



# **Cables in wind power installations**

## **Market data and technical requirements**

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**Kemmler Consulting**

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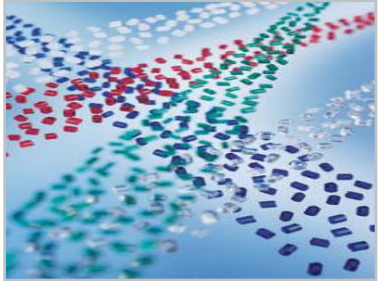
# Agenda



- 1 About Kemmler Consulting
- 2 Configuration of a wind tower
- 3 Technical requirements for cables in wind tower installations
- 4 Power cables in wind tower installations
- 5 Data cable in wind tower installations
- 6 Market data
- 7 Offshore installations
- 8 Conclusions

# About Kemmler Consulting

More than 20 years experience in Wire & Cable Industry



- Research and Development into new materials
- (Special) cable design
- Wire & Cable manufacturing technologies



- Market studies and evaluations
- Customer surveys
- Definition of performance specifications



- Realisation of international negotiations
- Project management
- Customers in EUR, USA, Africa and Asia

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# Configuration of a wind tower



- First windmills can be traced back in the 9<sup>th</sup> century
- Wind power used for drive systems, mainly for grinding gears



- Enhancements over centuries lead to more sophisticated design
- Again mechanically connected systems



- First wind towers for generation of electric power
- Starting in 1980s in Denmark, Germany, USA

# Principal sections of a wind tower



## **Nacelle**

Mounted on top, it contains an energy generating system as well as control cabinets and system control units.



## **Tower**

Made of steel or concrete the tower has a strong baseplate (onshore) or a tripod system fixed on the seabed (offshore)



## **Grid connection**

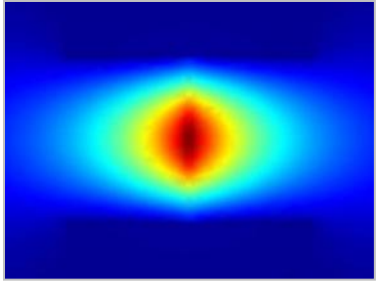
At the bottom of the tower the generated electricity is fed into the grid or to the substation of a wind park respectively

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# Technical requirements for cables



- Operating **temperatures** from  $-40^{\circ}\text{C}$  (or even less) to  $+80^{\circ}\text{C}$
- Start of system after windless period in frozen environment
- Intense sunlight in permanent wind areas



- **Vibration** in nacelle and tower
- Varying frequencies



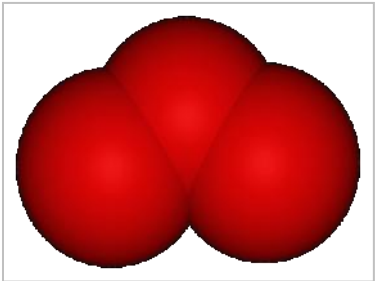
- **Fire protection** in nacelle (many different installations)
- Chimney effect in concrete or steel towers



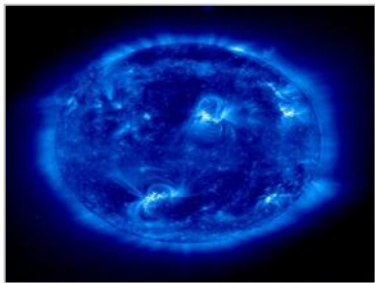
# Technical requirements for cables



- **Oil resistance** against generator and/or hydraulic oils
- Oil dust in top end areas of wind towers



- **Ozone** resistance
- Vented tower and nacelle



- **UV resistance** (interface nacelle and tower)
- Data cables on top of nacelle

# Technical requirements for cables

**VDE**



## Standardization

- To date there is no general “wind power standard” for cables
- UL issued subject 2277 WTTC for power cables
- Most power cables in non UL areas are based on “HD-style” cables
- Many individual agreements or specifications of wind tower manufacturers

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# Power Cables in wind towers



Picture: Draka

- Cables at interface between tower and nacelle (“loop”)
- Typically “rubber cables” rated 1.000V AC
- Also used as tower cables



- Low voltage control cables for drive control, HVAC, pumps, monitoring etc.
- “All types” of cables
- WTTC (wind turbine tray cable) acc. To UL 2277



- MV (HV) cables for grid connection
- According to requirements of local public utility providers

