PUBLICATION INFORMATION	II
Icons used in this publication	iii
Icons representing categories	iii
Icons representing physical parameters	iii
Icons representing water quality parameters	iii
Icons representing sectors and applications	iii
EXECUTIVE SUMMARY	IV
System architecture showing importance of different sensors	V
Utility spending by sector (networks, water treatment & wastewater treatment)	vii
Industrial spending by sector	viii
1. INTRODUCING WATER'S DIGITAL FUTURE	1
1.1 What is water's digital future?	1
Figure 1.1 Big data capabilities: water versus other industrial sectors	2
1.2 Evolution into the digital	3
1.2.1 The need for greater efficiency	3
1.2.2 Cost	4
1.2.3 Regulation	4
1.2.4 Institutionalised digitisation	4
1.2.5 Market fragmentation	4
1.2.6 Cybersecurity	5
1.2.7 Internal barriers	5
1.3 Benefits of digital solutions	6
1.3.1 Water resources	6
1.3.2 Drinking water treatment	6
Figure 1.2 Potential savings due to digital solutions in drinking water treatment	6
1.3.3 Drinking water distribution	7
Figure 1.3 Potential savings due to digital solutions in drinking water distribution	7
1.3.4 Customer service, metering and billing	7
Figure 1.4 Potential savings due to digital solutions in customer service, metering, and billing	8
1.3.5 Wastewater collection and drainage	8
Figure 1.5 Potential savings due to digital solutions in wastewater collection and drainage	8
1.3.6 Wastewater treatment	8 9
Figure 1.6 Potential savings due to digital solutions in wastewater treatment	9
1.4 Envisioning water's digital future	
2. SYSTEM ARCHITECTURE	25
2.1 Overview	25
Figure 2.1 The architecture and composition of data-driven control and monitoring systems	26
2.1.1 Key market players	26
Figure 2.2 A selection of key smart water and digital solutions providers	27
Figure 2.3 Selected acquisitions in the control & monitoring space	28
Figure 2.4 Selected partnerships in the control & monitoring space	29
2.2 Physical layer	30
2.2.1 Definition	30
2.2.2 Developments and innovation	30
2.2.3 Key drivers and trends	30
2.2.4 Key market players	32
Figure 2.5 Major companies with smart solutions	32
2.3 Sensors/meters 2.3.1 Definition	32 32
	32
2.3.1.1 Sensors Figure 2.6 Water quality and physical parameters and the rationale for measurement	33
Figure 2.7 Sensor methods and time of testing	34
2.3.1.2 Meters	34
Listing motors	J- 1

2.3.2 Key drivers/trends	35
2.3.3 Developments/innovation	35
2.3.4 Key market players	36
Figure 2.8 Sensor and metering market players	36
2.4 Automation & control	38
2.4.1 Definition	38
Figure 2.9 Typical SCADA system	38
2.4.2 Key drivers/trends	39
2.4.3 Developments/innovation	39
2.4.4 Key market players	40
Figure 2.10 Automation and control market players	40
2.5 Data management and analysis	41
2.5.1 Definition	41
Figure 2.11 The role of data management and data analysis (traditional & advanced analytics)	41
2.5.1.1 Data management	41
Figure 2.12 Data management systems	42
2.5.1.2 Data analysis	42
Figure 2.13 Types and functions of data analytics	43
2.5.2 Developments	43
2.5.3 Key market players	44
Figure 2.14 Data management and analysis market players	44
3. MARKET FORECAST	48
3.1 Global forecast	48
Figure 3.1 Global market for control and monitoring solutions for utility and industrial users, 2014-2021	48
Figure 3.2 Global market for control and monitoring solutions by region, 2014-2021	49
Figure 3.3 Global market for control and monitoring solutions in industry, 2014-2021	50
Figure 3.4 Global market for control and monitoring solutions by category, 2014-2021	51
Figure 3.5 Global market for control and monitoring solutions by application, 2014-2021	51
