

# Index

- absorption, 80–81, 92
- acid, 90, 125, 127
- acid number, 114, 115
- activated carbon, 30–31
- actual conversion, 117–18, 124
- adsorbent, 30–31
- adsorption, 31
- aerodynamic, 15–17
- agglomeration, 37, 59
- agricultural, 12, 66, 78, 89
- agriculture, 1, 30, 78
- alcohol, 142, 151
- alcohol to oil molar ratio, 115, 119, 124
- algae, 12, 111
- alternative, 15, 17, 37, 55, 66, 74, 77, 109
- alternative adsorbent, 30
- alternative energy, 4, 9–10, 55
- alternative renewable energy, 17
- analysis, 34, 46, 60, 74, 78, 82, 94, 116
- aromatic, 81, 91
- ash content, 32, 33, 37, 42, 45–46, 93, 95–96, 102–3
- bio-based energy, 4, 10, 12
- bio-based oil, 113
- bio-char, 30–32, 34–35, 42–46, 54, 94
- bio-char production, 42, 44
- bio-char yield, 31, 44, 46, 91, 102
- biodiesel, 109–12, 116, 126
- biodiesel feedstock, 110, 112
- biodiesel production, 110–12, 128–30
- biodiesel yield, 111–12
- bioelectricity, 13
- bioenergy, 12–14
- biofuel, 13, 29–31, 91
- biofuel feedstock, 30–32, 37
- biofuel production, 30–32
- biogas, 10, 12, 14, 18, 30, 32, 44, 47–48
- biogas yield, 35, 43–47
- bioheat, 13

- biomass, 2, 10, 12–14, 18,  
32, 44–46, 48, 54–55,  
70–71, 77–78, 84, 89–  
91
- biomass characterization,  
33, 36–38
- biomass energy, 14, 89
- biomass feedstock, 14, 45,  
66, 90
- bio-oil, 30–32, 34–36, 42–  
48, 54, 65–66
- bio-oil production, 44–45
- bio-oil yield, 32, 42–46, 65–  
66
- blade length, 15–16
- brine, 142, 145, 147–52,  
155
  
- calorific value, 37, 78–79,  
81–85
- carbon, 7, 37–38, 55, 58–  
59, 66, 79, 84, 95, 109
- carbon content, 36
- carbon dioxide, 7, 89, 109
- carbon neutral, 77, 89
- carbonization, 14, 56, 57,  
60, 84
- catalyst, 66–68, 72, 74,  
111–12, 127
- cellulose, 33, 38–40, 55, 81,  
91, 98, 99, 102
  
- challenges, 4, 111
- char, 31–32, 45–46, 54, 65,  
70, 81, 102–3
- char production, 54
- char yield, 31–32, 35, 42–  
43, 54, 103
- characteristic, 30–31
- characteristics, 56
- characterization, 36, 59,  
113, 142, 150
- coal, 1–2, 4, 6–7, 12, 18,  
20, 54, 78, 89
- coal consumption, 6–8
- cocoa, 13
- coconut, 13, 91–96, 100–  
103, 110
- coconut copra biomass, 96,  
102–3
- co-firing, 13
- combustion, 13, 36, 55, 90,  
109
- computational fluid  
dynamic, 141–45,  
148–49, 151, 157
- construction, 9, 14
- consumption, 5, 10, 17, 77,  
110
- contaminants, 14
- content, 36, 39–40, 45, 91,  
102, 110

- conventional, 12, 17, 21,
  - 111–13, 125–27, 143–44
- conventional acid, 111
- conventional energy, 4, 15,
  - 21
- conventional fuel, 1, 4, 6,
  - 8–10, 20
- conventional power, 21
- conversion, 13, 21, 30, 34,
  - 81, 112–13, 115, 117, 121–24, 126, 128–30
- crops, 12–13, 29, 90, 111
- crude oil, 140, 147, 149
  
