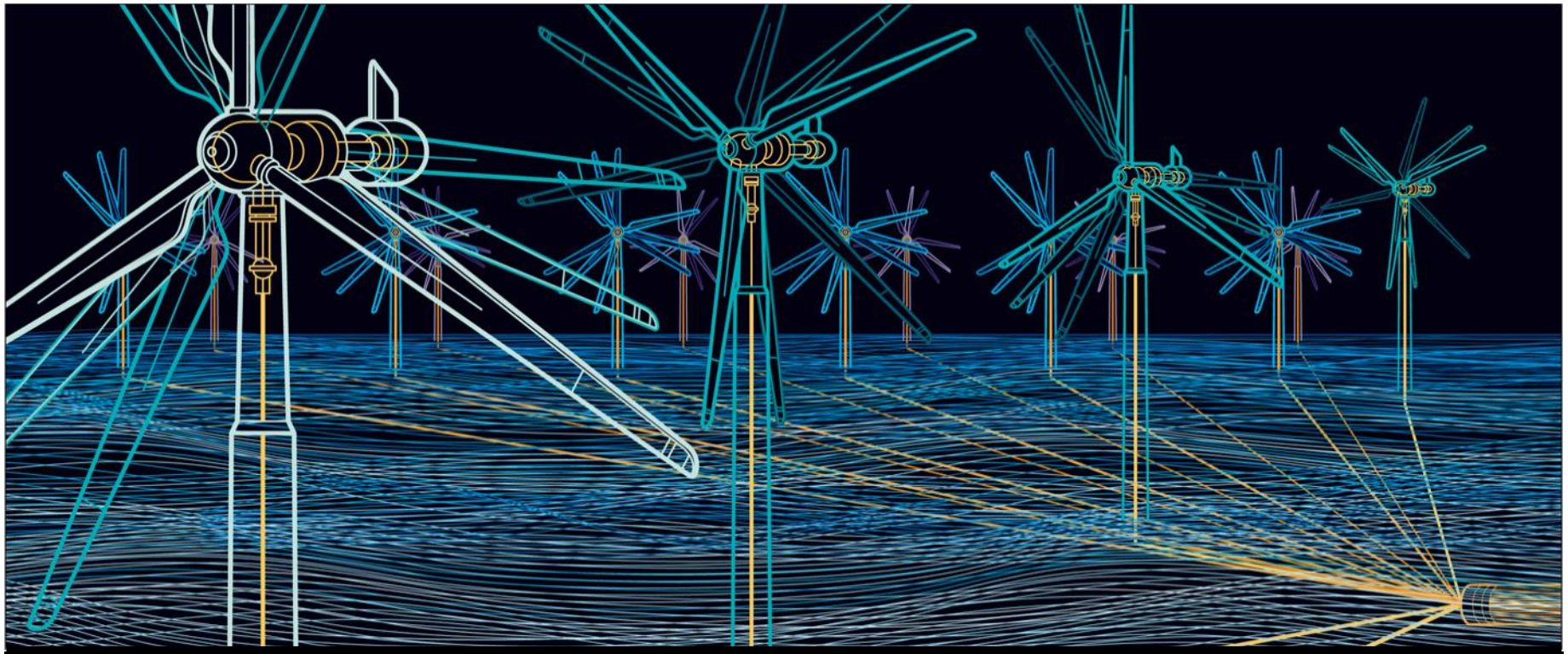


Tomasz Komalski GPMM Indoor Switches and Fuses, 2016

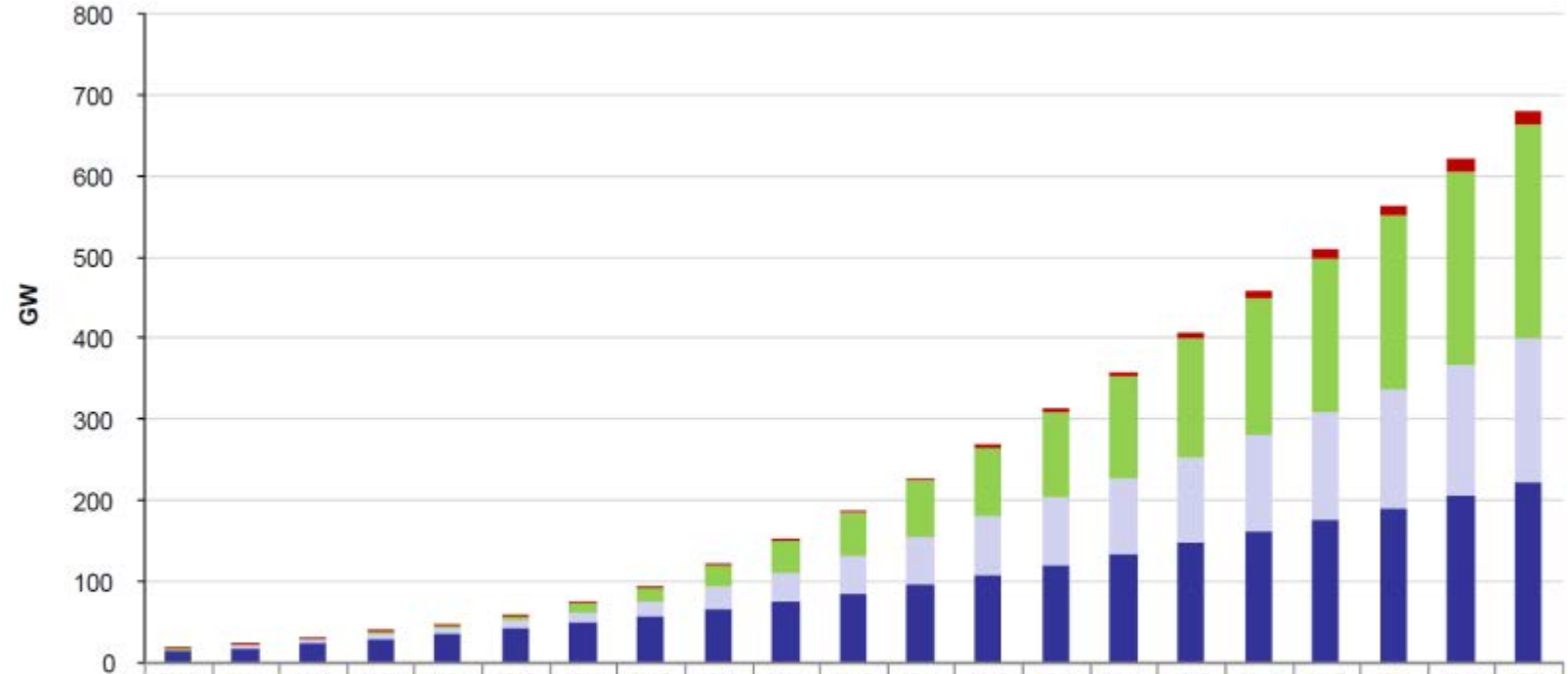
NALFWind™ optimized solution for wind farm switching and protection

Market data for wind farms
