Grid Integration of ENERCON Wind Turbines

ENERCON Sales - Grid Integration
Richard Ogiewa, M. Eng.

07 October 2015, Stockholm

Which turbine type?

Where is the PoC?

How many turbines?

Is there more than one PoC?

“I want to build X turbines.
The project has to fulfill the grid code.”

Which voltage level at the PoC?

Which grid code?

What is ENERCON‘s scope?

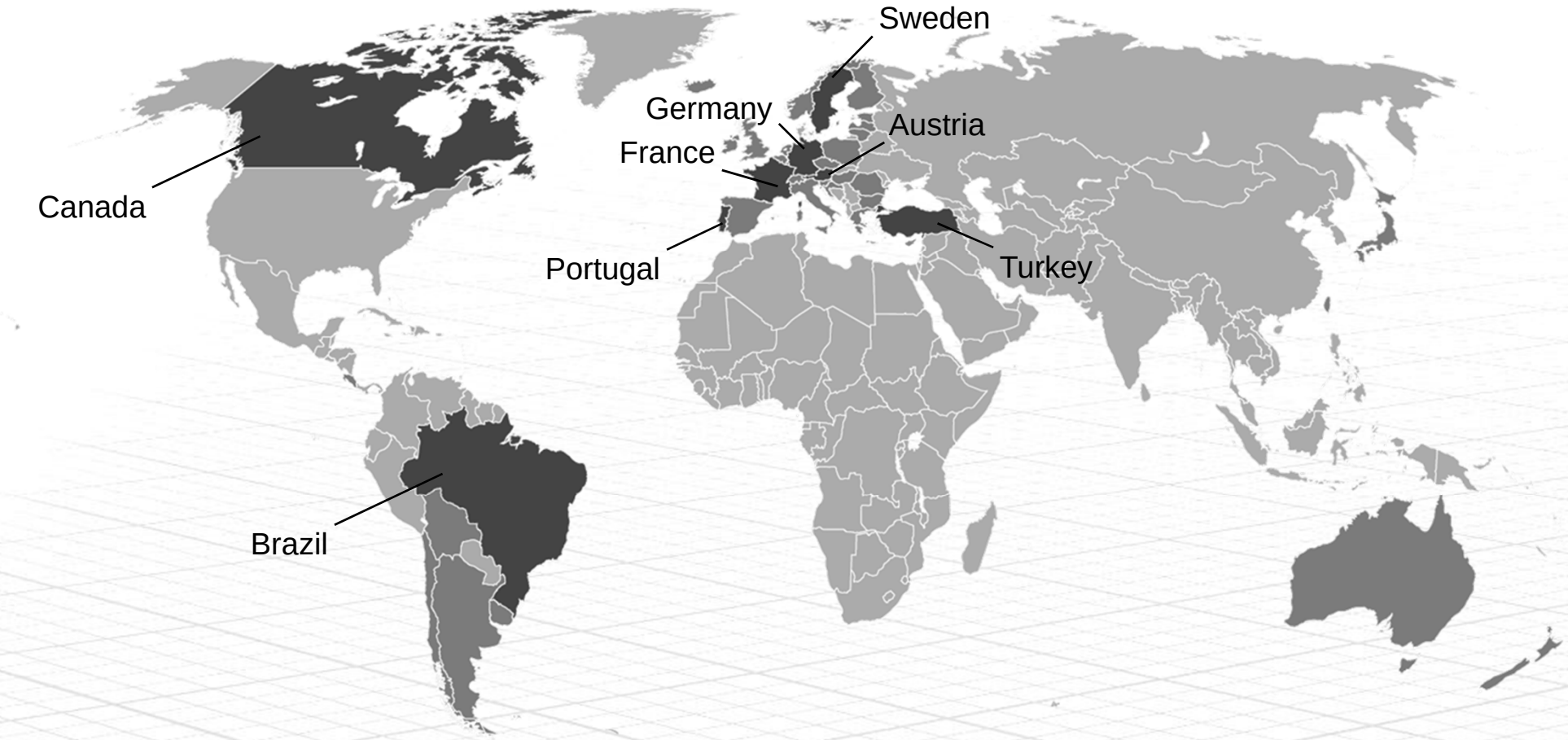
Agenda

- ENERCON in general
- Main parameters of a power system
- Turbine concept
- A typical wind power project
- Ongoing development
- Conclusions
- Career at ENERCON
- Field trip

ENERCON – overview

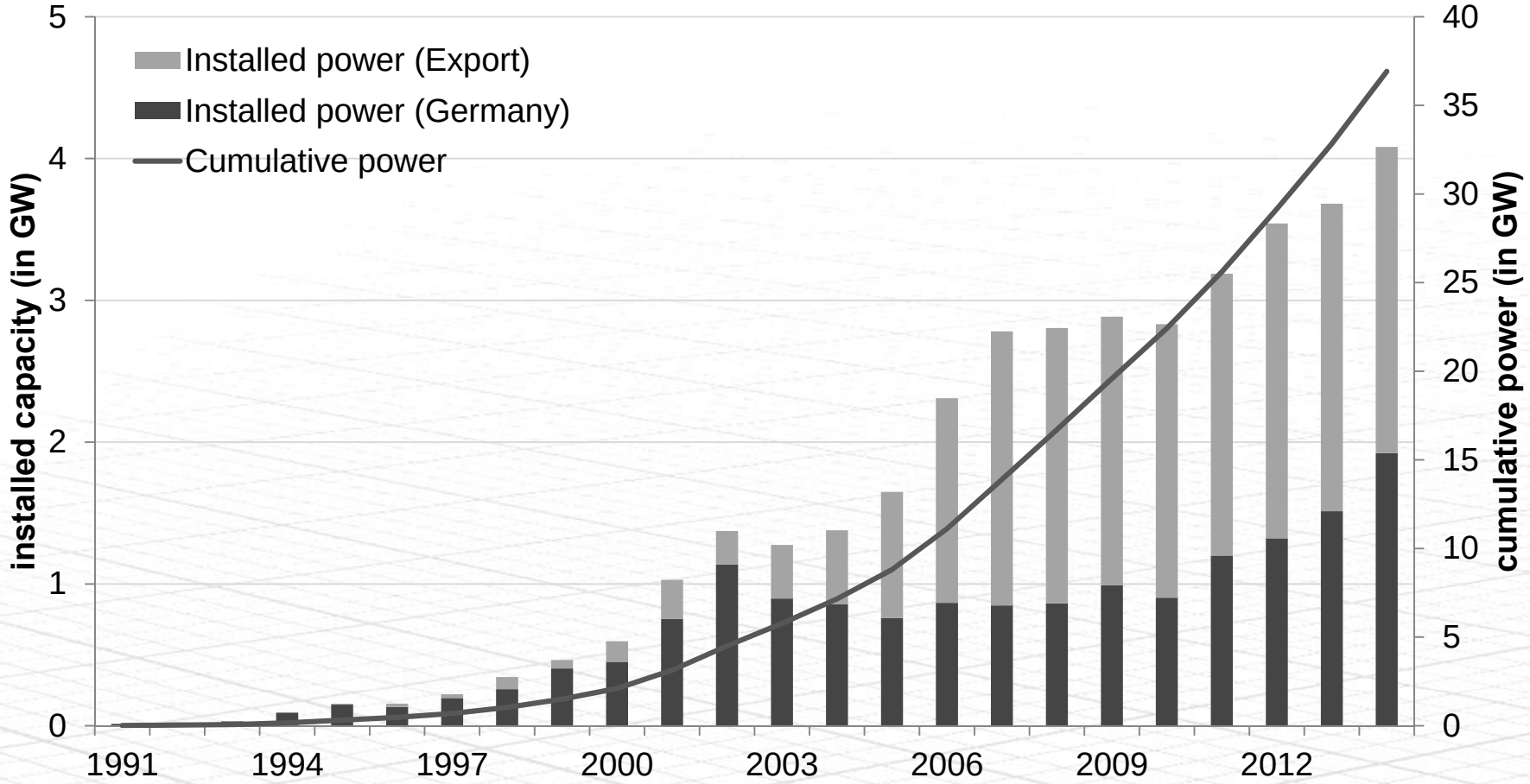
Headquarter	Aurich
Employees	> 15,000
Production facilities (national)	Aurich, Emden, Magdeburg, Haren
Production facilities (international)	Sweden, Brazil, Turkey, Portugal, Canada, Austria, France
Production area	870,000 m² (as of 2015)
Sales offices	9 domestic; 36 international
Service stations	more than 300 worldwide
Logistics	- E-Ship 1 (transport ship) - e.g.o.o. Eisenbahngesellschaft Ostfriesland-Oldenburg mbH - Mobile cranes up to 1,600 t - Hundreds of service vehicles

Global activities of ENERCON



➔ ENERCON is active in many markets with production facilities in 8 countries.

Installed power of ENERCON turbines



➔ Over 24100 ENERCON turbines with more than 37 GW installed worldwide (as of May 2015).

ENERCON product overview

- ENERCON produces only onshore turbines

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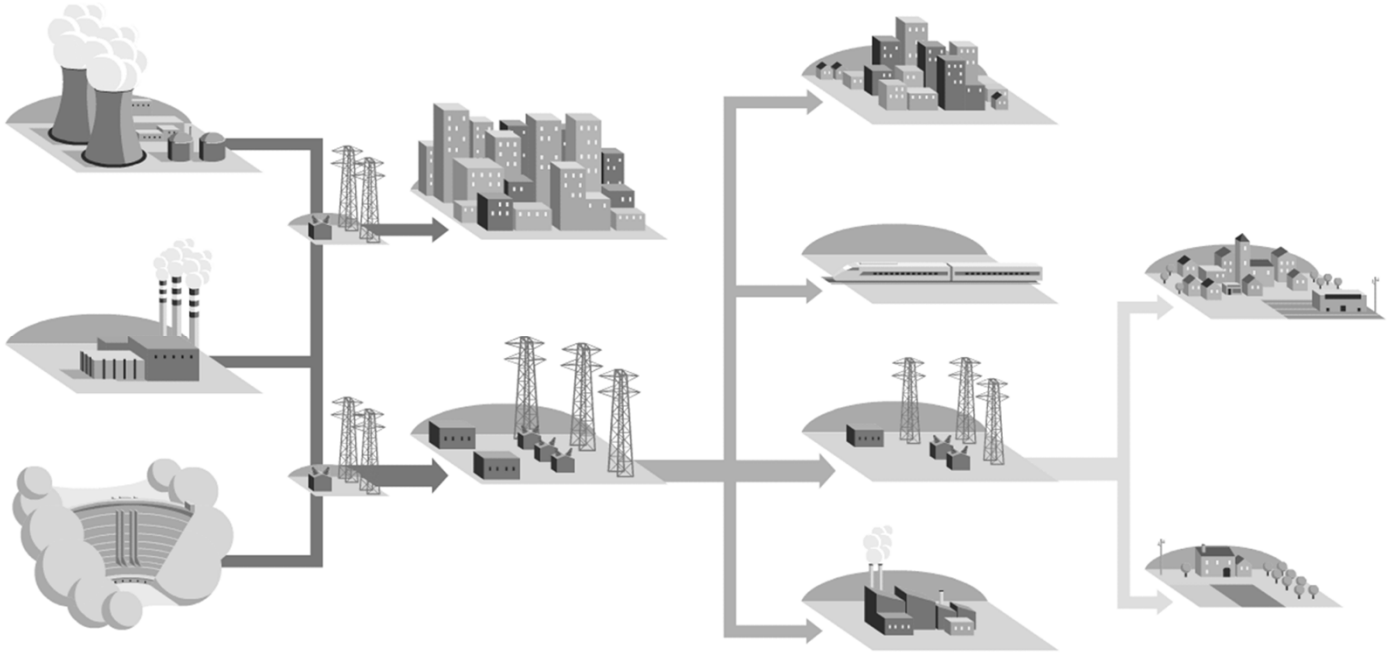
What does an electrical power system consist of (simplified)?



