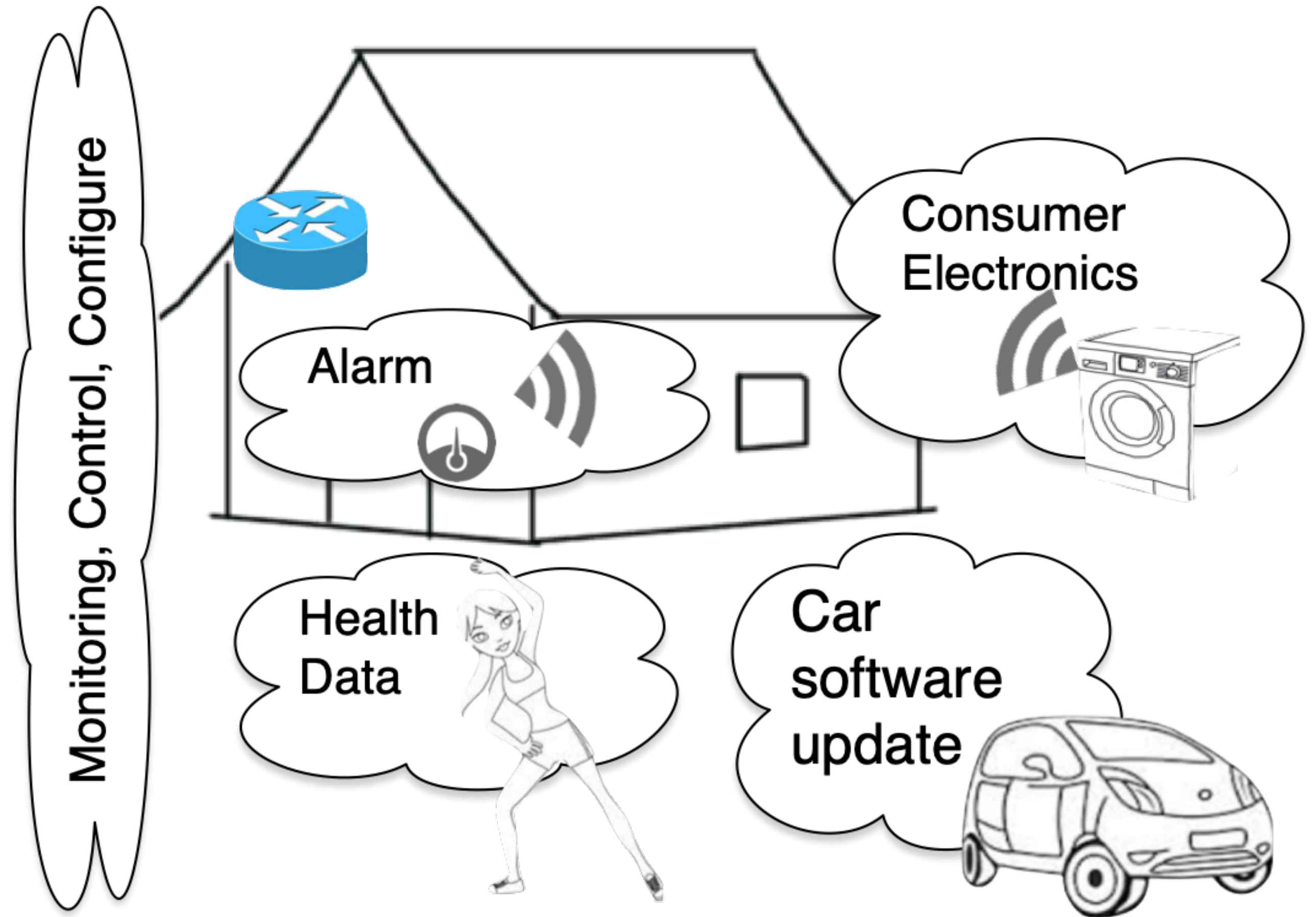
Fig. 1. "Internet of Things" paradigm as a result of the convergence of different visions.

# Utviklingen av VA, AMS og fiber



# Internet of Things (IoT)

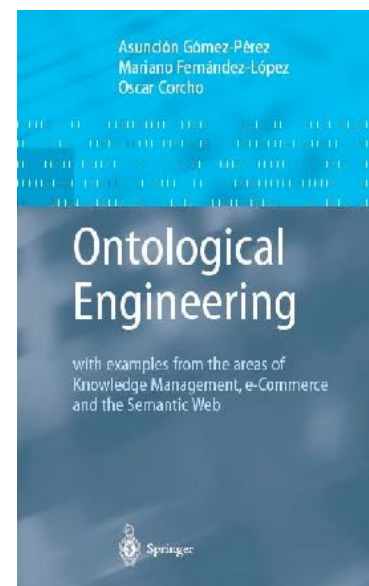
- Interconnected power systems
  - measure:
    - Voltage,
    - Frequency variation
  - automatic control
- Controlling home appliances
  - Power consumers:
    - heat pump, water heater
    - car charger
    - washing machine, dish washer
  - Convenience & Security



# Why Semantics?

## → Syntax vs. Semantics

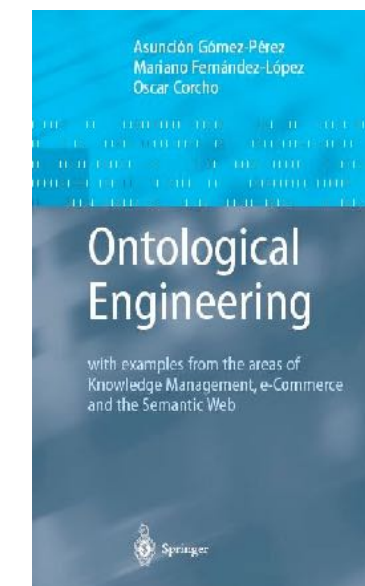
Arab



الهندسة فعلم التطور : الاسم  
 أسنسيون غومز بيرز : المؤلفون  
 السّعر: \$74.95  
 الكتاب : المنتج

<</الاسم>> الاسم<الاسم> الهندسة فعلم التطور ر  
 <</المؤلفون>> المؤلفون<المؤلفون> أسنسيون غومز بيرز /  
 <</السّعر>> السّعر<السّعر> 74.95\$  
 <</الكتاب>> الكتاب<الكتاب> المنتج />

English



**Title:** Ontological Engineering  
**Authors:** Asunción Gómez-Pérez...  
**Price:** \$74.95  
**Product:** Book

<Title>Ontological Engineering</Title>  
 <Author>Asunción Gómez-Pérez...</Author>  
 <Price>\$74.95</Price>  
 <Product>Book</Product>

What do the tags **mean** for the machine?

Source: Juan Miguel Gomez, University Carlos III de Madrid



# Why Semantics?

## → Conceptual Level



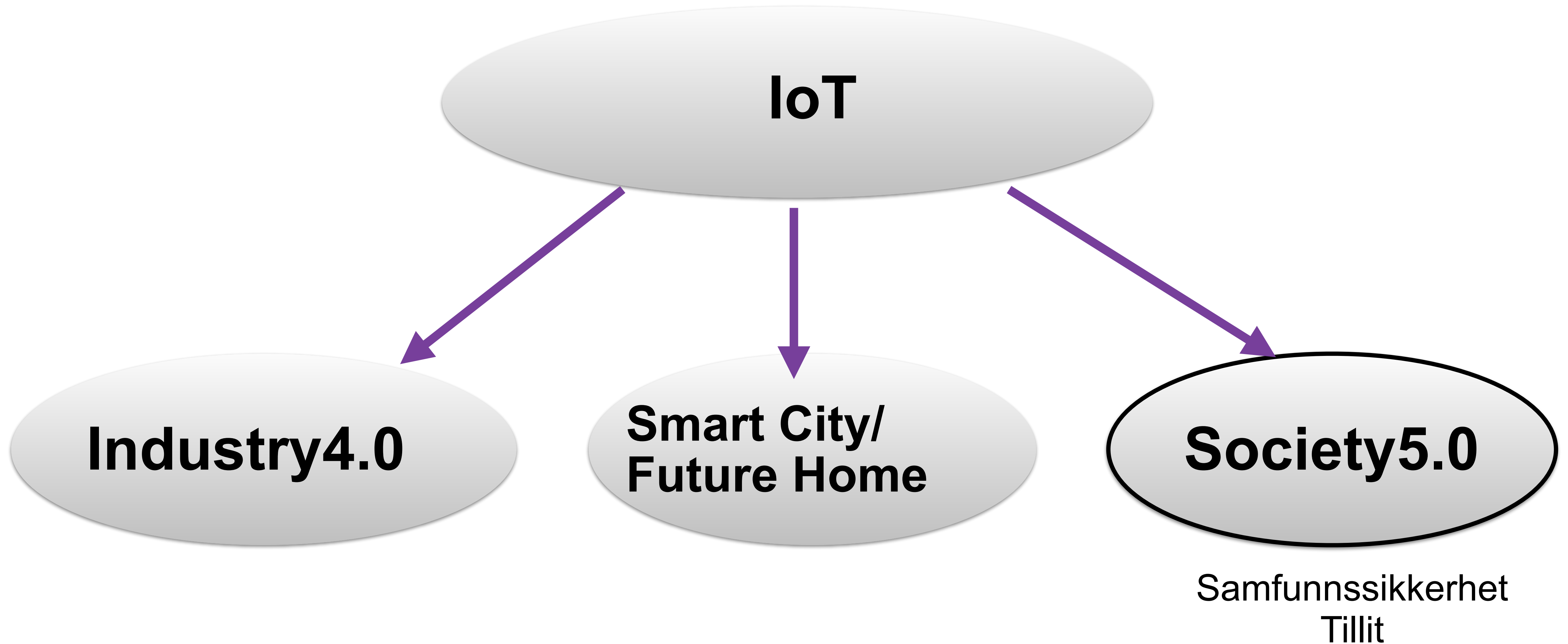
lunch (.no)



lunch (.es)

Source: Juan Miguel Gomez, University Carlos III de Madrid

# Internet of Things (IoT)



# Addressing the Threat Dimension for IoT

- Hollande (FR), Merkel (DE) had their mobile being monitored
- «and we believe it is not happening in Norway?»

18. Dezember 2014, 18:14 Uhr Anhören von Handys

## So lässt sich das UMTS-Netz knacken



[source: Süddeutsche Zeitung, 18Dec2014]

[source: [www.rediff.com](http://www.rediff.com)]

# Significance

## IoT security challenges

### → Mirai attack

- “security by obscurity”
- different security viewpoint

### → “it is just the beginning”

- 4x increase in capability in 2018

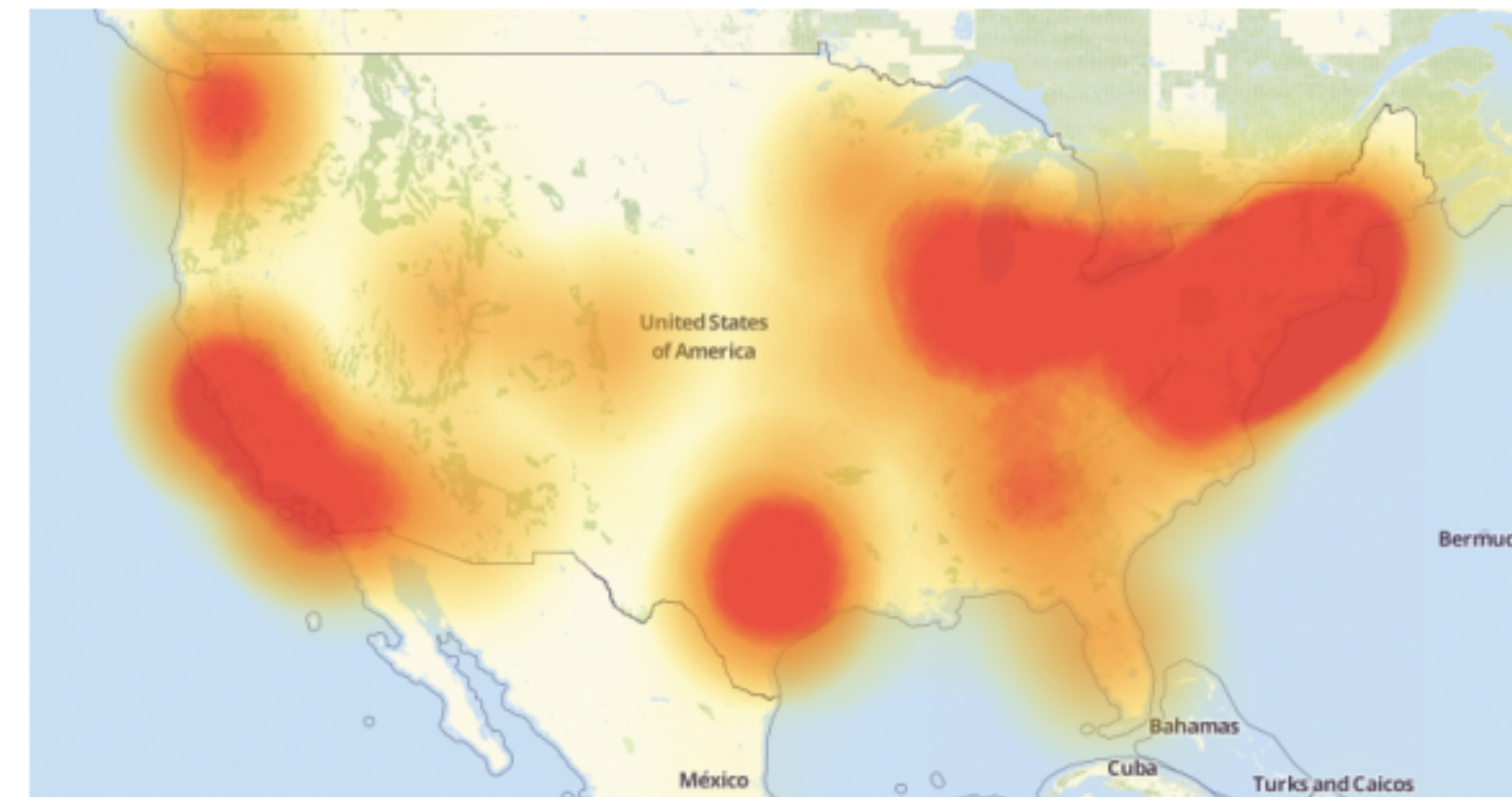
## 21 Hacked Cameras, DVRs Powered Today's Massive Internet Outage

OCT 16

16Oct2016

A massive and sustained Internet attack that has caused outages and network congestion today for a large number of Web sites was launched with the help of hacked “Internet of Things” (IoT) devices, such as CCTV video cameras and digital video recorders, new data suggests.

Earlier today cyber criminals began training their attack cannons on **Dyn**, an Internet infrastructure company that provides critical technology services to some of the Internet's top destinations. The attack began creating problems for Internet users reaching an array of sites, including Twitter, Amazon, Tumblr, Reddit, Spotify and Netflix.



