

T&D Report 2005

Edition 5

Vol 1

**The Growth of the World's T&D Systems
&
Markets for Transmission and Distribution Equipment
2005 - 2010**



ORDER FORM

Name of Report	Quantity	Price
*Add hard copy costs		
*Add hard copy and PDF costs		
Total		

PLEASE CONFIRM THE FOLLOWING DETAILS _____:

Name..... Title ~~Mr/Ms~~ ~~Mr/Ms~~ (Please circle)

Job Title..... Department.....

Company.....

Address.....

Postcode..... City..... County/State.....

Country..... Email.....

Tel..... Fax.....

Your preferred method of delivery:

Hard copy PDF (via email – 1-3 users only) PDF & Hard copy

***Additional charges:**

PDF (1-3 users only): No extra costs
 Hardcopy: UK - £40, Europe - £60/€100, Rest of world - £75/\$150
 Hardcopy and PDF(1-3 users only): UK - £85, Europe - £105/€175, Rest of world - £120/\$240
 Courier costs are inclusive
 For multiple users of PDF files and multiple hard copies please contact info@absenergyresearch.com
 Please note VAT is added where applicable for UK customers

Payment method _____:

Credit Card Bank Transfer Cheque Invoice

I enclose a cheque payable to ABS Energy Research for the sum of

Please debit my credit card (please tick choice) Visa Mastercard

Card No Expiry Date.....

Card Verification Number (last 3 numbers on back of card).....

Signature

VAT/TVA Number.....

Please send me details of other ABS products and services

Are you responsible for ad hoc market research? If not please confirm details of the person responsible:

Name..... Tel.....

Fax..... Email.....

ABS and/or carefully selected companies would like to contact you in the future with news and special offers. If you prefer not to be contacted please tick this box

Our usual terms and conditions apply please consult

www.absenergyresearch.com

Please return your order to: ABS Energy Research
 8 Quarry Rd, London SW18 2QJ, UK
 Tel: +44 (0)20 8432 6378
 Fax: +44 (0)20 8328 7117
 Email: info@absenergyresearch.com
www.absenergyresearch.com

Contents

1. Executive Summary.....	xiii
Transmission and distribution network developments	xvi
International transmission developments	xvii
Underground cables	xvii
The global market for transmission and distribution	xvii
Historical development of transmission and distribution	xvii
New and replacement markets	xix
The equipment markets	xx
Transformers	xxi
Switchgear	xxi
Power systems	xxii
Utility automation	xxii
HV cables	xxii
Overhead lines	xxii
Insulators and fittings	xxii
EHV towers	xxii
Major T&D Manufacturers.....	xxii
T&D Activity in China	xxiii
ABB	xxiii
Siemens	xxiv
Areva	xxiv
2. International Transmission Grids.....	1
Europe	1
UCTE	1
ETSO	3
CENTREL	3
NORDEL	4
BALTREL - Baltijos Ziedas - the Baltic Ring	4
UPS Unified Power Systems	5
BG/RO	6
SUDEL	6
The Middle East and North African Inter-Connectors	6
Middle East	6
North Africa	7
Pan-African Interconnection Plans	7
Medring.....	7
Americas	8
United States	8
Canada	8
Mexico	8
Interconnection in Central America	8
SIEPAC	8
Interconnections in South America	8
ASEAN Power Grid.....	8
3. Europe.....	10
European transmission and distribution network structures	11
Albania.....	12
Austria	14
Belgium	15
TSO	15
Jurisdiction.....	15
DNOs - Distribution system operators	15
Bosnia Herzegovina	16
Electrical utilities	16
Transmission and dstrubution	16
Distribution companies	17
Bulgaria	18
Transmission.....	18
Distribution	18
Croatia	19

Cyprus	20
Development Plan	20
Czech Republic.....	21
Transmission.....	21
Power grid control	21
Distribution	22
Interconnections	22
Denmark	23
TSOs.....	23
Electricity Transmission Network	23
ELTRA	24
ELKRAFT	24
Distribution.....	24
Estonia.....	25
Transmission and distribution	25
Baltrel	25
Finland.....	26
Transmission.....	26
TSO.....	26
Interconnections	27
France.....	28
TSO.....	28
DNOs	28
Germany.....	29
The control areas of the four German TSOs	29
Verbandvereinbarung	29
Greece	30
Transmission.....	30
Distribution	31
Interconnections	31
Hungary	32
ISO	32
Distribution	32
Interconnections	32
Iceland	33
Transmission and distribution	33
Ireland.....	34
Transmission and distribution	34
Interconnections	34
Italy	35
TSO.....	35
Distribution	35
Latvia	36
Lithuania.....	37
DNOs	37
Baltrel	37
Luxembourg.....	38
Macedonia.....	39
Transmission and distribution	39
Interconnections	39
Malta	40
Netherlands.....	41
TSO.....	41
Distribution	41
Power exchange.....	41
Norway.....	42
TSO.....	42
Poland.....	44
TSO.....	44
International trade.....	44
Polish Power Exchange	45
Portugal.....	45
The Portuguese transmission network	46

Distribution	46
Romania	47
Distribution	47
Interconnections	48
Serbia and Montenegro	49
Transmission.....	49
Distribution companies	49
Slovakia	50
Distribution utilities (RDUs).....	50
Interconnections	50
Slovenia.....	51
Transmission.....	51
Distribution	51
Interconnections	51
Spain.....	52
TSO.....	52
Major electricity groups	53
The Iberian market	53
Sweden.....	54
TSO.....	54
Distribution	54
Interconnections	54
Switzerland	56
TSOs.....	56
Distribution	56
Interconnections	56
Turkey.....	57
Transmission and distribution	57
Interconnections	57
United Kingdom.....	58
The electricity sector in 2005.....	58
Generation	58
Transmission.....	58
Interconnections	58
Distribution.....	58
Supply	59
Market opening	59
TSOs.....	59
UNMIK Kosovo	60
An independent region within Serbia Montenegro with a population of 2 million.....	60
CIS - Commonwealth of Independent States.....	61
Armenia	62
Transmission.....	62
Distribution	62
Interconnections	62
Azerbaijan	63
Transmission.....	63
Distribution	63
Interconnections	63
System up-grades and modernisation	64
Belarus	65
Transmission.....	65
Distribution	65
Interconnections	65
Georgia.....	66
Transmission.....	66
Distribution.....	66
International electricity trade.....	67
Kazakhstan	68
Transmission.....	68
Distribution	69
International electricity trade.....	69
Kyrgyzstan	70

