The Power Sector Reports encompass the entire spectrum of power generation, transmission and distribution; utilities, merchant generators, industry, small captive and domestic generators, and the growing segment of “hidden power” not included in national statistics.

The Power Sector series consists of 9 volumes, providing modules of information, so that you can access exactly what you want, no more no less.

Vol 3. T&D provides data and analysis of the Capex, Markets and Infrastructure of the Transmission and Distribution sector, with historical data and forecasts.

- Capex - separately for transmission and distribution
- Markets - sales of mechanical and electrical T&D equipment
- Marketing commentary
- Vendor and competitive analysis
- Infrastructure - T&D lines, lengths and voltages
- Analysis of utilities
- Special chapters with technical and market analysis
EXECUTIVE SUMMARY
THE POWER SECTOR REPORT
THE STRUCTURE OF THIS REPORT
How this volume fits into the Power Sector Report series.

1. INTRODUCTION TO THE POWER SECTOR
The scale of the power sector is outlined as an introduction, in capacity and $ with commentary on its composition by the constituent sectors - generation, transmission and distribution.

2. THE ELEMENTS OF AN ELECTRICAL NETWORK
The transmission and distribution networks transport and deliver electricity from generators to consumers. To accomplish this they transform it up and down to different voltage levels, with step-up and step-down transformers. In the T&D industry, power and distribution transformers are probably the major single component of equipment, except for the cables through which electricity is transmitted and distributed, and they are the most costly single item. Transformers are needed at all stages in an electrical supply system when the voltage level changes.

3. UTILITY SECTORS
The 135,000 electricity, gas and water & waste utilities are shown regionally on a global map and the 11,000 electrical utilities are analysed by region and major country, with a breakdown of public/private ownership. A table summarises the electrical utility sector in every country.

4. THE USE OF ELECTRICITY BY SECTOR
Use by end-sector, with further analysis by type of industrial use and purpose of use.

5. THE HISTORICAL DEVELOPMENT OF TRANSMISSION AND DISTRIBUTION NETWORKS
A brief history of the development of the electricity power systems from their earliest start to the present day.

6. TRANSMISSION AND DISTRIBUTION LINE LENGTHS BY COUNTRY
Growth of the transmission and distribution networks is charted globally from 1900 to 2015. Installed transmission and distribution line lengths are tabulated at 10 year intervals from 1980 to 2030 in the PDF report and annually in the Excel database. This analysis is provided globally, regionally and for 216 countries.

7. ANNUAL DEMAND FOR T&D LINES, ADDITIONS AND REPLACEMENT
Global installed line lengths and annual demand for T&D lines is charted annually from 1900 to 2015 and forecast to 2050. Demand is analysed by new and replacement installations globally, by regions and for 216 countries, in five year segments from 2016-2020 to 2031-2035. Demand is also shown with replacement as a % of total demand to 2050.

8. DISTRIBUTED POWER
The status of distributed power is outlined together with captive power, cogeneration and “hidden power”, together with analysis of the impact on the retail cost of electricity.

9. NETWORK VOLTAGES
The global network base for transmission is analysed by region in four voltage groups – 35-89 kV, 90-199 kV, 200-329 kV, ≥300 kV, and subsea. Distribution is analysed by region and four groups – MV OH, MV UG, LV OH, LV UG and subsea. Transmission and distribution are not defined by voltage but by function
and there are considerable variations around the world as to the point of hand-over. A table demonstrates the substantial differences in Europe. This chapter contains 141 tables analysing voltage levels for as many countries.

10. CAPITAL EXPENDITURE
Capex is plotted globally from 2000 to 2015 and forecast to 2020, with analysis by segment; generation, transmission and distribution.

11. T&D CAPEX
Transmission and distribution capex is plotted for the world, 7 regions and 11 major countries, at eight intervals in the PDF for 2000, 2010 and annually from 2015 to 2020 - and in the Excel database annually from 2000 to 2020.

12. REGIONAL AND NATIONAL EQUIPMENT MARKETS BY PRODUCTS
Each regional and national market for T&D equipment is analysed by product, tabulated by product in nominal values in the PDF from 2000, 2010 and annually from 2015 to 2020 - and in the Excel database annually from 2000 to 2020. Products include transformers, switchgear, circuit breakers, circuit protectors, surge arresters, distribution panels, fusegear, switches, disconnectors, protection relays, lightning arresters, isolators, energy cable - insulated and uninsulated conductors, insulators and bushings, spacers and dampers, HVDC, AC filters for HVDC, steel towers, poles of wood, concrete, steel and composite, pole-top assemblies, meters and utility automation.

13. SALES OF T&D EQUIPMENT BY REGION
Each product market is tabulated by region and country, for the world, 7 regions and 11 major countries for the following products; transformers, switchgear, circuit breakers, circuit protectors, surge arresters, distribution panels, fusegear, switches, disconnectors, protection relays, lightning arresters, isolators, energy cable - insulated and uninsulated conductors, insulators and bushings, spacers and dampers, HVDC, AC filters for HVDC, steel towers, poles of wood, concrete, steel and composite, pole-top assemblies, meters and utility automation.

Vendor shares or rankings are provided for the individual category/products and sections have marketing and technical commentary. Where available these have been supplemented with extracts from dedicated StatPlan product marketing reports, with higher levels of detail.

14. THE VALUE CHAIN – FROM MATERIALS TO CAPEX
The cost of any product can be measured at various stages, from being a piece of unworked metal, to its installation in working order and finally as a share of capital expenditure. Different price levels apply through the supply chain, and the point of interest in the chain depends on the business to which the value is being applied. The report analyses the value chain at 6 levels, from BOM (bill of materials) to capex, with all mark-ups included. In using the market information in this and other reports it is essential to specify which point in the value chain is being used. Capex can be 2½ times the factory gate price, over 3 times manufacturing cost and 5 times materials cost.

15. PRICE TRENDS AND FACTORS DRIVING PRICES
In recent years the prices of electrotechnical products have been volatile due to variations in many factors which affect them. Price trends are reviewed with commentary on PPI - Producer Price Index, industry trends, production capacity, and the manufacturing input cost composition.
16. LAND-BASED UNDERGROUND CABLES – HV, MV & LV
Insulated underground land cables are not the most profitable segment of the power cable market nor the one with the highest long term growth prospects but together with bare conductors it has the most stable demand. EHV is the most profitable segment reflecting increased profitability with more advanced technology. There is steady and increasing demand for insulated MV and LV cable in the utility sector, driven by growing utility transmission expansion, undergrounding due to urbanisation. All voltage levels are used in the industrial sector, from HV in heavy industry such as steel manufacture and milling, down to a myriad of LV applications in the residential, commercial and automotive sectors. This chapter contains charts of the incidence of underground insulated cable use by voltage in major countries and examines drivers, high costs and the impact of urbanisation.