Global Wind Market

- Global wind market Onshore vs Offsore.

Market data for wind farms
Global Wind MW installed 2000-2020

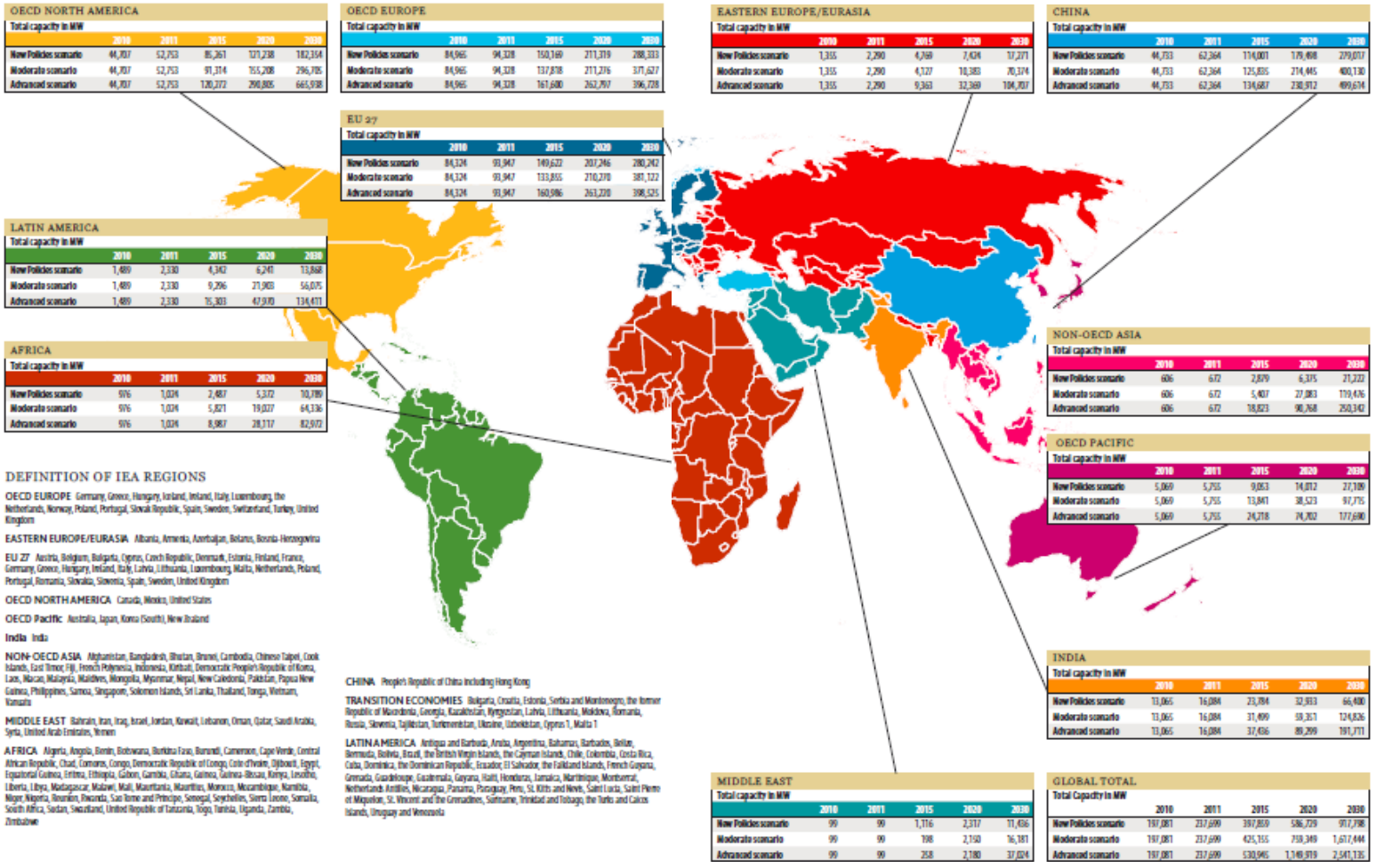
Exhibit 1-1: Global Wind Cumulative MW Installed by Region: 2000–2020