[Source: <https://krebsonsecurity.com/2016/10/hacked-cameras-dvrs-powered-todays-massive-internet-outage/>]

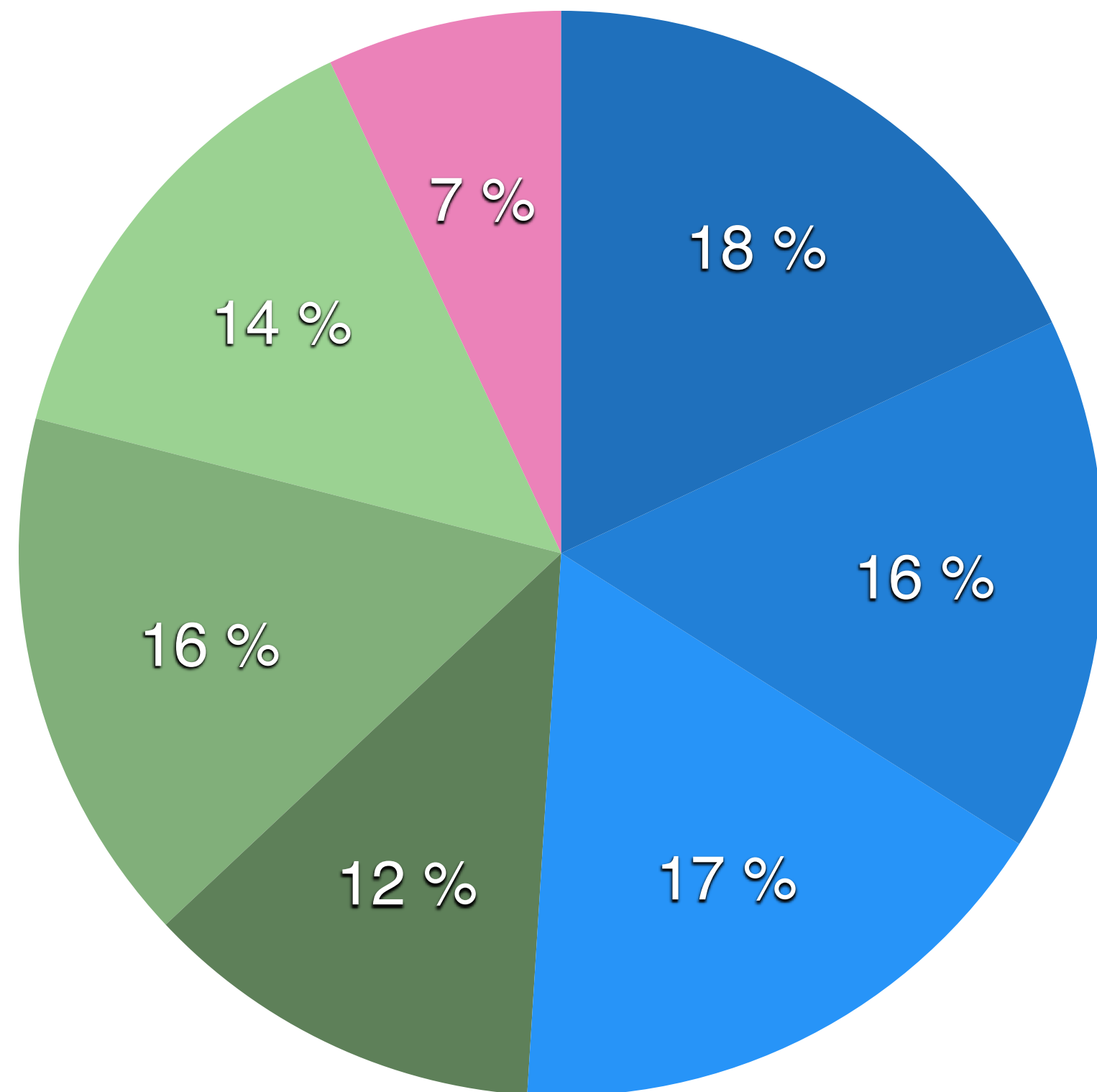


**teach our sensors to talk  
Norwegian**

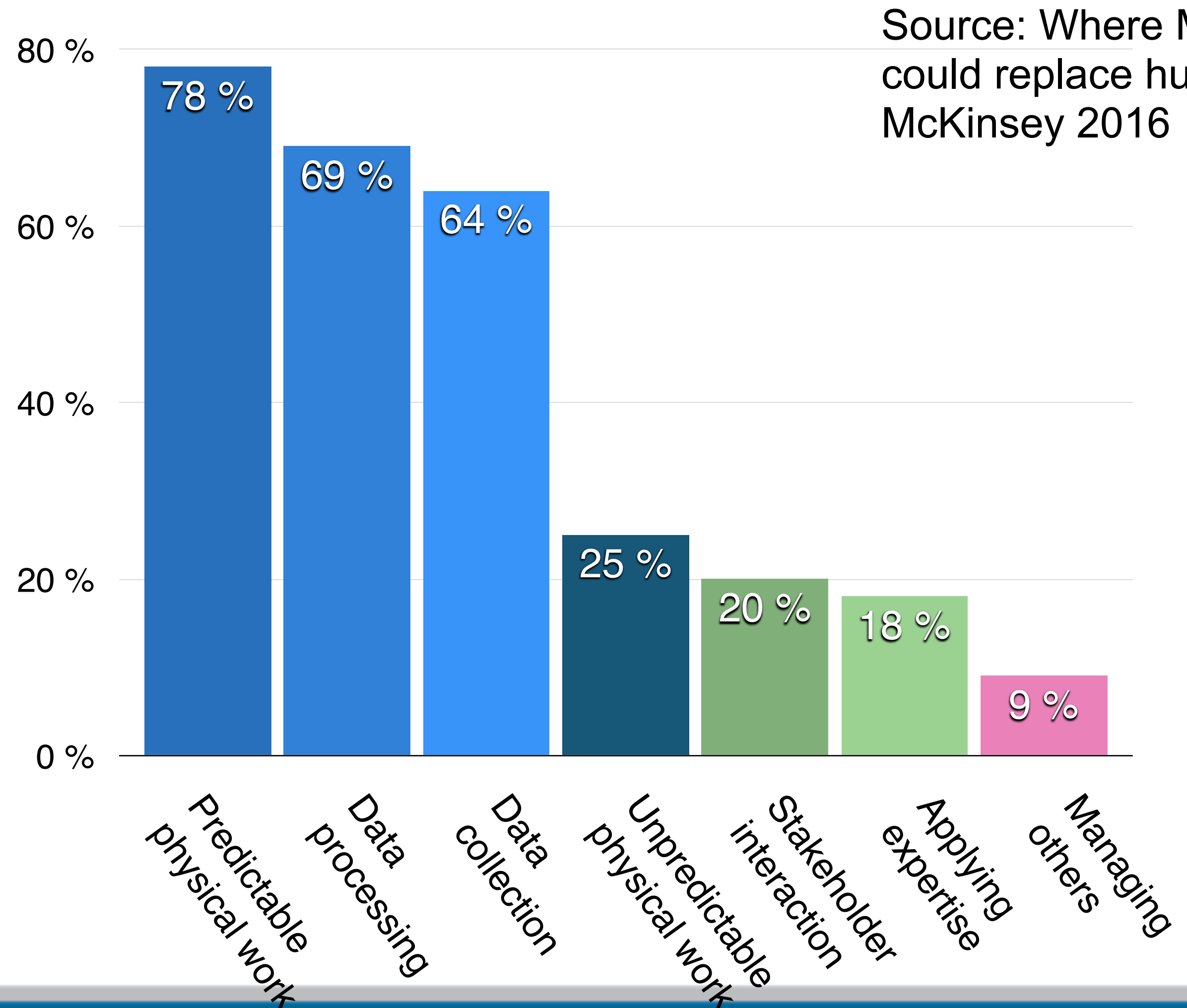
# Automation will come

USA work force time spent [%]

- Predictable physical work
- Data collection
- Stakeholder interactions
- Managing others
- Data processing
- Unpredictable physical work
- Applying Expertise



Technical automation potential **2016** [%]



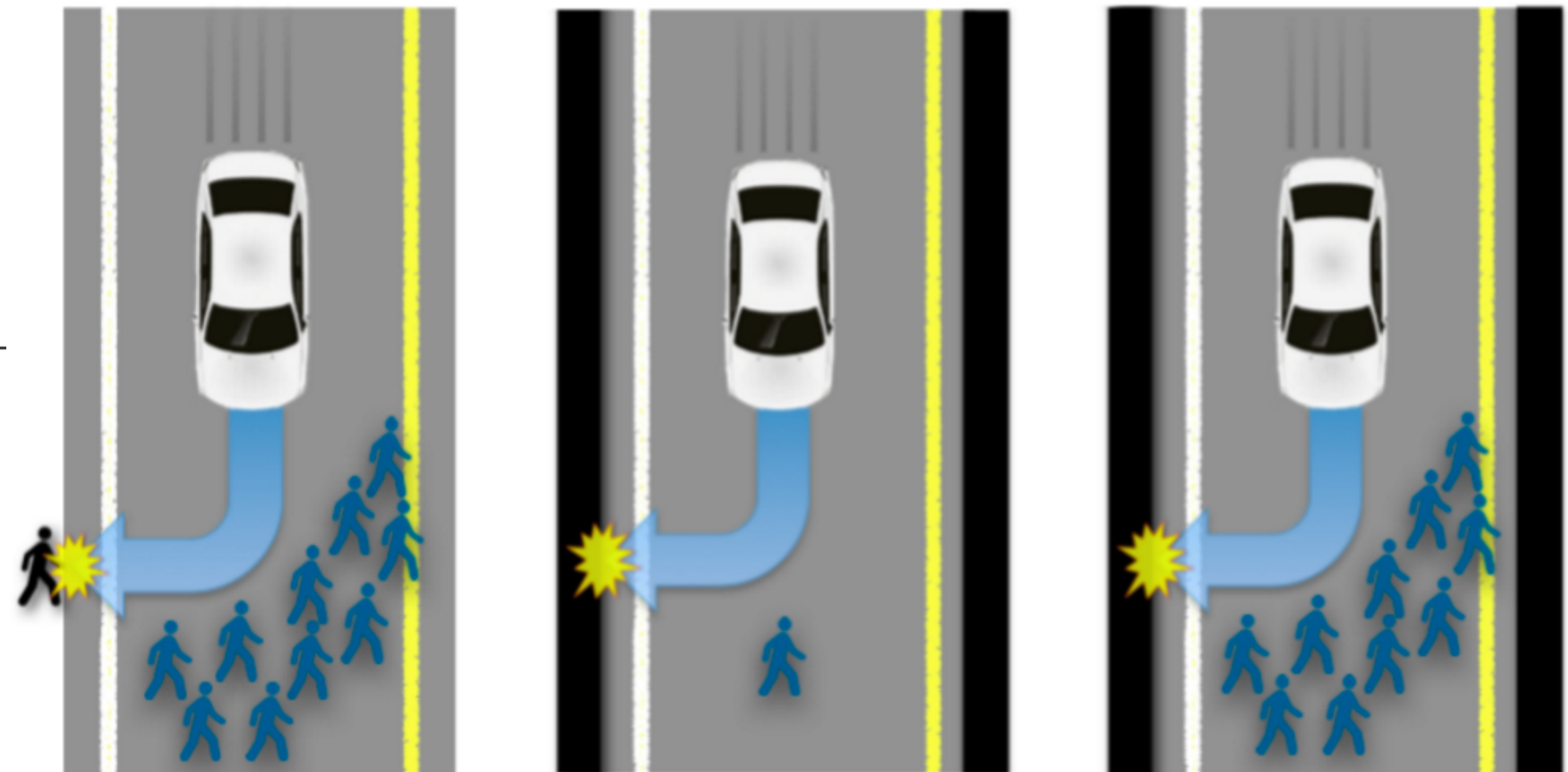
Source: Where Machines could replace humans, McKinsey 2016

# IoT challenges - “programmed to kill”

## Why Self-Driving Cars Must Be Programmed to Kill

Self-driving cars are already cruising the streets. But before they can become widespread, carmakers must solve an impossible ethical dilemma of algorithmic morality.

October 22, 2015



<https://www.technologyreview.com/s/542626/why-self-driving-cars-must-be-programmed-to-kill/>

# Change in Business Models due to IoT

## Volvo to 'accept full liability' for crashes with its driverless cars

But decide on rules so we can make the dang vehicles



13 Oct 2015 at 06:04, OUT-LAW.COM



Volvo will "accept full liability" for collisions involving its autonomous vehicles, the company has confirmed.



**Internet of Things (IoT)**

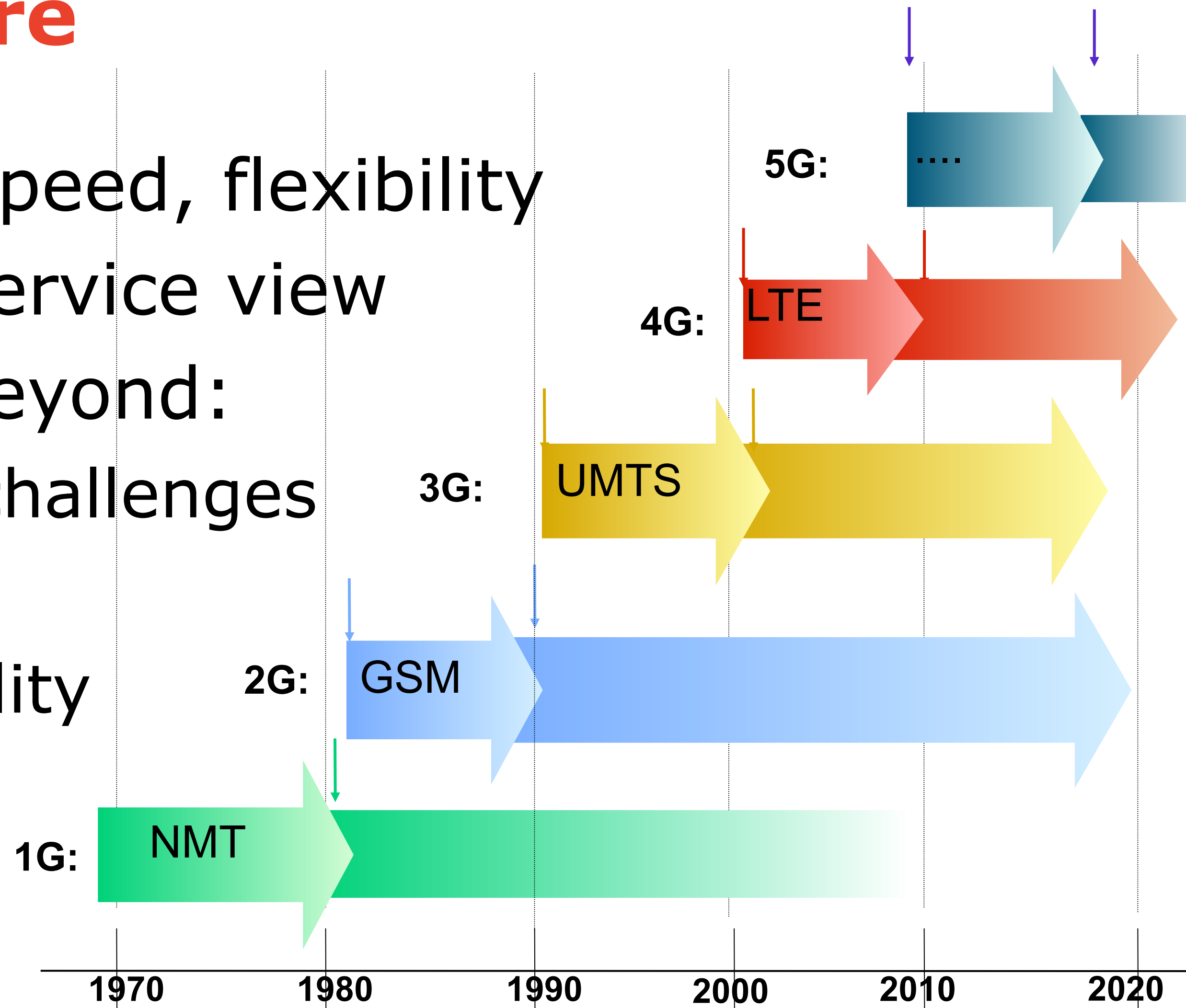
**5G (6G)**

**Energi og Elektro**

**Bærekraftsmålene**

# 5G: Speed, Bandwidth, latency and much more

- ➔ 1G-3G: Speed, flexibility
- ➔ 3G-4G: service view
- ➔ 5G and beyond:
  - Business challenges
  - ownership
  - sustainability