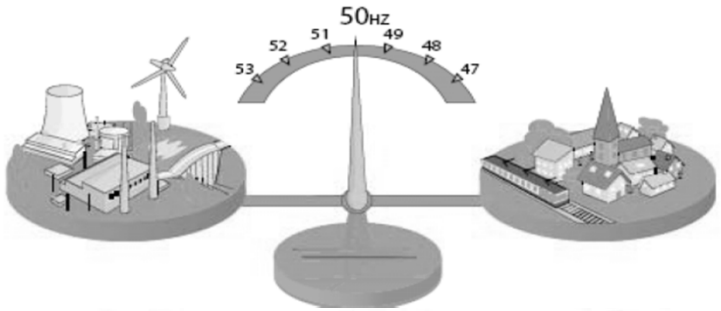
Generation Transmission Distribution & Consumption

Higher Voltage level Lower

Main parameters of a power system

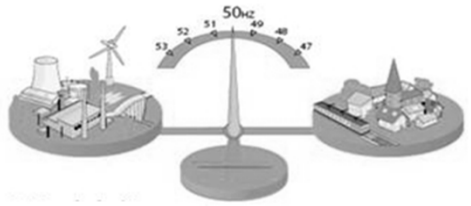
1) Frequency “f”

- Depends on the balance between power production and consumption
- From Portugal to Turkey: same frequency
- NORDEL mainly independent from Central Europe



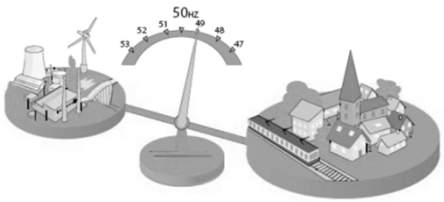
Frequency f depends on the balance of active power in a power system

Generation = Consumption
f = const.



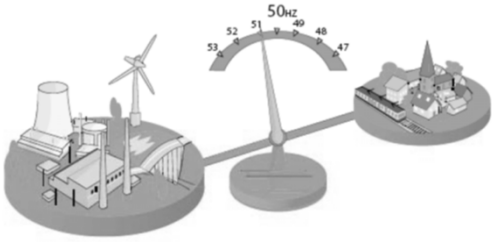
Generation < Consumption

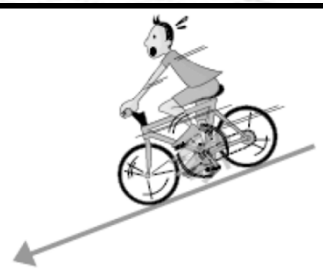
f ↓



Generation > Consumption

f ↑





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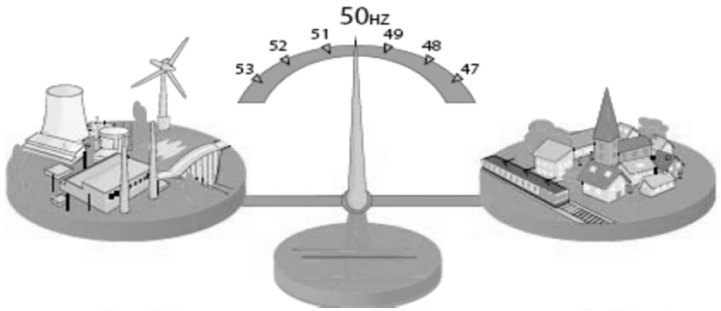
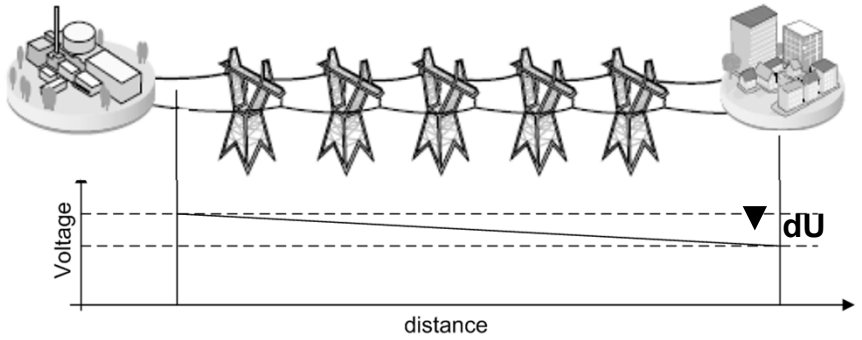


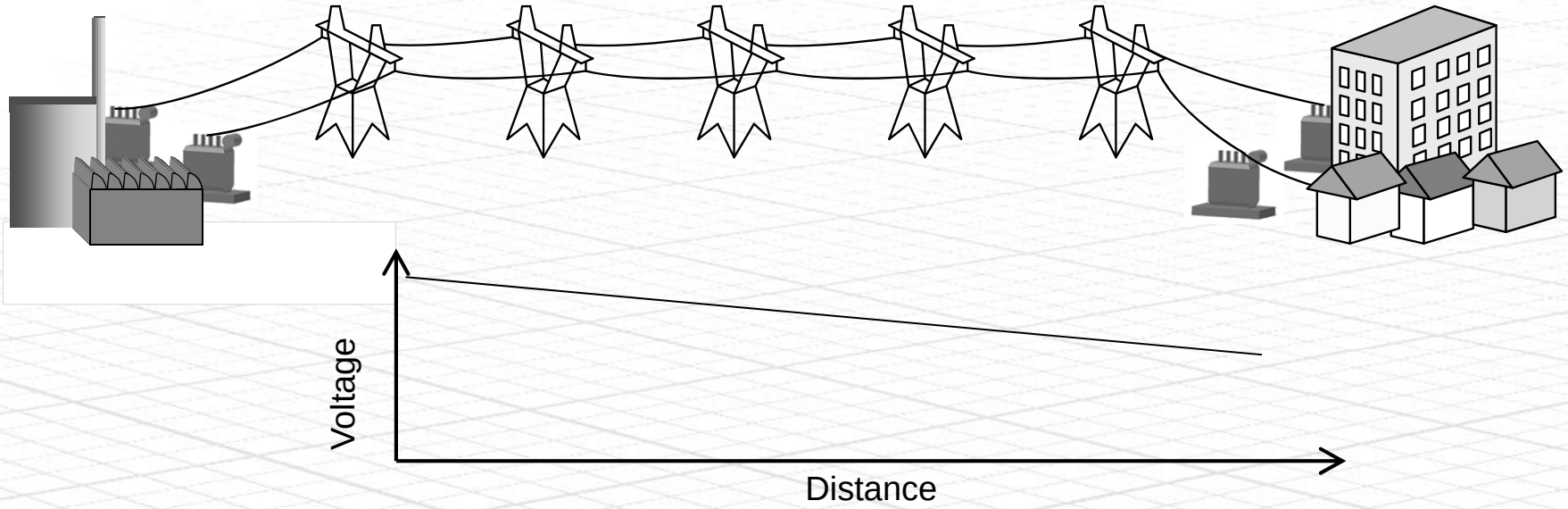
2) Voltage “U”

- Depends on (active and) reactive power flows, and on system design
- Needed and provided locally



Voltage U as a local parameter

- Voltage drops along the line between generator and consumer
- Change of reactive power flows changes the voltage



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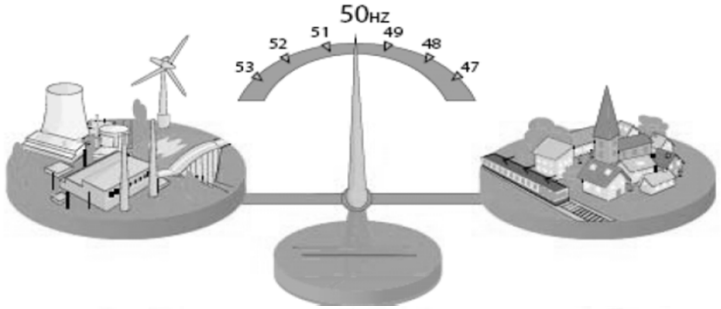

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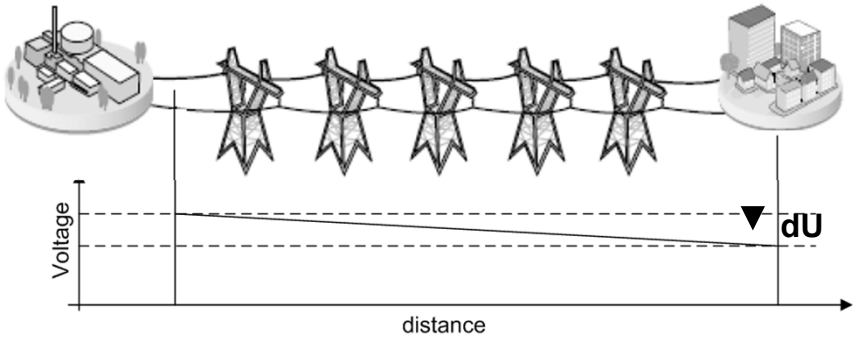

Possible influence of Wind Power Plants:

Change of active power flow	Influence on	Frequency
Change of reactive power flow	Influence on	Voltage

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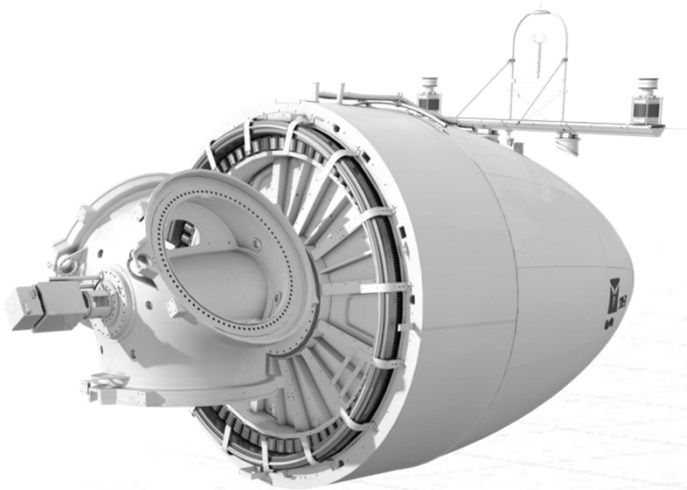
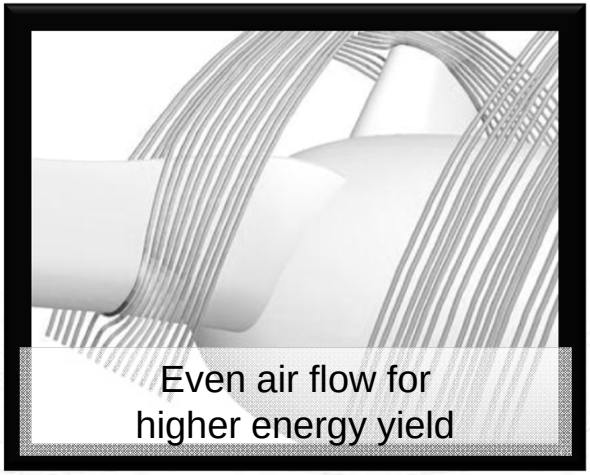
Typical ENERCON features