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Rest of World	0.2	0.3	0.3	0.3	0.4	0.4	0.8	1.0	1.3	1.9	2.5	3.1	3.9	4.9	6.0	7.3	9.0	10.8	12.9	15.2	17.7
Asia Pacific	1.8	2.3	2.8	3.6	5.1	7.6	11.5	17.3	26.5	38.9	53.4	69.3	86.4	104.7	124.9	146.1	168.1	191.0	214.6	239.1	264.2
North America	2.7	4.5	4.9	6.7	7.2	9.8	13.1	18.9	28.0	36.3	46.5	59.8	72.0	83.5	95.2	107.2	119.7	132.9	147.0	162.2	178.6
Europe*	12.9	17.4	23.6	29.0	34.9	41.4	48.9	56.7	66.2	74.2	83.9	94.8	107.0	119.7	132.8	146.3	160.6	175.1	190.0	205.3	221.3

- Source : Emerging Energy Research

Market data for wind farms
Global Wind Farms Market Structure 2010-2030



OECD NORTH AMERICA
Total capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	44,707	52,753	85,261	121,238	182,354
Moderate scenario	44,707	52,753	91,314	155,208	296,705
Advanced scenario	44,707	52,753	120,272	298,805	665,938

OECD EUROPE
Total capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	84,965	94,328	150,149	211,319	288,333
Moderate scenario	84,965	94,328	137,878	211,276	377,627
Advanced scenario	84,965	94,328	161,600	262,797	396,728

EASTERN EUROPE/EURASIA
Total capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	1,355	2,290	4,769	7,424	17,271
Moderate scenario	1,355	2,290	4,727	10,383	70,374
Advanced scenario	1,355	2,290	9,363	32,369	104,707

CHINA
Total capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	44,733	62,364	114,001	179,498	279,017
Moderate scenario	44,733	62,364	125,835	214,445	400,130
Advanced scenario	44,733	62,364	134,687	230,912	499,614

EU 27
Total capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	84,324	93,947	149,622	207,246	280,242
Moderate scenario	84,324	93,947	133,855	210,270	383,122
Advanced scenario	84,324	93,947	160,986	261,220	398,525

LATIN AMERICA
Total capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	1,489	2,330	4,342	6,241	13,868
Moderate scenario	1,489	2,330	9,296	21,903	56,075
Advanced scenario	1,489	2,330	15,303	47,970	134,471

AFRICA
Total capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	976	1,024	2,487	5,372	10,789
Moderate scenario	976	1,024	5,821	19,027	64,136
Advanced scenario	976	1,024	8,987	28,717	82,972

NON-OECD ASIA
Total capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	606	672	2,879	6,375	21,222
Moderate scenario	606	672	5,407	27,083	179,476
Advanced scenario	606	672	18,823	90,768	250,342

OECD PACIFIC
Total capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	5,069	5,755	9,053	14,012	27,109
Moderate scenario	5,069	5,755	13,841	38,523	97,775
Advanced scenario	5,069	5,755	24,718	74,702	177,698

INDIA
Total capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	13,065	16,084	23,784	32,933	66,400
Moderate scenario	13,065	16,084	31,499	59,351	124,826
Advanced scenario	13,065	16,084	37,436	89,299	191,771

MIDDLE EAST
Total capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	99	99	1,116	2,317	11,436
Moderate scenario	99	99	198	2,150	16,181
Advanced scenario	99	99	258	2,180	37,024