# Power cables in wind towers



Power cables used in the nacelle

- **A wide variety of low voltage cable types**
  - Different cross-sections
  - Screened / unscreened
  - “Classic” PVC control cables
  - HFFR / LSOH materials
- **Different definitions for requirements**
  - No stringent standards (non UL) for fire or oil resistance, ozone etc.
  - UL 2277 type WTTC developed for basic requirements in wind towers (refers to other UL standards, such as UL1277, UL62, UL44 and others)
- **Many sub-suppliers of components**
  - Hence many different cable types and qualities



# Power cables in wind towers



Power cables used in the tower

- **Interface tower / nacelle (“loop”)**
  - Robust and flexible cables required
  - High torsion resistance required (even at low temperatures)
- **Tower cables**
  - Often same type as above
  - Different qualities (e.g. non fine wire strands) due to cost optimization
  - Weight problems on higher towers
  - Aluminum conductors gain market share (non flexible use)
  - CCA (copper clad aluminum) an alternative?
- **Designs often in the style of “H07RN-F” (HD) types**

# Power cables in wind towers



Power cables used for onshore grid connection

- Medium voltage cables for each separate tower
- High voltage cables for connection of entire wind farms
- Cables have to be in accordance with local regulations plus the regulations from public utility providers

# Power cables in wind towers



Power cables used for offshore grid connection

- **Medium voltage**

- Between wind towers
- Typically up to 33kV
- Integrated FO elements

- **High Voltage**

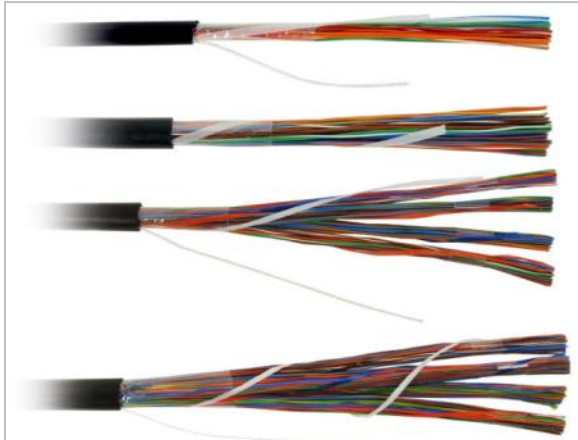
- From substations to shore
- Up to 245kV AC or HVDC cables 150...500kV DC
- Integrated FO elements

# Agenda

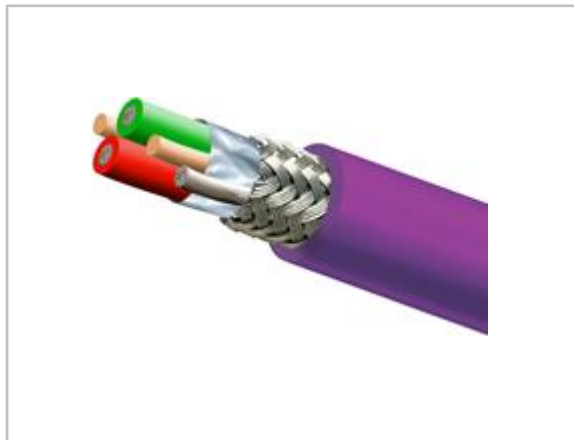


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# Data Cables in wind towers



- Standard data cables
- Twisted pair
- Screened and unshielded



- Variety of BUS cables, e.g. Modbus, Ethercat, CAN, Industrial Ethernet



- Fibre optic cables
- Typically multimode within towers and single mode for inter tower (wind park) connections