**Service & Sustainability**  
 Seamless integration    Security,  
 Sustainability

Mobile broadband services

Web, Multimedia, Communications

Mobile telephony, SMS, FAX, Data

Mobile telephony

[adapted from Per Hjalmar Lehne, Telenor, 2000]

# How did we measure the quality of the mobile network

1998



# Mobile nett i Afrika

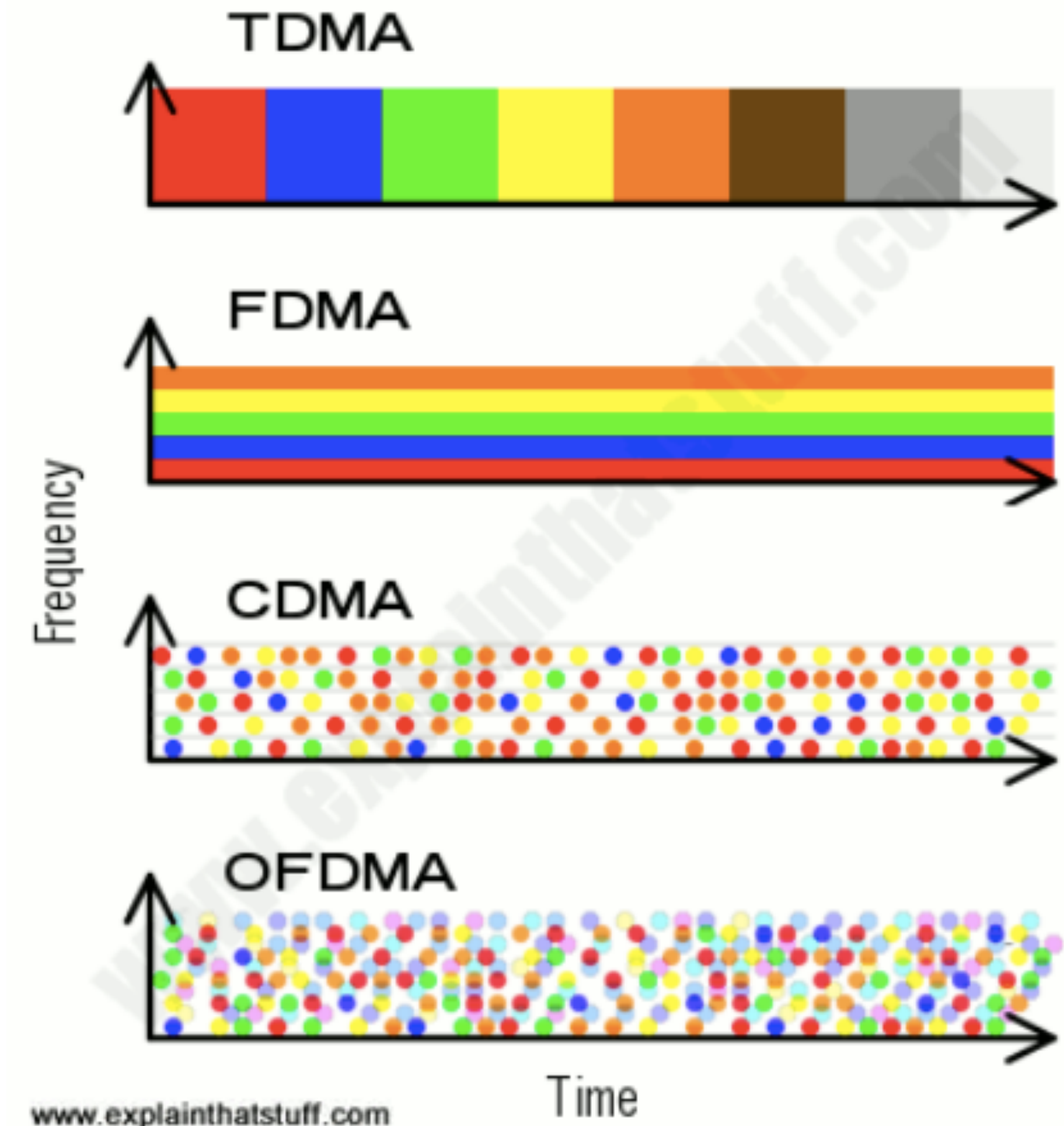


og spørsmål om 5G:  
<https://titan.uio.no/teknologi/2020/5g-nettet-er-til-fordel-teleoperatorene-ikke-forbrukerne>



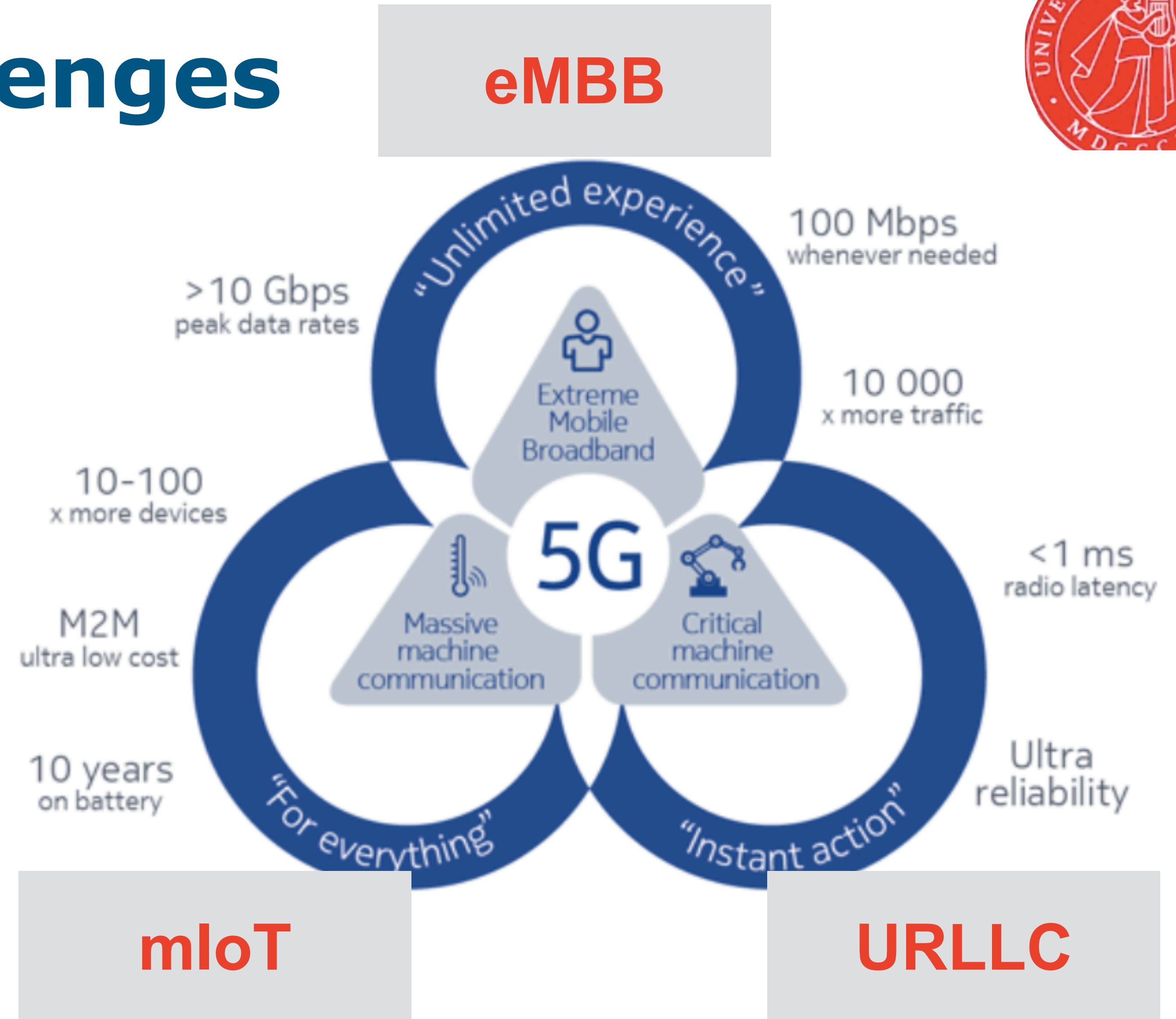
# Principles 2G-5G

- Principles
  - frequency, time, code
  - allocation
- New applications
  - Internet of Things (4G, 5G)
  - Control systems (5G)
    - latency, reliability



# 5G: Industrial Challenges

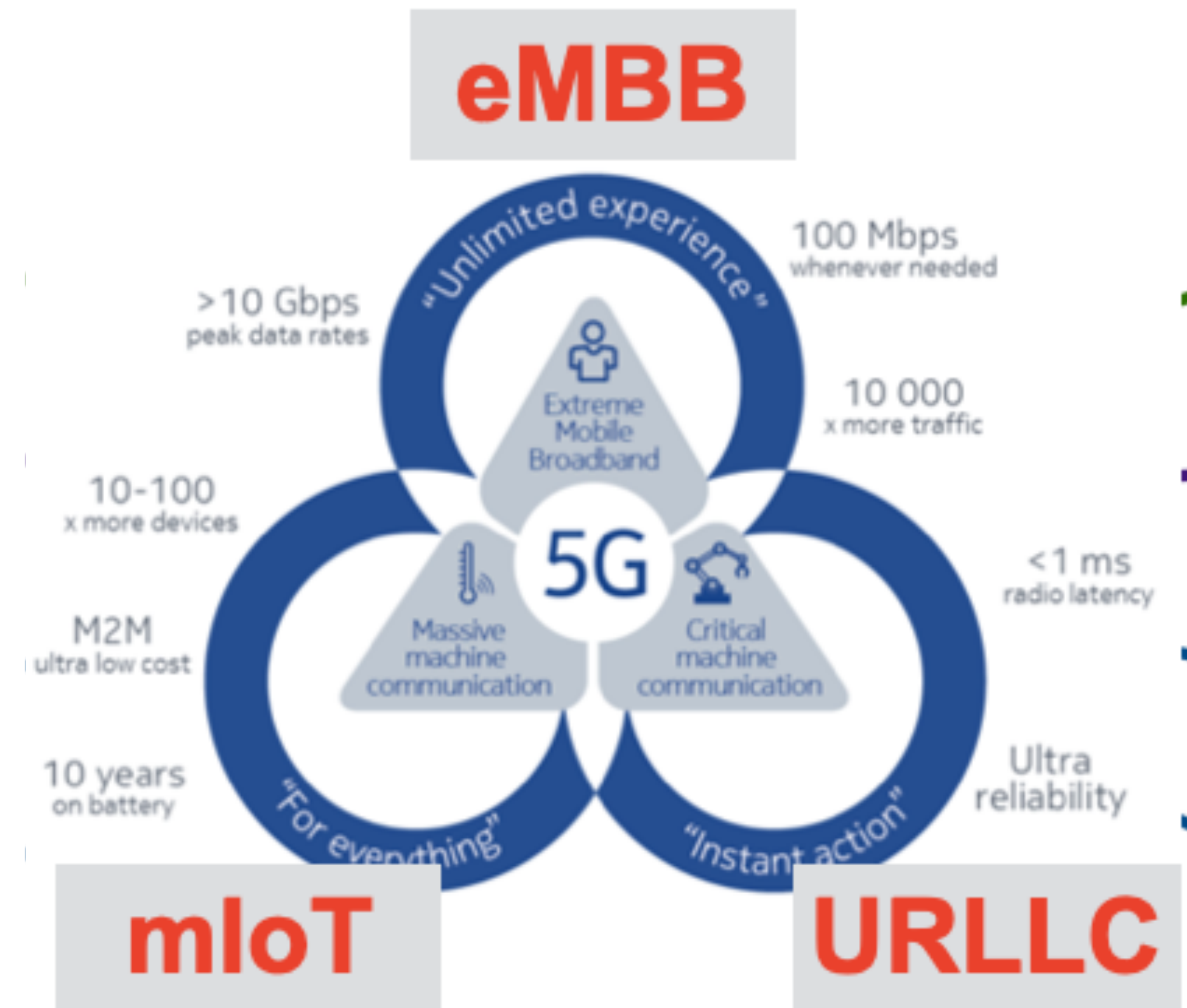
- enhances Mobile Broadband
- massive IoT
- ultra Reliable, Low Latency communication



[source: Nokia <https://networks.nokia.com/5g/get-ready>]

# 5G Application areas

- 5G har tre hovedfokusområder
  - mer bredbånd, opp til 1 Gbit/s
  - stor antall dingser
  - pålitelig nett med liten forsinkelse
- nye forretningskonsepter & kunder
  - prosessindustri
  - hver dings har en (elektronisk) SIM



# Teknologier for 5G

- høyere frekvens:  $>20$  GHz
  - økt båndbredde
- bedre koder
  - prosesseringskapasitet har økt
  - hente 2-3 ganger mer data ut av lufta
- flere antenner (MIMO)
- virtualisering
  - "alt er programvare"
- deling av nett ("network slicing")