GLOBAL TOTAL
Total Capacity in MW

	2010	2011	2015	2020	2030
New Policies scenario	197,081	237,699	397,859	586,729	917,798
Moderate scenario	197,081	237,699	425,155	758,349	1,617,444
Advanced scenario	197,081	237,699	530,945	1,149,919	2,541,135

DEFINITION OF IEA REGIONS

OECD EUROPE Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom

EASTERN EUROPE/EURASIA Albania, Armenia, Azerbaijan, Belarus, Bosnia-Herzegovina

EU 27 Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom

OECD NORTH AMERICA Canada, Mexico, United States

OECD Pacific Australia, Japan, Korea (South), New Zealand

India India

NON-OECD ASIA Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia, Chinese Taipei, Cook Islands, East Timor, Fiji, French Polynesia, Indonesia, Kiribati, Democratic People's Republic of Korea, Laos, Macao, Malaysia, Maldives, Mongolia, Myanmar, Nepal, New Caledonia, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Thailand, Tonga, Vietnam, Vanuatu

MIDDLE EAST Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen

AFRICA Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Democratic Republic of Congo, Cote d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, United Republic of Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe

CHINA People's Republic of China including Hong Kong

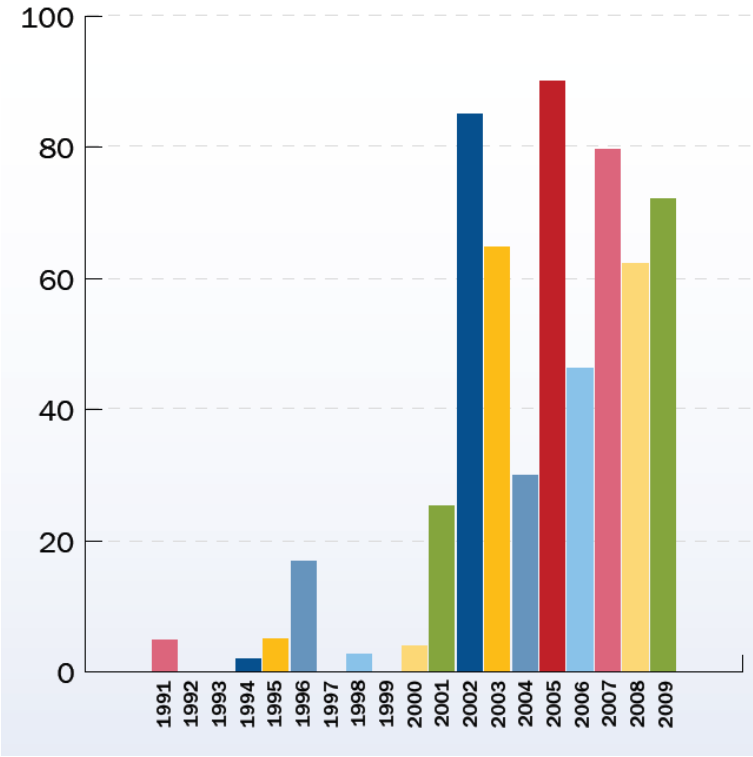
TRANSITION ECONOMIES Bulgaria, Croatia, Estonia, Serbia and Montenegro, the former Republic of Macedonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Romania, Russia, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, Cyprus †, Malta †

LATIN AMERICA Antigua and Barbuda, Aruba, Argentina, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, the British Virgin Islands, the Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominica, the Dominican Republic, Ecuador, El Salvador, the Falkland Islands, French Guyana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, St. Kitts and Nevis, Saint Lucia, Saint Pierre et Miquelon, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, the Turks and Caicos Islands, Uruguay and Venezuela

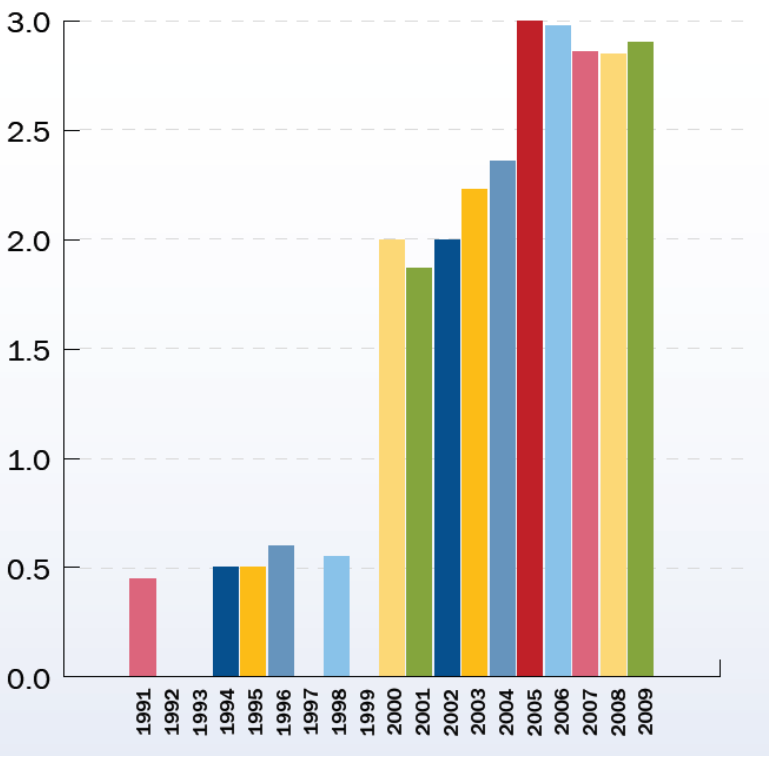
- Source : GWEC (Global Wind Energy Council)

