

List of Figures

Figure 1.1	Sub-approval Process for the Assessment of EEC Building Design Submission	3
Figure 1.2	Guide for the Development of EEC Buildings in Temburong District	3
Figure 1.3	Pyramid of Commercial Sector Indicators	7
Figure 1.4	Typical Breakdowns of Office Cooling Loads in Malaysia	9
Figure 1.5	Efficiency (%) vs Mechanical Motor Output Power (KW) as per IEC 60034-30:2014 Classes	20
Figure 1.6	Global MEPS Mapping Based on Classification of IEC IE Efficiency	21
Figure 1.7	Overview of Procedures for EEC Building Design Assessment	24
Figure 1.8	EEC Building Design Assessment Criteria and Flowchart	25
Figure 2.1	Organisational Structure of the Electricity Sector, Brunei Darussalam	32
Figure 2.2	Transmission Network of DES and BPC	34
Figure 2.3	Changes in Maximum Demand of DES (Including Temburong)	35
Figure 2.4	Changes in Maximum Demand of BPC	35
Figure 2.5	Monthly Maximum Daily Load Curve in Main Grid of Brunei Darussalam (as of 2019)	36
Figure 2.6	Changes in Maximum Demand in Temburong District	36
Figure 2.7	Monthly Maximum Daily Load Curve in Temburong District (as of 2019)	37
Figure 2.8	Temburong Transmission Line Plan	38
Figure 2.9	SAIDI in Brunei Darussalam	39
Figure 2.10	SAIFI in Brunei Darussalam	39
Figure 2.11	International Comparison of SAIDI (as of 2015)	40
Figure 2.12	International Comparison of SAIFI (as of 2015)	40
Figure 2.13	Installed Capacity Portfolio in Brunei Darussalam	41
Figure 2.14	PV Installation Plan in Brunei Darussalam	42
Figure 2.15	Monthly Average Daily Solar Irradiance at Tenaga Suria Brunei Power Station	43

Figure 2.16	Hourly Solar Irradiance for 2018 at Tenaga Suria Brunei Power Station	43
Figure 2.17	Precipitation at Tenaga Suria Brunei Power Station in 2018	44
Figure 2.18	Average Temperature at Tenaga Suria Brunei Power Station in 2018	45
Figure 2.19	Monthly PV Generation at Tenaga Suria Brunei Power Station in 2018	45
Figure 2.20	Monthly Average Hourly PV Generation at Tenaga Suria Brunei Power Station	46
Figure 2.21	Changes in Installed Capacity of vRE under RPS in Japan	47
Figure 2.22	Basic Mechanism of Feed-In-Tariff	48
Figure 2.23	Changes in Feed-In-Tariff Price in Japan	49
Figure 2.24	Changes in Installed Capacity of vRE under FIT in Japan	50
Figure 2.25	Installed Capacity Ratio of PV in Each Region	52
Figure 2.26	Overview of PV Generation Suppression in Kyushu Region on 28 October 2019	52
Figure 2.27	Conceptual Figure of Calculation Condition for Connectable Capacity of vRE in Japan	53
Figure 2.28	Definition of Connectable Capacity	54
Figure 2.29	Conceptual Figure of Calculation Method for Connectable Capacity of vRE in Japan	54
Figure 2.30	Conceptual Figures of Output Pattern of vRE for Connectable Capacity Calculation	55
Figure 2.31	Flowchart of Connectable Capacity Calculation Method in Japan	55
Figure 2.32	Definition of Thermal Base Output	57
Figure 2.33	Conceptual Figure of the Brunei Darussalam's Power Grid for Simulation	58
Figure 2.34	Flow of the Calculation Method for Case 1	61
Figure 2.35	Conceptual Figure of the Calculation Method for Case 1	62
Figure 2.36	Demand–Supply Balance of DES in Case 1-1 on 9 November	63
Figure 2.37	Demand–Supply Balance of DES in Case 1-2 on 9 November	64
Figure 2.38	Demand–Supply Balance in Case 1-3 on 9 November	65
Figure 2.39	Demand Supply Balance of DES in Case 1-4 on 9th November	65

