CONTENTS

Preface ix
Professional Biography xi

1 Introduction to Gasification / Pyrolysis and Combustion Technology(s) 1
   Historical Background and Perspective 1
   Introduction 2
   What is Pyrolysis? 3
   What is Pyrolysis/Gasification? 5
   What is Conventional Gasification? 6
   What is Plasma Arc Gasification? 8
   What is Mass Burn (Incineration)? 9
   Which Thermal Process Technology is the Most Efficient and Economical? 10
   Performance/Thermal Efficiency of Technologies 10
   What is the Economic Comparison Between the Thermal Processes? 10
   References 15

2 How Can Plasma Arc Gasification Take Garbage to Electricity and a Case Study? 16
   Basis 19
   Economic Cases 19
   Logical Approach for Future Progress 20
   References 21

3 How Can Plasma Arc Gasification Take Garbage to Liquid Fuels and Case Studies? 23
   MSW To Syngas to Liquid Fuels Via Chemistry (Fischer–Tropsch Synthesis) and a Case Study 23
   Basis 26
   Economic Case 27
   Logical Approach for Future Progress 28
   MSW to Syngas to Liquid Fuel via Biochemistry and a Case Study 29
CONTENTS

Basis and Economics 31
References 33

4 Plasma Economics: Garbage/Wastes to Electricity, Case Study with Economy of Scale 35
Conclusions and Recommendations (Opinions) 39
References 40

5 Plasma Economics: Garbage/Wastes to Power Ethanol Plants and a Case Study 41
Basis 44
Economic Cases 45
Logical Approach for Future Progress 46
References 47

6 From Curbside to Landfill: Cash Flows as a Revenue Source for Waste Solids-to-Energy Management 49
References 123

7 Plasma Economics: Garbage/Wastes to Power, Case Study with Economics of a 94 ton/day Facility 124
More Recent Events About the Project 126
References 128

8 Plant Operations: Eco-Valley Plant in Utashinai, Japan: An Independent Case Study 129
References 133

9 Municipal Solid Waste and Properties 135
What is Municipal Solid Waste (MSW) and How Much is Generated in the United States? 135
MSW Properties 137
References 153

10 MSW Processes to Energy with High-Value Products and Specialty By-Products 155
Production of Ammonia (NH₃) from Syngas via Chemical Synthesis Route 157
Production of Gas to Liquids from Syngas via Chemical Synthesis Route 158
Production of Methanol (CH₃OH) from Syngas via Chemical Synthesis Route 164
Production of Synthetic Natural Gas (SNG) from Syngas via Chemical Synthesis Route 167
Production of Hydrogen (H₂) from Syngas via Chemical Synthesis Route(s) 169
Gasifier 172
Air Separation Unit (ASU) 172
Hot Gas Cleanup System 173
Sulfuric Acid Plant 173
CO2-Rich Separated Gas Stream/Conventional Turbine Expander 173
Production of Ethanol (CH₃CH₂OH) from Syngas via Chemical Synthesis Route 175
Production of Ethanol and Methanol from Syngas using Fischer–Tropsch Synthesis Process 175
Production of Ethanol from Syngas via a Bio-Chemical Synthesis Route 178
Production of Ethanol via a Combination of Chemical and Bio-Chemical Synthesis Routes Using Biomass (Cellulosic Material) 181
Oxosynthesis (Hydroformylation): Syngas and Olefinic Hydrocarbons and Chemical Synthesis 186
Slag or Vitrified Slag or Ash from Gasification Reactor and Specialty By-Product Options 188
Vitrified Slag, Slag, and Ashes: Research and Development (R&D), Marketing, and Sales 192
Process for Resolving Problems with Ashes 192
Production of Road Material from Slag and Vitrified Slag 196
Production and Uses of Rock Wool, Stone Wool, and Mineral Wool 197
Production of Aggregate 200
Production of Flame-Resistant Foam 200
Destruction of Asbestos Wastes via Vitrification 201
Discussion of Potential Markets for the Vitrified Slag 202
References 204

11 MSW Gasifiers and Process Equipment 208

Conventional Gasifiers/Gasification Reactors 210
ChevronTexaco Entrained-Flow Gasifier 212
E-Gas™ Entrained-Flow Gasifier 213
Shell Entrained-Flow Gasifier 214
Lurgi Dry-Ash Gasifier and British Gas/Lurgi Gasifier 215
Prenflo Entrained Bed Gasifier 217
Noell Entrained Flow Gasifier 218
High-Temperature Winkler Gasifier 218
KRW Fluidized Bed Gasifier 219
Plasma Arc Gasification Technology 221
Alter Nrg Plasma Gasifier (Westinghouse Plasma Corporation) System 222
CONTENTS

EUROPLASMA, Plasma Arc System 223
Phoenix Solutions Plasma Arc Torches, Phoenix Solutions Company (PSC) 226
PyroGenesis Plasma-Based Waste to Energy 227
Integrated Environmental Technologies, LLC (InEnTec) 227
Other Gasification Technology 230
Primenergy’s Gasification System at Moderate Temperatures 231
Nexterra’s Gasification System at Moderate Temperatures 234
Other Process Equipments 234
Candle Filter 234
Pressure Swing Adsorption (PSA) Units 235
Mercury Removal Systems 236
Main Sulfur Removal Technologies 236
Combustion Turbine for Syngas and Gas Engine for Syngas 237
Siemens-Westinghouse Syngas Combustion Turbine for Syngas 237
General Electric (GE) Combustion Turbine for Syngas 238
GE Gas Engine for Syngas 240
Noncontact Solids Flow Meter for Waste Solids (RayMas® Meter) 241
References 251

12 Other Renewable Energy Sources 255

Wind Energy: Introduction 255
Big Wind Systems to Energy 258
Economic Example and Cases 259
Discussion of Economics For the Large Wind Farm Cases 266
Economy of Scale Associated With Wind Farms 270
Small Wind Systems to Energy 272
Discussion of Economics for the Small Wind Farm Cases 279
Hydroelectric Energy: Introduction 280
Hydroelectric Mill Dam: Nashua, Iowa 281
Discussion of the Nashua Hydroelectric Economic Analyses 285
Hydroelectric Mill Dam: Delhi, Iowa 293
Discussion of the Delhi Hydroelectric Economic Analyses 294
Hydroelectric Mill Dam: Fort Dodge, Iowa 298
Discussion of the Fort Dodge Hydroelectric Economic Analyses 305
Daily Flow and Production Methodology, Fort Dodge Mill Dam Hydroelectric Facility 316
References 360

13 Waste Energy to Recycled Energy 362

Introduction 362
References 378

Index 379