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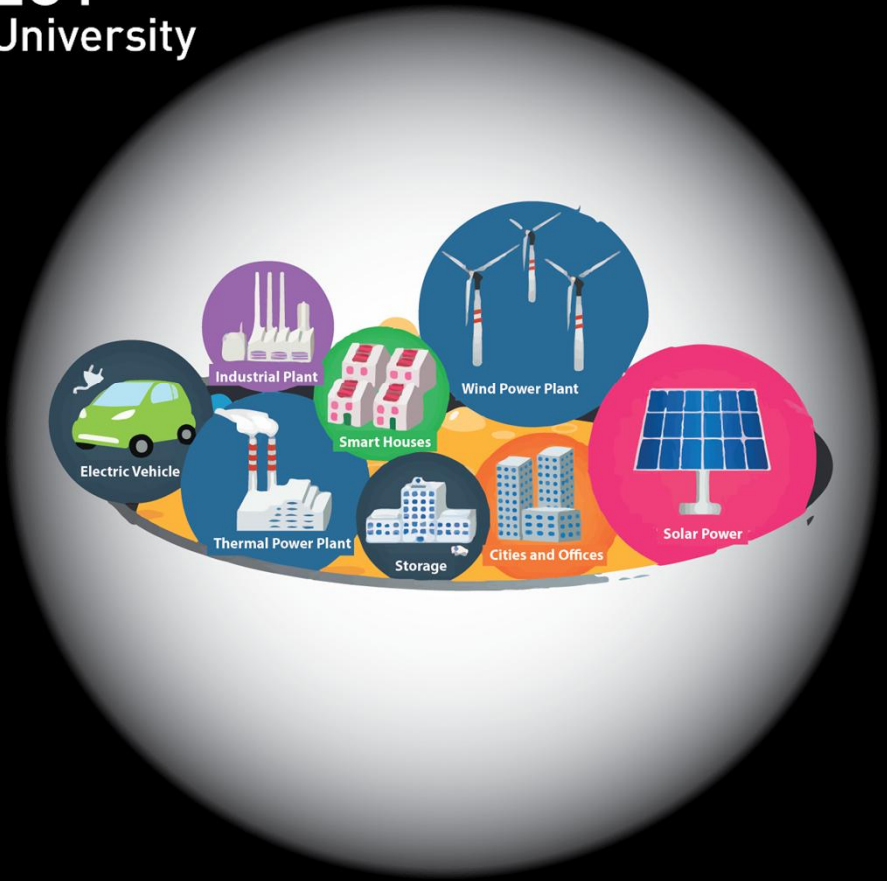