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# Market data

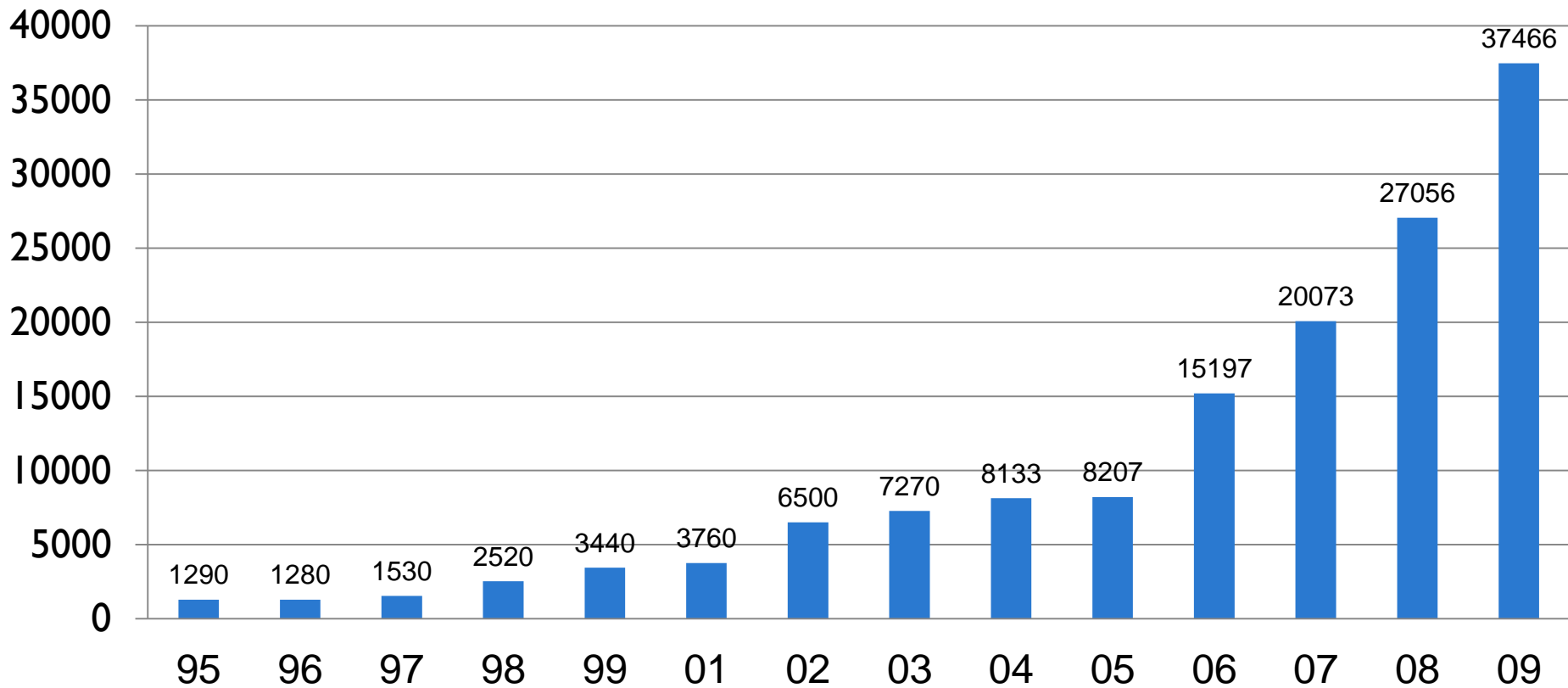
## Market share 2009

 Vestas	12,5 %
 GE Wind Energy	12,4 %
 Sinovel	9,2 %
 Enercon	8,5 %
 Goldwind	7,2 %
 Gamesa	6,7 %
 Dongfang Electric	6,5 %
 Suzlon	6,4 %
  Siemens Wind Power	5,9 %
 REpower	3,4 %