MIMO = multiple input, multiple output





# Example: The Connected Car

## WIRELESS ROUTER

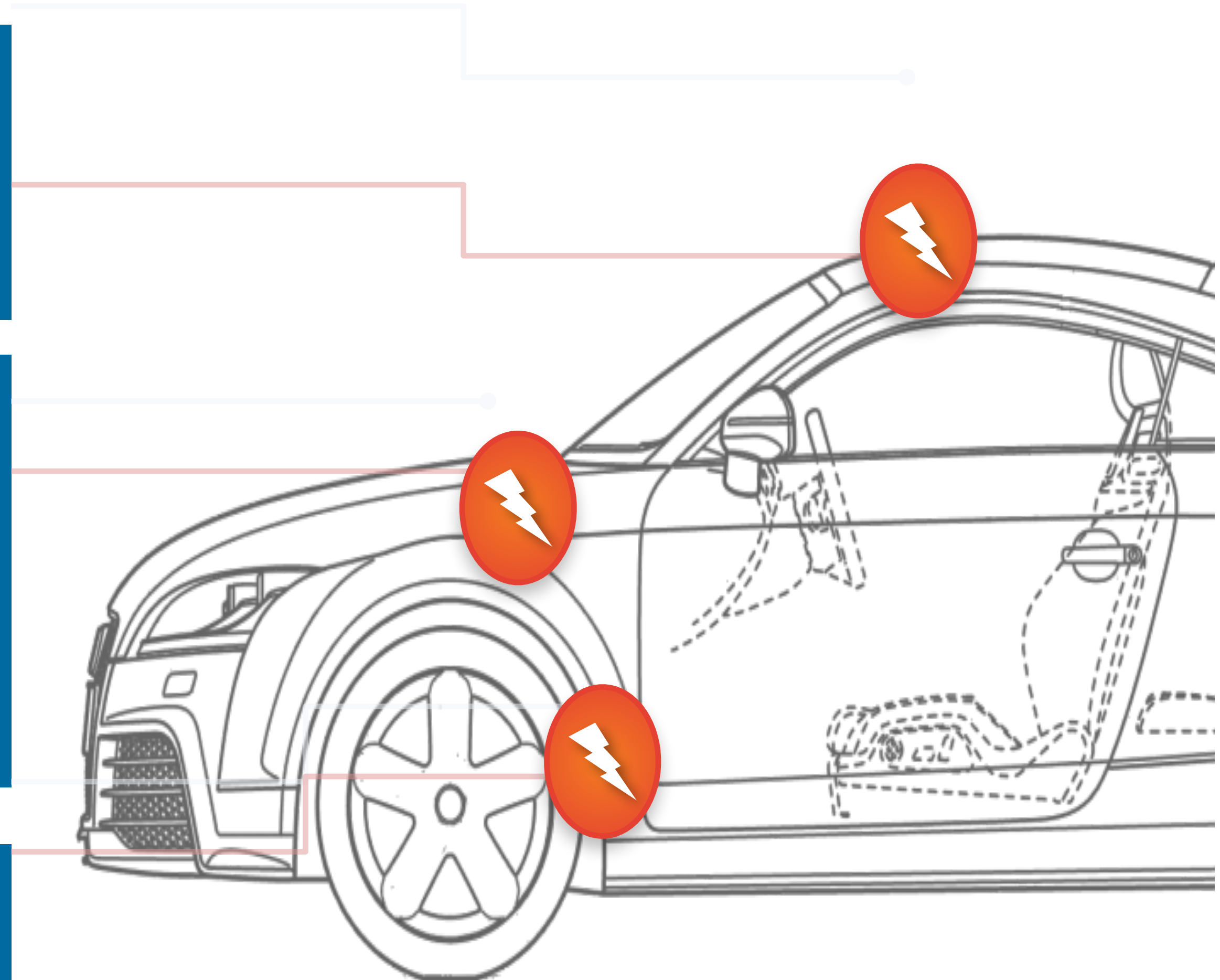
- Online entertainment
- Mapping, dynamic re-routing, safety and security

## CONNECTED SENSORS

- Transform “data” to “actionable intelligence”
- Enable proactive maintenance
- Collision avoidance
- Fuel efficiency

## URBAN CONNECTIVITY

- Reduced congestion
- Increased efficiency
- Safety (hazard avoidance)



# Trust for IoT

2 Trains following each other  
- wireless!

[?v=pMQ0CWzOKTI](https://www.youtube.com/watch?v=pMQ0CWzOKTI)



"Building Trust in the Internet of Things"

SECURITY



USABILITY



PRIVACY

SCOTT DEMONSTRATOR BOOKLET  
SCOTT USE CASE BOOKLET

What is SCOTT?

SCOTT RESULTS

Publications  
YouTube



SAFETY

TRUSTABILITY



[SCOTTproject.eu](http://SCOTTproject.eu)

# 5G Air Interface

- ➔ Scalable **OFDM**-based 5G NR air interface
  - Scalable numerology, scalable slot duration (efficient multiplexing of diverse latency and QoS requirements)
  - Frequency localisation
  - lower power consumption
  - Asynchronous multiple access
- ➔ Flexible slot-based 5G NR framework
  - Self-contained slot structure (independently decoded slots and avoid static timing relationships across slots)
  - see: <https://www.5gtechnologyworld.com/the-basics-of-5gs-modulation-ofdm/>

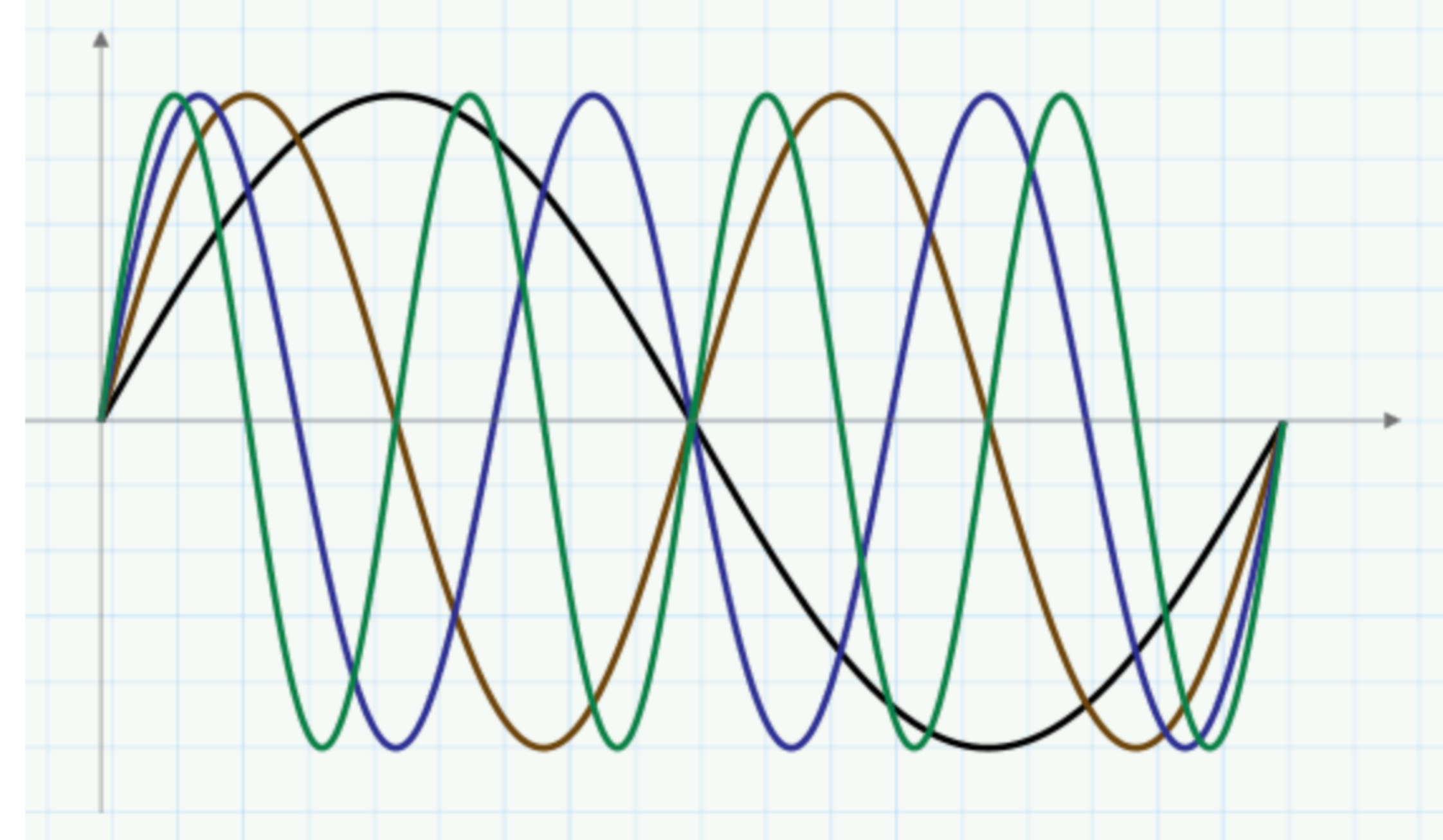


Figure 3. This OFDM signal contains four carriers spaced apart by  $\Delta f$  corresponding to  $f_0, f_1, f_2, f_3$ .

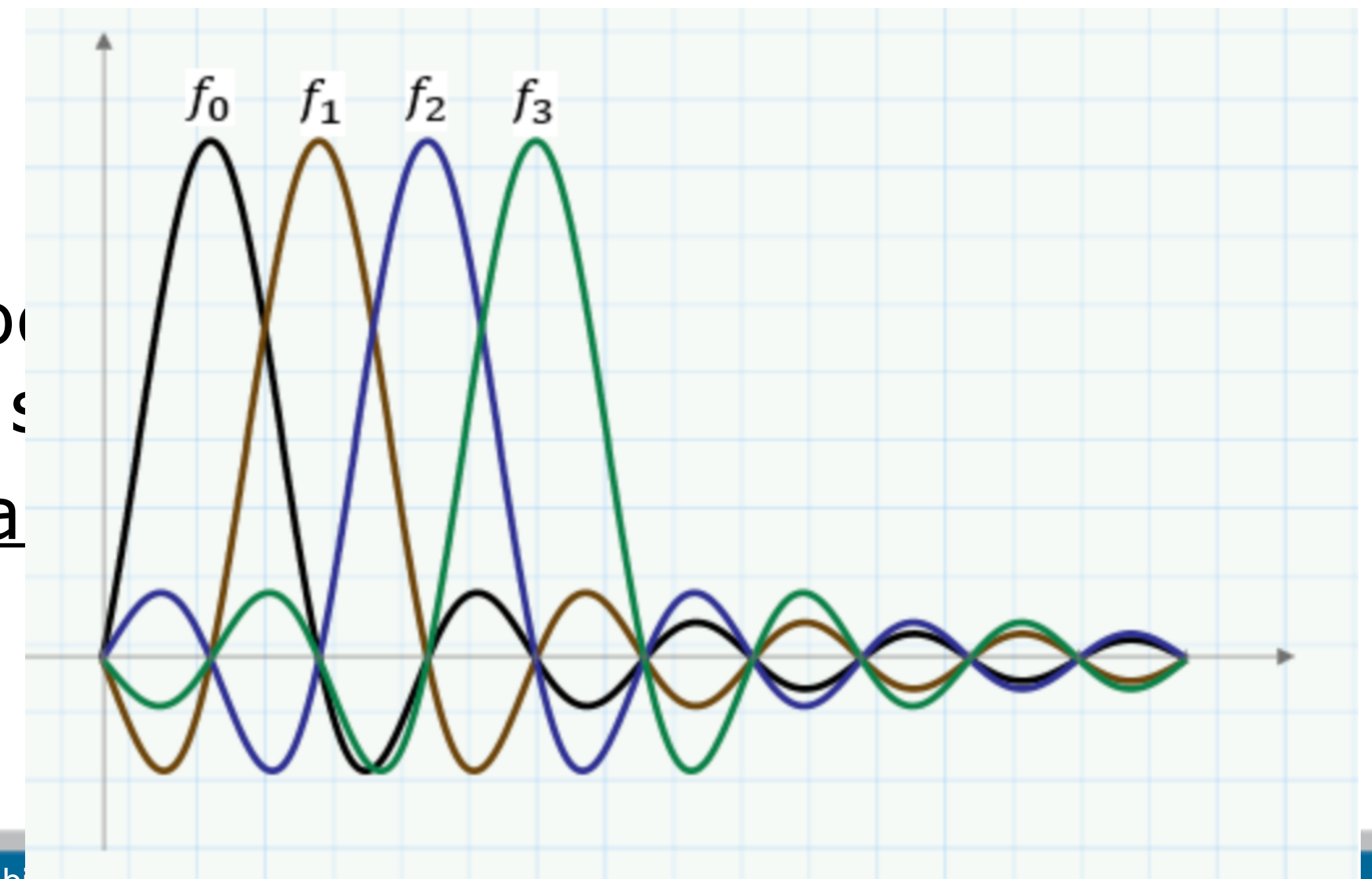


Figure 4. Frequency domain representation of a four-carrier OFDM signal

# 5G Channel coding

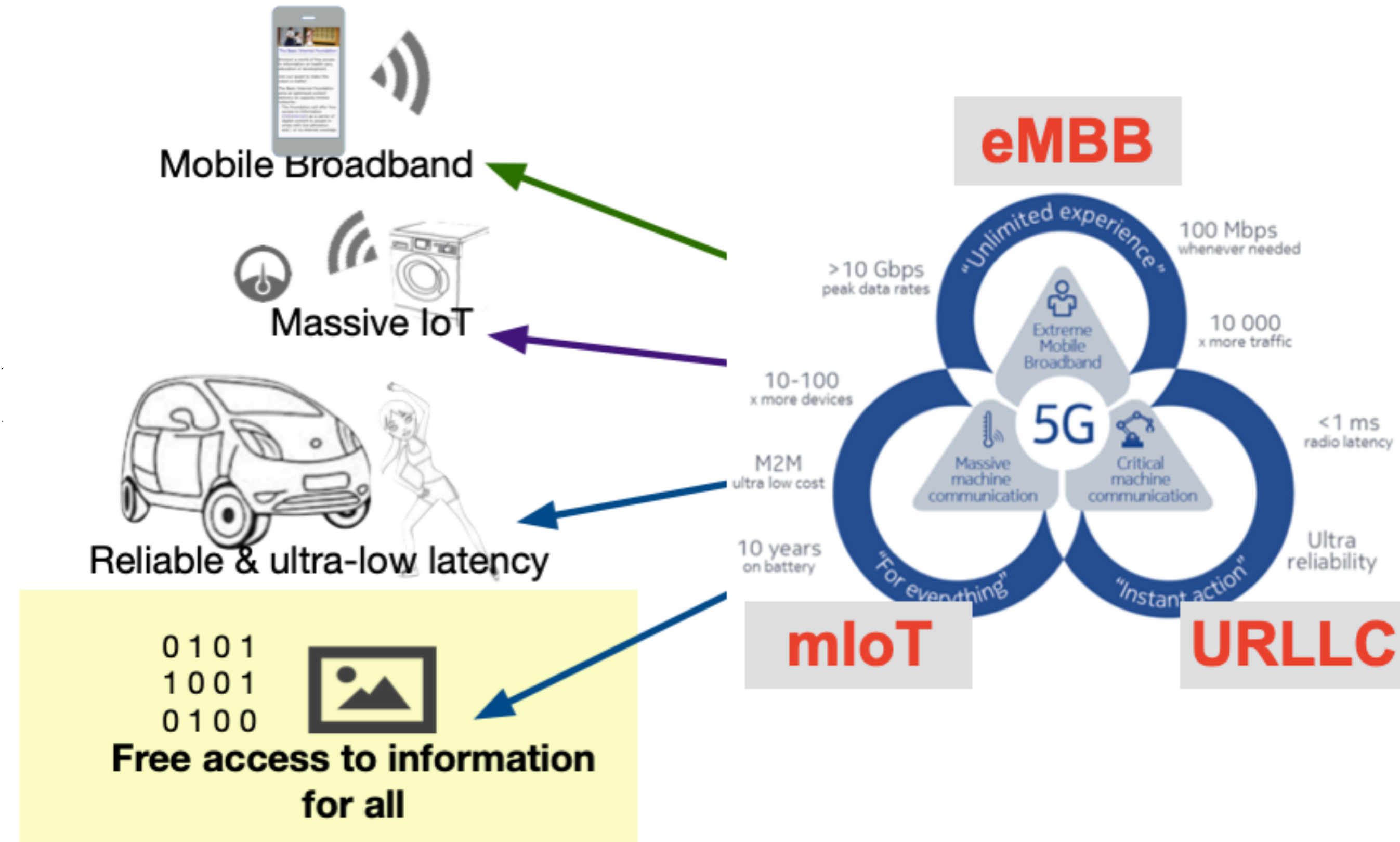
- Channel coding
  - Advanced ME-LDPC channel coding
  - more efficient than LTE Turbo code, 4x at Code rate  $(R)=0.65$ , 5 at  $R=0.9$
- **3x increase in spectrum efficiency**
  - explicit 3D beam forming with up to 256 antenna elements
  - typical 3.8x increase from 4x4 MIMO to 5G NR Massive (256 antennas) MIMO (52 Mbps to 195 Mbps)
- Large BW opportunity for mmWave
  - 5G NR sub-6GHz (3.4-3.6 GHz)
  - 5G NR mmWave (e.g. 24.25-27.5 GHz, 27.5-29.5 GHz)