- decomposition, 38, 45, 53,
  - 55, 59, 66, 71, 97–98, 99
- deforestation, 14
- degradation, 68–70, 71–72,
  - 96–100
- degradation rate, 40, 98–100
- degradation temperature,
  - 39–40, 68–69, 81
- demand, 5–7, 20, 29, 56,
  - 77, 139–40
- desiccator, 33
- dicationic, 112–13, 124,
  - 127–30
- diesel, 12, 109–10
  
- distribution, 18
- domestic, 5–6
- downstream, 2
  
- efficiency, 2, 10, 21, 130,
  - 140–42, 155–56
- efflorescence, 53
- electricity, 4–5, 10, 12, 14,
  - 17, 18, 20–21, 55
- electricity distribution, 9
- electricity generation, 7, 9
- elemental analysis, 37–38,
  - 92, 95
- emissions, 7, 9, 17, 109
- empty fruit bunch biomass,
  - 65–66
- energy, 1–2, 4, 7, 9–10, 12–14, 17–21, 30, 89,
  - 141, 146
- energy consumption, 4,
  - 112, 139
- energy content, 54, 84–85,
  - 90
- energy demand, 1, 5, 15,
  - 55, 139
- energy generation, 7, 9, 13–14, 15–16, 89
- energy production, 1, 14,
  - 30, 77
- energy resources, 4, 21, 77,
  - 139–40

- energy security, 17, 20
- energy supply, 1–2, 4, 7, 9, 13, 21
- enhanced oil recovery, 140–41
- environmental, 2, 9, 14, 17, 20, 77–78, 91, 110–11, 127
- esterification, 111–13, 119–21, 124–30
- evolution, 2, 96
- exfoliation, 53–54
- extraction, 53, 84
  
- fatty acid, 110, 113, 117, 127
- fatty acid methyl ester, 114–16, 126, 128
- fatty acid methyl ester
  - production, 113, 117, 121–22
- fatty acid methyl ester yield, 112
- Feed-in Tariff mechanism, 8–10, 18–21
- feedstock, 12, 21, 29, 34, 43, 54, 68–72, 74, 113, 129
- financial, 2, 19, 48, 61, 74, 85, 103
  
- fixed carbon, 33, 36, 93, 95–96, 99, 103
- flooding, 141–43, 145, 147, 150, 151–52, 155
- flow rate, 34, 93, 116
- fluid, 145, 147, 149, 151–52
- footprint, 7
- forestry, 12
- formulation, 20, 142–43, 149, 152, 155
- fossil energy, 16
- fossil fuel, 1, 9–10, 14, 20–21, 65, 77, 89, 139
- fouling, 37
- free fatty acid, 110, 113, 128–30
- FTIR, 79–80, 116, 126
- fuel, 4, 13, 17, 29, 55
- fungi oil, 110–11
- furnace, 34, 56, 67, 94
  
- gas, 1–2, 5–6, 18, 20, 30, 54, 116, 140
- gas chromatography, 74, 116, 126
- gas generation, 96
- gas production, 103
- gas yield, 43, 103
- gasification, 14, 90

- generation, 9–10, 18–20, 90–91, 111–12
- graphene, 53–61
- graphene yield, 60
- greenhouse gas, 7, 89
- growth, 1–2, 4, 17, 20, 77, 139
  
- health, 14, 89, 91
- heat, 12–13, 36, 43, 55, 140
- heating rate, 29–32, 34, 45, 54
- hemicellulose, 33, 38–40, 81, 91, 96–99, 102
- heterogeneous, 143–46, 149, 155
- higher heating value, 30–31, 33, 37–38, 82, 90, 92–93, 95
- homogeneous, 112
- hydraulic, 9
- hydro, 2, 4, 9, 12, 18–20, 139
- hydrocarbons, 30, 78
- hydroelectric, 9
- hydrogen, 38–39, 55, 66, 79, 84, 95
- hydrogenation, 78–79, 84–85
- hydrogenation
  - temperature, 78–79, 81–85
- hydropower, 7, 9, 17, 77
- hydrothermal, 14
  