Figure 3.6 Global market for control and monitoring solutions by parameter, 2014-2021	52
3.2 Forecast methodology	53
3.2.1 Product type	53
Figure 3.7 Description of product categories	53
3.2.2 Applications	54
Figure 3.8 Description of application categories	54
3.2.3 Parameters	55
Figure 3.9 Description of parameter categories	55
4. UTILITY NETWORKS	56
4.1 Market directions	56
4.2 Water distribution networks	57
4.2.1 Key market drivers	57
4.2.2 Control and monitoring snapshot	58
4.2.2.1 Leakage detection	58
Figure 4.1 Types of leaks	58
Figure 4.2 Key parameters monitored for leakage detection in drinking water networks	58
4.2.2.2 Leakage prevention	59
Figure 4.3 Key parameters monitored for leakage prevention in drinking water networks	59
4.2.2.3 Smart water quality management	59
Figure 4.4 Key parameters monitored for water quality management in drinking water networks	59
4.2.2.4 Smart network optimisation	60
4.2.3 Unmet needs and future developments	60
4.2.3.1 Physical layer	60
4.2.3.2 Sensors	60
4.2.3.3 Communication	61
4.2.3.4 Data management and analysis	61
4.3 Wastewater networks	61
4.3.1 Overview	61
4.3.1.1 Key market drivers	62

4.3.2 Control and monitoring snapshot	63
Figure 4.5 Wastewater network infrastructure	63
Figure 4.6 Combined sewer overflows	64
4.3.2.1 Sewers and pipelines	64
Condition assessments	64
Combined sewer overflow (CSO) / stormwater sewer overflow (SSO)	65
Wastewater quality monitoring	65
Wastewater network flow meters	66
Household wastewater flow meters	66
4.3.2.2 Pumping stations	66
4.3.2.3 Detention tanks, gates and weirs	67
4.3.3 Unmet needs and future developments	67
4.3.3.1 Instrumentation	67
4.3.3.2 Monitoring and data analytics	67
4.3.3.3 Future directions	67
4.4 Metering and customer services	68
4.4.1 Control and monitoring snapshot	69
4.4.1.1 Automated meter reading (AMR)	69
4.4.1.2 Advanced metering infrastructure (AMI)	69
4.4.1.3 Uptake of AMR and AMI	70
4.4.2 Unmet needs and future developments	70
4.5 Market dynamics	71
4.5.1 Procurement	71
4.5.2 Key market players	71
4.6 Regional trends	75
4.6.1 Market forecast	76
Figure 4.7 Spending on control and monitoring solutions by region, 2014-2021	76
Figure 4.8 Spending on control and monitoring solutions by category, 2014-2021	77
Figure 4.9 Networks: Spending on sensors, meters and laboratory equipment by parameter, 2014-202	1 78
5 LITH ITV TREATMENT PLANTS	70
5. UTILITY TREATMENT PLANTS	79
5.1 Market directions	79
5.1 Market directions 5.2 Water at the source	79 80
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers	79 80 80
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot	79 80 80 81
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management	79 80 80 81 81
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments	79 80 80 81 81
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants	79 80 80 81 81 82 82
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers	79 80 80 81 81 82 82 83
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique	79 80 80 81 81 82 82 83
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot	79 80 80 81 81 82 82 83 83
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train	79 80 80 81 81 82 82 83 83 84
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants	79 80 80 81 81 82 82 83 83 84 84
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments	79 80 80 81 81 82 82 83 83 84 84 85
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast	79 80 80 81 81 82 82 83 83 84 84 85
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014-2021	79 80 80 81 81 82 82 83 83 84 84 85 86