# 5G Challenges

- require:
- overcome significant path loss in bands above 24 GHz
- robustness: innovation to overcome mmWave blockage from hand, body, walls, foliage - non-LOS is a problem
- Device size/power integration into a mobile
- Dense network topology and spatial reuse (150-250m distance)
- colocation of 28 GHz on LTE channels

# 5G - hva mangler vi

- ➔ #5GforAll
  - radio interface: Large cell, low mobility sites (low density rural areas)
  - freemium model for access (freemium = free + premium)
  
- ➔ Missing aspects in 5G
  - interface mobile-home network
    - we become network operators
  - application-specific routing (service quality)
  - interference with unlicensed technologies



**Internet of Things (IoT)**

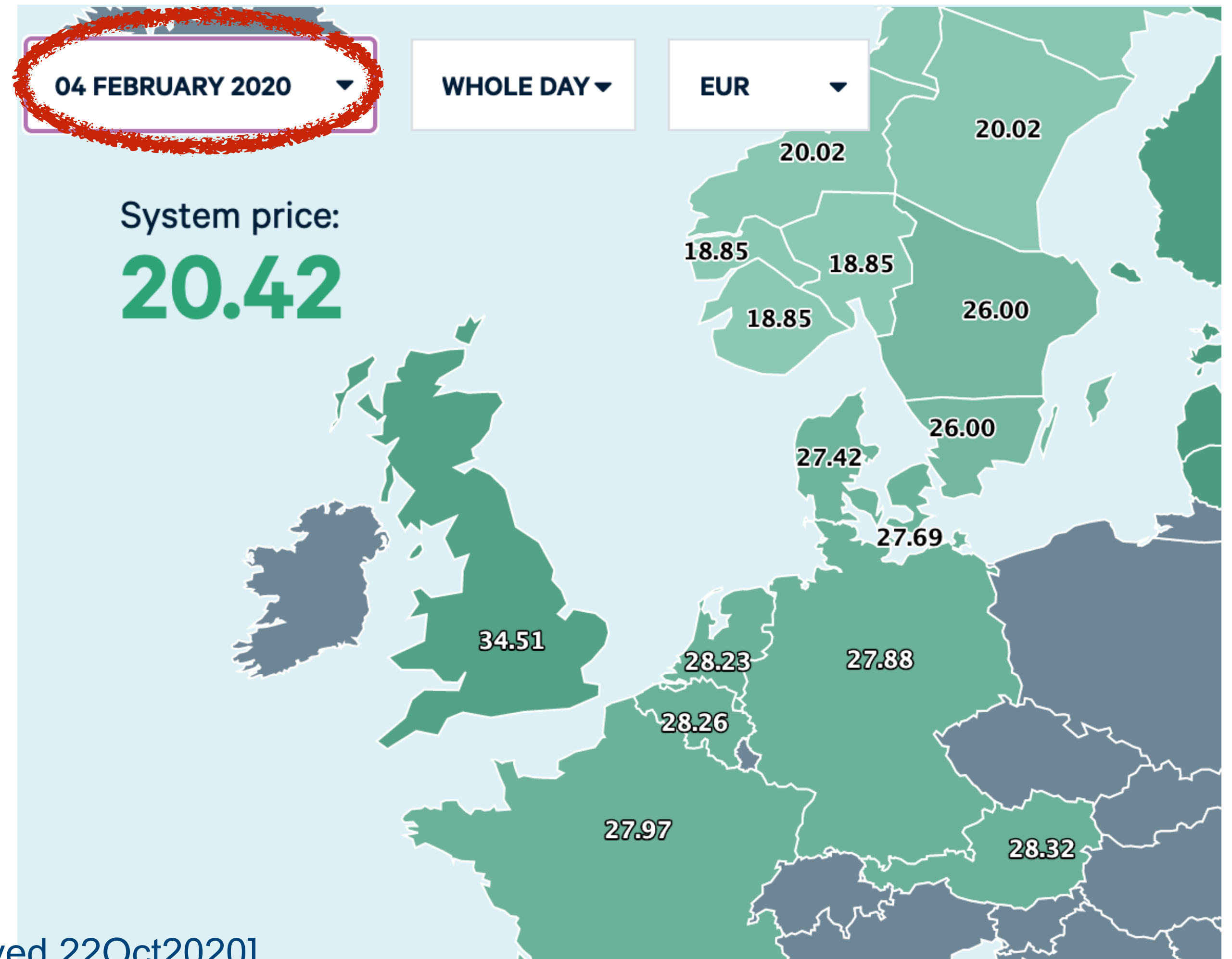
**5G (6G)**

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**Bærekraftsmålene**

# Change of electricity prices

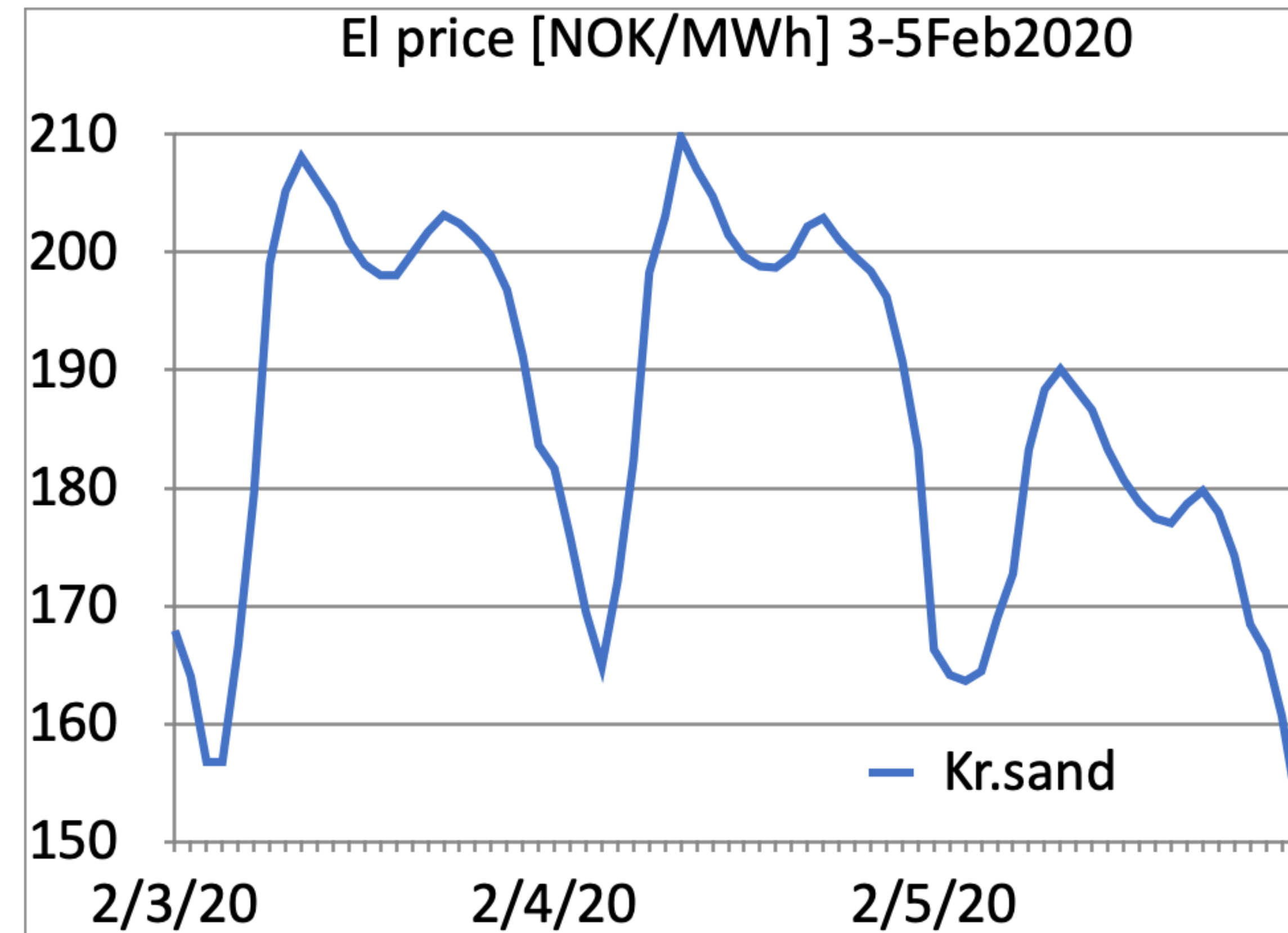
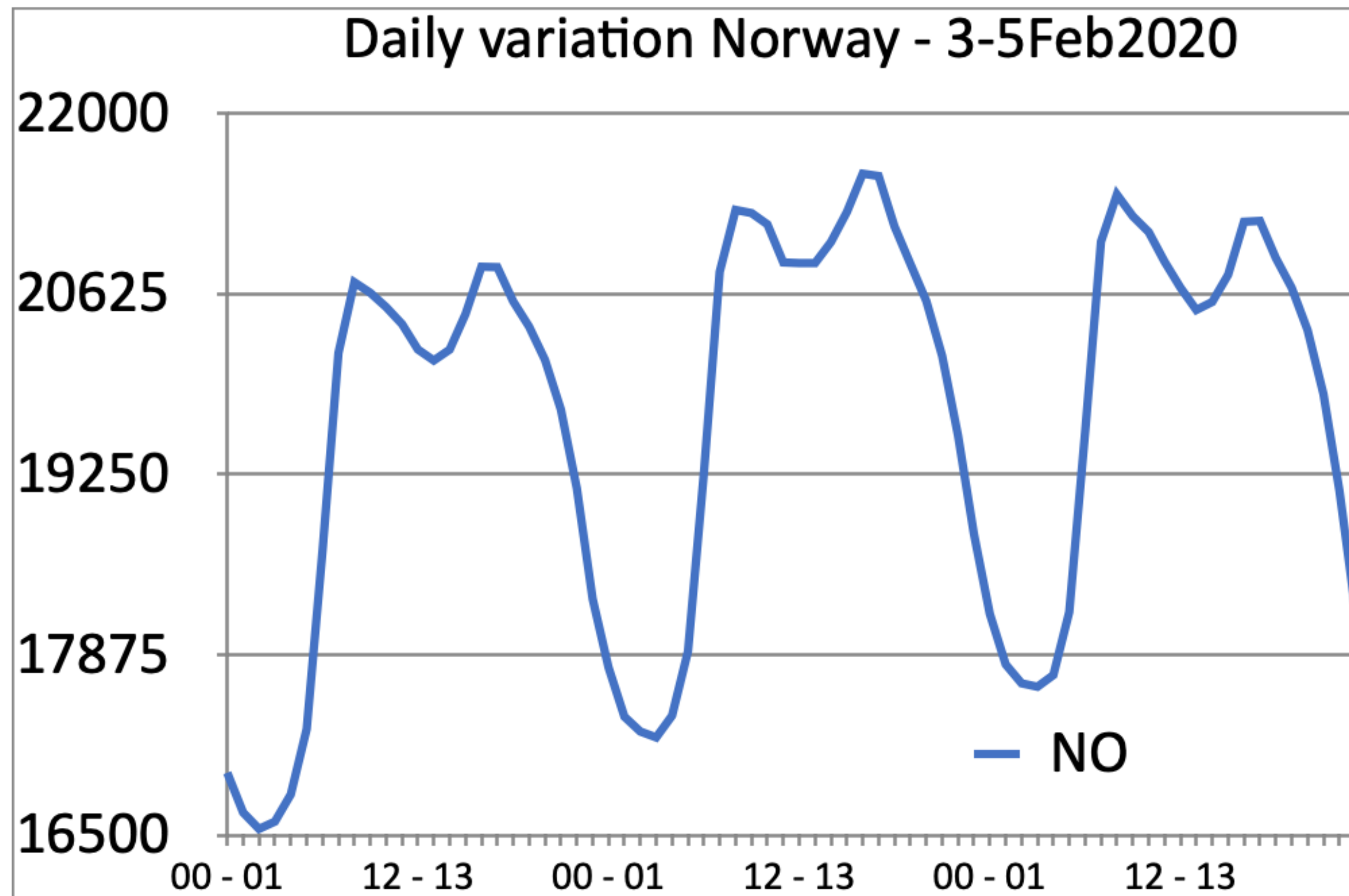
- <https://www.nordpoolgroup.com/historical-market-data/>
- Elspot prices 2020 [NOK]
- Exchange NO connections [MWh]
- Consumption prognosis [MWh]



[<https://www.nordpoolgroup.com/historical-market-data/> -retrieved 22Oct2020]