Transmission.....	70
Distribution.....	70
International electricity trade.....	70
Moldova.....	71
Transmission.....	71
Distribution.....	71
Interconnections.....	71
Russia.....	72
Reform of the Russian power sector.....	72
The reform package.....	72
Regulatory reform.....	73
Prices.....	73
The Russian transmission network.....	73
Distribution.....	73
Interconnections.....	73
Tajikistan.....	75
Distribution companies.....	75
Interconnections.....	75
Turkmenistan.....	76
Ukraine.....	77
Transmission.....	77
Wholesale Electricity Market: State Enterprise "Energoynok".....	77
Distribution.....	77
Uzbekistan.....	79
4. Africa.....	80
Algeria.....	81
Transmission.....	81
Distribution.....	81
Regulator.....	81
Egypt.....	82
Transmission.....	82
Distribution.....	82
Interconnections and the Africa Grid.....	82
Libya.....	83
Transmission.....	83
Distribution.....	83
Interconnections.....	83
Mauritania.....	83
Morocco.....	84
The open market.....	84
The regulated market.....	84
Transmission and distribution responsibilities.....	85
Transmission.....	85
Distribution.....	85
Interconnections.....	86
Sudan.....	86
Interconnections.....	86
Tunisia.....	86
Transmission.....	86
Distribution.....	86
Interconnections.....	86
Sub-Saharan Africa.....	87
Angola.....	88
Benin.....	88
Bophutatswana.....	88
Botswana.....	88
Burkina Faso.....	88
Burundi.....	89
Cameroon.....	89
Cape Verde.....	89
Central African Republic.....	89
Chad.....	90
Ciskei.....	90

Comoros.....	90
Congo Democratic Republic	90
(Formerly Zaire)	90
Congo, Republic.....	91
Cote d'Ivoire.....	91
Djibouti	91
Ethiopia	91
Gabon	92
Gambia	92
Ghana	92
Guinea	93
Guinea-Bissau	94
Guinea Equatorial.....	94
Kenya.....	94
Lesotho.....	94
Liberia.....	94
Madagascar	95
Malawi.....	95
Mali.....	95
Mauritius.....	95
Mozambique.....	95
Namibia.....	96
Niger	96
Nigeria	96
Rwanda.....	96
Sao Tome & Principe	97
Senegal.....	97
Seychelles	97
Sierre Leone.....	97
Somalia.....	97
South Africa	97
Transmission.....	97
Distribution	98
Rural electrification	98
Southern African Power Pool (SAPP).....	98
Swaziland	99
Tanzania	99
Interconnections	99
Future plans.....	100
Togo.....	100
Transkei.....	100
Uganda	100
Venda.....	100
Zambia	101
Zimbabwe.....	101
5. Middle East	103
Bahrain	104
Iran	104
Transmission.....	104
Distribution	105
Iraq	105
Israel	105
Jordan.....	105
Kuwait.....	105
Lebanon.....	106
Oman	106
Qatar	106
Saudi Arabia	106
Transmission and distribution	107
Syria.....	107
Transmission and distribution	107
Interconnections	108
UAE	108

Transmission and distribution	108
Yemen.....	109
6. Asia.....	111
ASEAN.....	111
Afghanistan.....	112
Bangladesh	112
Transmission.....	112
Distribution	112
Bhutan	113
China.....	114
Structure of the Chinese ESI	114
Restructuring.....	114
Generation	114
Transmission Networks	114
.....	115
Regional interconnections.....	115
.....	116
North China Power Network	116
Shandong Power Grid (Connected to NCPN)	116
Northeast Power Network	117
East China Power Network	117
Fujian Power Grid (Connected to ECPN).....	118
Central China Power Network (including Sichuan and Chongqing Power Grids).....	118
Northwest Power Network	118
South China Interconnected Power Network.....	119
Interconnections with Thailand.....	119
Possible power cooperation with Russia.....	119
Distribution	119
Hong Kong.....	120
India	121
Structure of the Indian ESI.....	121
Regional and State Organisation of the ESI.....	121
NREB - Northern Regional Electricity Board	121
WREB - Western Regional Electricity Board.....	121
SREB - Southern Regional Electricity Board	122
EREB - Eastern Regional Electricity Board.....	122
NEREB - North-Eastern Regional Electricity Board	122
Physical assets	122
Transmission and Distribution Networks.....	122
T&D losses.....	123
Japan	124
Transmission System.....	124
Distribution Networks.....	125
Transmission interconnections.....	125
Korea North.....	126
Korea South	127
Market restructuring and privatisation	127
Generation	127
Transmission and distribution	127
Transmission.....	127
Distribution	128
Macau	128
Maldives	128
Mongolia.....	129
Nepal.....	129
Transmission and distribution	129
Pakistan.....	130
Unbundling and privatisation	130
Transmission.....	130
Sri Lanka	130
Transmission and distribution	130
Taiwan	132
Deregulation and privatisation plans.....	132

