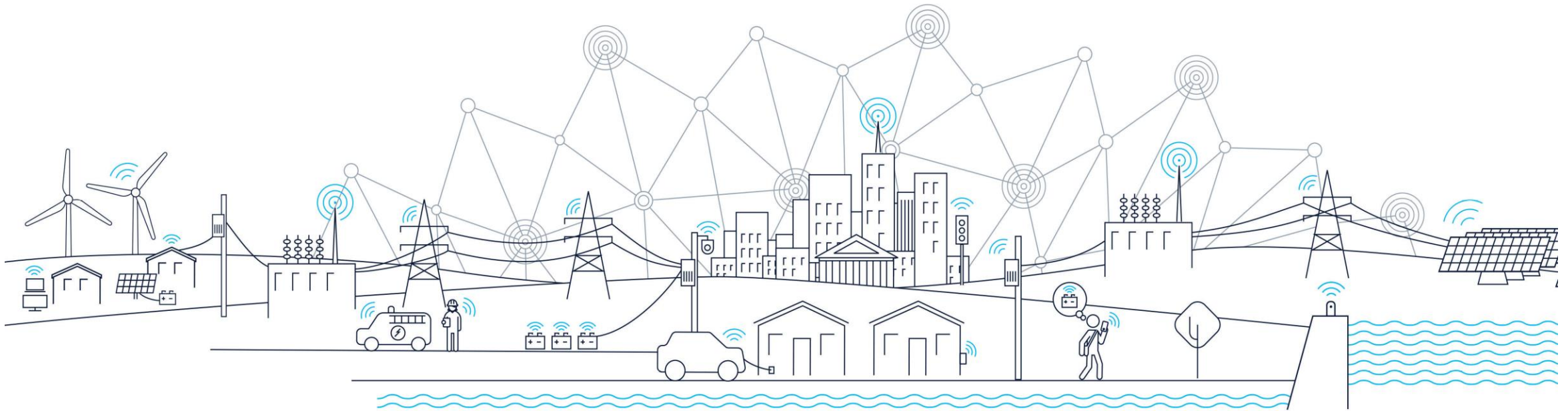


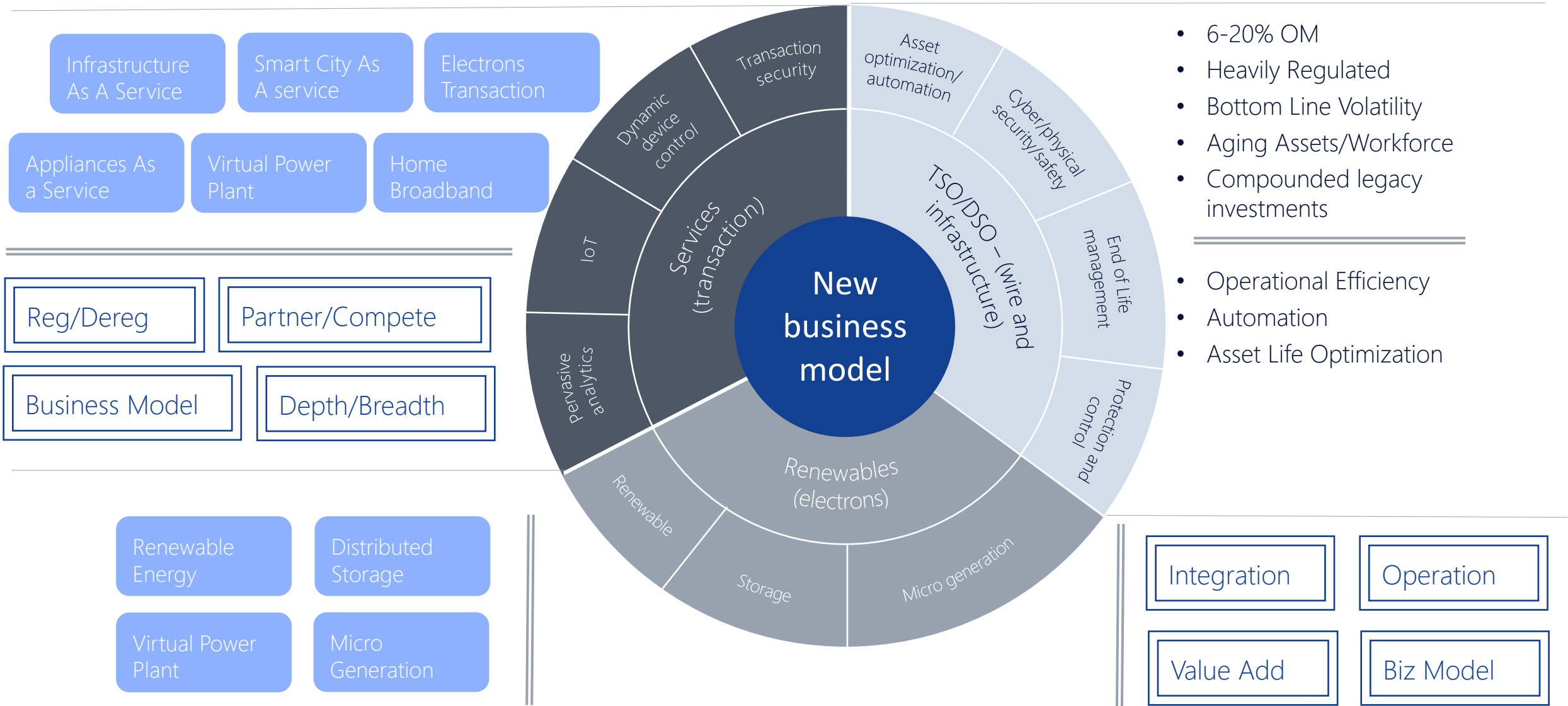
# Nokia

## Energy - mission-critical communications

February 2021



# The Disruption: Are You Ready?



# Nokia Business & Technology Groups

We create the technology to connect the world

## Mobile Networks (MN)

We help meet customer demands for mobile content and connectivity

## Fixed Networks (FN)

We help our customers to deliver the best broadband experience to everyone, everywhere

## IP/Optical Networks (ION)

We help our customers connect everyone and everything to the cloud, every time

## Nokia Enterprise

We enable the digitalization of asset-intensive industries with mission and business critical needs

## Global Services (GS)

We help our customers navigate through complexity and transform their business

## Nokia Software

We help our customers enrich and monetize digital experiences through the power of connected intelligence

## Nokia Technologies

We license intellectual property, including our patent portfolio and technologies as well as the Nokia brand

## Nokia Bell Labs

We are solving great industry challenges with disruptive inventions

# Industry 4.0 is driving new network requirements for asset intensive industries



Nokia has powered 1300+ of these mission critical networks globally  
220+ in industrial grade private wireless...



