

Index

a

- active solar systems 10
- adoption patterns 98, 213, 219
- advanced anomaly detection and
 - performance diagnostics 243
- advanced Earth System models 419
- agrivoltaics 11, 12, 50, 184, 199, 315, 316, 320, 321, 326, 332, 334, 340, 348, 439
- agrivoltaic systems 11, 12, 181, 332
- AI and IoT in solar power systems
 - case studies and real-world implementations 251–253
 - challenges and future trends 253–255
 - components of 245
 - imperative for 242–243
- AI applications in solar energy
 - benefits and impact analysis
 - contribution to decentralized energy goals 201
 - efficiency gains and cost reduction 199–200
 - enhanced resilience and reliability 201–202
 - environmental and societal impact 200
 - challenges and future prospects 202
 - cybersecurity and data privacy concerns 203
 - future trends and research directions 204
 - regulatory and policy barriers 203–204
 - energy forecasting and load balancing 194–195
 - energy generation and consumption 192–193
 - fault detection and diagnosis using machine learning 193–194
 - optimization algorithms, efficiency improvement 195
 - synergistic integration 196–198
- AI-driven monitoring and predictive maintenance 246–247
- AI-enhanced grid services and market participation 254, 255
- AI-IOT solar systems 160–161
- AI to solar power management 243–244
- antireflection coatings (ARC) 321, 324, 334
- Apple's vertically integrated solar strategy 100–101
- aquifer thermal energy storage (ATES) 329
- architectural integration 5, 292–294, 360
- array of light 409
- artificial intelligence (AI) 227
 - blockchain and 374
 - in energy systems 150–152
 - for environmental monitoring and optimization 351–352
 - Internet of Things (IoT) 9, 12–14, 288–290
 - and IOT in power systems 152–153
 - smart sensors 156–158
- artificial photosynthesis 320

assembling modules 107
 automated cleaning 157, 200
 automated fault diagnosis 243–244
 Autonomous Solar Plant 254, 255
 Autoregressive Integrated Moving
 Average (ARIMA) 243

b

balance-of-system (BOS) 14, 111, 123,
 185, 242, 342, 438
 balancing trade-offs 129
 bandgap energy 4, 322
 battery charge-discharge cycles 445
 battery energy storage systems (BESS)
 243, 390
 battery management 298–299
 battery management systems 181
 behavioral insights 289–290
 bibliometric analysis 415–435
 bifacial cells 321, 401, 408–409
 bifacial panel 49, 52, 183, 409, 442
 bifacial solar cell 8, 323, 409
 bifacial solar panels 49
 biomass energy 1, 416, 418, 421
 BIPVT 15
 blockchain 38, 93, 158–162, 186,
 201–204, 235, 254, 276, 374, 446
 blockchain-based platforms 254, 446
 borehole thermal energy storage (BTES)
 329
 building-integrated photovoltaics (BIPV)
 8, 14–16, 49, 70, 130, 184, 186, 287,
 293, 294, 320, 321, 332, 406, 438,
 439, 442–444, 448
 bulk heterojunction (BHJ) structure
 168, 169, 173–175

c

cadmium telluride (CdTe) 4, 40, 115,
 182, 323, 324, 343
 cadmium telluride photovoltaic cells
 404–405
 carbon emissions
 quantitative assessments and regional
 variations 343

sources of 342
 technological innovations 343
 carbon footprint 111
 assessing 111–112
 emissions, estimates 113
 reducing 113
 standards 112–113
 carbon footprint, reduction of 19–20
 carbon nanotubes (CNTs), graphene 7
 Central Receiver Systems 43
 charge controllers 186, 325
 chemical treatment 121
 Chi-square test 265
 circular economy
 approach 447
 environmental justice 130
 integration 255
 models 52
 PV life cycle 129
 PV manufacturing practices in 129
 and social benefits 130–131
 in solar PV sector 352
 solar waste and 349, 350
 circularity design 129
 clean energy
 access to 22
 improve affordability 306
 closed-loop recycling 129
 cloud-oriented framework 219
 clustering 13, 193
 communication networks 315, 374
 community health workers (CHWs) 231,
 234
 community level optimization 360
 community solar projects
 advantages of 291
 smart cities, integration 291–292
 components, manufacturing of 107
 comprehensive remote monitoring and
 supervisory control (SCADA
 Evolution) 244
 concentrated solar power (CSP) systems
 8, 328
 dish stirling systems 44
 linear Fresnel reflectors (LFR) 44