Transmission.....	132
ASEAN.....	135
Brunei.....	135
Cambodia.....	135
Indonesia.....	135
Laos.....	135
Malaysia.....	135
Myanmar.....	135
Philippines.....	135
Singapore.....	135
Thailand.....	135
Vietnam.....	135
Brunei.....	136
Cambodia.....	136
Future Development.....	136
Power Development Plan.....	136
2006-2010.....	136
Interconnection with Thailand.....	136
Interconnection with Vietnam.....	137
Indonesia.....	138
Transmission and distribution.....	138
Java-Sumatra Interconnection.....	138
The objectives of the Java-Sumatra Interconnection.....	138
East-South Kalimantan Interconnection.....	139
The objectives of the East Kalimantan Interconnection.....	139
Laos.....	140
Distribution grids.....	140
Interconnections.....	140
Interconnection Plan.....	140
Malaysia.....	142
Transmission.....	142
Peninsular Malaysia.....	142
Sarawak.....	143
Sabah.....	143
Myanmar.....	143
Transmission.....	143
Distribution.....	143
Philippines.....	144
ESI structure and liberalisation.....	144
Transmission grids.....	144
Distribution.....	145
Electric Power Industry Reform Act (EPIRA).....	145
Wholesale market.....	146
Singapore.....	147
Transmission and distribution.....	147
Interconnections.....	147
Thailand.....	148
Table 6.10: ESI characteristics in Thailand.....	148
Transmission.....	148
Distribution.....	148
Vietnam.....	148
Transmission and distribution.....	149
7. Pacific.....	150
Australia.....	150
Fiji.....	150
New Zealand.....	150
PNG.....	150
Solomon Islands.....	150
Tonga.....	150
Australia.....	151
Interlinked transmission.....	152
Fiji.....	153
New Zealand.....	153

Timeline.....	153
Papua New Guinea.....	154
Distribution	154
Solomon Islands	155
Tonga	155
Western Samoa	155
8. South America.....	156
Argentina.....	157
Interconnections	158
Bolivia.....	158
Transmission.....	158
Regional transmission lines	158
Distribution	159
Interconnection	159
Brazil.....	160
Eletrobras	160
Regional subsidiaries of Eletrobras	160
Minority holdings of electrobras	161
Transmission System.....	161
Distribution.....	162
Transmission Plans	162
Medium-term Transmission Plans	162
Long-term Transmission Plans	162
Distribution System	163
Ten-Year Investment Plan 1997/2006.....	163
Chile.....	163
Generation and transmission	163
Distribution	164
Colombia	164
Transmission.....	165
Distribution	165
Ecuador	166
Transmission.....	166
Distribution.....	166
Interconnection	166
French Guiana	166
Guyana	166
Paraguay	167
Transmission.....	167
Distribution	167
Interconnection	167
Peru.....	167
Transmission.....	167
Distribution	168
Interconnection	168
Surinam	168
Uruguay.....	169
Venezuela.....	170
Transmission.....	170
Distribution	170
9. Central America and the Caribbean.....	171
Bahamas.....	172
Barbados	172
Belize	172
Bermuda.....	172
Costa Rica	172
Transmission.....	172
Distribution	172
Interconnections	173
Cuba.....	173
Dominican Republic.....	173
El Salvador	173
Transmission.....	173

Distribution	173
Interconnections	173
Guatemala	174
Transmission	174
Distribution	174
Haiti	174
Honduras	174
Jamaica	175
Mexico	176
Transmission and distribution	176
Interconnections	176
SIEPAC	176
Netherlands Antilles	177
Nicaragua	177
Transmission	177
Distribution	177
Panama	178
Transmission	178
Distribution	178
Interconnection	178
Puerto Rico	178
St Lucia	178
Trinidad and Tobago	179
10. North America	180
Canada	181
Interprovincial trade	182
US trade	182
Market structure and regulation	182
Alberta	182
British Columbia	183
Manitoba	184
New Brunswick	184
Newfoundland	185
Northwest Territories	185
Nova Scotia	185
Ontario	185
Hydro One Inc.	186
Prince Edward Island	186
Quebec	186
Saskatchewan	187
Yukon	187
The Canadian transmission and distribution system	187
USA	188
Crisis in the US Electrical System	188
Background of the electrical sector in the US	189
The origins and development of the US transmission system	189
Cascading outages	191
August 14, 2003 blackout in the US and Canada	191
November 9, 1965: Northeast Blackout	192
July 13, 1977: New York City Blackout	192
December 22, 1982: West Coast Blackout	192
July 2-3, 1996: West Coast Blackout	192
August 10, 1996: West Coast Blackout	192
June 25, 1998: Upper Midwest Blackout	193
Common or similar factors among major outages	193
California	193
Regulatory Framework	193
Composition of the 10 Regional Councils	194
ASCC (Alaska System Co-ordination Council)	194
ECAR (East Central Area Reliability Co-ordination Agreement)	194
ERCOT (Electric Reliability Council of Texas)	194
MAIN (Mid-America Interconnected Network)	194
MAAC (Mid-Atlantic Area Council)	195

MAPP (US) (Mid-Continent Area Power Pool).....	195
NPCC (US) (Northeast Power Co-ordinating Council)	195
SERC (South-eastern Electric Reliability Council).....	196
SPP (Southwest Power Pool).....	196
WSCC (US) (Western Systems Co-ordinating Council)	196
FRCC (Florida Reliability Co-ordinating Council).....	197
The HI Region	197
1. Balance power generation and demand continuously.	197
2. Balance reactive power supply and demand to maintain scheduled voltages.	198
3. Monitor flows over transmission lines and other facilities to ensure that thermal (heating) limits are not exceeded.	198
4. Keep the system in a stable condition.	198
5. Operate the system so that it remains in a reliable condition even if a contingency occurs, such as the loss of a key generator or transmission facility (the “N-1 criterion”).	198
6. Plan, design, and maintain the system to operate reliably.	198
7. Prepare for emergencies.....	199
RTOs (Regional Transmission Organisations).....	200
Standard Market Design and Structure (SMD).....	200
Distribution	201
Demand-Side Management.....	201
Aging infrastructure	201
The reasons for the low commitment to infrastructure	202
Competition	202
Grid 2030	203
Grid 2030 consists of three major elements:	203
Smart power delivery.....	203
National Electricity Backbone	205
Regional Interconnections.....	205
Local, Mini- and Micro-Grids.....	205
Information technologies.....	206
New materials.....	206
Distributed energy resources.....	206
Automation.....	206
Power electronics controllers.....	206
11. Underground cables.....	207
National underground penetration in Western Europe	208
Austria.....	208
Belgium	208
Denmark.....	208
Finland	208
France	209
Distribution networks should be underground or protected.	209
Transmission networks.....	209
Germany.....	209
Greece.....	209
Ireland	210
Italy	210
Luxembourg	210
Netherlands	210
Norway	210
Portugal.....	210
Spain	211
Sweden.....	211
Switzerland	211
United Kingdom	211
Possible contribution of underground cables to the “European Energy Infrastructure”	212
Available Technologies for underground cables.....	212
Technical aspects	212
AC underground cables	212
DC underground cables	213
New technological developments	214
Gas insulated line (GIL).....	214
High temperature superconducting cables (HTS).....	214