Figure 2.40	Demand–Supply Balance of BPC on 24 March	66
Figure 2.41	Flow of the Calculation Method for Case 2	68
Figure 2.42	Conceptual Figure of the Calculation Method for Case 2	68
Figure 2.43	Comparison of Demand–Supply Balance between Cases 1-1 and 2-1 on 9 November	70
Figure 2.44	Comparison of Demand–Supply Balance between Cases 1-2 and 2-2 on 9 November	71
Figure 2.45	Comparison of Demand–Supply Balance between Cases 1-3 and 2-3 on 9 November	72
Figure 2.46	Comparison of Demand–Supply Balance between Cases 1-4 and 2-4 on 9 November	73
Figure 2.47	Conceptual Figure of Utilising Interconnection	74
Figure 2.48	Conceptual Figure of Optimal Generation Control for Maximising vRE Generation in Brunei Darussalam	76
Figure 2.49	Total Installed Cost for Utility-Scale Solar PV Projects and the Global Weighted Average, 2010–2018	78
Figure 2.50	Annual Installation Cost of PV in Brunei Darussalam	78
Figure 2.51	O&M Costs for PV Projects in ASEAN Member States	79
Figure 2.52	Annual O&M Cost Estimation of PV in Brunei Darussalam	79
Figure 3.1	Data and Modelled Car Ownership Rate	89
Figure 3.2	Estimated number of passenger cars in use	89
Figure 3.3	Energy Consumption of Passenger Cars – Business-As-Usual Scenario	92
Figure 3.4	Energy Consumption of Passenger Cars – EV20 Scenario	93
Figure 3.5	Energy Consumption of Passenger Cars – EV40 Scenario	93
Figure 3.6	Energy Consumption of Passenger Cars – EV60 Scenario	94
Figure 3.7	Electric Energy Needed in Electric Car Scenarios	94
Figure 3.8	Generated Electricity – Electric Cars Scenarios	95
Figure 3.9	CO ₂ Emissions from Passenger Cars – Electric Cars Scenarios	96
Figure 3.10	CO ₂ Emissions from Electricity Generation – Electric Car Scenarios	96
Figure 3.11	Changes in Total CO ₂ Emissions in Electric Cars Scenarios Relative to BAU(%)	97

Figure 3.12	Energy Consumption of Passenger Cars – FC10 Scenario	98
Figure 3.13	Energy Consumption of Passenger Car Transport – FC20 Scenario	98
Figure 3.14	Energy Consumption of Passenger Car Transport – FC30 Scenario	99
Figure 3.15	Produced Hydrogen – Fuel-Cell Hydrogen Scenarios	99
Figure 3.16	CO ₂ Emissions of Passenger Car Transport – Fuel-Cell Hydrogen Cars Scenarios	100
Figure 3.17	CO ₂ Emissions from Hydrogen Production – Natural Gas Steam Reforming without CCS – Hydrogen-Powered Fuel-Cell Car Scenarios	100
Figure 3.18	Changes (%) in Total CO ₂ Emissions in Hydrogen-Powered Fuel-Cell Car Scenarios vis-à-vis BAU – Hydrogen Produced from Natural Gas Steam Reforming without CCS	101
Figure 3.19	Natural Gas Input to Produce Hydrogen from Natural Gas Steam Reforming without CCS	102
Figure 3.20	Natural Gas Input to Produce Hydrogen from Natural Gas Steam Reforming with CCS	102
Figure 3.21	CO ₂ Emission from Hydrogen Production from Methane Steam Reforming with CCS – Fuel-Cell Car Scenarios	103
Figure 3.22	Grid Electricity Needed to Produce Hydrogen by Electrolysis	104
Figure 3.23	CO ₂ Emission from Hydrogen Production from Grid Electricity-Based Electrolysis – Fuel-Cell Car Scenarios	104
Figure 3.24	Three Traffic Flow Categories	106
Figure 3.25	Pan-Borneo Highway	108
Figure 3.26	Current Main Road Access To and From Temburong District	109
Figure 3.27	Suitable Location for Development Hubs in Temburong	111
Figure 3.28	Mobility Network of Temburong District	112
Figure 3.29	Mobility Hub Design	113
Figure 3.30	Mobility Hub Zone	113
Figure 3.31	Daily Trip Origins and Destinations (All Modes – Persons) in 2012	115
Figure 4.1	Future Image of City of Living Lab in Temburong Ecotown	121
Figure 4.2	Hydrogenation Plant in Brunei	127

Figure 4.3	International Supply Chain of Hydrogen using SPERA Hydrogen Technology	128
Figure 4.4	Location of Solar Park	129
Figure 4.5	Development Areas Proposed in Temburong District Plan, 2006–2025	130
Figure 4.6	Mobility Network of Temburong and Connectivity with Bandar Seri Begawan	131
Figure 4.7	Route of Bandar Seri Begawan–Temburong Bridge	133
Figure 4.8	Image of Hydrogen Supply Station	133
Figure 4.9	Image of Mobility Hub Zone	134
Figure 4.10	Image of Fuel Cell Bus	135
Figure 4.11	Proposed Bus Network in Temburong District	135
Figure 4.12	Potable Water Supply in Temburong District	136
Figure 4.13	Potable Water Supply for Temburong District	137
Figure 4.14	Location of Ecotourism Focus Areas in Temburong District	138
Figure 4.15	Image of Resort and Convention Zone in Gate Zone	139
Figure 4.16	Location of Tourism Hub in Gate Zone	140
Figure 4.17	Image of Nature Amusement Park in Gate Zone	141
Figure 4.18	Image of Agro Park in Gate Zone	142
Figure 4.19	Location of New Campus for Universiti Islam Sultan Sharif Ali	144
Figure 4.20	Image of Eco-residential Area in the Gate Zone	146
Figure 4.21	Location of Residential Area in Labu Estate	147
Figure 4.22	Location of New Internal Roads and Bridge in Bangar Urban Centre	148
Figure 4.23	Location of New Port and the Riverside Development Area in Bangar Urban Centre	149