- operating principle 43
 - parabolic trough systems 43
 - power towers 43
 - thermal energy storage (TES) 44
 - condition monitoring methods 369
 - copper indium gallium selenide (CIGS) 7, 324, 405
 - corporate social responsibility (CSR)
 - conceptual framework 277–278
 - corporate image and stakeholder integration 89
 - corporate solar adoption, case study
 - Apple's vertically integrated solar strategy 100–101
 - Tata Steel's industrial solar transformation 101–102
 - Walmart's Comprehensive Solar Energy Program 100
 - definition 87
 - environmental and economic rationale 88–89
 - financial and economic constraints 95
 - findings 278–280
 - institutional support and policy
 - incentives 90
 - literature review 275–276
 - market and supply chain constraints 99
 - methodology 276–277
 - organizational and cultural barriers 97–98
 - regulatory and policy barriers 96–97
 - renewable energy in 87–88
 - return on investment (ROI) 275
 - social effect 274
 - solar energy
 - corporate sustainability 88
 - implementation 93–95
 - solar energy adoption 90–93
 - technical and logistical challenges 95–96
 - Corporate Sustainability Reporting
 - Directive (CSRD) 92
 - Corporate Sustainability Strategy 278
 - COVID-19 pandemic 231, 236
 - crystalline polymers solar cells 402
 - crystalline silicon (c-Si) 40, 81, 183, 323, 324, 347, 375
 - crystalline silicon photovoltaic cells 403–404
 - cybersecurity 371, 372
 - blockchain and artificial intelligence in 374
 - Czochralski method 401
- d**
- data acquisition
 - AI-based predictive maintenance 246, 247
 - devices 373
 - data-centric workflows 229
 - data-driven energy management 13
 - decentralized energy system (DES) 17, 153, 154, 292, 351, 446
 - decentralized photovoltaic systems 361
 - decentralized renewable energy (DRE) 294, 307
 - Decentralized Smart Energy Grids (Microgrids and VPPs) 254
 - decommissioning 106, 107, 117, 256
 - DeepMind AI 251
 - demand-response 18–19
 - demand-response management 298
 - Design for Disassembly 447
 - diesel generators 20, 46, 199, 200, 306, 392
 - digital instruments 311–312
 - digital thread processes 228
 - digital twin 162, 370, 371
 - direct emissions 46, 111
 - direct normal irradiation (DNI) 8
 - dish Stirling systems 44, 68
 - distributed Bragg reflector (DBR) 167, 172
 - distributed energy resources (DERs) 152, 184, 244, 326
 - distributed generation 15, 17, 18, 45, 97, 247, 287
 - district energy systems 293–294, 296

district heating and hybrid systems
328–329
domestic and industrial heating 328
dual-dimensional ROI evaluation model
277
dye-sensitized solar cells 5, 7

e

eco-friendly architecture 359
ecological effect, classifications of
108
economic empowerment 279, 390
economic impact 62–63, 222, 314
efficiency development 125
electricity, access 305
electrifying rural areas 385, 389
embodied carbon 339, 341, 440
emissions
analysis of 108
reduction 124
end-of-life-management 326
end-of-life phase 124
energy developmental stage 107
energy forecasting models 189
energy independence 20–22, 52, 216,
286, 297, 435
energy optimization
real-time data analytics for
290–291
energy payback, evaluation 108
energy payback time (EPBT) 106, 343,
441
energy poverty in India 306
energy production 9, 50, 158, 163, 192,
201, 241, 286, 293
energy security 2, 46, 106, 125, 204, 241,
281, 297, 308, 415
energy storage 18
and smart integration
smart grid and decentralized energy
system 446
solar power management 445, 446
storage technologies 444, 445
solutions 374
systems 50