Market data for wind farms
Global Wind MW farm size 1991-2009

AVERAGE WIND FARM SIZE IN MW FIGURE 4.0

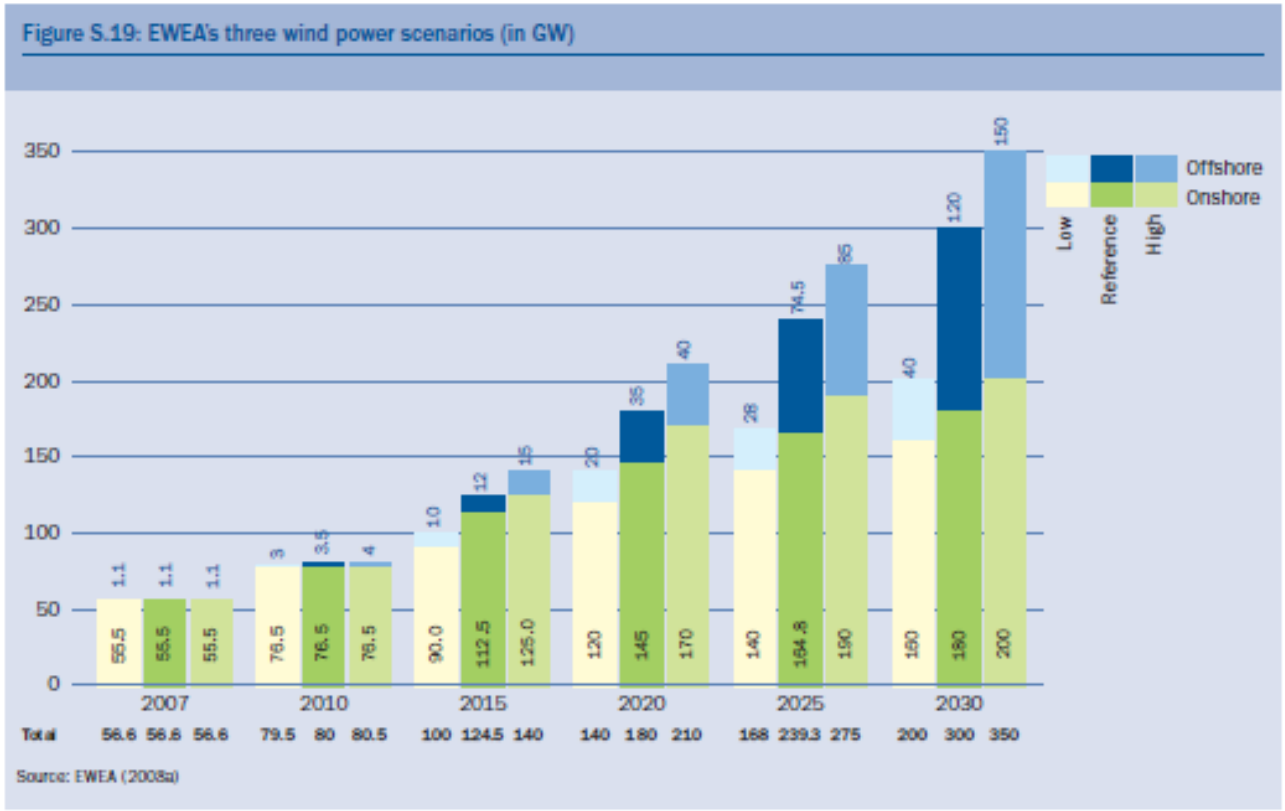


AVERAGE OFFSHORE WIND TURBINE CAPACITY FIGURE 4.1



- Source : EWEA (European Wind Energy Association)

Market data for wind farms
EWEA Wind Farms Onshore vs Offshore 2007 - 2030



- Source : EWEA (European Wind Energy Association)

Market data for wind farms
EWEA Wind Farms Facts

- How big is a wind turbine?
  - The average size of onshore turbines being manufactured today is around 2.5-3 MW. One 2.5 MW onshore turbine produces power for over 1,500 average EU households.
  - The largest onshore turbine is a 7 MW turbine with a rotor diameter of 127 m.
  - Offshore turbines currently reach just over to 6 MW with a rotor diameter of 120 metres – longer than a football field and powering around 5,500 average EU households.