17. THE SUBMARINE CABLE MARKET - OFFSHORE WIND POWER, OIL & GAS
Submarine cable is a premium growth market. The technical barriers to entry are relatively high and order backlogs are solid. These cables also achieve margins of 15-20% EBITDA which are significantly higher than the average for the cable industry. Over the last five years a number of developments have created demand for submarine cable. The technology and market issues are explored in this chapter.

18. ADVANCED TECHNOLOGY, SUPERCONDUCTORS
Superconductors are materials that have no resistance to the flow of electricity; they are one of the last great frontiers of scientific discovery. Some materials, cooled below a material-specific temperature called “critical temperature” (Tc) undergo a phase transition into the superconducting state. Markets for superconducting wire are in many ways similar to early descriptions of the market for transistors. Today, transistors are ubiquitous, and are used in virtually every application that harnesses electricity. In a similar fashion, superconducting wire has market applications that are virtually limitless. The fundamental value proposition of superconducting wire is the elimination of electrical loss, along with its accompanying heat, resulting in the efficient transmission of vast amounts of electricity using materials and equipment that are a fraction of the size and weight required for conventional copper wire electrical cables and equipment. The technology, development and market status are explored in this chapter.

19. N-1 STANDARD, N-2, 2N, REDUNDANCY AND REPLACEMENT
Redundancy is a crucial consideration in infrastructure design and has major implications for market size calculations. The following factors are reviewed; the impact of network failure, transformer failure, industrial reliability, network reliability, N-1 and the networks, contingency planning for network failure and electricity distribution.

20. ELECTRIFICATION
The impact of increased electrification on future markets is described with its advantages in terms of electrical goods and aspirations, which vary according to the sophistication of the electrical market in a country. Factors driving the increase in numbers of electrical connections are assessed with tables of electrification levels for every country, from 1950 to 2050.

21. CURRENTS, CIRCUITS and PHASES
Currents - AC and DC, circuits, and an overview of infrastructure

METHODOLOGY
EXECUTIVE SUMMARY.................................................................................................................. 17
THE POWER SECTOR REPORT........................................................................................................ 34
THE STRUCTURE OF THIS REPORT ............................................................................................. 35
1. INTRODUCTION TO THE POWER SECTOR ............................................................................ 36
   The scale of the power sector ........................................................................................................ 36
   The participants in the Power Sector .............................................................................................. 37
2. THE ELEMENTS OF AN ELECTRICAL NETWORK ................................................................. 39
3. UTILITY SECTORS ....................................................................................................................... 41
4. THE USE OF ELECTRICITY BY SECTOR ................................................................................ 52
5. THE HISTORICAL DEVELOPMENT OF TRANSMISSION AND DISTRIBUTION NETWORKS .... 56
6. TRANSMISSION AND DISTRIBUTION LINE LENGTHS BY COUNTRY ................................ 59
7. ANNUAL DEMAND FOR T&D LINES, ADDITIONS AND REPLACEMENT ............................. 73
8. DISTRIBUTED POWER ................................................................................................................ 104
9. NETWORK VOLTAGES .............................................................................................................. 107
    GLOBAL TRANSMISSION AND DISTRIBUTION VOLTAGES .................................................... 107
    EUROPE ..................................................................................................................................... 109
    CIS ............................................................................................................................................ 121
    MIDDLE EAST ........................................................................................................................... 125
    NORTH AFRICA .......................................................................................................................... 128
    SUB-SAHARAN AFRICA .............................................................................................................. 130
    ASIA PACIFIC ............................................................................................................................ 138
    NORTH AMERICA .................................................................................................................... 144
    LATIN AMERICA ..................................................................................................................... 145
10. CAPITAL EXPENDITURE .......................................................................................................... 150
11. T&D CAPEX ............................................................................................................................. 154
12. REGIONAL AND NATIONAL EQUIPMENT MARKETS ............................................................ 157
    T&D plant, United States .............................................................................................................. 161
    T&D plant, Europe ....................................................................................................................... 163
    T&D plant, France ....................................................................................................................... 165
    T&D plant, Germany .................................................................................................................... 167
    T&D plant, Italy ............................................................................................................................ 169
    T&D plant, Spain .......................................................................................................................... 171
    T&D plant, United Kingdom ........................................................................................................ 173
    T&D plant, CIS ............................................................................................................................. 175
    T&D plant, Russia ........................................................................................................................ 177
    T&D plant, Asia Pacific .............................................................................................................. 179
Figure 19: Comparison of expenditure on GTD in real ($2015) and nominal values, 2000 to 2020 .......................... 150
Figure 20: Global capital expenditure broken by GTD, nominal $ billion, 2000 to 2020 ................................. 151
Figure 21: Total capex in GTD 200-2010 compared with 2010-20 ............................................................... 151
Figure 22: Total Capital Expenditure on GTD by region in 2016 ................................................................. 152
Figure 23: Total Capital Expenditure on GTD by Region and Year, nominal $ billion, 2000, 2010 and 2020  .... 152
Figure 24: Composition of global capital expenditure Generation, Transmission and Distribution, 2015 ........ 153
Figure 25: Where circuit breakers are used in electricity systems ............................................................... 205
Figure 26: Commodity price Index 1996 to 2016 .......................................................................................... 254
Figure 27: Industrial metals prices 2007 to 2016 ......................................................................................... 255
Figure 28: Labour compensation cost, including direct pay, social insurance expenditures, and labour taxes. .... 256
Figure 29: Labour costs including wages and salaries, social insurance and labour-related taxes ................ 256
Figure 30: Minimum wages in China in yuan per month 1995 to 2012 .......................................................... 257
Figure 31: Underground cable as a percent of the total network in European countries ................................ 259
Figure 32: Underground cable as a percent of the total network in CIS countries ......................................... 260
Figure 33: Underground cable as a percent of the total network in MENA countries ................................. 260
Figure 34: Underground cable as a percent of the total network in Asia Pacific countries ......................... 260
Figure 35: Underground cable as a percent of the total network in Pacific countries .................................. 261
Figure 36: Percent of population in urban areas, 1960-2010 by region ......................................................... 262
Figure 37: Market shares of different offshore segments ............................................................................. 264
Figure 38: Undersea communications cables linking the world ................................................................. 269
Figure 39: A high voltage substation with four transformers, three active and one redundant .................... 282
Figure 40: Additions of electrified households between 2015 and 2050 by region ......................................... 286
Figure 41: Countries with greatest population declines by 2050 ............................................................... 287
Figure 42: The Household Electrification Wheel .......................................................................................... 288
Figure 43: Population growth % in each decade by region ....................................................................... 289
Figure 44: Average household size, World, 1900 to 2050 ......................................................................... 289
Figure 45: World electrification - % of households with electricity, 1900-2050 ........................................ 290
Figure 46: World electrification – Number of households with and without electricity, 1900-2050 .......... 291
Figure 47: Share of people without electricity access for developing countries, 2008 ............................... 291
Figure 48: Regional totals of electrified households 2010 to 2050 ............................................................. 292
Figure 49: Selected major countries - % of households with electricity, 1900-2050 ................................. 292
Figure 50: Single phase power .................................................................................................................. 300
Figure 51: Three phase power .................................................................................................................... 300
Figure 52: The composition of annual demand for capacity, new plus replacement ............................. 303