# Energy Systems and Automation

## Key Requirements and Potential Technologies for Beyond 5G Networks

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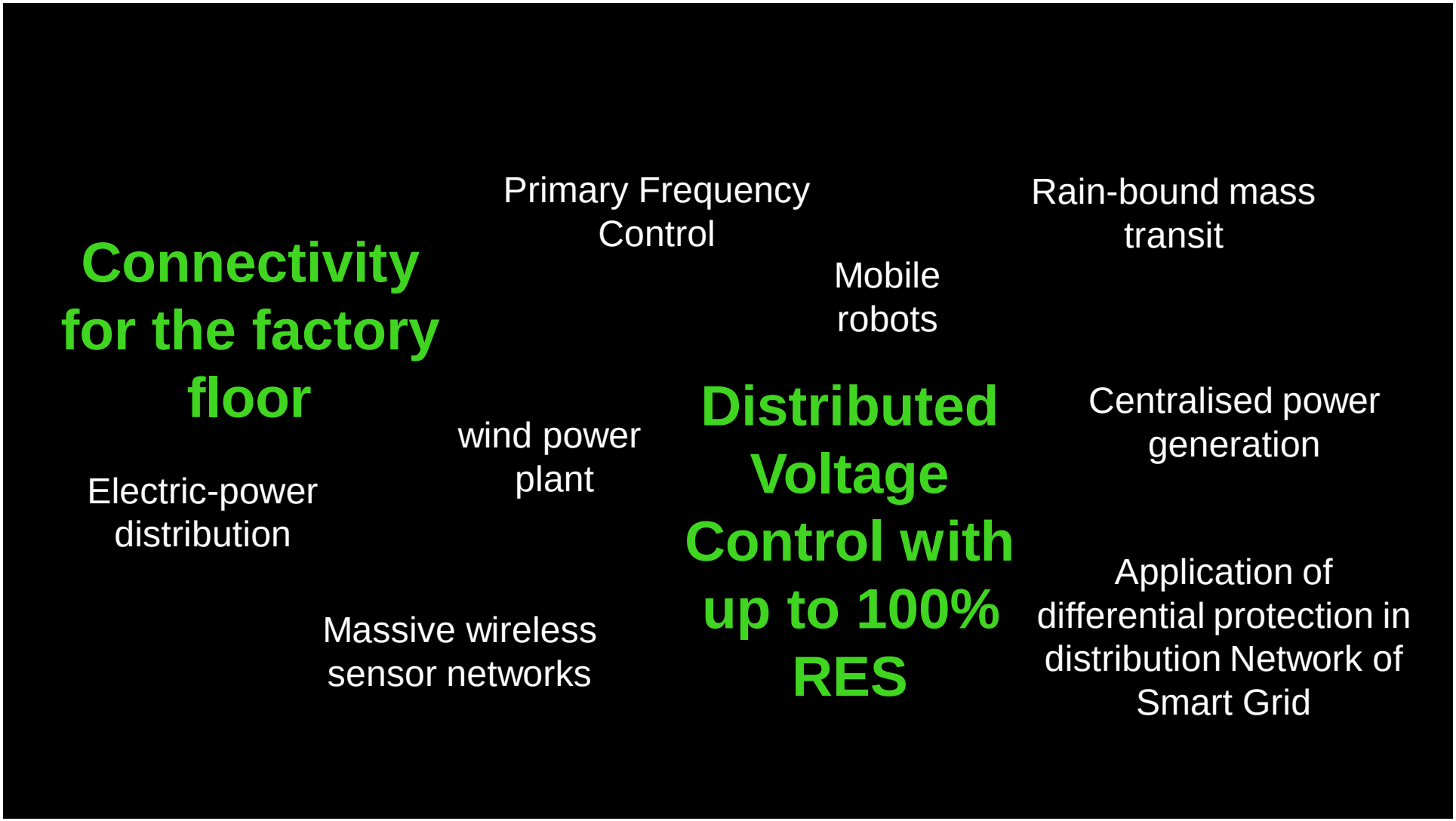
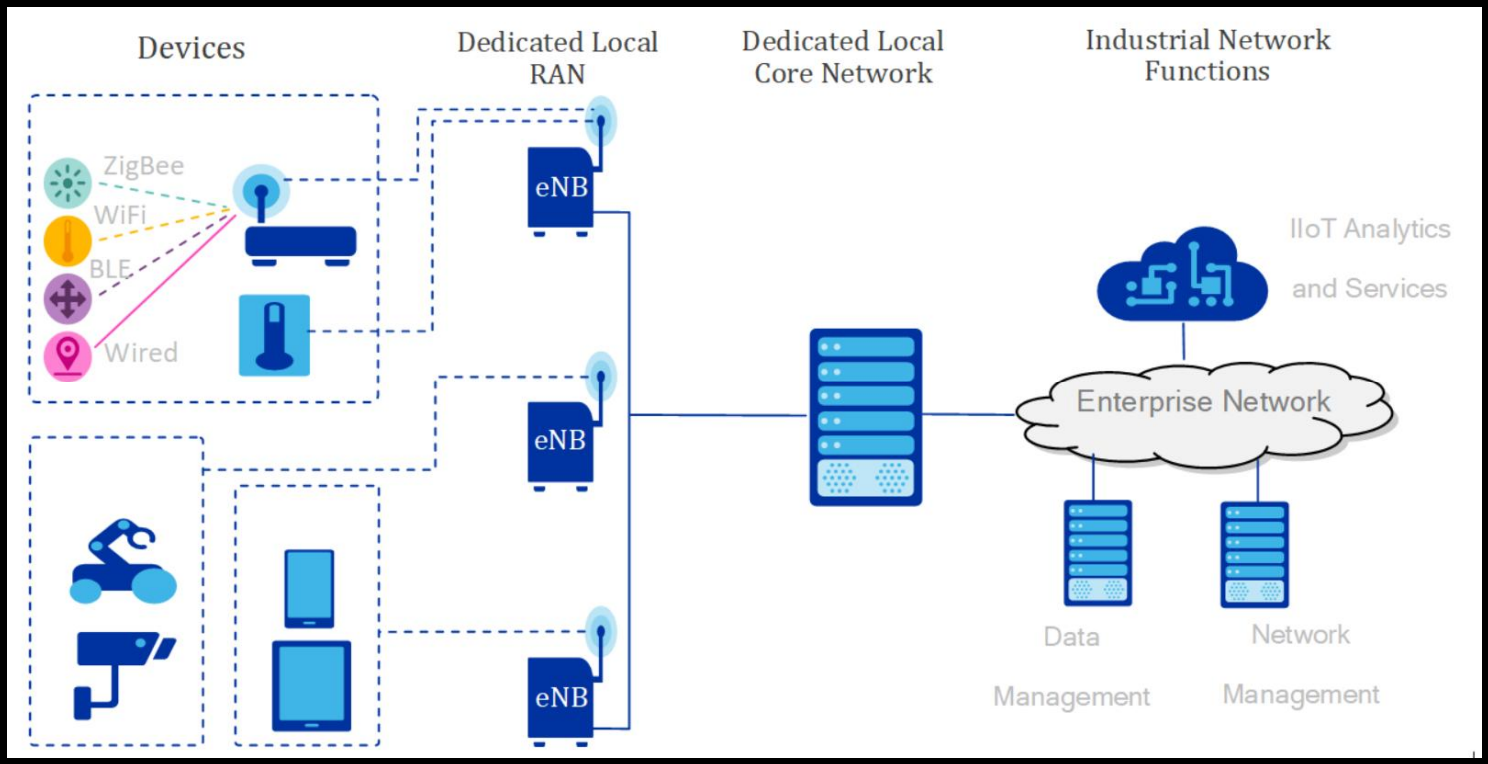
## Network-type to support Industry