12.	Network voltage analysis.....	216
13.	Market forecasts	230
	Network statistics- historical and forecast	230
	Market forecasts	230
	Market categories	230
	Annual market	230
14.	Methodology of Models and Forecasts	233
	Methodology	233
	Stage 1 - T&D forecasts.....	233
	The Master Database	233
	Capital expenditure validation.....	234
	Stage 2	234
	MVA: MW > 6	234
	MVA: MW - 4 to 6.....	235
	MVA: MW < 4	235
	Stage 3	235
	Stage 4	236
	Large country models – USA, China, Russia, Brazil	236
15.	Sources.....	237
16.	Transmission & Distribution System Forecasts	239
	Transmission line lengths km	239
	Distribution line lengths km.....	239
	System capacity MVA.....	239
	Market forecasts	239

Figures

Figure 1.1:	The growth of the world’s transmission networks, km from 1970 to 2010	xviii
Figure 1.2:	The growth of the world’s distribution networks, km from 1970 to 2010.....	xix
Figure 1.3:	Global market shares of power transmission and distribution companies.....	xxiii
Figure 3.1:	Typical network structure in European countries	11
Figure 6.1:	The new structure of the Chinese electricity sector.....	115
Figure 6.2:	The regional transmission networks of China	116
Figure 6.3:	Investment in generation, transmission and distribution in Japan	125
Figure 6.4:	Major transmission links between service areas in Japan in 2003.....	126
Figure 10.1:	Basic structure of the electrical system	189
Figure 10.2:	US Interconnected electricity systems 2005	190
Figure 10.3:	NERC regions and control areas	197
Figure 10.4:	Transmission constraints in the contiguous USA.....	200
Figure 10.5:	The imbalance between growth of demand and system capacity, 1998 to 2009.....	202
Figure 10.6:	Conceptual design of the Grid 2003 Vision	204

Tables

Table 1.1:	Installed generating capacity (MW), T&D System Capacity (MVA), Transmission and Distribution Line Lengths (km) - 2005	xix
Table 1.2:	Components of construction.....	xxi
Table 1.3:	Capital expenditure in 2005 to 2010 (Current values)	xxi
Table 2.1:	South China Sea interconnection projects	9
Table 3.1:	ESI Characteristics in Albania.....	12
Table 3.2:	ESI Characteristics in Austria.....	14
Table 3.3:	ESI Characteristics in Belgium.....	15
Table 3.4:	ESI Characteristics in Bosnia Herzegovina.....	16
Table 3.5:	ESI Characteristics in Bulgaria.....	18
Table 3.6:	ESI Characteristics in Croatia.....	19
Table 3.7:	ESI Characteristics in Cyprus.....	20
Table 3.8:	ESI Characteristics in Czech Republic	21
Table 3.9:	ESI Characteristics in Denmark	23
Table 3.10:	Existing interconnections with the Nordel countries	24
Table 3.11:	Existing interconnections with other countries	24
Table 3.12:	ESI Characteristics in Estonia.....	25
Table 3.13:	ESI Characteristics in Finland	26
Table 3.14:	Existing interconnections with Nordel countries	27
Table 3.15:	Existing interconnections with other countries	27
Table 3.16:	ESI Characteristics in France	28

Table 3.17: ESI Characteristics in Germany	29
Table 3.18: ESI Characteristics in Greece.....	30
Table 3.19: ESI Characteristics in Hungary	32
Table 3.20: ESI Characteristics in Iceland	33
Table 3.21: ESI Characteristics in Ireland	34
Table 3.22: ESI Characteristics in Italy.....	35
Table 3.23: ESI Characteristics in Latvia	36
Table 3.24: ESI Characteristics in Lithuania.....	37
Table 3.25: ESI Characteristics in Luxembourg	38
Table 3.26: ESI Characteristics in Macedonia	39
Table 3.27: ESI Characteristics in Malta.....	40
Table 3.28: ESI Characteristics in Netherlands	41
Table 3.29: ESI Characteristics in Norway.....	42
Table 3.30: Existing interconnections with Nordel countries.....	43
Table 3.31: Existing interconnections with other countries	43
Table 3.32: ESI Characteristics in Poland	44
Table 3.33: ESI Characteristics in Portugal	45
Table 3.34: ESI Characteristics in Romania.....	47
Table 3.35: ESI Characteristics in Serbia Montenegro	49
Table 3.36: ESI Characteristics in Slovakia	50
Table 3.37: ESI Characteristics in Slovenia	51
Table 3.38: ESI Characteristics in Spain	52
Table 3.39: ESI Characteristics in Sweden	54
Table 3.40: Existing interconnections with Nordel countries.....	55
Table 3.41: Existing interconnections with other countries	55
Table 3.42: ESI Characteristics in Switzerland.....	56
Table 3.43: ESI Characteristics in Turkey	57
Table 3.44: ESI Characteristics in th UK	58
Table 0.1: ESI Characteristics in Armenia.....	62
Table 0.2: ESI Characteristics in Azerbaijan.....	63
Table 0.3: ESI Characteristics in Belarus.....	65
Table 0.4: ESI Characteristics in Georgia	66
Table 0.5: ESI Characteristics in Kazakhstan	68
Table 0.6: ESI Characteristics in Kyrgyzstan	70
Table 0.7: ESI Characteristics in Moldova	71
Table 0.8: ESI Characteristics in Russia	72
Table 0.9: ESI Characteristics in Tajikstan	75
Table 0.10: ESI Characteristics in Turkmenistan	76
Table 0.11: ESI Characteristics in Ukraine.....	77
Table 0.12: ESI Characteristics in Uzbekistan.....	79
Table 4.1: ESI Characteristics in Algeria.....	81
Table 4.2: ESI Characteristics in Egypt.....	82
Table 4.3: ESI Characteristics in Morocco.....	84
Table 5.1: ESI characteristics in Iran	104
Table 5.2: Existing & Planned Interconnections for Syria.....	108
Table 6.1: ESI characteristics in China.....	114
Table 6.2: ESI characteristics in India	121
Table 6.3: ESI characteristics in Japan	124
Table 6.4: ESI characteristics in South Korea	127
Table 6.5: ESI characteristics in Pakistan.....	130
Table 6.6: ESI characteristics in Taiwan	132
Table 6.7: ESI characteristics in Indonesia.....	138
Table 6.8: ESI characteristics in Malaysia	142
Table 6.9: ESI characteristics in the Philippines.....	144
Table 6.10: ESI characteristics in Thailand.....	148
Table 7.1: ESI characteristics in Australia	151
Table 8.1: ESI characteristics in Argentina.....	157
Table 8.2: Transmission networks in Argentina.....	157
Table 8.3: ESI characteristics in Bolivia.....	158
Table 8.4: ESI characteristics in Brazil.....	160
Table 8.5: Eletrobas regional subsidiaries responsible for generation and distribution	161
Table 8.6: ESI characteristics in Chile.....	163
Table 8.7: ESI characteristics in Colombia	164