They have done a great job

SDH & PDH technology sunset

Leased line service phasing out

Ageing workforce

New requirements driving new technologies

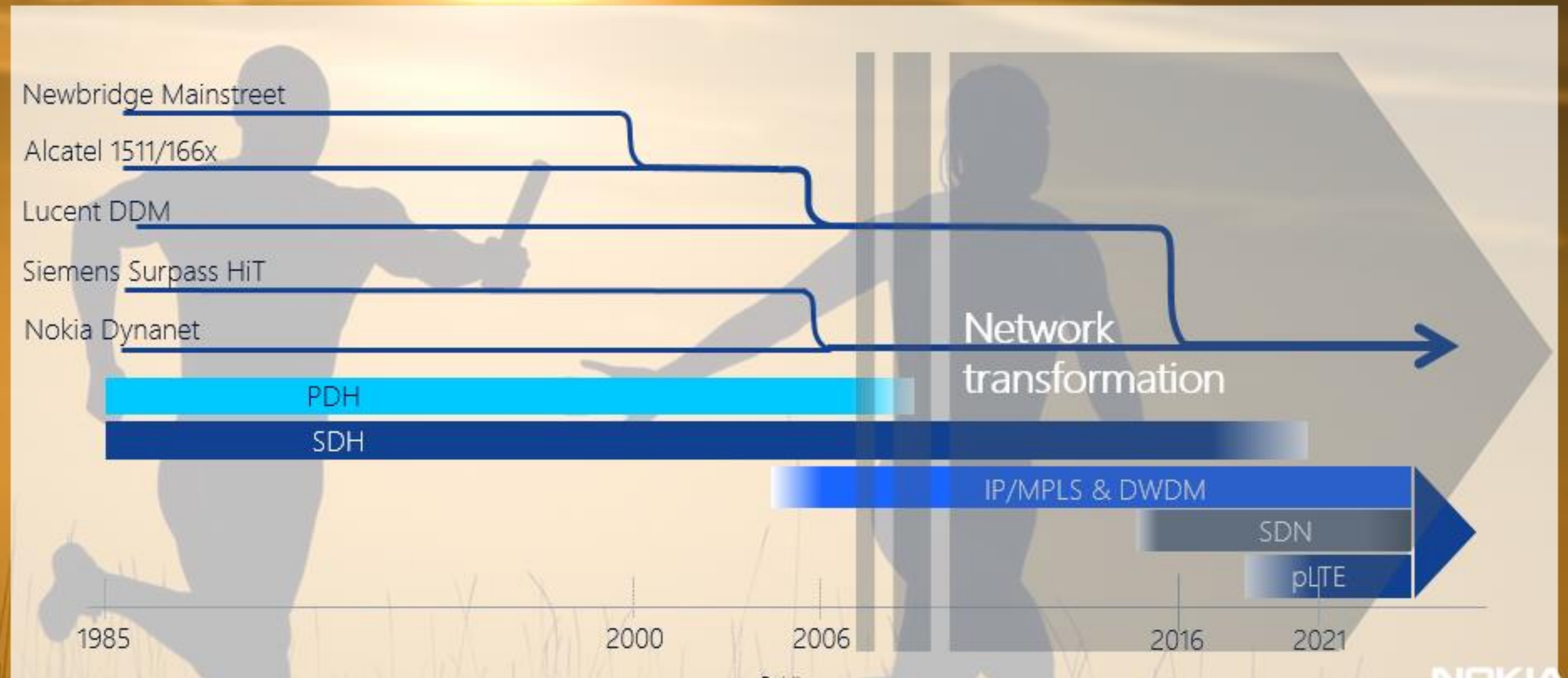
IP is coming, like it or not:

IEC 61850-90-5

R-GOOSE

IEEE C37.118.2 PMU's

# Nokia legacy in critical industry networks +35 years of commitment to the industry



# Empower your new energy future

## Nokia Bell Labs Future X architecture for power utilities

Leverage digitalization, automation and Industry 4.0

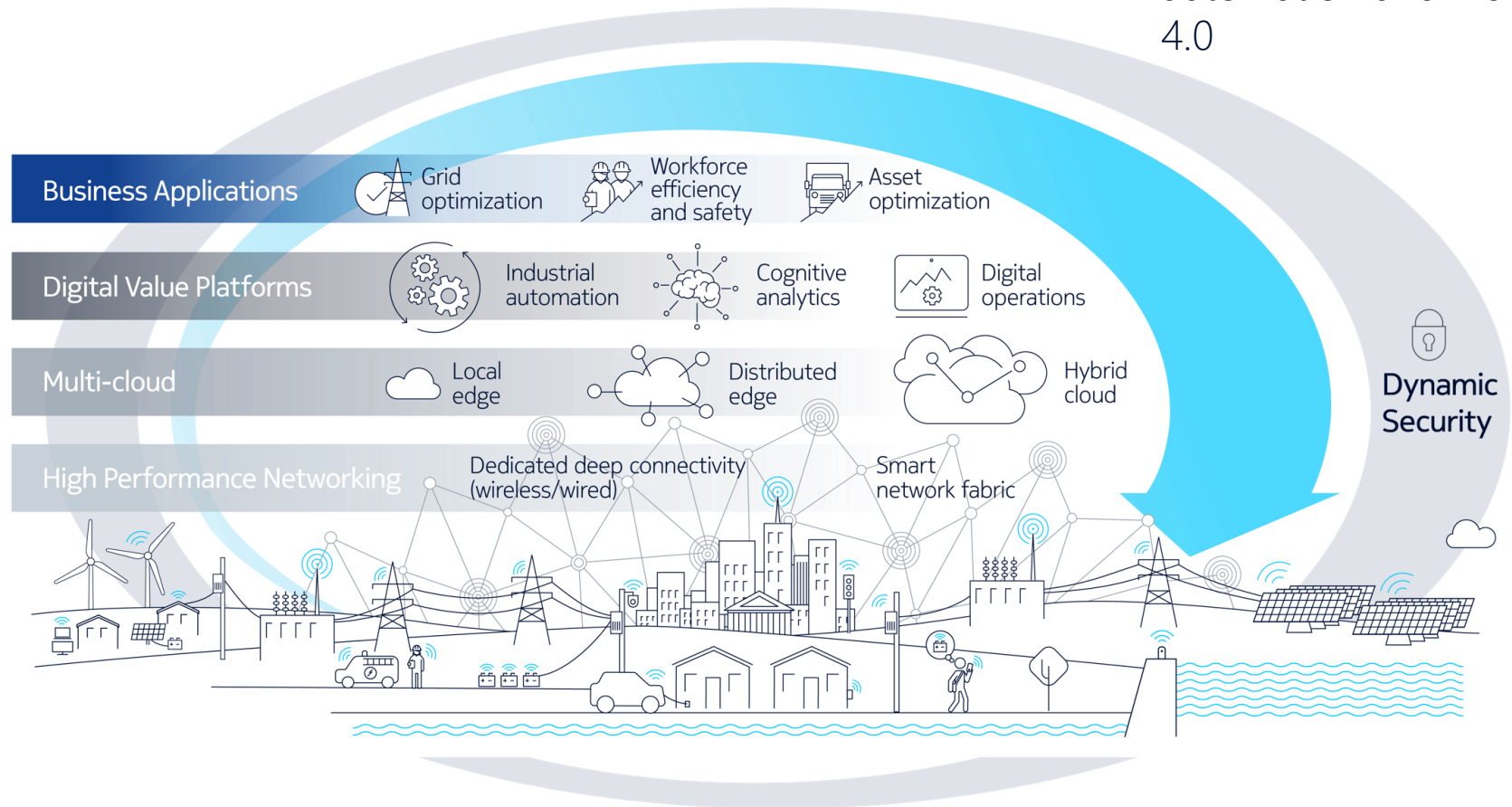
### Needs

Enhance existing operations and automate decision making while applying new operations applications and business models.

Support all devices and applications while optimizing existing investments into a stronger foundation for the future.

Massively extend to the edge for DER, automation, critical decision-making and new services.

Adopt new energy models, leverage new markets and move closer to your consumer.