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014-2021 Figure 5.6 Water treatment: Spending on control and monitoring solutions by category, 2014-2021	79 80 80 81 81 82 82 83 83 84 84 85 86
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014–2021 Figure 5.6 Water treatment: Spending on control and monitoring solutions by category, 2014–2021 Figure 5.7 Water treatment: Spending on sensors, meters & lab equipment by parameter, 2014–2021	79 80 80 81 81 82 83 83 84 84 85 86 86 87
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014-2021 Figure 5.6 Water treatment: Spending on sensors, meters & lab equipment by parameter, 2014-2021 5.4 Wastewater treatment plants	79 80 80 81 81 82 83 83 84 84 85 86 86 87 87
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014-2021 Figure 5.7 Water treatment: Spending on sensors, meters & lab equipment by parameter, 2014-2021 5.4 Wastewater treatment plants 5.4.1 Overview	79 80 80 81 81 82 82 83 83 84 84 85 86 86 87 87 88
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014-2021 Figure 5.6 Water treatment: Spending on sensors, meters & lab equipment by parameter, 2014-2021 5.4 Wastewater treatment plants 5.4.1 Overview 5.4.1.1 Key market drivers	79 80 80 81 81 82 82 83 83 84 84 85 86 86 87 88 89 89
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014–2021 Figure 5.6 Water treatment: Spending on control and monitoring solutions by category, 2014–2021 Figure 5.7 Water treatment: Spending on sensors, meters & lab equipment by parameter, 2014–2021 5.4 Wastewater treatment plants 5.4.1 Overview 5.4.2 Control and monitoring snapshot	79 80 80 81 81 82 82 83 83 84 84 85 86 86 87 87 88 89 89
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014-2021 Figure 5.6 Water treatment: Spending on control and monitoring solutions by category, 2014-2021 Figure 5.7 Water treatment: Spending on sensors, meters & lab equipment by parameter, 2014-2021 5.4 Wastewater treatment plants 5.4.1 Overview 5.4.1.1 Key market drivers 5.4.2 Control and monitoring snapshot 5.4.2.1 Instrumentation	79 80 80 81 81 82 82 83 83 84 84 85 86 87 87 88 89 89
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014-2021 Figure 5.6 Water treatment: Spending on control and monitoring solutions by category, 2014-2021 Figure 5.7 Water treatment: Spending on sensors, meters & lab equipment by parameter, 2014-2021 5.4 Wastewater treatment plants 5.4.1 Overview 5.4.1.1 Key market drivers 5.4.2 Control and monitoring snapshot Figure 5.8 Instrumentation Figure 5.8 Instrumentation at advanced WWTPs	79 80 80 81 81 82 82 83 83 84 84 85 86 87 87 88 89 89 89
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014-2021 Figure 5.6 Water treatment: Spending on sensors, meters & lab equipment by parameter, 2014-2021 5.4 Wastewater treatment plants 5.4.1 Overview 5.4.1.1 Key market drivers 5.4.2 Control and monitoring snapshot Figure 5.8 Instrumentation Figure 5.8 Instrumentation at advanced WWTPs Collection system	79 80 80 81 81 82 82 83 83 84 84 85 86 86 87 87 88 89 89 90 91
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014–2021 Figure 5.6 Water treatment: Spending on control and monitoring solutions by category, 2014–2021 Figure 5.7 Water treatment: Spending on sensors, meters & lab equipment by parameter, 2014–2021 5.4 Wastewater treatment plants 5.4.1 Overview 5.4.1.1 Key market drivers 5.4.2.1 Instrumentation Figure 5.8 Instrumentation at advanced WWTPs Collection system Aeration basin	79 80 80 81 81 81 82 82 83 83 84 84 85 86 87 88 89 99 90 91 91