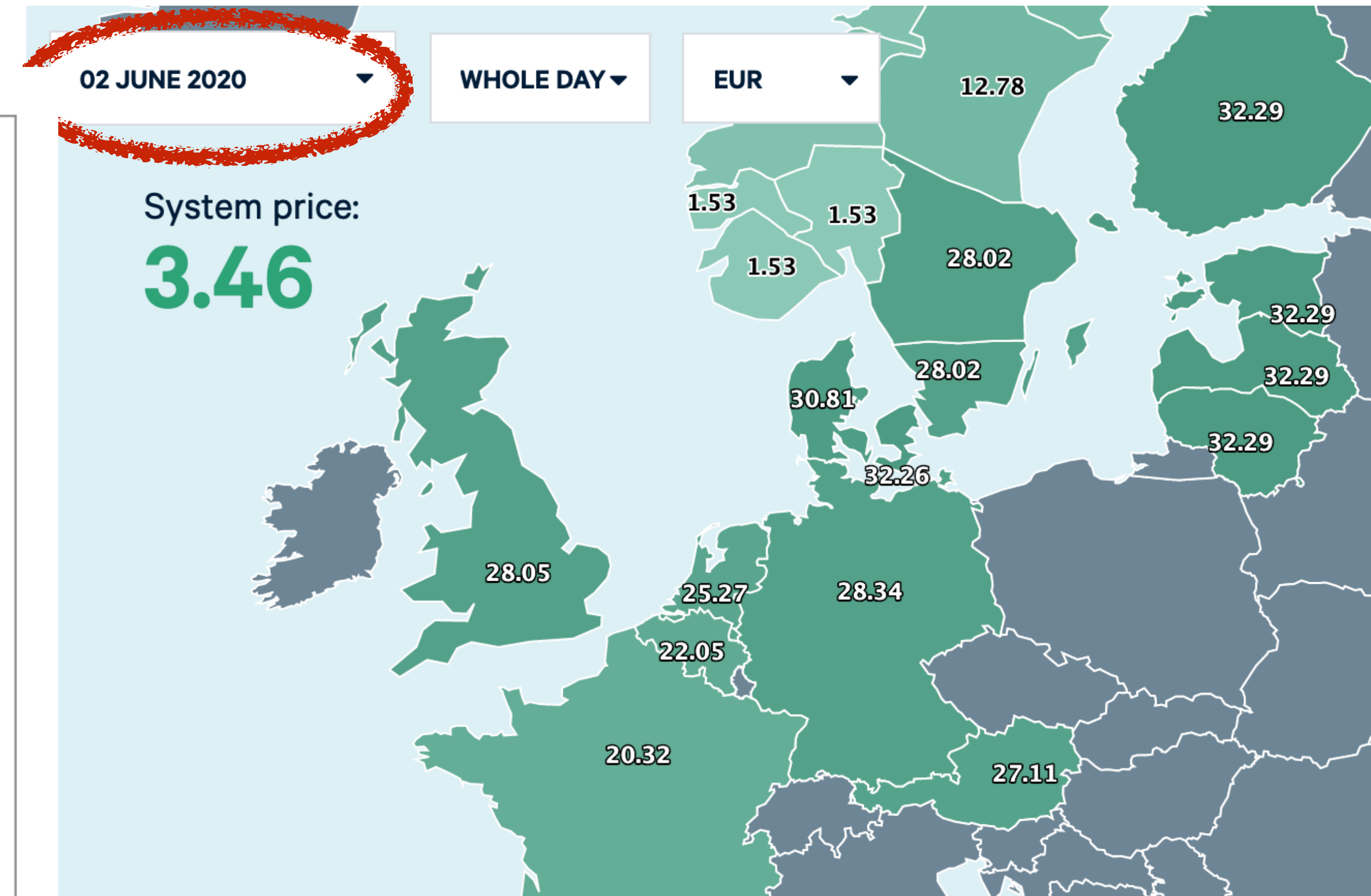
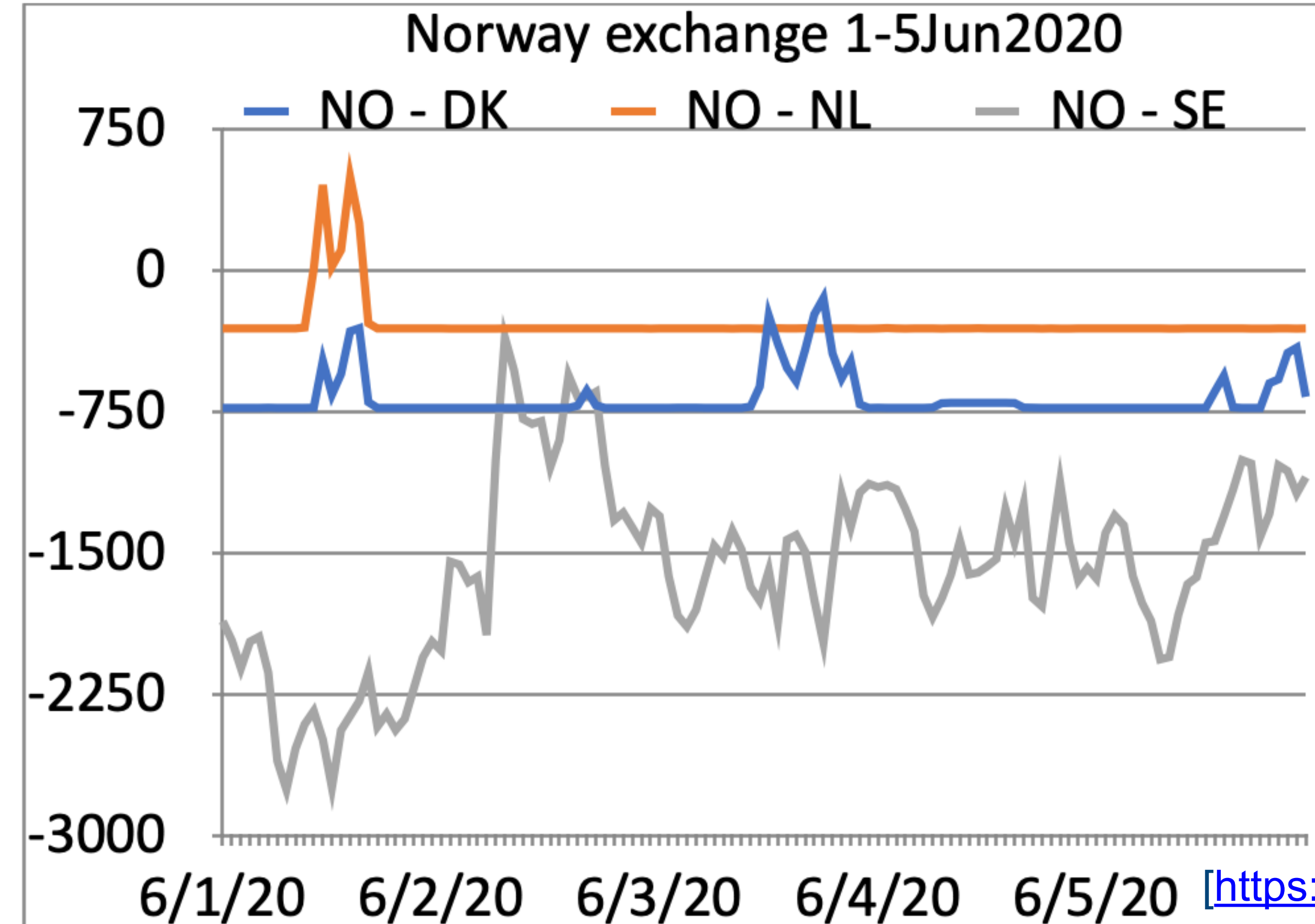
# Daily variation and price - Kristiansand Feb2020



[<https://www.nordpoolgroup.com/historical-market-data/> -retrieved 22Oct2020]

# What has happened on 3-5Jun2020?

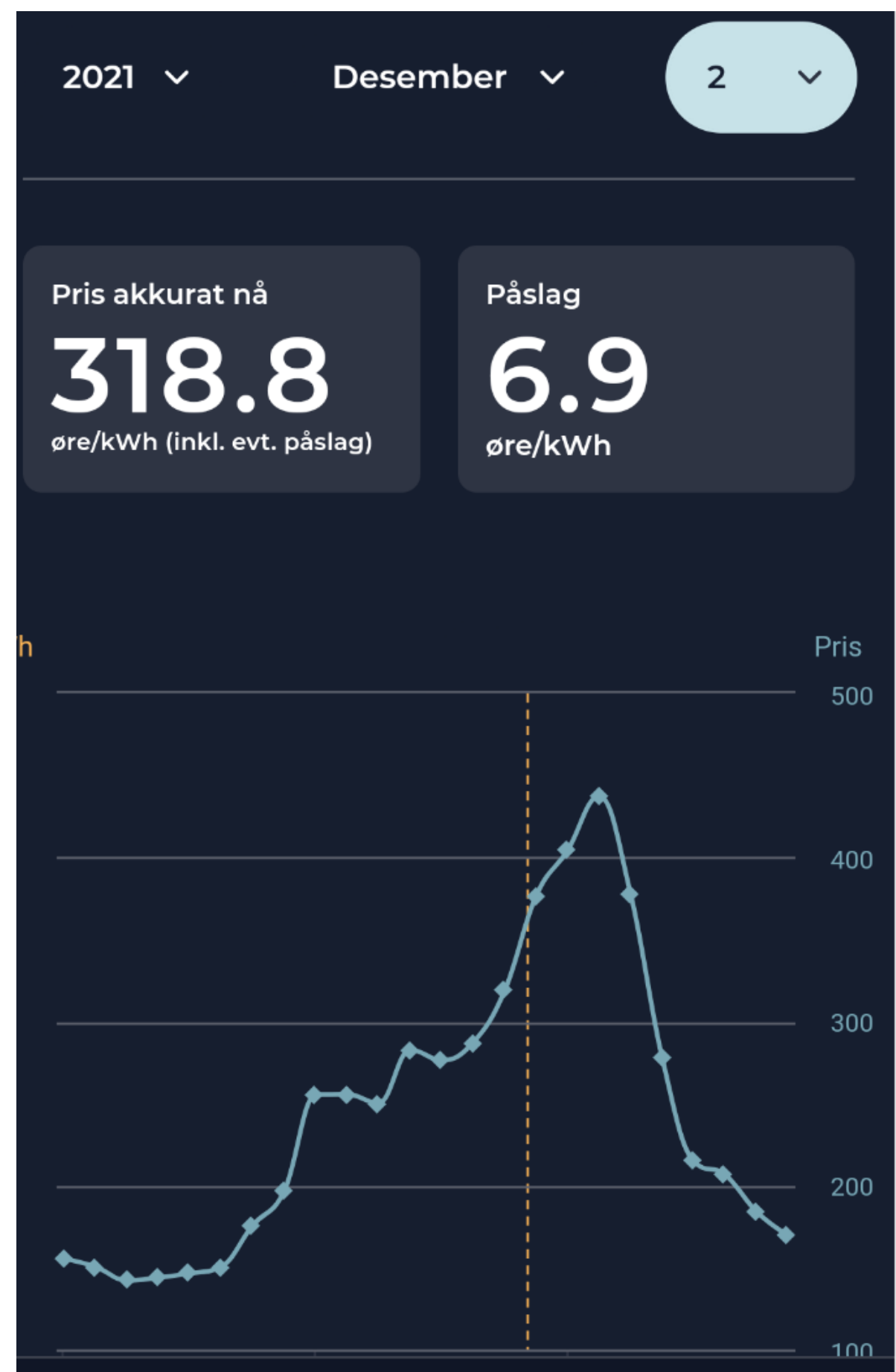
→ See: SE-NO, DK-NO



<https://www.nordpoolgroup.com/historical-market-data/> -retrieved 22Oct2020

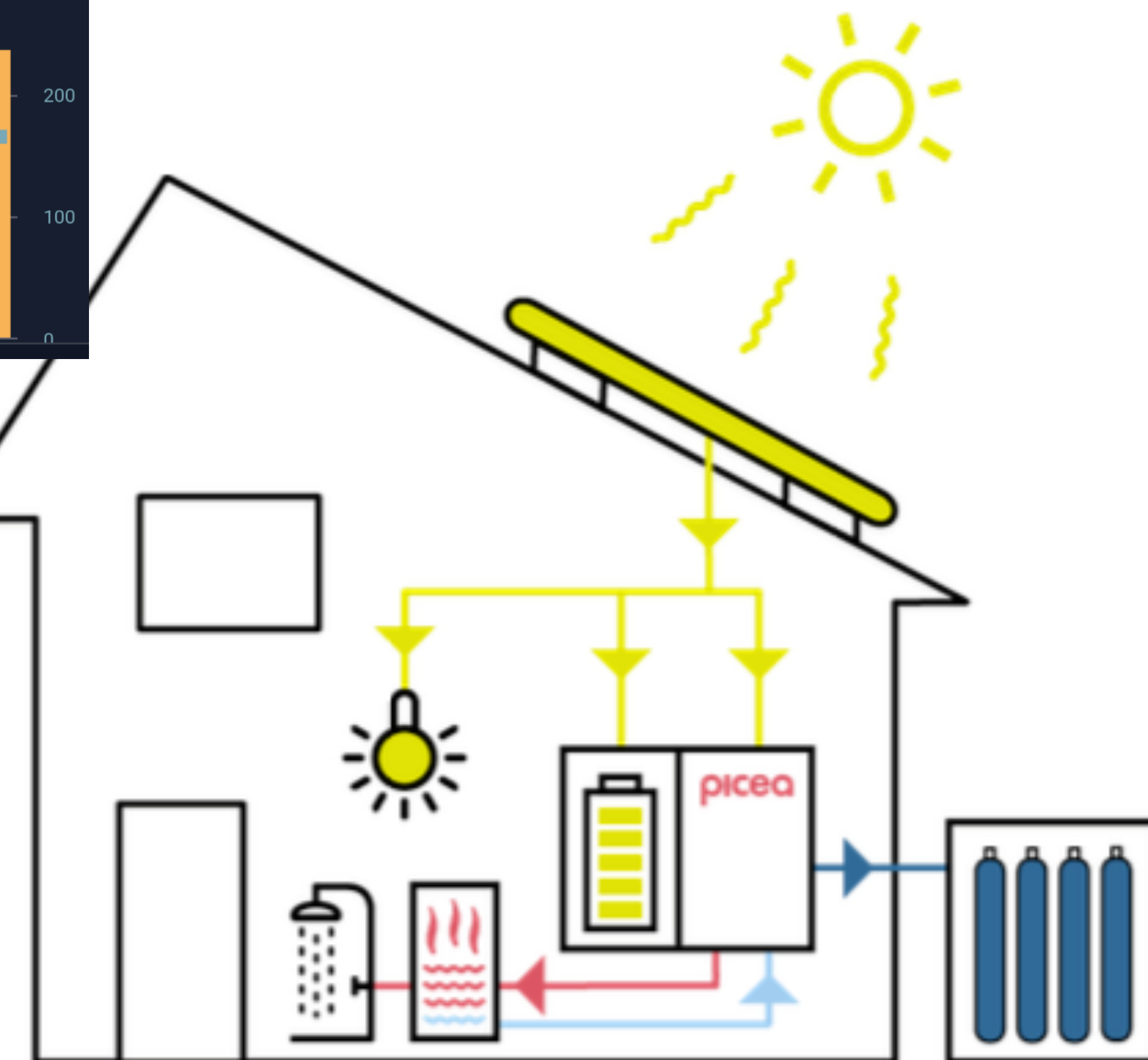
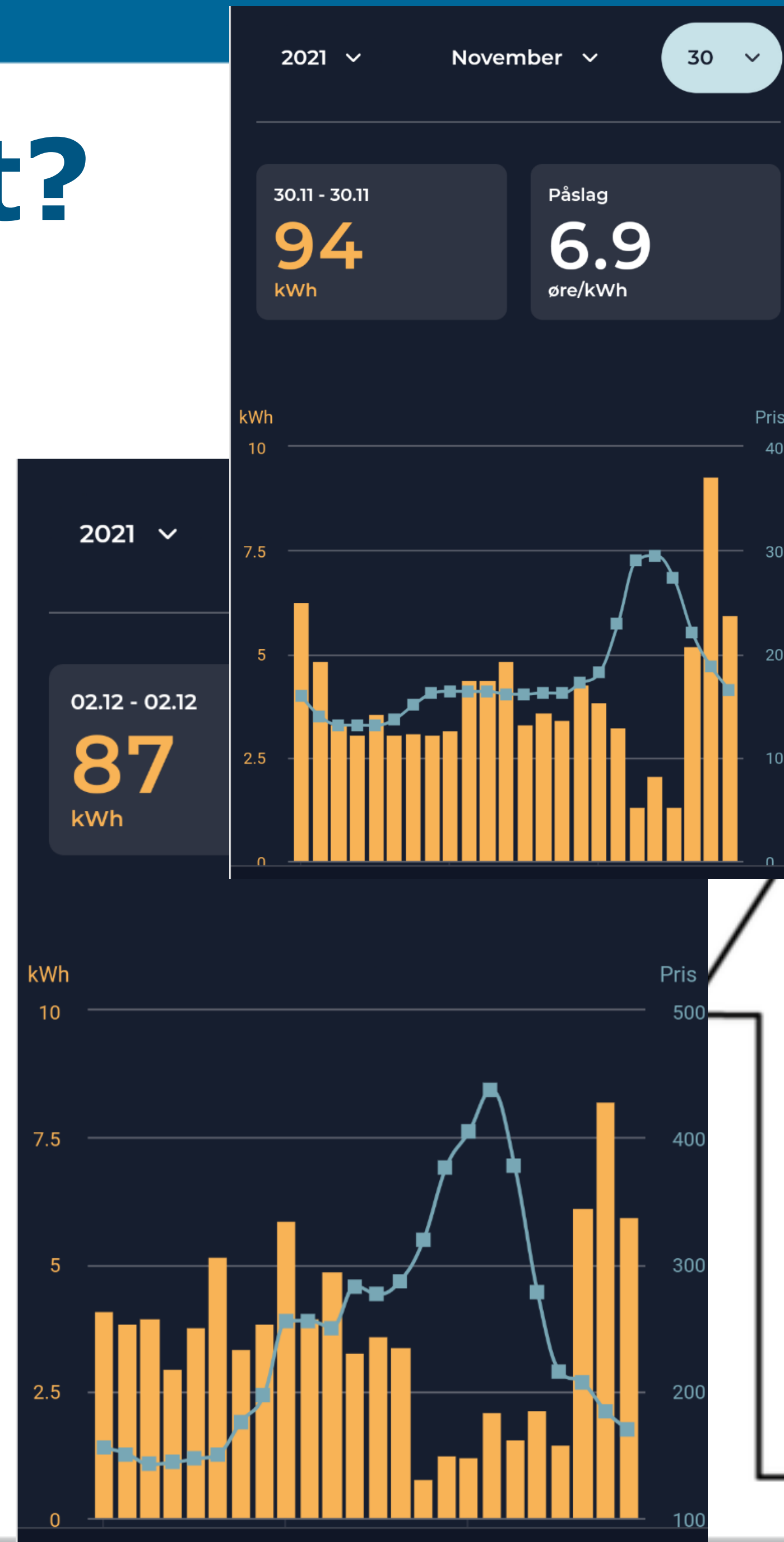
# The “new normal”