- Source : EWEA (European Wind Energy Association)

Technical demand for switch-fuse combination 36 kV
Wind farm application

NALFWind™ and CEF-S-TCU for wind farms

Technical demand for switch-fuse combination 36 kV
Wind farm application – NALFWind™&CEF-S

Medium Voltage Products

CEF-S/CEF-S-TCU 30/40,5 kV
Fast acting current limiting fuses
Release note

Dear reader,

We are pleased to announce the official sales release of the new CEF-S/CEF-S-TCU 30/40,5 kV current limiting fuses. This new type of fuses extends existing CEF-S fuse range for 30/40,5 kV and up to 63 A rated current value.

Application

The worldwide demand for renewable energy is growing constantly, with wind power as one of the fastest growing sectors. The introduction of the new CEF-S/CEF-S-TCU current limiting fuses completes ABB's offering for the 30/40,5 kV voltage – the voltage level which is now standard for both wind turbines and peripherals. The breaking capacity is type tested at 20kA and maximum protected transformer output is defined at 3000 kVA. This makes these fuse type especially suitable for application in CSS on shore and off shore wind farms which average power has increased recently.

Fast acting current limiting fuses

Medium Voltage Products

NALFWind™ for 36 kV
High performing switch-fuse combination
Release note

Dear reader,

We are pleased to announce the official sales release of the new 36 kV NALFWind™ air insulated switch-fuse combination. This new type of medium voltage switching device creates new application opportunities as competitive design of wind farms.

Application

The worldwide demand for renewable energy is growing constantly, with wind power as one of the fastest growing sector. To meet the current and future needs of network operators, manufacturers and designers of wind power systems need to be able to call on both advanced technologies and in-depth knowledge.

The NALFWind is adapted to 36 kV – the voltage level which is now standard for both wind turbines and peripherals. NALFWind's high breaking capabilities make it possible to protect transformers up to 3000 kVA with CEF-S/CEF-S-TCU fast acting fuses. It is offered as the standard configuration with an earthing switch with 40 kA making capability. All this means that NALFWind creates completely new possibilities in many different applications.

High performing switch-fuse combination

Technical demand for switch-fuse combination 36 kV
Wind farm application – **CEF-S** fuse technical data

- **Major technical parameters:**

- Rated voltage – 30/40,5kV
- Rated current – 6,3 - 63 A
- Breaking current – 20 kA
- Very low power losses especially suitable for application in RMU
- Superior time current characteristic improving transformer protection level
- Latest IEC standard type tested :
  - IEC62271-105: 2002; IEC 60282-1.2009

Technical demand for switch-fuse combination 36 kV
Wind farm application – **NALFWind™** technical data

- **Major technical parameters:**

- **TD Itransfer – 700 A; 36kV**
- Rated normal current - 200A; 36kV; 20 CO (for switch - disconnector)
- Rated normal current with fuses - 63A ; 36 kV
- Rated short –circuit breaking current – 31,5kA; 36kV (CEF-S 63A)
- Rated short -circuit making current - 79kA(peak) (CEF-S 63A)
- Frequency withstand voltage - 80 / 88 kV
- Lightning impulse withstand voltage -170 / 195 kV
- Mechanical class – M1
- Earthing switch with making capacity up to 40 kA
- Latest IEC standard type tested :
  - IEC62271-105: 2002; IEC 62271-103:2011; IEC 62271-1:2007

Technical demand for switch-fuse combination 36 kV
Wind farm application – **NALFWind™** technical data

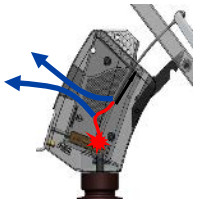
Line voltage (kV)	Transformer rating (kVA)																		
	25	50	75	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	**3000**
	Fuse-link rating I_n (A)																		
30	6,3*	6,3*	6,3*	6,3*	6,3	10	16	16	20	40	40	40	40	40	40	50	63	63	
36	6,3*	6,3*	6,3*	6,3*	6,3	6,3	10	16	16	20	40	40	40	40	40	50	50	63	63
38,5	6,3*	6,3*	6,3*	6,3*	6,3*	6,3	10	16	16	20	20	40	40	40	40	40	50	50	63
40,5	6,3*	6,3*	6,3*	6,3*	6,3*	6,3	10	16	16	20	20	40	40	40	40	40	50	50	63
Max. gG fuse-link at LV side (A)	40	80	125	160	160	200	250	250	300	400	400	800	1000	1000	1000	1000	1250	1250	1250

The table was calculated according to standards IEC 60787 and IEC 62271-105. The following transformer work conditions were assumed:
- Maximum long-lasting transformer overload - 120%,
- Magnetizing inrush current for transformers up and including 630kVA - 12 x I_n during 100ms,
- Magnetizing inrush current for transformers above 630kVA - 10 x I_n during 100ms,
- Standard ambient working conditions of fuses,
- For ratings marked with "*" transformer maximum short-circuit current at LV side is below fuse-link minimum breaking current I_3.