Tables

Table 1: Ownership of assets in the power sector by owner type .............................................................. 38
Table 2: The world’s electrical utility landscape ......................................................................................... 47
Table 3: Transmission line lengths in Ckm, 1980 to 2030, Europe .......................................................... 60
Table 4: Distribution line lengths in Ckm, 1980 to 2030, Europe .............................................................. 61
Table 5: Transmission line lengths in Ckm, 1980 to 2030, CIS ............................................................... 62
Table 6: Distribution line lengths in Ckm, 1980 to 2030, CIS ................................................................. 62
Table 7: Transmission line lengths in Ckm, 1980 to 2030, MENA ........................................................ 63
Table 8: Distribution line lengths in Ckm, 1980 to 2030, MENA ............................................................. 63
Table 9: Transmission line lengths in Ckm, 1980 to 2030, Sub-Saharan Africa ....................................... 64
Table 10: Distribution line lengths in Ckm, 1980 to 2030, Sub-Saharan Africa ...................................... 65
Table 11: Transmission line lengths in Ckm, 1980 to 2030, Asia ............................................................ 66
Table 12: Distribution line lengths in Ckm, 1980 to 2030, Asia ............................................................. 67
Table 13: Transmission line lengths in Ckm, 1980 to 2030, Pacific ......................................................... 68
Table 14: Distribution line lengths in Ckm, 1980 to 2030, Pacific ......................................................... 69
Table 15: Transmission line lengths in Ckm, 1980 to 2030, North America ........................................... 70
Table 16: Distribution line lengths in Ckm, 1980 to 2030, North America ............................................. 70
Table 17: Transmission line lengths in Ckm, 1980 to 2030, Latin America......................................................... 113
Table 18: Distribution line lengths in Ckm, 1980 to 2030, Latin America................................................................. 114
Table 19: New and replacement demand for transmission lines in Ckm, 2016 to 2035, World ........................................ 115
Table 20: Demand for transmission lines in Ckm, 2016 to 2050, World ................................................................. 115
Table 21: New and replacement demand for distribution lines in Ckm, 2016 to 2035, World .............................. 116
Table 22: Demand for distribution lines in Ckm, 2016 to 2050, World ................................................................. 116
Table 23: New and replacement demand for transmission lines by country in km, 2015-30, Europe .................. 117
Table 24: New and replacement demand for transmission lines by country in km and % of rep, 2015-50, Europe .. 117
Table 25: New and replacement demand for distribution lines by country in km, 2015-30, Europe ....................... 118
Table 26: New and replacement demand for distribution lines by country in km and % of rep, 2015-50, Europe ... 118
Table 27: New and replacement demand for transmission lines by country in km, 2015-50, CIS ............................ 119
Table 28: New and replacement demand for transmission lines by country in km and % of rep, 2015-50, CIS ....... 119
Table 29: New and replacement demand for distribution lines by country in km, 2015-30, CIS ............................. 120
Table 30: New and replacement demand for distribution lines by country in km and % of rep, 2015-50, CIS .......... 120
Table 31: New and replacement demand for distribution lines by country in km, 2015-30, MENA ..................... 121
Table 32: New and replacement demand for transmission lines by country in km and % of rep, 2015-50, MENA ... 121
Table 33: New and replacement demand for distribution lines by country in km, 2015 to 2030, MENA .............. 122
Table 34: New and replacement demand for distribution lines by country in km and % of rep, 2015-50, MENA..... 122
Table 35: New and replacement demand for transmission lines by country in km, 2015 to 2030, S-S Africa ....... 123
Table 36: New and replacement demand for transmission lines by country in km, % of rep, 2015-50, S-S Africa.... 123
Table 37: New and replacement demand for distribution lines by country in km, 2015-30, S-S Africa ...................... 124
Table 38: New and replacement demand for distribution lines by country in km, % of rep, 2015-50, S-S Africa .... 124
Table 39: New and replacement demand for transmission lines by country in km, 2015-30, Asia ....................... 125
Table 40: New and replacement demand for transmission lines by country in km and % of rep, 2015-50, Asia ..... 125
Table 41: New and replacement demand for distribution lines by country in km, 2015-30, Asia .......................... 126
Table 42: New and replacement demand for distribution lines by country in km and % of rep, 2015-50, Asia....... 126
Table 43: New and replacement demand for transmission lines by country in km, 2015-30, Pacific ....................... 127
Table 44: New and replacement demand for transmission lines by country in km and % of rep, 2015-50, Pacific..... 127
Table 45: New and replacement demand for distribution lines by country in km, 2015-30, Pacific ....................... 128
Table 46: New and replacement demand for distribution lines by country in km and % of rep, 2015-50, Pacific ... 128
Table 47: New and replacement demand for transmission lines by country in km, 2015-30, NAM .......................... 129
Table 48: New and replacement demand for transmission lines by country in km and % of rep, 2015-50, NAM..... 129
Table 49: New and replacement demand for distribution lines by country in km, 2015-30, NAM .......................... 129
Table 50: New and replacement demand for distribution lines by country in km and % of rep, 2015-50, NAM ....... 129
Table 51: New and replacement demand for transmission lines by country in km, 2015-30, LAC .......................... 130
Table 52: New and replacement demand for transmission lines by country in km and % of rep, 2015-50, LAC ....... 130
Table 53: New and replacement demand for distribution lines by country in km, 2015-30, Americas ................. 131
Table 54: New and replacement demand for distribution lines by country in km, % of rep, 2015-50, Americas .... 131
Table 55: Global transmission lines by voltage, km, 2014 .................................................................................. 132
Table 56: Global distribution lines by voltage, km, 2014 .................................................................................. 132
Table 57: Albania transmission and distribution ................................................................................................. 133
Table 58: Austria transmission and distribution ................................................................................................. 133
Table 59: Baltics transmission and distribution ................................................................................................. 133
Table 60: Belgium transmission and distribution ................................................................................................. 134
Table 61: Bosnia & Herzegovina transmission and distribution ................................................................. 134
Table 62: Bulgaria transmission and distribution ................................................................................................. 134
Table 63: Croatia transmission and distribution ................................................................................................. 134
Table 64: Cyprus transmission and distribution ................................................................................................. 134
Table 65: Czech Republic transmission and distribution ................................................................................... 135
Table 66: Denmark transmission and distribution ............................................................................................... 135
Table 67: Finland transmission and distribution ................................................................................................. 135
Table 68: France transmission and distribution ................................................................................................. 136
Table 69: Germany transmission and distribution ............................................................................................... 136
Table 70: Greece transmission and distribution ................................................................................................. 136
Table 71: Hungary transmission and distribution ............................................................................................... 137
Table 72: Iceland transmission and distribution ................................................................................................. 137
Table 73: Ireland transmission and distribution ................................................................................................. 137
Table 74: Israel transmission and distribution ................................................................................................. 138
Table 75: Italy transmission and distribution ................................................................................................. 138
Table 76: Japan transmission and distribution ................................................................................................. 138
Table 77: Kazakhstan transmission and distribution ....................................................................................... 139
Table 78: Korea transmission and distribution ............................................................................................... 139
Table 79: Latvia transmission and distribution ................................................................................................. 139
Table 80: Lithuania transmission and distribution ............................................................................................. 139
Table 81: Luxembourg transmission and distribution ...................................................................................... 139
Table 82: Mexico transmission and distribution ............................................................................................... 140
Table 83: The Netherlands transmission and distribution .................................................................................. 140
Table 84: Norway transmission and distribution ............................................................................................... 140
Table 85: Poland transmission and distribution ............................................................................................... 140
Table 86: Portugal transmission and distribution .............................................................................................. 140
Table 87: Romania transmission and distribution ............................................................................................. 140
Table 88: Russia transmission and distribution ................................................................................................. 141
Table 89: Slovakia transmission and distribution ............................................................................................... 141
Table 90: Slovenia transmission and distribution ............................................................................................... 141
Table 91: Spain transmission and distribution ................................................................................................. 141
Table 92: Sweden transmission and distribution ............................................................................................... 141
Table 93: Switzerland transmission and distribution .......................................................................................... 141
Table 94: Turkey transmission and distribution ................................................................................................. 141
Table 95: Ukraine transmission and distribution ............................................................................................... 141
Table 96: United States transmission and distribution ....................................................................................... 142
Table 97: Vietnam transmission and distribution.............................................................................................. 142
Table 98: Yemen transmission and distribution ................................................................................................. 142
Table 99: Zimbabwe transmission and distribution ............................................................................................. 142
Table 100: India transmission and distribution ................................................................................................. 143
Table 101: China transmission and distribution ................................................................................................. 143
Table 102: Brazil transmission and distribution ............................................................................................... 143
Table 103: South Africa transmission and distribution...................................................................................... 143
Table 104: Mexico transmission and distribution ............................................................................................... 144