- immortal, 9
- increment, 7, 10, 143
- incremental oil recovery, 140–44, 149–51, 155–57
- incumbent, 7
- industry, 2, 4–7, 13–14, 19, 66, 91
- injection, 140–42, 145
- innovations, 14
- inorganic matter, 46
- installation, 10, 15, 20–21
  
- kinetic energy, 146
  
- landfills, 14
- lignin, 33, 38–40, 55, 81, 91, 98, 99
- limitations, 9, 17, 150
- liquefaction, 14
- liquefied natural gas, 5–6

- maintenance, 10, 17
- material, 17, 36, 54–58, 69, 111
- mechanism, 6, 143, 155
- methanol, 112–14, 122, 124
- methanol to oil molar ratio, 117, 121, 125, 129
- methyl ester, 115, 123, 126–27
- mobility, 140–42, 155
- modeling, 147–49
- moisture, 33, 38–39, 55, 68–69, 90, 91, 92, 95–96
- moisture content, 32–33, 36, 93, 95–96
  
- natural gas, 4–5, 12, 17, 20, 89
- network, 5, 59
- new energy policies, 17–18
- nitrogen, 34, 38, 55–57, 67, 78–80, 90, 93–95, 140
- noise, 17, 120
- non-condensable gas, 65, 90
- non-renewable, 1, 4
- non-sustainable, 18
- NO<sub>x</sub>, 38
  
- oil, 1, 4–7, 13, 111, 126, 128, 139–42, 143–44, 149–57
- oil and gas, 2, 89, 91, 139
- oil and gas production, 89
- oil recovery, 140, 144, 152–57
- oil resources, 141
- oil yield, 42, 91, 102–3
- oleic acid, 113–14, 121, 123, 125–29
- optimum, 31, 124, 142–44, 151, 155–57
- optimum temperature, 31–32, 45–46, 48
- organic, 44, 55
- organic matter, 12, 54, 59
- oxygen, 30, 38, 54–55, 65–66, 83, 90, 95, 109
- oxygen content, 38, 66, 90–91
  
- palm, 13, 65, 77, 110
- palm oil, 65, 77–78
- paraffin, 147, 149, 151–52
- particle, 33, 54, 67, 92
- Peninsular Gas Utilization, 5
- permeability, 141–43, 144, 155
- photosynthesis, 13–14, 55

- photovoltaic, 10  
 physicochemical properties,  
     32–33, 37, 45, 48, 67,  
     92, 103  
 pineapple, 29–30, 32, 38,  
     45  
 pineapple leaves, 29–32,  
     37, 39, 41, 43, 47–48  
 pineapple peels, 30–32, 37,  
     39, 41, 47–48  
 pineapple production, 29–  
     31  
 pineapple waste, 31  
 pineapple waste biomass,  
     29–31  
 pipeline, 5  
 plantation, 13, 29  
 policies, 1–2, 20  
 pollution, 7, 14, 17, 65, 77  
 polymer, 140, 142–44, 150–  
     51, 155–56  
 polynomial, 81, 115  
 population, 77, 139  
 porosity, 141–43, 144, 152  
 potential, 10, 15–16, 18,  
     29–32, 37, 48, 60,  
     109, 127–30  
 power, 4, 9, 10–11, 15–20,  
     89  
 power generation, 2, 4–5,  
     12, 15, 20, 89  
 power plant, 5, 10  
 power production, 16  
 power sector, 5  
 power station, 6  
 predicted conversion, 117–  
     19, 124, 129  
 pressure, 34, 94, 142, 147,  
     149  
 production, 5–6, 29, 40, 44,  
     55, 77–78, 110, 147–  
     48  
 properties, 36, 78, 89, 95–  
     96, 103, 110–11, 140,  
     143, 151  
 protection, 17  
 proximate, 92  
 proximate analysis, 78, 92,  
     95  
 purity, 53, 114, 125  
 pyrolysis, 14, 29–36, 38,  
     42–48, 54–55, 56–58,  
     60, 65–67, 71–74, 81,  
     90–92, 101–3  
 pyrolysis feedstock, 32, 36,  
     48, 92–93  
 pyrolysis oil, 90–91, 94,  
     102, 103  
 pyrolysis temperature, 29–  
     35, 42–48, 92, 94, 101  
 rate, 11, 20, 93, 122, 147–  
     48, 149