The table above details the rated current of a particular fuse-link for a given line voltage and transformer rating. For different criteria, the fuse selection must be recalculated.

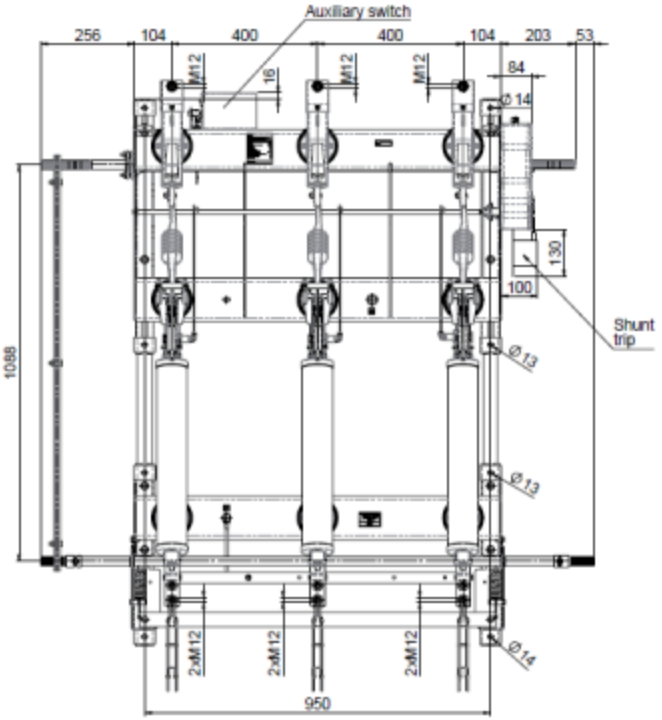
Technical demand for switch-fuse combination 36 kV
Wind farm application – NALFWind™ highlights

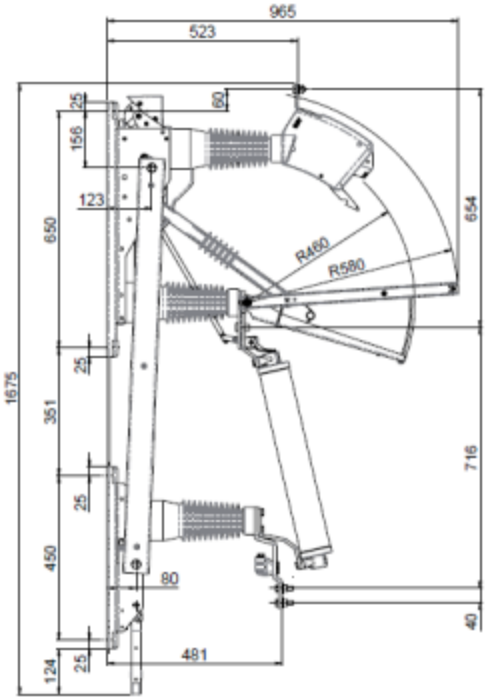
- New indoor **air** insulated switch-fuse combination with integrated earthing switch for transformer protection (up to **3 MVA at 36 kV**)
- Completely new patented interruption system
- **Safety:** Made to IEC standards (IEC 62271) smart design (without piston system), corrosion protected, visible break
- **Reliability:** Stringent testing of each unit, high and unique (in air insulation) interrupting capacity



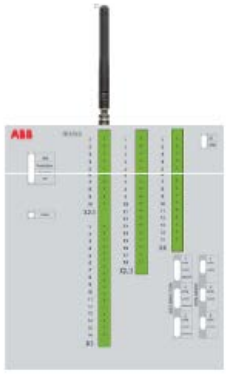
- **Performance**: best protecting and breaking solution for transformer protections with air insulation technology
- **Smart integration:** Modular construction, easy installation, partly based on NAL switch's tested parts, common accessories with NAL
- **Smart Grid ready**: integration with ABB Gateways and wireless controllers for GPRS/EDGE communication via SCADA. Control and monitoring functionality with two way communication through the implementation of the IEC 60870-5-104 protocol.