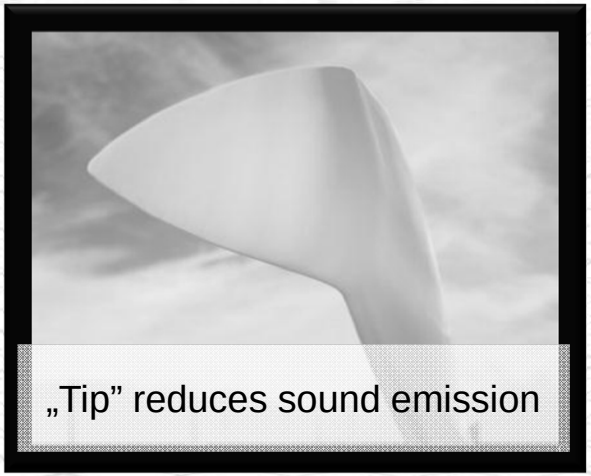


Direct driven generator



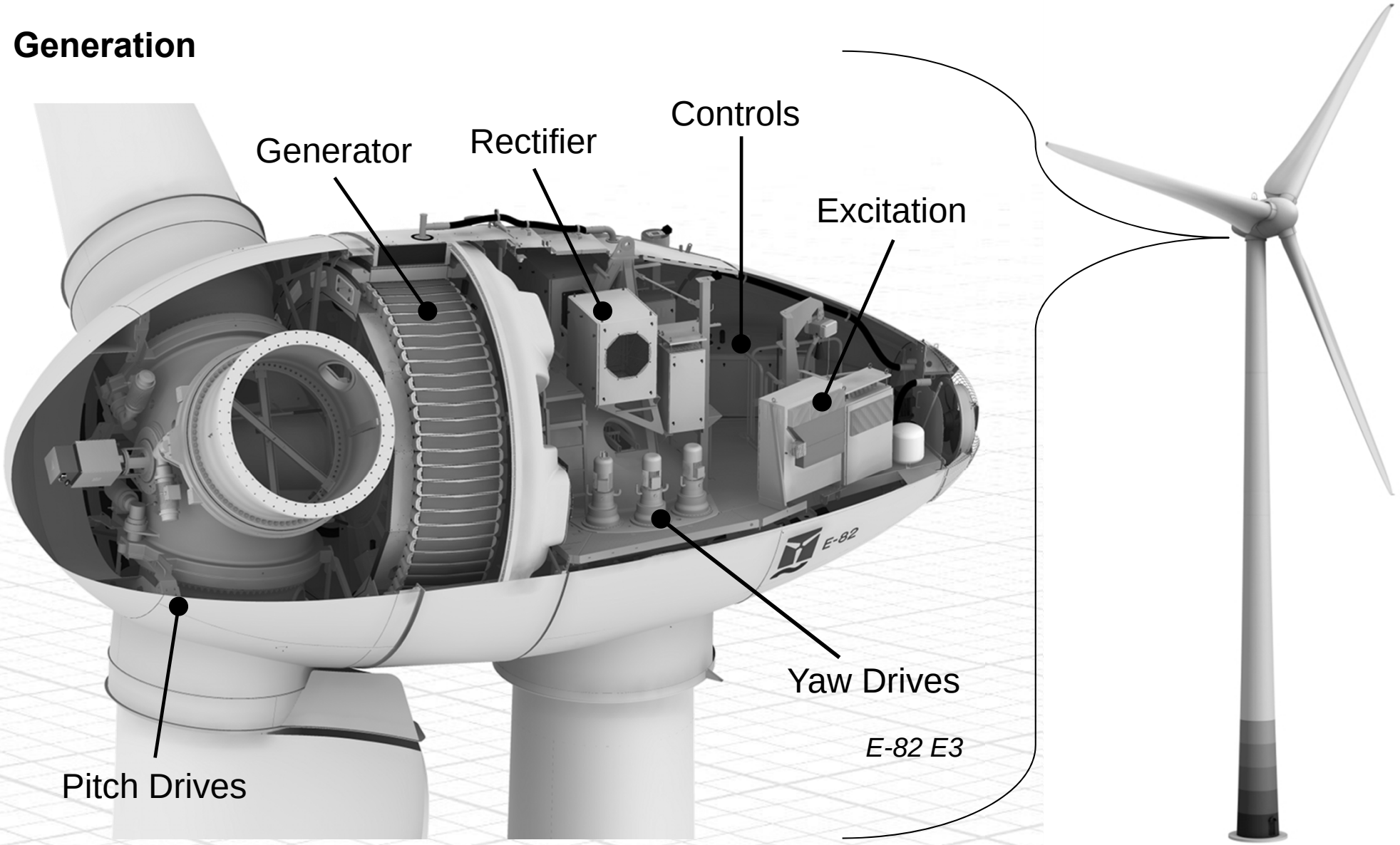
Even air flow for
higher energy yield

Rotor blade with spoiler

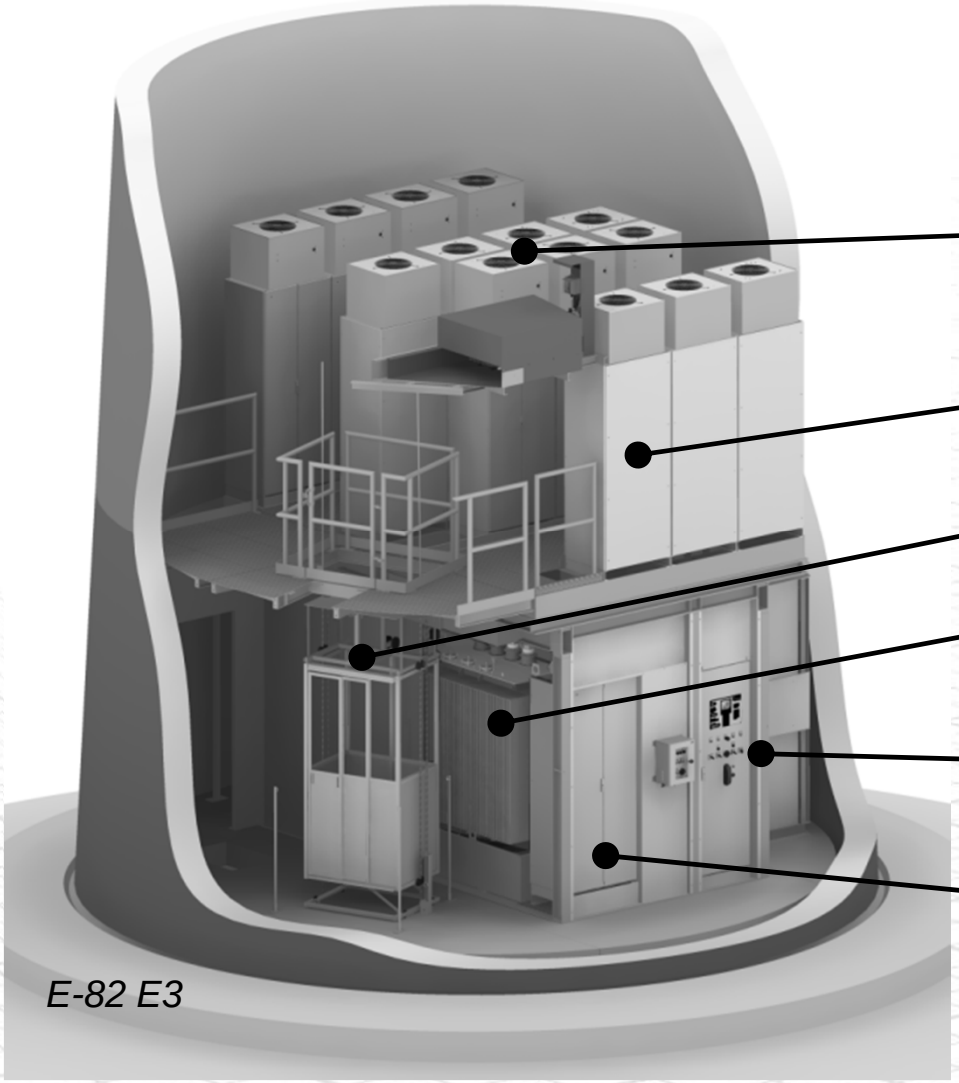


„Tip” reduces sound emission

Generation

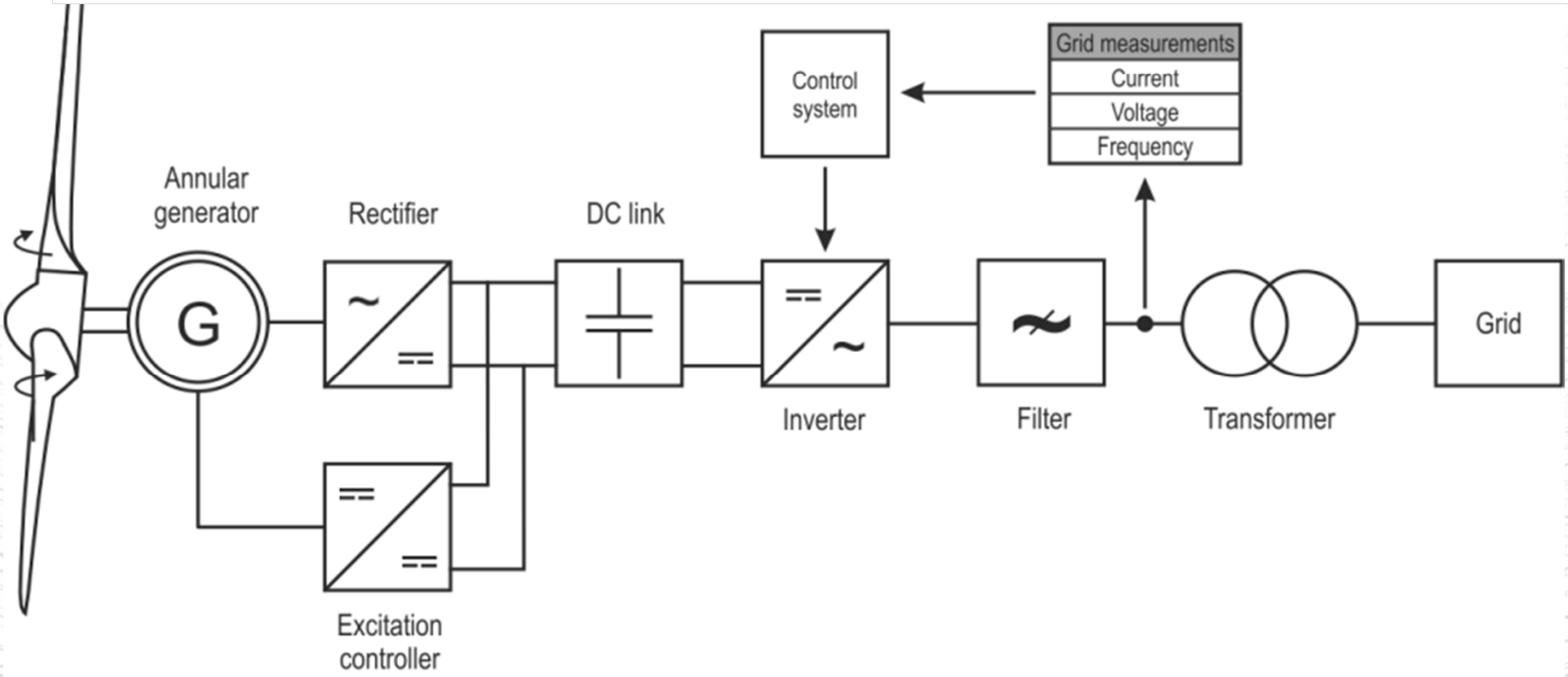


Conversion



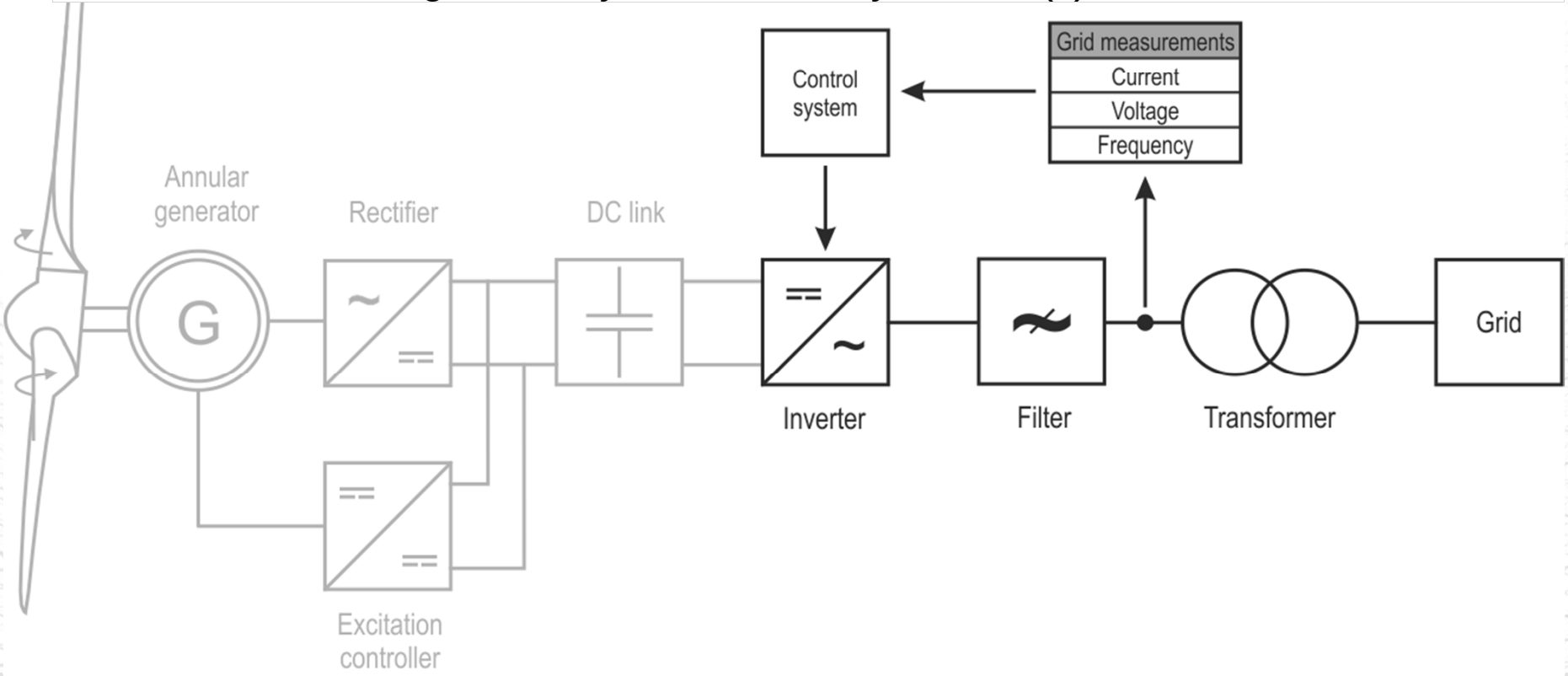
Key characteristics

- Type 4 Wind Turbine Generator (WTG), without gearbox
- Full scale power converters decouple the annular generator from the grid