Table 8.8: ESI characteristics in Ecuador	166
Table 8.9: ESI characteristics in Peru.....	167
Table 8.10: ESI characteristics in Uruguay.....	169
Table 8.11: ESI characteristics in Venezuela.....	170
Table 9.1: ESI characteristics in Mexico	176
Table 10.1: ESI characteristics in Canada	181
Table 10.2: ESI characteristics in the United States.....	188
Table 11.1: Length of high and extra-high voltage overhead lines and cables	207
Table 11.2: Underground cables in medium voltage networks 0-50 kV 12 EU countries	207
Table 11.3: Underground cables in low voltage networks 200-400 V 11 EU countries	208
Table 12.1: Western Europe	216
Table 12.2: Eastern Europe	218
Table 12.3: CIS	219
Table 12.4: Africa.....	220
Table 12.5: Middle East.....	224
Table 12.6: Pacific.....	224
Table 12.7: Asia.....	225
Table 12.8: South America.....	227
Table 12.9: Central America	228
Table 12.10: North America	229
Table 13.1: Capital expenditure on generation, transmission and distribution in Japan 1993-2003..	231
Table 14.1: Sample composition of US utilities.....	236
Table 16.1: Installed line lengths km 1970-2010 (5 yrs).....	239
Table 16.2: Installed line lengths km 2004-2009 (1 yr).....	239
Table 16.3: Annual new and 40 year old line lengths km	239
Table 16.4: Installed line lengths km 1970-2010 (5 yrs).....	239
Table 16.5: Installed line lengths km 2004-2009 (1 yr).....	239
Table 16.6: Annual new and 40 year old line lengths km	239
Table 16.7: Installed capacity MVA 1970-2010 (5 yrs).....	239
Table 16.8: Installed capacity MVA 2004-2009 (1 yr).....	239
Table 16.9: Annual new and 40 year old capacity MVA.....	239
Table 16.10: T&D capital expenditure.....	239
Table 16.11: Total T&D equipment market.....	239
Table 16.12: Power and distribution transformers.....	239
Table 16.13: Switchgear markets	239
Table 16.14: Power systems	239
Table 16.15: Utility automation.....	239
Table 16.16: HV insulated cables	239
Table 16.17: Overhead lines	239
Table 16.18: Insulators, bushings and fittings	239
Table 16.19: EHV transmission towers.....	239

3. Europe

Albania

Austria

Belgium

Bosnia-Herzegovina

Bulgaria

Croatia

Cyprus

Czech Republic

Denmark

Estonia

Finland

France

Germany

Greece

Hungary

Iceland

Ireland

Italy

Latvia

Lithuania

Luxembourg

Macedonia

Malta

Netherlands

Norway

Poland

Portugal

Romania

Serbia Montenegro

Slovakia

Slovenia

Spain

Sweden

Switzerland

Turkey

United Kingdom

Albania

Table 3.1: ESI Characteristics in Albania

Generators - 1 KESH Korporata Elektroenergetika Shqiptare Vertically integrated state-owned power monopoly
Large companies present Largest – Only KESH
TSO – 1 KESH Korporata Elektroenergetika Shqiptare Legally unbundled
TSO independence Ownership - Yes Legal form - Yes Organisation – Yes
TSO owner of grid assets – Yes, subsidiary of KESH
Network access – TPA legislation but no eligible customers or suppliers
Market model – Not yet agreed, regulated market planned for initial opening
Bilateral contracts – No
Monitoring of wholesale/balancing market – ni
Import capacity as % of installed capacity – 25%
DNO - 1 KESH subsidiary Separate from TSO – yes Managed
Regulator – Electricity Regulatory Authority (ERE) Ex-post
Implementation of market opening - None Market opening 2005 – 8% Full market opening - Not yet documented
How charges are set – Government sets
Dominant single generator within balancing area – 1
Number of active licensed suppliers – 1
Number of suppliers independent of DNO - 0
Number of suppliers with share > 5% - 1
Top 3 suppliers share – 100%
Switching since market opening Large eligible industrial users – 0% Small commercial / domestic – 0%
Eligible customers 2005 – 50GWh
Number of licensed suppliers other than DNOs – None
Exchange – None
Transmission line length (35 kV) – 3,812 km Distribution line length – 41,142 km

The government department responsible for power supply is the National Energy Committee, located in the same office as the Ministry of Public Economy and Privatisation. In 1997 operational responsibility for generation, transmission and distribution was vested in KESH, Kororata Elektroenergetike Shqiptare. Distribution is via 38 subsidiary distribution entities, including Shkoder, Elbasan and Vloa, which were subject to an unsuccessful pilot privatisation project. KESH as a whole and the distribution entities in particular require considerable restructuring to improve their operational efficiency, financial and commercial discipline. High levels of non-technical losses and widespread non-payment of electricity bills have become chronic.

The transmission system operates at 35, 110, 220 and 400 kV. Total line lengths amounted to 3,812 km in 2005.

The distribution network is comprised of 41,142 km of line at 10, 6 kV and 400 Volts.

Albania has the following international interconnections with Greece and FR Serbia Montenegro.