energy sustainability 45
energy systems
energy and power management
techniques 364
integrating renewable energy of 364
lifecycle stability 360
photovoltaic degradation analysis 365
predictive maintenance and smart
diagnosis 367–371
real time information and monitoring
365–366
research of 360–361
Suns-Vmp ineffectiveness 364–367
with traditional monitoring methods
366–367
types of 362–363
energy yield variability 439
engineers 9, 39, 70, 447
enhanced real-time monitoring 242
enhancing energy storage 298–299
entrepreneurs and solar enterprises,
strategies for 315
environmental impact, solar energy
61–62
environmental issues 105, 108, 118, 280,
340
environmental justice 130–131
environmentally friendly materials 447
environmental monitoring
and optimization 351–352
environmental regulations 128, 163, 278
environmental risks 115–118, 441
Environmental, Social, and Governance
(ESG)
disclosures 277
performance 276
environmental sustainability mitigation
strategies 349–351
environment assessment 375
equity issues 440
European Green Deal 88
evacuated tube collectors (ETCs) 42, 63,
68, 320, 328
e-waste rules, evolution of 121–122
existing solar policy 126

f

fault detection 179–182, 193–194, 289, 369, 370
 financial ROI dimension 277
 flat plate collectors (FPCs) 68, 320, 327
 floating solar farms 51–52, 183, 438, 442, 443, 448
 floating solar panels (FPV) 332–333
 floating solar systems 443
 floatovoltaic 184, 443
 flow battery energy storage system 77–78
 flow of information 196, 219, 250
 foundations of solar power systems
 designing solar architecture for maximum efficiency
 integration with building design 70
 orientation and tilt angle 69
 placement and shading considerations 70
 site-specific design tools 70
 system scalability and modularity 70
 fossil fuels 60
 global energy landscape 60–61
 integration with Solar Power Systems 78–79
 photovoltaic systems 63
 solar energy impact 61–63
 solar energy storage solutions 70–79
 solar power generation 63
 system components and hardware selection
 inverters 79
 mounting structures 80
 wiring and electrical protection 79–80
F-test (variance test) 266–267

g

gallium arsenide (GaAs) 4, 115, 324, 405
 gallium nitride (GaN) 405, 406
 geothermal energy 293, 418, 421–422
 global energy landscape 1, 60–61

government policies 51, 90, 311, 315, 326
 granular data acquisition 242
 graphene, carbon nanotubes 7
 green building standards 16–17
 greenhouse gas (GHG) emissions 19–20, 37, 279
 grid connected 17–18, 77, 127
 ground-mounted systems 79, 108

h

hazardous materials 50, 116, 121, 128, 340
 heat distribution mechanisms 10
 heat island effect 297, 349
 heat transfer fluid (HTF) flows 328
 High-Altitude Platform Stations (HAPS) 388
 high-density power generation 415
 high-temperature collectors 42
 human-machine interface (HMI) 369
 hybrid and solar advanced technologies 320–321
 hybrid energy storage systems (HESS)
 advances and challenges in 361–362
 energy storage types 362–363
 lifecycle stability with 363–364
 hybrid system 11, 101, 181, 183, 200, 320, 328–329, 361
 hydropower 419–420

i

III-V multijunction cells 324
 illuminative structural modelling (ISM) 263
 incentives and subsidies 51
 Indian Recycling Status 121
 India's renewable energy programs 209
 India's Solar Energy Policy 126
 indirect emissions 112
 innovative solar companies 309–310
 inorganic dyes 7
 insolation 67, 369, 401
 integrating digital tools into workflow 231