- Available for 50Hz and 60Hz grids: no special version required



Key characteristics

- Type 4 Wind Turbine Generator (WTG), without gearbox
- Full scale power converters decouple the annular generator from the grid
- Available for 50Hz and 60Hz grids: no special version required
- Performance on grid mainly determined by inverter(s)



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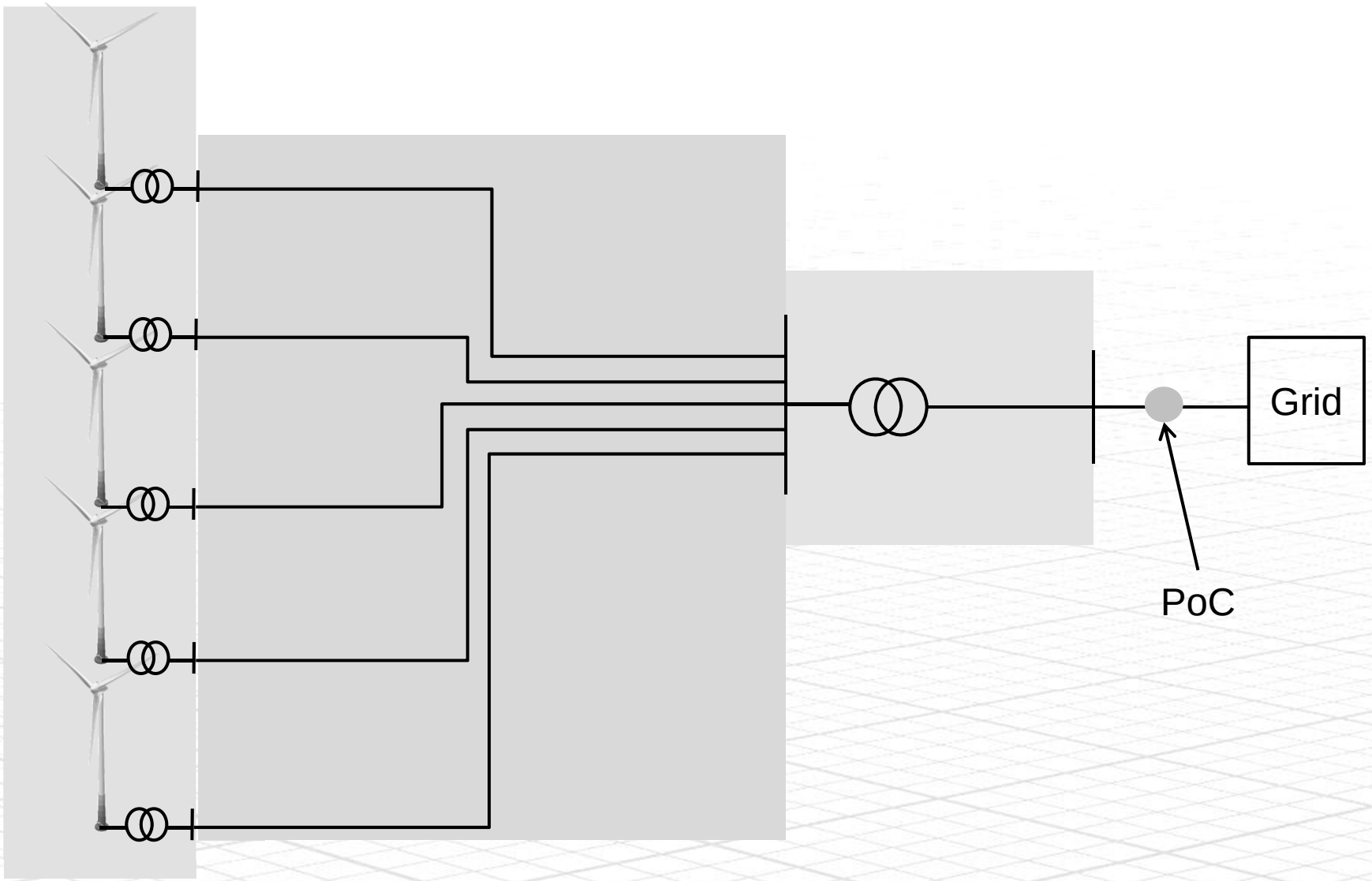
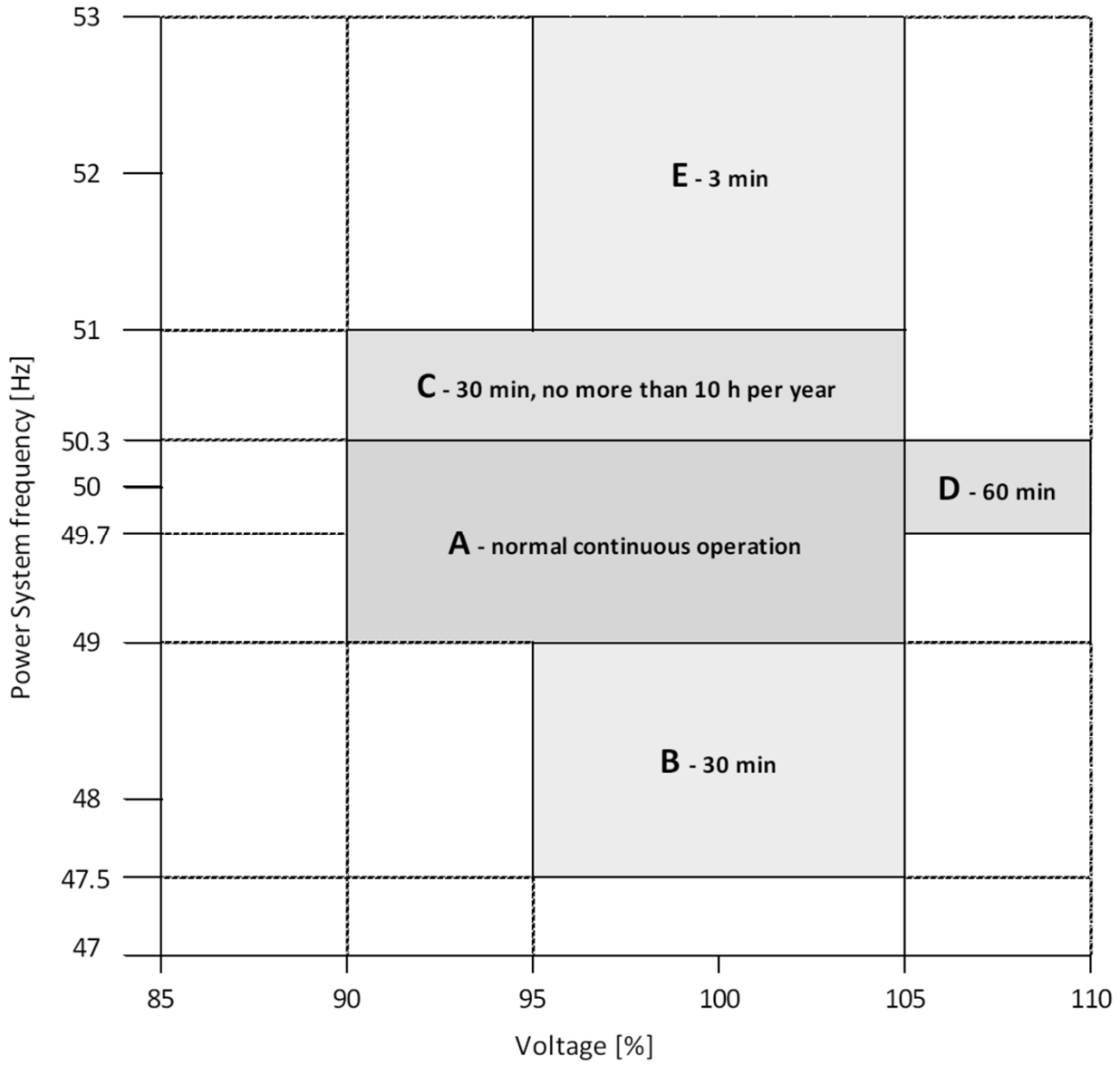
A typical wind power project