3GPP TR 22.804 Rel. 16

- **Type-A network:** a 3GPP network that is not for public use and for which service continuity and roaming with a PLMN is possible.
- **Type-B network:** an isolated 3GPP network that does not interact with a PLMN.


Primary Frequency Control
Rain-bound mass transit
Connectivity for the factory floor
Mobile robots
wind power plant
Distributed Voltage Control with up to 100% RES
Centralised power generation
Electric-power distribution
Application of differential protection in distribution Network of Smart Grid
Massive wireless sensor networks

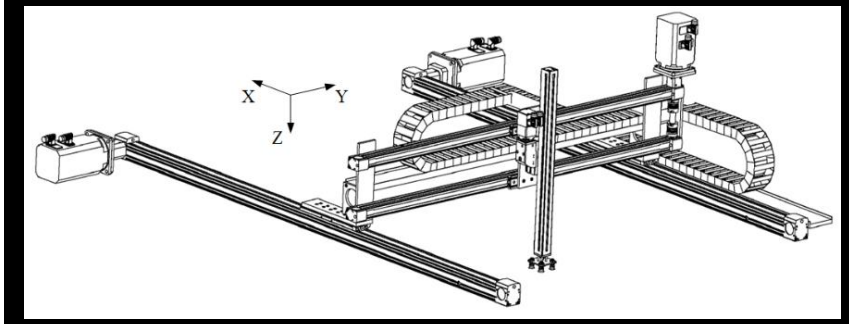
Adapted from 3GPP TR 22.804 V16.2.0 (2018-12)