- reactant, 114–15, 117,  
125–29
- reactor, 30, 34, 67, 93–94
- recovery, 124, 130, 140
- regression, 81, 115–17
- reliability, 1–2, 21, 35
- renewable, 2, 9, 13, 14, 17,  
18, 77, 109
- renewable energy, 1–2, 4,  
7, 9–10, 12–15, 18–  
21, 55, 77–78, 89
- renewable energy generation,  
2
- reservoir, 140, 144, 150,  
155
- resources, 1–2, 5–6, 14, 17,  
21
- restrictions, 9
- rice, 12, 55–56, 66
- rice husk, 13, 55–59, 60
- rice husk ash, 56, 66–67, 74
- rice production, 55
- risks, 21
- rock, 140
- room temperature, 34,  
112–13
- rubber, 13
  
- safety, 2
- salinity, 143–44, 150–52,  
155–57
  
- scanning electron  
microscopy analysis,  
57–58
- security, 1–2, 21, 110
- separation, 54, 112, 124,  
130
- simulation, 141, 144–47,  
148, 150–53, 157
- smoke, 34
- solar, 2, 4, 10–11, 18–20,  
139–40
- solar energy, 10, 14, 19, 55,  
77
- solvent, 67, 114, 140
- soybean oil, 112
- spectrums, 80
- stakeholders, 17
- sugarcane, 13, 30
- sulphur, 7, 38, 55, 78, 109
- supply, 2, 7, 20, 110
- surfactant, 140–44, 150–51,  
155–56
- surfactant polymer  
formulation, 147
- surfactant-polymer  
formulation, 142–45,  
149–57
- sustainability, 1, 21, 110,  
130
- sustainable energy, 17, 109



- Sustainable Energy  
 Development  
 Authority, 9, 18–19  
 synthesis, 54, 58, 61, 66,  
 74, 78, 83, 109, 113  
 synthetic gas, 54
- tariff, 5, 10, 17–19
- telecommunication, 1
- temperature, 54–57, 59,  
 112, 115, 117, 119–  
 23, 129, 143
- Tenaga Nasional Berhad,  
 8–11, 18–19
- thermal, 13, 30, 44, 54–55,  
 59, 96, 140
- thermal degradation, 30–  
 33, 36, 38–42, 48, 67,  
 79–80, 90–92, 96, 99,  
 103
- thermochemical  
 conversion, 36–38
- thermogravimetric analysis,  
 33–34, 38–39, 68, 74,  
 92–95, 96
- timber, 12
- torrefaction, 14, 90–92, 96,  
 98, 103
- torrefaction temperature,  
 90–93, 95–96, 99–103
- transesterification, 109,  
 112, 129
- transmission, 21
- transport, 4
- transportation, 1, 111
- turbine, 15–16
- turbulent kinetic energy,  
 147–48, 149
- unsustainable, 14
- utility, 7, 18
- utilization, 2, 13, 17, 21, 66,  
 141
- velocity, 142, 147–49
- viscosity, 140, 143–50, 155–  
 57
- volatile, 1, 36, 40, 44–45
- volatile matter, 33, 36, 81,  
 93, 95–96, 102
- waste, 12, 14, 29–30, 55,  
 65, 77–78, 91, 110–11
- waste cooking oil, 12, 110–  
 12
- water, 9, 36, 56–57, 112,  
 114, 140, 145
- wheat, 12
- wind, 4, 10, 15–16, 139–40

wind energy, 14–17  
windmills, 15–17  
wood, 12–13, 91  
woody fuel, 12–13

yield, 30–31, 35, 37, 42–48,  
54, 90–92, 94, 100–  
102, 110, 112–13,  
144, 151