### Renewables integration, automation and new business models



TELEPROTECTION  
VALIDATION  
Nokia Expertise

SIEMENS

GRID

ALSTOM

TOSHIBA

DIMAT  
ZIV

Schneider  
Electric

sprecher  
automation

ABB

SEL

RFL



BURNS & MCDONNELL

University of  
Strathclyde  
Glasgow

iometrix  
THE STANDARD FOR TESTING

UNIVERSITY of STRATHCLYDE  
POWER NETWORKS  
DEMONSTRATION CENTRE

The Nokia logo is property of Nokia, all other logos are property of the respective companies.



# Your gateway to accelerate communications innovation

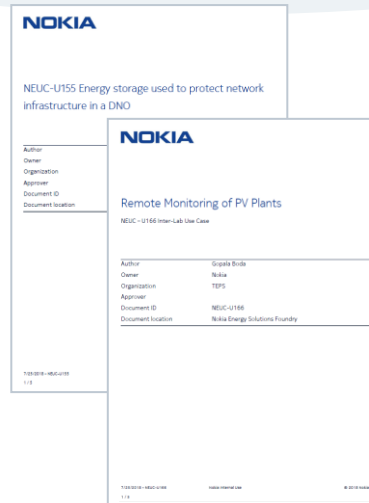
## For DER, cyber security and new business models



Nokia Energy Innovation Center

- Testing and demonstrations of solutions, features and management
  - Maintain business continuity: management, QoS, availability, ...
  - New priorities: Private wires use cases, security and asset optimization
  - Prepare for new normal: new remote worker capabilities, SD-WAN, ...
- Remote or onsite

Connect your lab,  
power your transformation,  
fuel your future



- Interactive use case library
- Utility executive forum

Intercontinental innovation



University of Strathclyde Dynamic Power Systems Laboratory

Innovation hub – define, test, validate and de-risk

# Why Nokia?

**+200**

Utilities with Nokia solutions

**+55**

Utilities with Nokia solutions for new services

Substation hardened IP/MPLS routers with 7 industry awards

**+1400**

Teleprotection circuits in service on IP/MPLS

**NERC/CIP**

Compliant end-to-end cyber security

Complete grid communications solutions with professional services

**€ 23.3bn**

Nokia revenues

**EIC**

Energy Innovation Centre

**MPLS**

Market leader

**DWDM**

Market leader

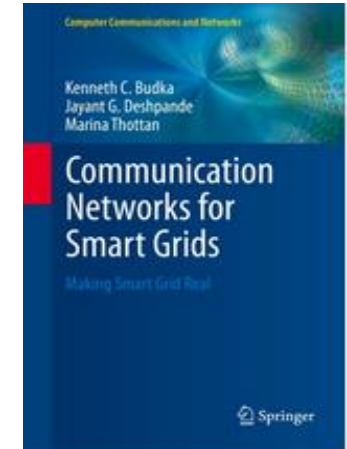
**P-LTE**

Market leader

**SDN**

Market leader

**NOKIA** Bell Labs



**NOKIA**

# WÄRTSILÄ

Business Finland Webinar  
2020.02.09.

## WÄRTSILÄ POWER PLANT FROM THE INSIDE



JORDAN, IPP3 (573 MW)

**7200 MW** capacity installed in the Middle East at **300+ locations**

\*Wartsila Middle East sales region consists of Pakistan, Jordan, Lebanon, Iraq, Afghanistan and Syria

# REMOTE SITES



DESERTS



JUNGLES



ARCTIC  
CLIMATE  
ZONES



- Full coverage - global network of Expertise Centres
- 450 power plants connected
- 53 installations monitored from Dubai Expertise Centre
- 24/7 operation
- 100+ power plants supported during COVID-19

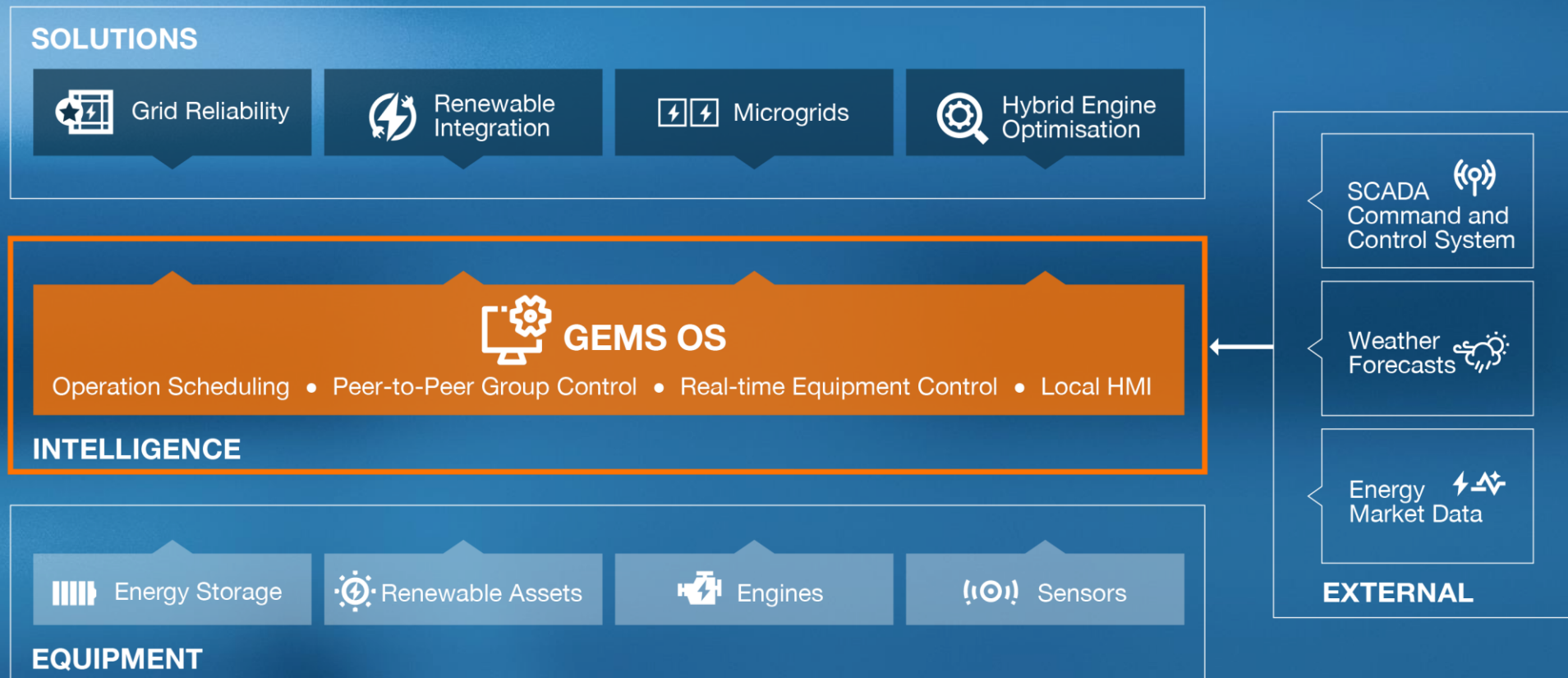
Virtual reality goggles & smart point-R to provide full support to site crews from the other side of the World