Source: BTM consult

# Market data

Newly added wind power in MW per annum



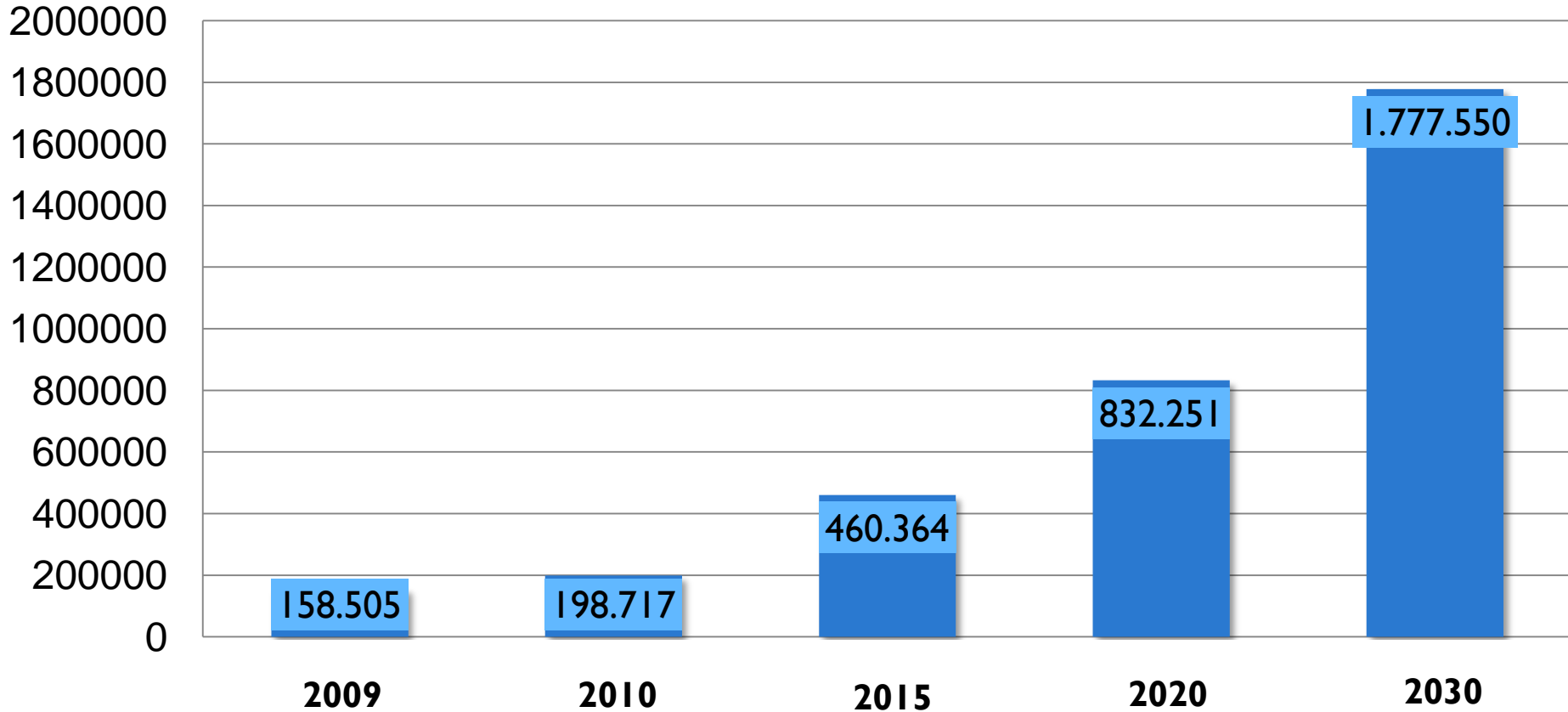
Source: GWEC

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# Market data

## Moderate scenario cumulative installations in MW



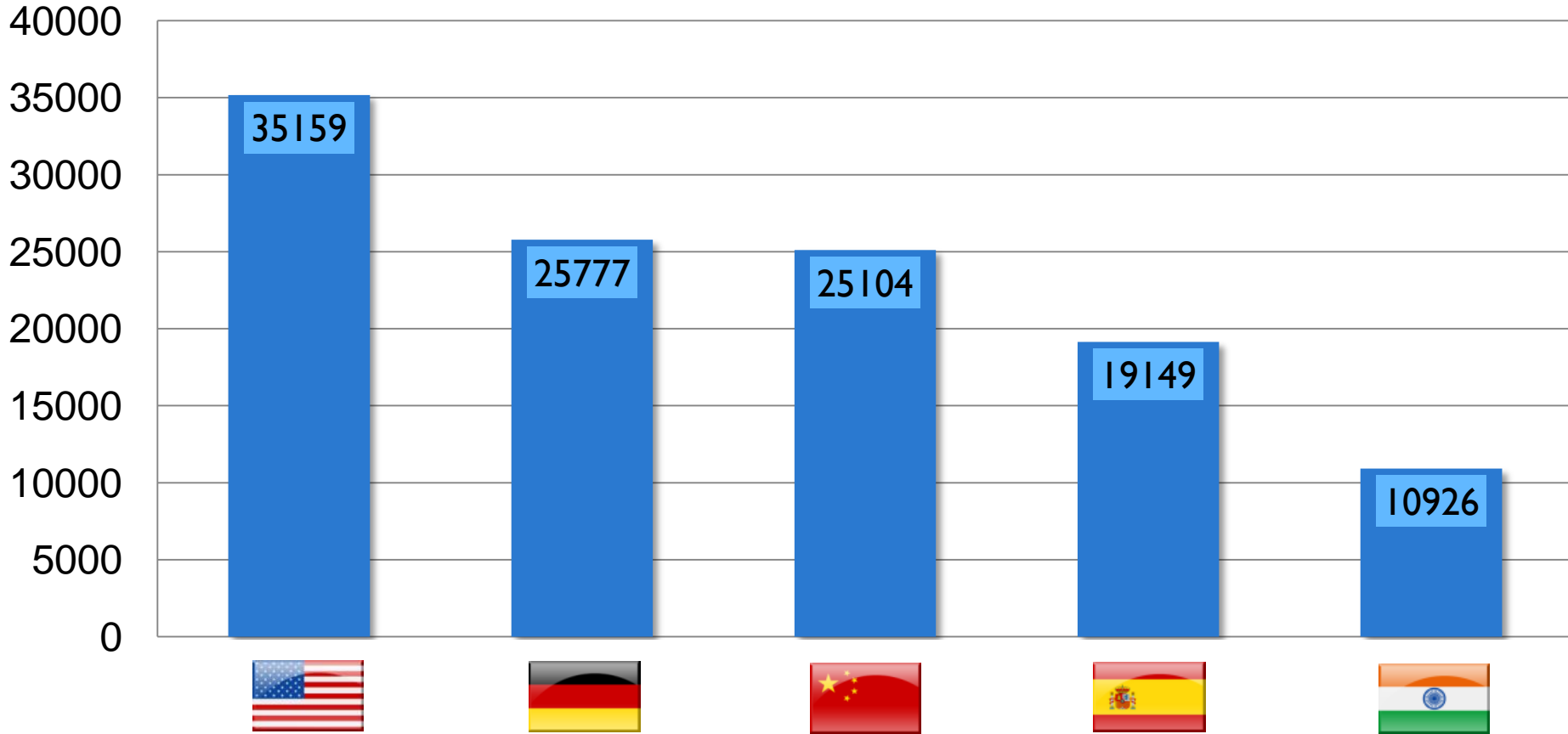