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3 Drinking water treatment plants 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014-2021 Figure 5.6 Water treatment: Spending on control and monitoring solutions by category, 2014-2021 Figure 5.7 Water treatment: Spending on sensors, meters & lab equipment by parameter, 2014-2021 5.4 Wastewater treatment plants 5.4.1 Overview 5.4.1.1 Key market drivers 5.4.2 Control and monitoring snapshot 5.4.2.1 Instrumentation Figure 5.8 Instrumentation at advanced WWTPs Collection system Aeration basin Nutrient removal	79 80 80 81 81 81 82 82 83 83 84 84 85 86 87 87 88 89 99 91 91 91
5.1 Market directions 5.2 Water at the source 5.2.1 Key market drivers 5.2.2 Monitoring and control snapshot Figure 5.1 Commonly monitored parameters in water source management 5.2.3 Unmet needs and future developments 5.3.1 Key market drivers Figure 5.2 Example of savings from the Coliminder controlled disinfection technique 5.3.2 Monitoring and control snapshot Figure 5.3 General drinking water treatment train Figure 5.4 Commonly monitored parameters in drinking water treatment plants 5.3.3 Unmet needs and future developments 5.3.4 Market forecast Figure 5.5 Water treatment: Spending on control and monitoring solutions by region, 2014–2021 Figure 5.6 Water treatment: Spending on control and monitoring solutions by category, 2014–2021 Figure 5.7 Water treatment: Spending on sensors, meters & lab equipment by parameter, 2014–2021 5.4 Wastewater treatment plants 5.4.1 Overview 5.4.1.1 Key market drivers 5.4.2.1 Instrumentation Figure 5.8 Instrumentation at advanced WWTPs Collection system Aeration basin	79 80 80 81 81 81 82 82 83 83 84 84 85 86 87 88 89 99 90 91 91

Final effluent discharge	92
Figure 5.9 Overview of parameters measured at a WWTP	93
5.4.2.2 Control and automation	93
Data generation and flow	93
5.4.2.3 Data analytics	94
Figure 5.10 An example of a sensor reliability report	94
5.4.3 Unmet needs and future developments	95
5.5 Market dynamics	96
5.5.1 Procurement	96
5.5.2 Key market players	96
5.6 Market forecast	99
Figure 5.11 WW: Spending on control and monitoring solutions by region, 2014-2021	99
	100
Figure 5.12 WW: Spending on control & monitoring solutions by category, 2014-2021 Figure 5.13 WW treatment: Spending on sensors, meters & lab equipment by parameter, 2014-2021	100
Figure 5.13 www treatment: Spending on sensors, meters & lab equipment by parameter, 2014–2021	101
6. UPSTREAM OIL & GAS	102
6.1 Market directions	102
6.2 Overview	102
6.2.1 Key market drivers	103
6.3 Monitoring and control snapshot	104
Figure 6.1 Key applications within the O&G industry and the parameters measured	104
6.3.1 Produced water treatment and management	105
Figure 6.2 Key parameters for produced water treatment and separation	105
Figure 6.3 Example of a three-phase separator and the main parameters to monitor	105
6.3.1.1 Produced water management: Re-injection	106
Figure 6.4 Key parameters monitored for produced water reinjection	106
6.3.1.2 Produced water management: Disposal	107
	107
Figure 6.5 Key parameters to monitor in produced water disposal	107
Overboard discharge	
Disposal wells	107
6.3.2 Unconventional oil and gas	108
6.3.2.1 Hydraulic fracturing: Shale gas/tight oil	108
Figure 6.6 The hydraulic fracturing process, with parameters to monitor	108
6.3.2.2 Steam assisted gravity drainage: Heavy oil/bitumen	109
Figure 6.7 The steam assisted gravity drainage process, with parameters to monitor	109
Figure 6.8 Key parameters monitored in steam assisted gravity drainage	109
6.4 Unmet needs and future developments	110
6.4.1 Instrumentation	110
6.4.2 Enhanced connectivity	110
6.4.3 Data analytics	110
Figure 6.9 Key application areas for advanced data analytics for upstream O&G	111
6.4.4 Sub-sea operations	111