Scope of: ENERCON Collector system sub-supplier HV system sub-supplier

Voltage and frequency operation range

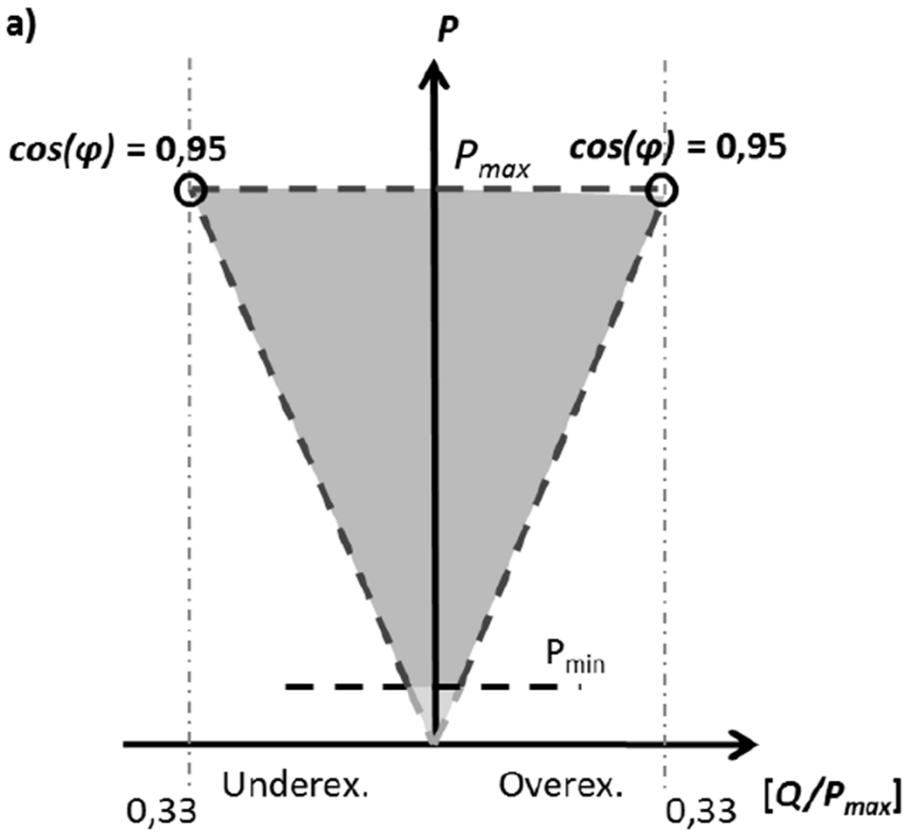
Voltage and frequency operation range



Source:
VJV2013

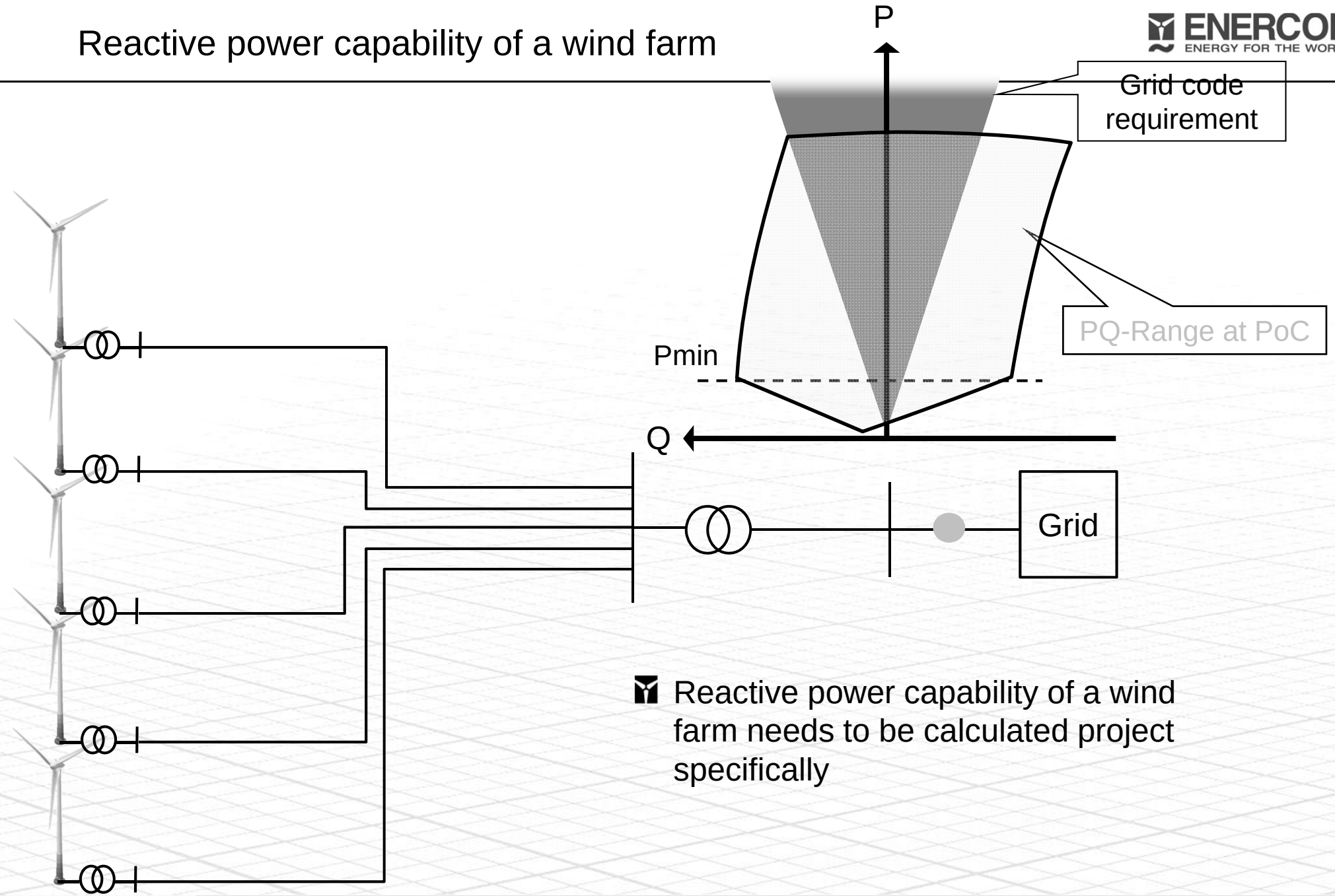
Steady state reactive power capability

Steady state reactive power capability



Source:
VJV2013

Reactive power capability of a wind farm

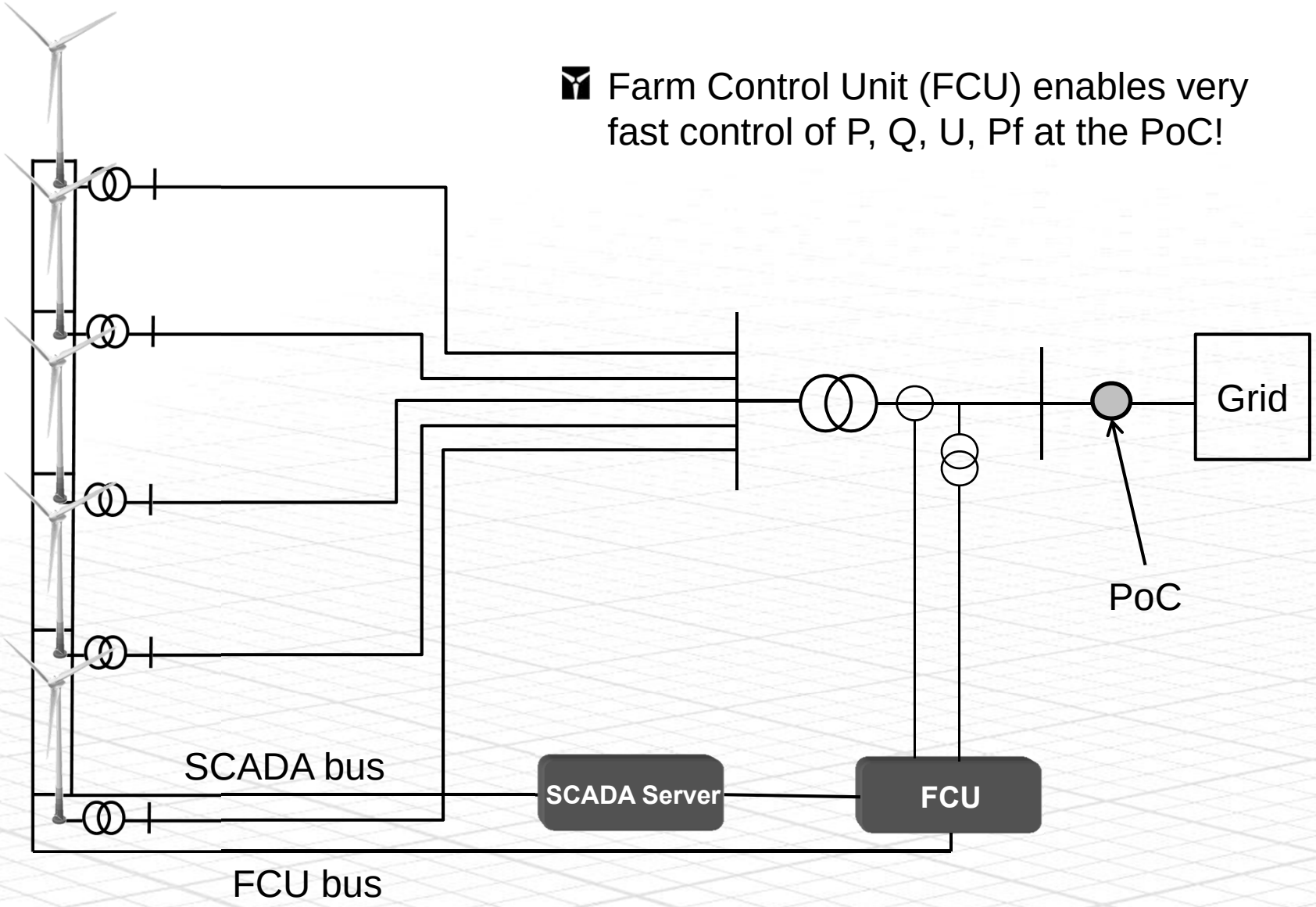


- Reactive power capability of a wind farm needs to be calculated project specifically