- intelligent energy system 200, 372–373
 - Internal Rate of Return (IRR) 95, 277
 - international collaboration 51
 - international cooperation 27, 51, 333, 448
 - International Solar Alliance (ISA) 27, 38, 51
 - Internet of Things (IoT) 160
 - artificial intelligence 9, 12, 288–290
 - solar cloud 219
 - solar LPWA 220, 221
 - to solar power management 244
 - inverters 9, 79, 325, 373
 - IoT-based smart grid and energy management 247–249
 - IoT-enabled smart irrigation system (IoT-SIS) 388
 - IoT in solar power systems
 - architectural and communication protocol 187–189
 - benefits and impact analysis 199
 - contribution to decentralized energy goals 201
 - efficiency gains and cost reduction 199–200
 - enhanced resilience and reliability 201–202
 - environmental and societal impact 200
 - challenges and future prospects 202
 - cybersecurity and data privacy concerns 203
 - future trends and research directions 204
 - regulatory and policy barriers 203–204
 - remote monitoring and maintenance 190–191
 - sensor integration and real-time data acquisition 189–190
 - synergistic integration 196
 - autonomous and self-healing 197–198
 - edge computing and real-time decision-making 197
 - integrated platforms for scalable solar management 198
 - smart grid connectivity and interoperability 196–197
 - IoT-LPWA technology
 - global perspectives 211
 - India's research landscape and gaps 211–212
 - India's solar energy
 - data analysis 213–214
 - data collection 213
 - data transmission and efficiency 221
 - enhanced GIS-based insights 219
 - ethical considerations 214
 - global case studies 222
 - performance metrics 216–217
 - policy and regulatory considerations 223
 - predictive analytics 216
 - predictive analytics performance metrics 217–219
 - qualitative themes 216
 - quantitative performance highlights 214
 - regional patterns from GIS mapping 214–215
 - social and economic impact and community engagement 222
 - system architecture 220
 - technological advancements and adoption disparities 222
 - traditional solar systems 217
 - triangulation of data 214
 - use cases 221
 - socio-economic considerations and community impact 212
 - technological innovations and future directions 212–213
 - irradiance 8, 12, 49, 70, 160, 181, 186, 189, 401
- k**
- key performance indicators (KPIs) 98, 217, 244

L

landfills 62, 113, 117, 118, 340, 349

land use 128, 130

- conflicts 50
- consideration 108
- constraints 439
- and habitat disturbance 348
- optimization 332

lead-acid battery 71–72

levelized cost of electricity (LCOE) 39, 61, 438

life cycle assessment (LCA)

- environmental impact categories in 108–109
- framework 115
- obstacles and prospects for 109
- purpose of 106–107
- in recycling 120
- stages in 107–108

lifecycle emissions 47, 117, 333, 348

life-cycle greenhouse gas emissions 117–118

life cycle sustainability assessment 360, 374–375

linear Fresnel reflectors (LFR) 8, 44

lithium-ion batteries (LIBs) 26, 50, 73–74, 182, 186, 202, 244, 326, 364, 390, 444