6.5 Market dynamics	112
6.5.1 Procurement	112
Figure 6.10 The supply chain for water control and monitoring systems in the upstream O&G sector	112
6.5.2 Key market players	113
Figure 6.11 Key instrumentation providers and systems integrators for the upstream oil & gas industry	113
6.6 Market forecast	115
6.6.1 Region	115
Figure 6.12 Spending on control and monitoring solutions by region, 2014-2021	115
6.6.2 Category	116
Figure 6.13 Spending on control and monitoring solutions by category, 2014-2021	116
6.6.3 Application	117
Figure 6.14 Spending on control and monitoring solutions by application, 2014-2021	117
6.6.4 Parameter	117
Figure 6.15 Spending on sensors and laboratory equipment by parameter, 2014-2021	118
Figure 6.16 Key parameters and forecast categories for the upstream oil & gas industry	119

7. REFINING & PETROCHEMICALS	120
7.1 Market directions	120
7.2 Overview	120
7.2.1 Key market drivers	121
7.3 Monitoring and control snapshot	122
Figure 7.1 Main water applications and key parameters to control and monitor	122
7.3.1 Process water	122
7.3.1.1 Desalting	123
Figure 7.2 Key parameters to monitor in desalting	123
Figure 7.3 pH monitoring and control in the desalting process	123
7.3.1.2 Boiler water	124
Figure 7.4 Key parameters to measure in refinery boiler feedwater	124
Figure 7.5 Conductivity and pH measurement in boiler systems for the refining industry	125
7.3.1.3 Cooling water	125
Figure 7.6 Key parameters to monitor in refinery cooling water	125
7.3.2 Wastewater treatment	126
Figure 7.7 Key parameters monitored in refinery wastewater	126
Figure 7.8 Contaminant specification for reuse water	127
7.4 Unmet needs and future developments	127
7.4.1 Instrumentation	127
7.4.2 Exchangeability and advanced processing	128
7.4.3 Big data and advanced data analytics	128
Figure 7.9 The key application areas for advanced data analytics for refining & petrochemicals	128
7.5 Market dynamics	129
7.5.1 Procurement	129
Figure 7.10 Procurement process for the water control and monitoring system	129
7.5.2 Key market players	130
Figure 7.11 Key instrumentation providers and systems integrators	130
7.6 Market forecast	132
7.6.1 Region	132
Figure 7.12 Spending on control and monitoring solutions by region, 2014-2021	132
7.6.2 Category	133
Figure 7.13 Spending on control and monitoring solutions by category, 2014-2021	133
7.6.3 Application	134
Figure 7.14 Spending on control and monitoring solutions by application, 2014-2021	134
7.6.4 Parameter	134
Figure 7.15 Spending on sensors and laboratory equipment by parameter, 2014-2021	135
Figure 7.16 Key parameters and forecast categories for the refining & petrochemicals industry	136
8. POWER	137
8.1 Market directions	137
8.2 Overview	137
8.2.1 Key market drivers	138
8.3 Monitoring and control snapshot	139
Figure 8.1 Water systems of a thermal power plant	139
8.3.1 Process water	140
8.3.1.1 Makeup water treatment plant	140
Figure 8.2 Typical parameters and locations for monitoring of demineralisation plants	141
8.3.1.2 Condensate polishing	142
8.3.2 Steam-water circuit	142
Figure 8.3 Typical parameters and locations for monitoring of the steam-water circuit*	142
8.3.3 Cooling water	143
Figure 8.4 Typical parameters monitored in cooling towers by control target	144
8.3.4 Wastewater	144
Figure 8.5 Typical parameters monitored in wastewater discharge	145
8.4 Unmet needs and future developments	145
8.5 Market dynamics	146
8.5.1 Procurement	146
8.5.2 Key market players	146

Figure 8.6 Key instrumentation providers and systems integrators for the power industry	146
8.6 Market forecast	148
8.6.1 Region	148
