

Contents

1	Introduction: Solar Energy and Human Civilization	1
	Why EROI?	3
	Solar Energy-Derived Fossil Fuels	4
	What Level of EROI Do We Need?	6
	Why the Kingdom of Spain?.....	7
	Spain (2009–2010): An Excellent Test Bed for Solar PV Energy Costs and Gains	9
	Energy in Spain.....	10
	Contemporary Spain	12
	References.....	13
2	The Evolution of the Demand for Primary Energy and Electricity in Spain	15
	Recent Evolution of the Spanish Electricity Supply	15
	An Overview of the Status of Renewable Energies in Spain	17
3	The Historical, Legal, Political, Social and Economic Context of Solar Photovoltaics in Spain.....	21
	Development and Deployment of Photovoltaic Energy Technologies in Spain.....	21
	Electrical Output of Solar Photovoltaic Plants	22
	Photovoltaic Technologies Utilized in Spain	22
	Large Government Subsidies and the Solar PV Installation Boom	24
	Bending the Rules	26
	Ups and Downs with the Royal Decrees: Growing Premium Tariffs vs. Growing Difficulties in Government Budgets	26
	Theoretical Interest Is Still Alive Despite the Reduction in Premium Tariffs and Assigned Quotas	28
	Dancing with the Prices	29

Impacts on Spain's Industries	29
... And Spain Died of Success.....	31
Difficulties Associated with the Success of the Spanish Solar PV Program	31
The Increasing Use of Imported PV Components and Equipment.....	32
Solar PV as a Financial Product, Rather Than a Renewable Asset	34
Fraud	35
The Financial Support to Renewable Energies from a Fossil-Fuelled Society	36
4 Calculating the Energy Return on Energy Invested (EROEI or EROI) for Spain's Solar Photovoltaic Energy	39
Energy Outputs (Numerator)	40
Energy Inputs (Denominator)	41
Deriving Energy Intensities for Money Spent on Inputs	41
Calculating an Extremely Rough EROI for a 1 GW Solar Photovoltaic Plant in Spain	43
Spanish Data Sources: A Good Start with Good Institutions and Public Companies.....	45
5 Methods: Calculating the Energy Output. The Energy Returned (ER or E_{out})	47
Definitions of Solar Photovoltaic Power Used in Our EROI Analysis	47
Annual Electrical Output Compared to Nominal Capacity for Spain.....	49
Factors Considered.....	49
l_1 : Mismatch of Modules.....	49
l_2 : Losses Due to Dust	50
l_3 : Angular and Spectral Losses	51
l_4 : Nonfulfillment of Nameplate (Peak) Power	51
l_5 : Losses Due to Temperature	52
l_6 : Shadowing/Shading	52
l_7 : Maximum Power Point Tracker.....	53
l_8 : Direct Current Wiring.....	53
l_9 : Alternative Current/Direct Current Output of Inverter.....	54
l_{10} : AC Wiring Within the PV Plant	54
l_{11} : Medium-Voltage Losses (Within the PV plant)	55
l_{12} : Voltage Switch Offs, Voltage Sags, and Voltage Swells	55
l_{13} : Peak Versus Nominal Installed Power Factoring	56
l_{14} : Losses in the Evacuation Line to the Electric Network	57
Would Rooftop PV Mountings Save These Losses?.....	58
l_{15} : Degradation of Modules over Time.....	59
Cumulative Impact.....	60

6 Methods: Calculating the Energy Input. The Energy Invested (EI or Ein): Analyzing the Total Energy Costs of Photovoltaic Systems in Spain 61

 Calculating the Energy Inputs..... 64

 Direct Energy and Material Inputs..... 64

 Other Necessary Energy Investments Derived from Economic Expenses and Translated into Energy Equivalences 72

 Indirect Energy Inputs and Material Inputs 78

 Operating Expenses 86

 Financial Services 88

 Energy Estimates from Monetary Values..... 89

 Other (Hardware) 104

 Summary of Energy Costs 113

7 Results, Sensitivity Analysis, and Conclusions..... 115

 Energy Return on Investment for Spanish Photovoltaic Energy in 2008..... 115

 Sensitivity Analysis..... 115

 Discussion 117

 Conclusion 118

References..... 121

Index..... 125

Spain's Photovoltaic Revolution

The Energy Return on Investment

Prieto, P.A.; Hall, C.A.S.

2013, XX, 128 p. 18 illus. in color., Softcover

ISBN: 978-1-4419-9436-3