

# Table of Contents

<i>Preface</i>	<i>xi</i>
<i>Introduction</i> by Robin H. Curtis	<i>xii</i>
<i>List of Acronyms and Abbreviations</i>	<i>xix</i>
<b>1 Reasons to Use a Heat Pump</b>	<b>1</b>
1.1 Environmental benefits	1
1.1.1 Our environment is in danger	1
1.1.2 Tracking down the culprit	2
1.1.3 Heat pumps offer emission-free operation on-site	2
1.2 Operating costs	4
1.3 Independence	5
1.4 Comfort	6
1.5 Security for the future	6
1.6 Non-flammability	8
1.7 Responsibility for the future	8
1.8 Ideal for low energy houses	8
1.9 Retrofit	8
1.10 Multiple functions	9
1.11 Public promotion	9
1.12 Energy politics/laws	9
<b>2 Theory of the Heat Pump</b>	<b>11</b>
2.1 The principle	11
2.2 The refrigeration cycle	12
2.3 Coefficient of performance	12
2.4 Carnot Cycle	13
2.5 Working fluid/refrigerant	15
2.6 Enthalpy-pressure diagram	16
2.7 Heat pump cycle with injection cooling	17
<b>3 Heat Pump Types</b>	<b>18</b>
3.1 Brine/water, water/water heat pump	18
3.1.1 Refrigeration cycle	19
3.1.2 Refrigerant	19
3.1.3 Electrical components and controller	20
3.1.4 Safety measures	20
3.1.5 Display	20
3.2 Direct expansion/water heat pump	21
3.2.1 Refrigeration cycle	22
3.2.2 Refrigerant	22

3.2.3	Electrical components and controller	23
3.2.4	Safety measures	23
3.2.5	Display	23
3.3	Direct expansion/direct condensation heat pump	23
3.4	Air/water heat pump – split units	24
3.4.1	Refrigeration components – indoor unit	24
3.4.2	Refrigeration components – outdoor unit	24
3.4.3	Refrigerant	25
3.4.4	Electrical components and controller	25
3.4.5	Safety measures	25
3.4.6	Display	25
3.5	Air/water heat pump – compact units, indoor installation	26
3.5.1	Refrigeration cycle	26
3.5.2	Refrigerant	26
3.5.3	Electrical components and controller	27
3.5.4	Safety measures	27
3.5.5	Display	27
3.6	Air/water heat pump – compact units, outdoor installation	27
3.7	Domestic hot water/heat pumps – air source, split units	28
3.7.1	Refrigeration cycle	28
3.7.2	Refrigerant	29
3.7.3	Electrical components	30
3.8	Domestic hot water heat pump – air source, split units	30
3.9	Ground/water heat pump – domestic hot water heat pump – air source, split units	32
3.10	Air/air heat pump – ventilation	33
3.11	Exhaust-air heat pumps, additional design	33
3.12	Heat pumps for air heating/cooling	33
<b>4</b>	<b>Complete System Planning</b>	<b>35</b>
4.1	Planning a heat pump heating system	35
4.2	Heat source selection	36
4.3	Heating system selection	36
4.4	Heat pump selection	37
4.4.1	Determination of heating demand	37
4.4.2	Utility interruptible rates	38
4.4.3	Domestic hot water heating	39
4.4.4	Operation configurations	39
4.4.5	Heat pump selection	41
4.5	Retrofit/renovation	44
<b>5</b>	<b>Planning Instructions for Ground Heat Source – Brine Systems (Horizontal Collector, Trench, Vertical Loop)</b>	<b>46</b>
5.1	Ground heat source	46
5.1.1	System description	46