long short-term memory networks (LSTMs) 243

long-term sustainability 60, 87, 274, 352, 390–392, 394, 418

LoRaWAN 188–190, 209–213, 217

low-cost solution-based methods 329

lower levelized cost of energy (LCOE) 360

low-temperature collectors 42

m

machine learning (ML) 13

- and AI 368–369
- algorithms 290
- within SAP systems 231

material lifecycle 50

material resource limitations 440

material scientists 447

materials, developments in 123

materials processing 107

maximum power point tracking (MPPT) 11, 182, 325

medium-temperature collectors 42

microclimate and ecosystem impacts 348–349

microgrids 49, 161, 192, 200, 212, 254, 299, 315, 389

micro inverters 325–326

Ministry of New and Renewable Energy (MNRE) 213, 310

mobile money 309

monocrystalline silicon 65, 182, 322, 323

monocrystalline solar power cells 401–402

multi-crystalline solar panels cells 402

multi-layer solar cells 402–403

multinational corporations (MNCs) 94, 97, 99, 230, 276

n

nanocrystals, in solar cell 407

narrowband IoT (NB-IoT) 189, 209, 217

National Solar Mission 209, 211, 316

net metering 326

- policy 51, 181

net present value (NPV) 277

Net Zero pledges 279

nickel-cadmium batteries 74–75

non-grid and hybrid methods 311

nonrenewable infrastructure 417

non-renewable sources 153, 181, 209, 241, 288, 320, 417–418

Northern Poland's 2 MW Solar Power Plan 114

nuclear energy 416–418, 429, 434

nuclear power 415, 418, 435

o

occupational issues 118

off-grid 18

- and battery backup 10

offshore solar 332–334

one way ANOVA 265, 266
 open-loop recycling 129
 operational phase 124, 130
 optical Tamm states (OTS) 167
 optimized energy distribution 242
 organic dyes 7
 organic photovoltaics (OPV) 64, 324, 330
 organic polymers 5–7, 65, 411

p

panel recycling 347, 353, 448
 parabolic dish systems 328
 parabolic trough collectors 328
 parabolic trough systems 8, 43
 passivated emitter and rear cell (PERC)
 323
 passivation technique 324
 passive solar design 10, 70
 pay-as-you-go (PAYG) solar home system
 309
 peer to peer (P2P) energy trading 153,
 158, 201, 254, 446
 performance, deterioration of 107
 performance ratio (PR) 244
 perovskite photovoltaic cells 408
 perovskites 324
 chemical composition of 6
 perovskite silicon tandem cells 182, 185,
 324
 perovskite solar cells (PSCs) 38, 48, 65,
 183, 329–330, 346, 375, 408, 440,
 441
 integration into infrastructure 442
 lifecycle sustainability 441
 material stability and toxicity 441
 policy and investment 442
 scalability 441
 phasor measurement units (PMUs) 247
 photodetectors (PDs) 167
 photoelectric effect 64, 111, 167, 399
 photovoltaic (PV)
 degradation 365
 end-of-life 130–131
 environmental impact of 120
 material properties 360

recycling 120
 stability and scalability of 409–411
 systems
 applications 41
 first-generation 40
 operating principle 40
 second-generation 40
 third-generation 41
 photovoltaic (PV) cells
 energy storage integration 325–326
 evolution of 323
 first generation 4
 fourth generation 5
 materials and efficiency improvements
 323–325
 power electronics 325–326
 real-world deployment 326, 327
 residential, commercial and utility scale
 system 325
 second generation 4–5
 smart grid and net metering 326
 third generation 5
 working mechanism of 3, 4
 working principle of 321–322
 photovoltaic degradation analysis 365
 photovoltaic effect 40, 321, 327, 385, 400
 photovoltaic energy conversion (PV) 64
 photovoltaic systems 63, 327
 harnessing sunlight for electricity
 advantages of 65–66
 disadvantages of 66–67
 emerging PV technologies 65
 monocrystalline silicon 65
 polycrystalline silicon 65
 thin-film solar cells 65
 harvesting heat from sunlight
 applications 68
 basic principle 67
 solar thermal collectors 68
 photovoltaic (PV) technology 2–5,
 183–185, 390
 photovoltaic thermal hybrid systems 11
 physical separation 121
 pico-photovoltaic 389
 pit thermal energy storage (PTES) 329