Figure 8.7 Spending on control and monitoring solutions by region, 2014-2021	148
8.6.2 Category	149
Figure 8.8 Spending on control and monitoring solutions by category, 2014-2021	149
8.6.3 Application	150
Figure 8.9 Spending on control and monitoring solutions by application, 2014-2021	150
8.6.4 Parameter	150
Figure 8.10 Spending on sensors and laboratory equipment by parameter, 2014-2021	151
Figure 8.11 Key parameters and forecast categories for the power industry	152
9. MINING	153
9.1 Market directions	153
9.2 Overview	153
9.2.1 Key drivers	154
9.3 Monitoring and control snapshot	155
Figure 9.1 Parameters measured for water quality and quantity at a mine site	155
9.3.1 Process water	156
Figure 9.2 Key parameters measured for process water	156
9.3.2 Industrial process monitoring	156
9.3.3 Wastewater	156
Figure 9.3 Key parameters measured for wastewater	157
9.4 Unmet needs and future developments	158
9.5 Procurement	158
9.6 Key players	159
Figure 9.4 Key instrumentation providers and systems integrators for the mining industry	159
9.7 Market forecast	161
9.7.1 Region	161
Figure 9.5 Spending on control and monitoring solutions by region, 2014-2021	161
9.7.2 Category	162
Figure 9.6 Spending on control and monitoring solutions by category, 2014-2021	162
9.7.3 Application	163
Figure 9.7 Spending on control and monitoring solutions by application, 2014–2021	163
9.7.4 Parameter	163
Figure 9.8 Spending on sensors and laboratory equipment by parameter, 2014-2021	164
Figure 9.9 Key parameters and forecast categories for the mining industry	165
10. FOOD & BEVERAGE	166
10.1 Market directions	166
10.2 Overview	166
10.2.1 Key market drivers	167
10.3 Monitoring and control snapshot	168
Figure 10.1 Main parameters measured in a food & beverage plant	168
Figure 10.2 An example of a typical pretreatment process	168
10.3.1 Clean-in-place	169
Figure 10.3 Main parameters measured for clean-in-place applications	169
Figure 10.4 An example of a CIP control and monitoring system with wireless sensor transmission	169
10.3.2 Brewing	170
Figure 10.5 Main parameters measured in brewing	170
Figure 10.6 Monitoring and control of the brewing process	171
10.3.3 Bottled water and soft drinks	171
Figure 10.7 Mineral water and spring water control and monitoring parameters	171
Figure 10.8 Main parameters for the control and monitoring of bottled water	172
Figure 10.9 Main parameters for the control and monitoring of soft drinks	173
10.3.4 Food	173
Figure 10.10 Main parameters for the control and monitoring of the dairy industry	173
10.3.5 Utility water	174
10.3.5.1 Boiler water	174

Figure 10.11 Monitoring and control of a plant steam generator	174
10.3.5.2 Cooling water	175
10.3.6 Wastewater treatment	175
Figure 10.12 Main parameters measured in food & beverage wastewater	175
Figure 10.13 Example of wastewater treatment plant monitoring in food & beverage	176
10.4 Unmet needs and future developments	177
10.5 Market dynamics	177
10.5.1 Procurement	177
10.5.2 Key market players	178
Figure 10.14 Key instrumentation providers and systems integrators for the food & beverage industry	178
10.6 Market forecast	180
10.6.1 Region	180
Figure 10.15 Spending on control and monitoring solutions by region, 2014-2021	180
10.6.2 Category	181
Figure 10.16 Spending on control and monitoring solutions by category, 2014-2021	181
10.6.3 Application	182
Figure 10.17 Spending on control and monitoring solutions by application, 2014-2021	182
10.6.4 Parameter	182
Figure 10.18 Spending on sensors and laboratory equipment by parameter, 2014-2021	183
Figure 10.19 Key parameters and forecast categories for the food & beverage industry	184
5 7.	