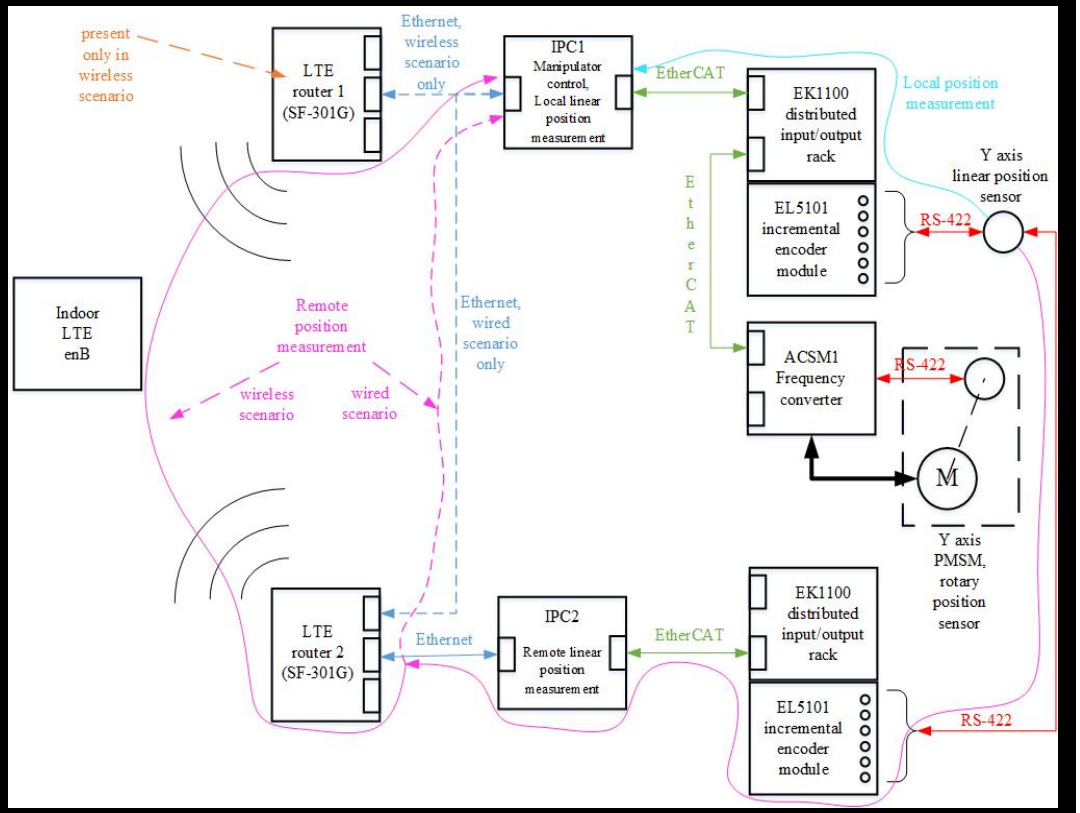

Factory of the future using a dedicated local network for industrial automation.