- planar and bulk heterojunctions 168
- PM KUSUM 209, 211, 221
- p–n junction diode 321, 322
- Pole-Mounted and Carport Systems 80
- policy frameworks
 - existing solar 126
 - India's solar energy 126
 - tool using 127–128
- policy-makers and regulators 447
- pollution reduction 124
- polycrystalline silicon 65
 - photovoltaic cells 402–403
- polymer solar cells 7, 407
- polysilicon 99, 114, 342, 345, 347, 440
- power electronics 325
- power optimizers 70, 325–326
- power towers 43
- predictive analytics 179, 192–193, 214, 216, 351
- predictive maintenance (PdM) 181, 211, 289
 - condition monitoring methods 369
 - machine learning and AI 368–369
 - powered, AI 242
 - and smart diagnosis 367–368
 - strategies 246
- project management 232, 324–326
- public-private partnerships (PPPs) 224, 280, 287, 310
- pumped storage system (PHS) 420
- q**
- quantitative assessments 343
- quantum dots (QDs) 6, 324, 331
 - solar cells 409
- r**
- racking system 9, 80, 81, 100, 157, 182, 185, 250, 442
- raw materials extraction 107
- real-time data analytics 187, 290–291
- real time information and monitoring 365–366
- real-time monitoring 155
 - and data analytics 288
- recovery, recycling and 108
- recyclability 52, 72, 333, 353
- recycling 118, 326
 - innovation 447
 - LCA in 120
 - and recovery 108
- reinforcement learning 13, 445
- remote areas, solar power in 392
- remote monitoring
 - and automation 13
 - and control 289
- renewable energy, use 129
- renewable sources 418, 419
 - biomass energy 421
 - geothermal energy 421–422
 - hydro energy 419–420
 - solar energy 419
 - wind energy 420–421
- resource depletion estimation 108
- resource efficiency 87, 124–125
- return on investment (ROI) 187, 275, 332
- robotic process automation (RPA) 227, 233
- roll-to-roll printing techniques 330
- roof-mounted systems 9, 80
- roof overhangs 10
- rooftop solar photovoltaic (RSPV) 260, 262
- Rooftop Solar Programme 209, 211
- root cause analysis 243
- rural agricultural areas 391
- rural electrification 49
 - business models in 308–311
 - digital instruments and mobile platforms 311–312
 - distribution and maintenance frameworks in 313
 - economic growth 305–306
 - energy poverty in India 306
 - entrepreneurs and solar enterprises, strategies for 315
 - entrepreneurship 305–306
 - financial innovations in 311–312
 - financial system 312

- rural electrification (*contd.*)
 - investment prospects and incentives for 316
 - opportunities 314, 315
 - renewable energy sources 306–307
 - Saubhagya project 307, 308
 - “Saubhagya” scheme 307–309
 - state and central governments, functions of 315–316
 - sustainable development goals, impact on 313–314
 - technological in 311–312
- rural solar electrification
 - entrepreneurial frameworks 310–311
 - entrepreneurial models 308–309
 - innovative solar companies 309–310
 - public private collaborations 310–311
- S**
- Science-Based Targets initiatives (SBTi) 279
- SDG 7 (affordable and clean energy) 46, 307, 313
- SDG 11 (sustainable cities and communities) 47
- SDG 12 (responsible consumption and production) 47–48
- SDG 13 (climate action) 48
- seasonal thermal energy storage (STES) 321, 329
- self-sustainability 361
- semi-supervised learning 13
- Shockley–Queisser limit 407, 411, 438
- Sigfox 209, 211, 216, 217, 220
- silicon-based photovoltaic (PV) cells
 - current and future technologies 438–439
 - economic barriers and soft costs 439
 - energy yield variability and intermittency 439
 - material resource limitations 440
 - scalability and land use constraints 439
 - social acceptance and equity issues 440
 - supply chain vulnerabilities 440
- silicon-based semiconductors 4
- silicon carbide solar cells 406
- skilled workforce and Awareness 327
- smart cities
 - dimensions of 286
 - environmental and social impacts 296–297
 - financial and economic considerations 295–296
 - policy and regulatory systems 294–295
 - solar energy management 297–299
- smart control systems 329
- smart grid
 - technologies 9
- smart grids 151, 212
 - and demand-response management 298
 - energy optimization and integration with 289
 - integration 242
 - and net metering 326
 - user engagement and behavioral insights 289–290
- smart inverters 180, 182, 184, 185, 197, 199, 202, 359, 373
- Smart Particle Swarm Optimization (SPSO) 235
- smart sensors, AI role 156–158
- social acceptance 440
- social equity 22, 38, 52
- social impact 62, 94, 102, 273, 278, 296–297, 346
- Societal Impact Assessment (SIA) 262
- socio-economic factors 219
- socio-economic impacts 49
- Socio-Environmental ROI Dimension 278
- sodium-ion batteries 75
- sodium-sulfur batteries 76
- solar architecture 10, 68–69, 359, 367
- solar array 9, 80, 154, 180, 188, 190, 191, 242, 321
- solar cell, advanced designs in 8–9