Source: GWEC

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# Market data

## Top 5 countries / installed wind power in MW 2009



Source: GWEC

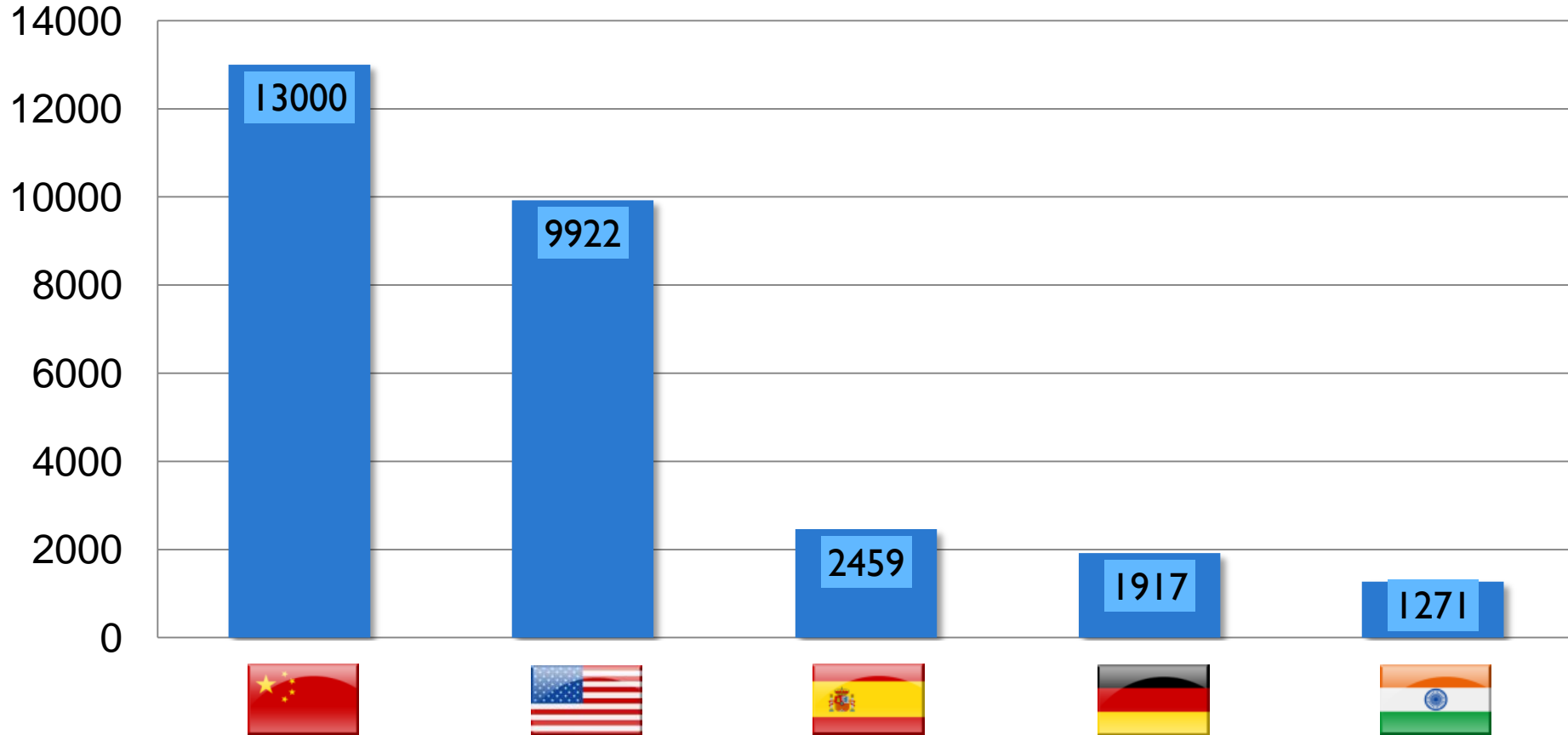
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# Market data