# WÄRTSILÄ ENERGY STORAGE

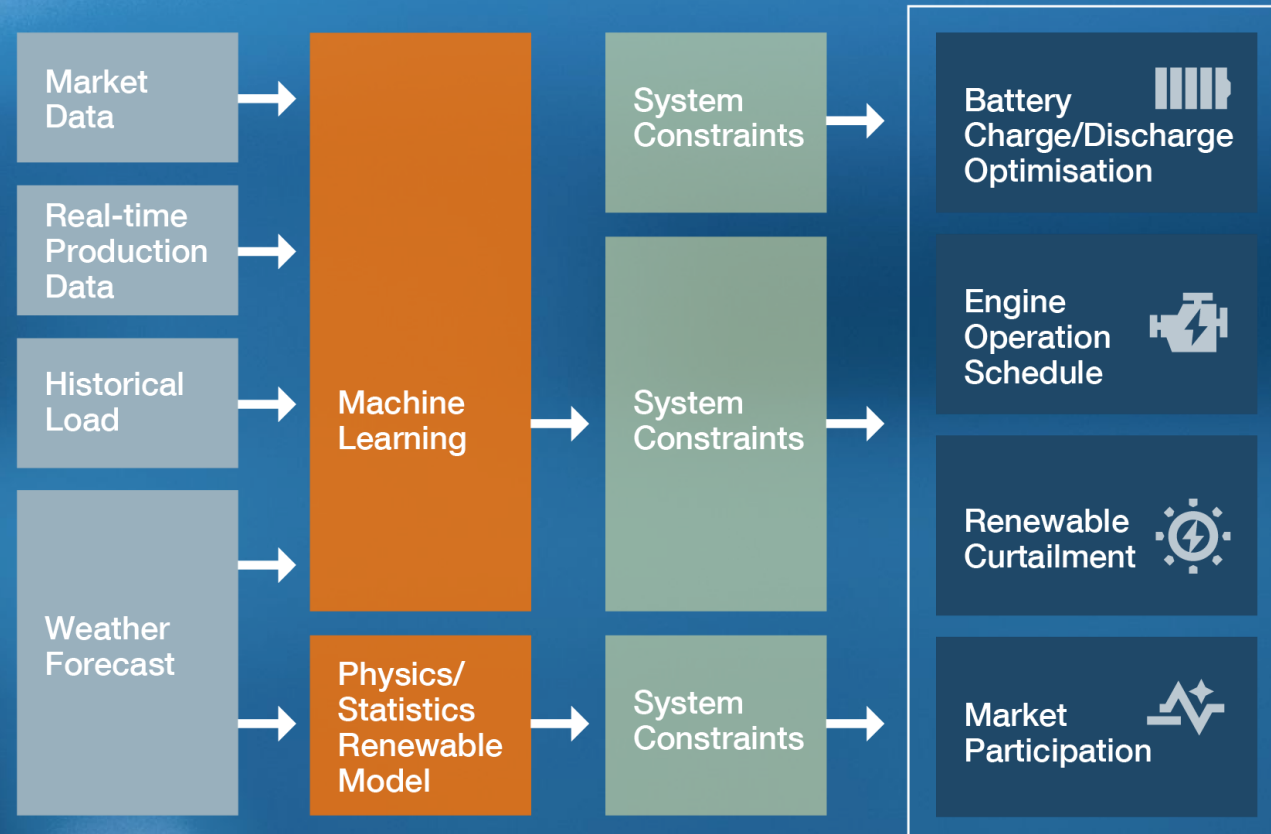
# GEMS: Software is at the heart of integration



Comprehensive software suite for planning, monitoring & optimization

Cloud-based computing enables to constantly building in new data to refine and adjust predictions

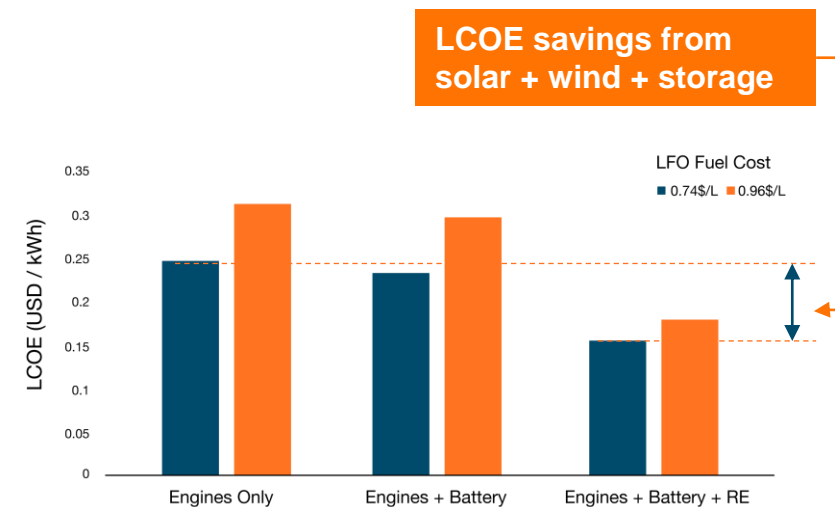
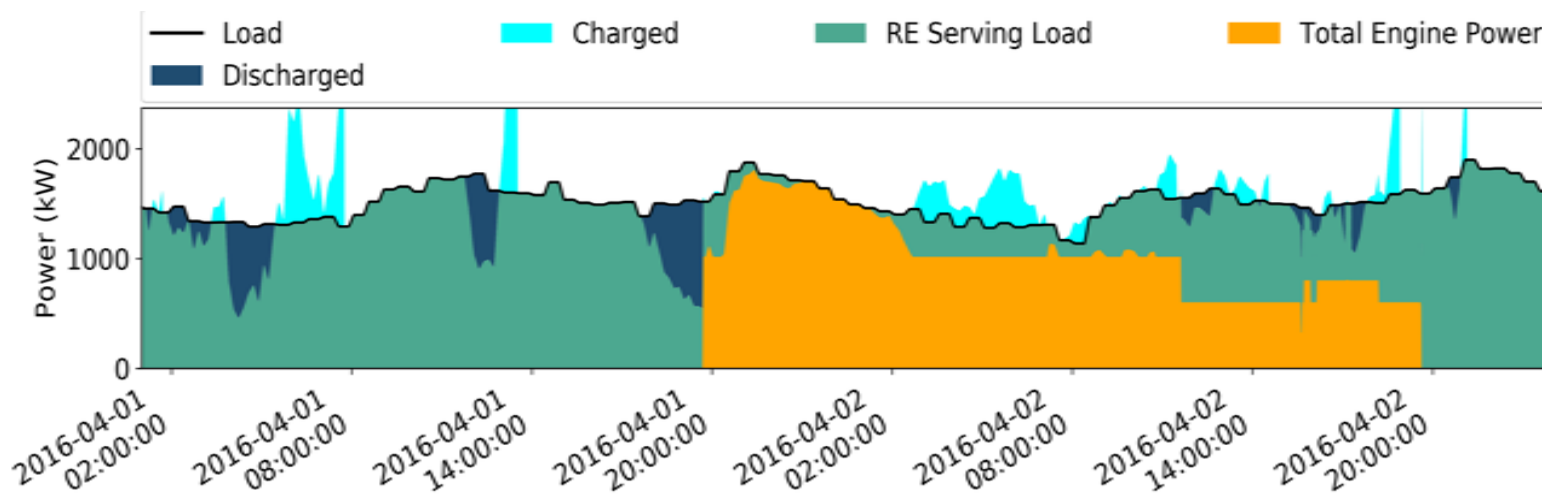
## GEMS Machine Learning— intelligent by predictions



# ISLAND GRID ON GRACIOSA

- Goal of EMS to maximize renewable resources, minimize diesel costs and to improve grid reliability
- Generation assets include diesel generator sets, wind and solar