Table 70: Greece transmission and distribution ................................................................. 114
Table 71: Hungary transmission and distribution ............................................................... 114
Table 72: Iceland transmission and distribution ................................................................. 115
Table 73: Ireland transmission and distribution ................................................................. 115
Table 74: Italy transmission and distribution ...................................................................... 115
Table 75: Luxembourg transmission and distribution ......................................................... 116
Table 76: Macedonia transmission and distribution ............................................................ 116
Table 77: Malta transmission and distribution .................................................................... 116
Table 78: Netherlands transmission and distribution ........................................................... 117
Table 79: Norway transmission and distribution ................................................................. 117
Table 80: Poland transmission and distribution ................................................................... 117
Table 81: Portugal transmission and distribution ............................................................... 118
Table 82: Romania transmission and distribution ............................................................... 118
Table 83: Serbia transmission and distribution ................................................................... 118
Table 84: Slovakia transmission and distribution ............................................................... 119
Table 85: Slovenia transmission and distribution ............................................................... 119
Table 86: Spain transmission and distribution .................................................................... 119
Table 87: Sweden transmission and distribution ............................................................... 119
Table 88: Switzerland transmission and distribution .......................................................... 120
Table 89: Turkey transmission and distribution ................................................................... 120
Table 90: United Kingdom transmission and distribution .................................................. 120
Table 91: Armenia transmission and distribution ............................................................... 121
Table 92: Azerbaijan transmission and distribution ............................................................ 121
Table 93: Belarus transmission and distribution ............................................................... 121
Table 94: Georgia transmission and distribution ............................................................... 121
Table 95: Kazakhstan transmission and distribution ......................................................... 122
Table 96: Kyrgyzstan transmission and distribution ........................................................... 122
Table 97: Moldova transmission and distribution .............................................................. 122
Table 98: Russia transmission and distribution ................................................................... 123
Table 99: Tajikistan transmission and distribution ............................................................. 123
Table 100: Turkmenistan transmission and distribution ..................................................... 123
Table 101: Ukraine transmission and distribution ............................................................. 124
Table 102: Uzbekistan transmission and distribution ......................................................... 124
Table 103: Bahrain transmission and distribution .............................................................. 125
Table 104: Iran transmission and distribution .................................................................... 125
Table 105: Iraq transmission .............................................................................................. 125
Table 106: Israel transmission and distribution ................................................................... 125
Table 107: Jordan transmission and distribution ............................................................... 126
Table 108: Kuwait transmission and distribution ............................................................... 126
Table 109: Lebanon transmission ...................................................................................... 126
Table 110: Oman: transmission ......................................................................................... 126
Table 111: Qatar transmission ............................................................................................ 127
Table 112: Saudi Arabia transmission and distribution ..................................................... 127
Table 113: Syria transmission and distribution ................................................................... 127
Table 114: United Arab Republic transmission .................................................................. 127
Table 115: Yemen transmission and distribution ............................................................... 127
Table 116: Algeria transmission and distribution ............................................................... 128
Table 117: Egypt transmission and distribution .................................................................. 128
Table 118: Libya transmission and distribution .................................................................. 128
Table 119: Morocco transmission and distribution ............................................................ 128
Table 120: Sudan transmission and distribution ............................................................... 129
Table 121: Tunisia transmission and distribution ............................................................. 129
Table 122: Angola transmission and distribution........................................................................................................130
Table 123: Benin transmission and distribution .............................................................................................................130
Table 124: Burkina Faso transmission and distribution ................................................................................................130
Table 125: Cameroon transmission and distribution ..................................................................................................130
Table 126: Central African Republic transmission and distribution ..............................................................................131
Table 127: Cote d’Ivoire transmission and distribution ...............................................................................................131
Table 128: Djibouti transmission and distribution ........................................................................................................131
Table 129: Ethiopia transmission and distribution .......................................................................................................131
Table 130: The Gambia transmission and distribution ................................................................................................131
Table 131: Ghana transmission and distribution ..........................................................................................................131
Table 132: Guinea Bissau transmission and distribution ...............................................................................................132
Table 133: Guinea Equatorial transmission ................................................................................................................132
Table 134: Kenya transmission and distribution ..........................................................................................................132
Table 135: Lesotho transmission and distribution........................................................................................................133
Table 136: Liberia transmission and distribution ...........................................................................................................133
Table 137: Madagascar transmission and distribution ................................................................................................133
Table 138: Malawi transmission .....................................................................................................................................133
Table 139: Mauritius transmission and distribution .....................................................................................................133
Table 140: Mozambique transmission and distribution ...............................................................................................134
Table 141: Namibia transmission and distribution .......................................................................................................134
Table 142: Nigeria transmission and distribution .........................................................................................................134
Table 143: Rwanda transmission ....................................................................................................................................134
Table 144: Senegal transmission and distribution .........................................................................................................135
Table 145: Seychelles transmission ................................................................................................................................135
Table 146: South Africa transmission and distribution ................................................................................................135
Table 147: Tanzania transmission ....................................................................................................................................136
Table 148: Togo distribution ..............................................................................................................................................136
Table 149: Uganda transmission and distribution .........................................................................................................136
Table 150: Zambia transmission and distribution .........................................................................................................136
Table 151: Zimbabwe transmission and distribution ....................................................................................................137
Table 152: Afghanistan transmission and distribution ................................................................................................138
Table 153: Bangladesh transmission and distribution ................................................................................................138
Table 154: Bhutan transmission and distribution .........................................................................................................138
Table 155: Cambodia transmission and distribution ....................................................................................................138
Table 156: China transmission and distribution ...........................................................................................................139
Table 157: India transmission and distribution ............................................................................................................139
Table 158: Indonesia transmission and distribution .....................................................................................................139
Table 159: Japan transmission and distribution ............................................................................................................139
Table 160: Laos transmission and distribution ..............................................................................................................140
Table 161: Malaysia transmission and distribution ......................................................................................................140
Table 162: Maldives transmission and distribution ....................................................................................................141
Table 163: Myanmar transmission and distribution ......................................................................................................141
Table 164: Nepal Transmission .......................................................................................................................................141
Table 165: Pakistan transmission and distribution ........................................................................................................142
Table 166: Philippines transmission and distribution ................................................................................................142
Table 167: Sri Lanka transmission and distribution ....................................................................................................142
Table 168: Singapore transmission and distribution ....................................................................................................142
Table 169: Taiwan transmission and distribution .........................................................................................................143
Table 170: Thailand transmission and distribution ......................................................................................................143
Table 171: Vietnam transmission and distribution .......................................................................................................143
Table 172: United States transmission and distribution ..............................................................................................144