Steady state use of reactive power

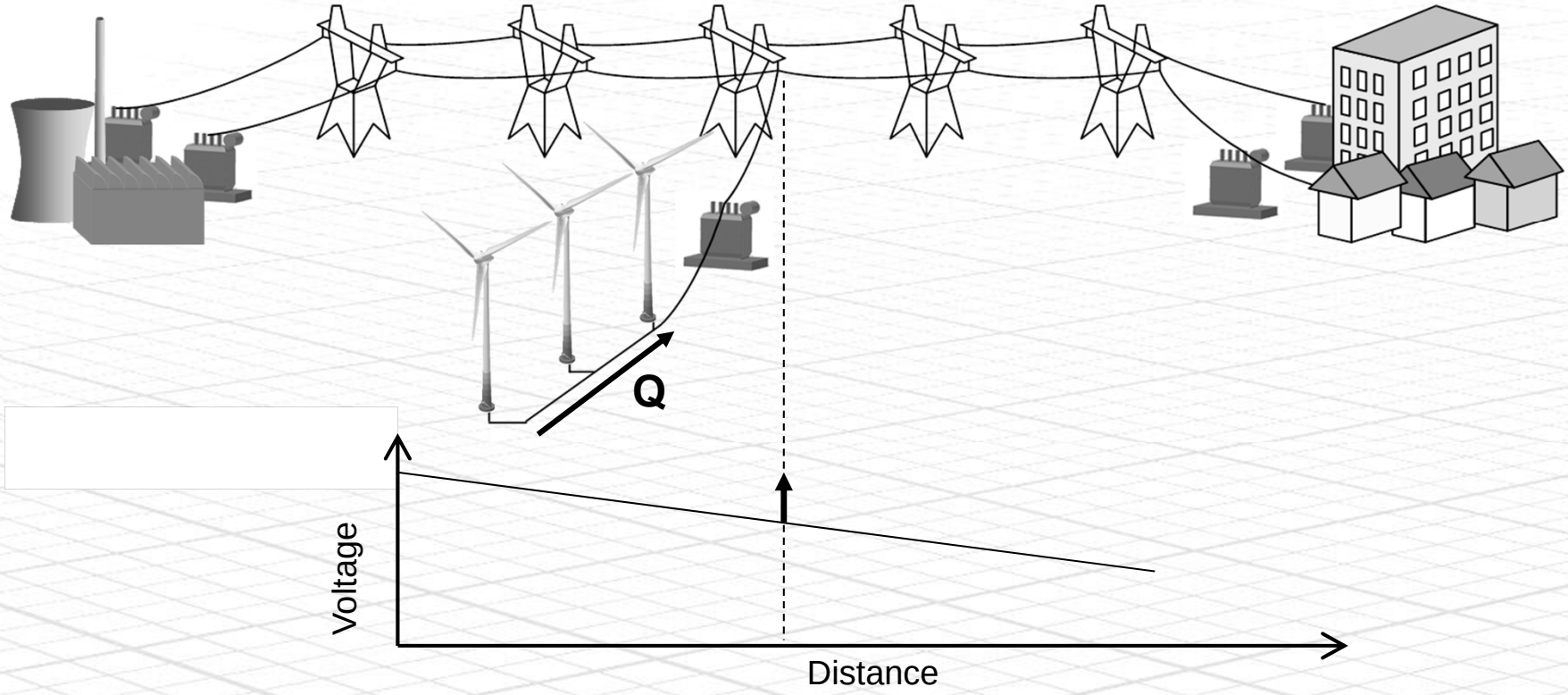
Wind farm control at the PoC

- Farm Control Unit (FCU) enables very fast control of P, Q, U, Pf at the PoC!



Power system voltage

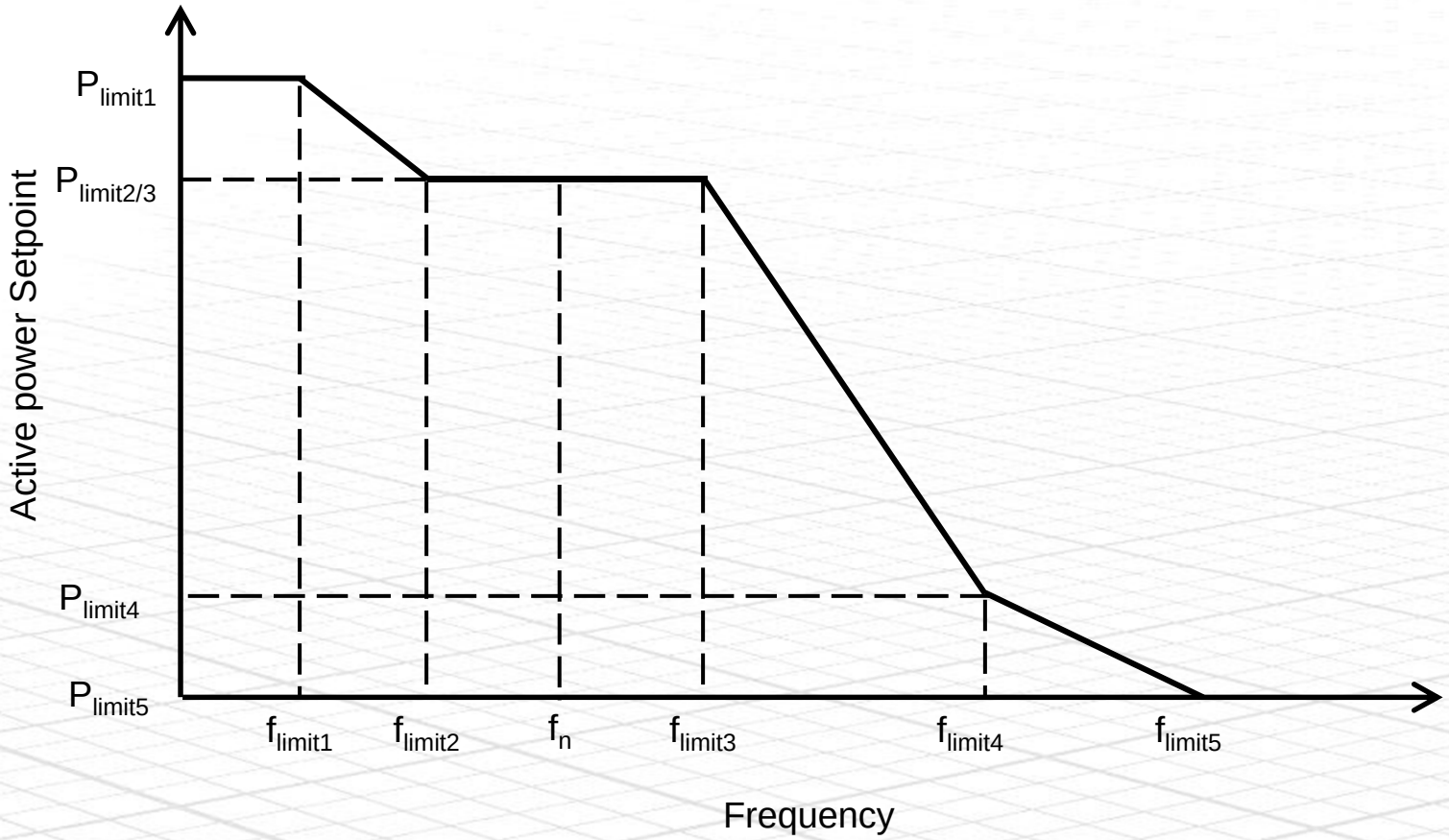
- Voltage decreases over length of power line
- Wind Farms can provide reactive power to contribute to grid voltage control