**120**  
days on variable  
renewable energy





# AI and Machine Learning in Modelling & Simulation of Grid Loads

**Klaus Känsälä**  
Principal Scientist

Technical Research Centre of Finland, VTT  
Klaus.Kansala@vtt.fi

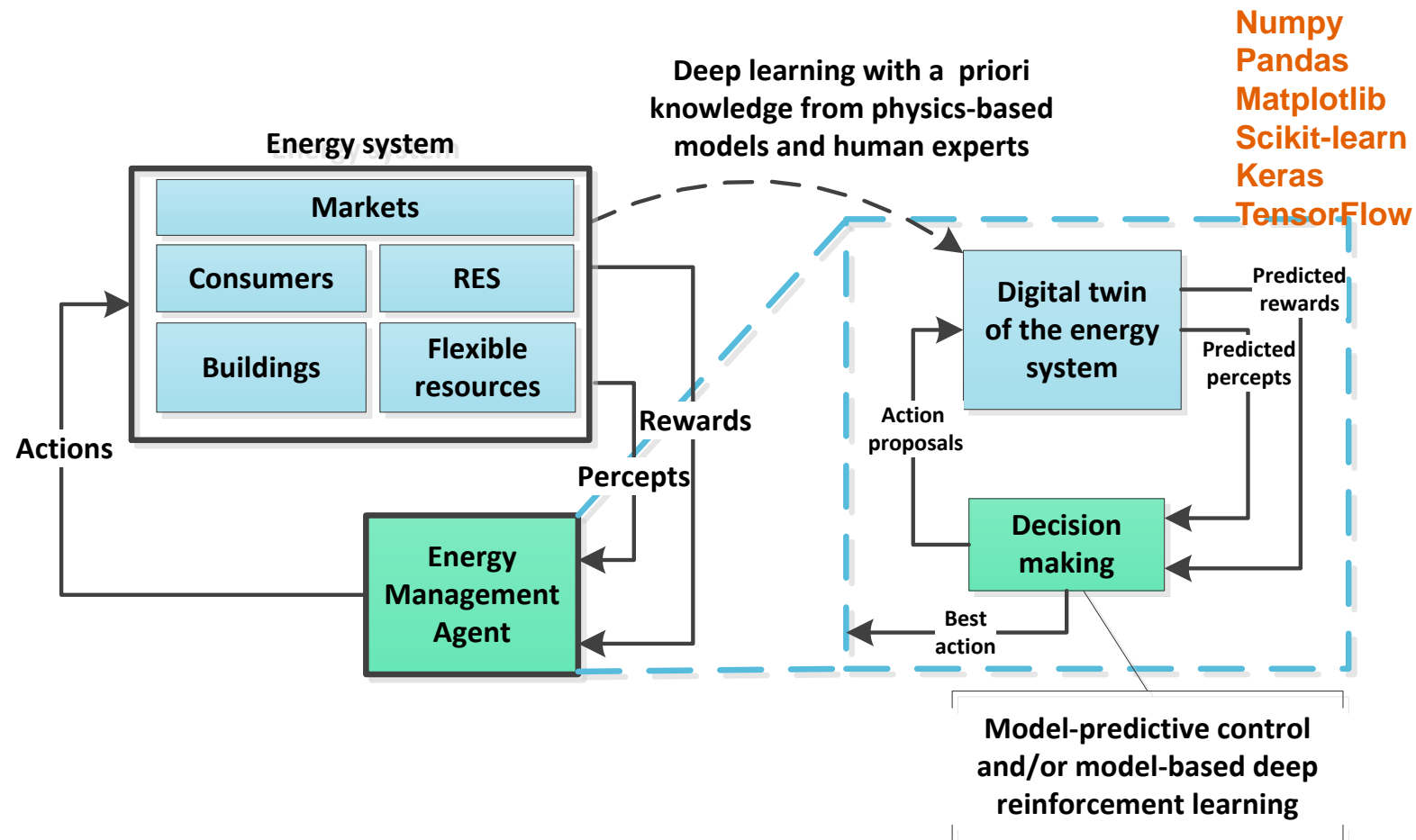
10/02/2021 VTT – beyond the obvious

# AI-based energy and flexibility management

**Core idea:** extend the AI approach that has worked in games and simulations to real-life energy systems.

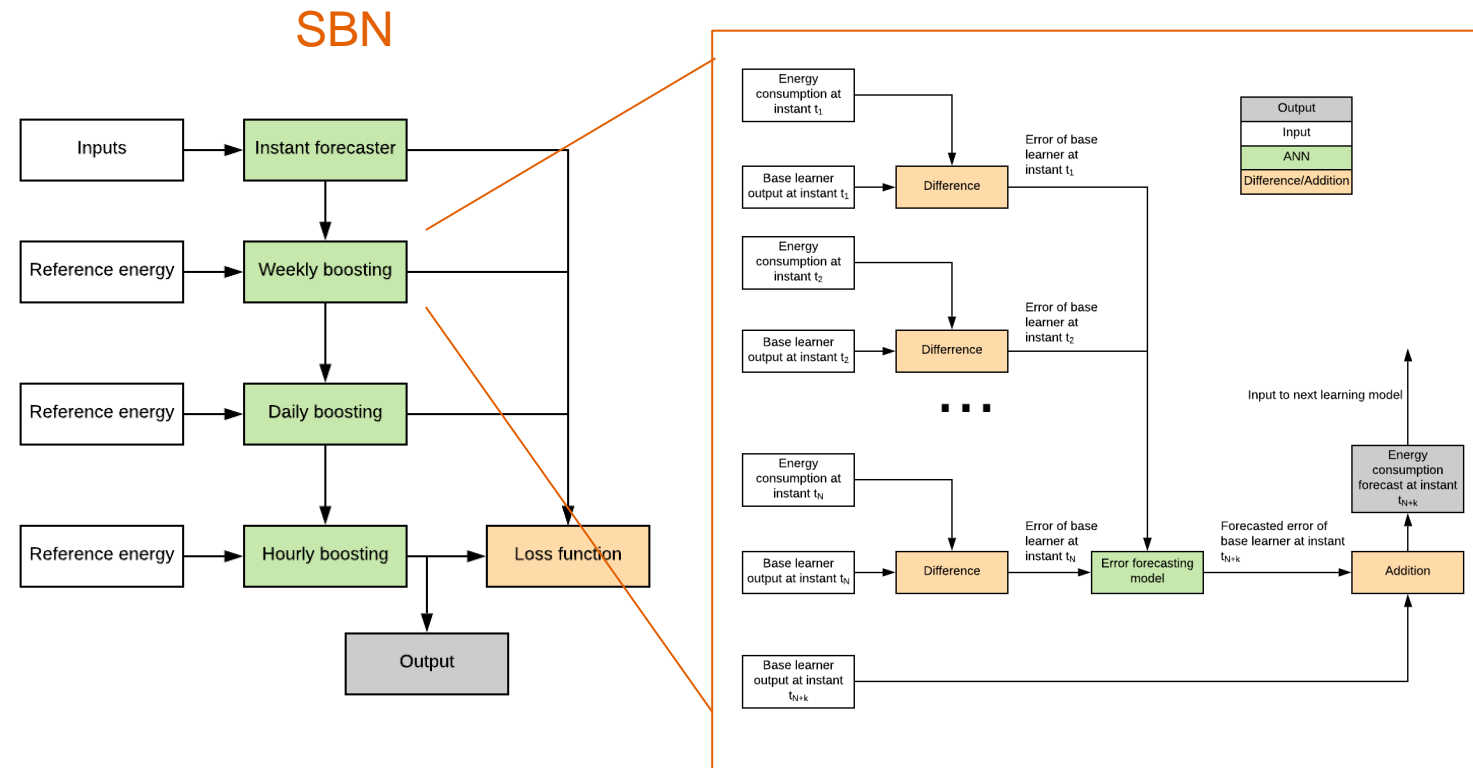
**Data-efficient Deep Learning** technologies are used for creating models of energy systems, which can be then used by **AI planning and decision-making algorithms** to optimize energy usage according to a custom criteria.