## Top 5 countries / newly added wind power in MW 2009



Source: GWEC

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# Market data

## Reflection about possible quantities (tower cables)

- Every tower includes about 15 to 18 power cables
- Towers are about 80m to 110m high (usual 2MW workhorses)
- A reasonable quantity of cables can be defined between
  - 15 x 80 m = 1.200 m and
  - 18 x 110 m = 1.980 m
  - Arithmetical mean 1.590 m, rounded 1.600 m
- A wind farm comprising of e.g. 45 towers will equal to 72.000 m tower cable only
- Remark:  
Additional, significant amount of different cable types in the nacelle and for “classis” grid connection (onshore)

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# Market data



## Different cable scenario for offshore wind tower installations

- From a “cable perspective” the nacelle and the tower of a wind tower installation are nearly the same for onshore and offshore installations
- **The big difference is the grid connection !**
  - Offshore wind towers are usually installed as wind farms (up to 20-25 wind towers in classic installations, 60 to 100+ in newer wind parks)
  - Wind towers are interconnected with subsea power cables
  - Offshore power substations serve as collection points
  - Higher voltage cables connect the substations with stations at land and the grid

# Offshore design of wind parks

Power cables Cables used in offshore wind parks



## Interconnection

- Subsea power cable up to 33kV
- Water tight  
(longitudinal and transversal)
- Armoured
- FO communication elements
- “Flexible”

# Offshore design of wind parks

Power cables Cables used in offshore wind parks



Picture: Siemens

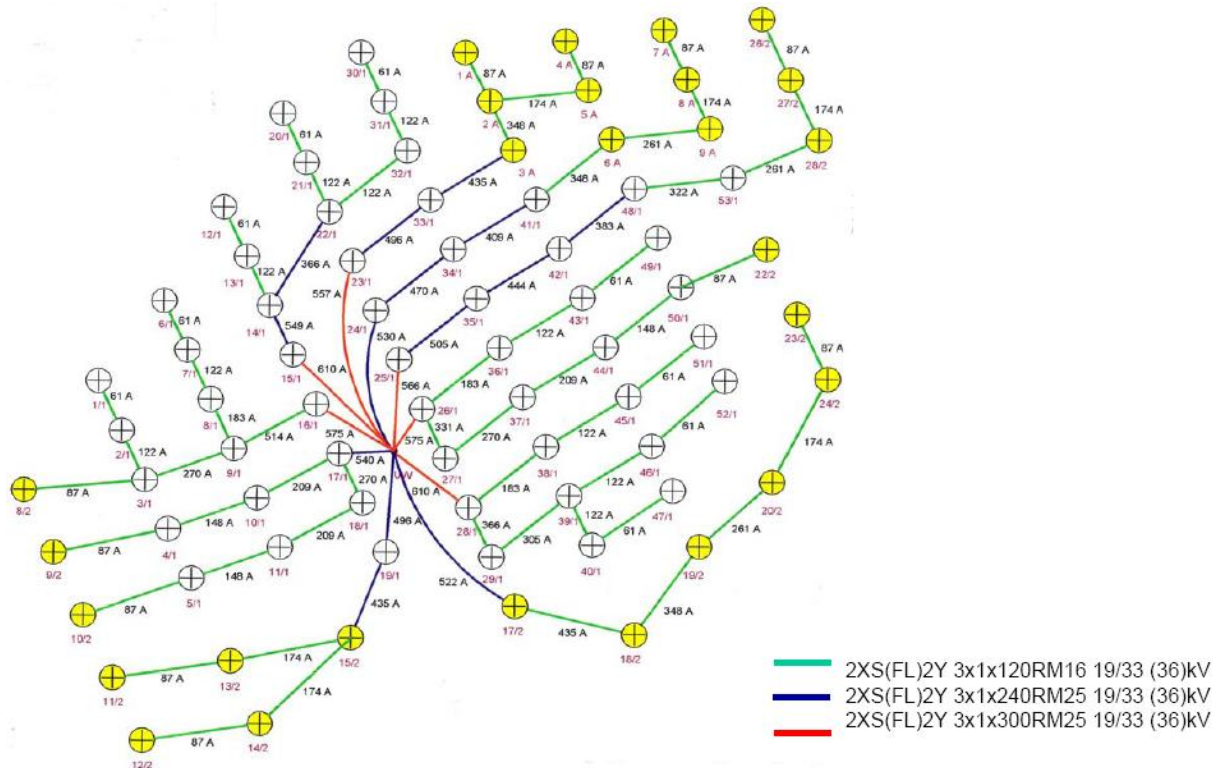
## Offshore substation

- Subsea power cable
  - up to 245kV (HVAC)
  - up to 500kV (HVDC)
- FO communication elements
- Turn-key projects