Power frequency control

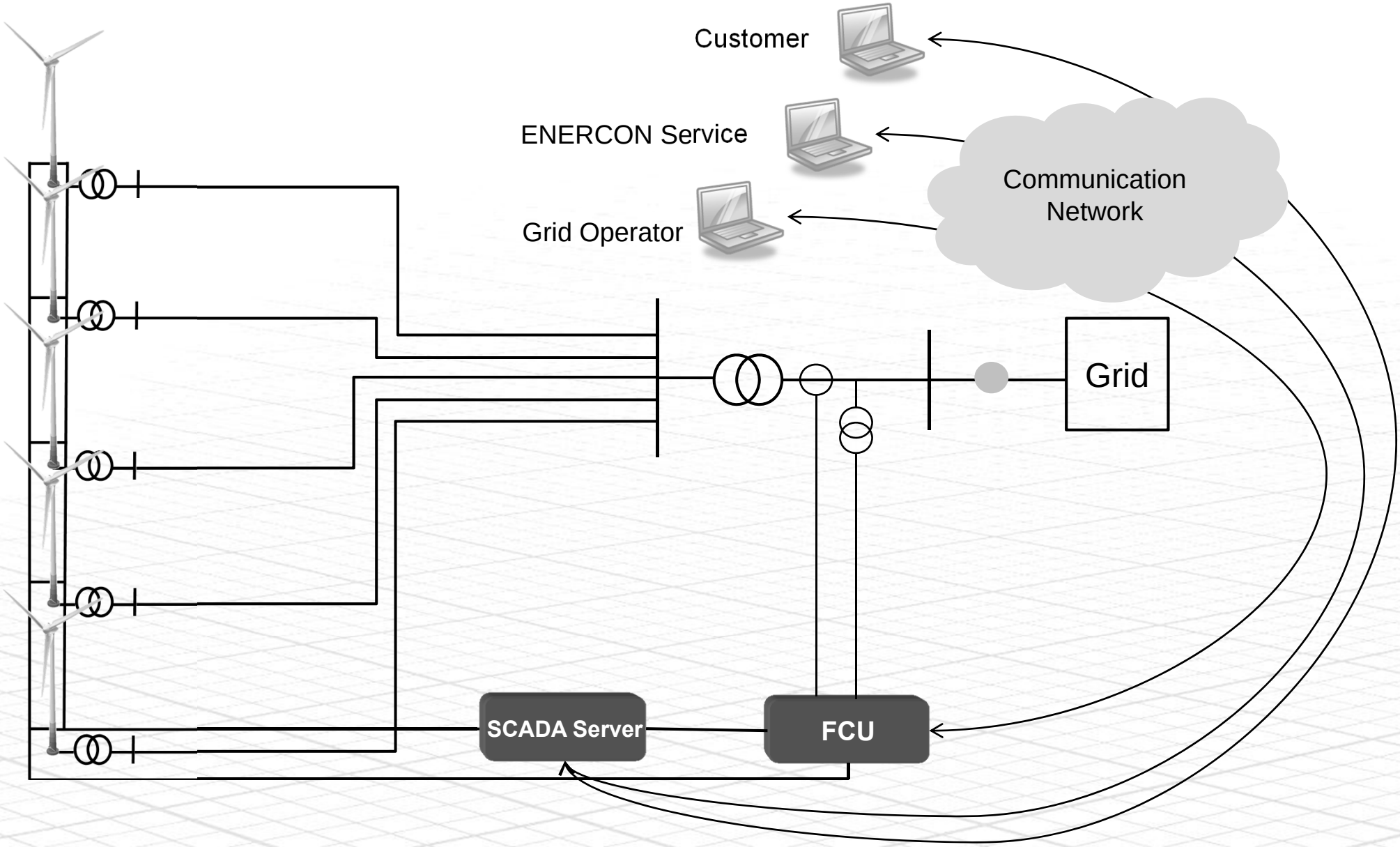
Power frequency control

- Curtailment in normal operation possible



Online communication

Online communication with the wind farm



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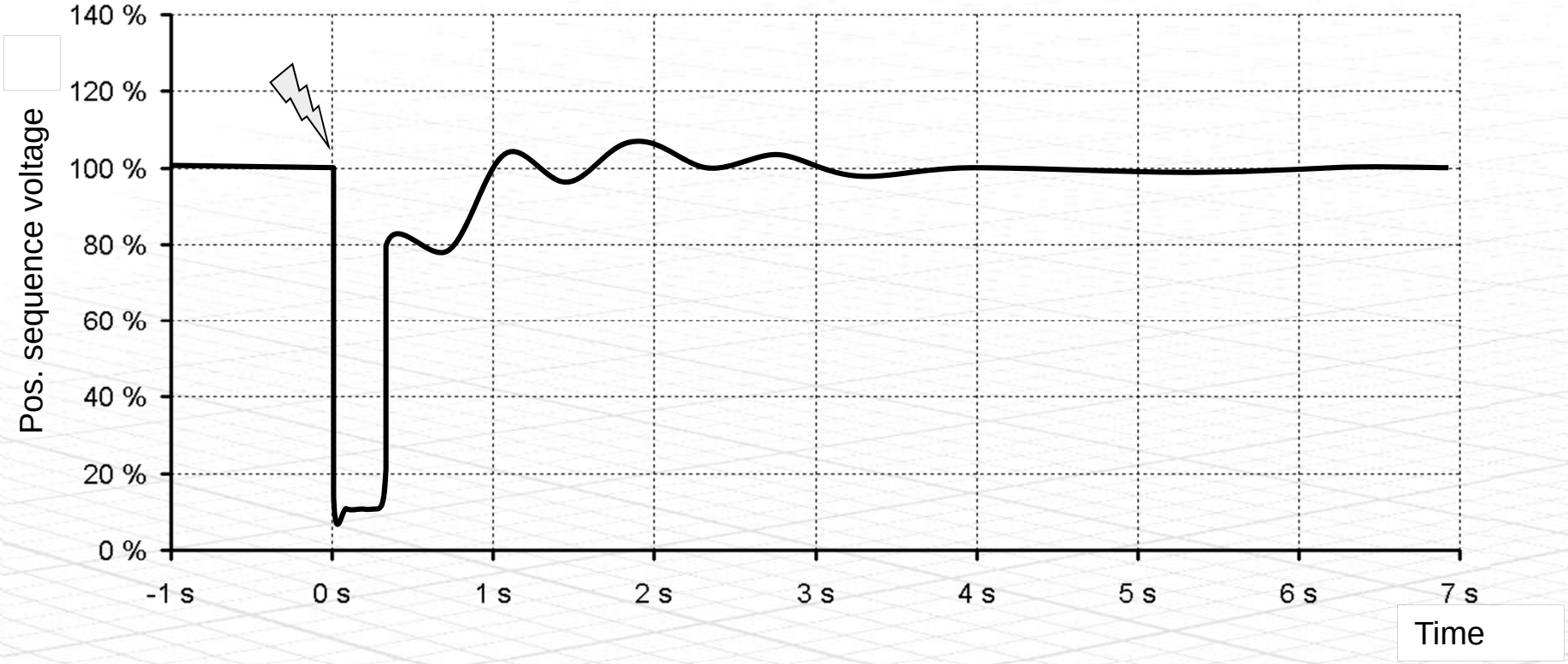
Fault ride through (FRT)

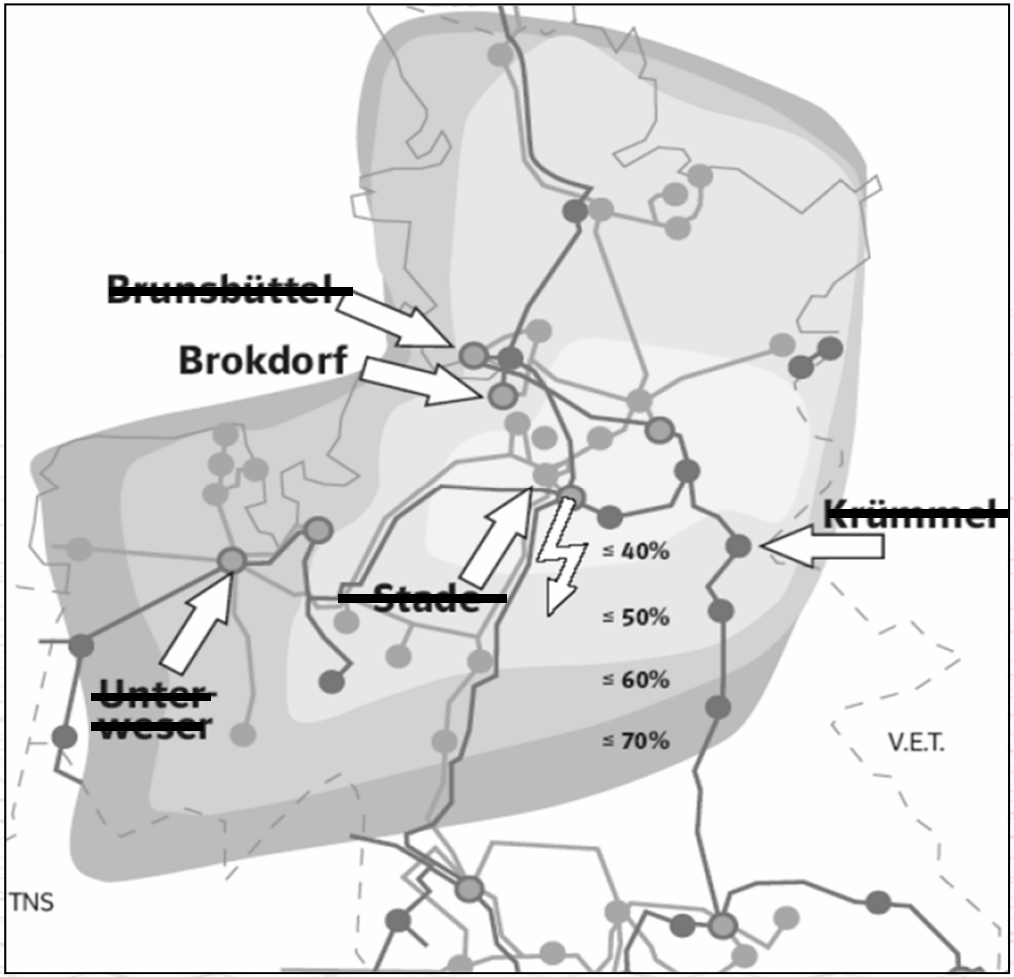
A typical short circuit in the grid



Aim of Fault Ride Through (FRT)

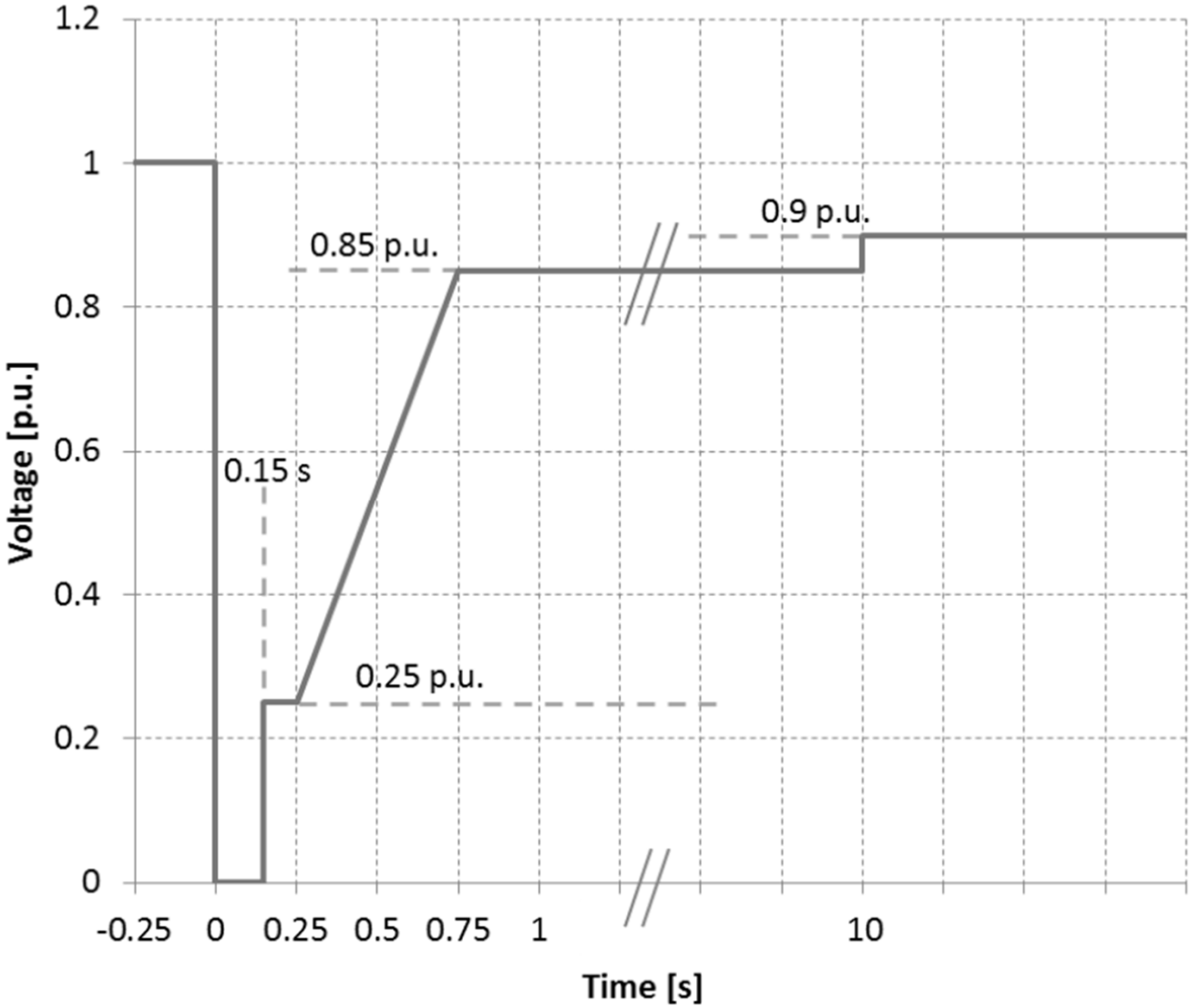
Simulated fault in German transmission system

- Voltage collapses around fault location
- Without Fault Ride Through (FRT)
  - Turbines disconnect
  - Loss of production
  - Imbalance of load and generation
  - Risk of blackout
- Most grid codes today ask for FRT
- Modern turbines support voltage during fault



Source: E.ON Netz

Fault Ride Through (FRT)