- ➔ Growth of Renewables
  - variability
- ➔ Gas prices
  - war, climate crisis
- ➔ Climate Crisis
  - unpredictable weather
  
- ➔ **High variation of electricity prices**



# How can we adapt?

- Empower the customer
  - capability to adapt
  - decentralised solutions
  - distributed grid
- Upgrade houses
- Neighbour-networks



# VGS samarbeid

## Elektrodata fra 100 hus

- High-resolution database for energy usage
  - per fuse, 1/10 s
  - Goal: 100 households
- Resilience
  - Grid adaption
  - Graceful degradation
- Customer empowerment
  - decentralised solutions



**Internet of Things (IoT)**

**5G (6G)**

**Energi og Elektro**

**Bærekraftsmålene**

# Starting Point:

**JOSEPH E. STIGLITZ**

WINNER OF THE NOBEL PRIZE IN ECONOMICS



# THE PRICE OF INEQUALITY

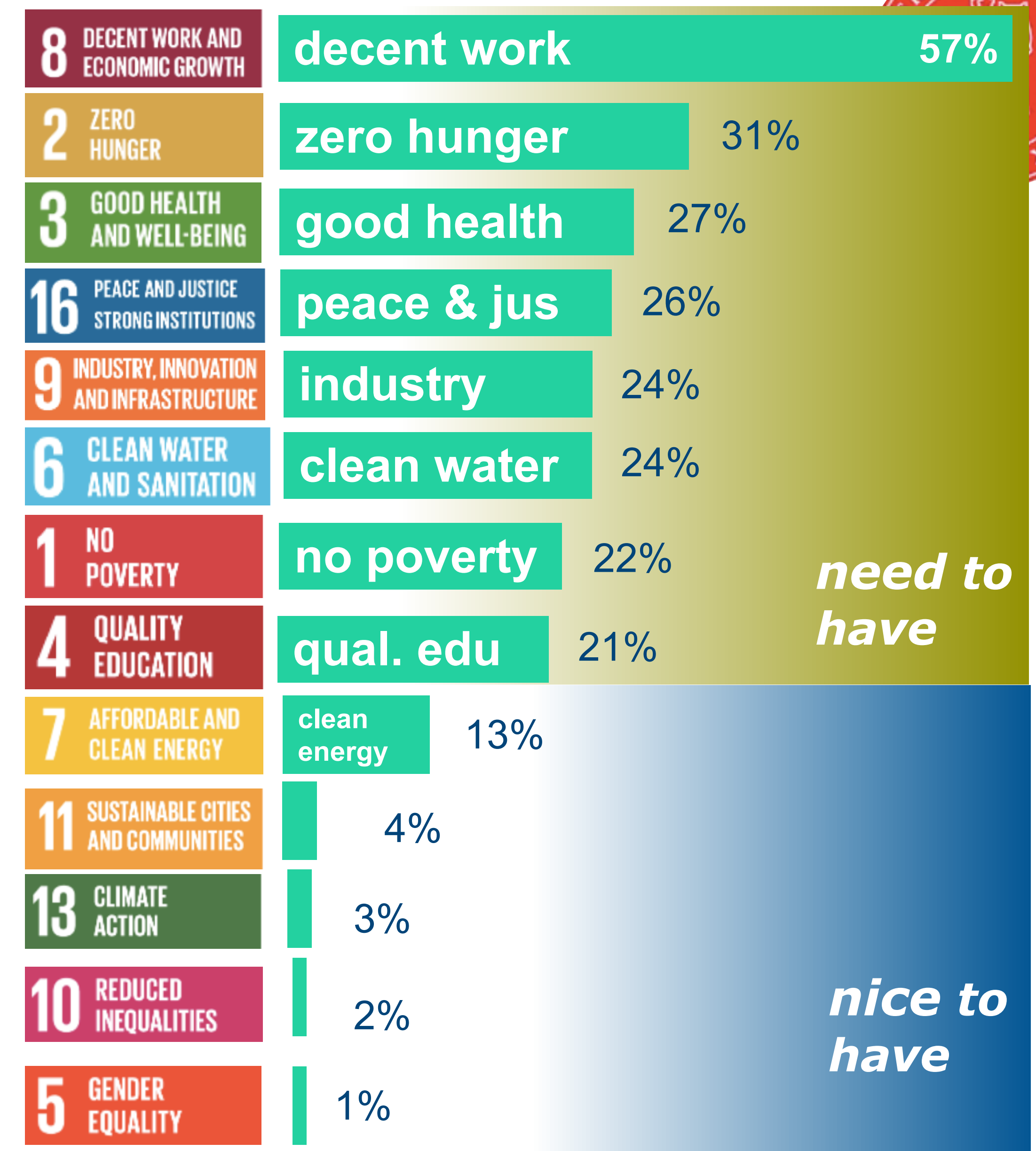
HOW TODAY'S DIVIDED SOCIETY  
ENDANGERS OUR FUTURE



# Public Opinion on SDGs ([afrobarometer.org](http://afrobarometer.org) )

→ Priorities by people in Africa

- decent work
- zero hunger
- good health
- ...





# “Connect the Unconnected” Izazi



Installation time: 1,5 h  
catching the signal from the Vodacom  
tower in Migoli (~10km away)



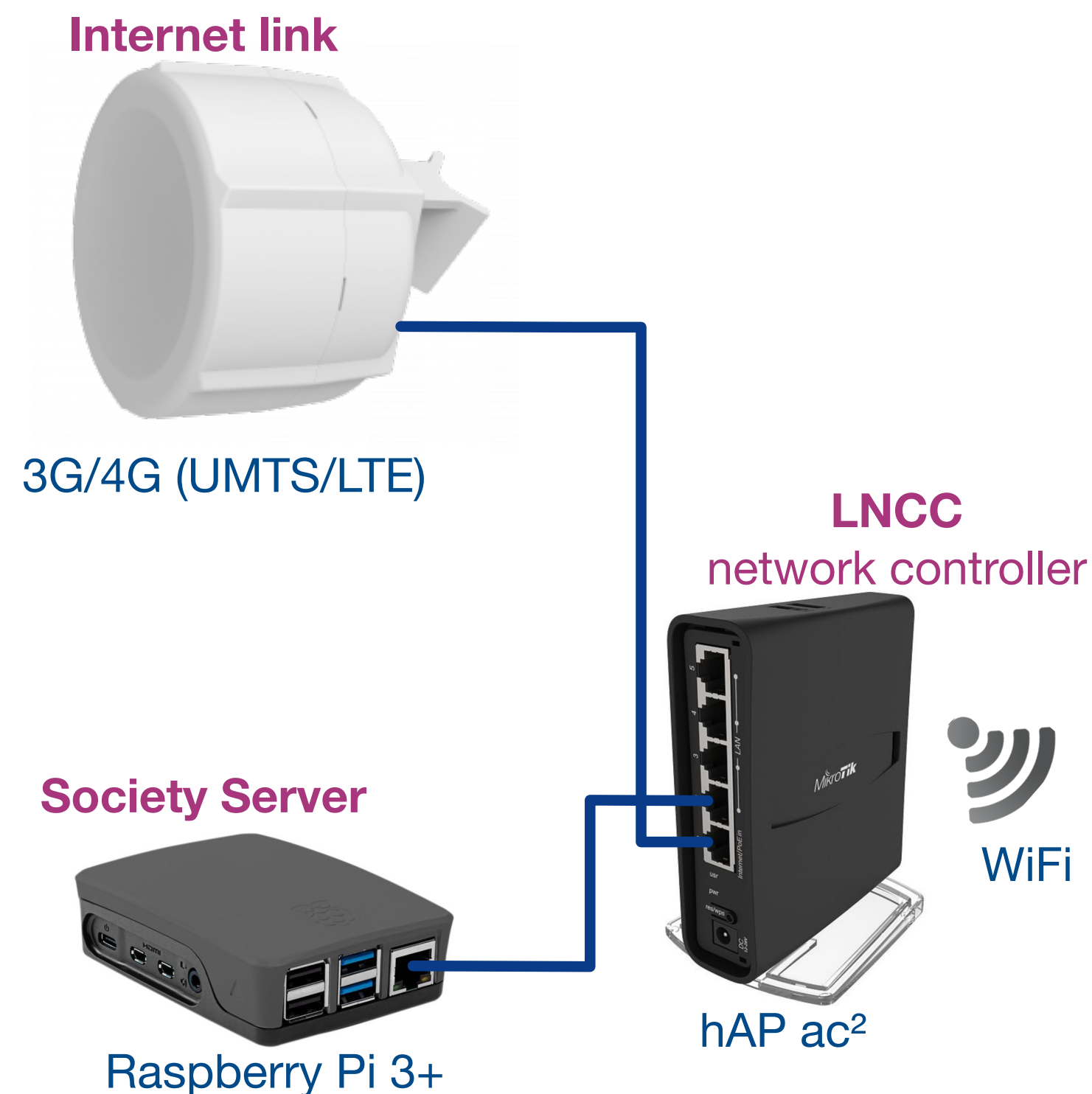
The mobile phone has replaced the machete (even in places without Mobile Broadband)

# VGS samarbeid

*dere konfigurerer, vi installerer i Afrika*

## Solving the challenge of access

- wireless information spot (InfoSpot)
- Reaching out >20 km to mobile network
- Affordable solution: OPEX <20 USD/month



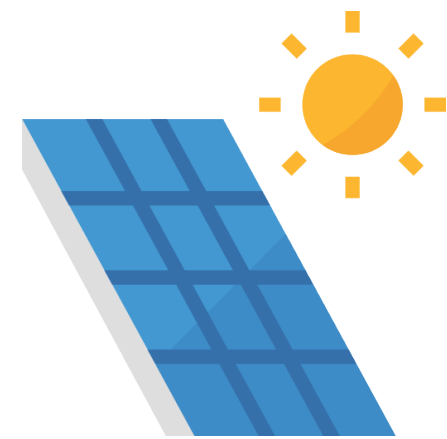


# What is SESA?

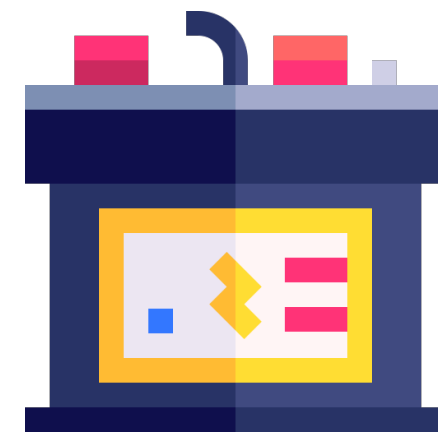
SESA is a collaborative project between the **European Union and nine African countries** (Kenya, Ghana, South Africa, Malawi, Morocco, Namibia, Tanzania, Rwanda and Nigeria) that aims at **providing energy access technologies and business models** that are easily replicable and generate local opportunities for economic development and social cohesion in Africa.