# What is the **impact of latency for industrial automation**?

## Ethernet vs. LTE

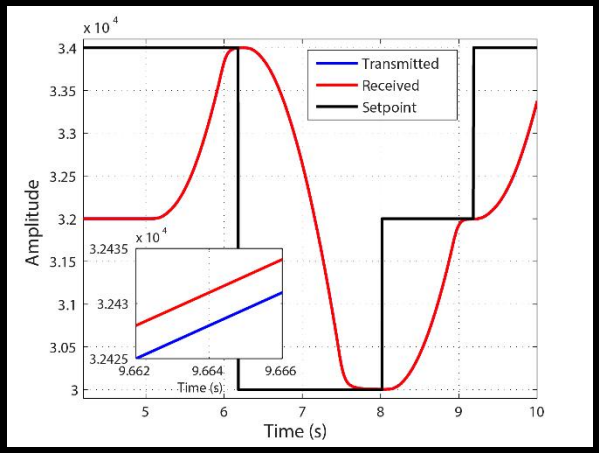



Position control using a Cartesian robot in axis Y

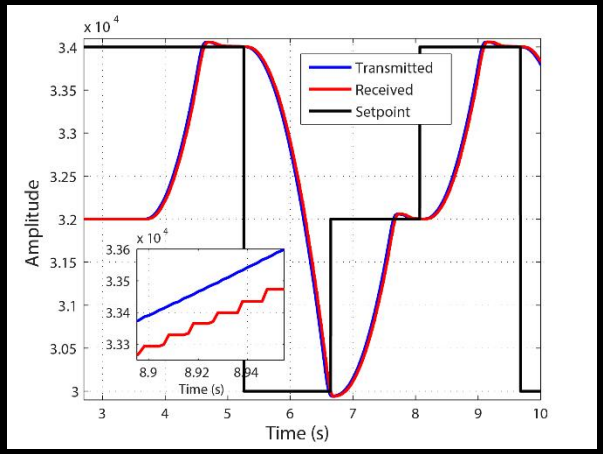



Functional setup diagram used in this experiment

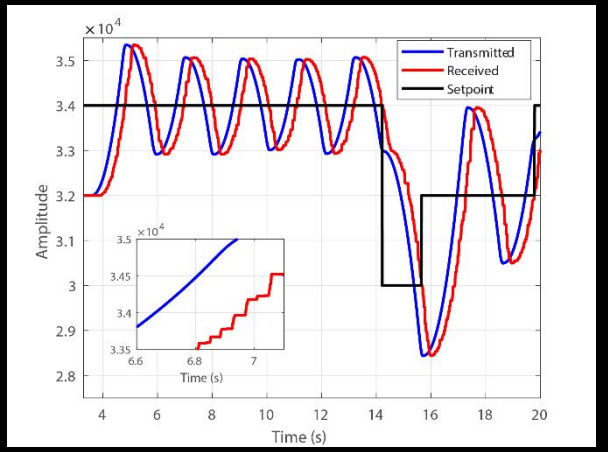
## Ethernet: 3 ms



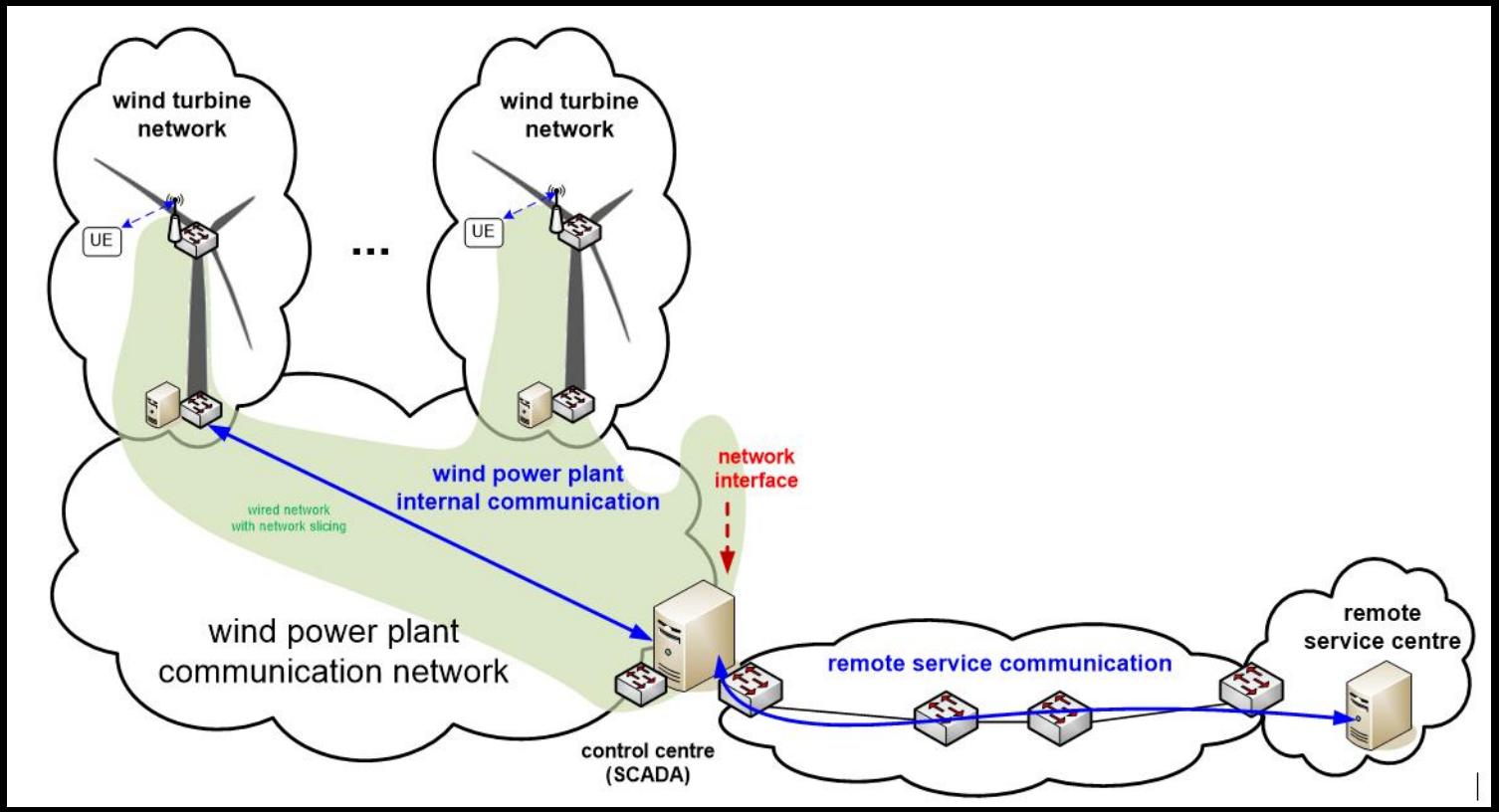

## LTE w/out impairments: 26 ms




## LTE with impairments: 290 ms

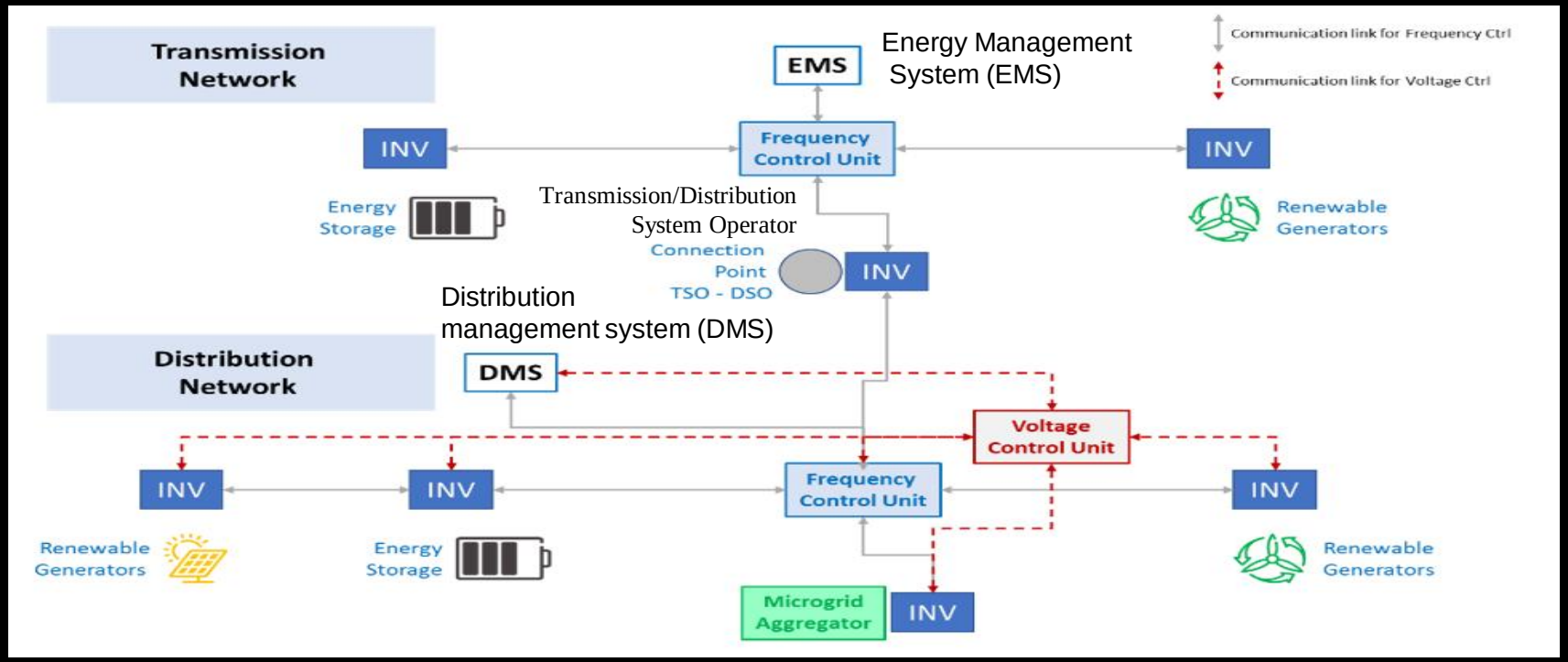


Adapted from 3GPP TR 22.804 V16.2.0 (2018-12)




# Communication network for a wind power plant

Adapted from 3GPP TR 22.804 V16.2.0 (2018-12)




# Communication network in future energy systems

**Key requirements**

- Diversity of latency requirements
- Massive sensor deployments
- Network flexibility
- Reliable connectivity with Guaranteed QoS
- Network security

## Potential technologies

**OFDM+OMA**
**OFDM+NOMA**
**GFDM+OMA**
**GFDM+NOMA**

Waveform and multiple access

+

**URLLC**
**mMTC**
**EH**

Latency, massive deployment, and Energy efficiency

+

**SDR**
**Edge computing**
**SON**
**Cyber Security**

Network architecture and flexibility

**THANKS!**

**Dick Carrillo Melgarejo**

Energy Internet and IoT-based Systems Group

**Currently projects:**

Ee-IoT: Energy Efficient IoT networks

Fireman: Predictive maintenance and rare events using IoT

Fusion Grid: Connectivity + micro-grid for remote areas

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