# Machine learning used to create digital twins of the real world systems



# Data-efficient and physics-aware deep learning for energy system modelling

- Combines the best parts of deep learning and physics-based modelling
- Stacked Booster Network (SBN)
  - Innovate Neural Network Architecture style for energy system modelling
- Physics-based building models used for pre-training the SBN model
  - I.e., we use the physics-based model to teach the physics to the deep learning model





The VTT logo consists of the letters 'VTT' in a bold, white, sans-serif font, centered within a solid orange square. The background of the entire slide is a photograph of high-voltage power lines and pylons against a bright orange sky, with the pylons appearing as dark silhouettes.

VTT

# VTT EnergyTeller

*The future of the  
energy sector*

10.2.2021

VTT – beyond the obvious

# Taking power generation capacity forecasts to a whole new level

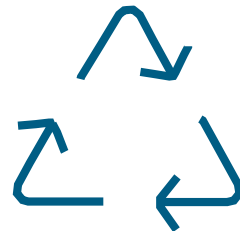
Online software crafted for **Fingrid** – Finland’s transmission system operator – solves a challenge well known by many grid operators. CapFor precisely forecasts the available production capacity of CHP and nuclear power plants.



Delivering daily forecasts  
up to 7 days  
in advance



Accurate forecasts  
with errors  
below 5%



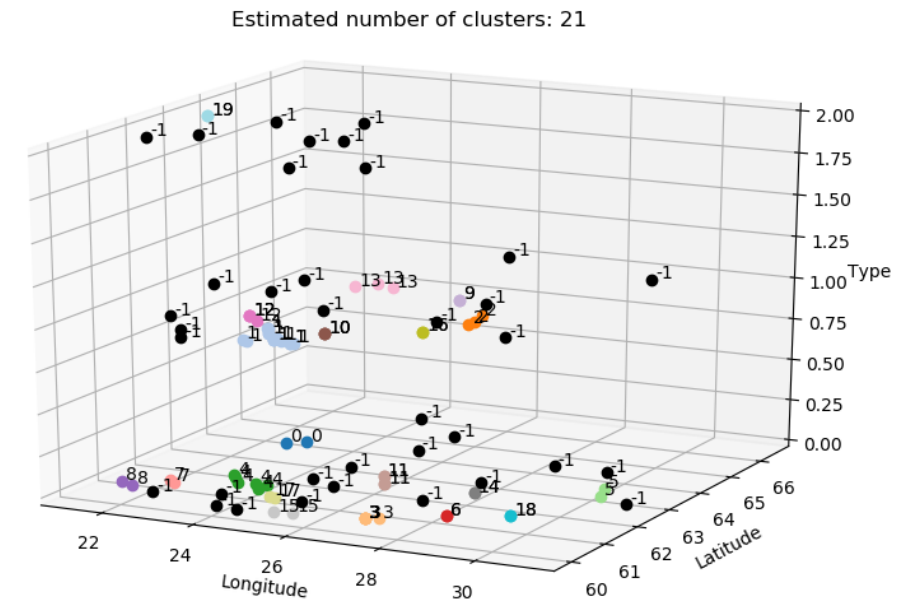
Enables  
increased  
grid reliability

“VTT connected its machine learning and energy system knowhow with novel ideas to create a unique solution answering the electricity market’s pressing needs.”

[Learn More](#)

# Aggregation methodology

- The idea behind the aggregation was to allow for an educated guess on the electricity production of small plants (<50MW)
- Small plants were clustered based on similar characteristics and behaviours
- Electricity production data (dependent on weather/location) could be estimated and scaled in terms of the plants' capacities
- Approach based in finding the error in production and assigning this error proportionally to the remaining plants

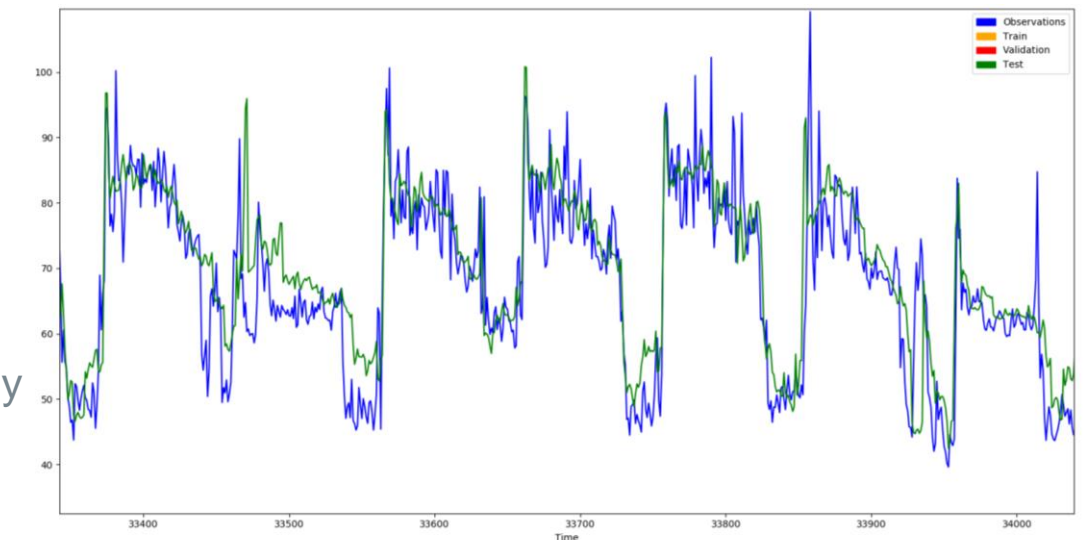
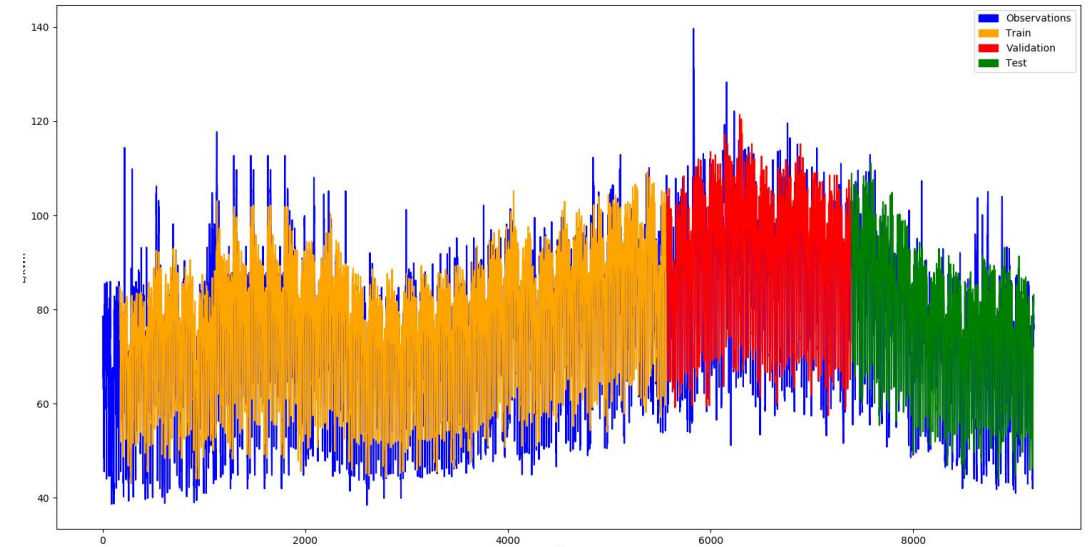