# ⚡ The technologies on focus



Decentralised renewables  
(Solar PV)



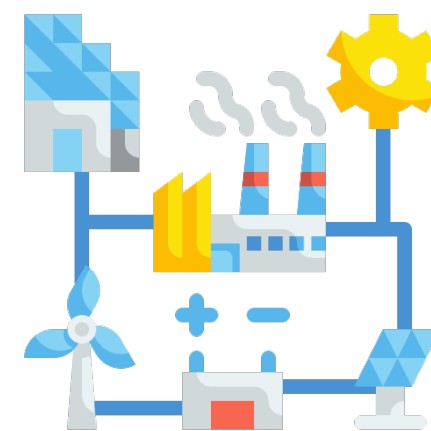
Second life electric vehicle (EV)  
batteries for stationary energy  
storage



Waste/Biogas-to-energy  
systems



Climate-proofing,  
resilience and adaptation



Smart micro-grids



Rural internet access &  
free Energy information



# Nextcloud.BasicInternet.org

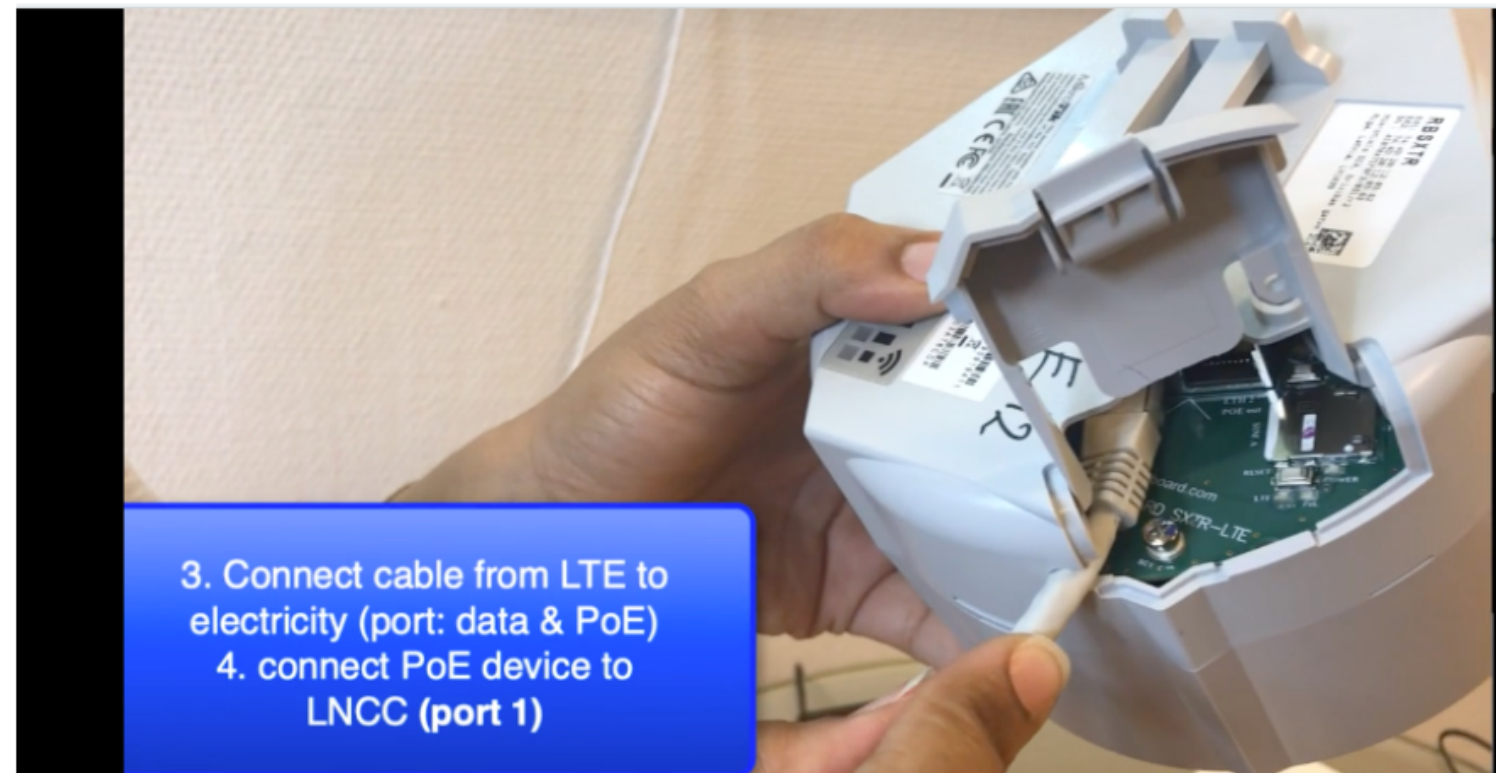
## open documentation (registration)

### Readme for LTE antenna configuration

Download Winbox.exe from Mikrotik and connect your antenna. Make sure to

- connect the power over ethernet (PoE) adapter such that "data+power" goes to the antenna.
- cable connects to port 1 (PoE in), see <https://vimeo.com/354375901>

SIM card is inserted (make sure to remove the PIN)



#### Establishing a Village Information Spot for Free Access to Information

##### Related Videos

Autoplay next video

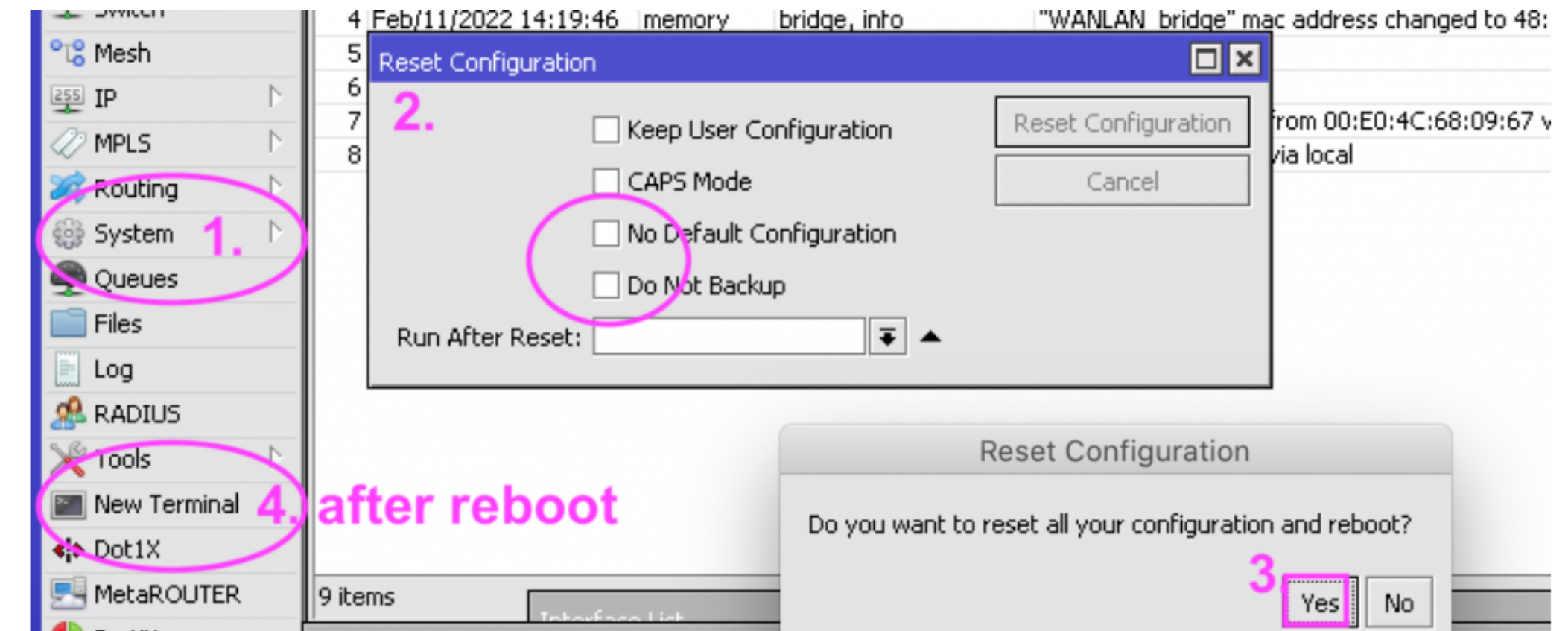


Catherine R. Kim...  
Josef Noll

How\_to\_connect\_BasicInternet.png

First, check if you see two green diodes (power & SIM). If you only see one light, it means that the antenna is not working with the Operator network (Vodacom, Tigo, MTN,...). If your antenna is configured, go directly to [01Control.md](#) and check for errors - if not configured, follow the steps below to install the software.

Once you are connected reset the device and **remove the old configuration**. Goto System = Reset Configuration (if you don't do that, we will end up with two configurations conflicting with each other)



System\_ResetConfiguration.png

The device will reboot. After, reboot, connect again using Winbox, and open terminal "New Terminal"

Paste the following code into the terminal (in Winbox)

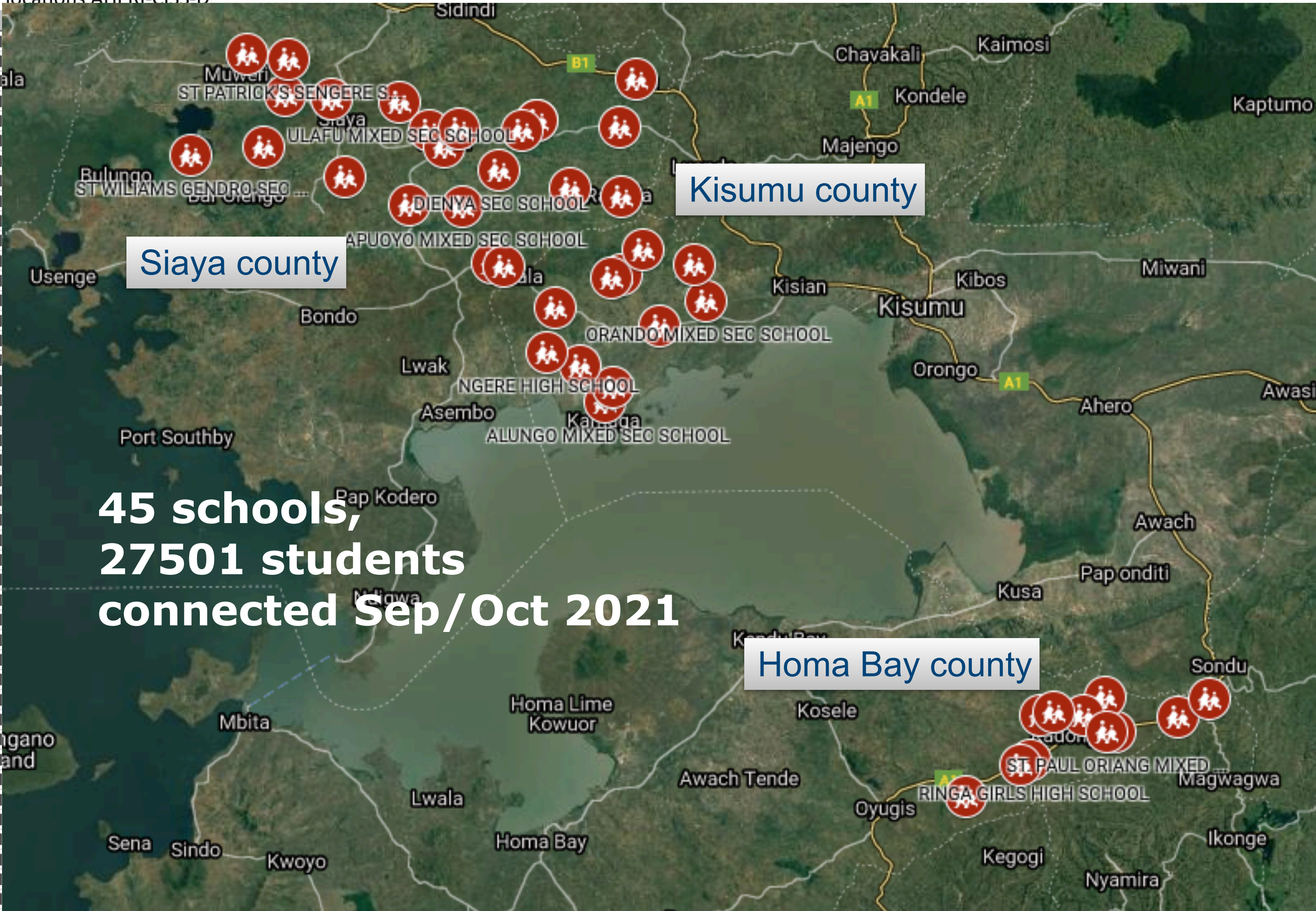
```
/interface lte
set [ find ] mac-address=AC:FF:FF:00:00:00 mtu=1500 name=lte1 network-
mode=3g,lte

/interface bridge
add comment="Bridge WAN(LTE) to LAN through Ether2" name=WANLAN_bridge
```

# 45 schools connected Sep/Oct 2021

#	name	location
1	ST. PAUL ORIANG MIXED SCHOOL	http://p
2	ORANDO MIXED SEC SCHOOL	http://p
3	MALELE MIXED SEC SHOOL	http://p
4	ULAFU MIXED SEC SCHOOL	http://p
5	BISHOP OKOTH GIRLS MBAGA SEC SC	http://p
6	PALA MIXED SEC SCHOOL	http://p
7	KOLWENY KINGSWAY SEC SCHOOL	http://p
8	KIT MIKAYI MIXED SEC SCHOOL	http://p
9	NDURU MIXED SEC SCHOOL	http://p
10	DANIS OBARA SEC SCHOOL	http://p
11	ATELA MIXED SEC SCHOOL	http://p
12	WANG'APALA BOYS HIGH SCHOOL	http://p
13	APUOYO MIXED SEC SCHOOL	http://p
14	AGORO OYOMBE SEC SCHOOL	http://p
15	RINGA GIRLS HIGH SCHOOL	http://p
16	ORERA MIXED SEC SCHOOL	http://p
17	DUDI GIRLS SEC SCHOL	http://p
18	BORO MIXED SEC SCHOOL	http://p
19	ST BARNABAS SEC SCHOOL	http://p
20	SINAGA GIRLS SEC SCHOOL	http://p
21	DIENYA SEC SCHOOL	http://p
22	RAMULA MIXED SEC SCHOOL	http://p
23	DHENE MIXED SEC SCHOOL	http://p
24	ST WILIAMS GENDRO SEC SCHOOL	http://p
25	ST PATRICK'S SENGERE SEC SCHOOL	http://p
26	ST MAR'YS YALA SCHOOL	http://p
27	NGIYA MIXED SEC SCHOOL	http://p
28	OBAMBO MIXED SEC SCHOOL	http://p
29	SENATOR OBAMA SEC SCHOOL	http://p
30	ST MATHEW NYASIDIUO MIXED SCHOL	http://p
31	ST PATRICK'S SENGERE SEC SCHOOL	http://p
32	ST PATRICK'S SENGERE SEC SCHOOL	http://p
33	ST PATRICK'S SENGERE SEC SCHOOL	http://p
34	ST PATRICK'S SENGERE SEC SCHOOL	http://p
35	ST PATRICK'S SENGERE SEC SCHOOL	http://p
36	ALONGO MIXED SEC SCHOOL	http://p
37	ST PATRICK'S SENGERE SEC SCHOOL	http://p
38	ALONGO MIXED SEC SCHOOL	http://p
39	MAGWAGWA MIXED SEC SCHOOL	http://p
40	RINGA GIRLS HIGH SCHOOL	http://p
41	NDURU MIXED SEC SCHOOL	http://p
42	ST PATRICK'S SENGERE SEC SCHOOL	http://p
43	BISHOP OKOTH GIRLS MBAGA SEC SC	http://p
44	ALONGO MIXED SEC SCHOOL	http://p

School locations AHERI-CISS-D



**45 schools,  
27501 students  
connected Sep/Oct 2021**

sponsored by our premium partner



- parallel to GIGIconnect first phase
- **5 Mbit/s over LTE** (dedicated SIM cards)
- 58 USD/month

# Oppsummert

“*det er bra å forstå hvordan ting fungerer*”

- Teknologiske utviklinger *møter* globale utfordringer
  - ➔ Milliarder av sensorer  $\Leftrightarrow$  elektronisk søppel
  - ➔ Cyber-/IoT-sikkerhet  $\Leftrightarrow$  **Trygghet** og **samfunnssikkerhet**
  - ➔ Automatisering, Industry4.0  $\Leftrightarrow$  **Tillit** og **transparens**
- Digital **partnerskap**
  - “Alle skal ha **fri tilgang til informasjon**”
  - Internett og teknologi til **samfunnsstøtte**
    - ➔ Project 1: Energy measurements
    - ➔ Project 2: InfoSpot configuration

**lær sensorer å snakke norsk**