Table 176: Canada transmission ............................................................................................................. 144
Table 177: Mexico transmission and distribution .................................................................................... 144
Table 178: Antigua transmission and distribution .................................................................................... 145
Table 179: Argentina transmission and distribution .................................................................................. 145
Table 180: Bahamas transmission and distribution .................................................................................. 145
Table 181: Bolivia transmission ............................................................................................................... 145
Table 182: Brazil transmission and distribution ....................................................................................... 146
Table 183: Cayman Islands distribution .................................................................................................... 146
Table 184: Chile transmission ................................................................................................................ 146
Table 185: Columbia transmission ......................................................................................................... 146
Table 186: Costa Rica transmission and distribution .............................................................................. 147
Table 187: Dominican Republic transmission .......................................................................................... 147
Table 188: Ecuador transmission ............................................................................................................ 147
Table 189: El Salvador transmission and distribution .............................................................................. 147
Table 190: Guatemala transmission ........................................................................................................ 147
Table 191: Jamaica transmission and distribution ................................................................................... 148
Table 192: Nicaragua transmission and distribution .............................................................................. 148
Table 193: Panama transmission and distribution .................................................................................. 148
Table 194: Paraguay transmission and distribution ................................................................................ 148
Table 195: Peru transmission ................................................................................................................ 149
Table 196: Puerto Rico transmission and distribution ............................................................................. 149
Table 197: Uruguay transmission .......................................................................................................... 149
Table 198: Venezuela transmission ........................................................................................................ 149
Table 199: World – T&D capex by technology, nominal $ million, 2000 to 2020 .................................... 154
Table 200: USA - T&D capex, nominal $ million, 2000 to 2020 ................................................................. 154
Table 201: Europe - T&D capex, nominal $ million, 2000 to 2020 ......................................................... 154
Table 202: France - T&D capex, nominal $ million, 2000 to 2020 ......................................................... 154
Table 203: Germany - T&D capex, nominal $ million, 2000 to 2020 ...................................................... 154
Table 204: Italy - T&D capex, nominal $ million, 2000 to 2020 ............................................................... 154
Table 205: Spain - T&D capex, nominal $ million, 2000 to 2020 ............................................................ 154
Table 206: United Kingdom - T&D capex, nominal $ million, 2000 to 2020 .......................................... 155
Table 207: CIS - T&D capex, nominal $ million, 2000 to 2020 ............................................................... 155
Table 208: Russia- T&D capex, nominal $ million, 2000 to 2020 .......................................................... 155
Table 209: Asia Pacific - T&D capex, nominal $ million, 2000 to 2020 ............................................... 155
Table 210: Japan - T&D capex, nominal $ million, 2000 to 2020 ............................................................ 155
Table 211: China - T&D capex, nominal $ million, 2000 to 2020 ............................................................ 155
Table 212: India - T&D capex, nominal $ million, 2000 to 2020 ............................................................. 155
Table 213: Southeast Asia - T&D capex, nominal $ million, 2000 to 2020 ............................................. 155
Table 214: Middle East - T&D capex, nominal $ million, 2000 to 2020 .............................................. 156
Table 215: Africa - T&D capex, nominal $ million, 2000 to 2020 ............................................................ 156
Table 216: LAC - T&D capex, nominal $ million, 2000 to 2020 ............................................................. 156
Table 217: Brazil - T&D capex, nominal $ million, 2000 to 2020 ............................................................ 156
Table 218: Global T&D equipment sales by category in $ million, 2000 to 2020 ................................. 157
Table 219: Transmission equipment cost , at purchase price, at installed cost and % of capex, World, 2000-20 ........................................................................................................ 158
Table 220: Distribution equipment cost, at purchase price, at installed cost and % of capex, World, 2000-20 ........................................................................................................ 158
Table 221: Transmission equipment cost at purchase price, World, 2000-20 ....................................... 159
Table 222: Distribution equipment cost at purchase price, World, 2000-20 ........................................... 159
Table 223: Transmission equipment cost, at purchase price, at installed cost and % of capex, USA, 2000-20 ........................................................................................................ 161
Table 224: Distribution equipment cost, at purchase price, at installed cost and % of capex, USA, 2000-20 ........................................................................................................ 161
Table 225: Transmission equipment cost at purchase price, USA, 2000-20 ........................................... 161
Table 226: Distribution equipment cost at purchase price, USA, 2000-20 ............................................ 162
Table 227: Transmission equipment cost, at purchase price, at installed cost and % of capex, Europe, 2000-20 ................................................................. 163
Table 228: Distribution equipment cost, at purchase price, at installed cost and % capex, Europe, 2000-20 .............. 163
Table 229: Transmission equipment cost at purchase price, Europe, 2000-20 ...................................................... 163
Table 230: Distribution equipment cost at purchase price, Europe, 2000-20 ...................................................... 164
Table 231: Transmission equipment cost, at purchase price, at installed cost and % of capex, France, 2000-20 ....... 165
Table 232: Distribution equipment cost, at purchase price, at installed cost and % of capex, France, 2000-20 ....... 165
Table 233: Transmission equipment cost at purchase price, France, 2000-20 ...................................................... 165
Table 234: Distribution equipment cost at purchase price, France, 2000-20 ...................................................... 166
Table 235: Transmission equipment cost, at purchase price, at installed cost and % of capex, Germany, 2000-20. 167
Table 236: Distribution equipment cost, at purchase price, at installed cost and % of capex, Germany, 2000-20... 167
Table 237: Transmission equipment cost at purchase price, Germany, 2000-20 ...................................................... 167
Table 238: Distribution equipment cost at purchase price, Germany, 2000-20 ...................................................... 168
Table 239: Transmission equipment cost in, at purchase price, at installed cost and % of capex, Italy, 2000-20..... 169
Table 240: Distribution equipment cost, at purchase price, at installed cost and % of capex, Italy, 2000-20 ........ 169
Table 241: Transmission equipment cost at purchase price, Italy, 2000-20 ...................................................... 169
Table 242: Distribution equipment cost at purchase price, Italy, 2000-20 ...................................................... 170
Table 243: Transmission equipment cost, at purchase price, at installed cost and % of capex, Spain, 2000-20...... 171
Table 244: Distribution equipment cost, at purchase price, at installed cost and % of capex, Spain, 2000-20........ 171
Table 245: Transmission equipment cost at purchase price, Spain, 2000-20 ...................................................... 171
Table 246: Distribution equipment cost at purchase price, Spain, 2000-20 ...................................................... 172
Table 247: Transmission equipment cost , at purchase price, at installed cost and % of capex, UK, 2000-20........... 173
Table 248: Distribution equipment cost, at purchase price, at installed cost and % of capex, UK, 2000-20 .......... 173
Table 249: Transmission equipment cost at purchase price in nominal $, UK, 2000-20 .............................................. 173
Table 250: Distribution equipment cost at purchase price, UK, 2000-20 ...................................................... 174
Table 251: Transmission equipment cost, at purchase price, at installed cost and % of capex, CIS, 2000-20 ....... 175
Table 252: Distribution equipment cost, at purchase price, at installed cost and % of capex, CIS, 2000-20 ....... 175
Table 253: Transmission equipment cost at purchase price, CIS, 2000-20 ...................................................... 175
Table 254: Distribution equipment cost at purchase price, CIS, 2000-20 ...................................................... 176
Table 255: Transmission equipment cost, at purchase price, at installed cost and % of capex, Russia, 2000-20 ..... 177
Table 256: Distribution equipment cost, at purchase price, at installed cost and % of capex, Russia, 2000-20 ...... 177
Table 257: Transmission equipment cost at purchase price, Russia, 2000-20 ...................................................... 177
Table 258: Distribution equipment cost at purchase price, Russia, 2000-20 ...................................................... 178
Table 259: Transmission equipment cost, at purchase price, at installed cost and % of capex, Asia Pacific, 2000-20179
Table 260: Distribution equipment cost, at purchase price, at installed cost and % of capex, Asia Pacific, 2000-20179
Table 261: Transmission equipment cost at purchase price, Asia Pacific, 2000-20 ...................................................... 179
Table 262: Distribution equipment cost at purchase price, Asia Pacific, 2000-20 ...................................................... 180
Table 263: Transmission equipment cost, at purchase price, at installed cost and % of capex, Japan, 2000-20 ...... 181
Table 264: Distribution equipment cost, at purchase price, at installed cost and % of capex, Japan, 2000-20 ...... 181
Table 265: Transmission equipment cost at purchase price, Japan, 2000-20 ...................................................... 181
Table 266: Distribution equipment cost at purchase price in nominal $ million, Japan, 2000-20............................ 182
Table 267: Transmission equipment cost, at purchase price, at installed cost and % of capex, China, 2000-20 ...... 183
Table 268: Distribution equipment cost, at purchase price, at installed cost and % of capex, China, 2000-20 ..... 183
Table 269: Transmission equipment cost at purchase price, China, 2000-20 ...................................................... 183
Table 270: Distribution equipment cost at purchase price, China, 2000-20 ...................................................... 184
Table 271: Transmission equipment cost, at purchase price, at installed cost and % of capex, India, 2000-20 ...... 185
Table 272: Distribution equipment cost, at purchase price, at installed cost and % of capex, India, 2000-20 ...... 185
Table 273: Transmission equipment cost at purchase price, India, 2000-20 ...................................................... 185
Table 274: Distribution equipment cost at purchase price, India, 2000-20 ...................................................... 186
Table 275: Transmission equipment cost, at purchase price, at installed cost and %of capex, SE Asia, 2000-20..... 187
Table 276: Distribution equipment cost, at purchase price, at installed cost and % of capex, SE Asia, 2000-20 ...... 187
Table 277: Transmission equipment cost at purchase price, SE Asia, 2000-20 ...................................................... 187
Table 278: Distribution equipment cost at purchase price, SE Asia, 2000-20 ...................................................... 188
Table 279: Transmission equipment cost, at purchase price, at installed cost and % of capex, ME, 2000-20 ...... 189
Table 280: Distribution equipment cost, at purchase price, at installed cost and % of capex, ME, 2000-20 ...... 189
Table 331: Sales of HV insulators and bushings at purchase price by region and country, 2000 to 2020

