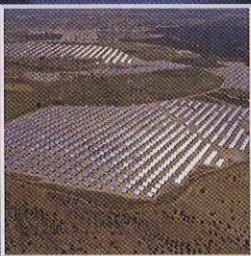
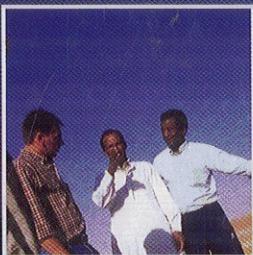
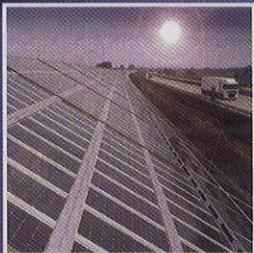


Electricity from **Sunlight**

An Introduction
to Photovoltaics

Paul A. Lynn



 **WILEY**

Contents

About the Author.....	ix
Preface.....	xi
Acknowledgements.....	xiii
1. Introduction	1
1.1 The Sun, Earth, and Renewable Energy.....	1
1.2 The Solar Resource.....	6
1.3 The Magic of Photovoltaics.....	10
1.4 A Piece of History	12
1.5 Coming up to Date	17
References.....	23
2. Solar Cells.....	25
2.1 Setting the Scene	25
2.2 Crystalline Silicon	29
2.2.1 The Ideal Crystal	29
2.2.2 The <i>p–n</i> Junction	32
2.2.3 Monocrystalline Silicon.....	35
2.2.3.1 Photons in Action	35
2.2.3.2 Generating Power.....	38
2.2.3.3 Sunlight, Silicon, and Quantum Mechanics.....	43
2.2.3.4 Refining the Design	46
2.2.4 Multicrystalline Silicon	54
2.3 Amorphous and Thin-film Silicon.....	55
2.4 Other Cells and Materials.....	61
2.4.1 Copper Indium Diselenide (CIS).....	61
2.4.2 Cadmium Telluride (CdTe)	65

2.4.3 Specialised and Innovative Cells	66
2.4.3.1 Gallium Arsenide (GaAs)	66
2.4.3.2 Dye-sensitised Cells	69
References.....	72
3. PV Modules and Arrays.....	73
3.1 Introductory	73
3.2 Electrical Performance.....	76
3.2.1 Connecting Cells and Modules	76
3.2.2 Module Parameters	80
3.3 Capturing Sunlight.....	84
3.3.1 Sunshine and Shadow	84
3.3.2 Aligning the Array.....	88
3.4 Concentration and Tracking.....	94
References.....	102
4. Grid-connected PV Systems.....	103
4.1 Introductory	103
4.2 From DC to AC.....	105
4.3 Completing the System.....	112
4.4 Building-integrated Photovoltaics (BIPV)	114
4.4.1 Engineering and Architecture	114
4.4.2 PV Outside, PV Inside	118
4.5 Large PV Power Plants	128
References.....	131
5. Stand-alone PV Systems.....	133
5.1 Remote and Independent	133
5.2 System Components	137
5.2.1 Batteries	137
5.2.2 Charge Controllers.....	141
5.2.3 Inverters	148
5.3 Hybrid Systems.....	152
5.4 System Sizing	155
5.4.1 Assessing the Problem.....	155
5.4.2 PV Arrays and Battery Banks	159
5.5 Applications	165
5.5.1 PV in Space	165
5.5.2 Island Electricity	170
5.5.3 PV Water Pumping	175
5.5.4 Solar-powered Boats	180

Contents

5.5.5 Far and Wide.....	186
References.....	190
6. Economics and the Environment.....	191
6.1 Paying for PV	191
6.1.1 Costs and Markets	191
6.1.2 Financial Incentives	197
6.1.3 Rural Electrification.....	200
6.2 Environmental Aspects	206
6.2.1 Raw Materials and Land.....	206
6.2.2 Life-cycle Analysis	210
References.....	215
Index	217