# Handling missing data

- Production curves for aggregated plants - location, type of production and temperature dependency - Several plants still missing
- Associated all plants to a closest weather measurement station, guaranteeing that all plants have weather measurements
- Approach based in finding the error in production and assigning this error proportionally to the remaining plants
- Plants without data would be bundled with plants that had historical production information

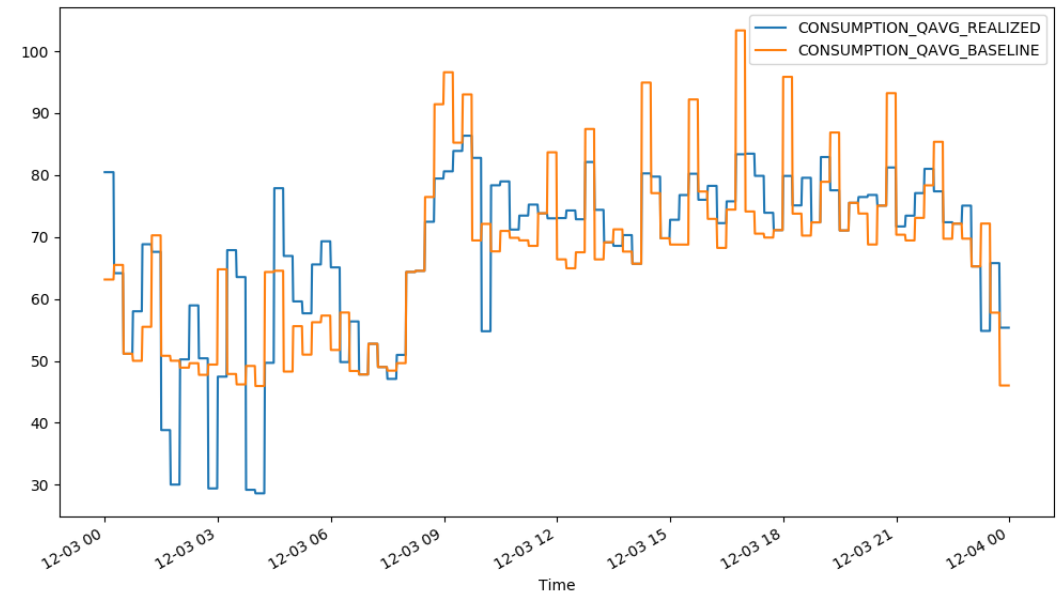
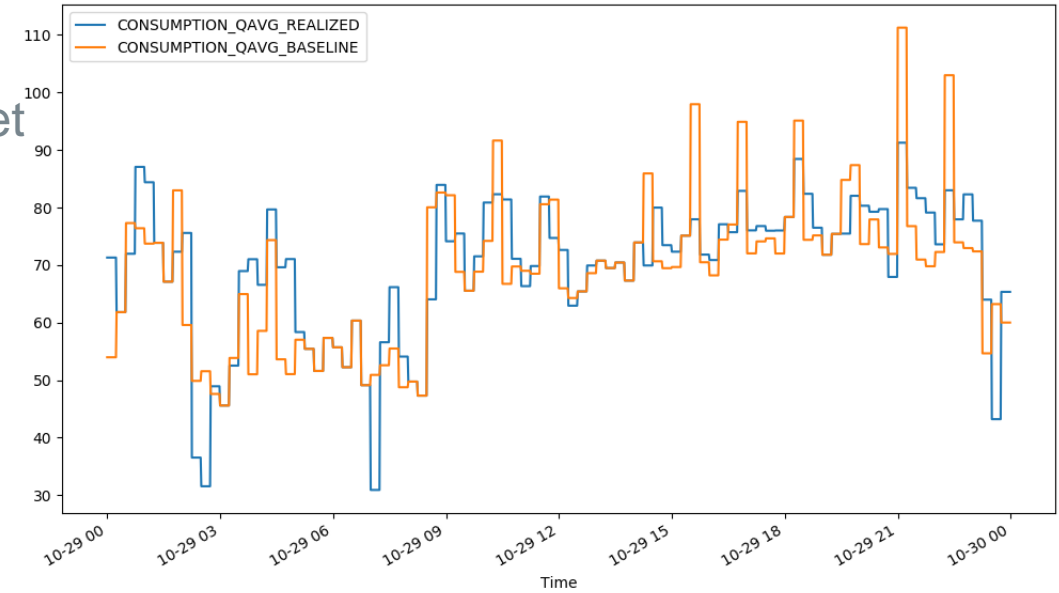
# Supermarket electric load forecasting @ S-Markets in Oulu

- Forecasting tasks
  - Total load and various sub-metering points (e.g. freezers & coolers, HVACs, etc.)
  - Forecast length: 2h-36h
  - Data resolution: 15min, 60min
- Evaluated methods:
  - Statistical and machine learning methods
    - ARIMA, SVR
  - Neural networks:
    - MLP, LSTM, GRU, 1D-CNN
- Results
  - Forecasting errors of best models varied between 3-16% depending on the forecasting length and metering point
  - SVR and LSTM were the best performing models in the study