Table 329: The top global cable manufacturers by industry

Table 328: Sales of MV and LV bare conductors at purchase price by region & country, 2000 to 2020

Table 326: Sales of MV and LV cable including MV subsea cable at purchase price by region & country, 2000-20

Table 324: cable types

Table 322: Sales of isolators for distribution at purchase price by region and country, 2000 to 2020

Table 321: Voltage levels in switchgear categories

Table 318: Sales of protection relays for distribution at purchase price by region and country, 2000 to 2020

Table 317: Sales of disconnectors for transmission at purchase price by region and country, 2000 to 2020

Table 316: Sales of distribution switches at purchase price by region and country, 2000 to 2020

Table 315: Sales of disconnectors for distribution at purchase price by region and country, 2000 to 2020

Table 314: Sales of distribution switches at purchase price by region and country, 2000 to 2020

Table 313: Sales of transmission switches at purchase price by region and country, 2000 to 2020

Table 312: Sales of distribution fusegear at purchase price by region and country, 2000 to 2020

Table 311: Sales of transmission fusegear at purchase price, ME, 2000-20

Table 310: Sales of air core reactors for distribution at purchase price by region and country, 2000 to 2020

Table 309: Sales of air core reactors for transmission at purchase price by region and country, 2000 to 2020

Table 308: Sales of distribution panels at purchase price by region and country in

Table 307: Sales of at transmission surge arresters purchase price by region and country, 2000 to 2020

Table 306: Sales of at transmission surge arresters purchase price by region and country, 2000 to 2020

Table 305: Sales of distribution circuit protectors at purchase price by region and country, 2000 to 2020

Table 304: Sales of transmission circuit protectors at purchase price by region and country, 2000 to 2020

Table 303: Sales of MV circuit breakers at purchase price by region and country, 2000 to 2020

Table 302: Sales of HV circuit breakers at purchase price by region and country, 2000 to 2020

Table 301: Distribution equipment cost at purchase price, ME, 2000

Table 300: Transformer manufacturers market shares

Table 299: Sales of distribution transformers at purchase price by region and country, 2000 to 2020

Table 298: Sales of power transformers at purchase price by region and country, 2000 to 2020

Table 297: Overall T&D market leaders

Table 296: Sales of distribution equipment at purchase price by region and country, 2000 to 2020