List of Tables

Table 1.1	Maximum U-value for Roof (W/m ² K)	5
Table 1.2	BEI Targets for Commercial and Public Sector Buildings	11
Table 1.3	Unitary Air Conditioners Minimum CSPF – Cooling Requirements	16
Table 1.4	Water-Chilling Packages, Electrically Driven: Chiller Energy Performance Rating	17
Table 1.5	Minimum Efficacy (lm/w) for Various Types of Lamps and Ratings	23
Table 1.6	Prerequisite Energy Efficiency Performance Requirements	26
Table 1.7	Interior Lighting Power Density (including Ballast Loss) Allowance for Typical Building Area	28
Table 1.8	Maximum Lighting Power Intensity Allowance of Building Exteriors	28
Table 1.9	Maximum Power Consumption for Pumping System	29
Table 1.10	Checklist for Step 3 Assessment of EEC Building Design Submission	30
Table 2.1	Power Outage over 1 Hour in Temburong District	39
Table 2.2	Installed Capacity Portfolio of vRE in Japan	51
Table 2.3	Summary of Simulation Assumptions	59
Table 2.4	Simulation Cases in this Study	60
Table 2.5	Calculation Result of Case 1	62
Table 2.6	Demand–Supply Balance of DES in Case 1-1 on 9 November	63
Table 2.7	Demand–Supply Balance of DES in Case 1-2 on 9 November	64
Table 2.8	Demand–Supply Balance of DES in Case 1-3 on 9 November	64
Table 2.9	Demand–Supply Balance of DES in Case 1-4 on 9 November	65
Table 2.10	Demand–Supply Balance of BPC on 24 March	66
Table 2.11	Yearly Electricity Consumption and PV Generation in Case 1	67
Table 2.12	Calculation Result of Cases 1 and 2	69
Table 2.13	Comparison of Demand–Supply balance between Cases 1-1 and 2-1 on 9 November	70

Table 2.14	Comparison of Demand–Supply Balance between Cases 1-2 and 2-2 on 9 November	71
Table 2.15	Comparison of Demand–Supply Balance between Cases 1-3 and 2-3 on 9 November	72
Table 2.16	Comparison of Demand–Supply balance between Cases 1-4 and 2-4 on 9 November	73
Table 2.17	Required Land Use for PV Introduction in Brunei Darussalam	77
Table 3.1	Assumptions on GDP Growth	86
Table 3.2	Energy Efficiency in Hydrogen Production	87
Table 3.3	Estimated Parameters of equation (2)	88
Table 3.4	Passenger Car–Related Assumptions for Electric Car Scenarios	90
Table 3.5	Passenger Car–Related Assumptions for Hydrogen-Powered Fuel-Cell Car Scenarios	91
Table 3.6	National and Local Programmes in the Land Transport Master Plan that Might Affect the Mobility and Emissions in Temburong District	107
Table 3.7	Green Vehicle and Border-Crossing Improvement Interventions	107
Table 3.8	Estimated Effect of Each Intervention to the Total Emissions of Greenhouse Gases in Temburong	116
Table 4.1	Population Framework of Temburong District	122
Table 4.2	Demand for Electricity in Temburong District	123
Table 4.3	Energy Mix for Power Generation in Temburong District	125
Table 4.4	Priority and Key Projects of the Energy Sector in Temburong Ecotown	126
Table 4.5	Priority and Key Projects of the Transport Sector for Temburong Ecotown	132
Table 4.6	Priority and Key Projects of the Water Supply Sector for Temburong Ecotown	137
Table 4.7	Priority and Key Projects of the Tourism Sector for Temburong Ecotown	139
Table 4.8	Priority and Key Projects of Education Sector for Temburong Ecotown	143

Table 4.9	Land Necessary for the New Campus of Universiti Islam Sultan Sharif Ali (2030)	143
Table 4.10	Priority and Key Projects of the Industry Sector in Temburong Ecotown	145
Table 4.11	Priority and Key Projects of the Housing Sector in Temburong Ecotown	145
Table 4.12	Priority and Key Projects of Urban Development of Bangar Urban Centre	147
Table 4.13	Summary of Priority Projects and Key Projects in the Roadmap for Temburong Ecotown Development	150