- solar collectors 10, 25, 64, 68, 287
- solar energy 419
 - architecture 293
 - awareness and discernment 25
 - cost-effectiveness 20–22
 - data analysis 265–267
 - with energy optimization and integration 289
 - environmental challenges 24–25
 - essentials and photovoltaic technology 2–5
 - examples 391–392
 - innovations from developing countries 299–300
 - intermittency and storage issues 22
 - and international cooperation 27
 - life cycle assessment (LCA) of 106–107
 - methodology 265
 - nanotechnology 26–27
 - need for 260
 - need for renewable and eco-friendly solutions 2
 - objectives 264–265
 - policy, regulatory, and infrastructural barriers 22–23
 - policy support 27
 - predictive maintenance and fault detection 289
 - real-time monitoring and data analytics 288
 - remote monitoring and control 289
 - research 264
 - and SDGs 448
 - socioeconomic advantages 391
 - storage, and grid integration 26–27
 - technological and economic constraints 23–24
- solar energy impact
 - economic impact 62–63
 - environmental impact 61–62
 - social impact 62
- solar energy in sustainable development 149–150
- solar energy management
 - and battery management 298–299
 - enhancing energy storage 298–299
 - performance optimization 298
 - predictive maintenance 298
 - smart grids and demand-response management 298
- solar energy storage 287, 288
 - FBES 77–78
 - lead-acid battery 71–72
 - lithium-ion batteries (LIBs) 73–74
 - sodium-ion batteries 75
 - solid-state battery 76–77
- solar energy technology 59, 151, 266
- solar heat 321, 328, 419
- solar home systems (SHS) 46, 49, 184, 299, 389
- solar installations 106
 - traditional and real-time monitoring 155–156
- solar mini-grids 306, 311, 316, 375
- solar neighborhoods 293, 294
- solar panel recycling 347–348
- solar panels 9, 153, 315
- solar photovoltaic (PV)
 - bifacial panel and sun-tracking system 442
 - building-integrated photovoltaics (BIPV) 443–444
 - operation of 400
 - performance of 400–401
 - systems 24, 59, 286, 287
 - technology 320
 - temporary solar farm 443
 - transparent solar panels and urban integration 444
- solar plant monitoring and maintenance 180
- solar-powered future 27–28
- solar-powered portable water pump (SPWP) 388
- solar power generation 59
 - photovoltaic system 63
 - solar thermal systems 63