Technical demand for switch-fuse combination 36 kV
Wind farm application – NALFWind™ technical data





Technical demand for switch-fuse combination 36 kV
Wind farm application – Smart grid NALFWind™

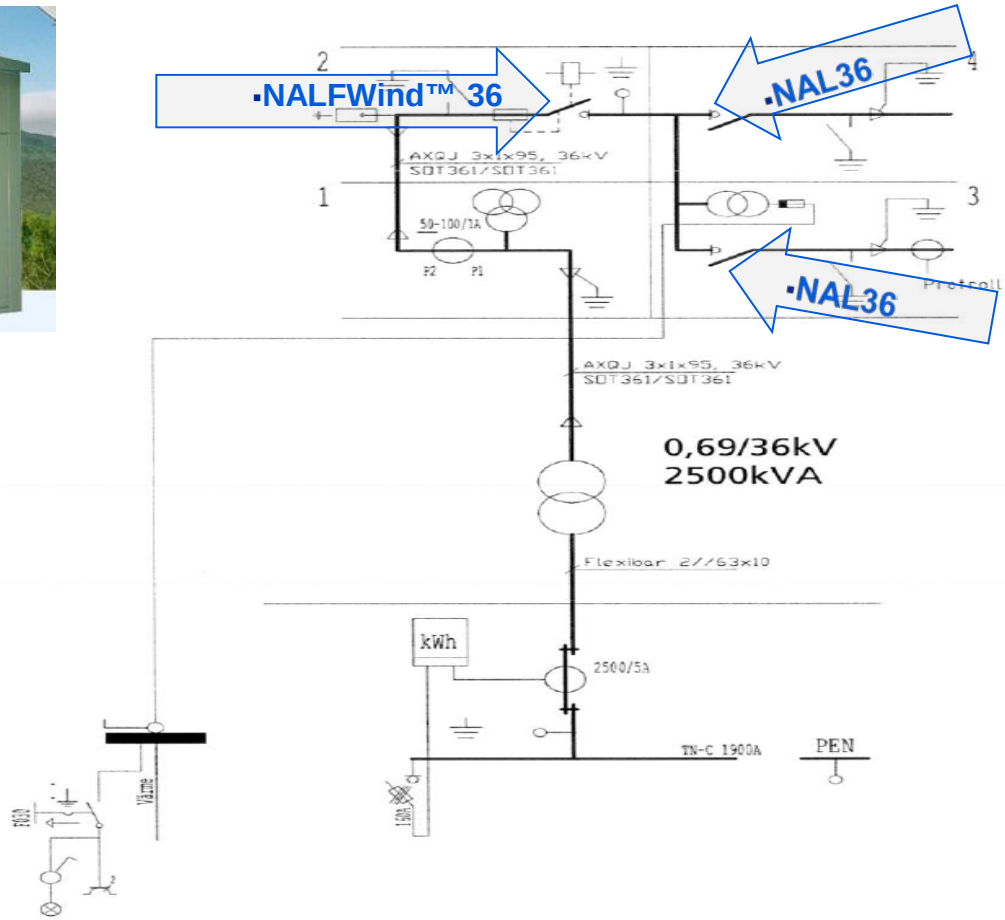


- REC 601 (603) plus RER 601 (603) Gateways
- Complete controller for one (up to **3** objects – disconnectors REC 603) including:
  - 2 (6) digital outputs for disconnector control
  - 5 (15) digital inputs for disconnector monitoring
  - Battery charger with temperature compensation
  - Battery monitoring
  - Battery deep discharge protection
  - Current measurement and overcurrent protection for **one**
- disconnector motor
  - 4-20 mA input (REC 603)
  - Heater control output
  - IEC 870-5-104 compatible control of all IO

Technical demand for switch-fuse combination 36 kV
Wind farm application-typical technical ratings

- Typical application scheme

Technical demand for switch-fuse combination 36 kV
Wind farm application – CSS related concepts



Technical demand for switch-fuse combination 36 kV
Wind farm application – CSS related concepts

- Protection by breaker require:
  - Breaker
  - Relay
  - CT
  - Disconnector or withdrawable breaker
  - Earthing switch (optional)

- Protection by switch-fuse combination require:
  - Switch-fuse combination with current limiting fuses
  - Earthing switch (optional)

The cost for switch disconnector may be even 1/3 of breaker in typical wind farm installation

Technical demand for switch-fuse combination 36 kV
Wind farm applications – **NALFWind™** & **CEF-S**

- All onshore projects with 36 kV CSS MV components requesting load break switch and switch-fuse combination
- All CSS projects for protection of transformers up to 3000 kVA at 36 kV
- Current limiting fuses 30/40,5 kV wind application requiring fast reaction for overload currents (feature supported by CEF-S superior time current characteristic)
- Air insulated installations
- Possible application inside primary panels for 30/36 kV operating range
- Wall mounted application in kiosks
- Industry, mining, wind power plants
- And many more…..
-

Technical demand for switch-fuse combination 36 kV
Wind farm application – NALFWind™ highlights

- **The only recognized switch-fuse combination in air insulation, capable for protecting 3 MVA TRANSFORMER UNITS with integrated earthing switch with making capability and type tested according to latest edition of relevant IEC standards**
- A safe and also **very cost-effective** solution for the wind industry
- Perfect offer for CSS manufacturers with possibility for creation high local value added

- Designed for CSS Wind Farms applicable onshore
- Product name protected by TM on global market

Power and productivity
for a better world™