- One 400 kV crossing from Elbasan in central-southeast Albania to Kardia in Northern Greece, currently restricted to 230 MW due to the limited capacity of the 400/220 kV sub-station at Elbasan.
- Two 220 kV lines, one from Vau Dejes in Albania to Podgorica in Serbia Montenegro and a second from Fierze in Albania to Prizren Serbia Montenegro.
- A 110 kV line connects Bistrice in south Albania with Mourtas in western Greece. The system works in parallel with the European network via the 400 kV interconnection line from Elbasan to Kardia. In 1992 a total of 185 HV substations had a total installed capacity of 4,450 MVA.

A new link with Macedonia is planned.

Most of the equipment in the 220 and 110 kV substations is of older Chinese, Russian or Serbia Montenegro manufacture and many require

substantial rehabilitation. In many cases spare parts are no longer available. Inadequate maintenance and development has resulted in a poor service which is not adequate or the country's needs. Work had begun on the reconstruction of parts of the Albanian electricity network on the basis of a joint study by ENEL and Albania's electricity corporation, with a substation in Tirana being modernised and future modernisation planned for other substations. The programme of work also includes the construction of new substations and the upgrading of the network's capacity, with most of the finance from an Italian government aid package. A Power Transmission System Feasibility Study has been conducted by Electroconsult of Italy, to plan for reliable operation by 2000 and to meet expected demand by 2005. The study recommended that the development of the transmission system be based on the following criteria.

- 110 kV lines should be interconnected to operate as a mesh similar to the 220 kV system.

- A single contingency including an outage of a 220 kV line, a 100 kV line or a substation transformer should not cause a thermal overload or a curtailment of load.
- New 110 kV transformers will be either 16, 25 or 40 MVA with an overload capability of 30%.
- The minimum operating range of the 110 kV line to be 105kV and the maximum 125 kV, with a normal level of 117 kV. The minimum and maximum voltage level should not be exceeded for any single contingency.
- The minimum and maximum operating range of the 220 kV line should be 209 kV and 245 kV with a normal level of 220 kV. The minimum and maximum voltage level should not be exceeded for any single contingency.
- The system shall not cascade into a major outage for a three phase fault that would result in the loss of the largest generator or a major 220 kV line.

The present 220 kV bulk system is adequate for load requirements up to 2005 but the 110 kV system is not adequate, either in transmission facilities or in transformer capacity.

Albania faces a very difficult situation, with a lack of power, limited interconnection capacity and other technical and organisational problems concerning the operation of the system. Although Albania is not a formal member of UCTE, it is interconnected synchronously within the UCTE 2 and considering its geographical position it will probably eventually be interconnected to the main UCTE grid together with the other power systems in the region.

12. Network voltage analysis

Table 12.1: Western Europe

Austria	2002
380 kV	2,474
220 kV	3,756
110 kV	3,456
380 V-110 kV	168,000
Belgium	2002
380 kV	883
220 kV	267
150 kV	2,257
Transmission	3,407
70 kV	3,026
36 kV	2,068
1-36 kV	67,519
<1 kV	109,453
Distribution	182,066
Cyprus	2002
132 kV OH	631.0
132 kV UG	64.0
132 kV @ 66 kV	292.0
66 kV OH	351.0
Transmission	1,338.0
11 kV OH	4,523.0
11 kV UG	1,920.0
415/240 V OH	7,353.0
415/240 V UG	1,486.0
Distribution	15,282
France	1999
400 kV	20,795
225 kV	26,212
63-90 kV	50,468
Transmission	97,475
MV	564,300
LV	626,500
Total	1,385,749
Germany	2000
380 kV	18,200
220 kV	21,250
110 kV	75,750
110-380	115,200
50-60 kV	1,182
30 kV	11,485
25 kV	1,976
20 kV	284,355
15 kV	24,172
11 kV	10,172
10 kV	147,453
<6 kV	6,325
MV	485,850
400.230 V	980,451
Total	1,582,770

Greece	2002	
Transmission		
Mainland		
400 kV	2,260	
150 kV	8,389	
66 kV	66	
Total	10,714	
Crete		
150 kV	488	
66 kV	142	
Total	630	
Rhodes		
66 kV	51	
Greece		
400 kV	2,260	
150 kV	8,876	
66 kV	258	
Total Greece	11,395	
Distribution	2002	
Overhead	OH	
22 kV	86,122	0.0%
20 kV		29.6%
15 kV		14.0%
6.6 kV		0.2%
380/220 V	96,107	48.8%
Total	182,229	92.6%
Underground		0.0%
22 kV	7,122	0.2%
20 kV		1.6%
15 kV	9,826	0.7%
6.6 kV		0.7%
380/220 V		4.2%
Total	16,948	0.0%
Submarine	1,025	7.4%
Total Greece	200,202	100.0%
Ireland	2002	
275/400 kV	451	
220kV	2,750	
110, 220, 400	2,800	
Transmission	6,001	
Distribution	160,000	
Italy	1999	
380 kV	9,751	
220 kV	10,411	
200 kV DC	857	
150-120 kV	33,776	
Transmission	54,795	
60 kV	2,901	
1-30 kV	325,085	
<1 kV	693,326	
Distribution	1,021,312	
Total Italy	1,076,107	

14. Methodology of Models and Forecasts

Methodology

The methodology of the market size estimates and forecasts of development of the transmission and distribution systems consisted of four stages, combining a top-down and a bottom-up approach. This methodology was found to be effective in creating the forecasts of electrical generating capacity in ABS Power Predictor, the companion study to the present volume. This has been augmented with independent forecasts for individual product groups which incorporate import and export data and where available production data.

ABS has now built up a series of over 20 separate forecasts of different components and aspects of the electricity supply industry globally. This collection of separate forecasts is valuable in providing validation of each forecast. For example, a database and forecast has been constructed for power and distribution transformers from commercial data (import, export and production figures). From the T&D Study, we can estimate transformer demand as a constituent of total capex, since we have established how capex is broken down. Each of these separate estimates either confirms or contradicts the other and we can reconcile them.