- solar power management
 - battery charge-discharge cycles 445
 - equipment failures 445
 - stability vs dynamic load conditions 445–446
 - storage lifetime and efficiency 445
- solar power optimization 361
- solar power systems 180
 - fundamentals of 182
 - energy storage and power management 186
 - photovoltaic technology 183–185
 - system components and architecture 185–186
 - objectives 182
 - safety and environmental concerns in 119
- solar power towers 328
- solar projects 11–12, 89, 94, 97–100
- solar PV manufacturing
 - circular economy in 352
 - environmental and social impacts of
 - material extraction 346
 - environmental monitoring and optimization 351–352
 - environmental sustainability mitigation strategies 349–351
 - key materials in 345–346
 - land use and habitat disturbance 348
 - microclimate and ecosystem impacts 348–349
 - mitigation strategies and innovations 346–347
 - process flow of 350
 - research 353
 - solar waste and circular economy 349, 350
 - supply chain pollution 349
 - sustainability 353
- solar radiation 3, 4, 8, 37, 59, 64, 293, 327
- solar-responsive urban design 292–293
- solar smart grids 287–288
- solar technology
 - life cycle 446
 - policy and global development 448–449
- solar thermal collectors
 - applications 43
 - concentrating solar collectors 68
 - evacuated tube collectors 68
 - flat-plate collectors 68
 - high-temperature collectors 42
 - low-temperature collectors 42
 - medium-temperature collectors 42
 - operating principle 42
- solar thermal energy
 - fundamentals of 327
 - photovoltaic systems 327
 - solar thermal collectors 327–328
- solar thermal (ST) systems 20, 63, 287, 320
- solar-to-hydrogen systems 51, 52
- solar urban mobility solutions 288
- solar urban planning spans 17
- solar waste, and circular economy 349, 350
- solid-state battery 76–77, 445
- stakeholders, incentives for 316
- state policy instruments 128
- strip mining 19
- subsidies 27, 29, 51, 90, 281, 295
- Suns-Vmp Ineffectiveness 364–365
- sun-tracking system 442
- Supervised Learning 13, 368
- supply chain pollution 349
- supply chain vulnerabilities 99, 440
- surplus electricity 51, 420
- sustainability, defined 45
- sustainable design developments 122–123
- sustainable development goals (SDGs) 210, 211, 275
 - SDG 7 46, 307, 313
 - SDG 11 47
 - SDG 12 47–48
 - SDG 13 48

solar energy and 448
 sustainable energy for all (SEforALL)
 211, 319
 sustainable manufacturing 124, 446
 sustainability and carbon footprint
 reduction 161–162

t
 Tamm plasmon-enhanced organic
 photodetectors
 narrowband near-infrared sensing
 device design and structural
 configuration 169–172
 simulation results 172–174
 tandem solar cells 331, 334, 402,
 438
 Tata Steel's industrial solar
 transformation 101–102
 technological innovation 212
 Technology Acceptance Model (TAM)
 100, 212–213, 343, 351
 temporary solar farm 443
 thermal batteries 329
 thermal energy storage (TES) 44
 thermal mass elements 10
 thermal treatment 121
 thin-film photovoltaic cells 403
 thin-film silica photovoltaic cells
 403–404
 thin-film solar cells 40, 65, 183, 406
 thin-film technologies 4, 81, 120, 323,
 345
 traditional inorganic photodetectors 168
 transfer matrix method (TMM) 169
 transitional metal dichalcogenides
 (TMDS) 7
 transparent solar panels 442, 444, 448
 transportation 105, 107, 111
 transverse electric (TE) polarizations
 167
 transverse magnetic (TM) polarizations
 167
 tree decision approach 370
 2D materials 325

u

unsupervised learning 13
 urban integration 14, 444
 urban planning
 building-integrated photovoltaics
 293
 solar neighborhoods or districts,
 development of 293–294
 solar-responsive urban design
 292–293
 urban solar integration 294
 urban solar integration 294
 user engagement 289–290

v

value-driven robotic process automation
 231
 virtual power plants (VPPs) 186, 244

w

Walmart's comprehensive solar energy
 program 99–100
 waste disposal, flow 120
 waste handling 116–117
 waste management 107, 128
 resource efficiency 124–125
 waste management issues 118, 120
 waste scenario assessment 117
 water usage 108, 116, 117, 130
 wavelength spectrum 3
 wildlife effect 128
 wind energy 113, 420–422
 windows oriented correctly 10
 workflow management technology 228,
 230, 234
 workflow optimization for solar power
 systems 249–251
 workflow optimization with digital tools
 benefits of 228
 data-centric workflows 229
 data management and analysis
 234
 digital thread processes 228
 digital transformation 236
 digital workflow adoption 230

workflow optimization with digital tools
(*contd.*)
 enhancing productivity with mobile
 solutions 233–234
 future trends 235–236
 identifying pain points and
 inefficiencies 229–230

measuring and improving workflow
 performance 234–235
RPA technologies 233
streamlining communication and
 collaboration 232
workflow enhancement
 230–232



