11. PULP & PAPER	185
11.1 Market directions	185
11.2 Overview	185
11.2.1 Key market drivers	186
11.3 Monitoring and control snapshot	186
11.3.1 Process water	186
Figure 11.1 Fresh water intake and deionisation monitoring and control	187
11.3.2 In-process water	188
Figure 11.2 Key parameters measured during industrial processing	188
11.3.3 Utility water	188
11.3.3.1 Boiler water	188
11.3.3.2 Cooling systems	189
Figure 11.3 Typical parameters monitored in cooling towers by control target	189
11.3.4 Wastewater	189
11.4 Unmet needs and future developments	190
11.5 Market dynamics	190
11.5.1 Procurement	190
11.5.2 Key market players	191
Figure 11.4 Key instrumentation providers and systems integrators for the pulp & paper industry	191
11.6 Market forecast	192
11.6.1 Region	192
Figure 11.5 Spending on control and monitoring solutions by region, 2014-2021	192
11.6.2 Category	193
Figure 11.6 Spending on control and monitoring solutions by category, 2014-2021	193
11.6.3 Application	194
Figure 11.7 Spending on control and monitoring solutions by application, 2014-2021	194
11.6.4 Parameter	194
Figure 11.8 Spending on sensors and laboratory equipment by parameter, 2014-2021	195
Figure 11.9 Key parameters and forecast categories for the pulp & paper industry	196
12. PHARMACEUTICALS	197
12.1 Market directions	197
12.2 Overview	197
12.2.1 Key market drivers	198
12.3 Monitoring and control snapshot	199
Figure 12.1 Water control and monitoring applications in biopharmaceutical manufacturing	199
Figure 12.2 Water control and monitoring applications in chemical pharmaceutical manufacturing	200
12.3.1 Pharmaceutical grade water	200

REFERENCES	228
INTERVIEWEES	225
Figure 13.9 Key parameters and forecast categories for the microelectronics industry	224
Figure 13.8 Spending on sensors and laboratory equipment by parameter, 2014-2021	223
13.6.4 Parameter	222
Figure 13.7 Spending on control and monitoring solutions by application, 2014-2021	222
13.6.3 Application	222
Figure 13.6 Spending on control and monitoring solutions by category, 2014-2021	221
13.6.2 Category	221
Figure 13.5 Spending on control and monitoring solutions by region, 2014-2021	220
13.6.1 Region	220
13.6 Market forecast	220
Figure 13.4 Key instrumentation providers and system integrators for the microelectronics industry	218
13.5.2 Key market players	218
13.5.1 Procurement	218
13.5 Market dynamics	218
13.4.3 Big data and advanced analytics	217
13.4.2 Control and automation	217
13.4.1 Instrumentation	217
13.4 Unmet needs and future developments	217
Figure 13.3 Key parameters to monitor in wastewater	216
13.3.2 Wastewater treatment and reuse	216
Figure 13.2 Key parameters to monitor in ultrapure water treatment	215
13.3.1 Ultrapure water treatment	215
Figure 13.1 Water distribution system of a wafer fab and the parameters monitored	214
13.3 Monitoring and control snapshot	214
13.2.1 Key market drivers	213
13.2 Overview	212
13.1 Market directions	212
13. MICROELECTRONICS	212
Figure 12.12 Key parameters and forecast categories for the pharmaceuticals industry	211
Figure 12.11 Spending on sensors and laboratory equipment by parameter, 2014-2021	210
12.6.4 Parameter	209
Figure 12.10 Spending on control and monitoring solutions by application, 2014–2021	209
12.6.3 Application	209
Figure 12.9 Spending on control and monitoring solutions by category, 2014–2021	208
12.6.2 Category	208
Figure 12.8 Spending on control and monitoring solutions by region, 2014-2021	207
12.6.1 Region Figure 12.9 Spending on control and manitoring colutions by region 2014, 2021	207
12.6 Market forecast	207
Figure 12.7 Main market players active in ultrapure water and wastewater treatment applications	
<u> </u>	205
12.5.1 Frocurement 12.5.2 Key market players	204
12.5.1 Procurement	204
12.4.3 Data analysis and advanced analytics 12.5 Market dynamics	204
12.4.3 Data analysis and advanced analytics	204
12.4.1.3 Rouge monitoring	204
12.4.1.3 Rouge monitoring	204
12.4.1.2 Rapid microbial testing	203
12.4.1.1 TOC and conductivity	203
12.4.1 Adoption of online instrumentation	203
12.4 Unmet needs and future developments	203
12.3.3 Pharmaceutical manufacturing processes	203
Figure 12.6 Key parameters measured in pharmaceutical wastewater	202
12.3.2 Wastewater	202
Figure 12.5 Key parameters measured in pharmaceutical grade water	201
Figure 12.4 WFI quality standards from USP, Ph. Eur., and JP pharmacopoeias	201
Figure 12.3 Purified water quality standards from USP, Ph. Eur. and JP pharmacopoeias	200