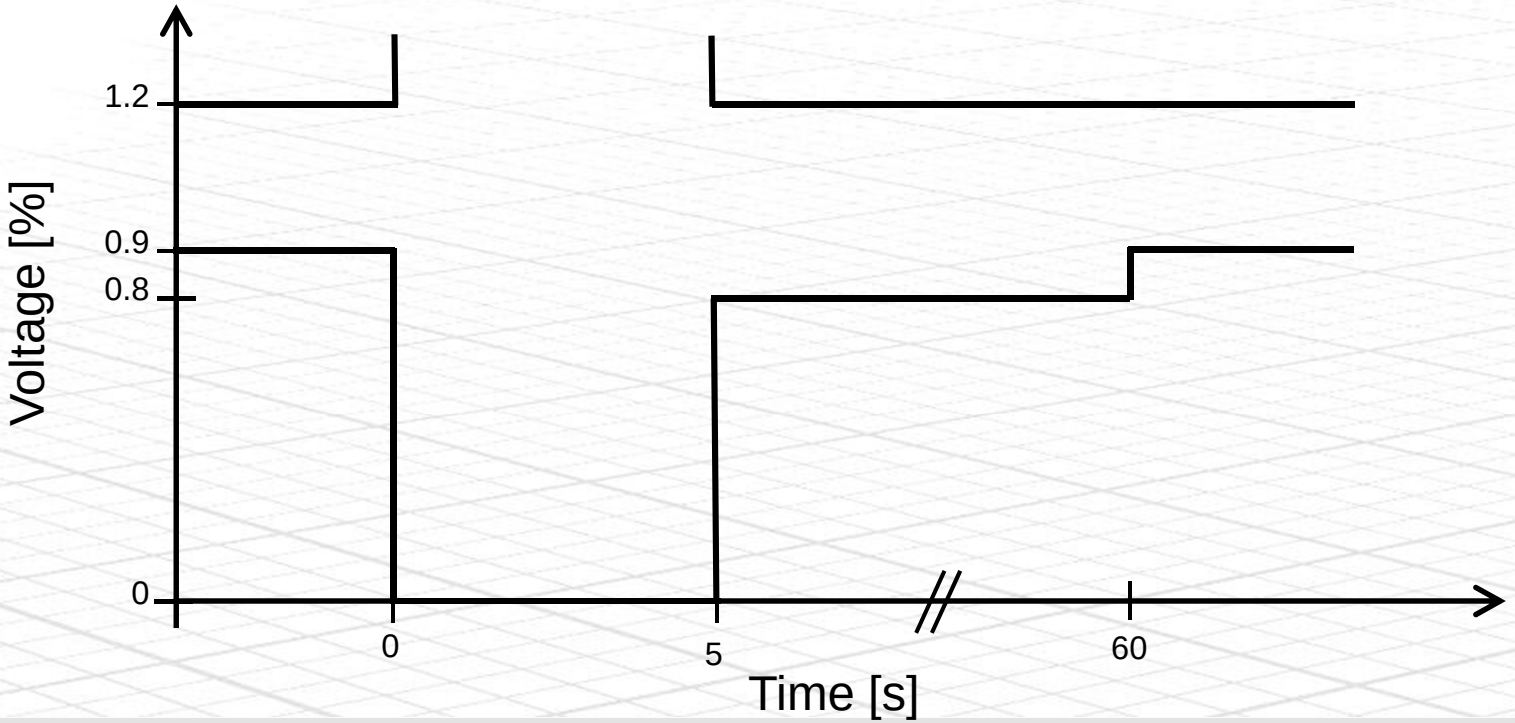
Why ongoing development?

- Turbine performance during FRT not specified in Scandinavia

Source: VJV2013

Under and Over Voltage Ride Through

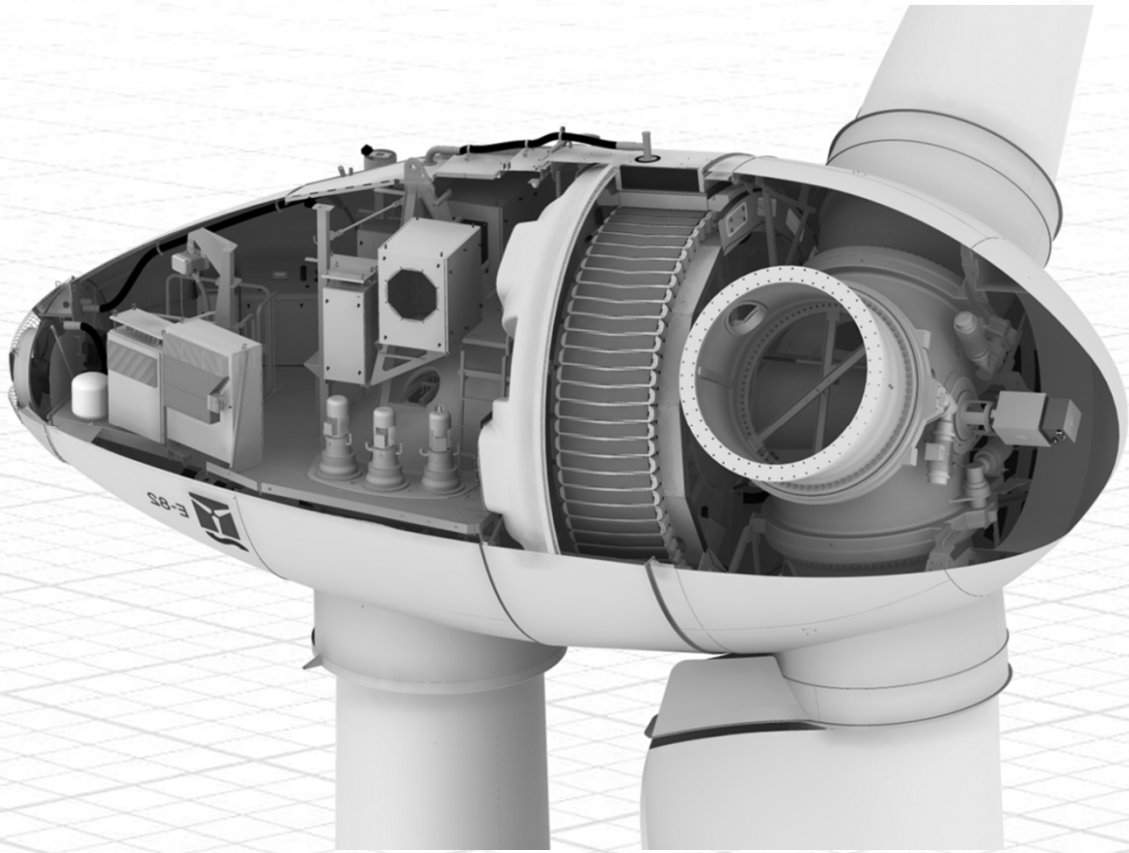
- All current ENERCON turbines can ride through:
  - Symmetrical and asymmetrical faults
  - Under- and over voltage conditions for up to 5 seconds per event
  - Faults down to 0V at turbine's low voltage terminals



Inertia Emulation

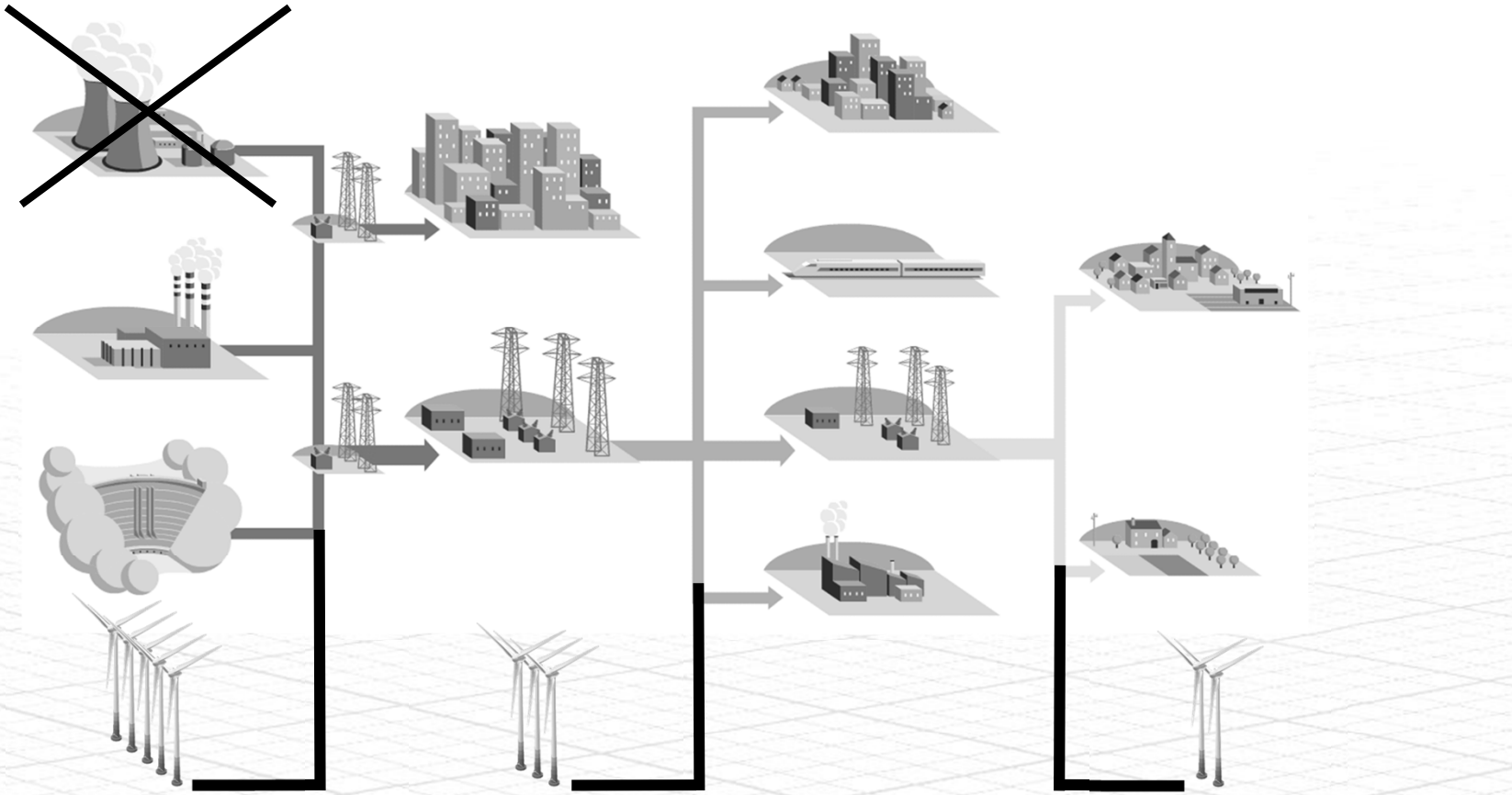
Overview about characteristics

- Extraction of kinetic energy stored in rotating mass
- No curtailment in normal operation necessary, no loss of yield
- Project-specific parameterization
- Triggered by absolute frequency



Future system needs

What will change?



Status of penetration with renewables

- All technical system needs have to be covered at any time.
- Explicit and inherent system beneficial features of rotating generators have to be replaced somehow.
- But: Markets today reflect mainly energy (MWh).
- They do not cover all physical system needs when rotating generators are replaced by inverters (Wind + PV).

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Conclusions

„The project has to fulfill the grid code“

- Project speficic studies need to be done in order to judge if a project fulfills the grid code
- Wind farms with ENERCON turbines can fulfill even demanding grid codes
- Wind farms have already today extensive capabilities to support the grid…
- … however they are often largely underutilized through system operators
- To anticipate the challanges imposed by the transition to a higher share of renewable generators we need more research and cooperation between all involved parties

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Career at ENERCON

- ENERCON welcomes young professionals, graduates and students for internships or theses
- Different ways to find your position at ENERCON
  - Check out our career portal for vacant positions: http://www.enercon.de/en/career-portal/
  - Send an email to studenten@enercon.de including cover letter, CV, and latest certificate from university. Explain your motivation and what you are looking for: Internship, thesis, job
  - Visit our HR team at one of the many fairs

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Agenda for the study visit in Aurich on 24th November 2015

- 09:45 to 11:45
  - Visit of nacelle and generator production
- 11:45 to 12:45
  - Drive to and visit of blade production
- 12:45 to 13:30
  - Lunch
- 13:30 to 16:00
  - Visit of „Renewable Energy Center“ with E-115 nacelle and more

ENERCON
ENERGY FOR THE WORLD

Richard Ogiewa
M. Eng.
Sales – Grid Integration Engineer

ENERCON GmbH - Sweden
Arlövsvägen 9
211 24 MALMÖ
SWEDEN

direct: +46 40 3814 35
mobile: +46 723 506006
switchboard: +46 40 1435 80
mail: richard.ogiewa@enercon.de
www.enercon.de/en-en/

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