Stage 1 - T&D forecasts

The Master Database

All available data about electrical installed capacity, transmission and distribution that we can locate is entered into a master database, which ABS started in 1993 and is continually up-dating. We have been able to augment this unique database continually since it was started and additional retrospective data become available all the time. Each report in this series is therefore based on better source data than its predecessors and sometimes the figure change radically. Generally there is less information available about transmission and distribution than about generation.

Basic information about electricity generation and consumption is included in the database historically from 1970 to the present for every country and for the major countries representing 83% of the world's installed capacity as far back as 1950. Original information about transmission and distribution is included in the database for 154 countries, varying in extent. In some cases it is extensive and over a period of time, in other cases it is restricted to circuit lengths of transmission and/or distribution lines at one point in time. The database contains information on the following areas:

- Installed generating capacity (MW), analysed by fuel type
- Transmission line lengths by voltage (kV),
- MV and LV distribution line lengths by voltage (kV and V),
- Transmission and distribution system capacity (MVA)
- Capital expenditure on generation, transmission and distribution, in some countries overall and in some cases broken by generation, transmission and distribution separately.

Information has been obtained from utility company reports, national industry association reports, national government statistics and international agencies.

The data available to the analyst is variable. Some very small national utilities have published exemplary reports for many years, with all the information required. There are several in Africa, the Middle East and Asia. The records of these countries are extremely valuable in providing benchmarks for similar economies where only the most elementary electrical statistics exist and which have to be modelled.

Most of the industrialised countries publish reasonably comprehensive information but by no means all. Data about distribution systems is much less common than for transmission. Detailed information is now becoming available for many of the former Comecon countries, which is a major advance on the accessible information available for the earlier editions of this report.

The data comes in so many forms and from so many sources that many conversions were required, the most common being from miles to kilometres. The sources were not all for the same year, so care is taken to ensure that data is recorded in the right year, where necessary being projected forwards or backwards to the base year for forecasting.

ABS is also building a library of maps of international systems and national networks, mostly reproduced from maps published by national TSOs and major utilities.

Capital expenditure validation

We have located national capital expenditure data published by utilities for transmission and distribution for 19 individual countries, representing 63% of the world's total estimated capital expenditure on transmission and distribution.

The major manufacturers of T&D equipment and systems publish various reports and presentations with varying amounts of data. Some of these are detailed and contain market size estimates and shares for the major manufacturers. The definitions and product categories differ from company to company but overall these sources provide valuable confirmations of order of magnitude and rankings.

Two official international energy agencies publish estimates for Europe and the world, and these figures are within 5% and 3.7% respectively.

Stage 2

A set of models was created for all countries, based on the data categories in the Master Database.

- Installed generating capacity, MW
- Transmission line lengths, circuit km
- Distribution line lengths, circuit km
- Transformer capacity, MVA
- Capital expenditure on transmission and distribution, US\$
- Capital expenditure on HV transformers
- Capital expenditure on switchgear
- Capital expenditure on power systems
- Capital expenditure on utility automation
- Capital expenditure on HV insulated cable
- Capital expenditure on insulators, lightning arresters and fittings
- Capital expenditure on EHV transmission towers

These models forecast system data in five year intervals from 2000 to 2010 and annually from 2005 to 2010 and product data annually from 2005 to 2010. Where past data is available it has been entered and where not available, estimates have been made. The global market was modelled on different criteria; installed generating capacity, transmission line lengths and transformer capacity and a series of projections made. Time series projections have been made on the basis of a number of variables.

The design of transmission and distribution networks varies considerably. Although there are patterns, there are also many exceptions to the patterns. This is apparent when comparing the ratios of network step-down transformer capacity (MVA) to installed generating capacity (MW). These ratios range from just under 2.2 to 7.5 and can be classified into three ranges. The high ratios exist in advanced countries with high levels of industrialisation and residential coverage. The lowest levels exist in countries with very little industrialisation and low domestic electrification. The patterns are clearer in the top and bottom category (> 6 and < 4) than in the middle group (4-6).

MVA: MW > 6

33 countries have transmission and distribution systems with MVA capacity 6 or more times the installed generating capacity, ranging from 2-3 times generating capacity in the transmission and sub-transmission systems and 3-4 in the distribution system. They are mostly High Income, with dense population concentrations (using World Bank classifications) in the Pacific, Europe and North America.

Seven are Upper Middle Income countries among the richer Eastern European countries. Hong Kong, Macau and several Caribbean islands also come into this category. These are the systems with well developed ring main grids serving large numbers of urban domestic consumers and a wide range of industrial and commercial customers. Typically these systems employ a lot of MV distribution drawing electricity from different generating sources to provide backup in case of power outages.

MVA: MW - 4 to 6

62 countries have an MVA: MW ratio between 4 and 6, indicating an intermediate network of both transmission and distribution. This compares with 42 in the previous study, indicating a substantial development of systems. These countries can be classified into several groups, ranging from those large countries which have specifically identified inadequate EHV and HV transmission as an obstacle to development; notably India and China.

Medium sized Upper Middle and Lower Middle Income countries. These include many of the CIS states and others scattered around the world, without any significant pattern. They also include geographically small countries without a need for much transmission capacity.

MVA: MW < 4

Countries with an MVA: MW ratio of < 4 mostly have Lower or Lower Middle Income economies, primarily developing countries in Asia or Africa. These countries have low electrification ratios. Because of distance and low demand in rural areas, isolated systems and renewable sources are used to reduce the need for transmission. The priority in these countries is to deliver power for centralised use, particularly industrial or governmental. In some African countries the numbers of electricity customers is extremely small. Malawi has 41,000 domestic consumers out of a total of 53,000, Mozambique has 128,000 out of 149,000 and Namibia has only 1,029 rural customers out of a total of 1,453. It was not the first priority of the planners to distribute power widely and the most basic radial networks are used, transporting power from the generating point direct to a few single users.

In many Low Income countries it is imperative to substitute electricity or another commercial fuel for firewood. High levels of deforestation often exist and are on the increase. This not only causes ecological problems but uses too much labour inefficiently. In Nepal forest covers 37% of the land area and is diminishing at 100,000 hectares a year, while only 15,000 hectares are being reforested. It is estimated that in the worst cases family members spend no less than five hours a day searching for firewood with the consequent loss of productive labour to the economy.