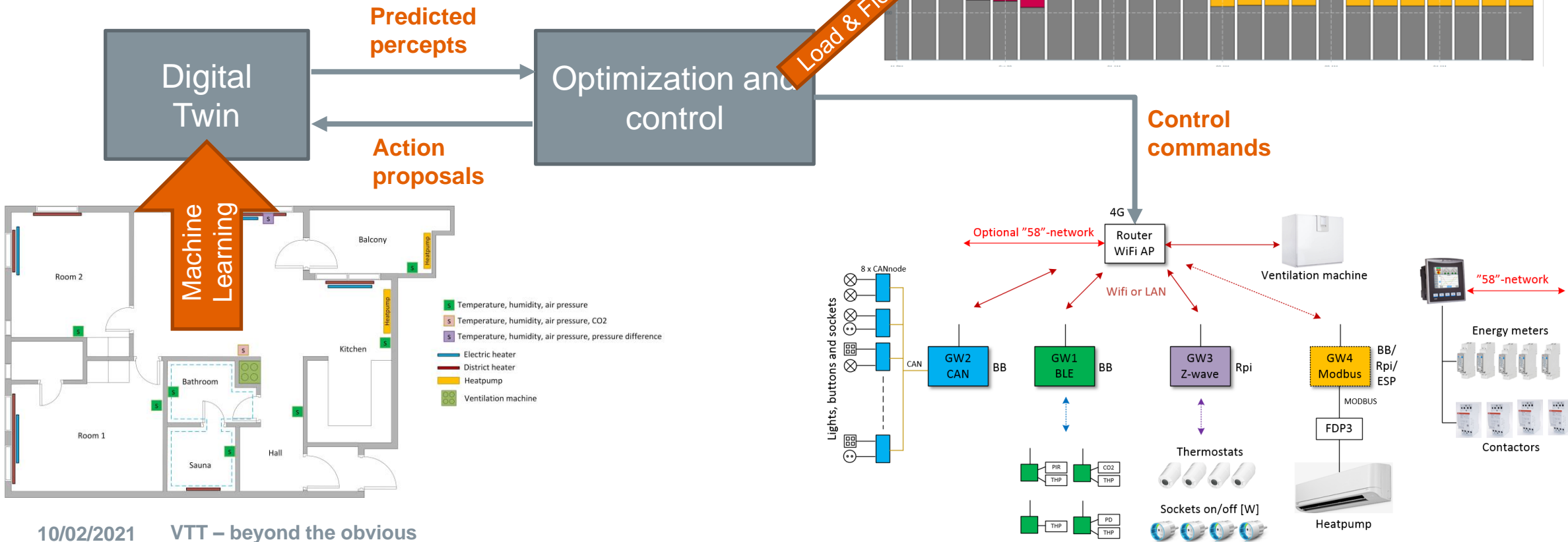
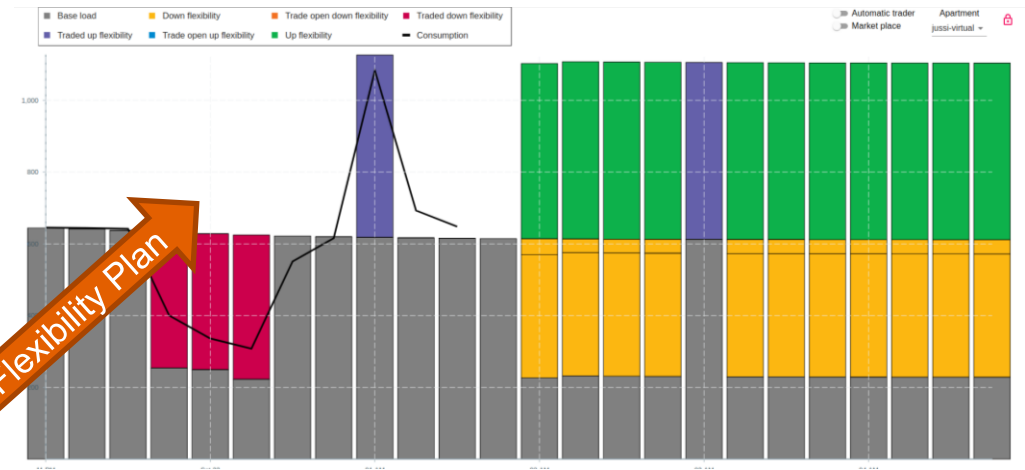
# Supermarket flexibility management

- Flexibility management study with data from S-Market Taira using a simulated battery (20 kWh capacity)
  - Optimization targets
    - Peak load (power tariff)
- Approach:
  - Model-predictive control with deep learning based load and generation forecasting
  - Trust-region based optimization methods
- Results:
  - 8.4% reduction of peak loads on average



# Energy Management Agent @ VTT Test Apartment

- Real time load and flexibility forecasting
- Flexibility management and optimization
- Integrated with building automation and control for demand management



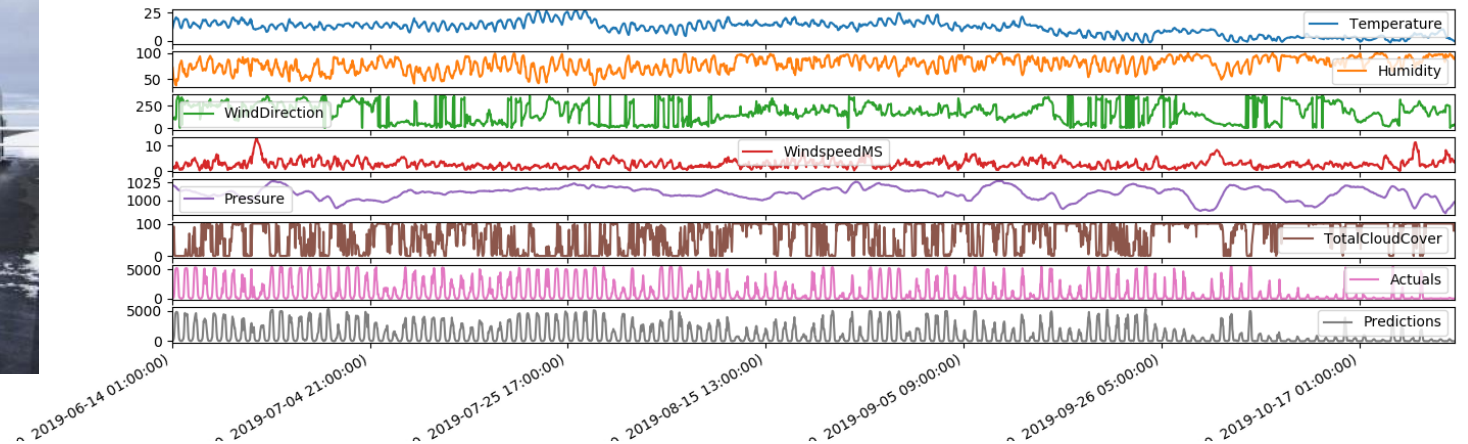
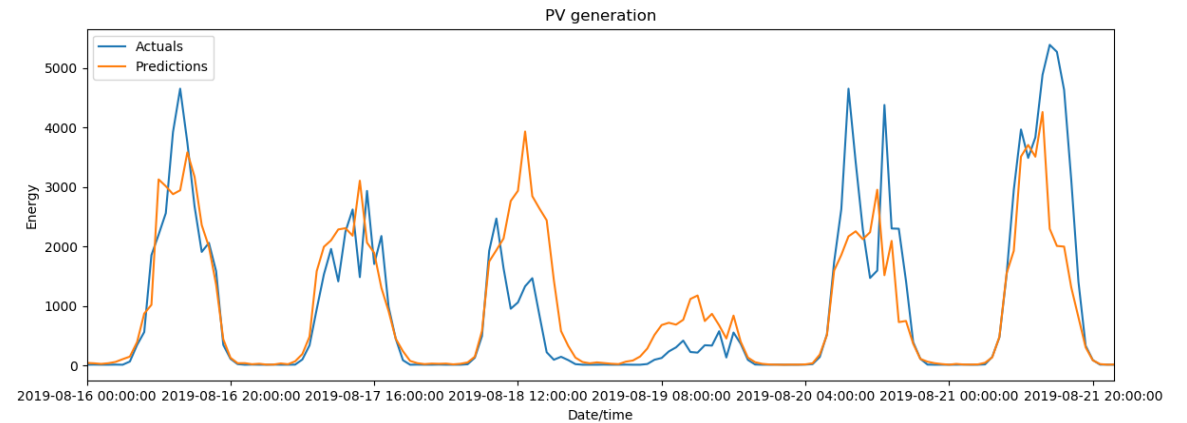
# Solar panel energy generation forecasting

- Forecasting based on FMI weather forecasts:
  - Temperature, Humidity, WindDirection, WindspeedMS, Pressure, TotalCloudCover

## Forecasting 1-24h ahead energy production at VTT Oulu premises



1 hour ahead forecast 11.7% (NRMSE)





# bey<sup>o</sup>nd

## the obvious

<https://www.vttresearch.com/en>