Table 295: Sales of transmission equipment at purchase price by region and country, 2000 to 2020

Table 294: Distribution equipment cost at purchase price, Brazil, 2000-20

Table 293: Transmission equipment cost at purchase price, Brazil, 2000-20

Table 292: Distribution equipment cost, at purchase price, at installed cost and % of capex, Brazil, 2000-20

Table 291: Transmission equipment cost, at purchase price, at installed cost and % of capex, Brazil, 2000-20

Table 290: Distribution equipment cost at purchase price, LAC, 2000-20

Table 289: Transmission equipment cost at purchase price, LAC, 2000-20

Table 288: Distribution equipment cost, at purchase price, at installed cost and % of capex, LAC, 2000-20

Table 287: Transmission equipment cost at purchase price, Africa, 2000-20

Table 286: Distribution equipment cost at purchase price, Africa, 2000-20

Table 285: Transmission equipment cost at purchase price, Africa, 2000-20

Table 284: Distribution equipment cost, at purchase price, at installed cost and % of capex, Africa, 2000-20

Table 283: Transmission equipment cost, at purchase price, at installed cost and % of capex, Africa, 2000-20

Table 282: Distribution equipment cost at purchase price, M 2000-20

Table 281: Transmission equipment cost at purchase price, ME, 2000-20
Table 333: Sales of HV spacers and dampers at purchase price by region and country, 2000 to 2020 ..........................228  
Table 334: Sales of MV spacers and dampers at purchase price by region and country, 2000 to 2020 .........................229  
Table 335: Number of HVDC installations ..................................................................................................................230  
Table 336: Sales of HVDC capacitors at purchase price by region and country, 2000 to 2020 .................................231  
Table 337: Sales of AC filters at purchase price by region and country, 2000 to 2020 .............................................231  
Table 338: HVDC vendors share by MW capacity .....................................................................................................232  
Table 339: Sales of steel transmission towers at purchase price by region and country, 2000 to 2020 ..................234  
Table 340: Sales of steel primary distribution towers at purchase price by region and country, 2000 to 2020 ....234  
Table 341: Sales of sub-transmission poles at purchase price by region and country, 2000 to 2020 .......................236  
Table 342: Sales of distribution poles at purchase price by region and country, 2000 to 2020 ..............................236  
Table 343: Sales of pole-top assemblies at purchase price by region and country, 2000 to 2020 ..........................237  
Table 344: Sales of pole-top assemblies at purchase price by region and country, 2000 to 2020 ......................237  
Table 345: Sales of grid, commercial and industrial meters at purchase price by region and country, 2000-20 ....239  
Table 346: Sales of residential meters at purchase price by region and country, 2000-20 ....................................240  
Table 347: Sales of HV smart grid technology for transmission at purchase price by region and country, 2000-20 ..241  
Table 348: Sales of MV smart grid technology for distribution at purchase price by region and country, 2000-20 ..241  
Table 349: Sales of automation technology for transmission at purchase price by region and country, 2000-20 ....243  
Table 350: Sales of distribution automation including SCADA at purchase price by region and country, 2000-20 ..244  
Table 351: Global meter market shares 2015 .............................................................................................................245  
Table 352: Costs and mark-up from Bill of Materials to Capex ..............................................................................248  
Table 353: Prices of copper and aluminium 1960-2014 ...........................................................................................251  
Table 354: Manufacturers of subsea power cable and communications cable ............................................................268  
Table 355: Installed superconductors .........................................................................................................................275  
Table 356: Superconductor manufacturers ..................................................................................................................277  
Table 357: Electrification in North America - % of households with access to electricity, 1950 to 2050...............293  
Table 358: Electrification in Europe - % of households with access to electricity, 1950 to 2050 .........................293  
Table 359: Electrification in the CIS - % of households with access to electricity, 1950 to 2050 .........................294
Distribution has followed a similar path, with one difference that Europe has declined less than North America, because of its higher population. The shares in 2015 were for Europe 18% and North America 16%, CIS 7%, while Asia Pacific had risen to 44%.

Figure 1: Transmission line lengths for major countries, 1900 to 2015
The following series of tables plot the progress of every country from 1980 to the present day and give

**Figure 21: Annual demand, new and replacement demand for transmission lines in ‘000 km, 1900 to 2050**

Table 1: New and replacement demand for transmission lines in 5 year segments by country in km, 2015 to 2030, CIS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
<td>144</td>
<td>106</td>
<td>84</td>
<td>57</td>
<td>229</td>
<td>382</td>
<td>961</td>
<td>961</td>
<td>961</td>
<td>961</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>417</td>
<td>347</td>
<td>308</td>
<td>285</td>
<td>355</td>
<td>329</td>
<td>961</td>
<td>961</td>
<td>961</td>
<td>961</td>
</tr>
<tr>
<td>Belarus</td>
<td>207</td>
<td>132</td>
<td>44</td>
<td>-12</td>
<td>2,119</td>
<td>4,416</td>
<td>961</td>
<td>961</td>
<td>961</td>
<td>961</td>
</tr>
<tr>
<td>Georgia</td>
<td>-46</td>
<td>-67</td>
<td>-79</td>
<td>-74</td>
<td>-12</td>
<td>-12</td>
<td>-12</td>
<td>-12</td>
<td>-12</td>
<td>-12</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>1,675</td>
<td>1,751</td>
<td>1,514</td>
<td>1,074</td>
<td>1,410</td>
<td>2,119</td>
<td>961</td>
<td>961</td>
<td>961</td>
<td>961</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>790</td>
<td>558</td>
<td>635</td>
<td>215</td>
<td>2,897</td>
<td>4,416</td>
<td>961</td>
<td>961</td>
<td>961</td>
<td>961</td>
</tr>
<tr>
<td>Moldova</td>
<td>117</td>
<td>151</td>
<td>1,251</td>
<td>330</td>
<td>3,158</td>
<td>5,416</td>
<td>961</td>
<td>961</td>
<td>961</td>
<td>961</td>
</tr>
</tbody>
</table>
There are just over XXX electricity, gas and water & waste utilities in the world; XXX electricity, XXX gas and XXX water & waste. With numbers like these the range in size is huge, especially for water. The XXX electrical utilities are the core of the power sector, the XXX gas and water & waste utilities consume a lot of energy and except for smallest water distributors they mostly generate it themselves. The XXX electrical utilities are the primary constituents of the power sector.

The patterns of ownership vary for the three segments of the industry. Generation is almost evenly split between state and private ownership, with 47% of utilities in state-ownership and 44% private, but all non-utility participants being private owners. Transmission and to a lesser degree distribution are more likely to be state-controlled, 75% for transmission and 59% for distribution. Private ownership of these segments is predominant in North America and Japan, about evenly split in Europe for transmission and about two thirds private and distribution. The dominance of state-ownership is because transmission and distribution are natural monopolies.