Rural electrification is regarded as a priority in Upper Middle and Lower Middle Income developing countries which are through the first economic hurdle, for several reasons. There is a genuine desire on the part of governments to improve living conditions and to increase literacy by enabling people to read at night. Perhaps a more pressing reason is a direct result of the rush for development, the need to reduce the flow of rural population into cities. The emergence of "mega-cities" in the developing world is a phenomenon of the last two to three decades and has urgent implications for network planners. The population of Mexico City now exceeds 17 million. In the last fifteen years over 2,600 MW of generating capacity has been installed to pump water and to process waste for the burgeoning population of the city. Before the massive inflow of rural population no electricity was consumed for water and waste, which were catered for locally. The consequent drain on the economy and the retardation of development is obvious. If rural areas had been electrified the emigration to cities would have been reduced and local economies enhanced. The inefficiency is compounded by the fact that when populations arrive in cities not only is the cost of other infrastructural support services higher but large urban areas then have to be electrified. There will be changes in the pattern of electrical distribution in these countries.

There are a few Upper Middle Income countries in Africa with an MVA: MW ratio of 4 or less.

These ratios form one of the data in-puts used to model the systems where no information exists and in others to validate it.

Stage 3

A literature search together with interviews with executives in the power and engineering industries have been conducted to construct a set of ratios of the composition of total capital cost for its components; land purchase or way rights, design and engineering, construction, M&L direct cost, FLOH indirect field cost and finance cost. There are wide variations in the composition of these costs. Average figures should not be used without careful evaluation of each situation but as an indicator. For example, there is a land cost in constructing distribution networks for Greenfield developments but there is no additional land cost in up-

grading either underground cables or overhead lines. Important issues in the transmission and distribution sector were explored in these interviews.

A set of models was constructed for product composition within the market when producing the first edition of this report in 1996. These models have been reviewed and adjustments made in 1999, in 2002 and 2004.

Stage 4

The final stage of analysis was a bottom-up examination of every estimate in the spreadsheets. Each figure was scrutinised in the light of market experience and carefully evaluated. Particular attention has been paid to evaluation of the actual achievements of governments against published development plans and targets. This is an area requiring considerable experience of the markets because the outcomes are not always obvious. An example is a comparison between India and Taiwan. Some knowledge of the Indian power market will reveal very quickly that India has not achieved a single power target in the Development Plans throughout the past fifty years and it is wise to be conservative about the targets in the current Ninth Plan. In comparison, Taiwan has an extraordinary record of economic development and with a very efficient power utility it is easy to accept that targets will be met. However, Taiwan is also experiencing a growing tide towards grass roots democracy and rapidly escalating public awareness about environmental issues. This is largely because of the pace of economic development which has led to unchecked exploitation of resources and lack of controls. As a result of this Taipower has had to revise its annual plans repeatedly, as protestors block the construction of new power stations and overhead transmission lines.

Large country models – USA, China, Russia, Brazil

The Federal Electrical Reliability Council of the United States (FERC) publishes the most comprehensive information and analysis of the country's electricity industry provided by any country, with one exception; data about transmission below the bulk system operated at 230 kV and above is not collected and consolidated.

Information was obtained for as many large investor owned and Federal or State-owned utilities as possible and samples of 207 municipals and 198 rural cooperatives were itemised. The numbers sampled and the universes in each category are shown below.

Table 14.1: Sample composition of US utilities

Ownership	Sampled	Universe
Investors	187	216
Federal or State	119	189
Municipal transmission	207	1,085
Municipal distribution	207	1,718
Cooperative transmission	198	603
Cooperative distribution	198	764

Note that the municipals and cooperatives are a mixture of transmission and distribution companies, which accounts for the lower numbers than the totals published by FERC. The data from the sampled utilities was weighted up to the universe values to give a total estimate of distribution lines for the US. The figures estimated in Ed 3 of this report were higher than those in Ed 2, firstly because of actual growth but also because a larger sample was employed and we consider that the previous estimate was too low.

Russia publishes data for transmission but not for distribution. However, Ukraine has published comprehensive data from 400 V to 800 kV, which has enabled us to construct a model for Russia, making allowance for the long EHV transmission installations spanning the vast distances of the Russian Federation.

Likewise, China publishes data down to 35 kV but no lower. India publishes comprehensive figures for all transmission, distribution and reticulation. We have used these to model China but have made one allowance. The term "electrification" does not necessarily mean household electrification. In India a village is classified as "electrified" by the Ministry of Power if only one electric connection point exists. 86% of villages are classified as "electrified" but only 32% of rural households have direct access to electricity. In China electrification applies to households. This means that a ratio of reticulation to distribution in China will be higher than in India. However, it will not be that much higher because villages where electrification is only to one point are relatively small places and the additional wires to reach every household are not very long.

In Brazil, comprehensive data is given for urban transmission and distribution and for additions in the annual update of the 10 Year the Plan, to distribution in rural areas. The original installed base in rural areas is not given. We have had to make a judgemental estimate of the installed base prior to the new electrification programme.

16. Transmission & Distribution System Forecasts

Transmission line lengths km

Table 16.1: Installed line lengths km 1970-2010 (5 yrs)

Table 16.2: Installed line lengths km 2004-2009 (1 yr)

Table 16.3: Annual new and 40 year old line lengths km

Distribution line lengths km

Table 16.4: Installed line lengths km 1970-2010 (5 yrs)

Table 16.5: Installed line lengths km 2004-2009 (1 yr)

Table 16.6: Annual new and 40 year old line lengths km

System capacity MVA

Table 16.7: Installed capacity MVA 1970-2010 (5 yrs)

Table 16.8: Installed capacity MVA 2004-2009 (1 yr)

Table 16.9: Annual new and 40 year old capacity MVA

Market forecasts

Table 16.10: T&D capital expenditure

Table 16.11: Total T&D equipment market

Table 16.12: Power and distribution transformers

Table 16.13: Switchgear markets

Table 16.14: Power systems

Table 16.15: Utility automation

Table 16.16: HV insulated cables

Table 16.17: Overhead lines

Table 16.18: Insulators, bushings and fittings

Table 16.19: EHV transmission towers