# Market data

## Typical cable layout for an offshore wind park



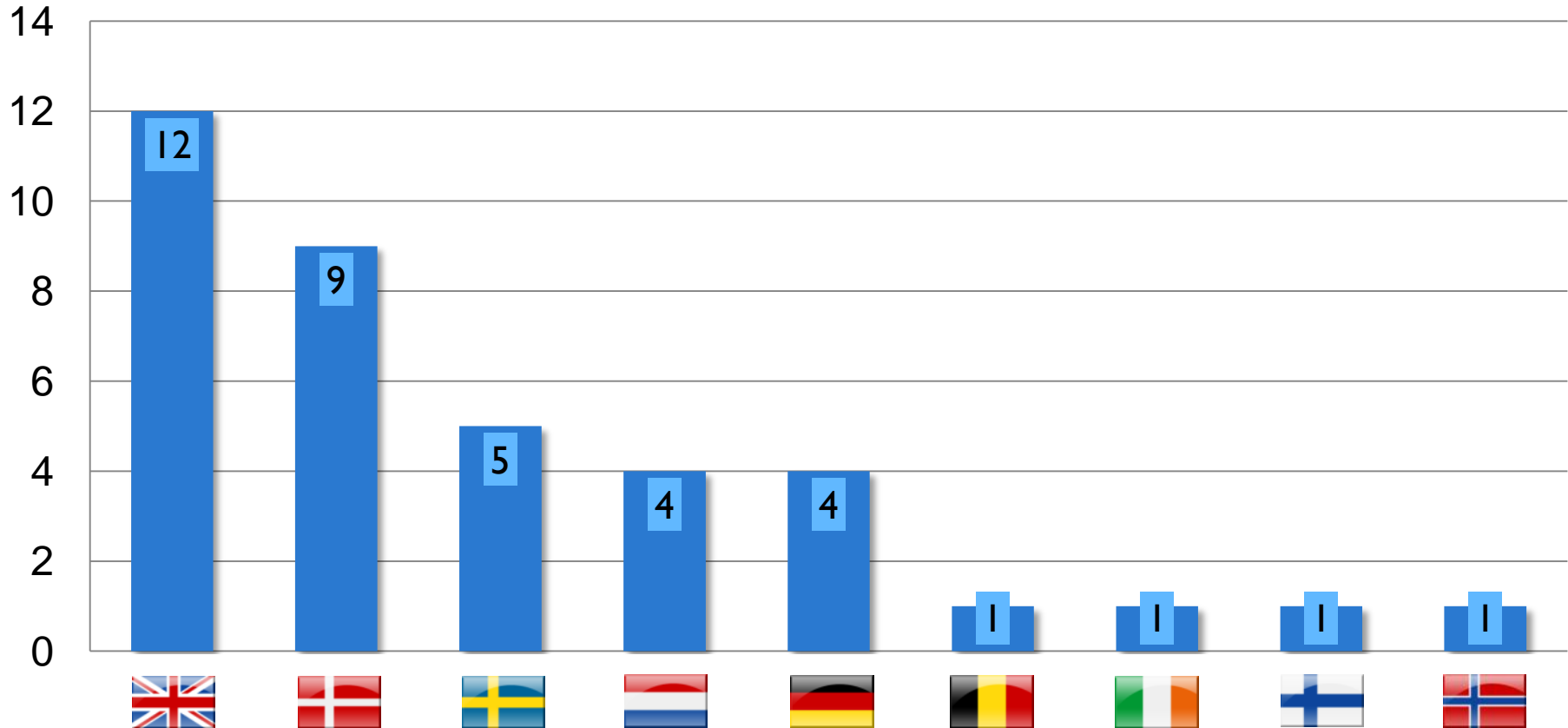
Source: SIEMENS HV Division

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# Market data

No. of offshore wind farms in Europe (in service 2009)