5.2	Ground conditions	46
5.3	Layout and installation of ground collector	47
5.3.1	Horizontal collector installations	47
5.3.2	Trench collector/spiral collector	49
5.3.3	Vertical loop	49
5.4	Connection	52
5.4.1	Collection vault	52
5.4.2	Safety clearance	53
5.4.3	Building penetrations	53
5.5	Brine circulation loop	53
5.6	Commissioning	56
5.7	CO <sub>2</sub> loop	57
<b>6</b>	<b>Planning Instructions for Ground Heat Source – Direct Expansion Systems</b>	<b>58</b>
6.1	Ground heat source	58
6.2	Ground conditions	59
6.3	Layout and installation of collector	59
6.3.1	Horizontal loop installations	59
6.4	Connection	61
6.4.1	Collection vault	61
6.4.2	Safety clearance	61
6.4.3	Building penetration	62
6.5	Commissioning	62
<b>7</b>	<b>Planning Instructions for Water Heat Source Systems</b>	<b>63</b>
7.1	Water heat source	63
7.2	Ground and well conditions	64
7.3	Design	64
7.4	Connection	66
7.5	Components/filter	66
7.6	Building penetrations	66
7.7	Commissioning	66
<b>8</b>	<b>Planning Details for Air Heat Source Systems</b>	<b>69</b>
8.1	Air heat source	69
8.2	Design	70
8.2.1	Split-system	70
8.2.2	Compact systems – indoor set-up	72
8.2.3	Compact systems – outdoor set-up	73
8.3	Operation configuration	75
8.3.1	Monovalent systems	75
8.3.2	Bivalent-parallel	76
8.3.3	Bivalent-alternate	77
8.4	Commissioning	77

<b>9 Planning Instructions – Heating Systems</b>	<b>78</b>
9.1 Heating circulation loop control	78
9.2 Hydraulic separation	78
9.3 Buffer storage tank	80
9.4 Circulation pump	80
9.5 Connection group	81
9.6 Heating/cooling distribution system	81
9.6.1 Radiant floor heating	82
9.6.2 Heating capacity and self-controlling effect	84
9.6.3 Radiant wall heating	86
9.6.4 Radiators	87
9.7 Domestic hot water production	87
 <b>10 Heating and Cooling – Reversible Heat Pump</b>	 <b>90</b>
10.1 Response to climate change	90
10.2 Technical requirements for buildings	90
10.3 Planning for active cooling	91
10.4 Sizing of ground collectors and vertical loops	92
10.5 Cooling distribution system: radiant/surface cooling	93
10.6 Refrigeration circuit for active cooling	93
10.7 Control	94
10.8 Economics	94
10.9 Solar cooling	95
10.10 Groundwater heat source	95
10.11 Operating range	95
 <b>11 Control of Heat Pump Heating Systems – Electrical Connections</b>	 <b>96</b>
11.1 Controller and control system	96
11.2 Heat pump control	96
11.3 Additional functions of heat pump control	97
11.4 Hydraulic schematics	97
11.5 Single room control/zone control	97
11.6 Other systems	98
11.7 Electrical connections	98
 <b>12 Domestic Hot Water Production</b>	 <b>100</b>
12.1 General instructions for domestic hot water	100
12.1.1 Why not with the heating loop?	100
12.1.2 Domestic hot water system comparison	100
12.1.3 Separation of domestic hot water from the heating system	103
12.1.4 Information for planning and operation of a domestic hot water system	104
12.1.5 Installation instructions	104
12.1.6 Hot water demand– guidelines	104
12.1.7 DVGW – worksheet W551	104

12.2	Additional optional functions of hot water heat pumps	105
12.2.1	Additional cooling benefit	106
12.2.2	Additional basement dehumidifying benefit	106
12.2.3	Additional distilled water benefit	106
12.2.4	Additional ventilation benefit	107
12.3	Installation	108
12.4	Water connections	109
12.4.1	Water connections	109
12.4.2	Air connections	109
12.4.3	Air ducts	109
12.4.4	Condensate water drain	109
12.4.5	Ground collector connection	109
12.4.6	Heating heat exchanger	109
<b>13</b>	<b>Controlled Dwelling Ventilation</b>	<b>111</b>
13.1	Why ventilate?	111
13.2	Why controlled dwelling ventilation?	112
13.3	Types of controlled dwelling ventilation	113
13.4	Comprehensive living climate	114
13.5	Combined units for heating, hot water preparation and ventilation	115
<b>14</b>	<b>Specialized Installations</b>	<b>116</b>
14.1	Renovations	116
14.2	Low energy/passive house	117
14.3	Swimming pool heating	119
14.4	Livestock stable heat pump	119
14.5	Absorber	120
14.6	Heat pumps for industrial applications	120
14.7	Industrial waste heat use/indirect water source	122
14.8	CO <sub>2</sub> -heat pipes	123
<b>15</b>	<b>Appendices</b>	<b>126</b>
A	Hydraulic schematics	126
B	Investment/operation costs (1/2007)	133
C	Units, symbols and conversion	141

*List of Figures and Sources*

*List of Tables and Sources*