### Table 188: Bhutan transmission and distribution

<table>
<thead>
<tr>
<th>Year</th>
<th>OH lines (km)</th>
<th>UG cable (km)</th>
<th>Total (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>3,706</td>
<td>1,530</td>
<td>5,256</td>
</tr>
<tr>
<td></td>
<td>850</td>
<td>450</td>
<td>1,300</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>1,728</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>325</td>
<td>425</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>364</td>
<td>374</td>
</tr>
</tbody>
</table>

### Table 189: Cambc

<table>
<thead>
<tr>
<th>Year</th>
<th>OH lines (km)</th>
<th>UG cable (km)</th>
<th>Total (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>3,706</td>
<td>1,530</td>
<td>5,256</td>
</tr>
<tr>
<td></td>
<td>850</td>
<td>450</td>
<td>1,300</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>1,728</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>325</td>
<td>425</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>364</td>
<td>374</td>
</tr>
</tbody>
</table>

**Figure 1: The global utility landscape**

The patterns of ownership vary for the three segments of the industry. Generation is almost evenly split between state and private ownership, with 47% of utilities in state-ownership and 44% private, but all non-utility participants being private owners. Transmission and to a lesser degree distribution are more likely to be state-controlled, 75% for transmission and 59% for distribution. Private ownership of these segments is predominant in North America and Japan, about evenly split in Europe for transmission and about two thirds private and distribution. The dominance of state-ownership is because transmission and distribution are natural monopolies.
1. T&D CAPEX

Tables 197 to 215 contain analysis of transmission and distribution capex for the major regions and countries.

Table 2: World – T&D capex by technology, nominal $ million, 2000 to 2020

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T&amp;D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: USA - T&D capex, nominal $ million, 2000 to 2020

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T&amp;D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Global T&D equipment sales by category in $ million, 2000 to 2020

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit breakers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HVDC capacitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panelboards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other switchgear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightning arresters and isolators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meters and smart technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulators and spacers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel towers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poles and assemblies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit breakers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HVDC capacitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panelboards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other switchgear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightning arresters and isolators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meters and smart technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulators and spacers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel towers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poles and assemblies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
T&D plant, Germany

Table 5: Transmission equipment cost in nominal $ million, at purchase price, at installed cost and % share of capex, Germany, 2000-20

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment price</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installed cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment price</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installed cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Distribution equipment cost in nominal $ million, at purchase price, at installed cost and % share of capex, Germany, 2000-20

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment price</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installed cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment price</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installed cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Transmission equipment cost at purchase price in nominal $ million, Germany, 2000-20

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Power transformers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HV circuit breakers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit protectors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surge arresters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HVDC capacitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC filters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air core reactors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusegear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disconnectors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

..........................................................and Hyosung. These two companies are strong in large GSU and power transformers and have recently been building production facilities in the United States and competing in that market.
Protection relays

Table 8: Sales of protection relays for transmission at purchase price by region and country in nominal $ million, 2000 to 2020

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southeast Asia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asia Pacific</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle East</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9: Sales of protection relays for distribution at purchase price by region and country in nominal $ million, 2000 to 2020

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. THE VALUE CHAIN – FROM MATERIALS TO CAPEX

The cost of any product such as cable, transformers or circuit breakers can be measured in a number of ways, from being a piece of unworked metal, to its final installation in working order and finally as a constituent of capital expenditure. Different price levels are important in this supply chain, and the point of interest in the chain depends on the business to which the value is being applied. The value chain starts with the input of raw materials, such as cold rolled steel, GOES, copper, aluminium etc. These inputs typically constitute from 60-80% of the manufacturing cost of a finished product.

The value chain at 6 levels

1. **BOM, bill of materials** - Metal producers and refiners are concerned about the prices they can get for their output in its basic form, ingots, rods, plates etc. For the equipment manufacturers this price translates into the BOM (bill of materials) as a cost of production.

2. **Manufactured cost** - Adding the cost of fabricating the materials into finished products produces the manufactured cost.

3. **Factory gate price (MSP)** - The addition of non-manufacturing costs such as sales and finance costs brings it up to the factory gate price or manufacturer’s selling price. This does not include any transport cost. (Note: factory gate price is sometimes quoted with manufacturer’s profit and sometimes not.)

4. **Buyer’s price (equivalent to RSP)** - Products such as electrical equipment is almost always sold with a multi-channel strategy. Power and distribution transformers are a good example; there are usually two sales channels. Power and large distribution transformers are bespoke items, each one manufactured to a unique design for a unique purpose. They are ordered direct from manufacturers and the buyer’s price is the factory gate price. Smaller distribution transformers are commodity items and are stocked by distributors, who purchase them from the manufacturers, so the end-user’s purchase price includes the distributor’s mark-up and profit, typically 30-35% of MSP. This stage may also include an electrical contractor’s mark-up. Some utilities and industries keep these costs in-house but the aging of skilled work forces is increasing leading to outsourcing as much as possible.

5. **Installed equipment cost** - The final stage in the value chain of the product takes in the cost of transport and installation, currently around 25%-30%. It is the cost to the end-user of having an item of equipment installed in working order.

6. **Capex** – However, the end-user has further costs which are not directly related to the equipment being installed although the equipment cannot function without these activities;
• Civil and structural costs – site preparation, drainage, construction of buildings on the site etc;
• Project indirect costs – engineering, distribution labour and materials, scaffolding, construction management etc;
• Owner’s cost - these included planning, feasibility and engineering studies, legal fees, permits, insurance costs, property taxes etc;

The BOM affects each stage in the value chain, because everything starts with it but there are additions in the value chain which are not dependent on the cost of materials. The manufacturing process is independent of the cost of the materials, but the next stage in the value chain, the manufactured cost is highly dependent on the cost of materials. In Stage 3, the manufacturer’s selling price, the non-manufacturing costs such as sales and administration costs are not dependent on the cost of materials. In stage 4, where a distributor adds a mark-up it is customarily as a % of the manufacturer’s selling price, although not all of the costs of distribution will escalate with the price of the product. Finance, warehousing and insurance costs will rise as the cost of the product increases but other distributor’s costs

The development and penetration of AQCS technology

Europe and the United States

FGD technology originated in the UK and Germany but the USA and Japan became the main developer since the 1970s. The air emission limits have over the years been tightened both in Europe and in North America and in Japan. In the last decade China has enacted some of the most rigorous regulations in the world. The US and Japan were the main markets for which the FGD technology was deployed and where it reached a degree of maturity. The first experimental FGD units on a power plant were set up in the UK in 1929-1933 in London, and the first full-scale unit commenced operation in 1933 at Battersea “A” power station. The technology used was based on scrubbing with river water from the Thames, with added chalk or alkaline waste sludge from water softening process. A few small-scale FGD units were built in the US before the 1960s, including an ammonia process as early as 1934. In the 1960s, concerns about the health effects of sulphur emissions from power plants and other industrial processes

Table 10: Penetration of end-of-pipe AQCS measures

<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>Germany</th>
<th>China</th>
<th>Japan</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FGD % of coal plants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nox SCR/SNCR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LNB (Nox)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LNB + SCR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>