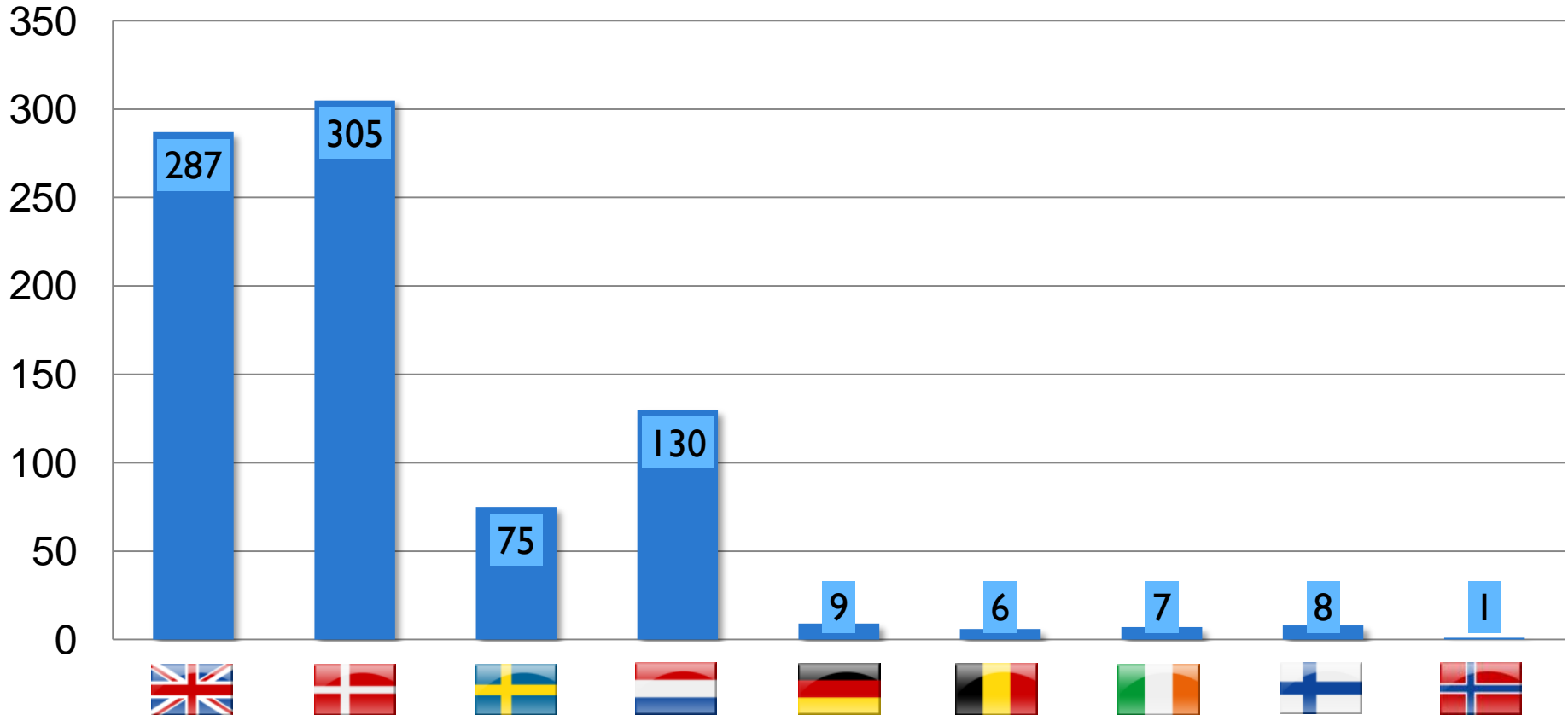
Source: EWEA and KC research

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# Market data

No. of offshore wind turbines in Europe (in service 2009)



Source: EWEA and KC research

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# Market data



## Global offshore installations

- Main market currently around Europe (lack of space and lack of acceptance for onshore systems respectively)
- International markets
  - China: One wind farm 102 MW in operation since spring 2010
  - USA: Ten offshore projects under evaluation (total about 2.000 MW)
  - Canada: NaiKun / 110 wind towers with 396 MW capacity

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# Conclusions



- ▶ Strong and growing global demand with off-shore installations gaining more market share
  - ▶ There is no “wind power standard” for cabling of wind towers yet (Besides UL subj. 2277, WTTC for tower cables)
  - ▶ Mix of cable types in the nacelle; room for improvements (space, weight, safety)
  - ▶ Cables in the tower are the most critical ones
  - ▶ Grid connection (systems) in off-shore applications not fully developed yet
- ➔ **Interesting but demanding market with none or proprietary specifications for nacelle and tower.**





# Do You Have Any Questions?

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